Science Aspects 1

An outcomes approach

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PEARSON
Education Australia

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Pearson Education Australia
A division of Pearson Australia Group Pty Ltd
Level 9, 5 Queens Road
Melbourne 3004 Australia
www.pearsoned.com.au/schools

Offices in Sydney, Brisbane and Perth, and associated companies throughout the world.

First published 2006

Designed by Polar Design Pty Ltd
Illustrated by Bruce Rankin
Edited by Writers Reign
Prepress work by The Type Factory
Produced by Pearson Education Australia
Printed in China

National Library of Australia
Cataloguing-in-Publication data

Science aspects 1: an outcomes approach

Includes index.
For secondary students.
ISBN 0 7339 7754 5.

1. Science – Textbooks. I, Linstead, Greg.

500

Contents

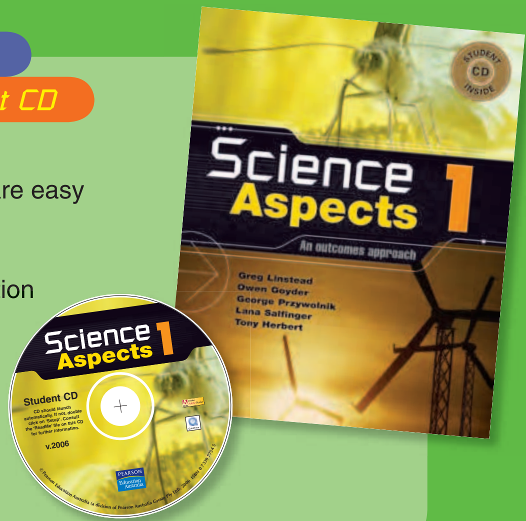
Science Aspects 1
An Outcomes Approach

The complete science package!

Science Aspects 1: An Outcomes Approach has been designed for to meet the requirements of the latest curriculum initiatives in Western Australia. It integrates an outcomes approach, drawing on the:

- Curriculum Framework
- Curriculum Framework Curriculum Guide
- Progress Maps.

Science Aspects 1: *An Outcomes Approach*
Coursebook *Includes Student CD*



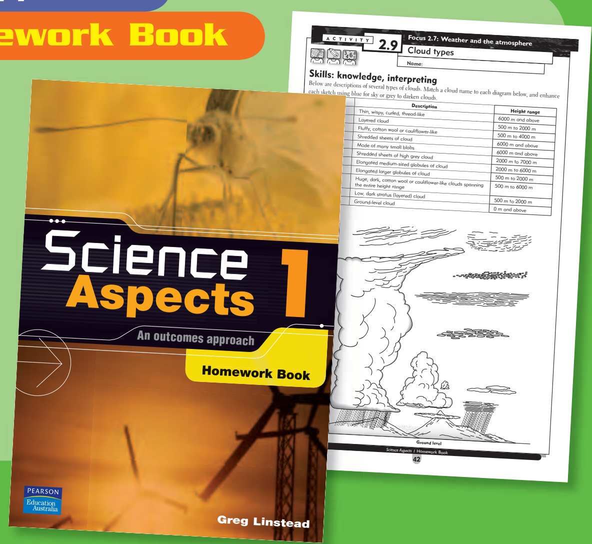
The **Coursebook** consists of chapters with the following features:

- the most up-to-date science content presented in foci (units) that are easy to read and follow
- graded review questions to allow all students to achieve success
- investigating questions to encourage further research and exploration
- section reviews to consolidate and apply learning
- practical activities.

Each **Coursebook** includes an interactive Student CD containing:

- an electronic version of the Coursebook
- the Companion Website on CD
- a link to the live Companion Website.

Science Aspects 1: *An Outcomes Approach*
Homework Book



The **Homework Book** provides a structured homework program to complement the Coursebook. These homework activities:

- cover various skills required in science
- offer consolidation and interesting extension activities
- provide revision activities, including the construction of a glossary
- cater for multiple intelligences through varied activity types.

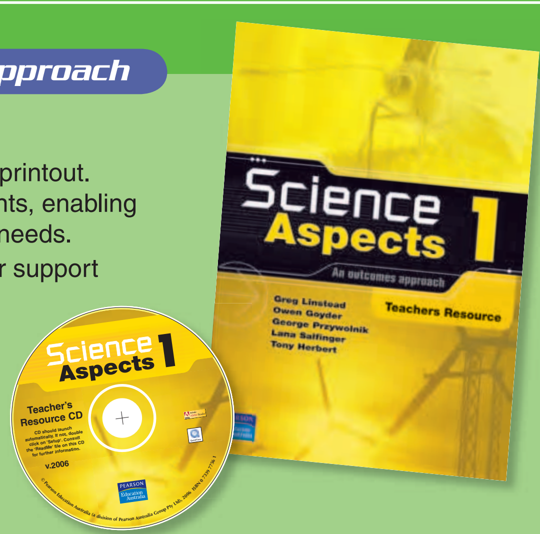
Science Aspects 1: *An Outcomes Approach*

Teacher's Resource

The **Teacher's Resource Pack** consists of a CD with printout. All documents are available as editable MS Word documents, enabling teachers to modify and adapt any resources to meet their needs.

The Teacher's Resource Pack provides a wealth of teacher support material including:

- Coursebook answers
- Homework Book answers
- assessment tasks and levelling grids
- teaching programs
- lab notes for practical activities.



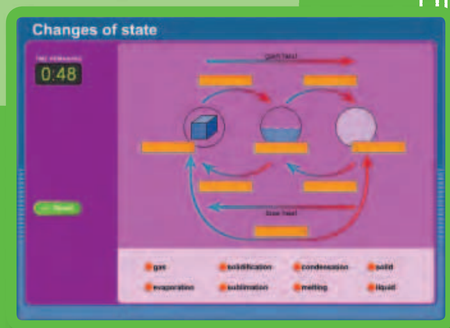
Science Aspects 1: *An Outcomes Approach*

Companion Website

www.pearsoned.com.au/schools/secondary

The **Companion Website** is available live, and on the Student CD. It contains a wealth of support material for students and teachers, written to enhance teaching and learning:

- **Review Questions**: autocorrecting multiple choice, labelling, matching and fill-in-the-blanks questions
- **Web Destinations**: a list of reviewed websites that support research and exploration
- **Interactive Animations** to engage students in exploring ideas
- **Drag and Drop Interactives** to revise key terms and key diagrams
- **QuickTime videos** to explore chemical concepts in a visually stimulating way
- **Interactive Crosswords** to revise basic concepts and key terms for each section
- **Teacher Resource Centre**: password-protected part of the site containing the teacher resources found in the Teacher's Resource Pack.



For more information on the *Science Aspects: An Outcomes Approach* series, visit www.pearsoned.com.au/schools/secondary

How to use this book

Science Aspects 1: *An Outcomes Approach* has been designed to meet the requirements of the latest curriculum initiatives in Western Australia. It integrates an outcomes approach with the latest science content to intrigue and motivate students. The content is presented through varied contexts to engage students in seeing the relationship between science and their everyday lives.

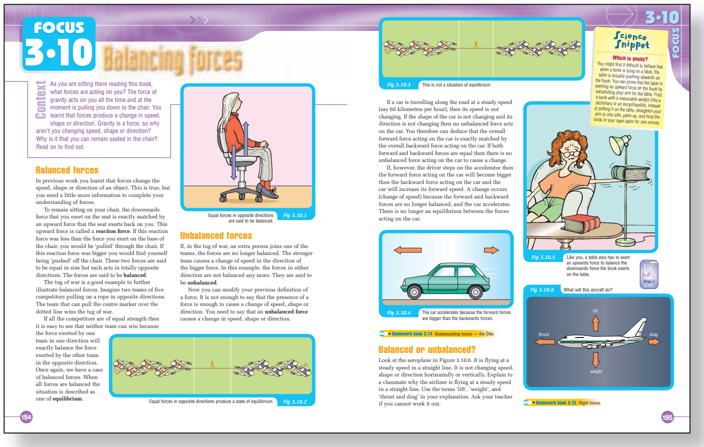
The structure of the Coursebook draws on information in the following documents to produce a cohesive resource that will allow teachers to meet the demands of teaching, learning, and assessment using an outcomes-based approach:

- Curriculum Framework
- Curriculum Framework Curriculum Guide
- Progress Maps.

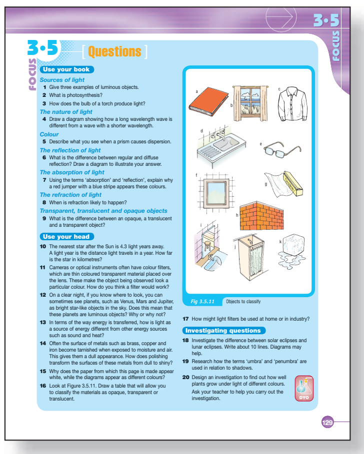
Each Coursebook consists of sections with the following features:

- **section opening pages**, which include:
  - Curriculum Guide Learning Focus relevant to the section content
  - Outcome Level Descriptions
  - photograph to simulate interest.

- **foci** (units) that open with a 'context' to encourage students to make meaning of science in terms of their everyday experiences. The foci also reinforce contextual learning by presenting theory, photos, illustrations and 'science snippet' boxes in a format that is easy to read and follow.

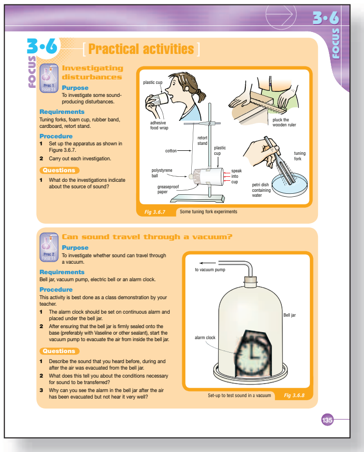


- **focus review sections**, divided into straightforward 'use your book' questions that build confidence and allow all students to achieve success, followed by 'use your head' questions requiring application and higher level problem-solving. There are also 'investigating questions' for further research and exploration, and to reinforce skills. These also include design-your-own investigations.



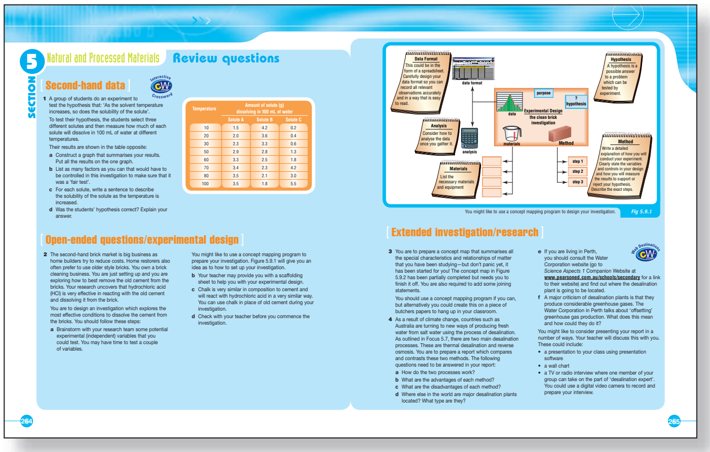
- **practical activities**, which are placed at the end of each focus to allow teachers to choose when and how to best incorporate the practical work. Icons for practical activities are included in the foci theory to signal suggested points for practical work.

Prac 3
p. 69



- **skills**, which are integrated throughout the Coursebook. Each section and focus has activities that will develop students' science skills, allowing progressive development in this area.
- **section review activities**, following the last focus in each section. These activities are divided into three types:
  - Second-hand data
  - Open-ended question/experimental design
  - Extended investigation/research.

These activities integrate outcomes from all foci for each section of the Coursebook, and provide opportunities for all students to consolidate new knowledge and skills. These activities are structured tasks that can be used as levelling assessment tasks. Levelling grids for these activities are supplied in the Teacher's Resource Pack. They can also be used as practice assessment tasks before an assessment activity from the *Science Aspects 1: An Outcomes Approach*—Teacher's Resource Pack is used.



Other icons used in *Science Aspects 1: An Outcomes Approach*—Coursebook are listed below:

Homework book 3.7 Sci-words

The Homework Book icon indicates an activity that is available in the *Science Aspects 1: An Outcomes Approach*—Homework Book.

DYO

The DYO icon indicates where a 'Design Your Own' investigation is suggested.

Interactive CW Animation

The CW icon indicates when an activity is available for students on the *Science Aspects 1: An Outcomes Approach*—Companion Website. The text written around the icon indicates the type of activity that is available. In the electronic version of the Coursebook on CD these icons are directly linked to the actual activity for convenience.

Science Aspects 1: *An Outcomes Approach* package

Do not forget the other ***Science Aspects 1: An Outcomes Approach*** components that will help engage and excite students in science:

- *Science Aspects 1: An Outcomes Approach*—Homework Book
- *Science Aspects 1: An Outcomes Approach*—Companion Website
- *Science Aspects 1: An Outcomes Approach*—Teacher's Resource Pack, including the Teacher's Resource CD.

Science Aspects 1: *An Outcomes Approach*

Curriculum correlation

Science Aspects 1: An Outcomes Approach is designed using the **Curriculum Framework**, the **Curriculum Framework Curriculum Guide** and **Progress Maps**. The following grid outlines how each focus of the Coursebook matches the contents of these documents to produce a cohesive resource, allowing teachers to meet the demands of teaching, learning and assessment using an outcomes-based approach.

Although Section 1 is dedicated to **Investigating**, this learning area outcome is integrated into all sections to ensure that it is covered progressively throughout the course.

		Progress Maps Aspect/Organiser	Curriculum Guide Learning focus/Content
SECTION 1 Working scientifically			
1.1	What is science?	Science in society, Science in daily life, Communicating scientifically, Acting responsibly in science	Meaning of science Role of science in society Scientific terms and methods
1.2	Equipment and safety	IS 2, 3, 4 Conducting	Using equipment
1.3	Observation and measurement	IS 2, 3, 4 Conducting	Observation and measurement Being accurate
1.4	Classification	IS 2, 3, 4 Conducting	Classification Making keys
1.5	Planning experiments: controlling variables	IS 2, 3, 4 Planning	Fair testing Types of variables Controlling variables
1.6	Planning experiments: the hypothesis and design	IS 3, 4, 5 Planning Conducting	Predicting and inferring Meaning of hypothesis Designing experiments Replicates and repeat trials
1.7	Conducting, processing and evaluating	IS 3, 4 Conducting Processing Evaluating	Recording data in tables Averages Interpreting data: patterns and trends Identifying difficulties and improvements
1.8	Processing data: graphs	IS 3, 4 Processing	Graphs
SECTION 2 Earth and beyond			
2.1	The Solar System	EB 2, 3, 4 Relationship between Earth, Solar System and the Universe	The Solar System: Sun, planets, comets and asteroids Gravity, orbits, distances, light source Suitability for life
2.2	The Sun, the Earth and the Moon	EB 2, 3, 4 Relationship between Earth, Solar System and the Universe	Tides Eclipses
2.3	Day and night	EB 2, 3 Relationship between Earth, Solar System and the Universe	Day and night Moon phases

	Progress Maps Aspect/Organiser	Curriculum Guide Learning focus/Content
SECTION 2 Earth and beyond (cont.)		
2.4 Weather, climate and the seasons	EB 3, 4 Relationship between Earth, Solar System and the Universe	Axial tilt and seasons Climate and weather
2.5 Earth materials: minerals and rocks	EB 2, 3, 4 Earth forces and materials	Rocks and minerals—origins and identification Weathering and the rock cycle
2.6 The atmosphere	EB 2, 3, 4 Sustainability Earth forces and materials	Atmospheric composition, sustainability of life Greenhouse effect and pollution
2.7 Weather and the atmosphere	EB 2, 3, 4 Earth forces and materials	Wind formation Land and sea breezes Weather and weather maps
2.8 Water resources	EB 2, 3, 4, 5 Sustainability Earth forces and materials	Water sources and use Environmental change and water supply
2.9 Soils	EB 2, 3, 4, 5 Earth forces and materials	Formation of soils Components and types of soil Differences in soils
2.10 Wise resource use	EB 2, 3, 4 Sustainability Earth forces and materials	Sustainability Air, soil and water problems Wise resource use
SECTION 3 Energy and change		
3.1 Storing energy	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Energy—definition and storage Kinetic and potential energy Internal energy
3.2 Transferring energy	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Energy sources and carriers Energy transfer and efficiency
3.3 Using energy	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Energy converters and receivers Power
3.4 Heating and cooling	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Heat and temperature Convection, conduction and radiation Insulators
3.5 Light	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Light—sources and nature Speed, colour Reflection, absorption and refraction
3.6 Sound	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Sound—source, speed and transmission Speech and hearing Echoes
3.7 Contact forces	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Nature of force Effects and measurement Friction

	Progress Maps Aspect/Organiser	Curriculum Guide Learning focus/Content
SECTION 3 Energy and change (cont.)		
3.8 Gravitational force	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Non-contact forces Gravity Mass and weight
3.9 Electric and magnetic forces	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Electric force and charge law Magnetic force and pole law Earth's magnetic field
3.10 Balancing forces	EC 3, 4 Energy sources, patterns and use Transfer and transformation	Balanced and unbalanced forces
SECTION 4 Life and living		
4.1 Cells	LL 4 Structure and function	Cell structure and function Cell specialisation Microscopes
4.2 Nutrition	LL 2, 3, 4 Interdependence	Structure and function Nutrition and diet Food types and energy content Photosynthesis
4.3 Movement and response	LL 2, 3 Interdependence	Structure and function Movement and response
4.4 Respiration and excretion	LL 2, 3, 4 Interdependence Structure and function	Respiration Breathing and respiratory structures Resuscitation Excretion
4.5 Reproduction and development	LL 2, 3, 4 Interdependence Structure and function Reproduction and change	Reproduction—sexual and asexual Development and parental care
4.6 Working together	LL 2, 3, 4 Interdependence Structure and function Reproduction and change	Systems Human systems, plant systems Interactions between systems
4.7 Environments	LL 2, 3, 4 Interdependence Structure and function Reproduction and change	Habitats and environment Types of environment Adaptations Environmental problems
4.8 Classifying animals	LL 2, 3, 4 Interdependence Structure and function Reproduction and change	Classification of animals Levels of classification
4.9 Other kingdoms	LL 2, 3, 4 Interdependence Structure and function Reproduction and change	Classification of plants and other kingdoms

	Progress Maps Aspect/Organiser	Curriculum Guide Learning focus/Content
SECTION 5 Natural and processed materials		
5.1 Living in a material world	NPM 2, 3, 4 Structures, properties and uses	Materials and materials scientists Properties of materials and their uses Classifying materials
5.2 States of matter	NPM 2, 3, 4, 5 Structures, properties and uses	Atoms and matter The particle theory States of matter
5.3 Changes of state	NPM 2, 3, 4, 5 Structures, properties and uses Interactions and changes	Change of state The particle theory and change of state Types of change of state
5.4 Elements, compounds and mixtures	NPM 2, 3, 4, 5 Structures, properties and uses Interactions and changes	Elements, compounds and mixtures Chemical symbols and formulas Types of mixture
5.5 Physical and chemical change	NPM 2, 3, 4, 5 Structures, properties and uses Interactions and changes	Physical changes Chemical changes Chemical equations Speed of chemical reactions
5.6 Properties of states and their uses	NPM 2, 3, 4 Structures, properties and uses Interactions and changes	Properties of solids, liquids and gases Types of solid and their uses Liquid properties—viscosity, density Uses of liquids Gases—properties and uses
5.7 Solutions and separation	NPM 2, 3, 4 Structures, properties and uses Interactions and changes	Solutions Methods of separation
5.8 Properties and uses of air	NPM 2, 3, 4 Structures, properties and uses Interactions and changes	Air composition, properties and uses Oxygen and carbon dioxide Laboratory preparation of gases

Acknowledgements

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Science Aspects 1

1 Working scientifically

Curriculum guide learning focus

Investigating

- experiments as fair tests
- dependent, independent and controlled variables in experiments
- the importance of replication and repeat trials in experiments
- science skills of observing, measuring, classifying and recording data
- equipment and safety in the science laboratory
- how evidence, experiments, what is known, and being creative and critical help in science

Communicating scientifically

- using scientific terms
- written and spoken reports for different types of audience
- collecting, evaluating and displaying scientific information

Science in daily life

- using science to solve problems in everyday life
- understanding that there are alternative scientific arguments and theories

Acting responsibly

- the effects of science on the environment
- monitoring the effects of science

Science in society

- how science and the rest of society affect each other
- the value that the scientific community places on honesty, reasoning and respect for evidence

Outcome level descriptions

The outcome level descriptions for Investigating covered in this section of the book are mainly I 2, I 3 and I 4.

FOCUS 1.1

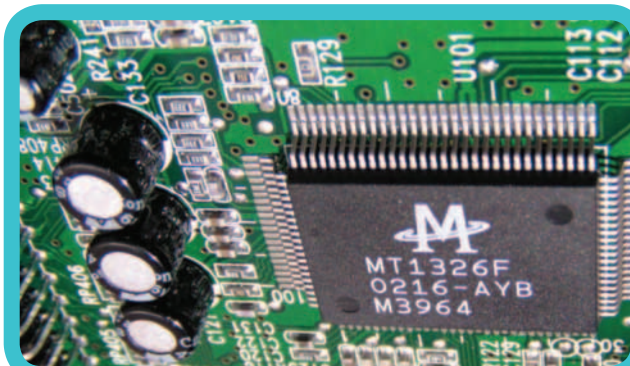
What is science?

Context

Science is a word you often hear or read. On the news scientists are reported as making new discoveries which change our world. You often hear about science in science fiction movies or on television. Many devices, such as the mobile phone, television and compact disc player, are based on scientific discoveries. Medical advances are largely carried out by scientific research. The effects of science are everywhere and it is a vital part of our lives. This is why every educated person needs to know about science. It is certain that science will go on changing our lives at an ever-increasing speed. Those who do not understand it will be left behind. This is why it is important to study science at school.

Fig 1.1.1 Science affects many areas of our lives. The MRI machine enables doctors to look inside our bodies.

This X-ray shows a heart pacemaker used to regulate a person's heartbeat. *Fig 1.1.2*



Integrated circuits enabled the development of electronic devices. *Fig 1.1.3*

What is science? One part of the answer is that science is a store of knowledge. Science is also a way of finding answers to questions.

Science as a store of knowledge

Hundreds of years of using a scientific approach have resulted in the accumulation of a large body of **scientific knowledge**. The total extent of this knowledge is now more than any one person can ever hope to learn. For example, we know how the heart works, what makes stars shine, why children look like their parents, why some chemicals explode and how a virus can make you ill. But there are many things we do not know enough about, such as how the human brain works, or all the causes of cancer, or whether life exists on other planets. The thrill of science is that we can discover new information.

The branches of science

The study of science is divided into smaller sections, called the **branches of science**. Usually a scientist becomes a specialist in one of these branches.

There are four main branches of science.

1 **Biology** is the study of living things. It has two main sub-sections. **Botany** is the study of plants, and **zoology** is the study of animals. People who study biology are called biologists.
2 **Geology** is the study of the structure of the Earth and of the rocks and minerals of the Earth's crust. People who study geology are called geologists.
3 **Chemistry** is the study of the tiny particles from which all the living and non-living materials of the Universe are formed, and how these materials can change and affect each other. People who study chemistry are called chemists.
4 **Physics** is the study of the behaviour of matter and energy. When you study physics you will learn about sound, electricity, light and heat. People who study physics are physicists.

Science Snippet

Let science help

If you learn about science you will understand our world a lot better. It can help you make decisions about how you live and the things you do. It can help you make the world a better place for all. You may be surprised to learn that people in many types of jobs use scientific knowledge—for example electricians, mechanics, pilots, nutritionists and sports coaches.

Fig 1.1.4 Microscopes are most widely used in the branches of biology, but can be used in other fields.

Science as a way of answering questions

Science is also a method by which we can find the answers to questions about the world around us. A **method** is a series of steps or rules to follow to discover an answer to a question. Some questions that science is trying to answer include what causes asthma attacks, how animals can navigate over long distances, how to cure diseases such as AIDS and how to prevent pollution of the environment.

Some questions take many years to be answered. We may have to do many experiments to find answers.

Fig 1.1.5 Saving endangered species from extinction is an important goal of science.

Some questions may never be able to be answered by science. So science does not have all the answers to every question we may ask.

There are many ways of finding the answers to our questions. Science investigations come in a variety of different forms but the key approach or method that science uses to discover answers is the 'scientific method'. You will learn about many of the variations on this method over the next few years.

Scientific method

The **scientific method** is a series of steps used to discover new information. While there can be some variations in this method, most scientists would agree the process generally consists of the following steps.

1 Making observations
We make observations using our senses of sight, hearing, touch, smell and taste. More accurate observations need measuring instruments such as thermometers and clocks.
2 Posing a question
Scientists are curious people. They want to know why. So the next step is to ask why something happened.
3 Making a hypothesis
A **hypothesis** is a possible answer to the question. You use your knowledge of science to decide what the answer to the question is likely to be.

This is where knowing quite a lot of science is really useful. A guess is a 'lucky shot', when you don't know anything about the subject concerned. A hypothesis is not a guess, as you use your knowledge to help you decide on a likely answer.

4 Testing the hypothesis
The hypothesis is then tested to see if it is backed up by evidence. You are trying to find out if it seems to be correct or not. This test is usually done by an **experiment**. Sometimes a second hypothesis has to be put forward if the first one is not supported.

5 Making a theory
If a hypothesis is tested many times and is found always to be supported by evidence it may be called a **theory**. An example of a theory is the atomic theory, which is about all matter being made of very small particles called atoms.

This is only a brief outline of the scientific method. You will look at it in more detail in later foci.

FOCUS 1·1 [Questions]

Use your book

Science as a store of knowledge

1 Give two answers to the question 'What is science?'

2 In which branch of science do you study:
- **a** animals and plants?
- **b** plants?
- **c** light and sound?
- **d** earthquakes?

Science as a way of answering questions

3 Do science investigations all use the same method?

4 What do we mean when we say science is 'a way of answering questions'?

The scientific method

5 Rearrange the letters in the following jumbled-up words to make words in the scientific method, and put the words in the correct order : stqeunio, pythishsoe, onsebriovat, pertixemne.

6 What do we mean by a hypothesis?

7 Is a hypothesis a wild guess?

Use your head

8 **a** Identify three items at your school that you think may have been produced by a scientist.
- **b** Indicate the type of scientists who probably helped to produce these items.

9 What type of scientist would work in each of the following situations?
- **a** an oil drilling company
- **b** a plastics factory
- **c** a plant nursery
- **d** a company that generates electricity
- **e** a company that builds aircraft
- **f** a zoo
- **g** a gold mine.

10 Consider each of the following quotes. Indicate which step of the scientific method each one represents.
- **a** '... before you base a law on this case, test it two or three times to see whether the tests produce the same effects' (Leonardo da Vinci)
- **b** 'Once you have asked the right question, many likely answers become obvious' (Karl Kruszelnicki)
- **c** '... all sciences are vain and full of errors ... that do not ... pass through any of the five senses' (Leonardo da Vinci).

11 Imagine you discover a dog with a cut and bleeding paw. The cut is 3 centimetres long and has clean, sharp edges. Indicate which of the following hypotheses are likely to explain this, and give reasons for your answers.
- **a** The dog stood on a piece of wire.
- **b** The dog bumped its paw against a wall.
- **c** The dog caught its paw in a door.
- **d** A cat slashed it with its claws.
- **e** The dog stood on a sharp object like a piece of sheet metal.
- **f** Someone stood on the dog's paw.

12 Consider your answer for Question 11 above.
- **a** What would your answer be if you were told the dog had been inside the house all day?
- **b** Do you need a new hypothesis?

Investigating questions

13 Find out what work is done by scientists who work as:
- **a** archaeologists
- **b** entomologists
- **c** biochemists
- **d** engineers.

14 Name two current problems that scientists are trying to solve. You might need to look through some newspapers or on the Internet for information.

15 Watch the news on television or listen to the radio news. Briefly describe one story which was about science.

16 Which branch of science you would have to study to be:
- **a** a doctor
- **b** an electrician
- **c** a physiotherapist
- **d** a pharmacist
- **e** a veterinarian
- **f** a computer technician
- **g** a nurse
- **h** a pilot?

FOCUS 1.2 Equipment and safety

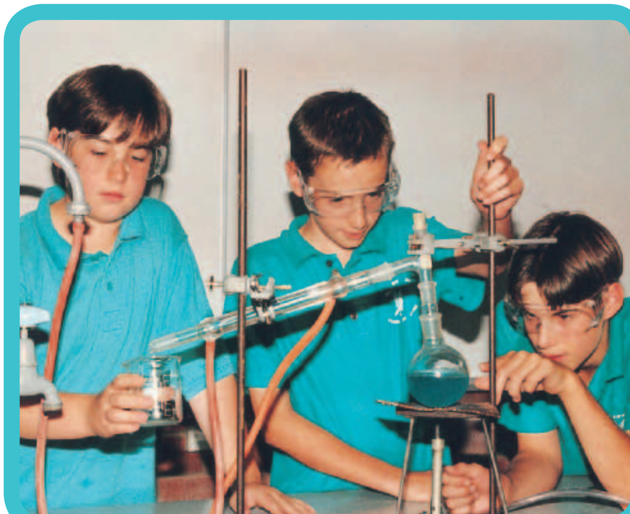
Context For the next three to five years you will be using science equipment and science laboratories to study science. You need to learn about the equipment you will be using. Science can be a dangerous subject and so requires you to learn about working safely. Safety rules are vital in science. This focus will help you learn the names and uses of science equipment and the safety rules needed to protect you and your friends.

Fig 1.2.1 A fire extinguisher

Safety features in the science laboratory

A **science laboratory** is a room in which science activities are done. Many people work in science laboratories in hospitals, universities, large industrial complexes and factories and special research facilities. The following safety features are common to most laboratories.

- **Main gas and water taps.** Usually a laboratory will have a gas shut-off valve and a main water tap so that all the gas and water can be turned off in an emergency. There usually is a master switch to turn off all the electricity. Make sure you know where it is.
- **Exhaust fan.** Chemical laboratories usually have an exhaust fan to remove dangerous fumes.
- **Emergency exits.** In a laboratory there are usually at least two exits that can be used in an emergency evacuation.
- **Fire extinguishers.** Fire extinguishers are available in case there is a fire in the laboratory. You should learn how to use a fire extinguisher as you may have to use one in an emergency.
- **Fire blanket.** A fire blanket is a non-flammable blanket which can be thrown over a fire to put it out or to wrap up a person whose clothes are on fire. **Non-flammable** means that it will not catch fire or burn with a flame.
- **Eye protection. Safety glasses** should be used whenever your teacher advises you to wear them.



Safety glasses are essential to protect your eyes. Fig 1.2.2

An **eyewash** should be available in case of accident. An eyewash is a bottle of water, which you can use to wash out any chemicals that have accidentally splashed into your eyes. Make sure you know where yours is.

Laboratory rules

The main rules for the laboratory are the following:

1 Be careful when moving around the laboratory.
2 Tie back long hair and wear protective glasses.
3 Wear covered footwear. Thongs are not acceptable footwear.
4 Only do experiments directed by your teacher.
5 Report accidents, breakages and damaged equipment.
6 Clean up and return equipment when finished.
7 Do not wash solids down the sink.
8 Listen carefully to your teacher's instructions.

Science Snippet

Science rules!

Laboratory rules are to protect everyone, including you and your friends. You must learn these rules and follow them at all times.

Find out if your teacher has given you a list of extra rules for your class. You may need to keep a copy in your science notebook. Find out why your teacher wants you to follow these extra rules.

Homework book 1.1 Commonsense safety rules

Laboratory equipment

You will learn the names and uses of the different pieces of equipment as your study of science continues. Below is a list of common pieces of laboratory equipment that you will use regularly during your science course. You can see what they look like in Figure 1.2.3.

1 **Test tubes** are used for holding small amounts of chemicals.
2 **Beakers** are used for holding larger amounts of substances. They can be used when heating liquids.
3 **Measuring cylinders** are used to measure volumes of liquids.
4 **Filter funnels** are used for pouring liquids into narrow containers, and for filtering solid particles out of liquids.
5 **Flasks** are used in some experiments in which liquids are used. They may be round-bottomed, flat-bottomed or conical.

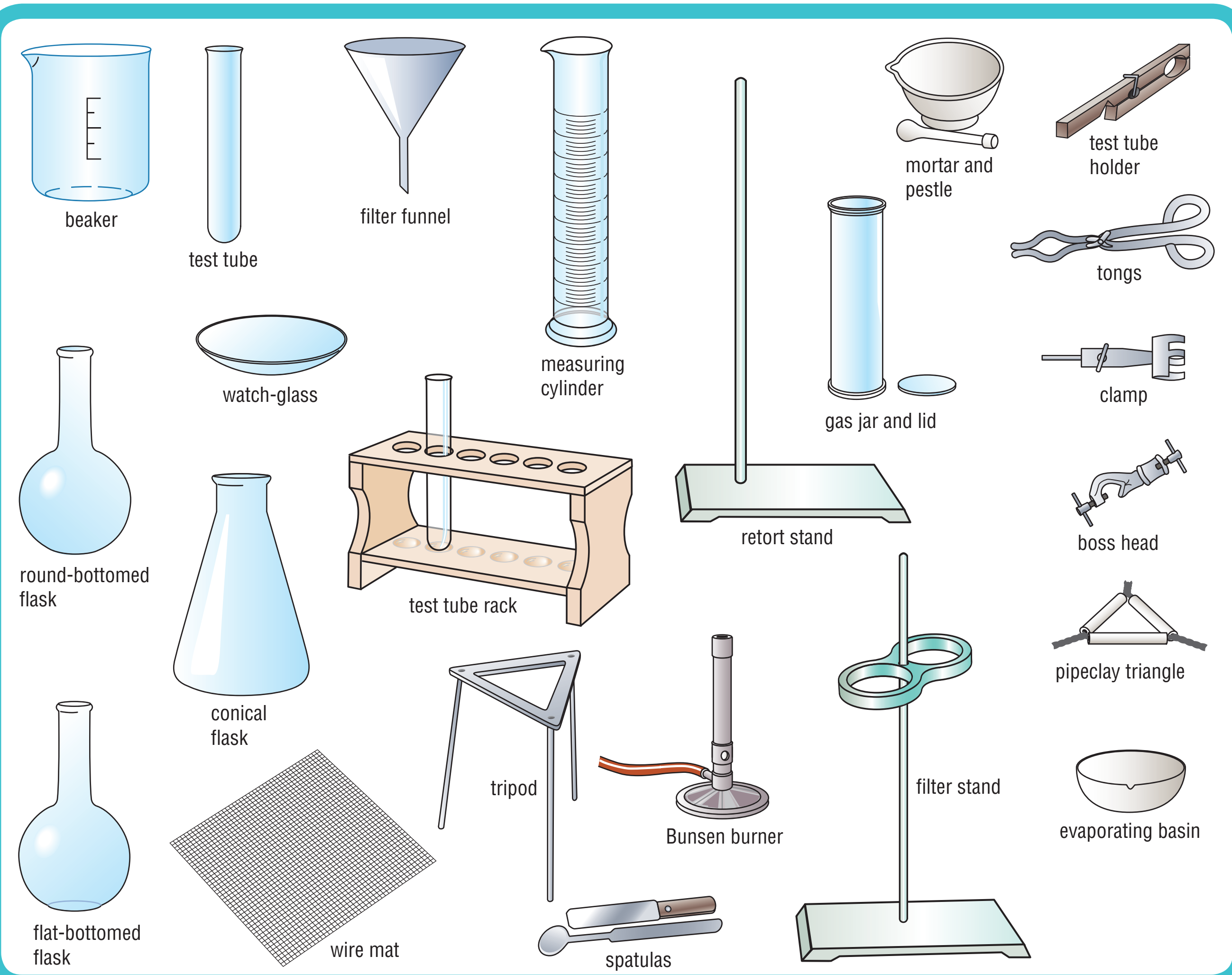


Fig 1.2.3 Some science equipment used in school laboratories

6 **Watch-glasses** are small dishes used for holding small specimens, and for helping liquids to evaporate quickly.
7 **Bunsen burners** burn gas to heat substances.
8 **Tripods** are stands with three legs. When a beaker is heated on a Bunsen burner, a **wire mat** is placed on the tripod, and the beaker is placed on the wire mat. The wire mat spreads the heat evenly.
9 **Bench protection mats** are placed under the equipment to protect the bench.
10 **Retort stands** and **clamps** are used for holding equipment. The **boss head** holds the clamp to the retort stand.
11 **Tongs** and **test tube holders** are used for holding hot objects, such as a test tube being heated over a Bunsen burner.
12 **Test tube racks** are for holding test tubes.
13 **Pipeclay triangles** are used for holding containers such as crucibles when they are being heated by a Bunsen burner.
14 **Spatulas** are used for picking up solids and putting them into containers.
15 **Gas jars** are used for holding gases produced in experiments.
16 A **mortar and pestle** are used to grind up solids into a powder. The mortar is the bowl-shaped piece.
17 **Filter stands** are used for holding filter funnels.
18 **Evaporating basins** are used to evaporate liquid quickly.

There are, of course, many other specialised pieces of equipment. You will learn their names and uses as you progress through this book. Some of these are stethoscopes, van der Graaf generators, dissecting instruments, microscopes, electrical meters, thermometers and manometers.

Drag and Drop CW Interactive

Homework book 1.2 Science equipment wordfind

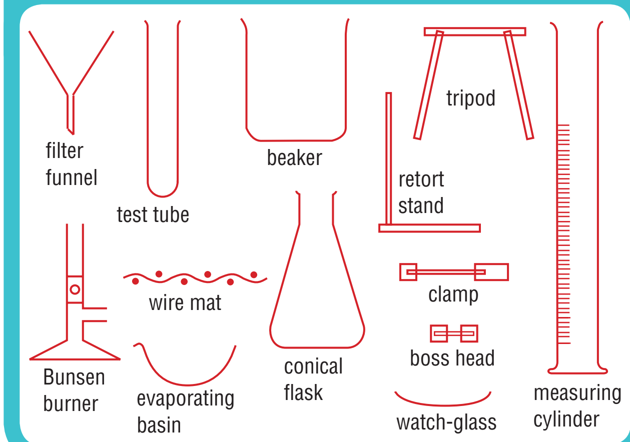
Homework book 1.3 Identifying science equipment

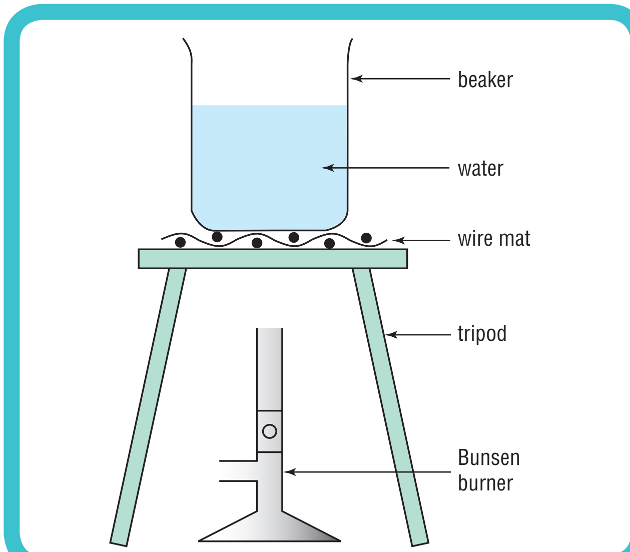
Sketching equipment

You always draw a piece of laboratory equipment as though it has been cut from top to bottom in the middle and you are looking at it from the side view. This is called a **vertical transverse section**. Figure 1.2.4 shows you how to sketch some laboratory equipment.

Figure 1.2.5 shows you how to sketch equipment set up for an experiment. You must always **label** your diagrams. This means you must write the name of each piece of equipment next to it and join it to the diagram with an arrow or line.

Fig 1.2.4 How to sketch science equipment





How to sketch and label equipment used in an experiment *Fig 1.2.5*

Using a Bunsen burner

Lighting

Figure 1.2.6 shows a Bunsen burner. When using a Bunsen burner you should follow these steps:

1 Clear the work area and place a bench protector under the Bunsen burner.
2 Close the air hole of the burner by turning the collar.
3 Light a match and hold it at the top of the burner, but not directly over the hole.
4 Turn on the gas and light the burner.

5 Leave the collar closed and the yellow luminous flame burning until a hot flame is needed.
6 Slowly turn the collar around to open the air hole if you need a hotter flame. If the burner flame goes out, turn off the gas and start again.

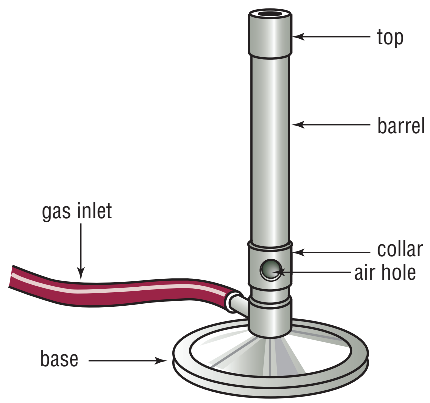


Fig 1.2.6 The parts of a Bunsen burner

Interactive CW Animation

Homework book 1.4 The Bunsen burner

Safety

Here are some very important safety rules to follow when using a Bunsen burner:

1 Always follow the steps described above when lighting a burner.
2 Do not lean over a burner because your hair or clothes could catch alight or you could be burnt.
3 When not using the burner for heating close the collar to produce the yellow luminous flame—it is easier to see and there are less likely to be accidents.
4 When heating a test tube over a burner make sure that the open end is not pointing at anyone in case some of the contents spit out of the test tube.

Prac 1 p. 10
Prac 2 p. 10

1·2 FOCUS [Questions]

Use your book

Safety features

1 Name four items in a science laboratory that you would not find in other classrooms.

2 Where are the main gas shut-off valve tap and the main water tap in your laboratory?

3 Where are the exits from your laboratory that could be used in an evacuation?

Laboratory rules

4 Write down any five rules you remember. Now check your book and write down any rules you could not remember.

5 If you are doing an experiment and you break some glassware, what should you do?

Laboratory equipment

6 Give the uses of the following pieces of equipment: wire mat, spatula, tongs, evaporating basin.

7 Use Figure 1.2.3 to answer the following questions:
- **a** What six glass containers can be used to hold liquids?
- **b** What piece of equipment can be used to measure the volume of a liquid?
- **c** What would you use to hold a clamp to a retort stand?
- **d** What would you use to hold a hot test tube?
- **e** What would you use for pouring water from a beaker into a narrow container?

Sketching equipment

8 Sketch and label a diagram that shows a flat-bottomed flask clamped to a retort stand and being heated by a Bunsen burner. The bottom of the flat-bottomed flask is just touching a wire mat, which is on a tripod stand.

Using a Bunsen burner

9 Why should the Bunsen burner be left burning with a yellow luminous flame when it is not being used for heating?

10 What is the important rule to follow when heating liquid in a test tube?

11 Why should you light the match before turning the gas on when using a Bunsen burner?

Use your head

12 What five rules do you think are the most important? Give your reasons.

13 What would you do if you splashed some acid in your eye?

14 Why must you tie back long hair and be careful not to lean over a Bunsen burner when it is burning?

15 If you had a test tube containing a solid and some liquid, what should you do to clean it?

16 Why is it especially important in science rooms that you are well behaved and thinking about what you are doing at all times?

17 Why do you think so many of the containers and vessels used in a laboratory are made of glass?

Investigating questions

18 What instructions are written on the side of the fire extinguisher in your laboratory?

19 What are the evacuation procedures for your science classroom?

FOCUS 1.2

Practical activities

Prac 1 Focus 1.2

Bunsen burner flames

Purpose

To investigate the properties of different Bunsen burner flames

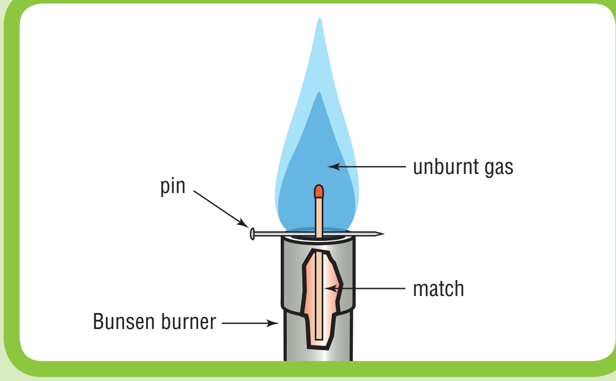
Requirements

Bunsen burner, matches, 2 test tubes, water, tongs, 2 nails, pin, test tube holder

Procedure

1. Light the burner and leave the collar closed. The flame produced is called the luminous flame. *Describe the appearance in your notebook.*
2. Using a test tube holder, hold a clean test tube half full of water in the flame for about 20 seconds. *Record the appearance of the test tube.*
3. Using the tongs, hold a clean nail in the flame for 20 seconds. *Record the appearance of the nail.*
4. Open the collar to produce a blue flame. The flame produced is called the non-luminous flame. Notice it has two areas, a darker blue inner cone and a lighter blue outer cone. *Draw the appearance of the flame.*
5. Repeat steps 2 and 3 with the blue flame, holding the object a few centimetres above the tip of the inner cone. *Record the appearance of the test tube and the nail.*

How to mount the match on the pin **Fig 1.2.7**



6. Push the pin through a match and place it in the Bunsen as shown in Figure 1.2.7. Then light the Bunsen burner and switch to the blue flame. *Record what you observe.*

Questions

1. Which flame do you think is hotter? Give your reasons.
2. The luminous flame is also known as the dirty flame. Which of your observations showed this?
3. Which is the safer flame if you have to leave your Bunsen burner alight? Give two reasons.

Prac 2 Focus 1.2

Doing an experiment with the Bunsen burner

Purpose

To do an experiment using the Bunsen burner. You will find out whether water keeps on becoming hotter if you keep on heating it.

Requirements

250 mL beaker, tripod, wire mat, Bunsen burner, 110°C mercury thermometer, retort stand, boss head, clamp, one-hole stopper, clock or timer, safety glasses, matches.

Procedure

1. You will be setting up your equipment as illustrated in Figure 1.2.8. However, you need to read through steps 2 to 4 below before you set up the equipment.
2. Very carefully push the top of the thermometer into the hole in the stopper so that it holds the thermometer. You must still see the 100°C mark. Fix the stopper into the clamp and attach it to the retort stand. Be very careful not to break the thermometer.
3. Loosen the boss head and lower the clamp so that the bottom of the thermometer is in the middle of the water, about halfway between the surface and the bottom of the beaker.
4. *Copy the table below into your notes and then record the temperature of the water in the table. Add as many rows as you need for your records.*

Temperature change while heating water

Time (minutes)	Temperature (°C)	Observations
0		
1		
2		
3		

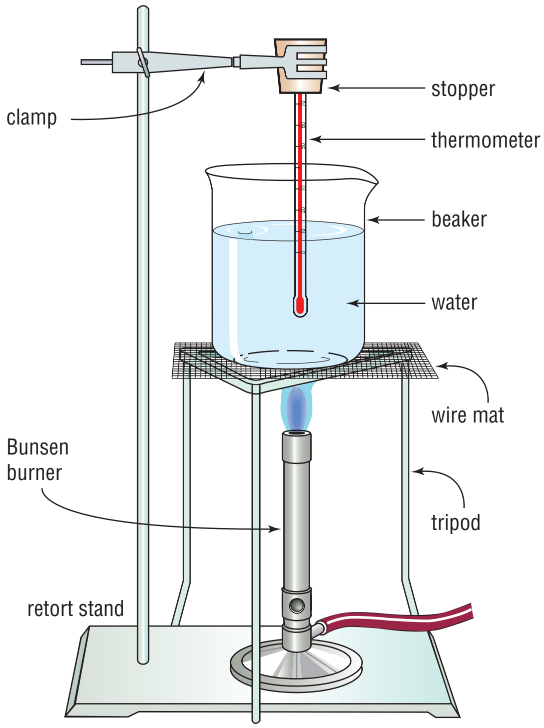


Fig 1.2.8 Set up your equipment as illustrated in this diagram.

5 Put on your safety glasses. Light the Bunsen burner, following the correct steps.
6 Using the hottest flame, heat the water. *Record the temperature every minute until the water boils. Note how the water appears in the 'observations' column.*
7 Continue recording the temperature for three minutes after the water boils.

Questions

1 Did the temperature rise through the whole experiment?
2 When did the temperature stop rising, and what did you see was happening to the water at this time?
3 Pure water boils at exactly 100°C, measured with an accurate thermometer. Does your experiment suggest anything to you about tap water?
4 Your teacher could do a demonstration with distilled water, or they may let you try it yourself—though distilled water is expensive.

FOCUS 1.3 Observation and measurement

Context

We discussed the scientific method in Focus 1.1. What was the first part of this method? If you said 'observation', you were correct. All science is based on observation as the first step. Making careful and accurate observations is the beginning of the process of trying to explain the world around us. You have to practise observing to become good at it.

You also need to understand the process of measurement, which is using instruments to find a number.

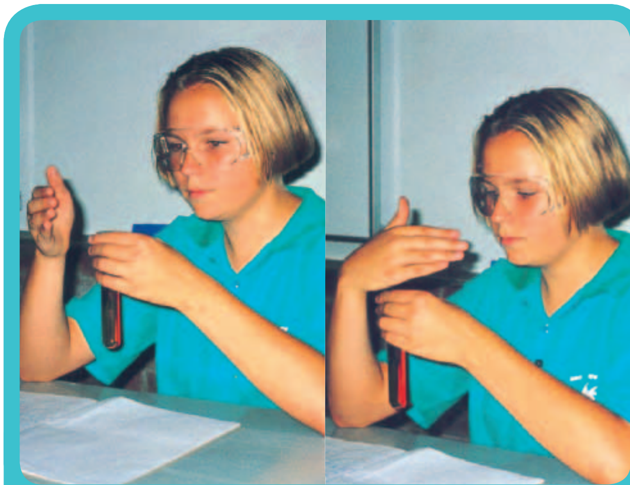


Fig 1.3.1 Wafting is the method used for smelling chemicals.

Observation

An **observation** is information gained from your senses. Your five main senses are sight, hearing, touch, taste and smell. When you use any of your senses to detect something, you are therefore making an observation.

Taking care with our senses

You must use your senses of smell, taste and touch carefully in science laboratories. It is not wise to taste unknown chemicals, or even familiar ones. There is always the chance that they may be **contaminated**. This means they may have been mixed with other chemicals, which could be **poisonous**.

It is very important to be careful when touching things in the science laboratory. Some chemicals are poisonous. A good rule to follow is not to touch chemicals with your skin unless you are certain they are harmless. Many objects you use in science are hot and can burn. Others can give an electric shock.

When smelling things scientists use a method called **wafting**. You hold the substance to be smelled about 30 centimetres or so away from your nose. You then wave your hand towards and away from your nose to push the air from around the object towards your nose. In this way only a small amount of the substance is **inhaled**. If the substance is dangerous it will not do as much harm as if you took a deep sniff.

Extending the senses

In science you can use instruments to help extend your senses to make observations.

You can extend your **sight** with microscopes, telescopes, hand lenses and other devices.

You can extend your **hearing** with a **stethoscope**. Doctors use these to hear sounds such as heartbeats.

Using a stethoscope to listen to chest sounds *Fig 1.3.2*

Microphones and **amplifiers** can be used to detect sounds and make them louder.

Measurement

A **measurement** is a number obtained by using an instrument. Scientists make measurements because they are easy to understand and can provide more accurate information than general observations. For example, more accurate information is provided about the length of a plank if you can say that it is 2.5 metres long rather than just that it is a long plank. In addition, your senses can sometimes be fooled because of the circumstances under which observations may be being made. Measurement is a more accurate form of observation than description.

Prac 1 p. 16

Measuring instruments

In science some commonly used measuring instruments are thermometers, scales or balances, rulers, measuring cylinders and timers. These are used to measure temperature, mass, length, volume and time.

Temperature

A **thermometer** is used to measure **temperature**. There are several types of thermometer. The main type used in science consists of a glass tube filled with mercury or coloured alcohol. It has a scale divided into sections called **degrees Celsius**. The degrees Celsius is called the unit of temperature. The symbol for it is **°C**. Water boils at 100°C and freezes at 0°C. Most thermometers have a scale between –10 °C and 110°C.

Science Snippet

I feel sick Mum!

Sometimes when you feel sick you have your temperature taken. The thermometer that is used is called a **clinical thermometer**. This has a scale between about 35°C and 42°C. A clinical thermometer is used to check a person's body temperature, which should be about 37°C. If your temperature is too high you must be cooled down or you could die. Who would use a clinical thermometer a lot in their job?

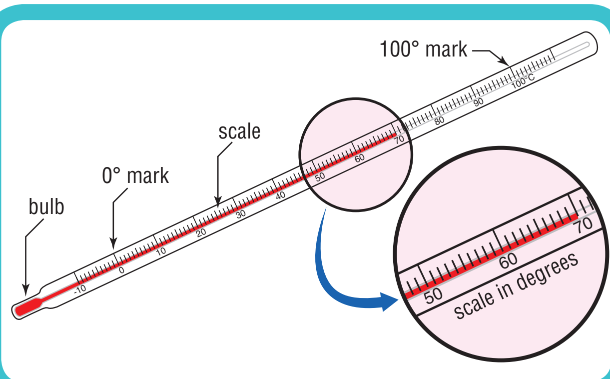
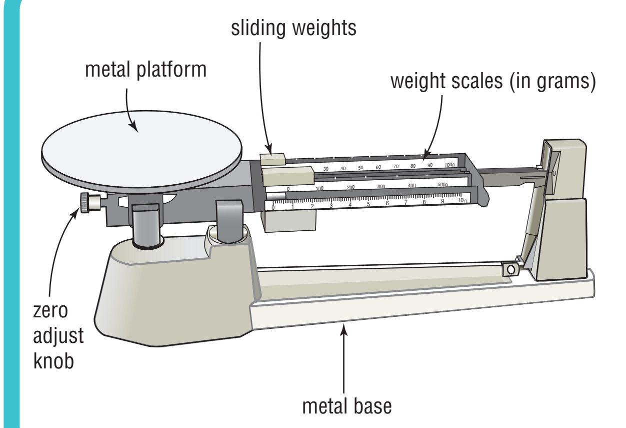


Fig 1.3.3 A thermometer is used to measure the temperature.

Mass

Scales or balances are used to measure the heaviness or mass of object. There are many different types of scales and balances. With electrical balances you simply put the object on a pan and read the dial to find out the mass. With others, such as a triple beam balance, commonly found in schools, you have to slide weights along a scale until you find the balance point. You then read off the mass from the scale. A triple beam balance is shown in Figure 1.3.4.



A triple beam balance is often used in schools to find the mass of an object. *Fig 1.3.4*

The unit of mass is the **gram** or **kilogram**. A five-cent coin has a mass of about 3 grams. One kilogram is the same mass as 1000 grams, while one tonne is the same mass as 1000 kilograms. A large car has the mass of about one tonne. The abbreviation for gram is **g** and for kilogram is **kg**. For example, 5 grams is written as 5 g and 5 kilograms as 5 kg.

Length

An **optical illusion** can provide a good example of why you need an instrument to measure **length**. For example, which of the lines in Figure 1.3.5 is the longer? Use a ruler to check your choice.

You will have discovered that the two lines in Figure 1.3.5 are the same length. Measuring the length told you this. The instrument you used is called a **rule**. A metre-rule is a rule that is one metre long and divided into millimetres and centimetres. There are 1000 millimetres in one metre.

An optical illusion of length Fig 1.3.5

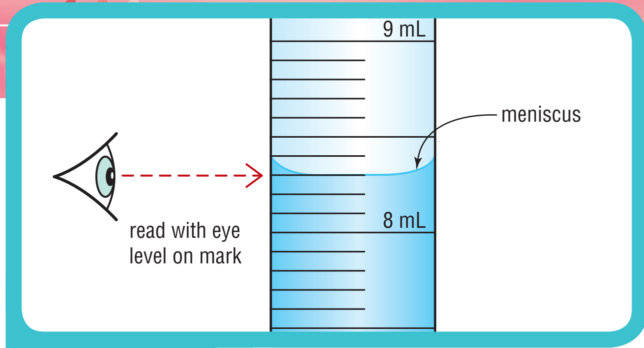


Fig 1.3.6 Reading a measuring cylinder with a curved meniscus

Large distances are measured in kilometres. There are 1000 metres in one kilometre. A kilometre is about four times the distance around your school oval.

The common units for measuring length are the **millimetre** (**mm**), **centimetre** (**cm**), **metre** (**m**) and **kilometre** (**km**).

Homework book 1.5 Observing and measuring

Volume of liquids

Volume is the amount of three-dimensional space taken up by an object. Sometimes you use instruments to measure this, or you can use a formula and calculate volume.

The volume of a liquid is measured by placing it into a measuring vessel. In the laboratory you use **measuring cylinders** or **beakers** to measure the volume of a liquid. Measuring cylinders are used when accurate volumes are required. The volume of a liquid is measured in **litres** or **millilitres**. The abbreviation for litre is **L** and for millilitres is **mL**. Milk comes in cartons that hold 600 millilitres, one litre and 2 litres. One millilitre is equal to one cubic centimetre.

Measuring cylinders come in many sizes. Small ones measure up to 10 millilitres. Large ones can measure up to a litre. The scale on the side of the cylinder is used to tell how much liquid is in the vessel. However, the shape of the top surface of the liquid is not flat. It is always slightly curved. Always use the bottom curved surface when measuring the volume of the liquid. This curved surface of the liquid is called the **meniscus**. You can see this in Figure 1.3.6.

Volume of solids

Regular-shaped solids

The volume of regular-shaped solids can easily be calculated from a few measurements and a **formula**. The volume of a solid rectangular prism such as a box can be calculated using the formula:

volume = length × width × depth

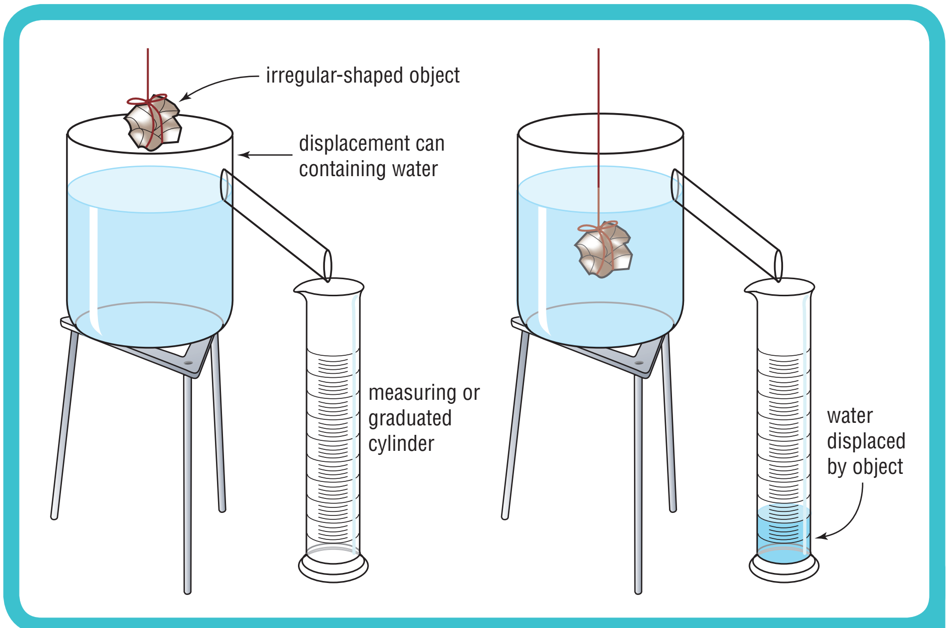
The units of volume will depend on the unit of length chosen. If length is in centimetres, then volume is in **cubic centimetres**. This is written as **cm³**.

Irregular-shaped solids

A **displacement can** is used to measure solids that are irregular in shape. The volume of water that overflows into the beaker is equal to the volume of the object submerged in the displacement can. This is shown in Figure 1.3.7.

Time

To measure **time** accurately you use a **clock**, **watch** or **timer**. The basic unit of time is the **second**. As the



A displacement can is used to measure the volume of some objects. Fig 1.3.7

second is an extremely small unit of time, larger units such as **minutes**, **hours** and **days** are often used. There are 60 seconds in a minute and 3600 seconds in an hour. The abbreviation for second is **s**, for minutes is **min** and hours is **h**.

Older-style clocks have second, minute and hour hands that circle the face of the clock. This type of instrument is called an analogue clock. It works on a complex system of springs, spindles and cogged wheels. Newer timing devices, called digital clocks, are electronic and present the time as a digital read-out.

Area

Area refers to the amount of surface of an object. An object with a large surface has a large area. The area of a 20-cent coin is larger than the area of a 5-cent coin. However, sometimes it is difficult to judge the area using your senses alone. For example, which has the bigger area, a dinner plate or a page of this book? It is difficult to compare areas when they are different shapes.

With many objects you can measure some lengths and then use a **formula** to calculate the area. For example, to find the area of one page of this book, you measure the length and the width then multiply the two together to find the area. So the formula for calculating rectangular areas is:

area = length × width

The unit for area depends on the unit used to measure length. If the length was measured in centimetres, then the area is in **square centimetres**. This is written as **cm²**.

Prefixes for units

When writing units in science, you often use **prefixes**. A prefix is a word written at the start of a unit to indicate the size of the unit. One prefix you probably know is **kilo**. This means **1000 times**. So one kilometre means 1000 times one metre, which is 1000 metres. The prefixes that you need to know are shown in the following table.

Unit prefixes

Prefix	How much is it?	What does it mean?
kilo	1000	one thousand times
deci	1/10	one-tenth
centi	1/100	one-hundredth
milli	1/1000	one-thousandth

Homework book 1.6 Metric units of measurement
Homework book 1.7 Extreme units
Drag and Drop CW Interactive

1.3 FOCUS [Questions]

Use your book

Observation

1 What is an observation?

Taking care with our senses

2 Why is it unwise to taste chemicals?

3 a Describe the safest way to smell an unknown gas in a test tube.
b Why is this method used?

Measurement

4 a What is a measurement?
b Why do scientists use measurements?

Measuring instruments

5 What instrument would you use to measure the temperature of:
a a cup of hot water
b your body, if you thought you may have a fever?

6 What instruments are used to measure:
a the mass of an object
b the length of an object?

7 a How many metres in a kilometre?
b How many litres in a decilitre?
c What part of a gram is a milligram?
d How many centimetres in a metre?

8 a Name two instruments that are used to measure the volume of liquids.
b What units are used to measure liquids?

9 Describe how to find the volume of a rock using a displacement can.

10 What is the formula to find the area of a rectangle or a square?

Use your head

11 a If you heard a sound, would it be an observation? Explain your answer.
b When you have to remember something, such as a person's name, are you making an observation? Explain your answer.

12 Convert the following:
a 4000 g to kg
b 100 mL to L
c 0.04 m to cm
d 5.7 L to mL
e 600 s to min
f 100 mm to m
g 120 min to h.

>>

13 What are the readings on each of scales A, B, C and D in Figure 1.3.8?

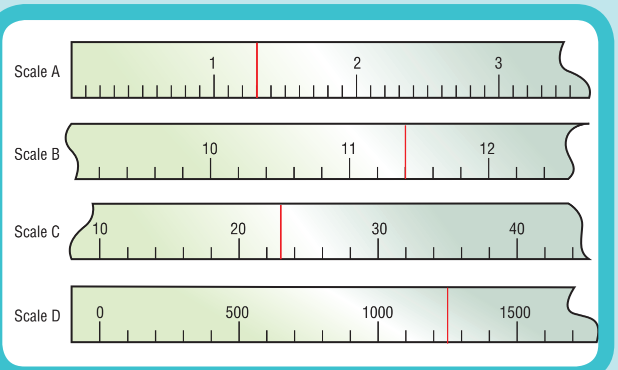


Fig 1.3.8 Use these scales to answer Question 13.

14 A student wanted to find the area of a rectangular piece of paper. She found that the length was 29 cm and the width was 21 cm. What was the area in cm^2?

15 What is the volume of sand in a trailer if the trailer is 182 cm long, 122 cm wide and 30 cm deep?

16 **a** What instrument would you use to measure the volume of water in a cup?

b Describe how to accurately read the level on the scale.

17 The police can catch speeding cars by observing from a helicopter. The maximum speed in the country is 110 kilometres per hour. Police observe the car as it passes over two lines marked on the road a certain distance apart. Describe what you would have to know to be able to calculate a vehicle's speed. A speed is a distance divided by a time.

18 When a nurse wants to see how fast your heart is beating, they count the number of pulses of the artery in your wrist. This is the pulse rate. The pulse rate is measured in beats per minute. Without having to count the pulses for one minute, explain how you could estimate your pulse rate.

Investigating questions

19 Use the library to find out what the following instruments are used to measure:

a sphygmomanometer
b voltmeter
c glucometer
d barometer.
e tachometer.

20 **a** Find the names of five instruments that are used in your home to measure quantities.

b What does each instrument measure?

c In what units does each instrument measure?

FOCUS 1·3 [Practical activity]

Fooled by your senses

Prac 1 Focus 1.3

Purpose

To compare the accuracy of your senses and a measuring instrument in detecting the temperature.

Requirements

Four 250 mL beakers, thermometer, tap water, ice, hot water.

Procedure

1. Fill two beakers with tap water at 20°C.
2. Fill another beaker at 5°C, using ice and water.
3. Add hot and cold water to the fourth beaker until it is at 45°C.
4. Sit with the four beakers in a line across the desk in front of you. Place the two beakers of tap water in the middle. Place the warm water on your right and the cold water on your left.
5. Place your right hand into the warm water, and your left hand into the cold water. Leave them in the water for about 20 seconds.
6. Place your right hand into one of the beakers of tap water at 20°C and your left hand into the other beaker.
7. Close your eyes and sit quietly for about 20 seconds. Concentrate on how warm or cold each hand feels. *Tell another student in your group to record whether your right and left hands feel about the same or different.*

Questions

1. When you put your right hand into the tap water at 20°C, how did it feel after several seconds?
2. When you put your left hand into the tap water at 20°C, how did it feel after several seconds?
3. The water in both beakers of tap water was at the same temperature of 20°C. Which method was more accurate at determining the temperature of the water in the beakers—your hands or the thermometer? Explain how you chose your answer.
4. What does this experiment tell us about our senses compared with measuring instruments?

FOCUS 1.4

Classification

Context

Classification is a skill needed in many areas of science, and also in our daily lives. We often use it without being aware of it. It is used in many stages of the scientific method. In making a hypothesis and testing the hypothesis classification is often used.

During experiments classification is mainly used in the stages of conducting and processing the results. In many branches of science, classification is also used regularly in investigations without being part of any experiment.

What is classification?

Classification is the arranging of objects into orderly groups using a system. It is widely used in all communities. For example, you can classify TV programs into groups such as sports, news, current affairs, documentaries, comedies and dramas. The system of classification used in this case is the content of the TV programs.

Another example of classification is the arrangement of goods in a supermarket. When you go into a supermarket the goods for sale are in certain areas. These have been grouped in special ways so that the customers can locate the goods easily. There is probably a canned food section, a cereal section, a frozen food section and so on.

Each of the main sections is then usually divided into further sections. For example, in the frozen foods section there will probably be a vegetables section, a sweets section, a meals section and so on. Within each of these sections there will be more sections. For example, the vegetables section of the frozen foods may be further sub-divided into areas for peas, carrots, beans and so on. This is illustrated in Figure 1.4.2.

In the supermarket, the goods have been classified. The manager has the goods arranged into these groups using a system. The purpose of this arrangement is to help the

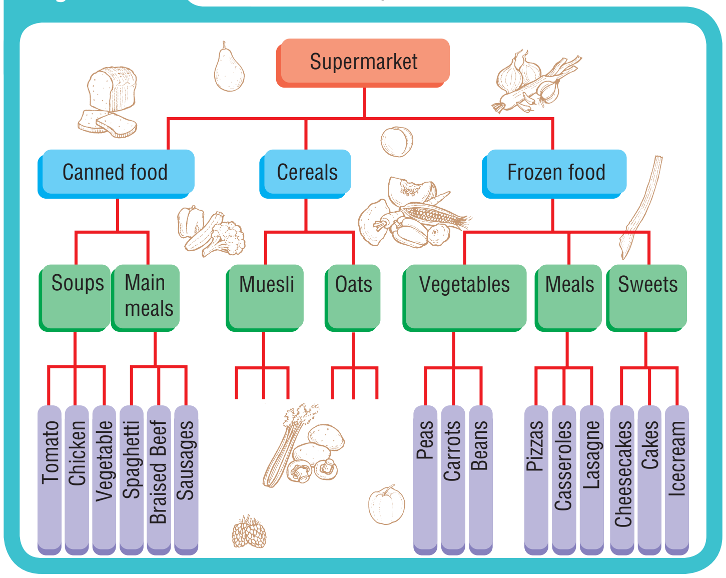
Science Snippet

Classification and you

You use classification every day of your life even though you probably don't know it. One example may be your music collection, if you group your CDs by the type of music, such as hip hop, heavy metal, pop, classical, country, folk etc. Another example may be the way you store your computer files. You decide which basic folders to create to store all your files—games, schoolwork, family photos, email, letters to friends, etc. When you have a workable system it is easier to find what you want quickly.

Fig 1.4.1 Goods in a supermarket are classified to help customers find them quickly.

Fig 1.4.2 This diagram shows that supermarkets are divided into many subsections.



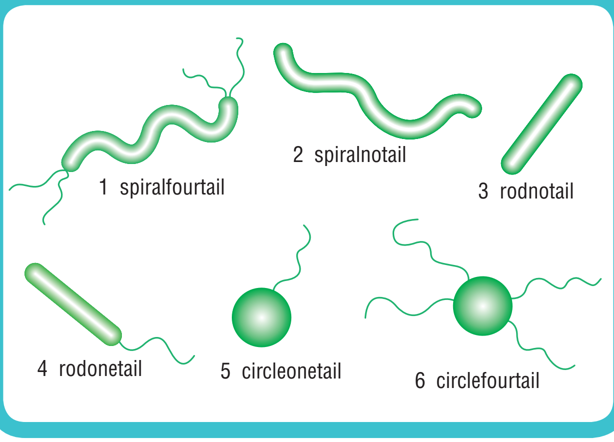
customers find their goods quickly. It also helps the store to keep a record of its stock.

Classification in science

Scientists use special systems of classification in each of the different branches of science. Before looking at the kinds of systems they use, it is useful to learn about keys. **Keys** are special tables or charts that help to **identify** the objects the scientist is studying. The key enables the scientist to name the object.

In order to understand keys, consider the creatures shown in Figure 1.4.3. These are actually imaginary, but will help you understand how keys work.

Fig 1.4.3 These creatures have been classified and named 'Micros'.



Any scientist who works with Micros but who does not know their names would want to be able to name them. A key to Micros will enable the scientist to name them. Figure 1.4.4 is a key to Micros.

To use the key in Figure 1.4.4, choose number 6 from the Micros in Figure 1.4.4 and assume that you do not know its name.

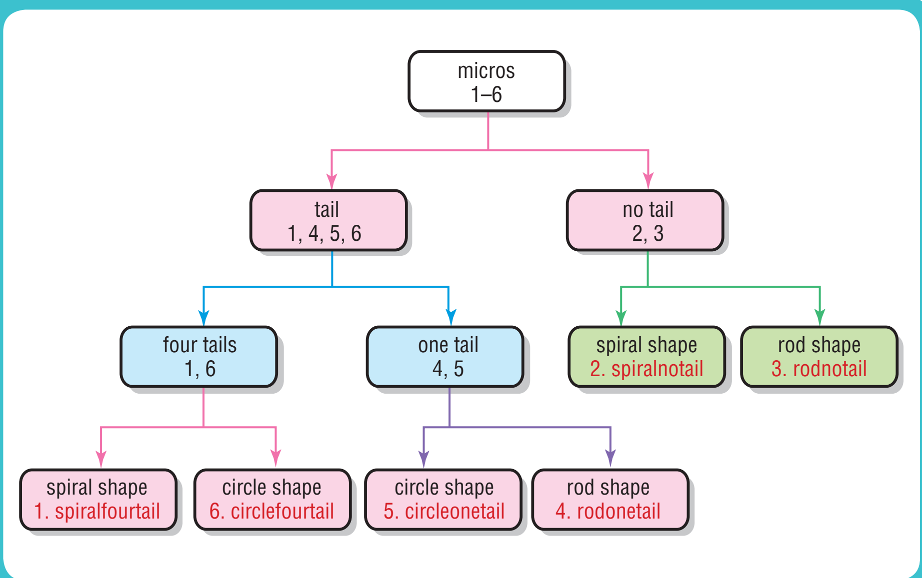
You start at the top of the key and work down, following the lines like paths. The first line divides into two paths. You are offered a choice, based on the creature's characteristics. The first choice is whether or not it has a tail. As it has a tail you follow the path that leads to 'Tail', which means it could be imaginary creature 1, 4, 5 or 6.

The second choice is about whether it has four tails or one tail. Since it has four tails you again choose the left path, called 'Four Tails', which means the imaginary creature could be 1 or 6. The final choice is whether the imaginary creature has a spiral shape or a circle shape. As it has a circle shape you choose the right path, called 'Circle Shape', which means that the imaginary creature is a 6 or *Circlefourtail*. So now you know its name.

Most keys used in science are not arranged like the key in Figure 1.4.4. This key would be more commonly written as in the table below, as it saves space, especially if there are a large number of different creatures.

Using the example of the Circlefourtail, the choices you would make using the key are 1a, 2a, 3b, Circlefourtail.

Fig 1.4.4 A key to Micros



Key to Micros

1a	Tail	Go to 2
1b	No tail	Go to 5
2a	Four tails	Go to 3
2b	One tail	Go to 4
3a	Spiral shape	Spiralfourtail
3b	Circle shape	Circlefourtail
4a	Rod shape	Rodonetail
4b	Circle shape	Circleonetail
5a	Spiral shape	Spiralnotail
5b	Rod shape	Rodnotail

Constructing keys

Keys can be constructed in any way by anyone who needs to identify something. The features used in the key can be anything, but they will work best if they satisfy the following rules:

1. The feature must be easy to observe. It is pointless using a feature that is very difficult to see or detect.
2. The feature must be used accurately and reliably by those who use the key. The key would not work if different people using it did not make the same choices. For example, if the key was for plants, and the feature chosen gave a choice of colours, such as light green, blue-green or yellow-green, different people may not place a particular plant in the same group. This is because people often differ in their ideas about colour.

In biology, the keys usually use features based on structures, such as legs, wings, eyes, skeletons and skin. Structure means the material of which the living thing is composed and the arrangement of its parts. In other branches of science keys may use different features, such as whether the material will allow electricity to pass through it, or the hardness of the material.

Prac 1 p. 20

Systems of classification

The choice of features used to classify things varies according to the needs of the different branches of science. The system used in biology is mainly based on structural features. These are usually easy to observe and most people can use them accurately and reliably. In some branches of science special equipment may be needed to construct the system of classification. Sometimes machines costing hundreds of thousands of dollars may be needed to identify and classify materials.

The purpose of classification in science

Scientists classify things to assist in their understanding of them and to be able to communicate about them. To be able to classify materials or creatures, scientists must study them in great detail and record their features carefully. As a result, scientists gain a more thorough understanding of the things they are investigating, and this knowledge then becomes available to the rest of the community.

The classification process also greatly assists the ability of scientists to be able to communicate with each other and the rest of the community because it provides a common language that can readily be understood and used by all. For example, when a scientist writes the word 'reptile', most people can imagine the features the creature is likely to have. The one word 'reptile' is easier to use than several sentences describing the creature.

Homework book 1.8 Classifying and identifying

1·4 FOCUS [Questions]

Use your book

What is classification?

1 What is meant by classification?

Classification in science

2 What are keys?

Constructing keys

3 What two rules should you follow if you are constructing a key?

Systems of classification

4 Why do biologists use structural features in keys?

The purpose of classification in science

5 What is the purpose of classification in science?

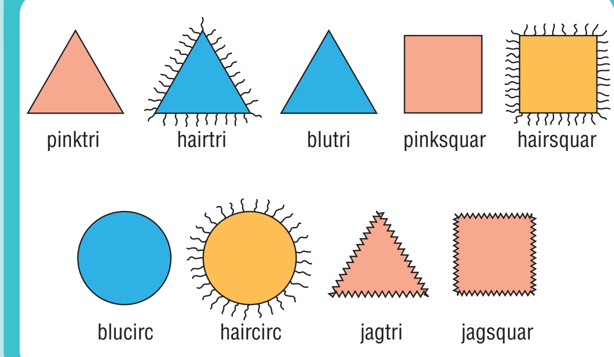
Use your head

6 When you put your possessions away in your room, you use a method of classification. What would you place with your with shirts? Explain your choice.

7 Explain a method of classification that could be used to place food in the pantry at home.

8 Figure 1.4.5 shows nine shapes.

Fig 1.4.5 Nine geometric figures



a Classify the objects into three groups on the basis of their surface being smooth, jagged or hairy.

>>

b Classify the objects into three groups on the basis of their shape being square, circular or triangular.
c What is a third basis for classification that you could use? Classify the objects using this basis.
d Is any one of these systems of classification better than the other two?

9 Write a key for the objects in Figure 1.4.5.

10 Figure 1.4.6 shows eight different types of screws.

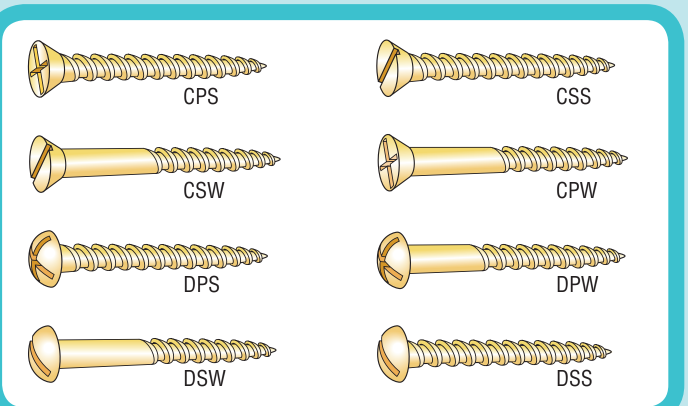


Fig 1.4.6 Eight different types of screws

a Classify the screws as having a countersunk head or a dome head by writing the letter for each screw in a suitable table.
b Classify the screws as self-tapping (long thread) or wood screws (short thread).
c Classify all screws as having a slot in the head or a Phillips (cross-shaped) head.

11 Write a key to the objects in Figure 1.4.6. Use the letters in the diagram as their names.

12 Is communication about music easier once it has been classified into different types? Explain your answer.

Investigating questions

13 If you were given a box of Australian money, including coins and notes, how would you set them out on a desk to quickly identify what is missing from a complete set?

14 In newspapers there is a section called 'Classified Advertisements'. Look them up in a paper and explain why you think they have been called this.

15 Animals are classified according to their structure. Find out the main differences between bony fish, amphibians, reptiles, birds and mammals.

FOCUS 1·4

[Practical activity]

Prac 1 Focus 1.4

Constructing a key

Purpose

To construct a key to some leaves.

Requirements

Six different leaves (different in colour, shape, etc—each group to have an identical set), one sheet of A3 paper, six sticky labels or a waterproof texta.

Procedure

1 Place the leaves on the desk in front of you. Number the leaves 1 to 6 using the texta or labels.

2 Look at the leaves and decide on some feature of them which you can use to divide them into two groups. For example, you may choose the shape. Separate the leaves into the two groups. You do not need equal numbers of leaves in each group.

3 *On your A3 sheet of paper start to draw a key like the key in Figure 1.4.4, only using the leaf feature you have chosen instead of the tail shown in that key. Write the numbers of the leaves in each group, just like in Figure 1.4.4 with the Micros. Make the key large enough to cover the whole page, so you can stick the leaves in the final boxes.*

4 For each group of leaves, choose another feature to separate them into two groups. There should now be four groups of leaves on the desk. Some groups may only have one leaf in them. Write the features you chose and the number of the leaves on your page, just like in Figure 1.4.4. Where a leaf is keyed out—that is, ends up in a group of its own—stick the leaf on the page in that spot.

5 Continue to separate the leaves and draw up your key, until each leaf is in a group of its own.

6 When you have finished look at other students' keys to see how different they are from yours.

Questions

1 Were all the keys in the class the same? Give about three differences you noticed.

2 Were any keys better than others? Give a reason for this.

3 Note down any criticisms made of your key and check with your teacher to see if they are justified.

FOCUS 1.5

Planning experiments: controlling variables

Context

How do scientists find the answers to questions such as 'Did this chemical cause his illness?', or 'Will our rock lobster fishery survive if we double the catch?' The way scientists find the answers to questions is the subject of the next few foci. The process is like a detective story, involving the use of special measuring instruments and methods. It can give us exciting and beautiful insights into nature. An important aspect of it is the process of experimenting, which is a part of the scientific method. This focus begins your study of scientific experiments.

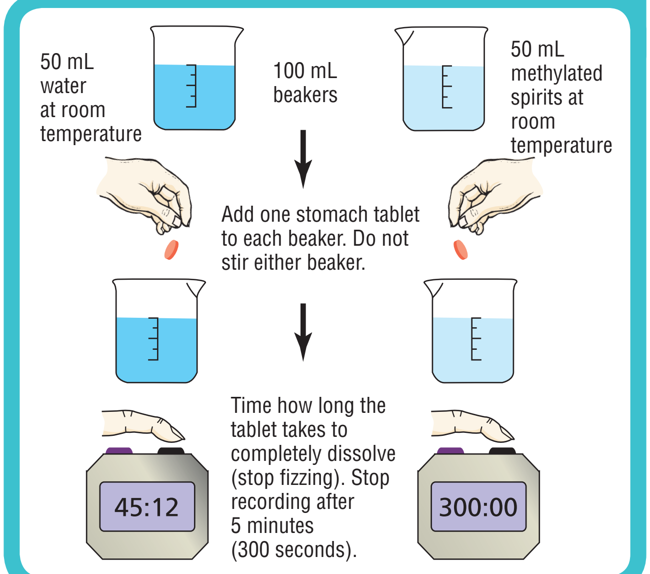
Fair tests

You probably remember from Focus 1.1 that a hypothesis is a 'possible answer' to a problem you are trying to solve. You can test the hypothesis, your possible answer, with an experiment.

Experiments have to be **fair tests**. To understand fair tests, you will consider how to test the hypothesis 'that a stomach tablet will dissolve faster in water than in other liquids'. The stomach tablet is the type you take for indigestion, or an 'upset stomach'. Dissolve means 'break up and disappear'. One way to test this is shown in Figure 1.5.1.

Testing the hypothesis that a stomach tablet will dissolve faster in water than in another liquid

Fig 1.5.1



If the tablet dissolved faster in water then the hypothesis seems to be correct. Rather than say that it is correct, though, you should say that the hypothesis is 'supported'. If the tablet dissolved just as fast in both liquids then the hypothesis is 'not supported'. If it dissolved more slowly in water then the hypothesis is also not supported.

This is a fair test because it allows you to collect information that can help you decide for or against your hypothesis. You are not just collecting information that helps to support the hypothesis. You allow results to occur that can show the hypothesis to be incorrect; to not be supported.

Variables

In the experiment in Figure 1.5.1, the two beakers contained different liquids. This was the only difference between the beakers. What seemed to be the same for both beakers?

1 Both beakers were the same size.
2 The same amount of liquid was placed in each beaker.
3 The timing was done in the same way for both beakers.
4 The liquids were at the same temperature.
5 Neither beaker was stirred.
6 The same types of tablets were used in each beaker.

The experimenter deliberately kept these six factors the same. This was so that they knew these could not affect the results. They could not affect the dissolving of the tablets. Factors such as these in experiments are called variables.

A **variable** is any factor in an experiment that can change and may affect the results. For example, the size of the beaker is a variable because if one beaker was larger than the other this may have made a difference to how fast the tablet dissolved. Then the experimenters could not be sure that the type of liquid made the difference. It may have been the size of the beaker that had the effect. In Figure 1.5.2 you can see what happens when a variable is not controlled.

Science Snippet

Sports variables

What makes a football team perform well one week and then poorly the next? AFL coaches are very interested in finding out. They try to identify all the variables that affect team performance. One variable that has been identified is the distance that a team must travel to play a game. Teams that travel more often may be disadvantaged in their performance—a factor that coaches watch very carefully, as they know it is a variable.

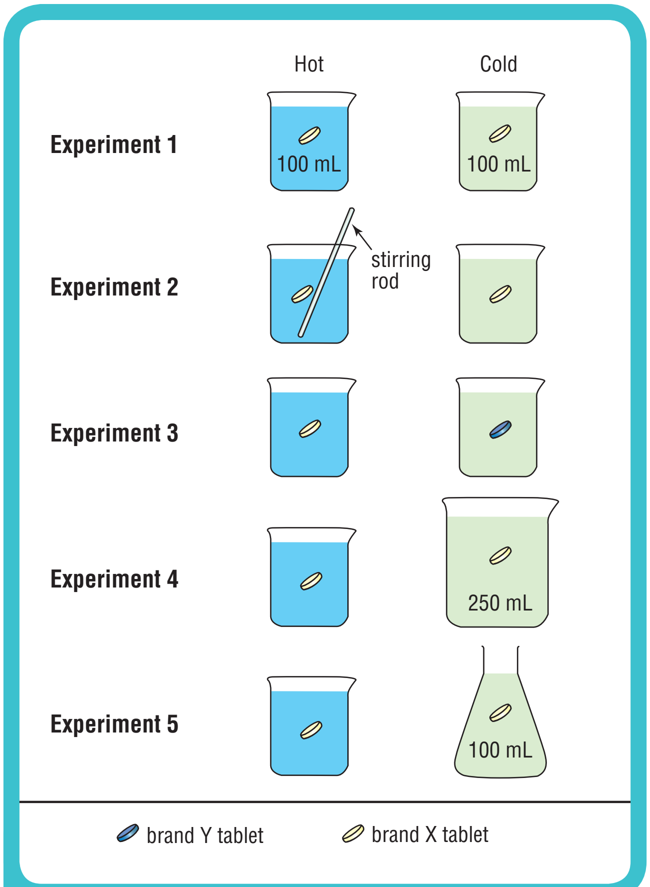


Fig 1.5.2 Some examples of the variable not being controlled

In the experiment shown in Figure 1.5.1 the six variables were kept the same, in order to conduct a fair test. You can be sure that they did not affect the results. These variables are called **controlled** variables.

Prac 1 p. 25

Types of variable

Independent variables

In Figure 1.5.1 there was one variable that was deliberately changed—the type of liquid. It was made different in each beaker to see if it affected dissolving time. It is the only one that should be deliberately varied, or changed, in this experiment. This variable is called the independent variable. An **independent variable** is what the experimenter deliberately changes to assess its effect. It can also be called the **manipulated variable**, or the **experimental variable**.

Dependent variables

The **dependent** or **responding variable** is the factor that changes in an experiment because of the effect of the independent variable. In Figure 1.5.1, the independent variable is the type of liquid. This affects the dissolving time of the tablet. So the dependent variable is the dissolving time.

The types of variable in an experiment are shown in the following table.

Prac 2 p. 25

Science Snippet

Variables and schoolwork

What are some of the variables that probably affect how well you do at school work?

A major variable affecting your performance is your attendance at school. The amount of attention you pay in class is also really important. There are some variables that you can change in your favour. Name a few.

Types of variable in an experiment

Name of variable	Alternative name for variable	Nature of this variable	Example in Figure 1.5.1
Independent	Manipulated or experimental	One deliberately changed to test its effect	Type of liquid
Dependent	Responding	Changes because of the effect of the independent variable	Dissolving time
Controlled		Those which must be kept the same through the experiment	Size of the beaker

Experimental and control set-ups

In Figure 1.5.1 there are two different beakers, one containing water and the other methylated spirits. These two sets of equipment are called **set-ups**. In this experiment you would call the beaker of water the **experimental set-up**. This because the hypothesis states that water is better than other liquids at dissolving the tablets. The beaker of methylated spirits is called the control set-up. The control set-up, often called just the **control**, is very important in an experiment. The control set-up provides a **comparison**—you are comparing something different from water with the water. This means that the control set-up can be used to compare results with the experimental set-up. It shows what the situation is like without the experimental variable.

Controlling variables

In an experiment that is a fair test, like in Figure 1.5.1, you can say that you are **controlling variables**—that is, you are keeping all the variables that can affect the experiment the same. They are kept the same in the experimental set-up and the control set-up.

If variables are controlled properly, then any differences in the results of the experimental and control must be due to only the independent variable. This is the variable that is deliberately changed. This was the type of liquid in Figure 1.5.1. The other variables cannot affect the dependent variable, the dissolving time, because these variables are the same for both beakers. So the independent variable must have made the difference, because it was the only factor that was different in the two set-ups.

Experiments

You can now give a new definition of an experiment. An **experiment** is a fair test of a hypothesis in which one variable is deliberately changed while all other variables are controlled. If the experiment is conducted well you should obtain clear results.

Variables and the hypothesis

In a hypothesis you can always find the dependent and independent variables. For example, consider the hypothesis for Figure 1.5.1. The hypothesis was that 'a stomach tablet will dissolve faster in water than in other liquids'. Before you read the next paragraph, see if you can find the independent variable in the hypothesis. Then try to find the dependent variable.

You can see that the independent variable is the type of liquid. This is the variable which will be tested in the experiment. Water must be compared with other liquids. The dependent variable is the dissolving time of the tablets.

Homework book 1.9 Soap bubbles

1·5 FOCUS [Questions]

Use your book

Fair tests

1 What do we mean by the term 'hypothesis'?

2 When would someone say a hypothesis was not supported?

Variables

3 What is a variable?

Types of variable

4 What is the difference between a dependent variable and an independent variable?

5 Which of the following is a manipulated variable: responding variable, dependent variable, controlled variable, independent variable?

Experimental and control set-ups

6 a What is the use of a control set-up in an experiment?
  b Describe the control set-up from Figure 1.5.1.

Controlling variables

7 What does 'controlling variables' mean in an experiment?

Experiments

8 What do we mean by an 'experiment'?

Variables and the hypothesis

9 What two types of variable should be easy to find in a hypothesis?

Use your head

10 Look at Figure 1.5.2. Pick any variable and explain why it would have to be controlled.

11 An experiment was performed which tested the hypothesis 'that the speed of sand flow through a hole depends on the size of the hole'. A diagram of the experiment and the results are shown in Figure 1.5.3.
  a What was the independent variable?
  b What was the dependent variable?
  c What was the responding variable?
  d Identify three variables that the experimenter probably had to control.

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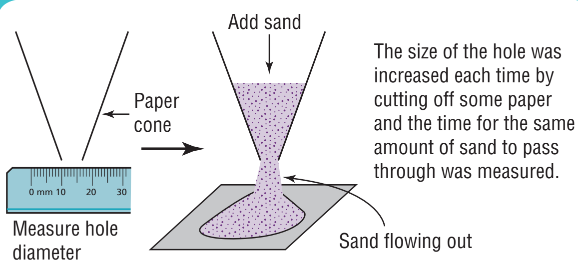


Diameter of hole (mm)	Time taken (seconds) Trial 1	Trial 2	Trial 3
6	38	42	40
8	17	19	18
10	10	11	9
12	5	5	5
15	2	2	2

An experiment on sand flowing through a hole in a paper cone

Fig 1.5.3

12 Suppose a student made the hypothesis 'that wheat plants will grow faster at higher temperatures'.

- **a** What variable will be tested?
- **b** What will be the independent variable?
- **c** Identify the responding variable.

13 Some students did an experiment to test the hypothesis 'that the wing area of a paper plane affects the distance of its flight'. They made four planes of the same design from different sized pieces of graph paper. The same person threw all four planes in the same way during the test. The results are shown in the following table.

Wing area (cm^2)	Flight distance (m)
180	30
100	27
60	26
24	22

- **a** Why did the students choose the same person to throw each time?
- **b** What was the independent variable?
- **c** List two variables that were controlled.
- **d** List one variable you are sure they did not control.
- **e** What was the dependent variable?

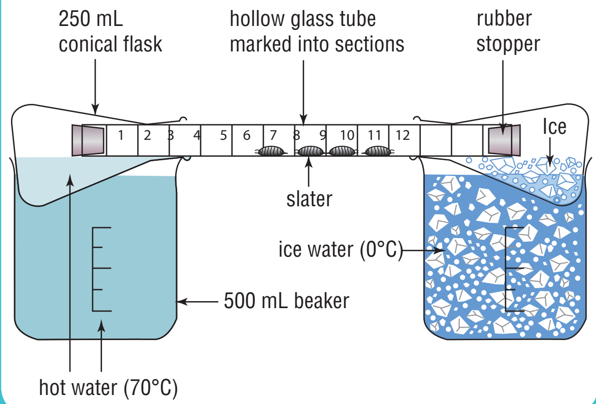
14 From the experiment described in Question 13 and your answers to it, give one example of the following science skills used by the students who performed the experiments.

- **a** observing
- **b** measuring
- **c** controlling variables
- **d** communicating.

15 Some students wanted to know if slater behaviour is affected by temperature. The students set up the experiment shown in Figure 1.5.4. They started the four slaters in section 1. Each minute for the next 10 minutes they recorded which sections contained slaters. Answer the following questions for this experiment.

- **a** What is the dependent variable?
- **b** What is the manipulated variable?
- **c** How would you know if the hypothesis is supported?

Fig 1.5.4 An experiment to test the hypothesis that slater behaviour is affected by temperature



16 Some students tried to test the hypothesis 'that snails will only eat particular foods when given a choice of different foods'. They set up an experiment using a box, a snail and several types of food. Figure 1.5.5 shows their experiment.

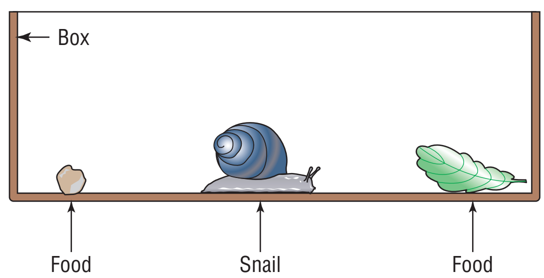


Fig 1.5.5 A set-up to test the food preferences of snails

Two different foods were tried each time the snail was tested. For this experiment to be a fair test, describe what you would do about each of the following and say why you would do it:

a the position of the food

b the amount of food

c the starting position of the snail.

17 To do the experiment in Question 16 effectively, the students should have a control set-up. Have they used a control? If so, what was it? If not, what should it be?

Investigating questions

DYO

18 Ask your teacher if you can try any of the experiments in Questions 11, 13, 15 or 16.

19 What variables do you think would be involved in affecting how much food a dog eats?

1·5 FOCUS [Practical activities]

Identifying variables

Prac 1 Focus 1.5

Purpose

To identify some variables that affect the time it takes for stomach tablets to dissolve.

Requirements

Two antacid tablets (eg Alka-Seltzer), stopwatch, access to different beakers (100 mL and 250 mL), and other containers, such as conical flask, tap water, hot water.

Procedure

1. Pick a variable to test that may affect dissolving time, as explained earlier in this focus under the heading ‘variables’. *Write down the variable you pick.*
2. Discuss in your group what you will have to do to control the other variables that could affect the results.
3. *Draw what your experiment will look like, using Figure 1.5.1 as an example.*
4. Show your teacher and then obtain the equipment.
5. Carry out the experiment and *write down your results*.
6. Find out what variables were tested by other groups. *Write down the variable each group tested and the times taken by the tablets to dissolve.*

Questions

1. What did you learn in this activity?
2. Did the variable you tested affect dissolving time? Give the reasons for your answer.
3. From the other group’s results, write a list of the variables that did affect dissolving time, and a list of those that did not affect it.

Variable bounce

Prac 2 Focus 1.5

Purpose

To conduct an experiment to identify some variables that affect the bounce height of different balls.

Requirements

Metre-rule, range of different balls such as tennis, table tennis, basketball, super ball, golf.

Procedure

1. Begin with one ball. Stand up and drop it onto the floor and watch how it bounces. Think of what may change how high it bounces. Discuss this with others if you are in a group.
2. Choose a different ball and do the same as for step 1.
3. *Write down at least three variables you predict will affect the bounce height of all of the different balls you have available.*
4. Consider how you can do a fair test to decide if your predictions are correct. *Write down a brief plan on how you will test your predictions.*
5. Show your plan to your teacher and when they give you permission, try your experiment.
6. *Write down your observations and measurements.*

Questions

1. What variables seemed to affect the bounce height of balls?
2. How sure are you of your results?
3. Check with other groups and find out if they discovered any variables you did not test.
4. Were there any variables that you or any other group predicted would affect the bounce height but which you found did not in your experiment? If so, what were they?

FOCUS 1.6

Planning experiments: the hypothesis and design

Context

How do scientists work out how to do their experiments? The plan they use involves four stages. The first two are stating the problem and identifying the variables that are relevant. You already know these from Focus 1.5.

This focus is about the other two stages of planning experiments. These are writing the hypothesis and designing the experiment. You also need to learn about inferences and predictions to understand how to do experiments.

Inference

An **inference** is an explanation for an observation. It is an attempt to give a reason for something that was observed. For example, if your dog came into your house all wet, you may think that it was raining outside. This is an inference. The observation was the wet dog, the inference was that it must have been raining.

Fig 1.6.1 The observation that your dog is wet could lead you to the inference that it was raining.

Inferring is an important part of science. Inferences provide reasons for observations. This helps people understand the world around them.

An inference may not always be correct. For example, there are other inferences that could be drawn from the observation that the dog was wet—it fell into the river or it was wet by a hose. To be fairly confident an inference is correct, you must **test** it. More information is needed to be sure. For example, you could check around outside to see if it is raining or had been raining. This will help you decide if your inference about the rain wetting your dog was correct.

An important point to remember about inferences is that they are made *after* some observation has been made, not before the event occurs. To test them further you have to collect more evidence.

Prediction

Another important process in science is prediction. A **prediction** is a forecast of what may happen in the future. For example, a weather forecast is a prediction based on past observations and inferences of weather patterns.

Prediction is vital in science because it is part of the process of discovering new information.

As an example of prediction and inference, imagine that you observed your dog's water bowl seemed to empty faster on Saturday than on Friday. One inference could be that your dog drank more water on Saturday because it was a warmer day. So you could predict that your dog will drink more water on a warm day than on a cool day. You could test this prediction by measuring how much water your dog drinks on the next warm and cool days.

Science Snippet

On a winner

Some people who bet on a horse race such as the Melbourne Cup just hope the horse will win without really having any idea. The more scientific punters make a prediction. They study what the horse's recent racing performance has been like. From this they make inferences about the kind of distance and track condition that best suit the horse. Then they decide if it is worth risking money on a bet. If they predict that the horse can win then they will bet on it.

It is important to realise that predictions are not always correct. This is mainly because the inferences on which they are based may be incorrect. For example, the inference that your dog drank more water on the Saturday because it was warm may not have been correct. Perhaps you had played with the dog more that day and so it had become thirsty due to the activity. So an alternative inference is that your dog drank more water because it was running around. If the second inference is the correct one, the prediction that the dog will drink more water on a warm day may not come true. It may be that when you play with the dog on a cool day it drinks more water than when it is resting in the shade on a warm day.

Fig 1.6.2 When you play with your dog you may cause it to drink more water.

Being able to make correct inferences is an important skill for a scientist. Correct inferences lead to accurate predictions and an advance in knowledge.

A better definition of the hypothesis

In Focus 1.1, you learnt that a hypothesis was a possible answer to a problem. In Focus 1.5 you learnt that the hypothesis tells you the independent (manipulated) and dependent (responding) variables in an experiment.

In Focus 1.5 you also learnt that variables are given in any hypothesis. The variables are the independent (manipulated) and dependent (responding) variables. You also saw that a hypothesis is a possible answer to a problem. You can now put these two ideas together for a better definition of the hypothesis. A **hypothesis** is a statement that explains the relationship between variables. It is a statement of how variables affect each other.

To make a hypothesis, you must make a prediction about variables based on some past observations. You cannot say your prediction is true until you have tested it by experiment.

So a hypothesis predicts the answer to a problem. It is a possible answer to a problem that can be tested by an experiment. The data must be collected after the hypothesis is made, not before.

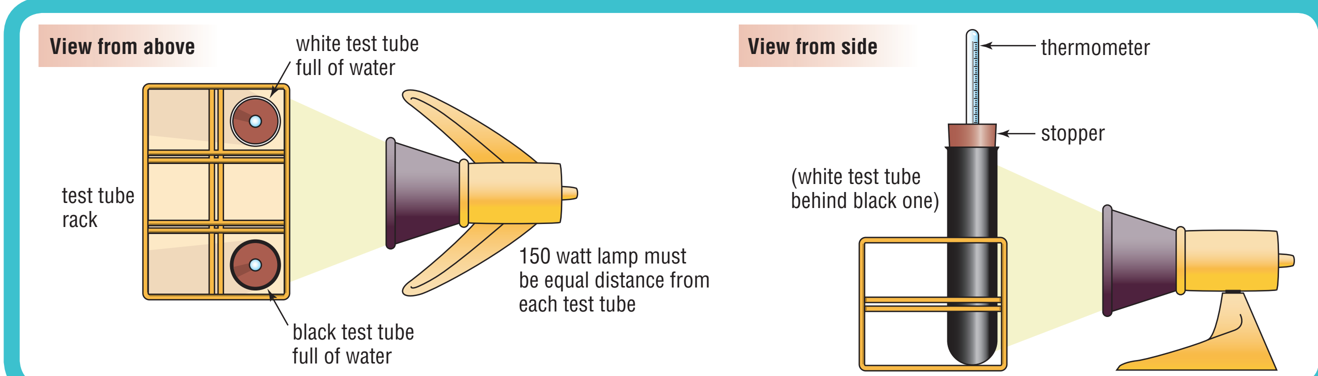
A hypothesis must be clearly worded so that it can be tested. It must mean the same thing to all scientists. Consider the hypothesis 'that dark-coloured objects heat up faster than light-coloured objects'. To test this hypothesis, you would have to clearly explain what is meant by 'dark-coloured' and 'light-coloured'. You would also have to say what you mean by 'heat up faster'.

The working hypothesis

The **working hypothesis** is the hypothesis that is actually tested in an experiment. It gives a specific and detailed statement for each variable in the hypothesis. It states what to do and what to observe or measure.

A definition of 'dark-coloured' could be 'a 50 mL test tube painted black, filled with tap water and placed near a lamp'. The definition of 'light-coloured' could be 'the same set-up, but with the test tube painted white'. This is shown in Figure 1.6.3.

Fig 1.6.3 Experimental design to test the hypothesis that dark-coloured objects heat up faster than light-coloured objects



Science Snippet

Who cares if black heats up faster than white?

The results of the experiment in Figure 1.6.3 are really useful. With this information you can choose the best colours for your car, clothes, your house roof and the bricks. When you make choices based on this information, you can also save the government money by reducing your demand for electricity for air-conditioning.

The definition for 'heat up faster' could be 'a larger rise in the water temperature (°C) of the black test tube over 20 minutes'.

It is important to note that the working hypothesis is determined by the person doing the investigation. There are many possible working hypotheses for any hypothesis.

Science Snippet

A different working hypothesis

Can you think of a different working hypothesis for the experiment in Figure 1.6.3? One way could be to find two identical cars one painted black and the other white. You could sit a student in each car with a thermometer and have them record the temperature every minute for about 30 minutes. What variables may be a problem here?

Designing experiments

When you design an experiment you work out a way of testing the hypothesis.

An **experimental design** must specify:

1 the equipment to be used and how it will be arranged
2 the variables that will be controlled and how they will be controlled
3 the observations and measurements that will be made and how many of each will be made.

Consider Figure 1.6.3 again. It seems clear from the working hypothesis what equipment is to be used, what measurements are to be made and which variables are to be controlled. From the diagram you can see some of the variables that are controlled—the size of the test tube, the distance from the tube to the lamp, the length of time that both tubes were allowed to heat up and the source of the water (from the same tap).

Some other variables are not clear but must be specified in the design. One such variable is the type of paint. For this experiment to be a fair test the paint must be the same type, only a different colour. A thicker paint on one tube could affect the rate of heat gain by the water.

Replicates

An experimental design must indicate how many measurements to make. In the experiment in Figure 1.6.3 more test tubes should be used. There should be at least three sets of black and white test tubes. An identical set of equipment used in an experiment is called a **replicate**.

Replicates are necessary because they reduce the chance that an error will affect the results. The results for all the replicates should be similar. If one is very different, there may have been a mistake made in that replicate.

Repeat trials

In some experiments, instead of using replicates the experiment can be repeated several times. They can be done at different times. This can only be done if doing them at different times will not affect the results.

The experiment in Figure 1.6.3 could be done another way. One set of tubes could be used, and the experiment done several times, one after the other. Graphs of each set of results should be done. For each trial the graph for the temperature change in the dark test tube should be compared with that for the light test tube.

Sometimes it is only possible to do replicates, not repeat trials. This would be the case if the first experiment actually destroyed or changed the material used, for example if you are working with living organisms such as seeds—once a seed grows it cannot be used again.

Prac 1 p. 30

Homework book 1.10 Hypothetical paper drop

FOCUS 1.6 [Questions]

Use your book

Inference

1 What is an inference?
2 Are inferences always correct? Give a reason for your answer.

Prediction

3 What is a prediction?
4 Are predictions always correct?

A better definition of the hypothesis

5 Give a good definition of a hypothesis.
6 Give an example of a hypothesis.

>>

The working hypothesis

7 What is a working hypothesis?

Designing experiments

8 What must be specified in any experimental design?

9 What are replicates?

10 What are repeat trials?

Use your head

11 Classify each of the following as observation, inference or prediction.
- **a** That tree is snapped off at the base.
- **b** It was the wind last night that snapped the tree.
- **c** The tree is lying on the ground.
- **d** A car could have knocked the tree over.
- **e** He will become ill because he smokes cigarettes.
- **f** His smoking caused the lung cancer.
- **g** The smoker's lungs were black with tar.
- **h** He will not be able to give up smoking.

12 Classify each of the following as observation, inference or prediction.
- **a** The tablet dissolved faster in the first beaker because it contained water.
- **b** The volume of liquid in a beaker will affect the dissolving time.
- **c** Dogs will drink more on warm days than on cool days.
- **d** His temperature was 37°C.
- **e** Your temperature will fall if you have a cold shower.
- **f** Her fever was caused by an infection she caught at school.
- **g** I think it will rain tomorrow.
- **h** The boy had a higher pulse rate than the dog.

13 How can different scientists who have the same data make different inferences?

14 Consider the following hypotheses. Identify the manipulated and responding variable in each hypothesis. Then write down the variables you would actually test in a working hypothesis if you did the experiment.
- **a** Insects move faster at higher temperatures.
- **b** Dogs drink more water on warm days than on cool days.
- **c** The type of material in a ball affects how it bounces.
- **d** Only metals are attracted to a magnet.

15 Suppose you wanted to test the hypothesis 'that the temperature at which water boils increases as the amount of salt in the water is increased'.
- **a** Which variable are you going to change during this experiment?
- **b** Which variable are you going to measure during this experiment?
- **c** What definition would you use for 'the amount of salt in the water'?
- **d** What variables must be kept constant during this experiment?

16 For each diagram in Figure 1.6.4 make two observations and one inference.

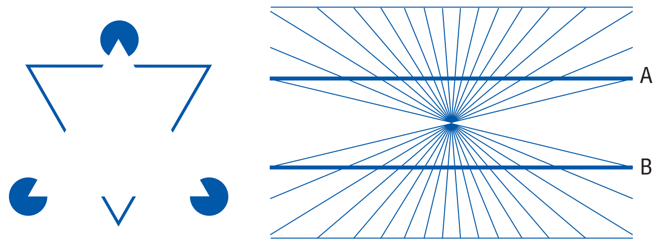


Fig 1.6.4 Some optical illusions

17 Consider each of the following experiments from Focus 1.5 and indicate whether replicates or repeat trials should be done. Describe what these would be.
- **a** Figure 1.5.1
- **b** Figure 1.5.3
- **c** Question 13 on page 24
- **d** Figure 1.5.4.

18 Suppose you notice that an ice block in your drink took a long time to melt, but the ice in a friend's drink seemed to melt very quickly. When you ask her about it she says that her ice block was broken into pieces when it was added to her drink. You decide to investigate if that made a difference to the rate of melting.
- **a** Write a hypothesis or state the problem for this investigation.
- **b** Give the independent (manipulated) and dependent (responding) variables for your investigation.
- **c** Draw a diagram showing the equipment and the way you will use it to test the hypothesis.
- **d** Explain what measurements and observations you will make.
- **e** Explain how you will control variables.

19 Examine Figure 1.5.4. What was the definition of 'slater behaviour' in the working hypothesis?

20 Examine Figure 1.5.1. What was the definition of 'type of liquid' in the working hypothesis?

>>

Investigating questions

21 Design an experiment to investigate the hypothesis 'that an ant's activity increases as temperature increases'. Ask your teacher if you can do the experiment. If you can't find ants, use insects that are available.

DYO

22 Design an experiment to solve one of the following problems. Write out your design, including all the features required in an experimental design. Ask your teacher if you can do the experiment.

DYO

a Does the rate of evaporation change if the surface area of water exposed to the air is changed?

b Does more salt dissolve in warmer water than colder water?

c Which of the following makes a better soap bubble mix:

- **i** soapy water
- **ii** detergent
- **iii** a mixture of glycerine and detergent?

d Is detergent or soap better at cleaning an oily cloth in tap water?

FOCUS 1·6

[Practical activity]

Prac 1 Focus 1.6

Testing a prediction

Purpose

To build a better glider than the one shown in Figure 1.6.5 by making slight changes to the design.

Requirements

Three drinking straws, thick paper or light cardboard, sticky tape, scissors, tape measure, safety glasses

Procedure

1. Build the glider shown in Figure 1.6.5. Do not throw it yet. This is your control glider.

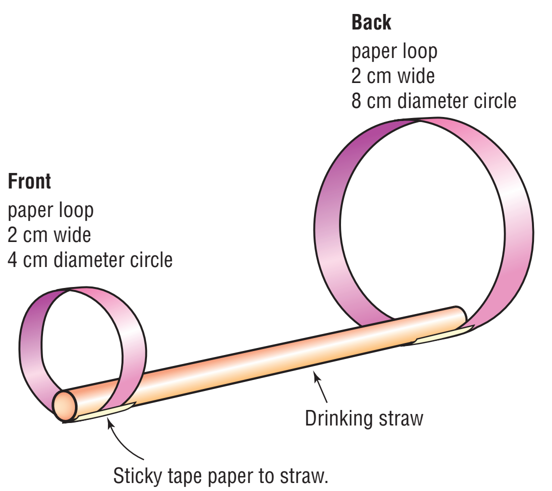


Fig 1.6.5 A model glider. This is the control in the experiment.

2. Decide on the measurements you will make and how you will test your control glider fairly. *Write down what you will do.*
3. Put on your safety glasses. Test your control glider. Be careful not to throw your glider near anyone else, as you might hit them in the eyes. *Write down your results.*
4. Think of a variable that may make the glider fly further. Test this variable by building a new glider with your suggested change. This is the experimental glider. *Write a description of your variable. If you can write this as a hypothesis then do so.*
5. Build the experimental glider and test your variable fairly. *Record the results of your testing.*
6. If you have time, repeat this experiment several times, trying different variables each time. You will need to build a different experimental glider each time. *Record the results of your testing.*

Questions

1. What did you do to make this a fair test?
2. Did your experimental glider fly further than the control glider? Give your measurements.
3. What was the independent (manipulated) variable in your experiment? Give a detailed description.
4. What was the dependent (responding) variable in your experiment?
5. Was your prediction (hypothesis) supported by your results? Give reasons for your answer.

FOCUS 1.7 Conducting, processing and evaluating

Context

When conducting experiments we collect and record information, which we call data. The data is then processed, which means we try to find any patterns in it. We then evaluate the experiment to see if it seemed to work or if it had any major faults. Focus 1.7 is about the ways in which we can record data, how we process results and how we can evaluate the experiment.

Recording information

Data is information collected by scientists. When scientists do experiments or collect information by any means, they record it using:

1 sketches or drawings
2 photographs
3 tables
4 notes.

Figure 1.7.1 shows how Leonardo da Vinci, the famous Italian scientist and artist, recorded his investigations. Leonardo da Vinci invented technical drawing and was probably the first person to use a real scientific method. Many of his great ideas have been found in drawings and were clearly the result of some experiments he had conducted.

Science Snippet

The mirror writer

Leonardo da Vinci was a very secretive man. He wrote his results backwards. His writing could only be read by holding it up to a mirror. This may have been to protect his ideas from others.

Tables

A **table** consists of vertical **columns** and horizontal **rows** in which information is recorded, as shown in the following three examples.

The first table below shows a list. All the items under 'metals' in the metals column are metals, while the others in the 'non-metals' column are not metals. So gold is a metal, while nitrogen is a non-metal.

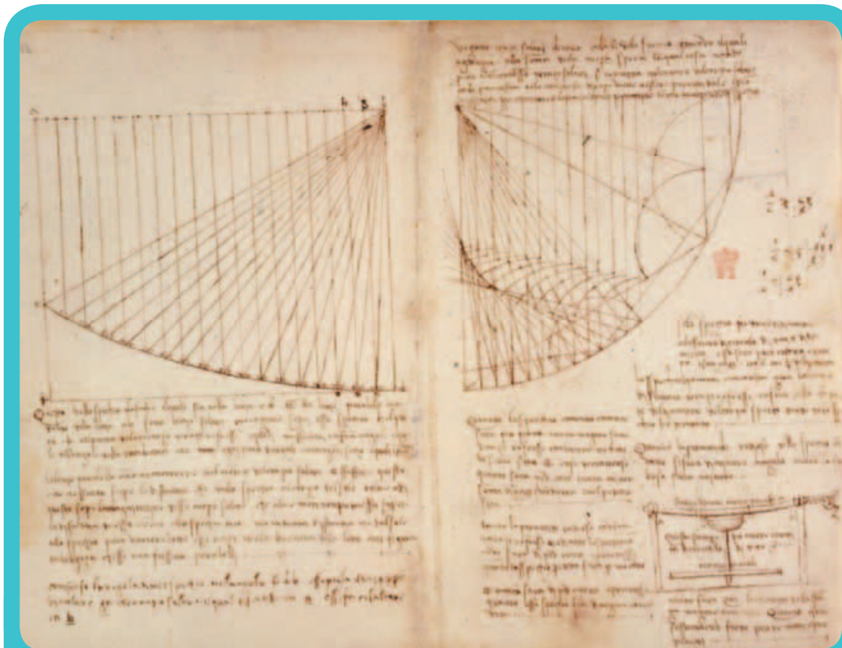


Fig 1.7.1 A page from a notebook of Leonardo da Vinci, in which he recorded his scientific investigations

Metals	Non-metals
Gold	Nitrogen
Lithium	Oxygen
Copper	Chlorine
Lead	Carbon
Tin	Hydrogen
Silver	Helium
Aluminium	Neon

To read the next table (page 31), you read across the rows. So Earth is 149.6 million kilometres from the Sun, while Pluto is 5899 million kilometres from the Sun.

Each column should have a heading. If the columns contain measurements, such as time, then the units of the measurements should be written with the heading.

Planet	Distance from the Sun (millions of kilometres)
Mercury	57.9
Venus	108.2
Earth	149.6
Mars	227.9
Jupiter	778.3
Saturn	1427
Pluto	5899

Science Snippet

Why use tables?

Tables are used in science because they show information in a way that is easy to find and understand. It is quicker to find information in a table than to have to read several sentences or paragraphs.

To read the third table you have to look at the left-hand column ('Air hole') to see the labels for each of the horizontal rows, 'Open' and 'Closed'. Then you read the top line to see the headings for the vertical rows. For example, the second column of the table shows the heading 'Flame colour'. So to find the flame colour when the air hole is open, you start in the row 'Open' and go across to the column 'Flame colour' and read the information in that space. It indicates that the flame colour is blue. So the flame colour is blue when the air hole is open.

Air hole	Flame colour	Visibility of flame	Type of flame
Open	Blue	Difficult	Clean
Closed	Yellow	Easy	Dirty

Processing data

After the data has been collected in an experiment, the next step in the scientific method is to process the data. To **process data** means to find patterns in the data that answer the problem being investigated. The information may be reorganised, perhaps by drawing a graph or putting it into another table. This makes it easier to see patterns in the data.

Part of processing data is interpreting data. To **interpret data** means to decide what the data indicates about the hypothesis or problem being investigated. This helps scientists know if the data supports the hypothesis, or not. For example, consider the experiment in Figure 1.5.1. Some data from this experiment is shown in the following table.

Type of liquid in beaker	Time taken to dissolve (s)
Water	45
Methylated spirits	Did not dissolve

This data can be interpreted directly from the table. You do not have to reorganise it to see a pattern in the results. The results show that water will dissolve the stomach tablets but methylated spirits will not. The inference is that the type of liquid does affect the dissolving time. There is a relationship between the variables. A **relationship** means that one factor or variable affects another.

On this basis it is reasonable for you to decide that your hypothesis was supported. This is called the **conclusion** to the experiment. The conclusion should always make it clear whether or not the hypothesis is supported. Sometimes a hypothesis can be partly supported. It then will have to be modified and another experiment done to test the new hypothesis.

Trends

Often the data is not as easy to interpret as in the last table shown above. Scientists have to look for trends in the data. A **trend** is a change in the data in a particular direction, either increasing, or decreasing.

Find the table of results for Question 13 in Focus 1.5. This is data collected to test the hypothesis 'that the wing area of a paper plane will affect flight distance'. To interpret this data, you must look at how the flight distance changes as the wing area is increased. You can see a trend in the data. It clearly shows that the plane flies further as the wing area increases. So there is a relationship between the variables of wing area and flight distance. You would make a conclusion that the hypothesis was supported.

Averages

One important method of processing data is to calculate an **average** from trials or replicates. The mathematical average of a set of results is calculated from the formula:

$$\text{average} = \frac{\text{sum of results}}{\text{number of results}}$$

An example of an average is the average distance of three flights by a paper plane. If the distances were 7, 6 and 8 metres, the average would be:

$$\text{average} = \frac{7 + 6 + 8}{3}$$

$$\text{average} = \frac{21}{3}$$

$$= 7$$

An average is more likely to be correct than a single measurement. This is because you have more information. There is less chance that some unusual result could affect the conclusion.

With replicates or repeat trials, the different trials or replicates can be compared against each other to see if each group gives similar results. If they do, you would feel more confident that the results are accurate. For example, imagine you did three science quizzes and scored 5, 15 and 18 out of a 20. You could be more confident that the 15 and the 18 indicate how good a student you are. The score of 5 is unusual and may have been due to feeling ill, or missed schoolwork.

Evaluating experiments

After the stages of planning, conducting and processing experiments comes evaluating. This stage in an experiment is where you identify any difficulties you had in the experiment. You also try to say what you can do to improve the experiment.

A common problem is that errors may have occurred in using the instruments. For example, you may not have used correct procedures to measure the data.

Another common problem is that you may have failed to control all the variables. If you don't consider all the variables that could make a difference, then you may not control for some. These can then change the data and your conclusion. Sometimes you may have forgotten to use a control set-up.

Any of these problems can make the results useless, so it is very important to identify them. Evaluation is a vital part of any experiment.

Prac 1 p. 34

Homework book 1.11 Testing rubber bands

1·7 FOCUS [Questions]

Use your book

Recording information

1 What is data?

Tables

2 Why do scientists use tables to display data?

Processing data

3 a What do we mean by 'processing data'?
  b What does 'interpreting data' mean?

4 What do we mean by a 'relationship' when discussing variables?

Trends

5 What do we mean by a 'trend in data'?

Averages

6 Why do scientists calculate averages?

Evaluating experiments

7 If you find that the equipment you used in an experiment does not seem to work properly, can you reach a conclusion about your hypothesis? Give reasons for your answer.

8 If the results of an experiment do not help you to decide for or against a hypothesis, what should you do?

Use your head

9 Draw up a suitable table, with suitable headings, in which you can record the following measurements: Wednesday 30°C, Friday 37°C, Monday 28°C, Tuesday 29°C, Thursday 30°C.

10 Set out the following measurements in a suitable table: A human at rest pumps about 250 mL of blood per minute to the heart muscle, about 1200 mL per minute to the skeletal muscles and about 750 mL per minute to the brain. When exercising lightly the amount of blood pumped is 350 mL per minute to the heart, 4500 mL per minute to the skeletal muscles and 750 mL per minute to the brain. When exercising as hard as possible the blood volumes become 1000 mL per minute to the heart muscle, 22 000 mL per minute for the skeletal muscles and still 750 mL per minute to the brain.

11 Examine the third table in this focus on the Bunsen burner (page 32). Modify the table for two other features of Bunsen burners, 'How hot the flame is', and whether the 'Flame is noisy or quiet'.

12 Draw up a table that could be used to record results from the experiment shown in Figure 1.5.4 on slaters.

13 Draw up a table that could be used to record results from the experiment shown in Figure 1.6.5 on the straw gliders.

14 A table of results from the experiment illustrated in Figure 1.5.3 is shown in the following table.

Diameter of hole (mm)	Time for trial 1 (s)	Time for trial 2 (s)	Time for trial 3 (s)
6	38	41	40
8	17	18	18
10	10	11	10
12	5	4	5
15	2	2	2

a Copy the table out but add a column at the end with the heading 'Average time taken (s)'.
b Calculate an average time taken for each hole size. Show your calculations underneath the table.
c Why were three trials done instead of just one? >>

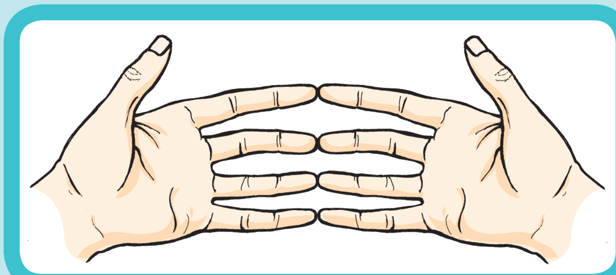
15 Why do you think scientists go to the trouble of writing down or recording all their data in an experiment? Why not just write down the hypothesis and say it was correct after they have tested it?

16 Many experimenters now record all their results on the 'hard drive' of a computer. What problems do you think this could cause, and what solutions do you see to the problems you have identified?

Investigating questions

17 Hold your hands in front of you with the palms facing you. Put your fingertips together as shown in Figure 1.7.2.

Now keeping your hands together, hold them about 30 centimetres in front of your face. Look through your fingers at something across the room.



Put your fingertips together and look between them. *Fig 1.7.2*

a What can you see at your fingertips?

b Record your data in a sketch. Do this from memory.

c What is the best way to record your data—as a table, a description or a diagram? Why do you think so?

1·7 FOCUS [Practical activity]

Processing data and evaluating an experiment

Prac 1 Focus 1.7

Purpose

To practise processing data and evaluating an experiment aimed at discovering some variables affecting the time taken for a paper helicopter to fall.

Requirements

Thick paper or graph paper, scissors, glue or sticky tape, ruler, tape measure or metre rule.

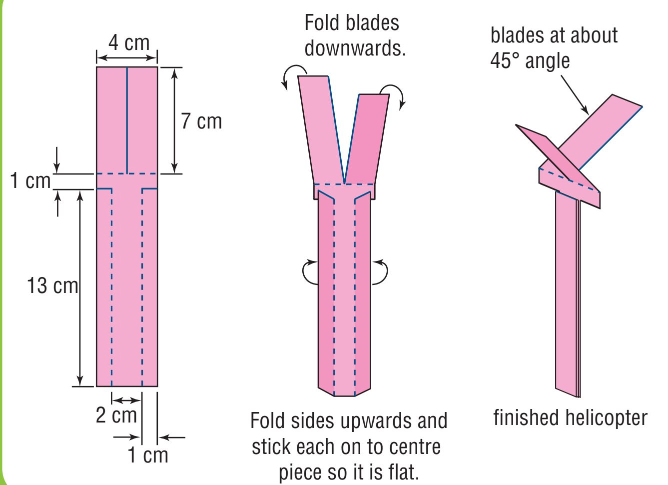


Fig 1.7.3 Making the helicopter. Use these measurements for a large helicopter.

Procedure

1 Consider the diagram in Figure 1.7.3. One way to change variables is to make the helicopter from graph paper. This makes it easy to measure and change the proportions of the parts. Make the helicopter in Figure 1.7.3. This is your control helicopter. Time how long it takes to fall a measured distance. *Record the distance and the times taken in each trial for the helicopter to fall. Note this in a suitable table.*

2 Choose two variables to change, and make two more helicopters. *Draw a diagram to show what you changed on each of your two new helicopters.*

3 Time how long the new helicopters take in each trial to fall the same distance as your control. *Note the times in a table for each helicopter.*

4 *Process your data by combining your results from steps 1 and 3 into a single table, and by calculating an average time for each helicopter.*

Questions

1 What did you do to make this a fair test of each variable?

2 Which of your two variables affected the helicopter, and what was the effect?

3 Find out from other groups which variables did, and did not, affect the helicopter.

4 Evaluate the experiment. Find out from other groups their answers to Question 1. Is there anything that could have done to make the experiments more accurate?

FOCUS 1.8 Processing data: graphs

Context

Tables are one way to process data. Another way of processing data is to draw graphs. **Graphs** are diagrams that present information in a visual way which makes it easier to understand. There are several types of graph, some of which are described below. You need to be able to read and draw these graphs.

Types of graph

Technology CW Activity

Column graphs

Column graphs are used to show the quantity of each of the items being investigated. The information is displayed in vertical columns. For example, a student collected information on the favourite sports of her classmates. The results are shown in the following table.

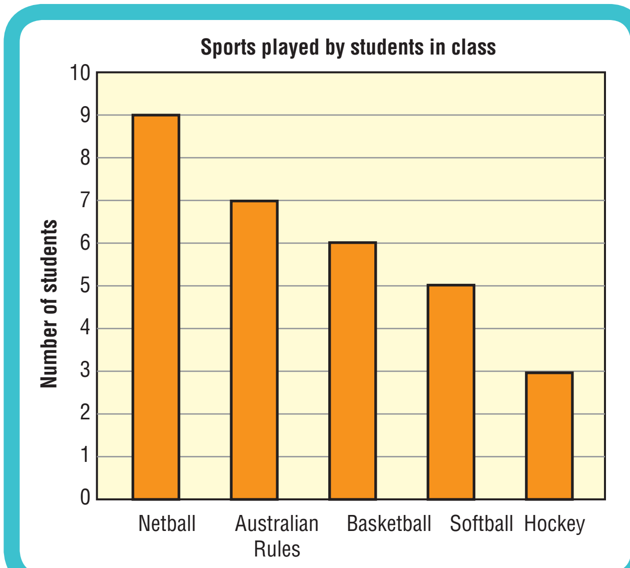
Sport	Number of students
Netball	9
Australian rules	7
Basketball	6
Softball	5
Hockey	3

To draw a column graph of these results, you use **graph paper**. This consists of horizontal and vertical lines equal distances apart.

To construct the column graph you rule a vertical line in pencil on the far left-hand line of the paper and a horizontal line on the bottom line. These lines are called **axes**. Each line is an **axis**. The vertical line is called the **vertical axis**, and the horizontal line is called the **horizontal axis**. Each axis is labelled with its name. In this case the vertical axis is labelled 'Number of students'.

The vertical axis is then divided into numbers to form a **scale**. On this scale you show the number of students choosing each sport. To do this, you find the largest number in the table—9. Then you divide the vertical axis into equal spaces to show all the numbers in the table. This is shown in Figure 1.8.1

You can see that on the vertical axis each line of the graph is equal to one student, so that the nine who chose netball are represented by the ninth horizontal line up the vertical axis.



A column graph of the data in the table opposite **Fig 1.8.1**

The next step is to divide the horizontal axis up into the number of sports chosen. This is done so that each sport is one square wide with one square space between. Then you choose which sport you want to place first on the horizontal axis. You could choose any one, but it is easier to read the graph if you put the sports in order of popularity. So the first one is netball.

The next step is to rule two vertical lines up to the 9 mark. The lines are one square width. This column is often shaded in to make it easier to see. The rest of the sports are then drawn on the graph.

The last step is to give the graph a **title**. The title should explain to any person reading the graph the information that is contained in the graph.

Bar graphs

A **bar graph** is like a column graph, but the columns are horizontal instead of vertical. An example is shown in Figure 1.8.2.

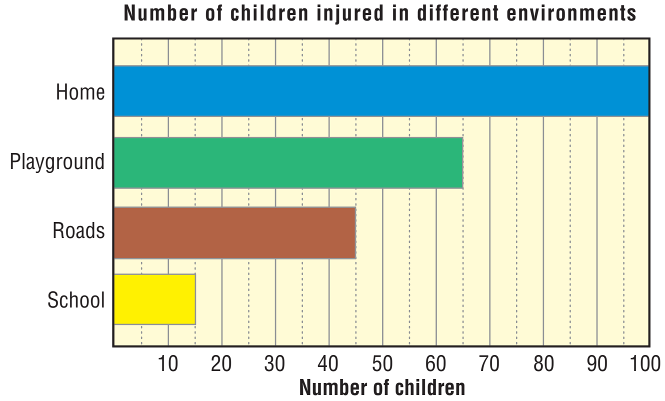
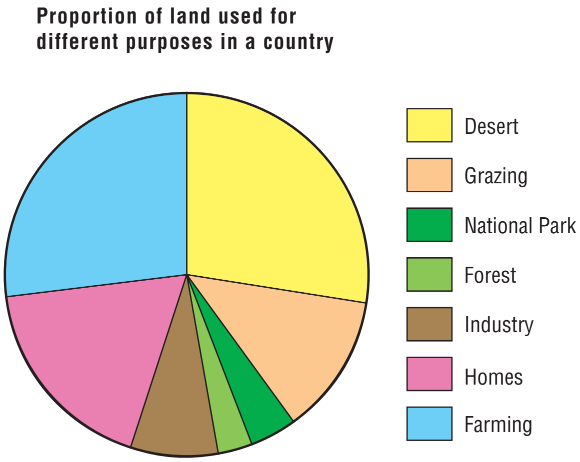


Fig 1.8.2 A bar graph is like a column graph but with the columns drawn horizontally.

Pie graphs

A **pie graph** is usually a round shape. An example is shown in Figure 1.8.3.

The amount of space taken up by each section shows the amount of that item. For example, in Figure 1.8.3 the proportion of desert in the country being investigated is about 27 per cent.



A pie graph Fig 1.8.3

Line graphs

Line graphs are used when two sets of items have been measured and the amount of each changes continuously. For example, consider the information in the following table. This was collected from an experiment such as the one illustrated in Figure 1.5.3 and described in Question 11, Focus 1.5.

Diameter of hole (mm)	Time for sand to run out (s)
4	80
6	40
8	18
10	10
12	5
15	2

To draw a line graph of the change in time for sand to escape as the hole size is changed, you first select the axes. You can see these in Figure 1.8.4. It is usual to put on the horizontal axis the item that causes the other one to change. For example, the hole size is what determines the time taken for the sand to escape. There is no way that the time taken can change the hole size. So the vertical axis is 'time taken', and the horizontal must be 'hole size'. This means the independent variable in an experiment is always drawn on the horizontal axis. The dependent variable is always on the vertical axis.

Each axis is then divided up to form a scale, so that all the numbers can fit on the graph. The same number of squares anywhere on the horizontal axis must equal the same amount of change in hole size.

To draw the graph, look at the table above and find the time taken for the first hole size of 4 mm. This is 80 seconds. So you go up the vertical line on the graph paper that is marked 4. You go up to where the horizontal line marked 80 meets this vertical line and

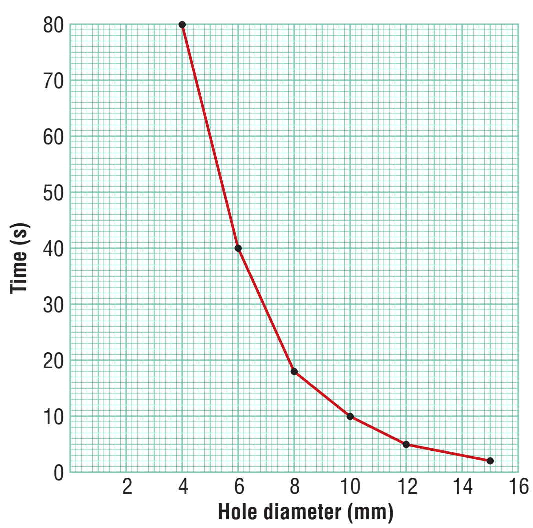


Fig 1.8.4 Line graph of the time taken for sand to run out of cones with different sized holes

place a dot there. You repeat this procedure for all of the hole sizes shown in the table. Then you join up all the dots with a ruler, as shown in Figure 1.8.4.

Interpreting data

When scientists are trying to understand some problem, they usually collect information by observation and measurement. Then they look for patterns in this information. **Data** is the information scientists collect by observation and measurement. **Interpreting data** means finding some pattern in the data that gives an answer to the problem. Graphs are very useful in assisting this process.

For example, scientists trying to discover whether drinking alcohol made people more likely to crash a car studied the data collected by the police about car crashes. Some data on this issue is outlined in the following table.

Blood alcohol level (%)	Risk of a crash (times more likely to crash)
0.00	1
0.05	2
0.08	4
0.12	10
0.14	17
0.15	25
0.16	37

A blood alcohol level of 0.05 per cent means about five parts of alcohol in 10 000 parts of blood. By examining the blood alcohol level, you can see that as it rises the risk of a car crash also rises. A person with a blood alcohol level of 0.05 per cent has twice the risk of crashing as someone who has not been drinking. However, a person with a blood alcohol level of 0.12 per cent has ten times the risk of crashing.

So you can interpret this data and conclude that there is a greater risk of a crash if you have more alcohol in your blood. More alcohol makes drivers more likely to be involved in a crash.

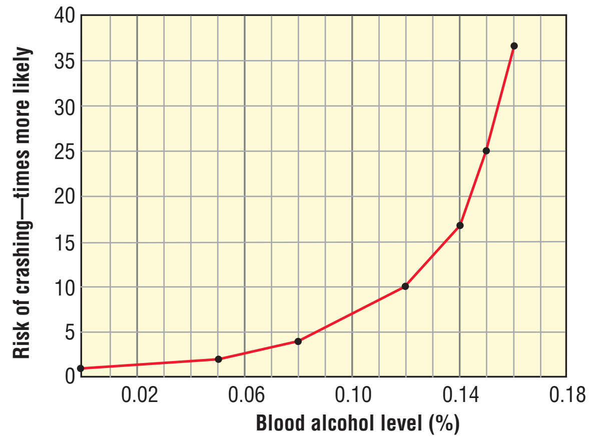
Interpreting graphs

Examining graphs of observations can make the task of interpreting data easier because graphs can provide a clearer picture of the data that has been collected. For example, consider the graph in Figure 1.8.5.

When a line graph rises from left to right as in Figure 1.8.5, the **slope** is said to be increasing.

Line graph of the risk of a car crash as blood alcohol level increases.

Fig 1.8.5

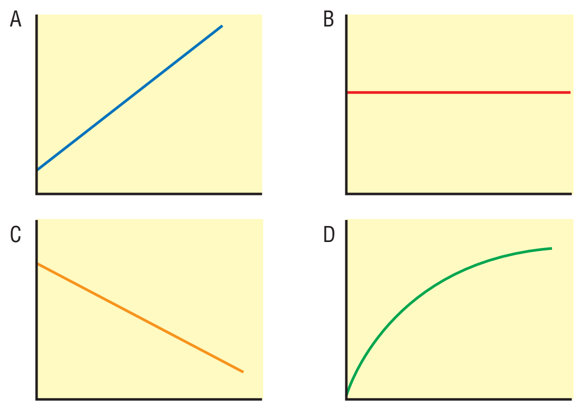


In this case the slope is increasing rapidly because the quantity on the vertical axis is increasing by a greater amount than the quantity on the horizontal axis.

As blood alcohol level rises at the start, the risk of a crash does not change by much. But at high levels of blood alcohol there is a much larger rise in the risk of crashing the car for the same increase in blood alcohol level. For example, a change of 0.02 per cent in blood alcohol level from 0.04 per cent to 0.06 per cent increases the risk of a crash from about 1.5 to 2.5. However, at a blood alcohol level of 0.14 per cent, the same rise of 0.02 per cent to 0.16 per cent increases the crash risk from about 17 times to 37 times.

Other graph shapes describe different patterns and relationships of data. In other words the different shapes of graphs lead to different interpretations of data. Consider the graphs in Figure 1.8.6.

In graph A, for any change along the horizontal axis, the change in the vertical axis is the same. The vertical axis shows a **constant increase**.



Some line graphs

Fig 1.8.6

In graph B there is no relationship between the horizontal axis and the vertical axis. This is because there is no change in the vertical axis as the horizontal axis changes.

In graph C there is a **constant decrease** in the vertical axis as the horizontal axis increases.

In graph D the vertical axis increases but at a gradually decreasing rate until it is eventually constant and does not increase any further.

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Interpolation of graphs

The shape of a graph can be used to obtain data that was not collected in the investigation. This is the process of **interpolation** of information from a graph. For example, look at Figure 1.8.4. There was no data given for a 9-mm hole size. When the line is joined between 8 mm and 10 mm, however, it passes through the line for 9 mm. Where the graph crosses the 9-mm line you can rule a horizontal line across to the vertical axis. Where the horizontal line meets the axis, this is likely to be how long the sand would take through a 9-mm hole—about 14 seconds. Similarly you could interpolate the time taken to be about 27 seconds with a 7-mm hole.

Extrapolation of graphs

Graphs can also be used to predict what will happen outside the range of the data displayed on the graphs. This is the process of extrapolation of information from a graph. **Extrapolation** is the extension of the graph beyond the data that has been collected. This is shown in Figure 1.8.7.

This graph shows data for a population of mice up to day 13. The shape of the graph has been extended to predict the population at day 15. The likely population of mice is about 190 on day 15.

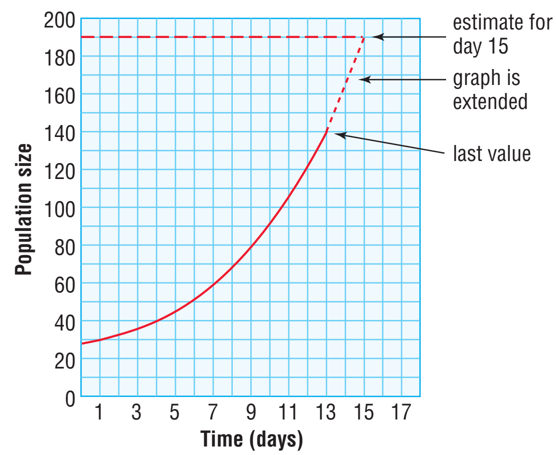


Fig 1.8.7 Extrapolation is the extension of the graph to find a value.

Homework book 1.12 Graphing skills

Homework book 1.13 Body mass index

1.8 FOCUS [Questions]

Use your book

Types of graph

1. What are the important features of any column graph?
2. Using Figure 1.8.4 to help you, identify all of the features of a line graph.
3. Do you put the independent or the dependent variable on the horizontal axis of a line graph?

Interpreting data

4. What do we mean by 'interpreting data' in a graph?

Interpreting graphs

5. What was the scientist's interpretation of the police data in Figure 1.8.5?
6. Look at Figure 1.8.6. Which graph shows that the variable on the horizontal axis did not affect the variable on the vertical axis?

Extrapolation of graphs

7. Consider Figure 1.8.7. Name the technique of extending the line to make an estimate of the population size at 15 days.

Use your head

8. Draw a bar graph of the information in Question 9 of Focus 1.7.
9. Use the information in the table below to draw a line graph showing the cooling of hot water.

Time (min)	0	5	10	15	20	25	30	35
Temperature (°C)	77	64	57	51	46	44	41	38

10. The data in the following table shows how far two toy cars had travelled after each of the times shown. Use this to answer the following questions.
    a. Draw two axes on graph paper and put a scale on each extending from 0 to 6. Label each axis.

Time (s)	Distance by car A (m)	Distance by car B (m)
1	1.0	0.5
2	2.0	1.0
3	3.0	1.5
4	4.0	2.0

- **b** Plot the data for car A on this graph and draw in the line. Label the line 'car A'.
- **c** Draw the graph for car B on the same axes. Label it 'car B'.
- **d** Extrapolate the graph to predict the distance travelled by each car after six seconds.
- **e** Interpolate the graph to find how far each car had travelled by 2.5 seconds.

11 Use your graph from Question 10 to answer the following questions.

- **a** Which car travelled the greater distance in the same time?
- **b** Which car travelled faster?
- **c** Which line has the greater slope?
- **d** What does the slope of these two lines tell you about car A and car B?

12 Consider the estimate of population size in Figure 1.8.7. Is this estimate an observation, a prediction or an inference? Give a reason for your answer.

13 Examine the table (above right) and answer the questions that follow.

Time (minutes)	Pulse rate (beats/min)
0	75
5	150
10	175
15	170
20	160
25	75

- **a** What type of graph should be used to display this information? Explain your answer.
- **b** Draw the graph.

14 Compare the extrapolation from the graph in Figure 1.8.7 and the answer you gave to Question 10d.

- **a** Which extrapolation do you feel is more likely to be accurate?
- **b** Give a reason for your answer.

15 Graphs are said to be easier to understand than tables. Compare the table from Question 9 with the graph you drew from that table. In what ways is the graph easier to understand than the table?

Investigating questions

16 Use your library or the Internet to find out what the following types of graph record:

- **a** electroencephalograph
- **b** electrocardiograph.
- **c** barograph
- **d** seismograph.

1·8 FOCUS [Practical activity]

Prac 1 Focus 1.8

DYO

Keeping it hot

Purpose

To design and conduct an experiment to investigate whether black coffee or white coffee loses heat faster, and to show this by using graphs.

Requirements

Two 250 mL beakers, two teaspoons coffee, 10 mL milk, 400 mL boiling water, two 110°C thermometers, timer, labels or permanent texta, graph paper.

Procedure

1. Predict whether white or black coffee will lose heat faster. *Write down your prediction. Write it as a hypothesis if you can.*
2. In your group, design an experiment to test this prediction. The equipment you have available is in the requirements list. Draw a flow diagram, similar to Figure 1.5.1, showing what your experiment will look like. *List the variables you are controlling.*
3. Show your teacher and then obtain the equipment.
4. Carry out the experiment. *Write down your results.*
5. *Draw a graph showing the data from both the black and white coffee on the one set of axes.*

Questions

1. What conclusion can you make from your results?
2. Write a few sentences explaining how your graphs helped you make a conclusion about your prediction/hypothesis.
3. How sure are you of your results in this experiment? Give the reasons for your answer.

SECTION 1 Working Scientifically

Review questions

Second-hand data

Interactive CW Crossword

1 A student was studying the cooling of salt water and fresh water after they had been heated. She used two beakers, one containing fresh water and the other containing salt water. Both beakers were heated to 70°C and then allowed to cool. She measured the temperature every minute using a thermometer. The results are shown below.

a What do you think the student was probably trying to find out? If you can, give one hypothesis that the student could have been testing

b Draw a graph showing both sets of data on the same axes.

c For this to have been a fair experiment, describe the variables that the student probably had to control, and describe how you think she probably controlled them.

d Were there any faults in her experiment? What could she have done to improve on her experiment?

e Imagine these results really were obtained from a perfectly designed experiment. What conclusion do you think the student can make?

Time (minutes)	Fresh water temperature (°C)	Salt water temperature(°C)
0	70	70
1	46	60
2	35	50
3	29	43
4	25	37
5	22	32
6	20	27
7	20	23
8	20	21
9	20	20

Open-ended questions/experimental design

2 You are the chief engineer of the Flying Straw Company in Matchbox Land. Flying Straw Company makes straw gliders to transport empty matchboxes across the river, which is a frightening 10 metres wide. You have to modify the design of the straw glider from Figure 1.6.5 to transport your matchbox passenger.

Your first thought was to use two straw gliders joined by a matchbox between the straws. Your second idea was to use just one straw glider with the matchbox slung underneath the glider. Your job is to find the most cost effective way of transporting matchboxes. You suspect it may be cheaper to use only one straw. However, you are not sure if this will mean you need more paper for the wings, and you are not sure if the glider will fly. The cost of the materials is as follows

Material	Cost (matchbox dollars)
Straws	50
Thin cardboard for wings	10 per A4 sheet
Sticky tape	1 per 10 cm

Your task is to design, carry out and report on some experiments you did to decide on the most cost-efficient design for the glider to achieve the flight target.

a Decide what you will try to design first, given the costings. You must state why you made this decision.

b Write out a list of the variables you think will affect the flight of the glider.

c Choose two variables you think are likely to be the most important. You are going to test each of these as an independent variable in an experiment. Note that you are doing two separate experiments. If you can, write a hypothesis for each of these variables. If you are not sure about a hypothesis then just write the two variables you are going to change on the glider.

d Write out a list of the variables you must control to test the two independent variables you chose in **c**.

e Explain how you are going to test each of the hypotheses or variables you chose. A diagram of what you intend to do is important. You need to show what the gliders will look like with your two modifications.

f Build your gliders and carry out some preliminary trials on them. If they are flying poorly then you may need to identify the problem. You may have to reconsider your variables and change your design. What problems did you have? Have you decided to try a different variable?

g If you have fixed up any problems you had and the glider now appears to be flying, then do your trials and record the results.

h Report on your conclusions about the two independent variables you tested.

i Is the glider you have built the most cost-effective glider for the job? How do you know?

[Extended investigation/research]

3 You are a member of a group of scientists in a company that is investigating setting up in the 'super ball' business. You want to produce a super ball that will bounce as high as possible. You have to find a good recipe in the laboratory to make the ball. You have discovered from your reading that the ingredients of a super ball are PVA glue, and borax solution, and that borax should not be ingested. To make a borax solution, borax powder must be dissolved in water, but you have no idea how much powder you need to dissolve. You have heard verbal reports that you need to mix similar amounts of glue and borax solution, and that you have to stir them together. But you are not really sure how accurate these reports are. You have decided to test two different PVA glues to see if one is better than the other. You must be wary of wasting company money on large quantities of these ingredients. It is also important that you are tidy and clean up any glue you spill.

Your group needs to determine:

a how much of each ingredient you need

b how you should mix the ingredients

c what equipment you will use for your laboratory investigation

d the steps you will take to determine the variables involved in making the ball

e how you will determine the ball quality

f what jobs each person has in your group

g how you will report your research findings.

You need to hold discussions in your group first about all the points listed above before you even start trying out any experiments. You may need to do a few small tests first and go back to modify your plan again. When you have a fairly good idea of a plan to tackle this task, talk to your company chief scientist (who looks remarkably like a science teacher you had when you were a year 8 student). If the chief scientist is happy, you can begin some preliminary experiments. The chief scientist will monitor your progress and you need to give them a regular verbal report on your progress.

When all your experiments are done you need to clear up and then get down to the report writing.

The chief scientist will probably think you can achieve all this in about four hour's laboratory time, but you may need to negotiate this.

Homework book 1.14 Working Scientifically crossword

Homework book 1.15 Sci-words

Earth and beyond

2

Curriculum guide learning focus

- the position of the Earth in space and what makes up the Solar System
- the movements of the Earth, Sun and Moon
- daily and seasonal changes due to the movement of the Earth
- properties and structure of materials making up the Earth: rocks, air, soil and water
- our use of resources and our impact on the environment
- the processes going on inside the Earth and on its surface

This section on Earth and Beyond also contains information which will help students with the outcomes of Investigating, Communicating Scientifically, Science in Daily Life, Acting Responsibly and Science in Society

Outcome level descriptions

The outcome level descriptions for Investigating covered in this section of the book are mainly EB 2, EB 3 and EB 4.

FOCUS 2.1 The Solar System

Context

If you go outside on a dark, moonless night and look up at the sky, you see lots of little lights. Most are stars, some are planets, and a few might be rarer objects such as meteors, comets or artificial satellites. On the darkest nights you can see thousands of these lights in the sky. You only get the full effect if you are a long way from city lights. We will start by looking closely at a few of these objects in the sky. Some will have names that you recognise, while others may be new to you. All of them are our closest neighbours in space: members of our Solar System.

How we see Solar System objects

Stars are very hot and give off light. The planets and most other objects in our Solar System are much colder than stars, and do not give off light. So why do planets look like little bright lights in the night sky?

The answer is that they reflect sunlight. If the Sun suddenly stopped shining, the planets, asteroids and comets would all seem to disappear. They would still be there, but they would not be able to reflect light to us, so we would not be able to see them. Planets look brighter if they are large, if they are close, and if they reflect light well. They look dimmer if they are small, or far away, or if they reflect light poorly.

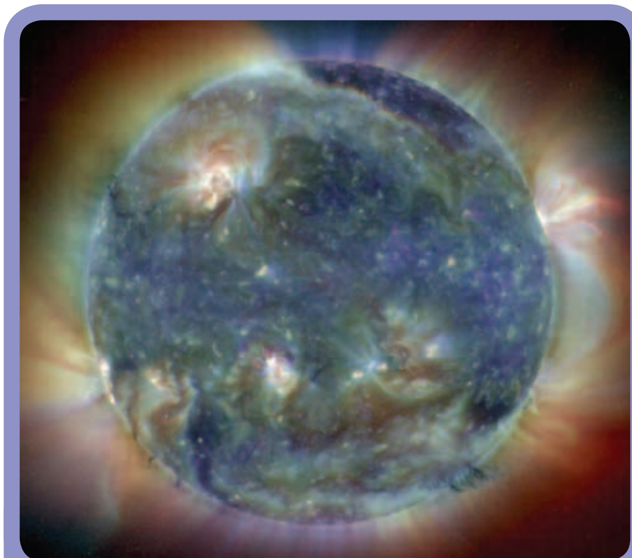
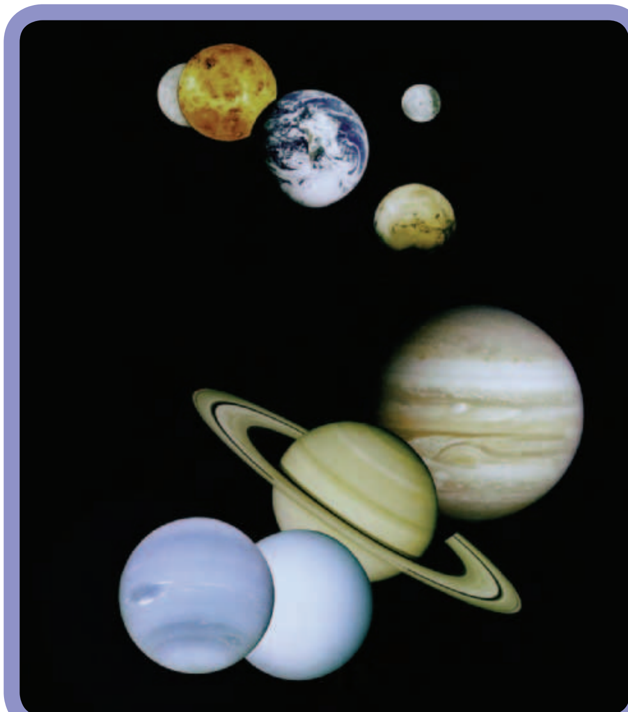


Fig 2.1.1 The Sun is a huge ball of very hot gas.

Movement in the Solar System

The nearest star to us is the Sun. The Sun's mass is huge, and its gravity affects the movement of every nearby object. The planets, asteroids and comets all travel in curved paths around the Sun. This collection of objects is known as the Solar System.The **orbit** of an object is the curved path it follows. Most planets' orbits are nearly circular. Other objects such as comets have oval-shaped, or elliptical, orbits. The Earth revolves around the Sun in a nearly circular orbit. At the same time, the Earth spins (rotates) on its axis. Meanwhile, the Sun follows a curved path as it revolves around the centre of the Milky Way Galaxy. The Sun's gravity takes the Solar System, including our Earth, with it as it travels. The planets of the Solar System are shown in Figure 2.1.2.

Drag and Drop CW Interactive



The known planets of the Solar System (not to scale) *Fig 2.1.2*

One of the hardest ideas to get used to is that all these objects, including our Earth, move through space at very high speeds. Sitting in a chair, you do not feel as if you are moving at all. However, you are really moving much faster than any jet aircraft can fly.

Distances in the Solar System

Another really strange idea is how far away most of the lights in the sky are. Familiar ways to express distance, such as metres or kilometres, are too small to describe astronomical distances properly. In kilometres, the distance from Earth to the Sun is a huge number—imagine that you were told the distance between Perth and Adelaide in millimetres; the number would be huge, and probably wouldn't mean much to you.

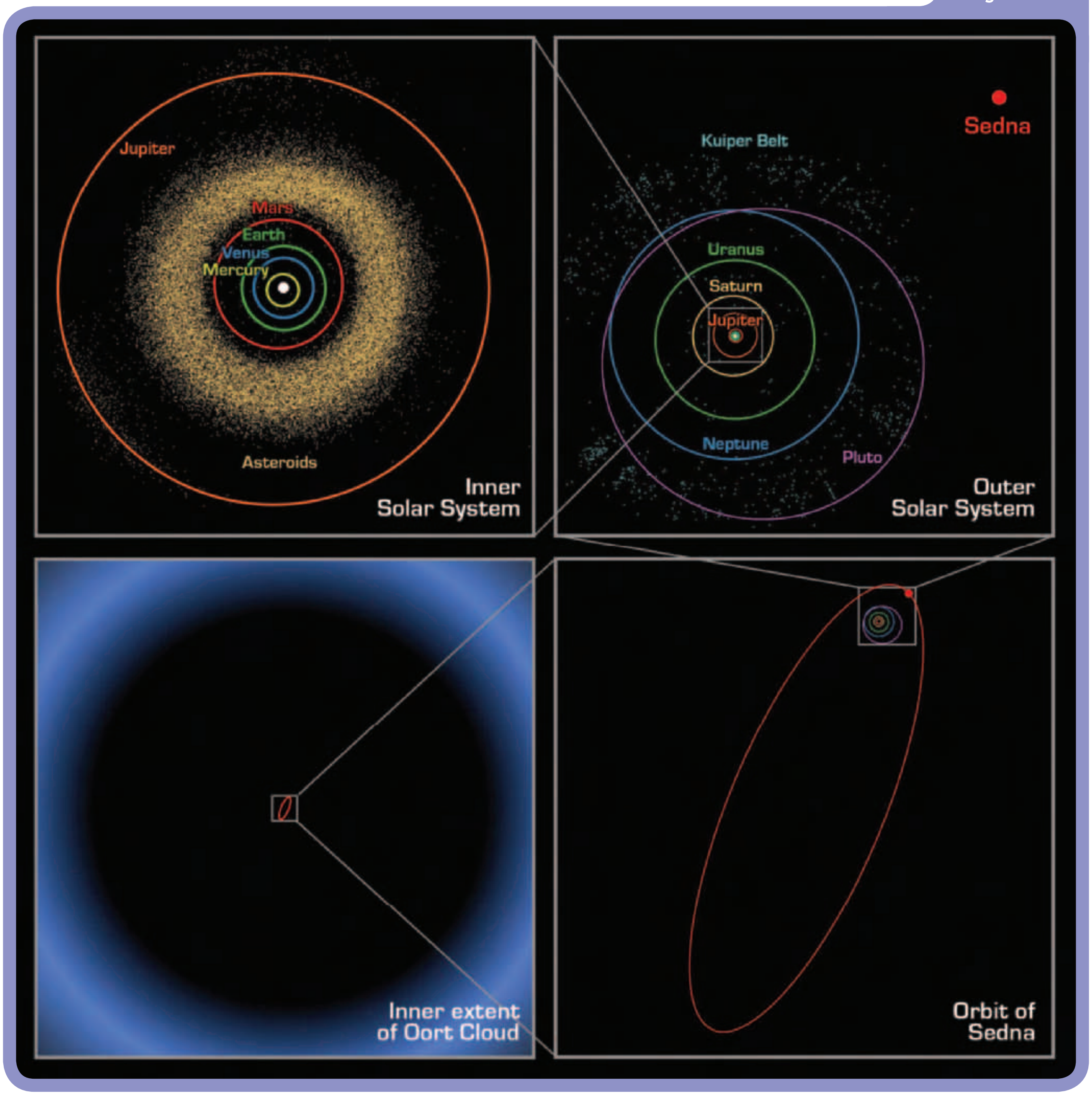
Science Snippet

Right for life

Earth is the only planet that humans can stay alive on without constant help. No other planet has what humans need to stay alive. Those planets lack oxygen in the atmosphere, have no liquid water, and are too hot or too cold.

The Sun and the planets. The distances are drawn to scale.

Fig 2.1.3



Astronomers are people who observe and explain those lights in the sky. They often express distances around our Solar System in **astronomical units (AU)**. This is the average distance between the Earth and the Sun. One AU is about 150 million kilometres, or 150 billion metres.

The closer a planet is to the Sun, the faster it moves in its orbit. The time a planet takes to go around the Sun is its orbital period. The Earth's **orbital period** is almost exactly 365 $^1/_4$ Earth days. Mercury, much closer to the Sun, has an orbital period of 88 Earth days. Pluto, a very long way from the Sun, has a very large orbital period.

The planets

The four planets closest to the Sun—Mercury, Venus, Earth and Mars—are called the **inner planets**. While they are all alike in some ways, they are different in others. The rocky surfaces of Mercury and Mars show old impact craters that were made by falling meteorites. The clouds are so thick on Venus that we never see its surface. Even the most powerful telescopes show only the tops of its clouds. We know about its surface from photographs sent back by a few space probes that landed there, and from satellites that use radar to take pictures through the clouds.

Jupiter, Saturn, Uranus and Neptune are the 'gas giants'. They are big, with very deep atmospheres. Like Venus, the gas giants show only the tops of their clouds. No one knows for sure what is under those clouds. Each of the gas giant planets has many moons, and some also have rings around the planet made of small pieces of ice and rock.

Science Snippet

The tenth planet?

Astronomers have recently found a possible tenth planet orbiting the Sun, which they have named Sedna. Not everyone agrees that Sedna is another planet. It is smaller than our Moon. It is also far away from the Sun (about 90 AU) and its path is far from being a circle. Several thousand years from now, it will be about 900 AU from the Sun. For the astronomers involved, the debate about Sedna being a planet is important. No one has discovered a new planet in our Solar System since Pluto was first seen in 1930. This is a once-in-a-lifetime event.

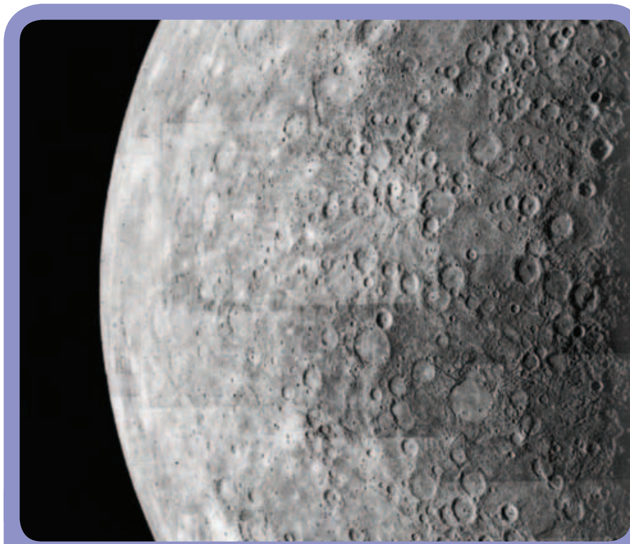


Fig 2.1.5 The surface of Mercury shows many impact craters.

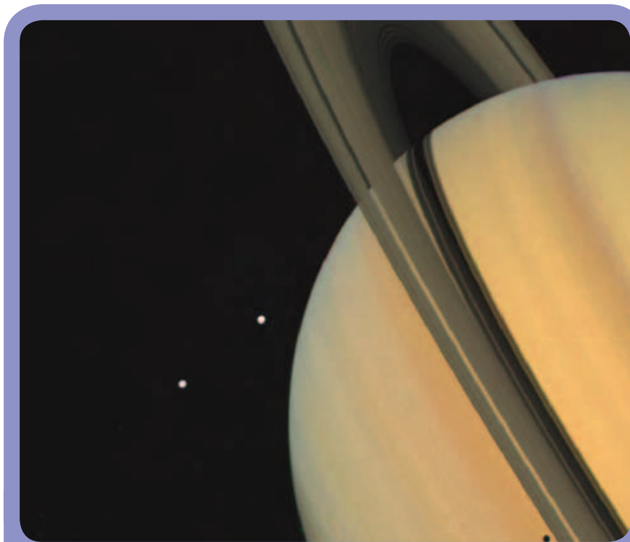
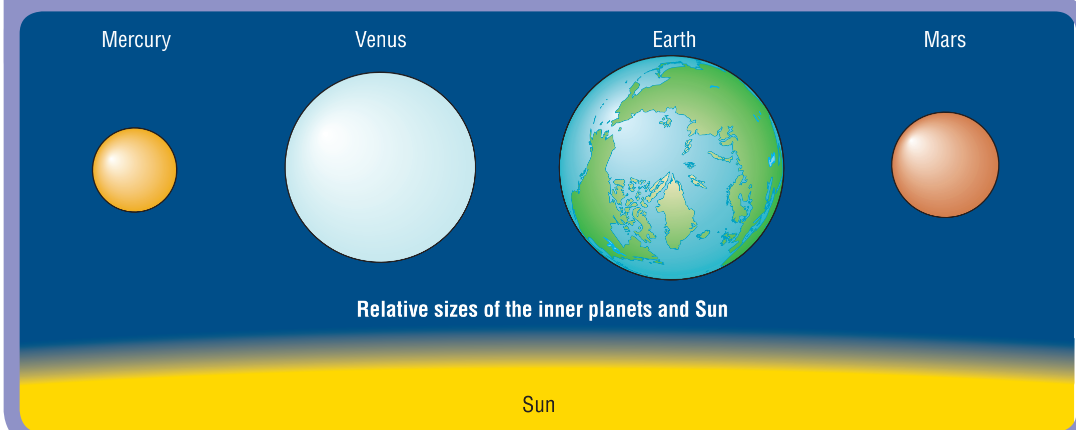


Fig 2.1.6 Two of Saturn's many moons and part of its ring system

Fig 2.1.4 The inner planets, drawn to the same scale.



Pluto is very different from the other outer planets. It is small, has almost no atmosphere and has three moons that we know of. Pluto's orbit is very elliptical.

Interactive CW Animation

Homework book 2.1 Gravity and the solar system

Asteroids and comets

Asteroids can be made of either rock or metal. They are much smaller than planets. Many asteroids are only a few kilometres across. Thousands of these asteroids orbit in various parts of the Solar System. A few asteroids have very elliptical orbits that sweep in close to the Earth's orbit, and out beyond Jupiter's orbit.

Far beyond Pluto's orbit is a region called the Oort Cloud. This contains millions of icy minor planets. Every so often, one of these objects is disturbed. It falls in toward the Sun, warming up as it comes closer, and begins to give off evaporated gas, which forms a 'tail' around the icy mass. We call this a **comet**. Comets have very elliptical orbits.

An asteroid Fig 2.1.7

When close to the Sun, comets have 'tails' that always point away from the Sun. Fig 2.1.8

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Prac 2 p. 48

Homework book 2.2 Discovering the asteroid belt

FOCUS 2·1 [Questions]

Use your book

How we see Solar System objects

1 The planet Mars does not produce any light, but we can see it in the night sky. How does light come from Mars to us?

2 The planet Pluto is not visible to us without the help of a powerful telescope. How would the following make Pluto hard to see?
- **a** the distance of Pluto from Earth
- **b** the size of Pluto
- **c** the light-reflecting ability (reflectivity) of Pluto.

Movement in the Solar System

3 There is a large object in our Solar System that other objects orbit around.
- **a** What is this large central object?
- **b** What is the shape of the Earth's path as it travels around this large central object?

4 Why don't objects in the Solar System travel along a straight-line path?

Distances in the Solar System

5 How far away from the Earth is the Sun, as measured in:
- **a** astronomical units
- **b** kilometres?

6 Venus is closer to the Sun than is Mars.
- **a** Which of these planets has the longer orbital period?
- **b** How did you decide on your answer to **a**?

The planets

7 What are the names of the outer planets?

8 No one is really sure what is on the surface of Jupiter. Why is this?

9 What are two ways in which Pluto is different from the other outer planets?

Asteroids and comets

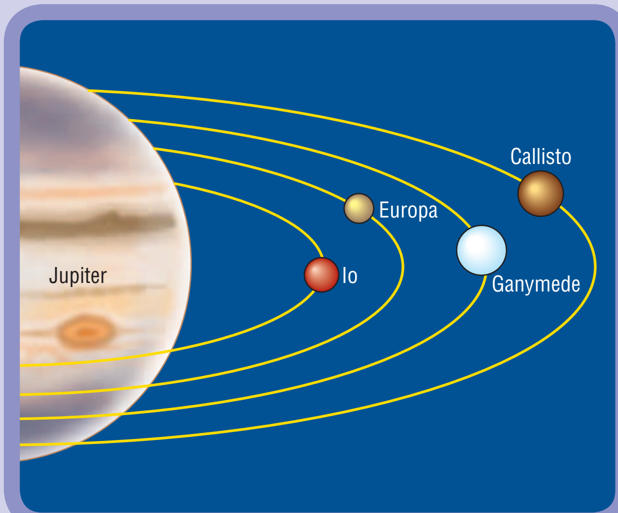
10 **a** In what ways are comets similar to asteroids?
- **b** In what ways are comets different from asteroids?

>>

Use your head

11 If astronomers agree that Sedna is our tenth planet, will they classify it as an inner planet or as an outer planet? Explain.

12 Figure 2.1.9 shows the orbits of the four moons of Jupiter that you can see with the help of binoculars or a small telescope.



The orbits of Jupiter's largest moons *Fig 2.1.9*

- **a** Which of Jupiter's four largest moons has the longest orbital period? Explain.
- **b** Sketch a diagram showing the orbits of Io, and a moon having a shorter orbital period than Io.
- **c** Jupiter has many other moons which are not so easily seen. Suggest why these other moons might be harder to see.

13 The word 'asteroid' means 'star-like object'.

- **a** Is this an appropriate name? Explain.
- **b** Asteroids are sometimes called 'minor planets'. Is this an appropriate name? Explain.

14 One substance humans need to survive is water. Astronomers have looked for evidence of water on other worlds. The results are shown in the following table:

Solar system object	Where water was found
Mars	Frozen in the polar ice caps
Earth's moon	Frozen at the bottom of a deep crater where sunlight never reaches
Europa (one of Jupiter's moons)	Surface is covered in ice, and there may be liquid water underneath the surface
Most comets	Comets are mostly made of ice along with other materials, eg rocks

- **a** Which of these sources of water would be the cheapest to travel to? Explain.
- **b** Could any of this water come to the Earth? Explain.
- **c** Could any of this water support life as we know it? Explain.

Investigating questions

15 The planet Mars has fascinated watchers of the night sky for thousands of years. People's ideas of what Mars is, and what we would find if we went there, have changed over the years. Find out some of the history of ideas about Mars, and make a poster or website, or write a background news item, showing the development of our understanding of the nature of Mars.

16 In the future, space travel may become cheap enough to allow tourists to visit other worlds. Choose one planet or moon that you would like to visit. Research conditions on that world and make a tourist brochure or a poster advertising its attractions.

2·1 FOCUS

[Practical activities]

Modelling the Solar System

Prac 1 Focus 2.1

DYO

Purpose

To design and create a model of the Solar System using students as the parts of the Solar System.

Requirements

Access to a large open space such as a school oval, access to whiteboards, measuring tape, calculators, a camera.

Procedure

1. Measure the length of the open space. *Write down the length you measured.*
2. Discuss in your group what you will have to do to work out a scale so a model solar system fits into the open space. You will need to agree where the Sun will be, how far from the Sun Mercury will be, and so on, right out to Pluto. Are the planets going to be lined up or spread out?

>>

3 *Draw what your model solar system will look like, using Figure 2.1.1 as an example.*

4 Using your calculators, work out the distances involved and *write down your results in a table*.

5 Using whiteboards to display your tables, compare your table with those of other groups. Make a decision as a class about which table is best, and why. *Write down the details from the table that is the best for the job, and the reasons for choosing that table.*

6 Decide who will do which job. For example, someone (or some people) will represent the Sun, someone will represent Mercury and so on, out to Pluto. Some students will have to measure out the distances. Some will have to operate the camera to create a record of what the model solar systems look like. *Write down the job each person does.*

7 Create your model and take some photographs of it.

Questions

1 What did you learn in this activity? Discuss or brainstorm this as a group or as a class. Write down a summary of the ideas discussed.

2 Did the table you all agreed on accurately show the planets on a suitable scale for the area you were using? Write down your answer, and the reasons for it.

3 The next nearest star (after our Sun) is more than 250 000 AU away from us. If you wanted to include it in your model, where would that student have to stand? Write down your answer, showing any working out you did.

Prac 2
Focus 2.1

DYO

Extrasolar planets

Purpose

To find out about other solar systems, in which planets orbit around stars far from us.

Requirements

Access to the Internet and/or journals such as *New Scientist*.

Procedure

1 Begin by deciding on the resources you are going to use, and how you will show your final answers to other groups (eg a poster, a web page, a song, a TV news item)

2 Read the questions below very carefully. *Write down in your notebook the main or key words from each question.* If your teacher gave you a photocopy of the questions then underline the main or key words on the photocopy.

3 The words you have identified will help you search for information. In your group, discuss and agree on the key words for each question. *Write down in your notebook the agreed key words from each question.*

4 Decide who in your group will answer which question (choose one question each).

5 Carry out your search. *Write down, photocopy or print out the useful information you find.*

6 Show your information to the others in your group and look at their information. Discuss how well your key words worked, especially if you tried other key words as you searched. Also, discuss what to write as answers to the questions.

7 *Write down your answers to the questions.*

8 Create your presentation and show other groups what you found out.

9 In your group, discuss which presentation was the most effective, and why. *Write down what you have decided*.

Questions

1 Some astronomers have reported that they have discovered extrasolar planets going around stars far from our Sun. How many extrasolar planets have been found?

2 Extrasolar planets are so far away that seeing them is difficult, or even impossible. What methods do astronomers use to discover such planets?

3 Astronomers are quite sure that extrasolar planets exist. Why are they so confident?

4 Astronomers have no trouble seeing the stars the planets go around. Why is it so hard to see the extrasolar planets?

5 None of these newly discovered planets are like the Earth. Does this mean that there are no other planets like Earth?

FOCUS 2.2

The Sun, the Earth and the Moon

Context

To almost everyone, the most important objects in the Solar System are the Earth, the Moon and the Sun. We live on the Earth; in fact it is the only place we know of where we can live without help. The Sun dominates the sky in the daytime and provides light and warmth. The Moon seems to influence many things, from the time that corals reproduce, to people's moods.

The Sun

The Sun is the central object in the Solar System. Its diameter and mass are both very large. It is also very hot and glows brightly. The Sun has been hot and glowing for about 4 $^1/_2$ billion years, and will probably keep on glowing for another 5 billion years.

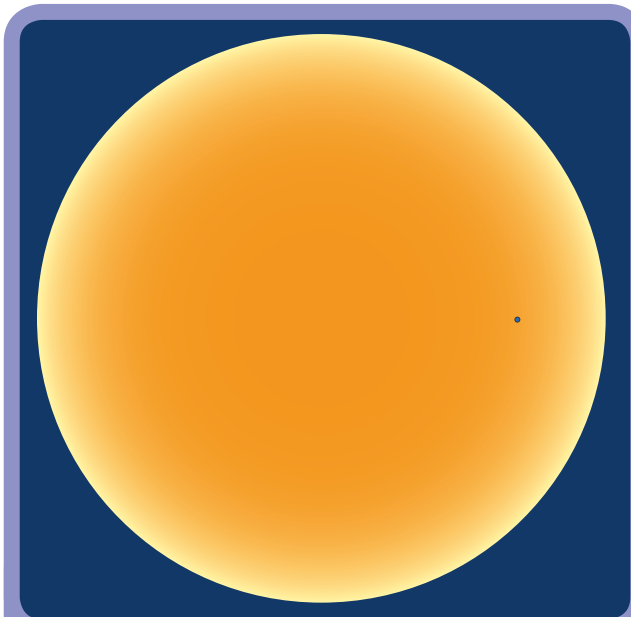


Fig 2.2.1 The black dot shows how big the Earth is compared with the Sun.

The Sun is made mostly of hydrogen with a small percentage of helium and even smaller amounts of other elements. The nuclear reactions that produce the Sun's energy change hydrogen into helium. In the far future, the Sun will become mostly helium.

The Sun produces huge flares of glowing gas from its surface. *Fig 2.2.2*

On the Sun's surface are dark areas called sunspots. They are not really dark, just cooler and less bright than the rest of the surface. Sunspots come and go in cycles in which the maximum activity periods are about 11 Earth years apart.

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The Earth

As far as we know, the Earth is the only place in the Universe where humans can live without special equipment. Everything we need is here. There is oxygen and liquid water. Temperatures are not too high or too low. There are plants and animals that we can use as food.

The Earth as it looks from close to the Moon's surface. *Fig 2.2.3*

The Earth's atmosphere is a busy place. Air moving around creates winds and breezes. Water evaporates then condenses in the air, forming clouds, rain, hail, snow and fog. Some types of cloud make lightning and thunder. The energy needed to keep all this going on comes from the Sun.

About two-thirds of the Earth's surface is covered by water, mostly in the oceans. The rocky part of the surface is called the **crust**. Below the crust, the **mantle** is less solid, rather like heavy, stiff plasticine. Temperature increases with depth. Deep down, the **outer core** is so hot that rock can only exist as a liquid. Even deeper than that, the **inner core** is squeezed so hard by the weight of all the material above that it is solid.

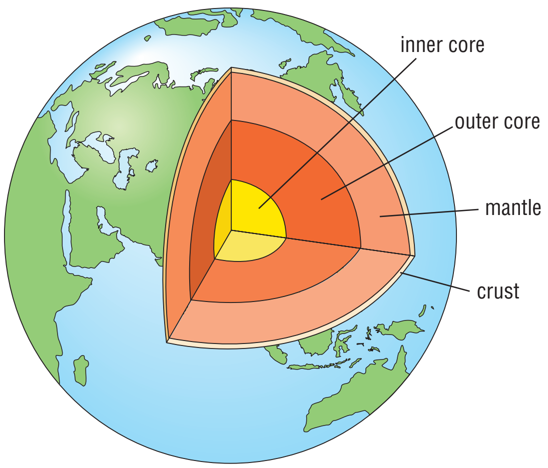


Fig 2.2.4 The Earth is made of layers of different thicknesses and with different properties.

Homework book 2.3 Calculating the distance to the Sun and Moon

Science Snippet

Dinosaur killer?

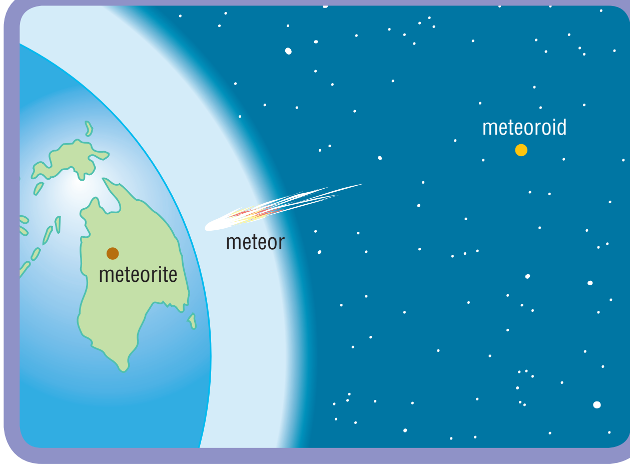
For millions of years, dinosaurs left their remains as fossils. These include bones, tracks, eggs and droppings. About 60 million years ago, fossil evidence of dinosaurs suddenly stopped. Dinosaurs were extinct. One possible cause was an asteroid impact. The impact created huge tsunamis, lit forest fires and threw up a dust cloud that completely covered the Earth. Perhaps the dust cloud changed the climate so much that the dinosaurs could not survive.

Visitors to Earth

Thousands of **meteors** enter the Earth's atmosphere every day, but few reach the surface. Friction with the thin air 100 kilometres above the Earth causes them to heat up. Most meteors become white-hot and vaporise while still very high up.

Only large meteorites reach the Earth's surface. Long ago, thousands of large meteorites hit the inner planets. Big meteorites create big holes

A single piece of rock may have different names, depending on where it is. *Fig 2.2.5*



called **impact craters**. If you look at the Moon through binoculars you can see its larger craters. Most of the Earth's meteorite craters are long gone. They were destroyed by the processes that lift up and wear down mountains.

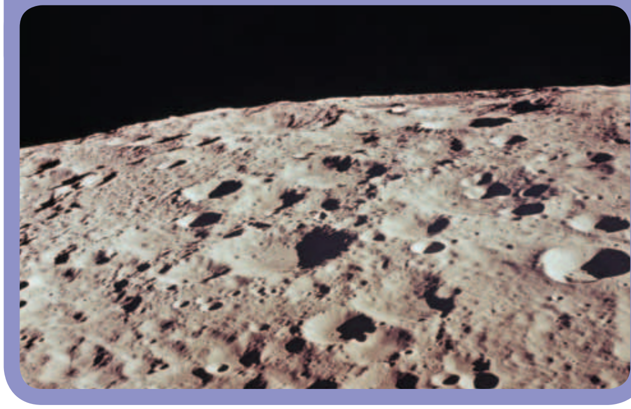
Every year, Earth's orbit crosses several comets' orbits. Every comet leaves a trail of tiny meteoroids, which are the size of grains of sand, along its orbital path. When the Earth passes through a comet's orbit these meteoroids create spectacular meteor showers.

The Leonid meteor shower occurs once every year. *Fig 2.2.6*

The Moon

After the Sun, the brightest and most obvious Solar System object is our **Moon**. Only about 384 000 kilometres (about 0.0026 AU) away from the Earth, it is our nearest neighbour in space. The surface of the Moon is a rocky wasteland. There is no atmosphere

Fig 2.2.7 A close-up of the surface of the moon.



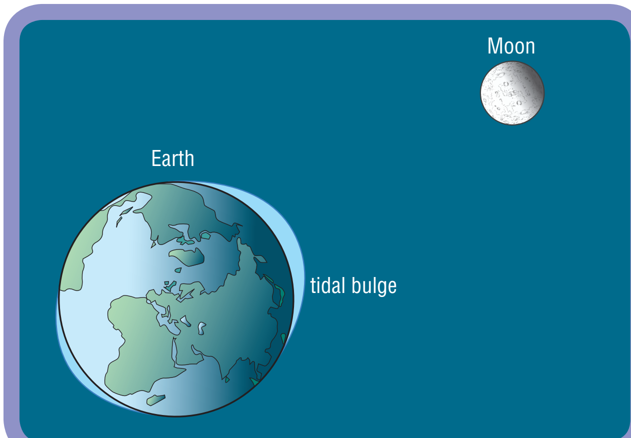
to breathe, or to burn up meteors. Impact craters of all sizes are scattered across the surface. There are light-coloured mountains and flat dark areas called **maria**.

The Moon is the same distance from the Sun as the Earth, but its surface is much hotter in the daytime and much colder at night. This is because the Moon, unlike Earth, has no atmosphere to moderate the temperature.

Prac 2 p. 54

Tides

The Sun's gravity pulls on the Earth, as does the Moon's. The Moon, smaller but much closer than the Sun, pulls harder. The Moon strongly attracts the water in the oceans closest to it. It pulls less strongly on the centre of the Earth, which is further away. Ocean water bulging up towards the Moon creates a **high tide**. There is a second, smaller bulge on the far side of the Earth. This is due to the Moon's gravity pulling the Earth away from the oceans on the side furthest from the Moon.There are two high tides each day and two **low tides** in between.



How the Moon makes the tides Fig 2.2.8

The Sun also pulls on the oceans, but its attraction is less and the bulges are smaller. Sometimes the Moon and Sun work together to create extra-high tides. There are tides in the rocks of the Earth's surface, too.

Eclipses

Eclipses are caused by shadows. The Moon is the right size to just block out the Sun if the Moon passes between the Earth and the Sun. The Earth is so big that its shadow can cover the Moon if the Earth is between the Sun and the Moon.

A **lunar eclipse** (eclipse of the Moon) is a fairly common event, and starts as the Earth's shadow cuts into the edge of a full moon. The shadow passes across the Moon, then passes off the other side. If the shadow completely covers the Moon, we call it a total lunar eclipse. A partial lunar eclipse occurs when the Earth's shadow only partly covers the Moon.

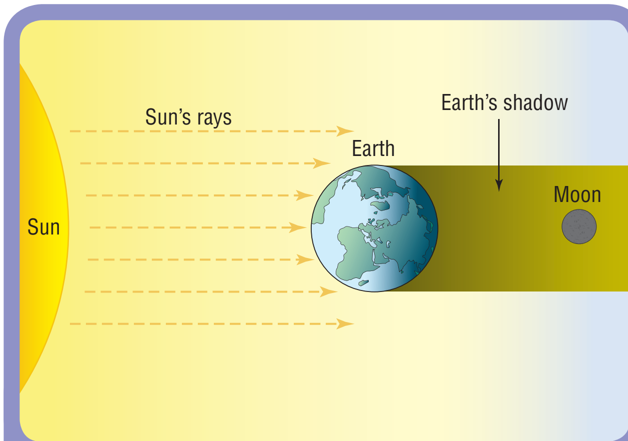


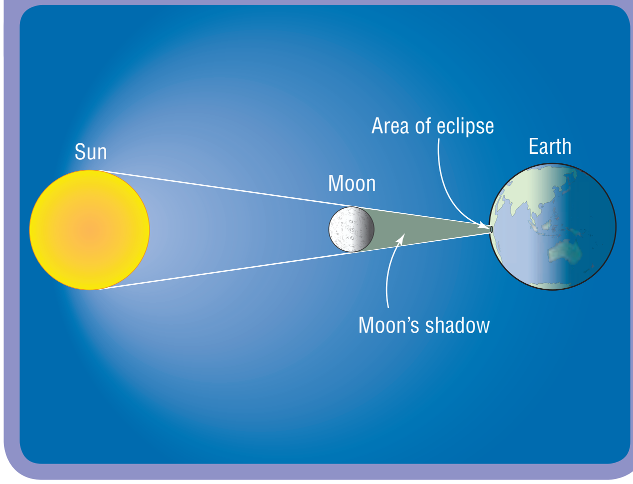
Fig 2.2.9 An eclipse of the Moon

Interactive Animation

Anyone on the side of the Earth facing the Moon at the time can see a lunar eclipse. It is safe to look directly at a lunar eclipse, because the eclipse does not expose us to any dangerous rays. From start to finish, lunar eclipses can last for hours.

A **solar eclipse** (eclipse of the Sun) is a fairly rare event, and starts as the Moon seems to cut into the edge of the Sun. The Moon's shadow passes across the Earth, then off the other side. If you are in the umbral (total) part of the shadow, the Moon completely covers the Sun. You see a total solar eclipse. You see a partial solar eclipse if you are in the penumbral (partial) section of the Moon's shadow, and the Moon only partly covers the Sun.

Fig 2.2.10 An eclipse of the Sun



Only people in a narrow band, on the side of the Earth facing the Sun at the time, can see a solar eclipse. It is dangerous to look directly at a solar eclipse. The Moon covers the disc of the Sun but does not get in the way of harmful ultraviolet rays from the corona (the Sun's atmosphere). The 'total' phase of a solar eclipse lasts only seconds, and the whole thing is over in less than an hour.

Science Snippet

Space travel

The Moon is the only Solar System object that humans have actually visited. Between July 1969 and December 1972, a total of 12 people landed there and then returned to Earth. They collected many samples of dust and rock for study back on Earth. Expeditions have carried a Moon Buggy and golfing equipment. Although no human has ever travelled further than the Moon, many space probes have visited other planets. There are plans to send people to Mars and back. It will be a very long and very dangerous trip.

Fig 2.2.11 The Moon Buggy

FOCUS 2.2 [Questions]

Use your book

The Sun

1 a For how many years has the Sun been hot and bright?

b How much longer is the Sun expected to shine?

c What is the total expected lifetime of the Sun?

2 What occurs in the Sun to provide the energy to let it shine for so long?

3 Why is the Sun slowly changing from being made of hydrogen to being made of helium?

The Earth

4 A cyclone carries a huge amount of energy. Where does this energy come from?

5 What makes the Earth different from other planets in our Solar System?

Visitors to Earth

6 What causes meteor showers?

7 What is the difference between a meteor and a meteorite?

8 Why does the Earth have only a few visible meteorite impact craters?

The Moon

9 Why does the Moon have so many visible meteorite impact craters?

10 If you look at a full Moon, you see a bright, round disc. However, it is not the same brightness all over its surface.

a Why does the Moon have some areas that are light-coloured?

b Why does the Moon have some areas that are darker in colour?

Tides

11 Which Solar System objects cause the tides in our oceans?

12 Extra-high tides, or spring tides, happen when the tides created by the Moon and the Sun occur at the same time in the same place. Draw a diagram showing the locations of the Earth, Sun and Moon at the time of a spring tide.

Eclipses

13 Is it safe to look directly at an eclipse of the Moon? Explain.

14 Is it safe to look directly at an eclipse of the Sun? Explain.

>>

Use your head

15 Extra-low tides are called neap tides. They happen when the tides caused by the Sun and the Moon work against each other. Show in a labelled diagram the arrangement of the Earth, Moon and Sun that might lead to a neap tide occurring.

16 **a** If a lunar eclipse is visible from Perth, would it also be visible from Sydney? Explain.

b If a solar eclipse is visible from Perth, would it also be visible from Sydney? Explain.

Investigating questions

17 Some people believe that ancient monuments such as Stonehenge may have been used to predict when eclipses would happen.

a Why might this have been important?

b How do astronomers predict eclipses now?

c Why is predicting the time of an eclipse not so important to our society?

18 The local landscape has a big effect on tides. For example, the tidal range (difference between high and low tide heights) at the end of a long narrow bay can be very large.

a What is the tidal range at a coastal location near you?

b Where in Western Australia is the tidal range large?

c How does having a large tidal range affect people's lives?

2·2 FOCUS

[Practical activities]

Prac 1
Focus 2.2

Tracking sunspots

Purpose

To observe the Sun's surface and keep track of sunspots over a period of days.

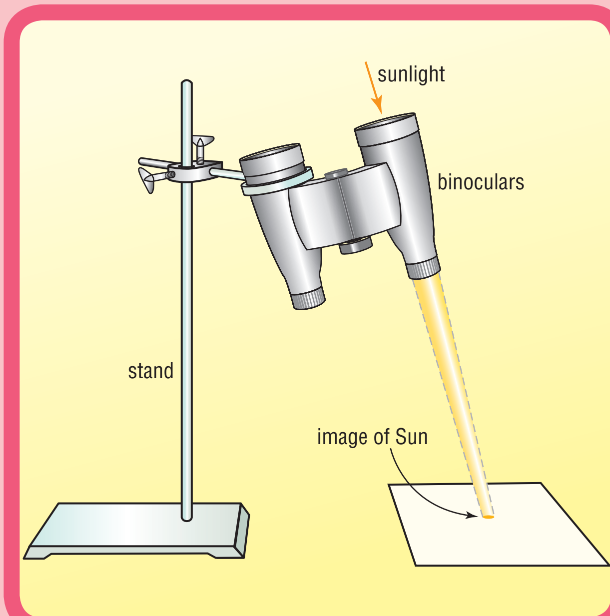
Requirements

Sheet of white paper or card; binoculars or telescope if available, stand and clamp.

Safety note: In this exercise, you will make images (pictures) of the Sun on a sheet of paper or card. This is the only safe way to observe the Sun, which is too bright to observe directly without causing eye damage. Do NOT look directly at the Sun, either with unaided eyes or through the binoculars or telescope.

Procedure

1. Take your equipment outside to where the Sun can shine directly onto a sheet of paper. Use the binoculars or the telescope to project an image of the Sun onto the sheet as shown in Figure 2.2.12. When you have a focused picture on the card, look for dark spots (sunspots). *Trace the edge of the Sun on the card and mark locations of any sunspots.*
2. Do this on at least three different days, using a new sheet of card each time to record the positions of the sunspots. *Make a poster that shows your maps of the Sun's surface.* Leave room on the poster for some extra work to be added later.
3. Compare your poster to those of other groups. Did everyone map the same sunspots? How can you tell? *Write a description of any changes you observed and add this to your poster.*



How to view the Sun in safety *Fig 2.2.12*

Questions

1. Do sunspots change their location from one day to the next? What is your evidence? Write down a summary of the ideas discussed and add this to your poster.
2. Find out why we think sunspots happen. Write down your answer and add this to your poster.
3. If we could see other stars clearly, do you think they would have sunspots too? Write down your answer and explain why you came to this conclusion.

Prac 1
Focus 2.2

How wide is the Moon?

Purpose

To measure the diameter of the Moon. This is best done when you can see the full moon, or almost full moon, in the daytime.

Requirements

Metre-ruler, 5-cent piece, about 3 metres of string, plasticine.

Procedure

1. Stick a small piece of plasticine on one end of the ruler. Use the plasticine to attach the 5-cent piece to the end of the ruler so the coin stands up. Also attach one end of the string to the plasticine.
2. Your group needs to be where you can see the Moon. Hold the ruler up in front of the Moon, and move to where the coin covers, or partly covers, the Moon. Move slowly towards or away from the ruler until the coin just exactly covers the Moon. Hold the string near your eye and use it to measure how far your eye is from the coin (for example, your eye may be 150 cm from the coin end of the ruler, or 220 cm from it, or 182 cm …). *Write down the eye-to-coin distance, in centimetres, that you find.*

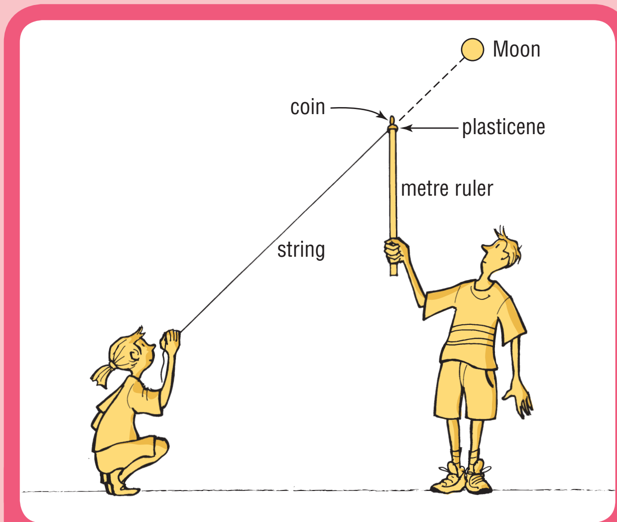


Fig 2.2.13 Measuring the diameter of the Moon

3. Repeat this until everyone in the group has done the measurement. *Write down the results.*
4. Look at the results. Is there a pattern? Should you repeat any of the measurements?
5. Return to the classroom if you have been outside. Calculate the average of the measurements you made. (You can do this by adding up the measurements and then dividing the answer by the number of measurements. For example, if your group found the distances to be 190 cm, 193 cm and 199 cm, the total is 190 + 193 + 199 = 582 cm. There were three measurements, so now divide 582 cm by 3 = 194 cm.) *Write down what you did and what the average value is.*
6. Measure the diameter (width) of the 5-cent coin in centimetres. *Write down its width.*
7. The Moon is about 384 000 km from the Earth. You now have enough data to work out how wide the Moon is. To work out the Moon's width, first multiply 384 000 by the width of the 5-cent coin. *Write down your answer.*
8. Divide your answer by the average eye-to-coin distance. *Write down your answer.* This number is the width of the Moon, in kilometres, according to your measurements.
9. Show other groups what you found out. Is there a pattern to the class results?

Questions

1. Why should you take the average of several measurements when you measure the distance from your eye to the coin?
2. Find out the accepted width (diameter) of the Moon. Was your experiment accurate? How do you know?

FOCUS 2.3 Day and night

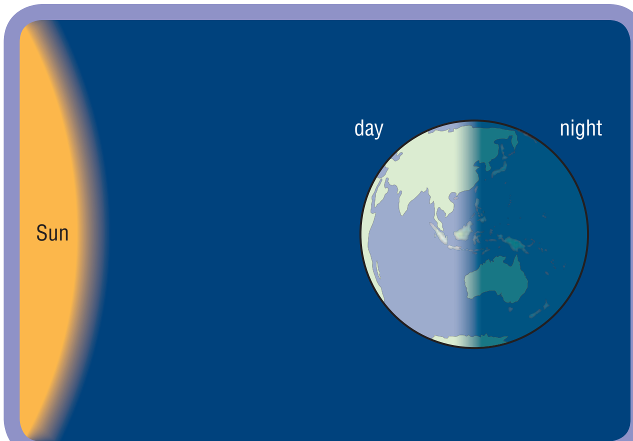
Context

We can rely on the fact that night follows day, every time. The lengths of day and night change as the seasons change, and also depend on our location on Earth.

Our language reflects some strange ideas about why we have day and night. What do words such as 'sunrise' and 'sundown' suggest?

Day and night on Earth

At any one time, half the Earth is in daylight, while the other half is in the dark. The side of the Earth that faces the Sun receives sunlight. This is what we call 'day'. The other side of the Earth, where sunlight does not reach, is in shadow; this is what we call night.



The side of the Earth that receives sunlight is the day side. *Fig 2.3.1*

The Earth spins around an **axis** that runs north–south, in a movement called **rotation**. It behaves like a huge spinning top. This means that the south pole always points towards the same area of the sky and the north pole always points towards another part of the sky. Every other part of the Earth's surface moves once around the axis every 24 hours, rotating towards the east. This means that, apart from the poles, every other part of the surface continuously turns to face a different part of the sky.

When our part of the surface faces a part of the sky that includes Sun, we have daylight. When our part of the surface has spun around to face a part of the sky that does not include the Sun, we have night.

Sunrise occurs when the Earth's rotation places our part of the surface where the Sun is just on the eastern edge of what we can see. As the Earth turns, the Sun looks as though it moves westward up into the sky. At midday, the Sun seems to be high in the sky; then it seems to slide down to the western horizon. At sunset, the Earth's rotation makes it look as though the Sun moves below the horizon.

This is a complicated idea, and the evidence for it is not obvious. It has only been widely accepted in Western culture for the last few hundred years. For thousands of years before that, most people believed that the Sun moved around the Earth. Our everyday speech still reflects many of these old ideas.

The relationship between the rotation of the Earth and the time of day is shown in Figure 2.3.2.

Science Snippet

How long is a day?

There is evidence that the day has not always been 24 hours long. Millions of years ago, when the dinosaurs first walked the Earth, the day was only about 23 hours long. Billions of years ago, the day was even shorter. In the far future, the day will be longer. The Earth is actually slowing down as it spins on its axis. Every 1000 years the day gets 23 milliseconds longer. This is not a fast process, but over millions of years, the difference is large. The reason for our lengthening day is the Moon's tidal forces.

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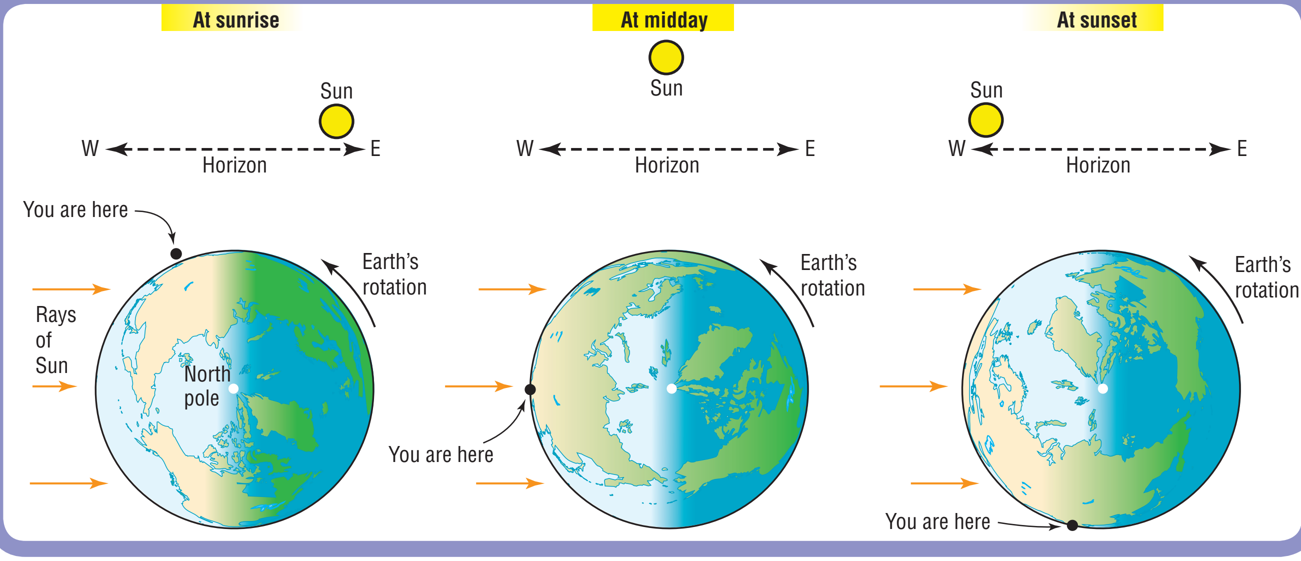
Homework book 2.4 Change in day length with seasons

Fig 2.3.2 The relationship between the rotation of the Earth and the time of day

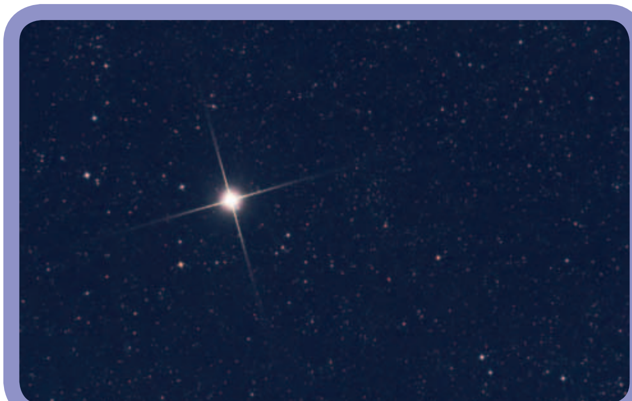


Where do the stars go in the daytime?

The stars, planets and all the other things we see in the night sky seem to disappear at sunrise, and seem to return when the Sun goes down. Why does this happen?

We see stars and planets at night as bright lights against a dark background. That is, compared with the dark background of the sky, the stars and planets we see at night look bright. During daytime, however, the background sky looks much brighter. In fact, the daytime sky is brighter than most stars, making the stars and planets much harder to see. The Moon is much closer to us than any other sky object, and looks big and bright. We have no trouble seeing it even during the day.

The planets Venus and Jupiter are very bright objects. They are also sometimes visible during the day. People who see Venus or Jupiter as a tiny light in the daytime sky sometimes report it as a UFO (unidentified flying object).



The stars and planets are only visible at night. Fig 2.3.3

Fig 2.3.4 The Moon is visible in daytime as well as at night.

Homework book 2.5 Revolutions, axial tilt and day length

Day and night on the Moon

Some people think the far side of the Moon is always dark. This is not true for the Moon, any more than it is for the Earth. Like the Earth, the Moon rotates on an axis and, like the Earth, every place on the Moon experiences day and night. Unlike the Earth, however, a single day and night on the Moon lasts almost one

Earth month (27.3 Earth days). If you woke up with the sunrise on Earth, you could expect the next sunrise in 24 hours. If you woke up with the sunrise on the Moon, the next sunrise would be more than 650 hours away.

The Moon has no air. This, along with the long day and night, leads to extremes of temperature we do not see on Earth. Every day, the temperature of those parts of the surface exposed to the Sun climbs to around 115°C, and every night the temperature drops to around –165°C.

The night sky on the Moon would look much like our night sky, with a few differences. There are no clouds on the Moon, and no air to make the stars appear to twinkle. And, for a large part of the lunar night, the Earth would be visible as a much larger blue-and-white moon.

The daytime sky on the Moon is completely different from ours. With no atmosphere, the lunar sky is black even at midday. The stars and planets are clearly visible despite the bright Sun.

Science Snippet

Where does the Moon come from?

Over the centuries, astronomers have tried to work out how the Moon was created. The best current theory is that the Moon was once a part of the Earth. The early Solar System was a violent place, where asteroids and planets collided often and with great force. One such collision early in Earth's history was so powerful that it caused a huge piece of the Earth's surface to peel off into space. The Moon formed from the debris of that collision. This idea is supported by many aspects of the Moon's composition and behaviour.

Fig 2.3.5 On the Moon the daytime sky is black. Note the Earth above the flagpole.

Phases of the Moon

The Moon travels once around the Earth every 27.3 days. The Moon's day is also 27.3 Earth days long. It thus turns on its axis just fast enough to always show one side to the Earth. No one knew what the far side of the Moon looked like until satellites went around it and sent back photographs.

We only ever see the part of the Moon that is lit up by the Sun. From our viewpoint, the Moon goes through a series of changes, or **phases**, every month.

Fig 2.3.6 Phases of the Moon

At the new Moon stage, the Moon is between the Sun and the Earth. It is midday on the far side, but our side is dark. The new Moon is not visible to us. A few days later, we see a crescent Moon. This grows into a half-Moon, then into a full Moon. At the full Moon, when it is midday on our side of the Moon, it is midnight on the far side. The Earth is then between the Sun and the Moon. This means that the full Moon rises at about the same time that the Sun sets.

As the cycle continues, the full Moon shrinks back to a half-Moon, then to a crescent and finally to a new Moon again. This lunar cycle takes 29.5 days.

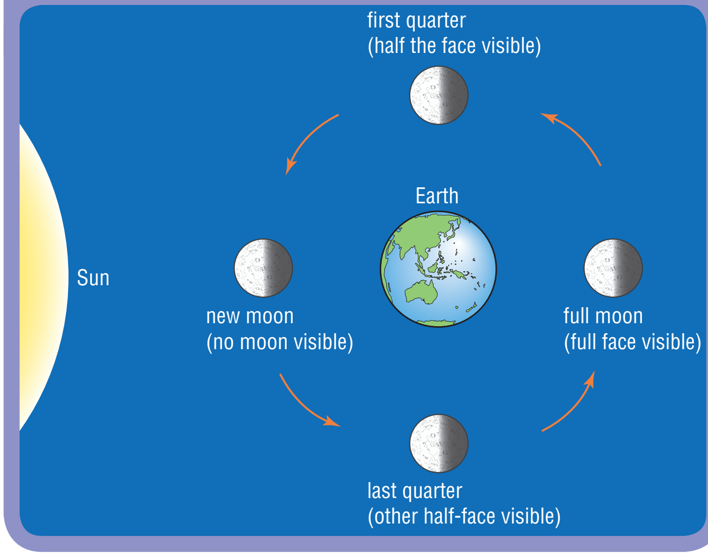
Science Snippet

Coral spawning

There are millions of corals along the Great Barrier Reef. Every year, all of them reproduce on the same night, in response to the phase of the Moon. This behaviour makes it harder for predators to eat all the eggs and so maximises the chance of the offspring surviving. There are other animal behaviours that appear to be controlled by the Moon, but few are as spectacular.

Prac 2 p. 59

Fig 2.3.7 How the phases of the Moon occur



2·3 FOCUS [Questions]

Interactive Crossword

Use your book

Day and night on Earth

1 Does the Sun really rise at sunrise? Explain your answer.

2 What do we call the time when the Earth's rotation has turned our part of the Earth to face away from the Sun?

Where do the stars go in the daytime?

3 We can see the Moon and stars at night. Why is the Moon visible in daytime although the stars are not?

4 During daytime, the only astronomical objects we can see in the sky are all in our Solar System. What are the names of these objects?

Day and night on the Moon

5 The rock group Pink Floyd once produced an album titled 'The Dark Side of the Moon'. Does the Moon have a dark side? Explain.

6 Why is one day on the Moon so much longer than one day on Earth?

7 The Moon has no atmosphere.

a What effect does this have on the appearance of the daytime sky on the Moon?

b What effect does this have on the daily temperature range on the Moon?

8 Imagine that you could stand on the surface of the Moon and look up into the sky.

a Would the stars twinkle? Explain.

b Would clouds ever ruin your view of the stars? Explain.

Phases of the Moon

9 **a** What do we mean by 'phases of the Moon'?

b Draw a labelled diagram of the relative positions of the Earth, Moon and Sun when the Moon appears as a crescent.

10 Draw a labelled diagram of the relative positions of the Earth, Moon and Sun at the new Moon phase.

Use your head

11 There is an old joke which goes something like this: An engineer from X (you can make X anywhere you like) tells you that they are going to be the first to send an astronaut to the Sun. You ask: 'Won't you burn up?' The man from X says, 'Hah, we've thought of that. We're sending them at night!' Does the Sun have night and day? Explain.

12 Why are so many UFO reports explained as 'a sighting of Venus'?

13 **a** If one day you could see stars in the sky, would you see the same stars that night? Explain.

b Would this depend on where you are on Earth?

14 Imagine that you could stand on the surface of the Moon and look up into the sky.

a Would the Earth be visible when it is the time of the new Moon? Explain.

b What would be the brightest object in the sky? Explain.

15 One day was about 6 hours long when the Moon was formed. If the day has been getting longer by 23 seconds every million years, about how long ago did the Moon form? Explain how you worked out your answer.

Investigating questions

16 **a** Do the other planets in the solar system have night and day?

b Which planet has the shortest day?

c Which planet has the longest day?

d Which planet has a day that lasts longer than its year?

e On which planet does the Sun rise in the west and set in the east?

17 One day is 24 hours, right? Not quite. There are at least two ways to define one day: a solar day, and a sidereal day. What is the difference? Why is one longer than the other?

18 A leap year is a year that has an extra day (29 February). Why do we have leap years?

19 How fast are you moving from west to east right now? You will need to find out some facts like the circumference of the Earth where you live, and the formula for speed.

2·3 FOCUS [Practical activities]

Prac 1 Focus 2.3

Modelling day and night

Purpose

To explain day and night using a model of the Earth.

Requirements

Cooking skewer, soft plastic ball, permanent marker, projector.

Procedure

1. Carefully push the cooking skewer through the ball to make an axis.
2. Use the marker to draw a sketch of Australia in the Southern Hemisphere (that is, on the bottom half of the ball). Mark your location on the map and show the direction of north, south, west and east.
3. Switch on the projector. This represents the Sun. One group member holds the ball in the projector beam, with the axis vertical. The others should observe from the side.
4. Hold the ball so that it is sunrise at your location marker. Turn (rotate) the ball towards the east. *Write down what you observe.*
5. Keep the equipment to use again when you model the seasons (see Focus 2.4).

Questions

1. What does one complete rotation of the ball represent? How long does the Earth take for one complete rotation?
2. Why does the Sun rise in the east and set in the west?
3. When it is midday in Perth, is it earlier or later in Sydney? What other parts of the Earth have midday at the same time as Perth?
4. If the ball represented the Moon instead of the Earth, what time period would one complete rotation represent?
5. If you were on a plane travelling from Sydney to Perth, how would the time on your watch be different when you reached Perth? What about if you flew the other way?
6. What would happen to the time on your watch from Sydney to Perth if the plane flew faster than the Earth rotated?

Prac 2 Focus 2.3

DYO

Phases of the Moon

Purpose

To explain the phases of the Moon using a model of the Moon.

Requirements

Light-coloured inflated balloon, string, projector, cardboard or paper for poster.

Procedure

1. Inflate the balloon and hang it in front of the projector with the string, so the projector beam lights up one side of the balloon. Darken the room as much as possible.
2. One after another, walk around the balloon in a circle. Be careful not to stand in the projector beam and so interrupt the light. Observe and discuss: What represents the Moon? What represents the Sun? What represents the Earth? Where do you have to stand to see the balloon's different phases?
3. In your group, decide who will do each of the following jobs.
   a. *Make a labelled diagram* showing the positions of the Moon, the Earth and the Sun at the phase called 'new Moon'.
   b. *Make a labelled diagram* showing the positions of the Moon, the Earth and the Sun at the phase called 'full Moon'.
   c. *Make a labelled diagram* showing the positions of the Moon, the Earth and the Sun at the phase called 'first quarter'.
   d. *Make a labelled diagram* showing the positions of the Moon, the Earth and the Sun at the phase called 'third quarter'.
4. In your group, combine all your diagrams to make one poster and show the other groups what you found out.
5. Look at other groups' posters. In your group, discuss any differences between your diagrams and those from other groups. Your teacher may also give you a diagram of the Moon revolving around the Earth to show how all the phases can occur.

Questions

1. How could you use this model to show a solar or a lunar eclipse? Design a demonstration that you could use to show other class members how an eclipse occurs.
2. Does everyone in Australia see the same phase of the Moon at the same time?

FOCUS 2.4

Weather, climate and the seasons

Context

Probably the most common topic of conversation is the weather. No matter where you are on Earth, though, the weather is mild compared with anywhere else in the Solar System. High and low temperatures, dust storms, cyclones—whatever weather feature you can think of, some other planet has a more spectacular version than any we have here on Earth. Beyond weather, though, we have climate, which is linked to the seasons. You cannot understand climate unless you know how the seasons occur.

Earth weather

Weather is the day-to-day variation in temperature, cloud cover, wind direction, wind speed, humidity and precipitation. No matter where you are on Earth, the weather tomorrow will be different from the weather today.

Weather varies during any one 24-hour period. In general, the temperature drops when the Sun goes down, and goes up again after sunrise. Clouds can affect the weather by reducing the highest temperature and raising the lowest temperature.

Weather also varies between one day and the next. You can see the changes coming if you look at a television weather report. These reports show maps that display the changing patterns of high and low air pressure that move across the Earth's surface and bring changing winds, clouds and temperatures. You will learn more about this in Focus 2.7.

The energy that drives our weather comes from the Sun. Sunlight warms the Earth's surface and the atmosphere. Warm gas tends to rise, while cooler gas sweeps in to take its place. This forms a convection current. You will learn more about this in Focus 3.4. Convection is the main reason we have weather. If you take a few minutes to watch low-altitude, fluffy clouds you will see how the convection currents in the clouds affect their shape, size and height.

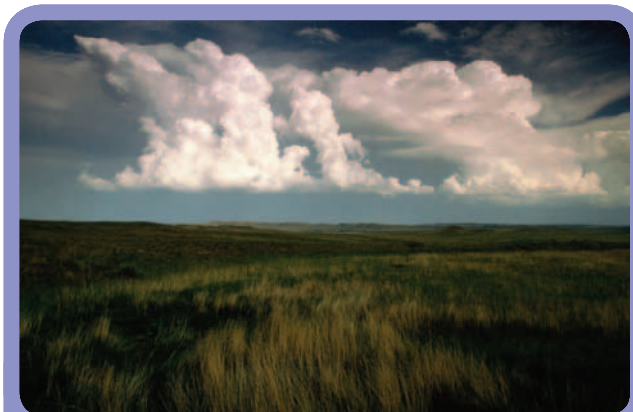


Fig 2.4.1 Cumulonimbus clouds like this one are commonly associated with sudden storms bringing heavy rain or hail. They contain very powerful vertical winds that can keep large hailstones in the air.

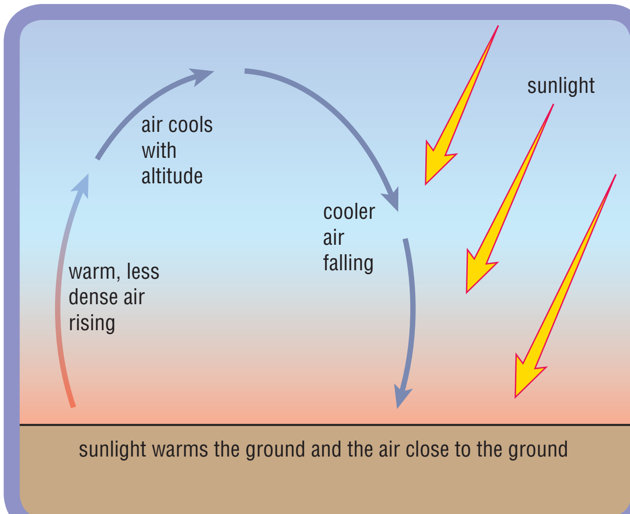


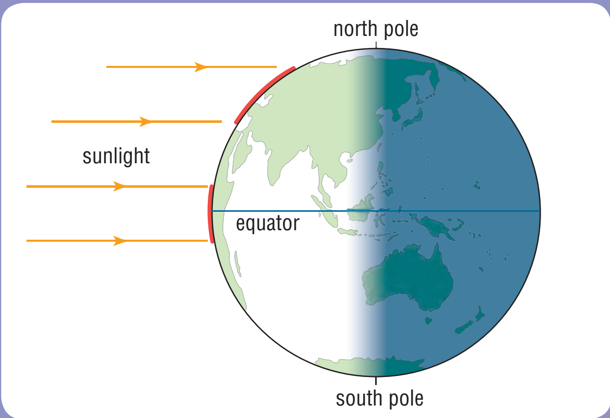
Fig 2.4.2 The Sun provides the energy that creates our weather. This diagram is not drawn to scale.

Location and climate

In general, the further your location from the equator, the cooler your climate. This happens because the curve of the Earth's surface means that sunlight lands less directly as you go north or south from the equator. The energy from sunlight is spread over a larger

Sunlight arrives at a steeper angle near the equator.

Fig 2.4.3



area and has less heating effect. At the north and south poles, the sunlight arrives almost parallel to the ground and has very little warming effect.

Prac 1 p. 64

Earth seasons

Over one year, the weather goes through a cycle of seasons. A **season** is a period of time when the weather stays roughly the same. The idea of four seasons is not universal. Some societies recognise as few as two seasons in a year, some as many as six. What we call **climate** is the pattern of the seasons over a year.

The Earth rotates about an axis that runs from one pole to the other. This axis is tilted compared with the plane of Earth's orbit around the Sun. The angle of tilt is about 23 $^1/_2$°, enough to make sure that sunlight falls more directly on the Southern Hemisphere for half the year, and on the Northern Hemisphere for the other half.

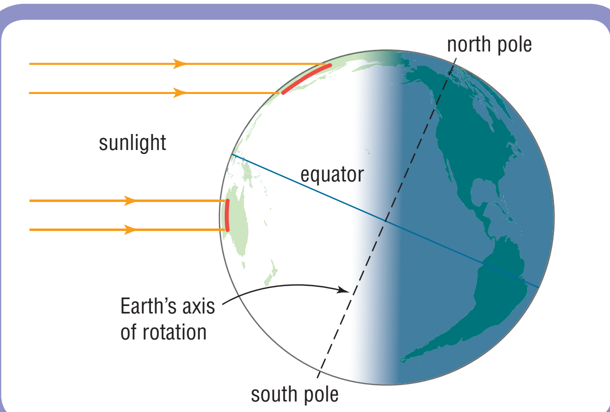
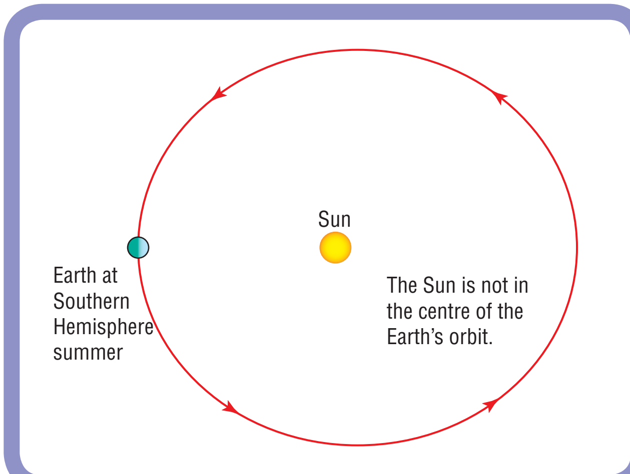


Fig 2.4.4 Summer for us means winter for the Northern Hemisphere.

When the axial tilt points the Southern Hemisphere at the Sun, the more direct sunlight gives us summer. At the same time, the Northern Hemisphere has less direct sunlight and thus has winter. Six months later the situation is reversed, with northern summer and southern winter. This different heating effect is due to the reasons you discovered in Prac 1.

Prac 2 p. 64

The Earth's orbit is **elliptical** rather than circular. During the southern summer the Earth is 147 million kilometres from the Sun and during the northern summer it is 152 million kilometres away. These differences in distance from the Sun are too small to have any real effect on the seasons.



The Earth is closest to the Sun during the southern summer, but this does not affect the climate. *Fig 2.4.5*

There is lots of evidence that the Earth's climate has varied greatly over time, from 'ice ages' in which average temperatures were significantly lower than they are now, to warmer periods when temperatures were on average higher than now. We seem to be in a warm but not especially hot period right now.

Weather and climate on the Moon

The Moon is about the same distance from the Sun as the Earth is. The Moon orbits the Earth as the Earth orbits the Sun. Conditions on the Moon are very different from those on Earth, because the Moon has no atmosphere. This means there can be no convection and so no wind, rain or cloud cover. Every day on the Moon is much like the one before.

Moon temperatures are much higher where the surface receives direct sunlight. *Fig 2.4.6*

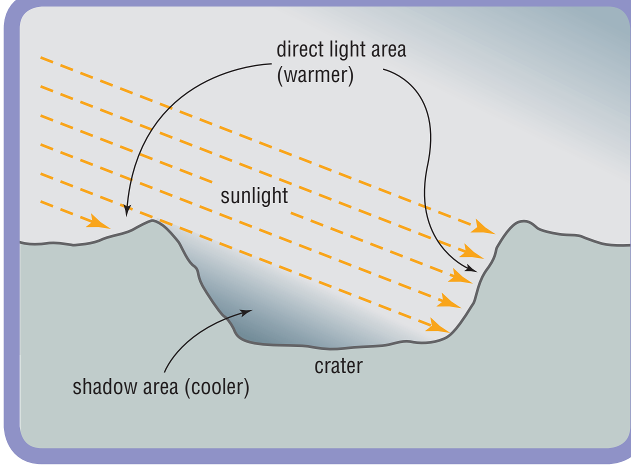


Fig 2.4.7 The Sun looks three times larger (and hotter) from the surface of Mercury.

The Sun looks like a bright star from Pluto. *Fig 2.4.8*

Basically, the temperature on the Moon is high where the surface is lit up by the Sun, and low where there is no sunlight. Even in daytime, the bottoms of some deep craters are in permanent shadow and are cold all the time.

Weather and climate on other planets

Mercury and Pluto have almost no atmosphere. Mercury is so close to the Sun that its midday surface temperature at the equator is 400°C. At midnight this drops to –180°C. Pluto is so far from the Sun that it only has an atmosphere when its very elliptical orbit carries it closer than usual to the Sun. Pluto's average temperature is –225°C, so cold that its atmosphere is frozen most of the time.

The other planets all have atmospheres, with varying effects. The atmosphere on Venus is so thick and so full of carbon dioxide that there is a 'runaway greenhouse effect'. Venus is even hotter than Mercury and it does not cool down much at night. Mars has a thin, cold atmosphere that creates real climate, including dust storms and polar ice caps, which change size in summer and winter.

We only ever see the tops of the clouds of the giant planets, Jupiter, Saturn, Uranus and Neptune. No one even knows if any of these planets has a surface. The cloud tops make swirling, changing patterns that suggest weather and climate are real effects, even in the outer Solar System.

Science Snippet

Observing Mars

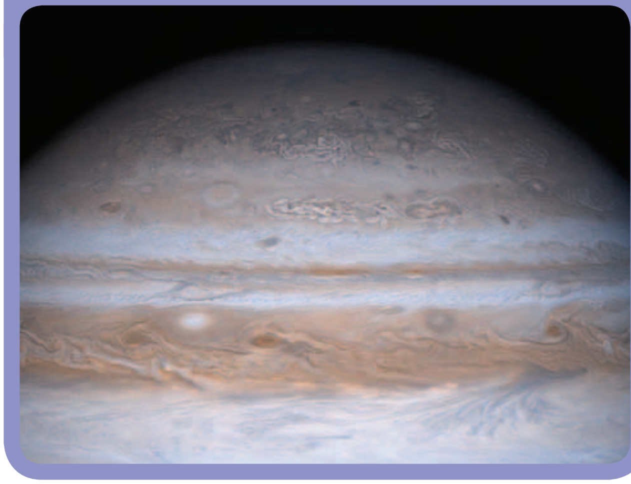
Astronomers looked keenly at Mars for hundreds of years. In many minds, Mars was the planet most like the Earth, and thus the most likely planet to support life. Over the centuries, astronomers mapped the surface of Mars and noted changes in its appearance. For many years, they thought or hoped that these changes were the result of seasonal changes in plant growth. When space probes reached Mars, they found a barren, probably lifeless world. It has seasons, but no plants or animals. The changes were caused by frost evaporating in summer and forming in winter.

Science Snippet

Jupiter's Great Red Spot

Compared with our Earth, Jupiter is a giant planet. It is so big that more than 1200 Earth-sized planets could fit into it. Jupiter has weather to match its size. You can see its Great Red Spot with a small telescope. This feature seems to be a huge cyclone that has swirled in Jupiter's atmosphere for hundreds of Earth years. The spot is wider than the Earth, and was seen first in 1664. Jupiter has no land under its clouds, so there is nothing to break up the storm, which may last for hundreds of years to come.

Fig 2.4.9 We see only the tops of the clouds in Jupiter's thick atmosphere.



Homework book 2.6 Earth and space revision

2·4 FOCUS [Questions]

Use your book

Earth weather

1 What is the energy source that causes weather on Earth?

2 Why does temperature tend to drop when the Sun goes down and rise when the Sun rises?

Location and climate

3 Why is the average temperature at the equator generally higher than at the south pole?

Earth seasons

4 What is the difference between weather and climate?

5 What is a season?

6 What causes the seasons?

7 Why does the Earth's varying distance from the Sun have so little effect on climate?

Weather and climate on the Moon

8 On average, the surface temperature on the Moon is only a little different from the average temperature on Earth. Why does this give a misleading idea of the temperature on the Moon?

9 If you wanted to write a story about what it would be like to visit the Moon, could you write about:

a being protected from temperature extremes? Explain.

b being caught in a lunar dust storm? Explain.

Weather and climate on other planets

10 Venus is further from the Sun than Mercury is, yet the temperature on Venus is higher than on Mercury. Why is this?

11 Pluto's orbit sometimes takes it closer to the Sun than Neptune, and sometimes carries Pluto further out. Would Pluto have an atmosphere, or would it be frozen when Pluto is inside Neptune's orbit? Explain.

12 Figure 2.4.10 is a view of the gas giant planet Saturn. What are the wavy features all over the planet?

Fig 2.4.10 The gas giant Saturn

Use your head

13 If the Moon had an atmosphere like the Earth's, would the weather and climate on the Moon be different from the way they are now? Explain.

14 One thing that every living thing on Earth needs is liquid water. In view of this, it seems unlikely that any other planet in our Solar System supports life as we know it. Why is this?

15 During the Earth's periodic 'ice ages', the average surface temperature drops and the ice caps that now cover the poles expand. There are several possible explanations. If the ice ages are caused by changes in the Earth's orbit:

a What would have to happen to the Earth's orbit to start an ice age?

b What would have to happen to the Earth's orbit to stop an ice age?

c How would these changes affect conditions on the Moon?

Investigating questions

16 Select a planet or moon, and prepare a weather report for it in:

a summer. b winter.

17 a What is a greenhouse effect?

b Why is Venus said to have a 'runaway' greenhouse effect?

18 Apart from changes in the Earth's orbit, there are several alternative explanations for the start and finish of ice ages on Earth. Find out about one such alternative explanation, and prepare a poster, electronic presentation or web page about it.

FOCUS 2·4

[Practical activities]

Prac 1 Focus 2.4

Modelling solar heating

Purpose

To investigate why location on the Earth's surface has an effect on surface temperatures.

Requirements

Torch with a narrow beam, graph paper, two thermometers, two wooden blocks, three or four books, black plastic (eg from a rubbish bag), sticky tape, desk lamp.

Procedure

1. Hold the torch about 30 cm directly above a sheet of graph paper. Shine the beam onto the paper and mark the edges of the lit area.
2. Hold the torch about 30 cm from another sheet of graph paper, but tilt the torch so the beam makes an angle to the page. Mark the edges of the lit area.

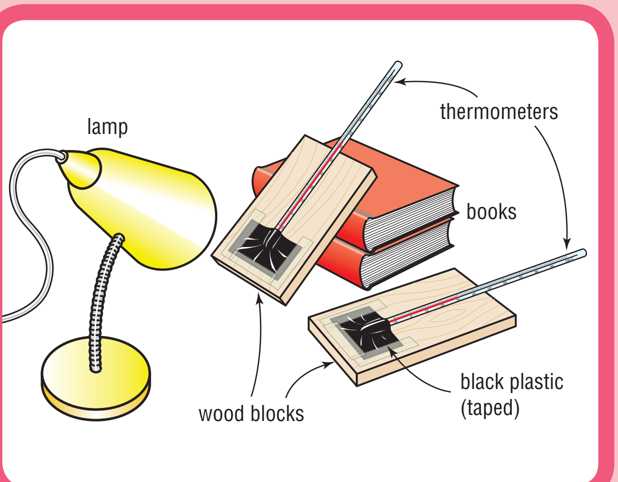


Fig 2.4.11 How to set up this equipment

3. Assemble the equipment as in Figure 2.4.11. Tape the black plastic over the bulb of the thermometers so that it is touching the bulb. Predict which thermometer will show the higher temperature after being under the desk lamp for 5 minutes and *write down your prediction*.
4. Measure the temperatures before turning on the lamp and *write down your results in a table*.
5. Carry out this investigation, measure the temperatures after 5 minutes and *write down your results*.
6. Using a board to display your tables, compare your measurements with those of other groups. Is there a general pattern? *Write down a short summary of the class results.*

Questions

1. What did you learn from steps 1 and 2? Discuss or brainstorm this as a group or as a class. Write down a summary of the ideas discussed.
2. In your group, discuss why you were instructed to hold the torch 30 cm from the graph paper each time. Write down your answer.
3. Write down what you learnt from steps 4, 5 and 6.
4. In your group, discuss why you were instructed to take the temperature values before turning on the lamp. Write down your answer.
5. Why is there no instruction about how far the lamp should be from the thermometers? Write down your answer.

Prac 2 Focus 2.4

DYO

Explaining Earth's seasons

Purpose

To model the conditions that create seasons on Earth.

Requirements

Cooking skewer, soft plastic ball (for example the ball used in Prac 1 of Focus 2.3), permanent marker, projector.

Procedure

1. If you have not done Prac 1 of Focus 2.3, do steps 2 and 3. If you have already done Prac 1, start at step 4.
2. Carefully push the cooking skewer through the ball to make an axis.
3. Use the marker to draw a sketch of Australia in the Southern Hemisphere (that is, on the bottom half of the ball). Mark your location on the map and show the direction of north, south, west and east.

>>

4 Use the marker to mark the location of a person in the Northern Hemisphere who is at the same longitude as you are (that is, their location is directly above your first mark on the ball).

5 Turn on the projector and hold the ball in its beam so that both marks (you and the Northern Hemisphere person) are on the line that separates light from dark. This represents sunrise for both of you. The skewer should be vertical.

6 Will the day be the same length for both of you? Check your answer by turning the ball. *Write down your answer.*

7 Tilt the ball by about 23° by moving the top of the ball away from the projector. Where will the sun rise first, in Australia or in the Northern Hemisphere? *Write down your answer.*

8 Keep the axial tilt the same and rotate the ball until 'sunset' has come for both people. Where does the Sun set first, in Australia or in the Northern Hemisphere? *Write down your answer.*

9 Where on the Earth does the Sun not rise at all? *Write down your answer.*

10 Where on the Earth does the Sun not set at all? *Write down your answer.*

Questions

1 This prac represents summer in the Southern Hemisphere. How could you change the investigation to find out about winter in the Southern Hemisphere? Do it if your teacher agrees.

2 Is the day longer in summer or in winter? Explain.

3 How would the seasons be different if the Earth's axis was not tilted?

FOCUS 2.5

Earth materials: minerals and rocks

Context

The four main types of natural materials on Earth are rocks, soil, air and water. We need to use these resources wisely so that they are **sustainable**—that is, so that we will not use them up or destroy them. Then we will always have them available for use. This focus is about the rocks of the Earth and how we use them.

Minerals

Rocks are made up of chemical substances called **minerals**. Most minerals are chemical compounds, such as iron oxide, copper sulfide or aluminium oxide. Some minerals are elements, such as gold or silver. The rocks containing these minerals are called **ores**. For example, iron oxide is found in iron ore.

An ore is the source of a mineral. Sometimes we use the whole mineral. For example, opal is made from silicon and oxygen combined. We want the piece of the ore which is only opal, and this is a compound. Sometimes we want to extract one element from the ore. For example, we are after the iron from iron ore to make steel. We have to remove the iron from the rock by separating the iron from the oxygen.

Some common minerals, their ores and their uses are shown in the following table.

Mineral	Ore type	Use of mineral
Hematite, limonite, magnetite	Iron oxide	Source of iron
Bauxite	Aluminium oxide	Source of aluminium
Galena	Lead sulfide	Source of lead
Chalcopyrite Azurite	Copper sulfide Copper carbonate	Source of copper
Opal	Silicon oxide	Gemstones
Rutile	Titanium oxide	Source of titanium
Cassiterite	Tin oxide	Source of tin
Chromite	Iron oxide and chromium oxide	Source of chromium
Pentlandite	Nickel sulfide	Source of nickel

Fig 2.5.1 Some minerals—from left, chalcopyrite, bauxite and hematite. What would we call the ores?

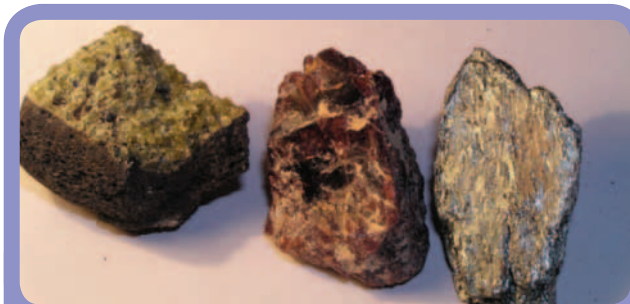


Fig 2.5.2 More minerals—from left, olivine, garnet and chlorite

Properties of minerals

Minerals can be identified by their physical properties, such as hardness, lustre, colour and streak colour.

Hardness is assessed using a scale called the Mohs scale, whereby a set of minerals is used to try to scratch the surface of an unknown mineral. This is shown in the table opposite.

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

For example, if a piece of feldspar will scratch a rock but apatite will not, then the hardness of the rock is between 5 and 6.

Another way of testing for hardness is shown in the table opposite.

Test equipment	Will scratch materials of hardness less than
Fingernail	2.5
Copper washer	4
Cast iron	4.5
Window glass	5.5
Steel knife or nail	6

The **lustre** of a mineral is how shiny it is. For example, coal does not have much lustre whereas opal does. The colour of the mineral is also useful in identifying it. The streak is the colour left behind on an unglazed white tile. This is often different from the colour that the mineral appears to be in the rock.

Rock types

Rocks are composed of minerals mixed together to form lumps. Most rocks have several minerals in them. Rocks are grouped according to the way in which they are formed.

Igneous rocks

Igneous rocks are formed when hot liquid rock from below the crust cools and becomes solid. The hot liquid rock from below the crust is called **magma**. Magma can sometimes reach the surface of the Earth in a volcano. Then it is called lava.

Extrusive igneous rocks

Igneous rocks that form at the Earth's surface are called **extrusive igneous rocks**. Examples of extrusive igneous rocks are **basalt** and **pumice**. There are often spaces in these rocks that contain gas bubbles, trapped when the magma cooled very quickly.

Extrusive igneous rocks contain very small crystals. The minerals solidify in them very fast and so don't have time to grow into large crystals. The crystals interlock, meaning they have grown into each other.

Basalt is a very hard, dark-grey igneous rock, formed when lava cools. Pumice is a light-grey igneous rock. It is very light.

Science Snippet

Floating rocks

Volcanoes that erupt under the ocean deposit lava in the water. The lava cools so fast that a large amount of gas is trapped in the rock that forms. This makes the rock very light and it floats. Pumice is formed this way and so is often found on beaches.

Science Snippet

The world's biggest rock

What is the biggest rock in the world? Some people say Uluru, commonly known as Ayers Rock. But there is one bigger—Mount Augustus in Western Australia, which is more than twice the size of Uluru.

Science Snippet

The sparking rock

On some gas barbecues you light the gas by pushing a button connected to a piece of quartz. When quartz is squeezed it gives out a burst of electricity. This then forms a spark when it jumps between two metal contacts in the igniter. The spark lights the gas flame.

Mount Saint Helens volcano, in the USA, erupting *Fig 2.5.3*

Fig 2.5.4 Pumice is an igneous rock that can float.

Three igneous rocks—from left, gabbro, granite and basalt *Fig 2.5.5*

Intrusive igneous rocks

Sometimes the magma from below the crust becomes trapped below the surface, where it cools very slowly to form rocks. These rocks are called **intrusive igneous rocks**. If they eventually become uncovered, we can see rocks that have very large crystals in them. The crystals also interlock. Two intrusive igneous rocks are **granite** and **dolerite**. It is easy to see the crystals in the photo of granite in Figure 2.5.6.

Prac 1
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A granite drill core showing the crystals of several different minerals that make up granite. *Fig 2.5.6*

Fig 2.5.7 The three main minerals in granite—from left, quartz, feldspar and biotite

Uses of igneous rocks

Most igneous rocks are quite hard and strong, so they are very good for constructing buildings or any stone structure that we want to last. Some common uses for igneous rocks are shown in the table below.

Sedimentary rocks

Most **sedimentary rocks** are formed when small pieces of solid material sink to the bottom of a body of water, such as a river, lake or ocean. Some sedimentary rock can form on land when wind-blown deposits build up.

The solid material can be small rock particles, dead animals or plants. These materials become pressed together by the weight of the material on top, and also cemented together by chemicals such as calcium carbonate. Layer upon layer builds up, each one turning to rock. In this type of rock we find the remains of dead animals and plants preserved as fossils.

Many sedimentary rocks are named after the main material in them. For example, mudstone is mainly mud and sandstone is often largely sand.

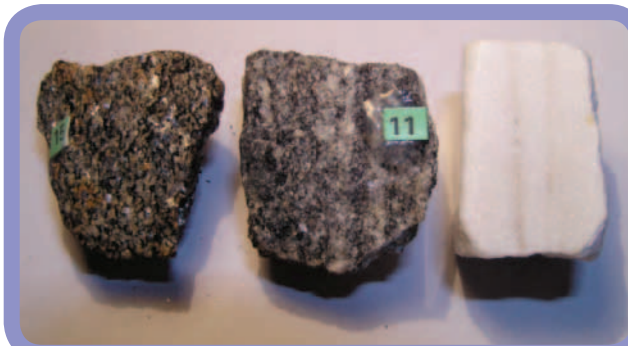
The main feature of many sedimentary rocks is a layered appearance. The particles also often seem to be pieces of rock cemented together, rather than crystals of only a few minerals. The particles do not seem to interlock. They do not look like they have grown into each other. There are also often fossils in the rock. Some types of sedimentary rocks and their uses are shown in the table on the next page.

Breccia, a sedimentary rock. *Fig 2.5.8*

Name of igneous rock	Use
Basalt	Aggregate in concrete, floor tiles, fibreglass, buildings
Granite	Buildings, monuments, road surfaces, kitchen benchtops
Scoria	Decorative road base, crushed rock filters, concrete aggregate, pot plant soil, barbecue rocks
Pumice	Cleaning dead skin off feet, emery boards for nail shaping, abrasive soaps
Obsidian	Natural glass. Ancient people used it for cutting, spear and arrow points, and pots and vases. Still used in ornaments.

Type of sedimentary rock	Description and composition	Use
Breccia/conglomerate	Often angular pieces and/or rounded pebbles of several different rocks cemented together, but not interlocking Multicoloured	Feature stonework on building surfaces
Sandstone	Sand grains cemented together, not interlocking	Buildings, feature stonework
Limestone	Shells and skeletons of marine animals	Buildings, walls, sculpture, road base
Coal	Dead plant material compressed into a rock	Fuel source

Fig 2.5.9 Two sedimentary rocks—from left, sandstone and limestone



Three metamorphic rocks—from left, schist, gneiss and marble *Fig 2.5.10*

Metamorphic rocks

Metamorphic rocks are formed when great heat and pressure are applied to igneous and sedimentary rocks, altering the structure and appearance of the original rocks. This change usually happens when magma forces its way into igneous or sedimentary rocks.

Homework book 2.7 Rock types

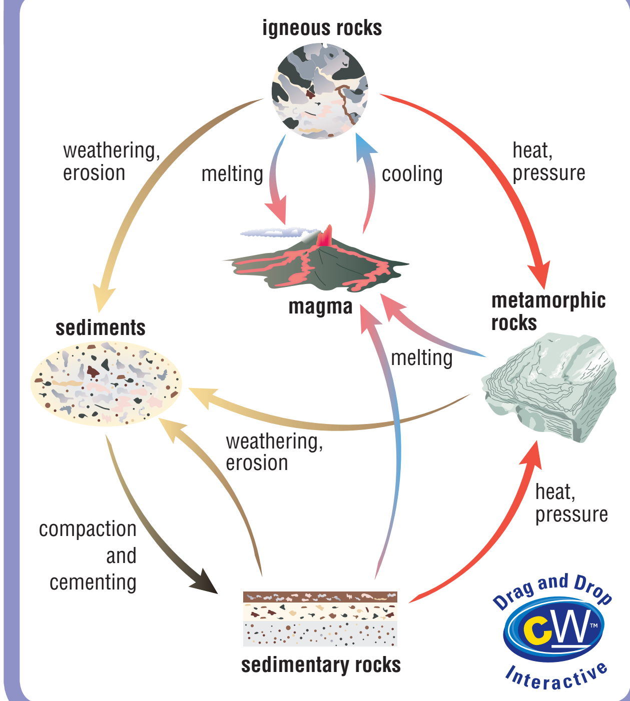
The rock cycle

Once rocks are formed they do not always stay the same. Rocks are continually being broken down into smaller pieces in a process called **weathering**. Weathering occurs through chemical attack and through a physical force such as ice or heat. The pieces are then carried away by water, wind or ice in a process called **erosion**. The pieces can be deposited as sediments and re-form into sedimentary rocks.

Type of metamorphic rock	Description and composition	Uses
Marble	Very fine grains sometimes too small to see without a microscope Can be very highly polished and carved Often white, but can be grey, green, red or cream	Statues, wall and floor tiles, benchtops
Quartzite	Very small sand grains, often in sheets or layers White or creamy	Building face stonework, walls, glass making, ceramics
Slate	Fine grains in sheets that can be split Easy to saw into pieces Dark grey mainly	Floor tiles, roof tiles
Schist	Very fine grains in shiny plates Easy to break along the plate lines Green, black or white	Source of garnets (semi-precious gemstones)
Gneiss	Bands of different colours through rock of interlocking crystals Will not split along the layers	Ornamental stonework, buildings

Any rock can also be melted by magma and turned into a metamorphic rock. All these changes are part of a process called the **rock cycle**. All the rocks of the Earth are part of this cycle.

Fig 2.5.11 Simplified rock cycle



FOCUS 2.5 [Questions]

Use your book

Minerals

1 What do we mean by a mineral? Give five examples.

2 Use an example to explain what we mean by an ore.

3 What is Mohs scale of hardness and why is it important for geologists?

4 Pyrite is a yellowish colour like gold but it has a brownish-black streak. What do we mean by 'streak' and why is it useful?

Igneous rocks

5 What is the difference between magma and lava?

6 What is the difference in the way extrusive and intrusive igneous rocks are formed?

7 Describe some visible differences between extrusive and intrusive igneous rocks.

Sedimentary rocks

8 Describe how sedimentary rocks form.

9 How would you determine if a rock is sedimentary?

Metamorphic rocks

10 Describe how metamorphic rocks form.

11 How would you determine if a rock is metamorphic?

The rock cycle

12 Describe what the rock cycle diagram shows.

13 What is the difference between weathering and erosion?

Use your head

14 If fluorite will not scratch a mineral but feldspar will, how hard is the mineral?

15 If your fingernail will not scratch a mineral but your penknife will, how hard could the mineral be?

16 Determine whether the following rocks are igneous, sedimentary or metamorphic.

- **a** Has black, pink and white crystals in it. They seem to be all growing into each other.
- **b** Looks like granite but seems to have black and white lines of crystals running through it.
- **c** Has lots of lumps in it which have sharp edges, but there are also round lumps in it. They look like pieces of different rocks. The lumps all seem to be separate but are all stuck in the rock.
- **d** Is creamy-white, very soft and has lots of little shapes in it. Some look like seashells.
- **e** Is light grey and seems to have lots of holes in it. It is very light and floats on water.
- **f** Is green and very shiny from some angles. It is flaky and splits into little sheets when pushed with a screwdriver.

17 If you had to pick a type of rock to build a strong building that would last for centuries, which type of rock would you choose and why?

Investigating questions

18 What are the five most important minerals to the economy of Western Australia and where are they mainly found?

19 What is concrete, what types of aggregate are used and why?

20 Make some different types of concrete by changing the aggregate type. Design a test for the strength of your concrete.

DYO

2.5 Practical activity

Prac 1
Focus 2.5

Cool crystals

Purpose

To investigate how cooling rate affects the size of crystals

Requirements

Safety glasses, water, four 250 mL beakers, Bunsen burner, tripod, wire mat, matches, ice, cotton wool, rubber gloves, 25 g potassium aluminium sulfate ($KAl(SO_4)_2.12H_2O$) (potash alum, potassium alum dodecahydrate), three 50-mL test tubes, oven mitt or towel, test tube rack.

Procedure

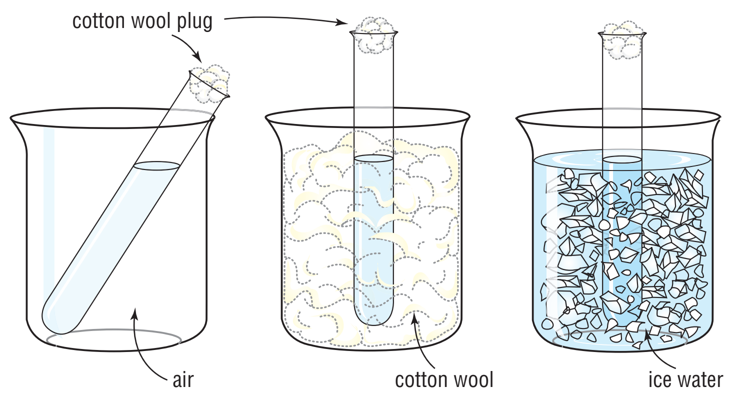
1. Put 100 mL of water into a 250 mL beaker and heat until boiling. One group member must watch this until it is required in step 4.
2. Another person in your group should make an ice bath by half-filling one of the beakers with ice and then pour in about 100 mL of tap water. Make sure the test tube does not float.
3. Insulate another beaker with enough cotton wool to allow a test tube to sit upright in the middle.
4. Wearing rubber gloves, dissolve as much potash alum in the hot water as possible.

   PERSONAL SAFETY: Wash the skin with soap and water immediately if potash alum solution comes in contact with your skin. Call your teacher immediately if it comes in contact your face or eyes. Remember: boiling water will burn you.

5. Place the three test tubes in a test tube rack. Hold the beaker of hot solution with an oven mitt or towel so that it will not burn you. Carefully pour about 25 mL of the super-saturated solution into each of the three test tubes. Place a plug of cotton wool in the mouth of each test tube.
6. Place one test tube in the cotton wool, one in the ice water and one in an empty beaker, as in Figure 2.5.8.
7. Leave the beakers in a safe place such as a cupboard until the next science lesson.
8. Observe the contents of the test tubes in the next lesson. You may have to gently pour off some liquid or filter the solution a bit. *Record your observations.*

Questions

1. Which test tube cooled the most quickly and which cooled the most slowly?
2. Which test tube had the biggest crystals and which had the smallest crystals?
3. How does this experiment help you to explain the difference in crystal size in extrusive and intrusive igneous rocks?
4. How does this experiment help you explain the difference in grain size in basalt and granite?



The experimental set-up *Fig 2.5.12*

FOCUS 2·6

The atmosphere

Context

The gases surrounding the Earth are different from the gases around all the other planets. They form a thin protective blanket called the atmosphere, and keep you alive. You breathe them in and rely on them to keep you warm, shielded from deadly rays and supplied with water. They are part of the weather and affect you every day of your life. Yet you can't even see them. We have to understand the atmosphere if we are to survive in the long term on planet Earth.

The gases in the atmosphere

The atmosphere, or air, is a mixture of gases. However, there are also particles of dust, plant spores, pollen, bacteria, droplets of water and many other substances floating around in the air. Sometimes these are a problem. For example asthmatics often have problems if there is too much pollen. Bacteria and viruses breathed in can make us sick. However, it is the gases which are the most important.

The main gases in air and their importance to us can be seen in the following table.

Gas name	Percentage in air	Importance to us
Nitrogen	78	Provides nutrients for plants to make proteins and other chemicals, which we and other animals can use as food
Oxygen	21	Essential for most living things Produced by photosynthesis in plants Helps release energy in human cells
Carbon dioxide	0.03	Essential for plants to make food by photosynthesis Produced as a waste by animals
Noble gases (mainly argon), water, ozone	0.97	Many uses depending on the gas Argon is used in light bulbs Ozone shields us from ultraviolet rays Water is needed for all cells for chemical reactions to occur

You can see from the table above that the amount of **oxygen** in the air is only about 21 per cent. Oxygen is constantly being used up by animals and plants, but is also constantly being replaced by plants, so the oxygen level stays about the same. All the oxygen on Earth is thought to have originally been produced by green plants. Plants produce oxygen as a by-product in the manufacture of their food. We breathe in oxygen in the air.

Even though there is a tiny amount of air (only about 0.035 per cent) that is **carbon dioxide**, most life could not exist without it. It is important to plants because they use carbon dioxide to make their food. Animals produce carbon dioxide as a waste product from the processes taking place in their bodies. We breathe out carbon dioxide. Carbon dioxide traps heat in the atmosphere. Without it Earth would be freezing, and most of the water would be frozen. Cells cannot exist if water is always frozen.

The layers of the atmosphere

The atmosphere is really a very thin layer around the Earth. About 99 per cent of all the gas is found in the first 80 kilometres. Though this sounds a long way, the first astronauts who ventured into space were amazed at how very thin and fragile it looked from space. Many said it made them think very deeply about the damage we are doing to it. You can see the atmosphere in Figure 2.6.1.

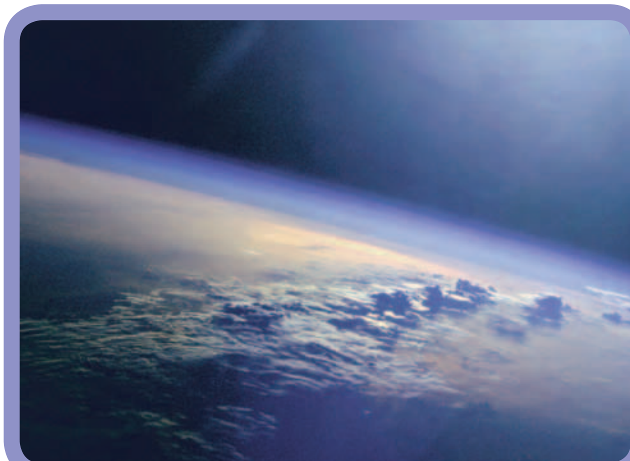


Fig 2.6.1 The atmosphere is the thin blue layer on the horizon. You can see some clouds extending across the photo.

The troposphere

The atmosphere can be divided into layers. The first layer from the ground, the **troposphere**, extends up to about 12 to 18 kilometres. There is no exact boundary for the troposphere as it depends on the seasons and the latitude. The troposphere officially ends where the temperature stops dropping with increased altitude. This is called the tropopause. This is on average at an altitude of 12 kilometres, where the temperature is around –60°C.

This is where all our weather is experienced. The rain, clouds, snow and wind occur here. The fact that snow occurs on the top of mountains shows us that the troposphere becomes colder with altitude.

Have you ever noticed your ears pop as you go up a hill? This shows you that the pressure is dropping as you rise up into the atmosphere, which means there is less gas as you go up. You will also find it more difficult to breathe. There is less oxygen as the altitude increases. The pressure drops away much faster at the beginning. The pressure is higher near the ground because the weight of air above squashes the gas particles together—so there are more particles in the same space. The wind speed also increases with increasing altitude.

Science Snippet

The highest mountain

The peak of Mt Everest is about halfway through the troposphere, at 8856 metres above sea level. At the peak there is only one-third as much oxygen as at sea level, and the temperature is –36°C. That is why climbers have to use oxygen masks and wear warm clothing to reach the top of Mount Everest.

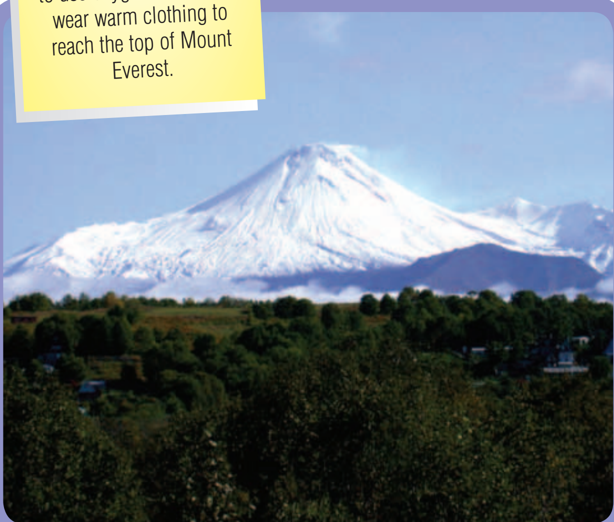


Fig 2.6.2 High mountains have snow and ice because the temperature drops with altitude.

The stratosphere

At the tropopause the temperature suddenly starts increasing again. Commercial airlines fly just above this height. The temperature rises back up to about 0°C at a height of about 50 kilometres. This region is called the **stratosphere**. You can see the changes in temperature in Figure 2.6.4.

The reason for the temperature rise with increased altitude is that a layer of a gas called ozone is found at this level. The ozone is formed when ultraviolet light from the sun breaks up oxygen molecules. Ozone absorbs heat and so the air becomes warmer. The ozone also reduces the amount of ultraviolet light reaching the ground and so protects people from skin cancers.

Large passenger aircraft cruise in the lower stratosphere. Fig 2.6.3

The mesosphere

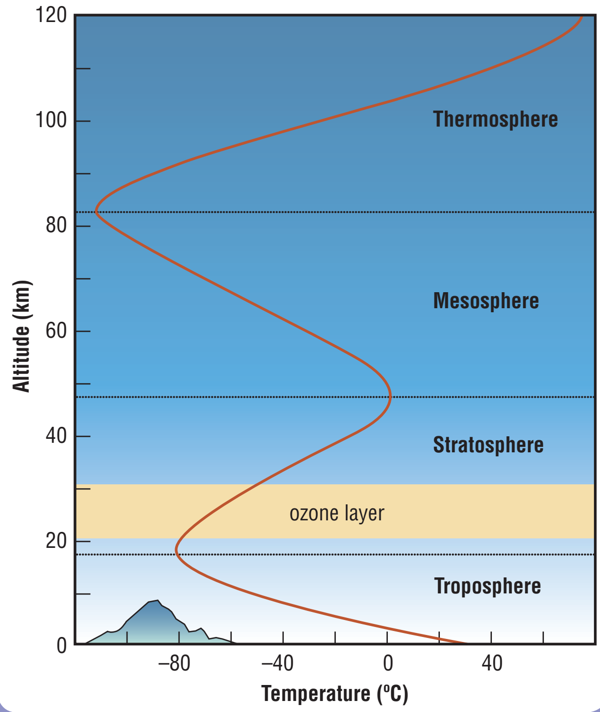
Above the stratosphere is the **mesosphere**. The temperature drops from 0°C down to about –90°C at a height of about 80 kilometres. There is little ozone here, or water vapour. The air is very thin with the pressure only one-thousandth of that at sea level.

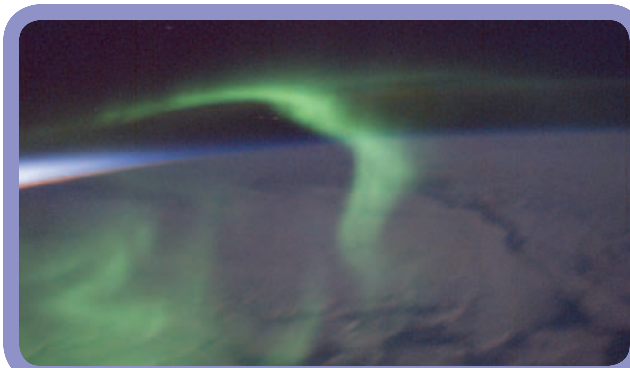
Science Snippet

Shooting stars

Particles of rock from space that enter our atmosphere burn up in the mesosphere. These rocks are called meteors. They travel at thousands of kilometres an hour. The friction with the gas particles in the air makes them so hot that they melt, trailing a shower of sparks. This is commonly called a shooting star.

Fig 2.6.4 The temperature changes with altitude in the atmosphere.





An aurora due to ions in the atmosphere Fig 2.6.5

The space shuttle orbiting in the thermosphere Fig 2.6.6

Fig 2.6.7 Space vehicles have protection against the great heat of re-entry to the atmosphere.

The thermosphere

At 80 kilometres and extending out to outer space is the **thermosphere**. The temperature rises to over 1000°C. In this layer the air particles are electrically charged due to radiation from the sun. The particles are called ions and the sublayer they form is called the **ionosphere**. The ionosphere is important for radio communication as it helps to reflect signals back to Earth. The ionosphere also results in beautiful natural light shows called Aurora.

Homework book 2.8 The atmosphere

FOCUS 2·6

[Questions]

Use your book

Drag and Drop CW Interactive

The atmosphere

1 Why is oxygen necessary for life?

2 Explain two different ways in which carbon dioxide makes life possible on Earth.

The layers of the atmosphere

3 In which layer of the atmosphere does our weather occur?

4 Why does the pressure drop with increased altitude?

5 a What is the ozone layer and where is it found?
  b Why is the ozone layer important to us?

6 What causes shooting stars?

7 What is the ionosphere and how is it useful to us?

>>

Use your head

8 Explain why there is a difference in the temperature changes with altitude in the troposphere and the stratosphere.

9 Knowing the air temperature and oxygen levels outside a plane at 12 000 metres, how could airline passengers stay warm and breathe?

10 When space vehicles such as the shuttle re-enter the Earth's atmosphere, what happens to them and why?

Investigating questions

11 What is the jet stream and what are its advantages and disadvantages for airline pilots?

12 **a** Why do commercial airlines fly so high?
b Why did the supersonic Concorde fly at 17 000 metres rather than the 12 000 metres of slower planes?

13 What are melanomas and how do they relate to the SPF number on sunscreen?

2·6 FOCUS

[Practical activity]

Prac 1
Focus 2.6

How much oxygen is in air?

Purpose

To find out how much oxygen is in air.

Equipment

Party candle (about 7 cm), small plastic takeaway food container, plasticine, 250 mL beaker, water, 50 mL test tube, matches, marking pen, retort stand, clean steel wool (cleaned with methylated spirits then rinsed in water and dried), clamp, 10 mL measuring cylinder.

Procedure

Part A

1 Stick the party candle to the inside centre of the plastic food container using plasticine.

2 Pour water into the container until the candle is about one-third under water.

3 Light the candle and quickly place the test tube over the candle so that the test tube is touching the water.

4 Hold the test tube still while the candle is burning. Don't lift the mouth of the tube up above the water or the water will run out. It should look like the illustration in Figure 2.6.8, Part A.

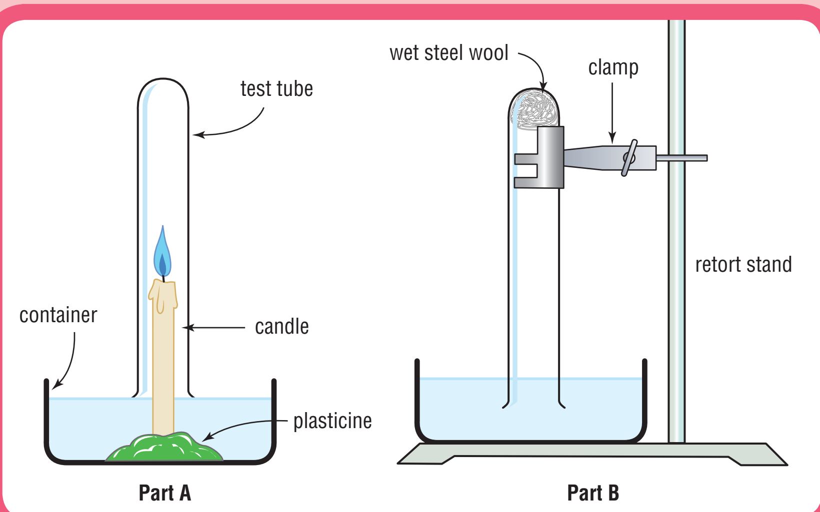
5 Mark where the water level reaches inside the test tube using the marking pen. Lift up the test tube and let the water run out.

6 Repeat steps 3 to 5.

7 Fill the test tube with water then pour the water into the measuring cylinder to measure the volume of the test tube. *Record the volume in your notes.* Empty the test tube. Now fill the tube up to the mark you made on it and again pour it into the measuring cylinder. *Record the volume in your notes. Deduct one from the other to find the volume of air that was replaced by water.*

Part B

Part A is not a good experiment. Some people claim this method tells us the amount of oxygen in air. But there are many problems with this experiment. It is not true that the flame goes out because all the oxygen is used up. Only some of it is used. The other problem is that carbon dioxide is made when we burn things like wax in a flame. Most of us know about carbon dioxide fire extinguishers! So Part B offers a different way to solve this problem.



Testing for oxygen content of air *Fig 2.6.8*

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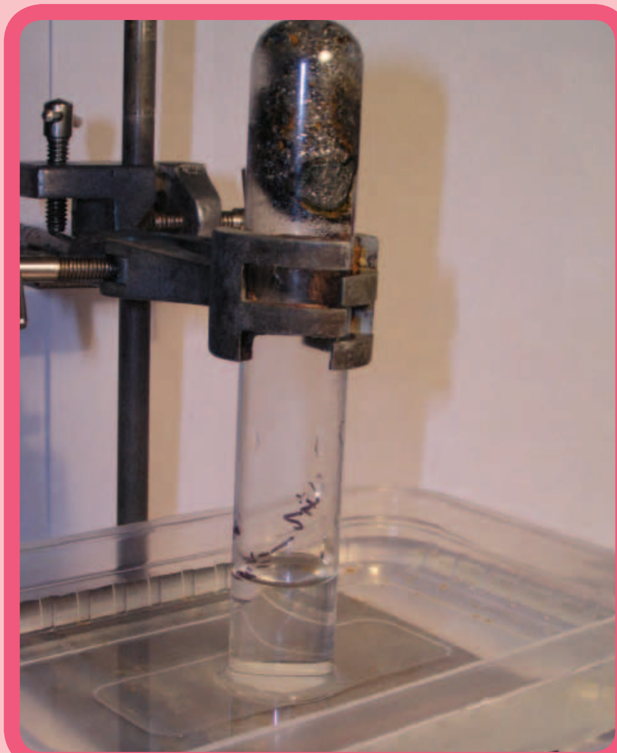
1 Place the food container on the base of a retort stand. Pour about 300 mL of water into it. Take some clean steel wool and push it to the bottom of the test tube. The plug of steel wool should be about 2 or 3 cm high in the bottom of the tube. Wet the steel wool and then clamp the test tube upside down over the beaker.



Testing the amount of oxygen in air **_Fig 2.6.9_**

The mouth of the test tube must be about half the depth of the water below the surface. The steel wool must not fall out of the bottom of the test tube. It should look like the illustration in Figure 2.6.8, Part B. Leave this set-up overnight. You will observe it next science period.

2 Next day observe the test tube and mark how high the water has risen in the test tube. Leave the set-up for another day and again mark the level of water in the tube. It should have now stopped rising.

3 Use the measuring cylinder to work out how much water entered the test tube. Use the same method as in step 7 above. Note that you must leave the steel wool in while doing this. *Record the volumes in your notes.*

Questions

1 In Part A, what proportion and percentage of the air in the test tube was replaced by water?

2 Air is about 21 per cent oxygen. How does this compare with the percentage you calculated in Question 1?

3 Why did you have to leave the steel wool in while measuring the volume in Part B, step 3?

4 In Part B what proportion and percentage of the air in the test tube was replaced by water?

5 Using the class results, which part of this experiment gave a more accurate estimate of the percentage of oxygen in the air?

6 What problems did you have with this experiment?

FOCUS 2·7 Weather and the atmosphere

Context

Why do we have weather patterns? What causes wind, lightning, rain and hail? What are cyclones and tornadoes? This focus is on these aspects of weather. The atmosphere is constantly changing, driven by temperature changes caused by uneven heating of the Earth by the Sun.

Winds

A **wind** is a moving mass of air. To understand what causes a wind you need to know about **pressure**. You may have already learnt about winds in Focus 3.2.

A wind begins when part of the Earth's surface is heated more than another. The air above the heated area becomes hotter. Hot air expands, which means the air particles spread out more. So there are fewer air particles in the same amount of space. This means the air is now lighter. We say it is less dense. But the really important point is that the air pressure is lower, which means it cannot push as hard.

Cooler air is heavier than warm air and exerts higher pressure, meaning it pushes harder against things. Cooler air starts to flow towards the warmer air, as it is pushing harder than the warmer air. It may push the warmer air upwards or out of the way.

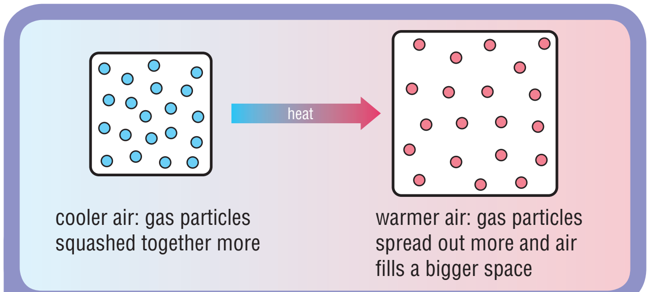


Fig 2.7.1 Air particles spread out more in warm air so it has a lower pressure.

Land and sea breezes

A **sea breeze** is a wind from the sea onto the land. A **land breeze** is a wind from the land to the sea. Sea breezes occur because land heats up faster than water. You can discover this for yourself in Prac 1 on page 81.

A sea breeze usually begins blowing in late morning. The morning sunlight heats up the land faster than it heats up the water. The air above the land is then warmed by contact with the ground. This air expands and becomes lighter. It is also a lower pressure than before. The air over the sea is cooler so it has a greater pressure. This higher pressure air starts to push onto the land towards the lower pressure warmer air. This is a wind that we call a sea breeze. You can see this in Figure 2.7.2.

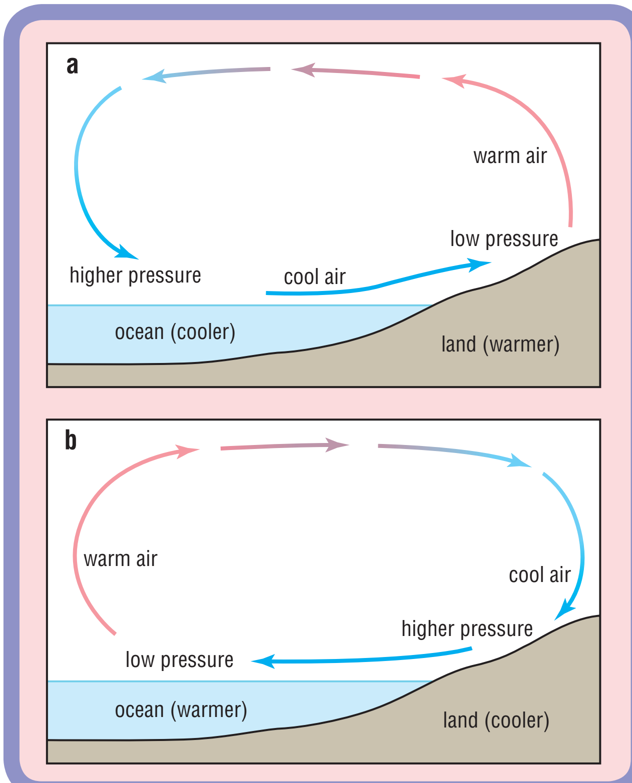


Fig 2.7.2 How land and sea breezes form. **a** Formation of a sea breeze or onshore breeze during the day; **b** Formation of a land breeze or offshore breeze during the night

A land breeze usually occurs in the evening and through the night. It happens because land cools faster than water. The land and the water begin to cool as the sun goes down. But the land cools faster. So at some time in the evening the land is cooler than the sea, and consequently the air over the land cools faster. It then contracts, becomes heavier and has a higher pressure than the air over the sea. The air over the land then pushes out to sea and forms a land breeze.

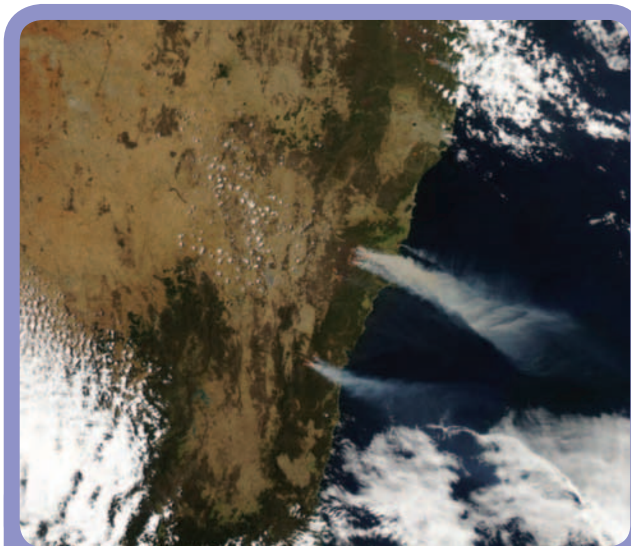


Fig 2.7.3 A photo from space showing a land breeze carrying bushfire smoke out to sea

Prac 1 p. 81

Weather maps

Figure 2.7.4 shows a weather map like the weather maps you see on television or in the paper.

On a weather map the lines you see with numbers such as 1016 are called isobars. An **isobar** is a line on a map showing places of equal pressure at sea level. So the line 1016 shows every place in Australia at this pressure at the time the map was drawn. Standard pressure is 1013 hectopascals (hPa). Anything above this is called high pressure and anything below it is called low pressure.

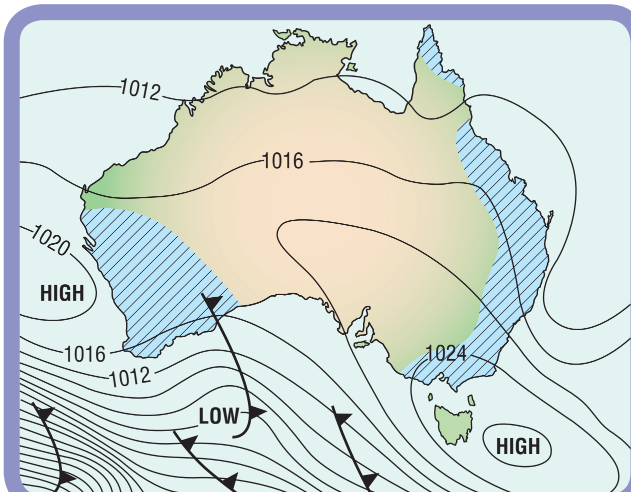
The lowest pressure ever recorded on Earth is 870 hPa and the highest ever is 1084 hPa.

On the weather map you can see areas where there are rings around the words 'High' or 'Low'. These areas are called **systems**. A 'High' is a high pressure system and a 'Low' is a low pressure system. Winds flow outwards in a high pressure area and inwards in a low pressure area. In the Southern Hemisphere the winds in a high pressure area flow out in an anticlockwise direction and in a low pressure system they flow inwards in a clockwise direction.

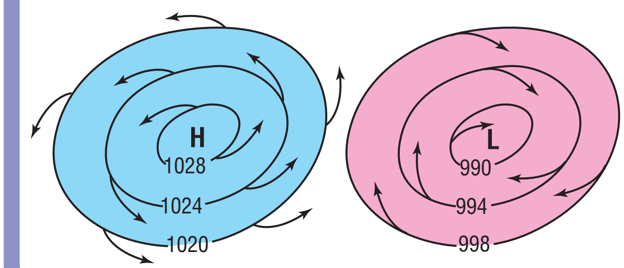
Science Snippet

The coriolis effect

Pressure systems rotate due to a force called the **coriolis** effect. This occurs because the rotation of the Earth below the flowing winds deflects the winds, making them turn.



A weather map showing low and high pressure areas Fig 2.7.4



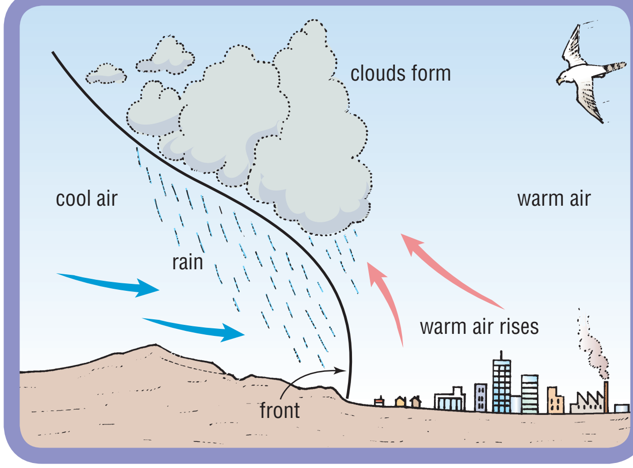
In the Southern Hemisphere the winds in a high pressure area flow out in an anticlockwise direction and in a low pressure system they flow inwards in a clockwise direction. Fig 2.7.5

Fronts and rainfall

The high and low pressure systems move across Australia from west to east. In Figure 2.7.4 you can also see several heavy lines with arrowheads on them. These are called **fronts**, which are where high and low pressure air come together. Where they meet, the warmer, lighter air is pushed upwards by the cooler, heavier air. This can create rain because the water vapour in the warm air can cool enough to condense to liquid, forming into drops that fall when they are too heavy to be held up by the rising air. If the water cools below freezing point snow or hail can fall.

A front is where a high and low pressure system come together.

Fig 2.7.6



Cyclones and tornadoes

Where the central pressure in a system is very low the winds can become very strong. This can result in a rapidly spiralling, twisting mass of air. Very large masses are called **cyclones**, while smaller ones are called **tornadoes**. Winds can reach over 400 kilometres an hour in a tornado and 300 in a cyclone, and are extremely destructive. A cyclone can be seen from space and a definite dark spot in the middle called the eye is often obvious. The air rises upwards around the eye, but the winds in the eye are relatively calm.

Science Snippet

Terrible tornadoes

Some tornadoes are so powerful that the wind can strip the tar surface off the road. Cars, cows and even houses have been lifted up into the spinning funnel of air.

Fig 2.7.7 A cyclone photographed from space

Tornadoes have funnels of rapidly spinning winds. Fig 2.7.8

Clouds

A **cloud** is either fine droplets of water or ice formed when water vapour was cooled as it rose upwards. There are many different types of cloud. The most dangerous are called cumulonimbus. These are often up to 20 kilometres in height and have violent updrafts and downdrafts, lightning and hail. No aircraft will fly near them.

Fig 2.7.9 Cumulonimbus clouds have violent winds, rain, hail and lightning.

Homework book 2.9 Cloud types

Lightning

Lightning is a rapid flow of electric charge from a cloud to the ground or another cloud. Exactly why it occurs is still being researched, but it seems to be due to air that is moving rapidly upwards in cumulonimbus clouds. We know the upper part of the cloud becomes positively charged and the lower part is negative. Electrons jump from the base of the clouds down to the Earth, which we see as a flash. The noise this generates is called **thunder**. Thunder happens when the air is superheated by the lightning bolt and suddenly expands and contracts. Many people every year are killed by lightning worldwide.

Lightning always hits the highest point on the ground that is a good conductor of electricity. Many people hit by lightning have been standing under trees. Quite a few golfers have also been hit while swinging a club. The safest thing to do if you are caught in the open in a lightning storm is to separate your feet and squat down as low as possible. Don't stand under trees or next to tall metal poles. Don't touch wire fences. If you are at home don't use your phone or computer because the lightning can travel along the wires to you if it hits your house.

Drag and Drop CW Interactive

Fig 2.7.10 Lightning is very dangerous but often beautiful.

FOCUS 2·7 [Questions]

Use your book

Winds

1 What is a wind?

2 When the ground is heated what effect does this have on the air above it?

3 Explain what is meant by high pressure and low pressure.

4 In which direction do winds blow?

Land and sea breezes

5 Explain why a sea breeze occurs.

6 Explain why a land breeze usually occurs at night.

Weather maps

7 What are isobars, and what units are used for them on weather maps?

8 What is the average atmospheric pressure at sea level and what is the lowest pressure ever recorded?

9 What is a low pressure system?

Fronts and rainfall

10 What is a front on a weather map?

11 How do rain and hail form?

Lightning

12 What is lightning and when is it likely to form?

Use your head

13 a If a fire started up in a hilly area 10 kilometres from a coastline, explain which way would you expect the fire and the smoke to move in the afternoon and what would happen to them later in the evening.

b Would knowing this type of information be of any use to anyone? Why or why not?

14 Consider the weather map in Figure 2.7.11. Predict and explain the direction of the winds in Perth and in Melbourne.

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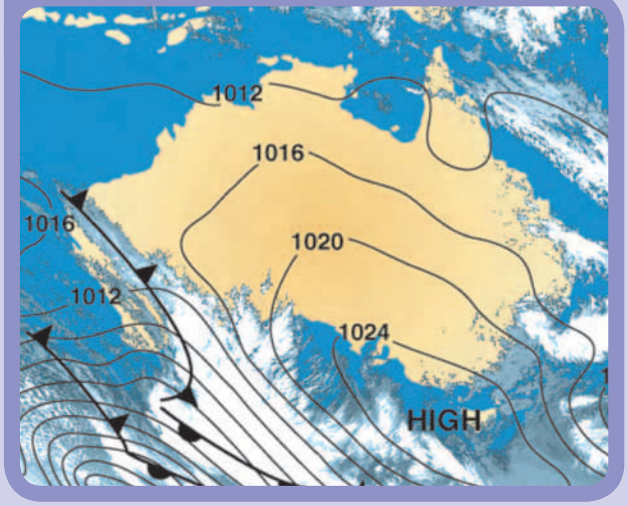
Fig 2.7.11 A weather map



15 You can calculate how far away a lightning flash is in the following way. Count the seconds from the flash until you hear the thunder then divide your count by 3—this is because it takes about 3 seconds for sound to travel a kilometre (the speed of sound is about 340 metres per second at ground level). Light travels so fast that we can assume it takes almost no time to reach you. The speed of light is about one million times faster than sound.

- **a** If you saw a lightning flash and counted to 6 before you heard the thunder, how far away was the lightning?
- **b** If you are standing out in a field under a tree when you see a lightning flash, and then you only count 3 on the next flash, explain what you would do to improve your safety.

Investigating questions

16 How are tall buildings protected from lightning strikes?

17 Why is it dangerous for aircraft to fly near cumulonimbus clouds?

18 What conditions in the atmosphere are most suited to the formation of tornadoes?

19 What steps does the Bureau of Meteorology, the Australian government body responsible for weather prediction, follow to produce a weather forecast? Go to the *Science Aspects 1* Companion Website at **www.pearsoned.com.au/schools/secondary** for a link to their website.

Web Destinations CW

2·7 FOCUS [Practical activity]

Prac 1 Focus 2.7

Heating land and water

Purpose

To investigate how fast land and water are heated by light.

Requirements

Two 50 mL test tubes, water, sand to fill one test tube, test tube rack, thermometers to fit stoppers, one hole stoppers to fit test tubes, lamp such as a halogen lamp or floodlight (about 150 watt) or sunlight if a sunny day.

Procedure

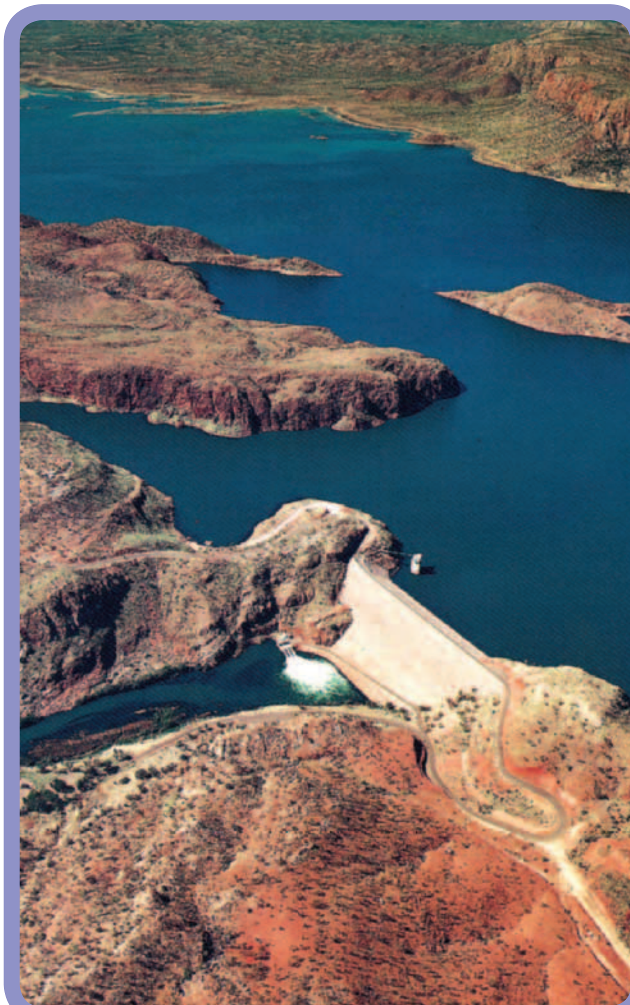
1. Fill one test tube with tap water, leaving a small air space at the top of about 1 cm.
2. Fill the other test tube with sand, leaving a similar gap at the top.
3. Carefully push each thermometer into a stopper. Don't force it if it seems very tight. Tell your teacher. Make sure the bulb of the thermometer will sit in the middle of the test tube when you put the stopper in the tube.
4. Place the test tubes in the test tube rack. If you are using a lamp, position it near the tubes but equal distance from each tube. Do not turn on the lamp yet.
5. Read the thermometers. If you have time, wait until the sand and the water are at the same (room) temperature. *Record your starting temperature for each test tube.*
6. Turn on the lamp or take the tubes out into the sunlight. *Record the temperature every minute for 10 minutes into a suitable table.*

Questions

1. Draw a line graph of the temperature against time for both test tubes on the same piece of graph paper.
2. Using your graph, describe the effect of the light on the temperature of the water and the sand.
3. Did sand or water heat up faster when placed in the light?
4. Do you think the same thing will happen if you placed the tubes out in the sunlight or under a lamp?
5. How did this practical activity help you to understand land and sea breezes?

FOCUS 2·8 Water resources

Context Liquid water is essential for life. You can survive for weeks without food, but only a few days without water. Cells cannot function without it because all cell chemistry must happen in a liquid. Did you know you are about 70 per cent water? Water is the liquid which allows this life-giving chemistry to occur. It is therefore one of our most important resources. Since many areas of Australia are becoming drier, caring about water is vital.



Dams store water supplied by rivers. *Fig 2.8.1*

Sources of drinking water

Where does the water that flows out of the tap come from? Most people think that all our water comes from dams. However, dam water is becoming less important in many places where natural rainfall is erratic or decreasing. Did you realise most of our water now comes out of the ground?

Water used for drinking is often called **potable** water. Other water is called **non-potable** water. The main sources of potable water are dams, underground water, rainwater tanks and desalination plants. The amount of water supplied to Perth from dams is now only about 40 per cent of total consumption. Groundwater is increasing in importance as our climate seems to have become drier. The rainfall has been declining for many years.

Science Snippet

Smelly water

To ensure that the water from dams and groundwater is of good quality for drinking some chemicals are added. Chlorine is added to kill microorganisms that may be in the water. This is why the water sometimes smells of chlorine.

Interactive Animation

Dams

A **dam** is a concrete or earth wall built across a river. The wall blocks the river and a reservoir builds up behind the dam. The water is then pumped out through a series of pipes. An example of this is the Mundaring Weir, a dam across the Helena River in Perth's hills district of Mundaring. The water is pumped through about 500 kilometres of pipes to the goldfields town of Kalgoorlie. The Mundaring Weir was constructed in the early part of last century to supply water to Kalgoorlie to support the new gold mining industry that was developing there. There are no rivers to dam anywhere near Kalgoorlie.

Dams have been decreasing in importance as a source of water in south-western Australia. This is because the climate is becoming drier. For example, the water run-off from streams into Perth's dams decreased by nearly two-thirds in the period 1998 to 2005. According to the Water Corporation, this worrying trend may continue.

Groundwater

About 60 per cent of Perth's potable water now comes from groundwater—water found beneath the ground. The water soaks into the ground from rainfall and builds up in the soil or soaks into rock layers. These sources of water are called **aquifers**. Rocks that allow water to soak in are called **pervious**. Those that do not allow water in are called **impervious**.

The soil and the top rock layers immediately under the ground constitute one type of aquifer. In Perth this is about 40 metres thick. The top surface of the water is called the **water table**. Sometimes the water table reaches the ground surface, where it forms a lake such as Lake Monger. The water table is usually higher where the land is higher. These areas are called mounds. In Perth there are two major mounds, at Gnangara and Jandakot.

The other type of aquifer is a layer of rock that is sandwiched between two impervious rock layers. This is often called artesian water, or a confined aquifer. In Perth there are two main artesian aquifers. The Leederville aquifer is about 300 metres thick and about 150 metres below the surface. The Yarragadee aquifer is about 500 metres down and can be a kilometre thick.

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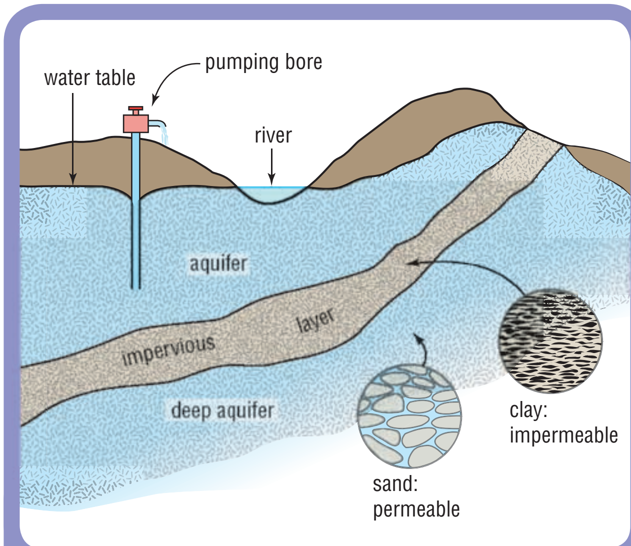


Fig 2.8.2 Aquifers include artesian water and unconfined aquifers.

The Water Corporation is responsible for the extraction of groundwater to provide water to homes. Some people also have bores, whereby a drilling contractor sinks a pipe down into the water table. A pump installed in a well then raises the water to the surface to be used on the garden. This bore water should not used for drinking without treatment to remove salts and other impurities.

Science Snippet

Tough teeth

In Western Australia fluoride is added to the drinking water. The fluoride helps to toughen the enamel on your teeth so you have fewer cavities and fewer visits to the dentist!

Desalination

Salty water such as seawater is a source of potable water if we can remove the salt. Removal of the salt is called **desalination**. Some desalination processes heat the water to evaporate it, so it can be expensive.

A new desalination plant is planned for Kwinana, which will use a process called reverse osmosis. This process is already used in some areas of Western Australia, mainly in smaller towns. The water is forced through a very fine membrane under pressure. This allows the water through, but stops the salts. This is being used on Rottnest Island and is powered by one wind turbine. The Kwinana plant will need 50 turbines to power it.

The desalination plant on Rottnest Island uses a reverse osmosis process. Fig 2.8.3

Sources of non-potable water

Non-potable water can be obtained by recycling wastewater. Wastewater is the used water from your bathroom, kitchen, toilet and laundry. This water is also called **sewage**. Most Perth houses and worksites are connected to a system of pipes called deep sewerage or main sewerage. Some places are not deep-sewered and use **septic tank**s for waste disposal.

Deep sewerage is the system of pipes and pumps which carry wastewater away to a treatment plant.

Fig 2.8.4 A sewage water treatment plant

Sewage contains over 90 per cent water. At the treatment plant, solids, dangerous bacteria, heavy metals, oil, excess nutrients such as phosphates, and detergents are removed from the wastewater.

Treated water is then pumped back through another system of pipes to users in industry. For example, an iron and steel plant at Kwinana uses a large amount of this water. Recycled water is also used for watering plants in plant nurseries, parks and farms.

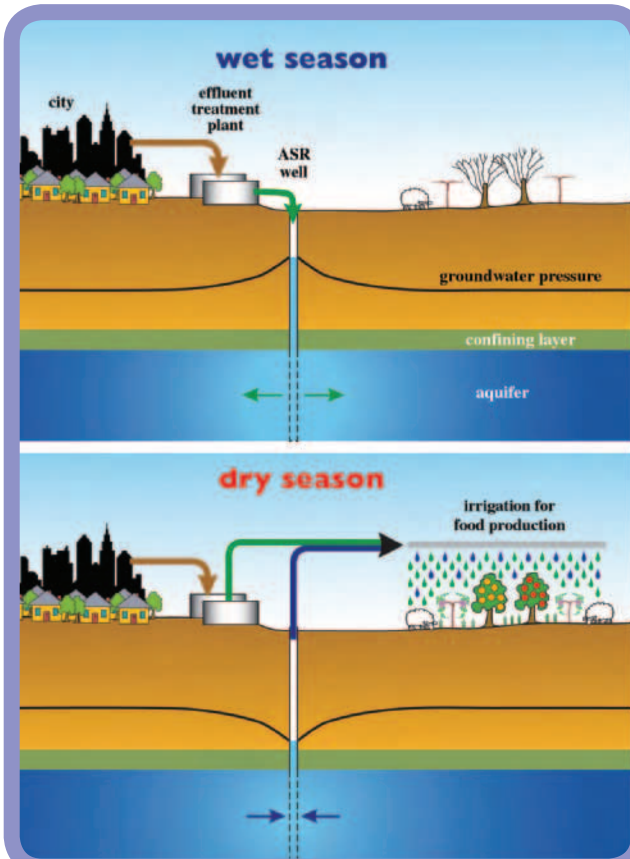
Treatment of wastewater

Wastewater is treated in a series of steps.

1. Screening—the wastewater is passed through a mesh to remove large solids such as rags and paper
2. Settling—the wastewater passes into tanks where smaller solids such as sand can settle out. The thickened liquid is called sludge.
3. Stabilisation—sludge is passed into tanks where bacteria convert it into solids suitable to use as a mix in soils to help plant growth. Another product at this stage is a gas which can be used to burn and generate electricity, so the water treatment plant can be self-sufficient in energy use.

Recharging aquifers

The Water Corporation also uses treated wastewater by returning it to aquifers. It can be stored in the aquifer during winter and then drawn out again in summer when needed to irrigate plants.



Aquifers can be recharged in winter to help cope with summer use. Fig 2.8.5

Water distribution

Water supply to homes involves pushing the water through a series of pipes. Water is not constantly pumped to every home, as it would be very costly. Large towers provide temporary storage for the water. These are always at the highest possible point near the suburbs being supplied with the water. You can see a water tower in Figure 2.8.6.

The water tower is used to create enough pressure in the water pipes to push the water through to all the houses in the nearby suburbs. As long as there is enough water in the tower the force of gravity exerts a high pressure on the water in all the pipes connected to the tower. Water is pumped into the tower continuously to keep the level of water high. As long as the level of the water in the tower is higher than the level of the pipes in the buildings it supplies, there is enough pressure in the pipes to push water out of the taps in those buildings.

Interactive Animation

Fig 2.8.6 Water towers ensure high pressure in water pipes.

Homework book 2.10 The water problem

2·8 FOCUS [Questions]

Use your book

Sources of drinking water

1 What is potable water? What is non-potable water?

2 Why has groundwater use steadily increased in Perth in the last decade or so?

Dams

3 What do we mean by a 'dam' and a 'reservoir'?

Groundwater

4 How would you correct someone who told you that all aquifers are artesian water?

5 How did our groundwater get there?

6 If you lived in Perth and bored down 300 metres below the ground, what aquifers would you hit? Drawing a quick diagram with some notes on it may help you.

Desalination

7 What is desalination and what desalination process can be used that does not involve heating the water?

Sources of non-potable water

8 What is sewage, where does it go and how does it get there?

9 What is done to the wastewater before it can be recycled for use again?

Treatment of wastewater

10 What are the three main steps in sewage treatment?

11 Describe the useful products we obtain from sewage treatment.

Water distribution

12 Why is water stored in towers on the highest ground available?

Use your head

13 Why do you think that camping and fishing are prohibited in the areas near dams?

14 If the store of water in dams is decreasing, why can't we just keep on increasing our usage of groundwater to supply potable water?

15 The Water Corporation has a policy of ensuring diversity of water sources. This means they try to obtain water from a wide variety of sources. Why is this a good policy?

16 Your sinks at home have an 'S' bend in the water pipes below the drain hole. You can see this in Figure 2.8.7.

Fig 2.8.7 The 'S' bend water trap in a sink

>>

The bend keeps some water trapped in the pipe. When you flush water down the sink the trapped water is pushed out and replaced by new water. You have a similar water trap in your toilet.

Suggest some reasons why a water trap is needed in a sink.

17 Figure 2.8.8 shows the structure of a septic tank. The tank is a sealed concrete unit, but the leach drains or soak wells have an open bottom and open sides as well for leach drains. The solids remain in the tanks where they are decomposed slowly by bacteria that live in the tank. The water (effluent) runs out of the tank into the leach drains or soak wells and slowly passes through soil, where microorganisms decompose impurities in the water and the sand filters out smaller particles. The water slowly soaks through to the water table and is carried away. Occasionally septic tanks have to be pumped out because the solids build up and completely fill the tanks.

- **a** Why would it be a bad idea to put disinfectants or bleach down the sink if you have a septic tank?
- **b** Why would it be a bad idea to put paint down the sink if you have a septic tank?
- **c** Why would it be a bad idea to put plastic materials down the sink if you have a septic tank?
- **d** Why might a septic tank fill up if you pour large amounts of water down the sink?
- **e** The government has a policy of replacing septic tanks with deep sewerage where possible. What reasons can you think of to support this?

Investigating questions

18 Imagine that a water tower holds a particular volume of water. Should the tower be tall and thin or short and wide? You can investigate this by using plastic cool drink bottles of different widths and heights. If you punch a hole in the bottom you can collect the water that runs out. By changing some variables you can answer the question. Design your experiment and ask your teacher if you can do it.

DYO

19 Look up the Water Corporation website on the *Science Aspects 1* Companion Website at **www.pearsoned.com.au/schools/secondary** and find the latest data on the water levels in the dams nearest you, or in Perth, if you have no dams near you.

Web Destinations

- **a** Report on whether the water storage is better this year than last year and what the trend has been like for the last five years.
- **b** Is there reason for the Water Corporation to be concerned about the levels in the dams this year?

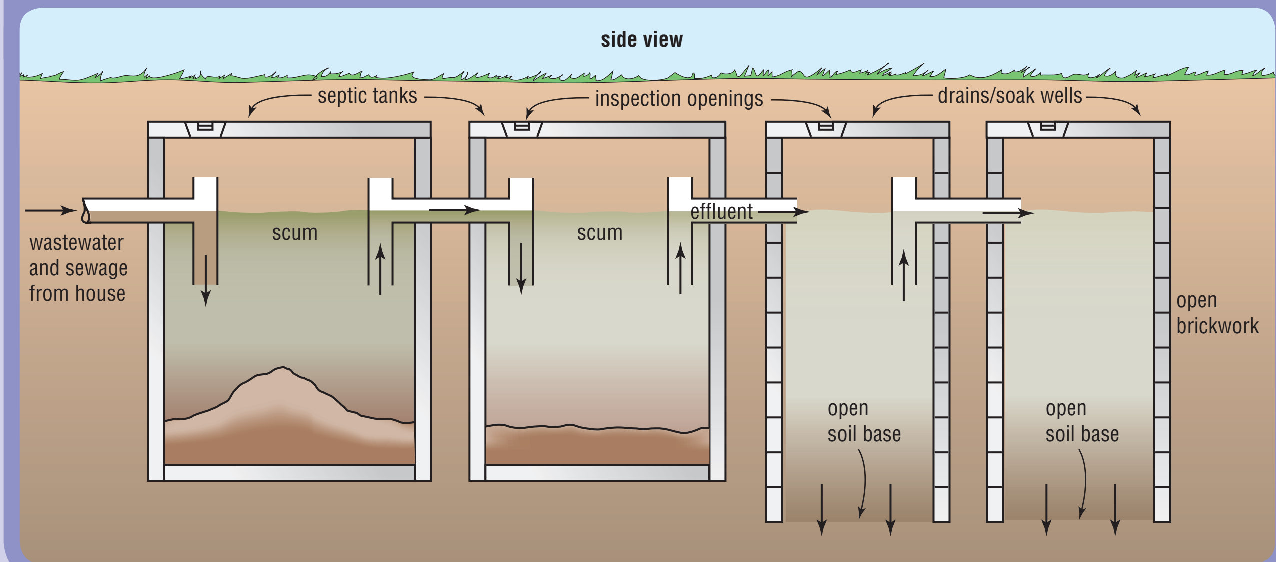
20 Design an experiment to investigate whether layers of different soils, such as fine and coarse sand and gravel, can clean sediment out of muddy water. Ask your teacher if you can try the experiment.

DYO

21 Design an experiment to test whether adding iron (II) sulfate, aluminium sulfate or sodium sulfate to muddy water causes some of the fine mud to be removed. Ask your teacher if you can try the experiment.

DYO

Fig 2.8.8 Septic tanks are still used in some areas.



2·8 FOCUS

[Practical activity]

Prac 1 Focus 2.8

Soil permeability

Purpose

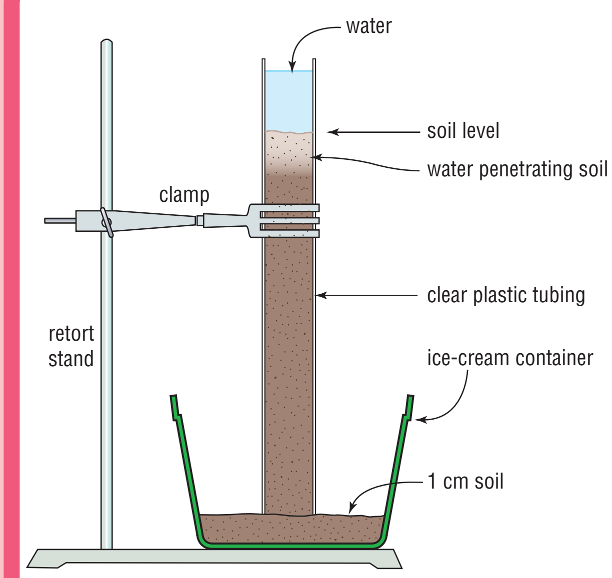
To compare how fast water soaks into different soil types.

Requirements

About 300 mL each of sand and clay soil, 20 cm ice-cream container, retort stand and clamp, transparent plastic tubing about 5 cm diameter, piece of dowel narrower than the tube, two 100 mL beakers, water, timer, ruler.

Procedure

1. Read through all these instructions before you start the experiment.
2. Place about 1 cm depth of sand covering the bottom of the ice-cream container.
3. Clamp the tubing upright in the middle of the container and use one beaker to fill it with sand up to 5 cm from the top. Tap the soil down with the dowel to make sure it is settled in the tube.
4. Fill the beaker with water and be ready to start the timer.
5. Start the timer as soon as you start pouring the water in. Carefully and slowly pour the water into the tube up to about 1 cm below the top. Try not to stir up the soil as you pour. Be careful it does not overflow.
6. As the water soaks in to the soil keep adding water at the top so the level does not drop. Measure the depth of the water mark below the soil surface every minute. *Record this in a table.*
7. *Record the results for 10 minutes or until the water reaches the bottom.*
8. Repeat the experiment using the clay soil.



Experimenting with soil permeability *Fig 2.8.9*

Questions

1. Draw a suitable graph of your results.
2. Compare your two soils and comment on any difference you notice.
3. Try to use a science idea to explain any pattern or difference in your results.
4. How does this experiment help you understand how groundwater forms?
5. Answer the following question after you have done ‘Use your head’ question 17: How is this experiment relevant to septic tank operation and wastewater treatment?

FOCUS 2·9 Soils

Context Soils are very important to us because most of our food comes from the plants we grow in soil. Soil is a farmer's most vital resource after water. Soils in Australia are very fragile and easily damaged—if we don't care about them and look after them we will not continue to be a prosperous nation. We may even be unable to survive.

Weathering is the process of rocks breaking down. *Fig 2.9.1*

Formation of soil

Weathering

Soil occurs as a result of the breakdown of rocks. We call the processes that break down the rock **weathering**. There are two main reasons why the rocks break down. One involves chemical change in the rock, while the other is a physical process.

Chemical weathering involves water and chemicals in the water changing the rock. The oxygen and carbon dioxide in air can react with some rocks. Rainwater contains acids that attack the rock. Water also can dissolve some materials in the rock and make the rock crumble.

Physical weathering involves water, temperature change and ice. Rapid temperature change between day and night makes rocks expand and contract. This can split the rock, and pieces can break off. Ice forming in the cracks can also split pieces off. In some countries glaciers can scrape pieces off the rock. Water running over the rock can gradually carry away some material.

Erosion

Particles of rock broken off from the parent rock are often carried away by wind, water and ice. This removal of small rock particles is called **erosion**. Erosion occurs most commonly in mountains and hills.

Deposition

The small rock particles are eventually dropped somewhere by the wind, water or ice that carried them away. We call this process **deposition** or **sedimentation**. The place where the rock particles are deposited is the site where a soil can form. Sedimentation from rivers usually happens on flatter ground because the flow of the river slows and the tiny rock particles then sink. Sedimentation often happens when a river floods or where it enters a lake.

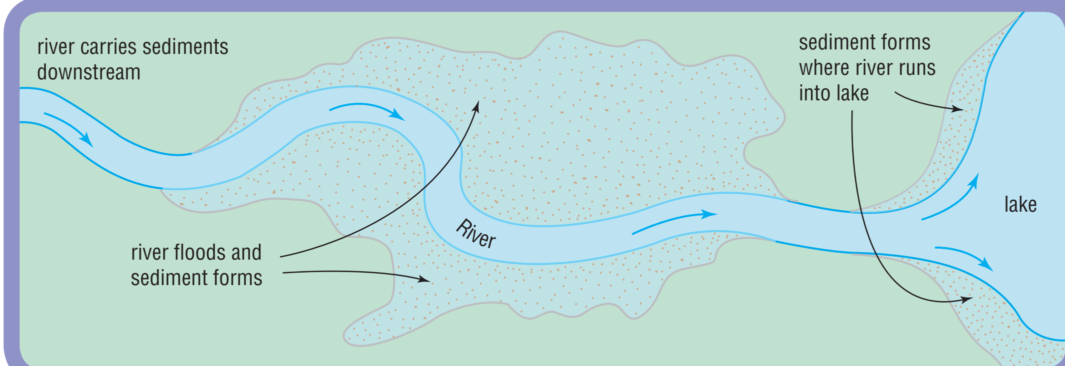
Sometimes the soil forms over the top of the rocks which weathered, because no erosion occurred. This means the soil has formed directly from the rocks below it, not rocks from somewhere else.

Science Snippet

Bad weathering

Some of our most precious old buildings suffer from the effects of weathering. Rocks can crumble and the cement mortar holding the stones or bricks together breaks down. No building can last forever.

Soils form where rivers drop sediments. *Fig 2.9.2*



Components of soils

Soils contain a range of components. Most soils are composed of rock particles, humus, organisms, minerals, air and water.

Rock particles

The common rock particles are clay, silt, sand and gravel. They are different in size and have very different properties, as you will see later in this focus.

Humus

Humus is the decayed remains of dead organisms or their wastes. Plant leaves, bark and sticks are usually the main components of humus. All the decayed matter becomes a brown-black sticky material that coats the rock particles, when it is then known as humus. Humus is very important in soil because it helps hold it all together. It absorbs moisture and it contains many plant nutrients.

Organisms

Animals such as earthworms help aerate the soil, adding oxygen for plant roots. Many bacteria live in soil and help enrich the soil for plant growth. Plant roots search through the soil for nutrients. Many small animals live in the soil.

Minerals, air and water

Plants use simple chemicals in the soil called minerals. They need these as nutrients. Some of the minerals come from the weathering of the rocks, while others come from the decay of organisms and their wastes. The water and air are vital for most living organisms.

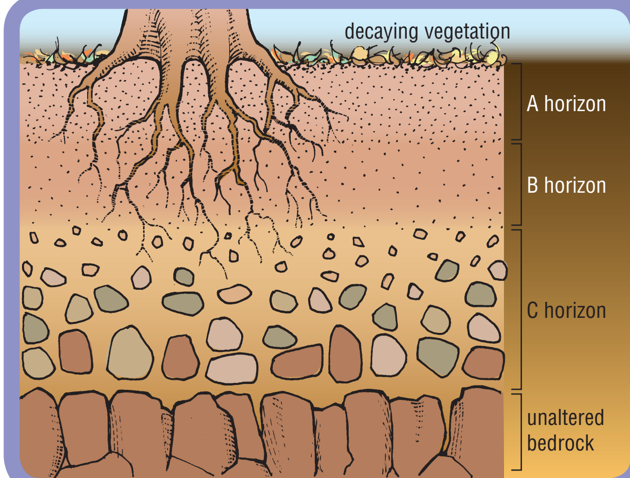
Soil profiles

When you dig down into the soil and look at the pit from the side, you can often see a change in the soil. It seems to have some different layers in it. These are called **horizons**. The top layer, or A horizon, is often a dark-brown or black colour due to the high humus content from the leaf litter that has accumulated. Most plant roots are found here and this is usually the vital layer for plant growth.

The B horizon is next. It usually contains less humus and is often a lighter colour due to this. The soil here is usually more compacted and there is less air. The water table is often in this layer.

The C horizon contains the bedrock at the bottom. It is usually below the water table and has little impact on plant growth.

A soil profile shows the soil changes as we dig down into it. *Fig 2.9.4*



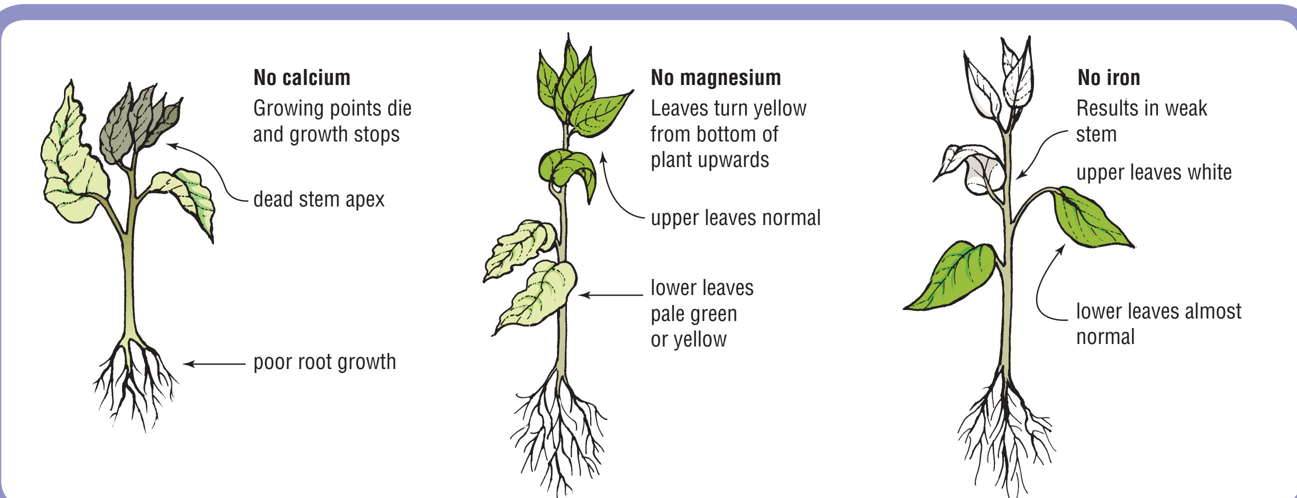


Fig 2.9.3 Plants need mineral nutrients from the soil. If there are not enough the plants show signs of poor growth.

Differences in soils

Soils differ in many ways. The most important differences for us are those that affect plant growth. However, soils affect buildings, roads, bridges and other structures as well. The main differences among soils that affect their suitability for plant growth are their texture, structure, consistency, water-holding capacity, permeability, humus content, acidity and fertility.

Texture

Texture refers to the size of the particles that make up soil. The main particles in soil are classified as clay, silt or sand. There are others as well. Clay particles are tiny—about 1500 times smaller than a silt particle. Silt is about eight times smaller than small sand grains. Most soils have various combinations of these particles. A soil called clay could still contain up to 50 per cent sand. A sand could have 10 per cent clay.

Structure

Structure refers to how well the soil particles join up to form lumps. These are called clods or crumbs. They are often about 3 to 5 millimetres wide. They are important because they allow spaces, called **pore spaces**, between them. Pore spaces let water and air enter the soil to improve plant growth. Farmers are very careful not to disturb the soil structure too much.

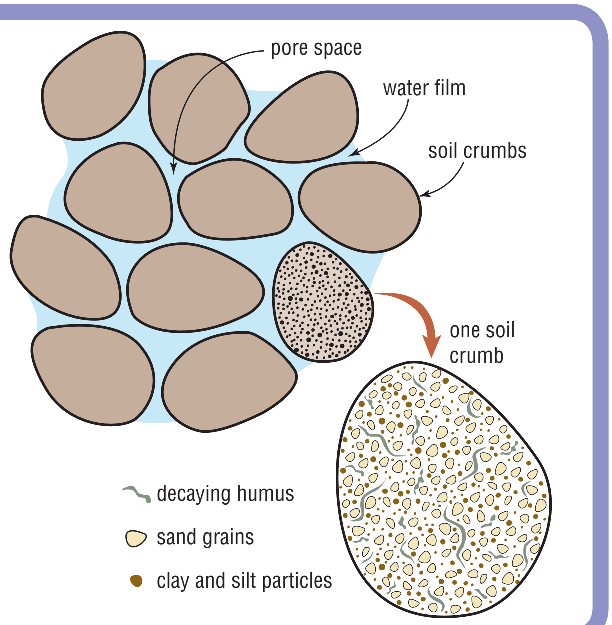


Fig 2.9.5 Soil structure is about how particles clump together.

Consistency

Consistency is the tendency of soil particles to stick together. Clay soils have a high consistency. Too much working of a clay soil can cause it to compact into a layer like concrete, which is poor for plant growth.

Water-holding capacity

Water-holding capacity is a measure of how much water a particular amount of soil can hold. Some soils hold onto water very strongly, so strongly that it is hard for plants to extract water from them. Soils high in clay are like this. When rainfall is low, heavy soils with more clay often produce poorer crops because plants cannot absorb enough moisture from them. It is easier for plants to remove water from sandy soils, as long as the water is in the soil. Sometimes there may not be enough water in the soil if there is a low humus content.

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Permeability

Permeability is the rate at which water enters the soil. If permeability is low the water may run off and not enter the soil. If soils are compacted by poor farming practice a lack of pore space may mean poor water entry.

If machinery is used too much on some soils they can become compacted. *Fig 2.9.6*

Humus content

Humus content was explained earlier in this focus. Plants grow very well in soils high in humus due to the superior moisture-holding and nutrient-holding capacity of humus. Many people try to improve the humus content by using compost, which is the rotting remains of food scraps and lawn clippings. These are often added to worm farms to feed the worms and the liquid that is produced is added to the soil.

Acidity

Acidity is very important for plant growth, as it affects the minerals available in the soil for the plants. Some plants are suited to growing in acid soils, while others are more suited to alkaline soils. You can test your soil for this, and horticulturalists in plant nurseries will give you advice on what plants grow best in your soil.

Fertility

The **fertility** of a soil refers to its ability to support plant growth. The level of fertility depends on the nutrients present, but also on air and water availability—anything affecting these affects plant growth. Clay is better than sand at holding onto and releasing minerals needed for plant growth. So plants usually grow well in soils which have some clay in them. Humus content obviously affects fertility as well.

Science Snippet

Fertilisers

Fertilisers are materials that supply plant mineral nutrients. There are two types of fertilisers, inorganic and organic. They contain elements such as phosphorus and nitrogen, which plants need for their cell chemistry to work.

Organic fertilisers are the product of living creatures or their wastes. Common organic fertilisers are untreated animal manures such as sheep or chicken manures. These have not been chemically altered by manufacturing them into simpler substances. Another organic fertiliser is 'blood and bone', which is the remains of meat and bone from animals slaughtered at abattoirs. These are dried and cooked but not altered very much.

Inorganic fertilisers are chemicals manufactured mainly from animal droppings, especially from birds. These have been chemically altered to a large degree and are much simpler chemicals than those in organic fertilisers. Farmers use large quantities of inorganic fertilisers such as superphosphate and ammonium nitrate. Some farmers are experimenting with organic farming, as there is evidence that some inorganic fertilisers are damaging the soil structure and fertility.

Homework book 2.11 The soil texture triangle

2·9 FOCUS [Questions]

Drag and Drop CW Interactive

Use your book

Weathering

1 What is weathering, and what is the difference between chemical and physical weathering?

Deposition

2 What is the difference between erosion and deposition?

Components of soil

3 Write a few sentences about the main components of soil.

Structure

4 What is the difference between a crumb and a particle of rock in soil?

5 Why are pore spaces important in soil?

Humus content

6 What is the benefit to soils of adding compost?

Fertility

7 What is soil fertility and how are fertilisers important to it?

Use your head

8 What is good soil structure and why does it matter?

9 How can a soil with a very high water-holding capacity and a high nutrient content, such as clay, be poor for plant growth?

10 Explain how soil structure and texture affect soil fertility.

11 Explain what you could do to minimise soil erosion if you were involved in one of the following activities: camping, bushwalking or boating.

12 When new roads are built through sandy, hilly areas there are often cuts made through the hills, leaving exposed banks either side of the road. The sides of these banks are sometimes covered with various materials, such as a spray-on paper-like material which has plant seeds mixed with it. What could be some good reasons for doing this?

Investigating questions

13 Find a container of plant fertiliser at home or in the science lab. Read the label to find out what plant nutrients are in the container. Pick five nutrients and research why they are needed by plants. Present your findings in about half a page of writing.

14 What is organic farming and why are some farmers going back to this ancient practice?

15 Design an investigation to compare the amount of pore space in sand and clay soils. A graduated cylinder, a beaker and different soils would be useful equipment.

DYO

2.9 FOCUS

[Practical activity]

Prac 1 Focus 2.9

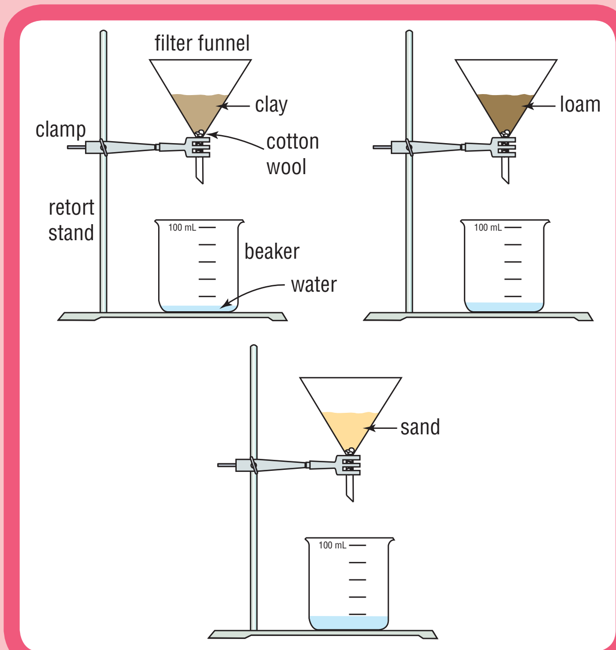
Water-holding capacity

Purpose
To compare the water-holding capacity of different soils.

Requirements
Cotton wool, three plastic filter funnels, retort stand and three clamps or filter stand, two 100 mL beakers, dry soil samples such as clay, loam or sand, 50 mL graduated cylinder, timer.

Procedure
1. Put a cotton wool plug in the neck of each funnel. Place the funnels in the filter stand or clamp them to the retort stand. Put a 100 mL beaker under each filter funnel outlet.
2. Half-fill each funnel with a different type of soil.
3. Pour about 20 mL of water into each funnel and collect any water that comes through. If no water comes through a particular soil, add another 20 mL of water to that soil until some water runs through it. *Record in a suitable table how much water you added to each soil and how much water collected in the beaker.*

Questions
1. Which soil had the largest water-holding capacity and which had the smallest capacity?
2. Explain how you decided on your answer to Question 1.
3. What are some possible reasons for soils having different water-holding capacities?
4. Well-drained soils allow much of the water which enters them to pass through them. Some plants, such as many native Australian plants, require well-drained soils. Which soil would be best for such plants?



How to do your experiment *Fig 2.9.7*

FOCUS 2·10 Wise resource use

Context This focus is about using the resources of the Earth wisely. We must be careful how we use the rocks, soils, water and air. We need to use them in a way that will ensure our environment is still able to sustain life on this planet. It is about caring and surviving.

Sustainability

Using resources in a way that ensures they continue to be available and our environment continues to support life is called **sustainability**. In the last 50 years or so we have realised that this is the most important task facing us. We are now very aware that we are damaging the very environment that sustains us. In this focus you will look at some examples of the changes we are making to our environment, and what we can do to fix them.

Air

The enhanced greenhouse effect

The enhanced **greenhouse effect** is the heating up of our atmosphere caused by air pollution. The main chemical causing the heating is carbon dioxide. The level of carbon dioxide in the air has been steadily rising for the last hundred years that it has been measured. This is due to more burning of fuels like wood, coal, petrol, oil and gas from the ever-increasing number of people on the planet.

The heating of the atmosphere happens in the following way. The sunlight that falls on the Earth heats it up. The Earth gives out heat radiation, which is like rays from a strip heater. However, you can't see these rays. The rays travel back into space through the atmosphere. Carbon dioxide molecules in the air are just the right size to be affected by this radiation. The carbon dioxide molecules start to vibrate more and this is what you feel as heat. So the atmosphere heats up. This is a bit like the way a glass greenhouse works, and so the effect has been named the greenhouse effect.

The problem with the atmosphere becoming warmer is that it may melt the polar ice caps and all the frozen lands on the planet. This could raise the

Fig 2.10.1 The burning of fuels produces carbon dioxide and contributes to the enhanced greenhouse effect.

sea level across the Earth by about 6 metres, enough to flood many countries, such as Bangladesh, most Pacific nations and many important capital cities such as London and New York. All the cities on the frozen tundra would sink into the swamps and mud. Millions would be homeless or perish.

The solution to the enhanced greenhouse effect is to greatly reduce our burning of fuels such as coal. We need to find alternative energy sources such as wind, water and solar power.

Prac 1 p. 98

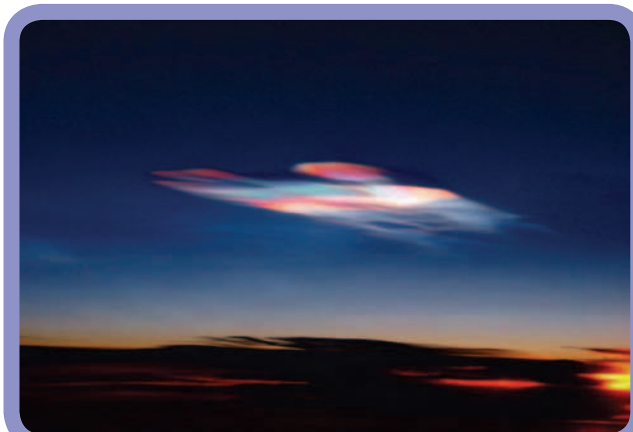
Wind power offers an alternative to coal-fired power stations. Fig 2.10.2

Ozone depletion

Ozone (O_3) is a form of oxygen found in the stratosphere. It forms a protective blanket around the Earth by filtering out a lot of ultraviolet light from the Sun. Ultraviolet light causes skin cancers and eye cataracts, which lead to blindness. Unfortunately we have discovered that the level of ozone is being reduced by pollutants that are reaching into the upper atmosphere. This means there could be an increase in the incidence of skin cancers and cataracts.

The thinning of the ozone layer has been caused by several chemicals, mainly chlorofluorocarbons (CFCs). These are gases used in refrigeration and plastic production. They used to be used in spray cans, but were banned when it became clear how damaging they were. The chlorine in them was destroying the ozone. To solve this problem we need to find alternative chemicals to use in refrigeration and plastic production.

Fig 2.10.3 Monitoring the stratosphere for ozone levels



This cloud in the stratosphere shows colours indicating ozone-damaging chemicals. *Fig 2.10.4*

Acid rain

Acid rain is rain that contains acids. Acid rain kills trees and many other organisms. It also affects buildings. Anything made from limestone is badly affected. The acid reacts with the limestone which then breaks down. Buildings can develop large holes in them.

Acids in rain can damage buildings. *Fig 2.10.5*

Acid rain forms when pollutants such as oxides of sulfur and oxides of nitrogen enter the atmosphere. These then dissolve in water, where they form acids such as sulfuric acid. When the water droplets fall as rain, they carry the acid down to the ground.

The solution to acid rain is to insist that industries producing these pollutants do not allow them to enter the air as waste.

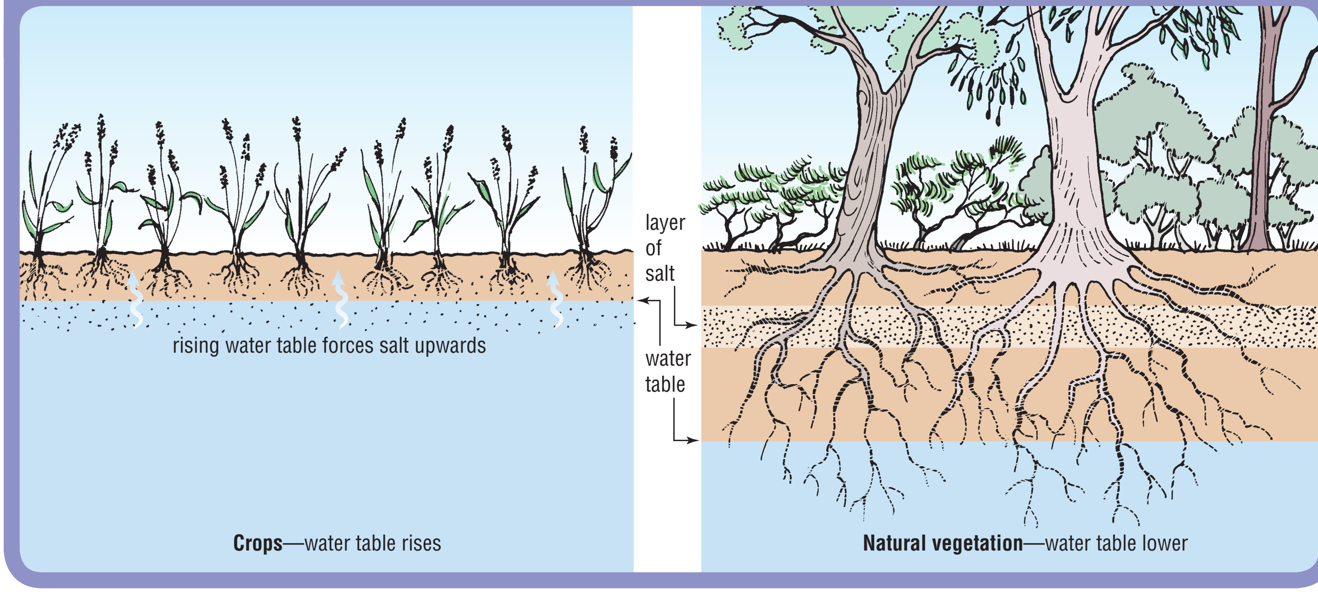
Soil

Salinity

One of the major problems with many soils in Australia is that they are becoming very salty. The scientific word for salty is **saline**, and we call the level of salt **salinity**. The high salinity is caused by land clearing for agriculture. This is the number-one environmental problem in Western Australia at present.

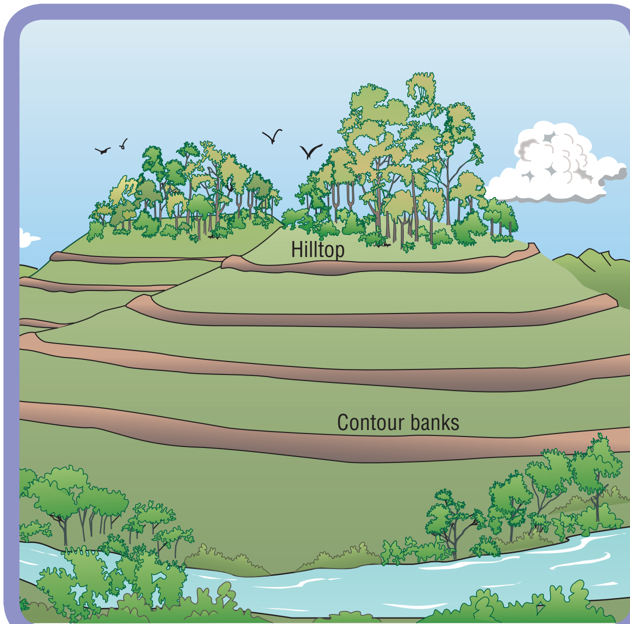
The increasing salinity happens in the following way. In Australia we have deposits of salt a few metres below the surface of the soil. These are above the normal water table when the natural vegetation of trees is present. The salt is deep enough not to affect shrubs growing there.

Fig 2.10.6 The clearing of trees has caused soils to become saline.



However, the salt has been rising to the surface, due to a rising water table. Trees remove a great deal of water from the soil and so naturally keep the water table lower. The clearing of trees to grow crops such as wheat means that less water is removed and so the water table rises. It then dissolves the salt above it and carries it up to the surface, where it affects crops and native vegetation. In many places it reaches the surface and deposits the salt in a lake or river. Most of the lakes and rivers in South Western Australia are now very saline.

One solution to increasing salinity is to introduce laws that restrict land clearing. Farmers and developers should not be able to clear land without some kind of environmental controls. There are laws at present that impose these controls. The other solution is to replace the native vegetation of trees. Many farming communities have realised this and are planting trees on as much land as they can spare. The government is also experimenting with salt-tolerant crops.



Contour banks reduce soil erosion by water. Fig 2.10.7

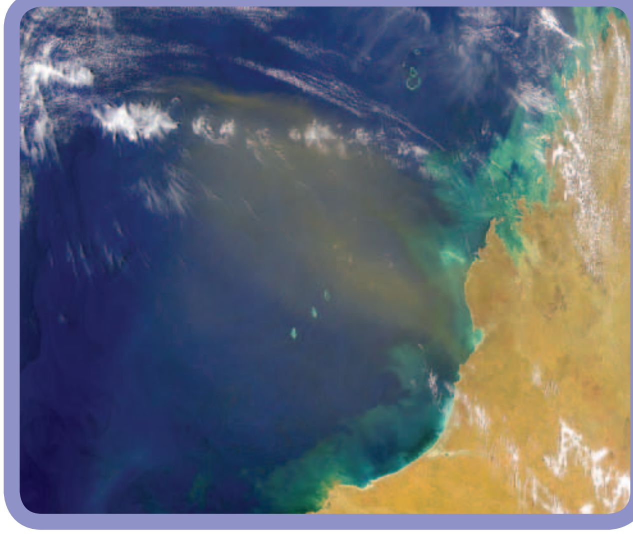
Soil erosion

Soil erosion is a major problem in some areas of Australia. In hilly country, where water can flow down hills, streams erode deep gullies by washing away soil. So farmers lose land for crop production. The solution to this is to use contour banks. These are small banks about half a metre high that run across the slopes along land at the same height. This stops water running fast down a hill.

Soil erosion also happens by wind. In seasons when the soil on farms is left without vegetation cover, strong winds can pick up soil and deposit it many kilometres away—and the productivity of the farm suffers. To prevent this, farmers often leave crop stubble behind and do not plough up their land as much. They try to sow seeds with minimum disturbance and choose carefully the time at which they will do this.

This photo from space shows how wind can erode soils. What do you think is happening?

Fig 2.10.8



Water

Using water wisely is essential for survival. Most states of Australia have had water restrictions on watering gardens for several years because of water shortages. These seem to be becoming more common, especially in south-western Australia. Most scientists think Australia is becoming drier, so it is very important to be careful with water.

Water in the house

What can you do to save water at home? Have a look at the following table and think about what you could do. These are average water use figures in Perth homes.

Where is the water used	Percentage of total water use	Actual volumes used (litres)
Bath and shower	33	Shower 15 L/min
Washing machine	27	Varies greatly depending on type—35–80 L per load of washing
Toilet	20	Single flush 11 L Dual flush (old) 9 L and 4.5 L Dual flush (new) 6 L and 3 L
All other uses–dishwasher, drinking, cooking etc.	20	Dishwasher 45 L per cycle or 18–32 L per cycle for newer ones

Some suggestions for being water-wise around the house are shown in the following table.

Where could you save water in the house?	What can you do?
Showering	Take shorter showers Buy a restricting shower head that has a finer spray of water
Toilets	Install dual-flush toilets
Washing machine	Use front-loading machines or those that use less water
Washing dishes	Don't buy a dishwasher, or use it only for big washes Hand washing usually uses only 9 L
Cleaning your teeth and washing your face	Don't leave the tap running
Dripping taps	Fix them

Water in the garden

In the garden there are several ways you can save water. One way is by planting native plants. These usually require less water. Instead of large areas of lawn you can plant native ground cover plants, shrubs and trees.

Another way of saving water is to improve soils by using a soil wetting agent. These are chemicals which help the water to soak into the soil. They are like detergents. Some are applied in liquid form, others as granules.

Instead of using sprinklers to water the garden you can use a drip-irrigation system or you can hand water. A drip-irrigation system consists of one pipe or a series of pipes in which there are small holes that allow the water to drip out. The water soaks into the soil slowly and can be absorbed by the plant, instead of flowing away through the soil. Lawn sprinklers should not be used for more than about 10–15 minutes every second or third day.

Science Snippet

Oily sands

Many sands become water-repellent in the garden. They become coated in oily chemicals that make water run off instead of soaking in. This seems to happen more in summer when the soil dries out. (See Investigating question 20.)

Water supply policy

The state government sets the laws that control water use and supply. These provide a framework within which the Water Corporation can work. Saving water is becoming increasingly important to the government as people become more aware of the need to conserve this resource.

Homework book 2.12 Using water wisely

Rocks and minerals

Wise use of rocks and minerals is important. There is a limited amount of every mineral on Earth. There is not an endless supply so it is in everyone's interests not to waste them.

One mineral that we need to use carefully is oil. Oil is vital for making plastics and for using as fuels and lubricants. If we run out of oil we will need to find another way of making plastics. Using other energy sources instead of oil makes sense. It is wasteful to burn oil to make electricity, when we can make it in other ways. We can run car engines on other fuels—for example alcohol, which can be made from sugar. We can also use fuel cells that use hydrogen to run an electric motor. Oil is not necessary for fuel; it is just convenient.

Fig 2.10.9 Saving oil with fuel cell buses in Perth

Wise use of rocks and minerals should involve **rehabilitation** of mine sites after ores are removed. Most mining companies now employ environmental scientists to repair the damage done in mining. The repair usually involves replacing soil and replanting native vegetation on the site. However, this may require some careful research to identify problems such as toxic soil due to wastes or compacted soil from machinery. For example, in gold mining, the dangerous chemical arsenic is often used. This may end up in the tailings dumps. Bauxite mining produces alkaline soils that are not suitable for plant growth. Problems such as these must be solved if we are to mine sustainably.

2·10 FOCUS [Questions]

Use your book

Sustainability

1 What is meant by sustainability?

The enhanced greenhouse effect

2 What do we mean by 'the enhanced greenhouse effect' and which chemical is the main problem?

3 What heats up the carbon dioxide in the atmosphere?

4 Why is the enhanced greenhouse effect a problem and what can we do about it?

Ozone depletion

5 Which two health problems does the ozone layer in the atmosphere protect us from?

6 What is damaging the ozone layer and what can we do about it?

Acid rain

7 Where does the acid that falls as acid rain come from?

8 What can we do about acid rain?

Salinity

9 What has caused the water table to rise in agricultural areas?

10 Why is the rising water table a problem and what can we do about it?

Soil erosion

11 Why does soil erosion occur on hilly land that has been cleared of vegetation?

12 What can farmers do to protect against wind and water erosion?

Water in the house

13 Which three main activities in a typical home use the most water?

Rocks and minerals

14 Wise use of rocks and minerals through mining involves rehabilitation. What does this mean?

Use your head

15 Show how to calculate how much water you would use if you had a 10-minute shower.

16 Describe 10 things the people in your house could do to reduce water use.

17 Explain some measures you can take to reduce the amount of carbon dioxide gas you add to the atmosphere.

18 Design a water-efficient back garden for your home. Draw a 'bird's-eye view' plan of your garden.

>>

Investigating questions

19 Find out where the water meter is for your house.

- **a** Do a survey of the water use in your house by reading the meter before and after anyone in your house uses water for showering, washing clothes, washing dishes, watering gardens or any activity likely to use a large volume of water.
- **b** Work out a typical amount of water used for each of these activities.
- **c** Do a reading of the meter at the start of the week and then another at the end of the week and work out the average water use per person per day in your house.
- **d** Are you surprised at how much water you use?

20 Design an experiment to compare the permeability of sand with the permeability of sand which has been treated with soil wetting agent. You are testing the hypothesis that 'sand treated with wetting agent is more permeable than untreated sand'. You could use a similar set-up to that in Prac 1, Focus 2.8. This is an especially interesting experiment if your teacher can supply sand that is water repellent. If no such sand is available then use a potting mix—some potting mixes can become water repellent.

DYO

21 Write a paragraph on what is being done to rehabilitate salt-affected land. Government agricultural scientists and interested farmers have been experimenting for many decades. What have they discovered and what are they still trying to solve?

FOCUS 2·10 [Practical activity]

Prac 1
Focus 2.10

The greenhouse effect

Purpose

To investigate the greenhouse effect.

Requirements

Two 2-litre identical plastic drink bottles, 4 tablespoons of sodium hydrogen carbonate, 2 tablespoons of vinegar, two one-hole stoppers with Celsius thermometers, timer, sunny day (or strong lamp such as a 150 W flood lamp or halogen lamp), two retort stands and clamps.

Procedure

1. If possible do this in the sunshine; if not, use a strong lamp in the laboratory.
2. Place two tablespoons of vinegar in each bottle. Place two tablespoons of sodium hydrogen carbonate in ONE of the bottles. Leave this for about 20 seconds. It should be 'fizzing' because it is making carbon dioxide gas. Carefully push the stopper and thermometer in this bottle. Label this bottle CO_2. Be careful that the gas pressure in the CO_2 bottle does not pop out the stopper.
3. Place the other stopper and thermometer in its bottle.
4. Place both bottles in the light being careful to support them with a retort stand and clamp so they do not topple over. *Record the temperature into a suitable table every 2 minutes for about 25 minutes or until a clear difference is seen in the two bottles.*
5. Draw a graph of your results.

Questions

1. What were the independent and dependent variables?
2. What trend did you observe in your results?
3. Try to explain your results with some science ideas.
4. How did this experiment help you understand the greenhouse effect?
5. If there were problems with your experiment what could you do to improve it?

Review questions

Second-hand data

Interactive CW Crossword

1 The table opposite shows a number of planets and moons, and the strength of gravity (technically, this is called the acceleration due to gravity) on each. In this case gravity strength indicates the force of attraction between objects. They are arranged in alphabetical order. Refer to the table when answering the questions that follow.

Name of planet or moon	Gravity strength compared with Earth's	Atmospheric pressure compared with Earth's	Orbital period compared with Earth's (Earth years)
Earth	1.00	1.00 atmosphere	1.00
Earth's Moon	0.16	0.00 atmosphere	0.08
Jupiter	2.36	Very high	11.9
Mars	0.38	0.01 atmosphere	1.9
Mercury	0.38	0.00 atmosphere	0.24
Pluto	0.06	0.00 atmosphere	248
Saturn	0.92	Very high	29.4
Uranus	0.89	Very high	83.8
Venus	0.91	96 atmosphere	0.62

a What do we mean by a planet's 'atmosphere' and 'atmospheric pressure'?

b What is an orbital period?

c In the table above is there any relationship between the atmospheric pressure and the gravity strength of the planet or moon? What might explain your answer?

d In the table above is there any relationship between the orbital period and the gravity strength of the planet or moon? What might explain your answer?

2 Some students carried out an experiment in which they placed carbon dioxide in a 2-litre drink bottle. They left it out in the sun next to another drink bottle containing only air. Each bottle had a thermometer in a one-hole stopper in the top and they recorded the temperature in the bottles over 30 minutes. Their results are shown in the table below.

a Draw a labelled diagram of their experimental equipment.

b Draw a graph showing both sets of data on the one graph.

c Describe the trend in each graph.

d What hypothesis or idea do you think they were testing?

e Why did they use carbon dioxide in one bottle?

f Name the atmospheric problem they were obviously studying, and write a few lines describing what is happening in the Earth's atmosphere to cause the problem.

g Explain carefully in several sentences why conditions would be unsuitable for life on Earth without this effect to some extent.

h These results give us an example of what can happen when we are not careful and wise in our use of the resources of the Earth. Explain what we mean by sustainable use of resources, and describe some of the ways in which we have caused the problem these students studied in their experiment.

Temperature (°C) at different times

Contents of bottle	0 min	2 min	4 min	9 min	12 min	17 min	21 min	30 min
Carbon dioxide	22	24	30	32.5	35	36	36	39
Air	22	22	31	33	33	34	34.5	34.5

Open-ended questions/experimental design

3 What we know about astronomy has been discovered, bit by bit, by a large number of people. Some astronomers have made great contributions to our knowledge.

a Choose one name from the list on page 100, or find out the name of another individual whose contribution to astronomy has been outstanding.

>>

Review questions

b Research what they invented, or what they discovered, that was so important to our knowledge of astronomy. Are they remembered in any special way– for example, has anything been named after them?

c Report on what you have found. Present your report in any way you choose—for example, you could design a documentary film, compose a song, draw a comic strip, or create an interview.

The Astronomer's Hall of Fame includes:

- Tycho Brahe
- Nicholas Copernicus
- Galileo Galilei
- Edwin Hubble
- Christiaan Huygens
- Johannes Kepler
- Eratosthenes
- Hipparchus
- Ptolemy
- Isaac Newton
- Aristarchus of Samos
- Harlow Shapley
- Karl Jansky
- Pierre Laplace
- Joseph Louis Lagrange
- Edmund Halley
- Johann Galle
- Clyde Tombaugh.

4 The changing seasons are caused by the movement of the Earth and its position in space. We may observe some changes in the position of the Sun in the sky in summer and winter, and relate this to how warm or cold you feel. At the same time the rainfall seems to change and winds and clouds often appear different. Your task here is to explain as well as you can why the seasons change and with them the position of the Sun in the sky. Make sure you give a detailed account of why temperature changes with the season. About one page of writing, including any diagrams, will probably be enough.

Extended investigation/research

5 Every culture and civilisation has had its own idea about what the Sun, Moon, planets and stars are, and what they do. Every culture also has its own way to predict and explain weather and the seasons. Some of these ideas are more persistent than others. For example, the English names for the days of the week include one named after the Sun, and another named after the Moon. Many people know the 'star sign' associated with their birth date, but few know where, when and why the idea of astrology began.

Read through all these instructions before you begin.

a Your first task, as a group, is to plan your research time (for example, make a time plan that shows when each stage should be finished). Indicate what each group member is expected to do, when you will be working on the research in class and when you will be working out of class. Make sure each member of the group has a copy of the time plan.

b Find out the names and locations and approximate start and finish dates of some cultures and civilisations. As a group, create a timeline that shows the dates for the cultures you have chosen. Check your group's time plan and adjust it if you need to.

c Choose one culture or civilisation each for further research. You might, for example, be interested in tracing the cultures of your own ancestors. As a group, discuss and negotiate your choices to make the spread of times and locations of the cultures you are researching reasonably wide.

d Find out how the culture or civilisation of your choice described and explained the Sun, Moon, planets and stars, OR how they explained and predicted the weather and the seasons. Write a report that summarises what you have found out. Check your group's time plan and adjust it if you need to.

e Find out if any of the ideas you have researched about the culture or civilisation of your choice are still with us in our society. Write a report that summarises what you have found out. Check your group's time plan and adjust it if you need to.

f How well did you plan your time? Is there any advice you would give yourself about planning in the future? Write a brief comment about your planning.

g As a group, make a poster, presentation or web page to explain your research results to others.

Homework book 2.13 Earth and Beyond crossword

Homework book 2.14 Sci-words

3 Energy and change

Curriculum guide learning focus

- the nature of energy—its sources, receivers and uses
- the different ways in which energy can be stored, for example as internal energy, electrical energy and chemical energy
- energy converters such as light bulbs and electrical generators
- efficiency of energy transfer
- forms of energy such as sound, heat, magnetism and light, and their interactions with different materials
- transfer of energy in different ways according to the form of energy
- types of forces, such as magnetic, electric, gravity, mechanical and friction
- detecting and measuring forces

This section on Energy and Change also contains information which will help students with the outcomes of Investigating Scientifically, Communicating Scientifically, Science in Daily Life, Acting Responsibly, and Science in Society.

Outcome level descriptions

The outcome level descriptions covered by this part of the book are EC 2, EC 3 and EC 4.

FOCUS 3·1 Storing energy

Context Everything we do involves using energy. However, energy means different things to different people. Can you explain what energy actually is? Talking about energy is difficult. First, we have to agree on what we mean when we use the word.

Energy

Cars use energy when they accelerate. Refrigerators use energy to cool down food and drinks. We use energy to walk, talk and breathe. Everything we do uses energy. The effects of energy are usually easy to see but, apart from visible light, energy itself is invisible and is often hard to detect.

The more energy something has, the bigger its effects can be. For example, a cyclone has more energy than a gentle breeze. We cannot see the winds themselves, or the energy they carry, but we can easily see what these winds do to our surroundings. A gentle breeze may lift and tumble waste paper, or wave the branches on a tree. A cyclone may lift the roof off a house, break off branches, or uproot a whole tree.

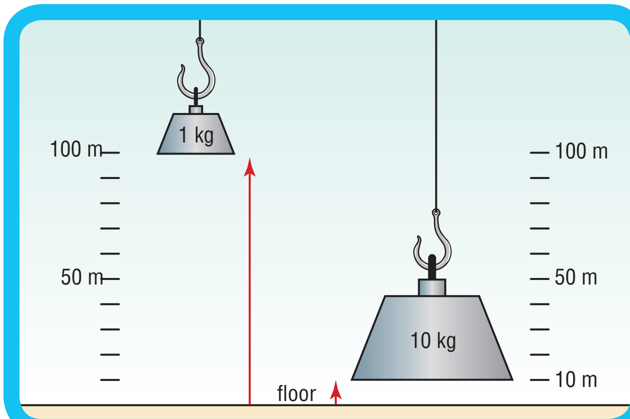
Work is the scientific name for the physical effects of energy. Lifting a piece of paper involves very little work, while lifting a house roof involves a lot of work. One way of explaining energy is that **energy** is what allows us to do work.

Fig 3.1.1 Some effects of high-energy winds

We measure energy and work in units called joules (J). The joule is a fairly small unit, so we commonly use kilojoules (kJ) or megajoules (MJ). One joule is the energy you use when you lift one kilogram about 10 centimetres. One joule will also lift 10 kilograms through one centimetre.

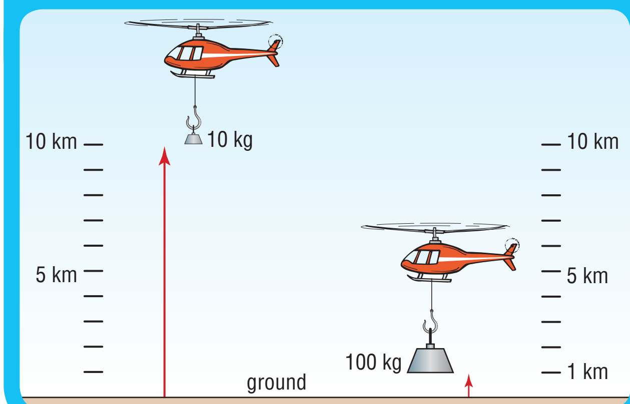
A kilojoule is 1000 joules. It is the energy you would use to lift a kilogram about 100 metres, or 10 kilograms through 10 metres. How far could you lift 100 kilograms by using a kilojoule?

A megajoule is 1 000 000 joules. One megajoule could lift 10 kilograms through 10 000 metres, or 10 kilometres. How far would a megajoule allow you to lift 100 kilograms?



Some effects of a kilojoule of energy. *Fig 3.1.2*

Fig 3.1.3 Some effects of a megajoule of energy.



Kinetic energy

If you were hit by a moving ball, would it be easier on you if the ball was heavy or light? Would it be easier on you if the ball was travelling slowly or quickly?

Kinetic energy is the energy an object has because it is moving. For example, the energy carried by wind (moving air) is kinetic energy. How much kinetic energy a moving object has depends on two factors: its speed and its mass.

A child (mass 40 kilograms) running at 5 metres per second has 500 joules of kinetic energy. An adult (mass 80 kilograms) running at the same speed has 1000 joules of kinetic energy. Doubling the mass gives double the kinetic energy.

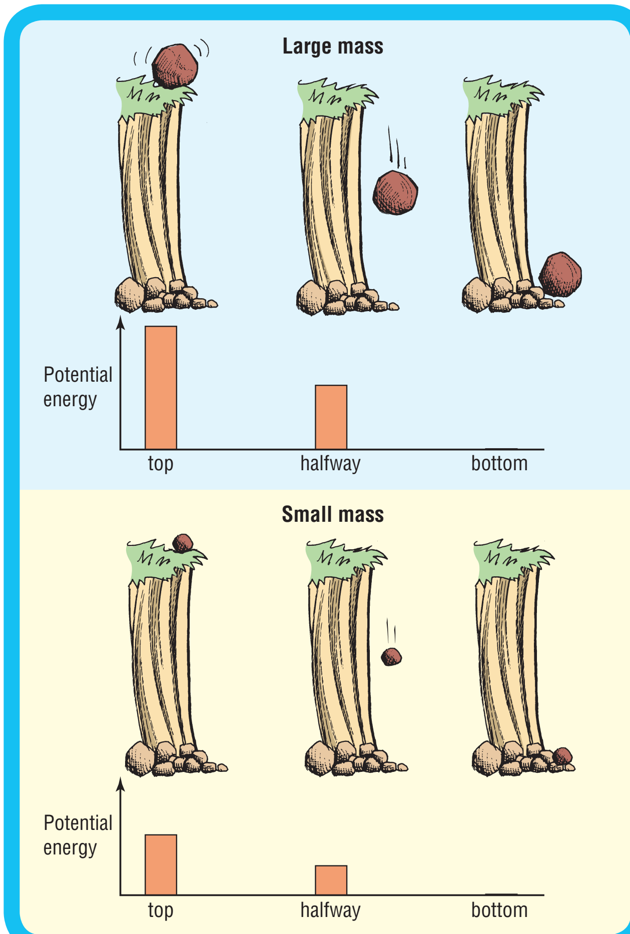
An 80-kilogram adult running at 5 metres per second has 1000 joules of kinetic energy. The same adult running at double the speed, 10 metres per second, has 4000 joules of kinetic energy. That is, doubling the speed increases the kinetic energy four times.

A fast-moving child may have the same kinetic energy as a slower moving adult. *Fig 3.1.4*

An object's speed thus has a bigger influence on its kinetic energy than does its mass. When an object stops completely, its mass is unchanged, but its kinetic energy becomes zero.

Potential energy

Potential energy is the energy an object has because of its position. The energy of a rock poised on the edge of a cliff is called gravitational potential energy. The rock has gravitational potential energy because gravity pulls down on it. The rock has the ability, or potential, to fall towards the centre of the Earth. When it falls, it can do work.



How much gravitational potential energy a rock has depends on both its mass and its position above the ground. *Fig 3.1.5*

The energy in a stretched rubber band is called elastic potential energy. The rubber band has elastic potential energy because it tends to return to its original, unstretched shape. That is, the rubber band has the potential to snap back. As it snaps back, it can do work.

How much potential energy an object has depends on two factors: its mass and its tendency to move in a particular direction. Consider the bungee jumper in Figure 3.1.6. At the moment the photo was taken, the bungee rope was stretched as much as it could be. That is, the jumper was at the lowest point in the jump.

Science Snippet

Tsunamis

Earthquakes happen when big chunks of rock crack and move. Trillions of tonnes of rock all moving together releases huge amounts of energy. If a quake occurs under the ocean, some of the energy released may move the water itself. The result is a fast-moving, very large wave called a tsunami. When they reach land, tsunamis are taller than ordinary ocean waves, and the water keeps coming in for a long time. The energy they deliver to the land can do a great deal of damage. Luckily, tsunamis are fairly rare events.

Fig 3.1.6 A stretched bungee rope gives the person using it potential energy.

The jumper had quite a lot of elastic potential energy. This was because of the stretched rope. The rope gave him a tendency to move upwards as the rope snapped back to its original length. The jumper also had some gravitational potential energy. This was because of his position some distance above the ground. Gravity gave him a tendency to move downwards. He had no kinetic energy at all, because at that moment he was not moving. What would the energy mix be like a little while later?

Internal energy

So far, you have looked at large objects such as cars, balls and rocks. Scientists believe that all matter is made of tiny particles called atoms. These atoms can move by vibrating, spinning, and travelling from one place to another. This gives them kinetic energy. Atoms can also attract or repel each other, giving them potential energy.

The kinetic and potential energy of the atoms in an object is called its **internal energy**. People often talk about heat when they really mean internal energy.

Every object, from ice cube to ocean, has internal energy. The amount of internal energy depends on the number and mass of its atoms, how much they move and how much they attract or repel each other.

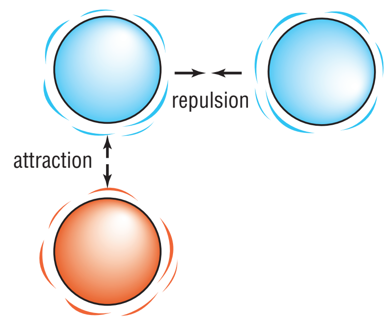


Fig 3.1.7 Atoms move, attract and repel, creating internal energy.

The kinetic energy and potential energy of an object can change from a large value to zero, such as when a rock falls from a cliff top. After the rock reaches the ground, its kinetic and potential energies are zero. They have become internal energy. That is, the atoms in the rock vibrate a bit faster after it lands. What happens to the kinetic and potential energy of a bungee jumper—that is, where does the energy go?

It is easy to change the kinetic and potential energy of an object into internal energy. Changing internal energy into kinetic or potential energy of an object is much more difficult.

Prac 1 p.105
Prac 2 p. 106

Homework book 3.1 Deciding how energy is stored

FOCUS 3•1 [Questions]

Use your book

Energy

1. What is a joule?
2. How many joules are there in a kilojoule?
3. How many joules are there in a megajoule?

Kinetic energy

4. What two factors determine how much kinetic energy a sprinter has?
5. A moving ball has kinetic energy. What happens to a ball's kinetic energy if you throw the ball twice as fast?

>>

Potential energy

6 What determines how much potential energy an object has?

7 What are two ways that you could have potential energy?

Internal energy

8 **a** What kinds of motion give atoms their kinetic energy?
b What gives atoms their potential energy?

Use your head

9 How far could you lift a one-kilogram bag of flour using a megajoule of energy?

10 Express the following amounts of energy in joules:
a 1 megajoule
b 25 kilojoules.

11 How many kilojoules are there in:
a 10 megajoules?
b 6500 joules?

12 How many megajoules are there in:
a 1000 kilojoules?
b 14 000 000 joules?

13 Consider the person on the trampoline in Figure 3.1.8.
a At what point will she have the greatest gravitational potential energy? Explain your answer.
b At what point will she have the greatest elastic potential energy? Explain your answer.
c When she hops off the trampoline onto the ground, where does her energy go?

A person on a trampoline *Fig 3.1.8*

Investigating questions

DYO

14 Elastic bands can store energy when you stretch them. If you hang weights on an elastic band, you can measure how much the elastic stretches. Design an experiment to find out what effect the size of the weight hanging from the elastic band has on the amount of stretch. Carry out your experiment. Do the results show a pattern that you could use, for example to predict the amount of stretch for a weight that you did not use? Explain.

15 **a** How much energy do humans use in total each year?
b Where does this energy come from?

3•1 FOCUS [Practical activities]

Prac 1 Focus 3.1

Energy from a burning nut

Purpose

To measure the chemical energy released when a nut reacts with oxygen.

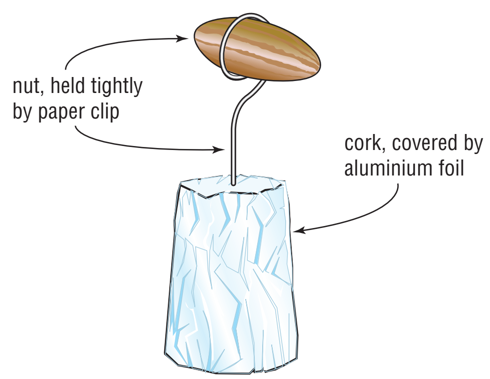
Requirements

Paper clip, nut (eg brazil nut, peanut), aluminium foil, cork, clamp, 10 mL measuring cylinder, test tube, thermometer, Bunsen burner, retort stand, matches.

Procedure

1 Straighten out the paper clip, then use one end to make a holder for the nut.

2 Use a small piece of aluminium foil to cover the cork, then push the end of the paper clip into it as shown.



Setting up your nut and its holder *Fig 3.1.9*

>>

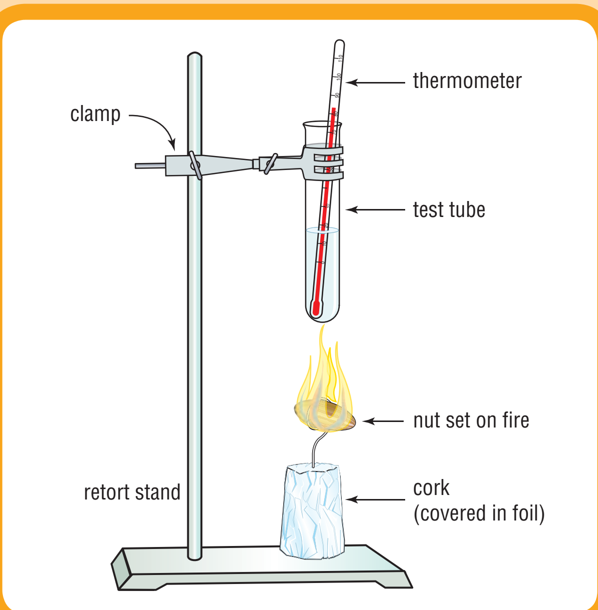


Fig 3.1.10 Setting up your equipment

3 Set up the equipment as in Figure 3.1.10. Adjust the clamp so the test tube is 2–3 cm above the nut.

4 Take the measuring cylinder and put exactly 5 mL of water into the test tube.

5 Measure the temperature of the water in the test tube. Leave the thermometer in the test tube, *and write down the result.*

6 Move the nut in its holder out from under the test tube and place it on a bench mat about 30 cm away from the test tube. Put on your safety glasses, light the Bunsen burner and hold the nut in the flame. When the nut starts to burn, quickly move it back under the test tube.

7 When the burning stops, use the thermometer to stir the water gently, then measure the temperature of the water. *Write down the result.*

8 Work out how many degrees difference there is between the starting and the final temperatures of the water. *Write down the temperature change.*

9 Every 1°C change in the temperature of 1 mL of water uses 4.2 joules of energy. You used 5 mL of water, so every 1°C increase involved 5 × 4.2 J, or 21 J. If you multiply the temperature change by 21, you will calculate how many joules have been absorbed by the water. Work out how many joules your water absorbed, *and write down your answer, showing any working out you did.*

10 When all groups have finished the experiment and worked out the result, compare the results, for example by putting all the results up on a board. *Record the class results.*

Questions

1 Did every group in the class get the same result? Why, or why not?

2 Did this experiment give you a good measure of the energy in the nut? If you are not sure, consider whether all the energy from the nut ended up in the water.

3 There are no actual fires burning in your body to extract the energy from food. What is the name of the body process that happens in your cells at normal temperatures to obtain energy from food and oxygen?

4 Why were you asked to cover the cork with aluminium foil?

5 What did you learn in this activity? Discuss or brainstorm this as a group or as a class. Write down a summary of the ideas discussed.

Prac 2 Focus 3.1

DYO

Energy-storing devices

Purpose

To investigate ways that we store energy.

Requirements

Access to the Internet and/or journals such as *New Scientist*.

Procedure

1 Begin by deciding what resources you are going to use, and how you will show your final answers to other groups (eg as a poster, a web page, a song, a TV news item …)

2 Read the questions below very carefully. *Write down in your notebook the main or key words from each question.* If your teacher has given you a photocopy of the questions then underline the main or key words on the photocopy. The words you have identified will help you search for information.

3 In your group, discuss, and agree on, the key words for each question. *Write down in your notebook the agreed key words from each question.*

4 Decide who in your group will answer which question (choose one question each).

5 Carry out your search. *Write down, photocopy or print out the useful information you find.*
6 Show your information to the others in your group, and look at their information. Discuss how well your key words worked, especially if you tried other key words as you searched. Also, discuss what to write as answers to the questions.
7 *Write down your answers to the questions.*
8 Create your presentation and show other groups what you found out.
9 In your group, discuss which presentation was the most effective, and why. *Write down what you have decided.*

Questions

1 If you want to operate a portable electric device such as a portable CD player, you will have to put batteries into it. Does a battery store energy as kinetic, potential or internal energy? What is the evidence for this?
2 A solar hot water system absorbs energy from sunlight and stores it in the water in a storage tank. Does a solar hot water system store the energy as kinetic, potential or internal energy? What is the evidence for this?
3 We get the energy we need to stay alive from the food we eat. Does food store the energy as kinetic, potential or internal energy? What is the evidence for this?
4 Some toys and appliances store energy by stretching or compressing a spring. Does a spring store the energy as kinetic, potential or internal energy? What is the evidence for this?
5 One way to store energy is in a flywheel. What is a flywheel? What sort of device or appliance uses a flywheel? Does a flywheel store the energy as kinetic, potential or internal energy? What is the evidence for this?

FOCUS 3.2 Transferring energy

Context

When you throw a ball, switch on the television, or light a Bunsen burner, you are transferring energy from one carrier to another. We can work out where the energy we use comes from. We can also trace what happens to it when we have finished with it.

This gives us a better grasp of how we can reduce the cost of energy use, both to ourselves and to our children. Where we get energy from, what we do with it and where it goes after we're finished with it is vitally important in our society.

Energy carriers

Objects can store energy as kinetic, potential or internal energy. A bird sitting on a tree branch has gravitational potential energy. It also has internal energy. The Earth goes around the Sun. The Earth's movement gives it kinetic energy. The Earth's position, separated from but attracted to the Sun, gives it potential energy. It also has internal energy, so the Earth has all of these at the same time.

Fig 3.2.1 An energy carrier

Not all energy has to be carried by objects. Light, for example from the Sun, is energy that can travel through empty space. Visible light, radio waves, infrared radiation, ultraviolet radiation, microwaves and X-rays are all different examples of a single type of energy carrier. We call it electromagnetic radiation, or emr for short.

Energy from the Sun can be useful. *Fig 3.2.2*

Everything is made of atoms. Remember that atoms can store potential and kinetic energy too. Some potential energy that is stored in atoms can be released through chemical reactions such as burning. We call this chemical potential energy, or just **chemical energy**.

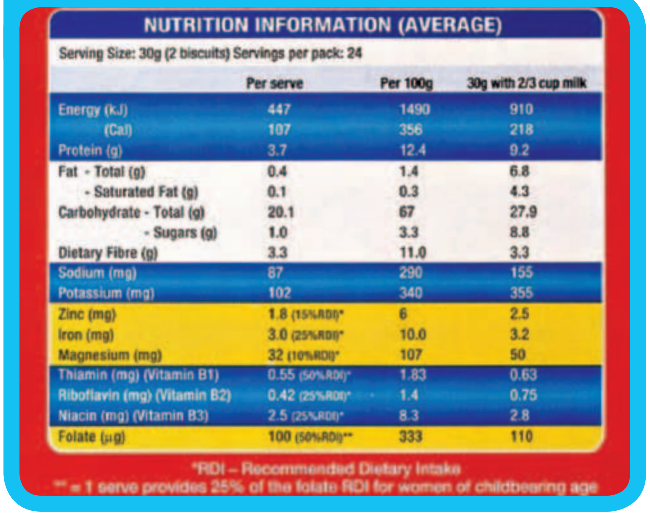
Drag and Drop CW Interactive

Energy sources

Over thousands of years, people have worked out which objects or chemicals can give up stored energy that we can use easily. We call these **energy sources**. We get our energy from all kinds of sources.

For you to be able to move around, you have to take in an energy source—which we call food. **Food** stores energy as chemical potential energy. In your body, food reacts with oxygen. This chemical reaction releases some of the chemical potential energy stored in the food and the oxygen. The reaction also produces chemical wastes such as carbon dioxide and water. These wastes have less chemical potential energy stored in them than the food and oxygen did.

Fig 3.2.3 Packaged food labels indicate the energy that your body can obtain through the reaction of the food with oxygen.


NUTRITION INFORMATION (AVERAGE)

Serving Size: 30g (2 biscuits) Servings per pack: 24

	Per serve	Per 100g	30g with 2/3 cup milk
Energy (kJ)	447	1490	910
(Cal)	107	356	218
Protein (g)	3.7	12.4	9.2
Fat - Total (g)	0.4	1.4	6.8
- Saturated Fat (g)	0.1	0.3	4.3
Carbohydrate - Total (g)	20.1	67	27.9
- Sugars (g)	1.0	3.3	8.8
Dietary Fibre (g)	3.3	11.0	3.3
Sodium (mg)	87	290	155
Potassium (mg)	102	340	355
Zinc (mg)	1.8 (15%RDI)*	6	2.5
Iron (mg)	3.0 (25%RDI)*	10.0	3.2
Magnesium (mg)	32 (10%RDI)*	107	50
Thiamin (mg) (Vitamin B1)	0.55 (50%RDI)*	1.83	0.63
Riboflavin (mg) (Vitamin B2)	0.42 (25%RDI)*	1.4	0.75
Niacin (mg) (Vitamin B3)	2.5 (25%RDI)*	8.3	2.8
Folate (µg)	100 (50%RDI)**	333	110

*RDI – Recommended Dietary Intake
** = 1 serve provides 25% of the folate RDI for women of childbearing age

Another important energy source is fossil fuel. **Fossil fuels** include coal, natural gas and petroleum. All of them can burn–that is, they can react with oxygen. Fossil fuels and oxygen are high-energy chemicals. They store potential energy. Burning releases some of this energy. Again, the products are low-energy wastes such as carbon dioxide and water.

Batteries use high-energy chemicals that do not burn. The high-energy chemicals turn into low-energy wastes. This releases chemical potential energy.

Transferring energy

To transfer energy is to move energy from one place to another, such as when you throw a ball. Throwing involves the transfer of energy from you to the ball. You get chemical potential energy from the reaction of food and oxygen. Your body uses this to move your arm, giving it kinetic energy. The ball you throw gets some of that kinetic energy, and flies off.

Our society is very dependent on the ability to quickly and easily transfer energy from one place to another. One example is electricity generation. Fossil fuels are burnt by energy companies. This gives energy to tiny particles called electrons. Electrons in the electrical mains transfer energy from the power station to your house. Appliances such as CD players, toasters and washing machines get energy this way. They use the energy of the electrons to create sound, heat or movement.

Some appliances get energy from batteries. In a battery, high-energy chemicals react. This releases chemical potential energy. Electrons absorb this energy. They transfer energy to run the appliance. When the reacting chemicals are used up, the battery is 'flat'. The flat battery is then full of low-energy wastes. Some special batteries can be recharged. Recharging turns low-energy waste back into high-energy chemicals. This is safe only when you use rechargeable batteries. Do not try to recharge ordinary batteries.

Prac 1 p. 112
Prac 2 p. 113

Science Snippet

Buying energy

When you turn on an electric light or an electrical appliance, the energy you use has to be paid for. There are two easy ways to buy energy for electrical devices—in batteries, or through the mains. Mains electricity is much cheaper; batteries can be more convenient. It costs hundreds, even thousands of times as much to run an appliance for an hour on batteries compared with using the mains supply. This does not include the environmental cost of dumping used batteries and adding heavy metals to landfill.

Fig 3.2.4 Throwing a ball involves some transfer of energy.

In power stations energy is transferred from fossil fuels and oxygen to the electricity grid. Fig 3.2.5

From the moment your alarm clock goes off to the moment you turn off the light at night, you depend on the transfer of electrical energy. Try to imagine what life was like before there were power stations and electrical appliances.

Where does the energy go?

Scientists believe that energy cannot be created or destroyed, except in nuclear reactions such as inside stars. In your daily life energy can only be released or absorbed. What happens to the energy of a thrown ball when it lands and rolls to a stop? What happens to the energy of a vehicle when it brakes?

Science Snippet

Hot brakes

For many years, vehicle brake linings were made of asbestos. This material resists the effects of heat. It also wears down slowly as the brakes are used. Every time a car braked, a little bit of asbestos entered the atmosphere. As our society slowly came to recognise the dangers of breathing in even small amounts of asbestos, manufacturers began to search for other materials that could do the job without the bad effects.

As a moving object slows down, its kinetic energy transfers away from the object. Usually, the atoms around it get most of this kinetic energy. The temperature of the material increases as its atoms move faster. Thus, slowing down a moving object heats up its surroundings. You can see this in Figure 3.2.6.

Bicycle brakes are another example. The bike brakes slow the bicycle by rubbing on the wheels. The bicycle's kinetic energy transfers to the atoms of the brake lining. These atoms vibrate faster and faster as more energy goes into them. As the bicycle slows down, the brake lining's internal energy increases. This quickly heats up the brake lining. The brake lining then slowly cools down by losing its extra internal energy. Most of this energy goes to the atoms in the wheel and the air around it. All the bicycle's kinetic energy is absorbed by atoms around it, so those atoms vibrate a little faster.

Fig 3.2.6 Braking hard may cause some of the rubber in the wheels and some of the road surface to vaporise.

Efficiency

We transfer energy to do work that we think of as 'useful'. Useful work might be lifting a weight, pushing a stalled car, or cooking a meal. Whenever we transfer energy, some energy goes into places we do not want it to go. This 'lost' energy is not useful. The lost energy almost always becomes internal energy.

Energy loss makes the transfer process inefficient. Take, for example, a light bulb in your house. Electrons transfer energy from the power station to a thin wire or filament in the bulb. The atoms in the filament gain kinetic energy, and the filament becomes white-hot. It releases energy as a mixture of visible light and invisible infra-red rays. The visible light is useful to us, the invisible rays are not.

Efficiency is a way to measure how much of the transferred energy is useful to us. A light bulb is about 3 per cent efficient. This means that out of 100 joules delivered by the electrons, about 3 joules

Fig 3.2.7 Fluorescent lights are more expensive to buy than ordinary light bulbs, but are more efficient.

becomes visible light. The other 97 joules become 'useless' invisible infra-red rays. You pay the energy company for 100 joules, but can use only 3 joules. Imagine having to buy 100 movie tickets, then throwing 97 of them away and being able to use only three!

The petrol engine of a car is about 30 per cent efficient. That means that out of every 100 joules released by burning fuel, about 30 joules turn into the kinetic energy of the car. The other 70 joules heat up the car and its surroundings.

Homework book 3.2 Energy changes

3·2 FOCUS [Questions]

Use your book

Energy carriers

1 What are three ways that objects can store energy?

2 Give two examples each of an energy carrier that has:
- **a** both kinetic and potential energy
- **b** potential, kinetic and internal energy.

Energy sources

3 How does burning release energy from fossil fuels?

4 Your body needs food and oxygen to stay alive. What do these substances do in your body that is so important?

5 **a** What are two chemical wastes produced by burning fossil fuels?
- **b** Why can't we get energy from these chemical wastes?

Transferring energy

6 Your friend Oscar has a great idea for making money and helping the environment at the same time. Oscar wants to collect old batteries, recharge them and sell them for a profit. Is this a good idea? Explain.

7 How does Western Power transfer energy from a power station to a suburban house?

8 When you plug an electric fan into the mains and turn it on, the fan blades quickly gain kinetic energy.
- **a** How do we know that the blades gain kinetic energy?
- **b** Where does the energy come from?

Where does the energy go?

9 Why do the brake linings get hot when a car comes to a stop?

10 Make a list of the energy changes that occur if you throw a ball into the air and let it fall to the ground.

Efficiency

11 What makes energy useful?

12 If a washing machine is 25 per cent energy-efficient:
- **a** what percentage of the energy it converts is useful?
- **b** what percentage of the energy it converts is wasted?
- **c** what happens to all the energy it converts?

Use your head

13 Describe two situations in which you transfer energy to another person or object.

14 Describe two situations in which another person or object transfers energy to you.

15 If you rub your finger along the top of the desk, your finger starts to feel hot. Explain this in terms of the energy changes involved.

16 When you run a race, there are many changes in energy both inside and around your body. Make a list of the energy changes that happen during a race.

Investigating questions

17 Stretching or relaxing an elastic band involves energy changes. Any difference you detect tells you about the energy that has gone into, or come out of, the elastic band. You can feel the difference when you:

DYO

- touch an elastic band to your lower lip
- then quickly stretch it and again touch the stretched elastic to your lip
- then relax the elastic band to its original length and touch it to your lip.

Be careful—if the elastic band breaks, it can hurt.
- **a** Is the elastic band colder or warmer when stretched?
- **b** Do you have to put energy into the elastic band to stretch it? What is the evidence for your answer?

18 How much does it cost to run a particular appliance (say, a CD player or a washing machine) for one hour? To find out, you will need to choose an appliance, and then answer the following questions:
- How much does your energy company charge for one unit of energy?
- How many joules are there in one unit of energy?
- How much does one joule cost if you buy it from an energy company?
- How much energy does the appliance use in one hour?
- What is the cost of running the appliance for one hour?

FOCUS 3·2

Practical activities

Prac 1
Focus 3.2

Build your own energy transfer device

Purpose

To build and test a machine that transfers energy.

Requirements

Elastic band, small cotton reel, matches, sticky tape, metal or plastic washer.

Procedure

1 Push the elastic band through the hole down the middle of the cotton reel.

2 Break a match and push a short piece of it through one end of the elastic band. Use a small piece of sticky tape to hold the match in place (see Figure 3.2.8). This will anchor one end of the elastic band.

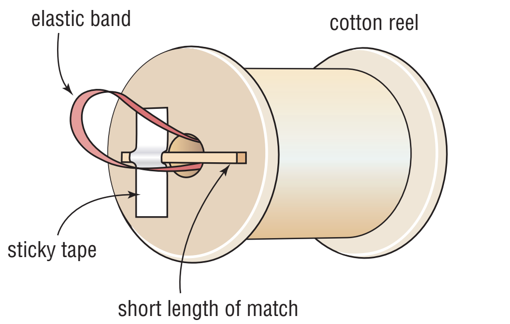
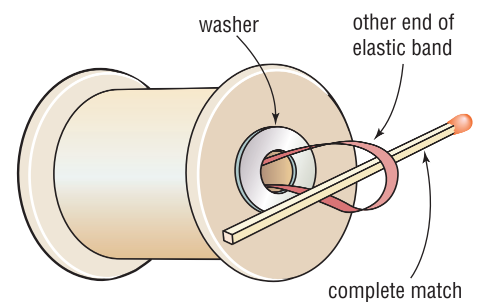


Fig 3.2.8 Tape the small piece of match to hold one end of the elastic band in place.

3 Slip the washer over the elastic band at the other end of the cotton reel, then push a whole match through the loop of elastic that sticks out of the washer. The ends of the match must extend past the edge of the cotton reel, as in Figure 3.2.9.

4 Wind up the elastic band by twisting it, using the match at the washer end. Keep hold of the match so it does not unwind. If the match breaks, replace it and use fewer turns to wind it up.



Push a match through a loop of elastic at the other end of the cotton reel. *Fig 3.2.9*

5 Put the device on the floor, then let go. *Write down what happens.*

6 Design and carry out an investigation to find out if there is a connection between how many times you turn the match to wind up the elastic, and how far the device travels. *Write down what you discover.*

Questions

1 What is the relationship between potential, kinetic and internal energy in this device? Discuss or brainstorm this as a group or as a class. Write down a summary of the ideas discussed.

2 Is there a relationship between the number of turns used to wind up the elastic, and the distance the device moves? Write down your answer, and the evidence for it.

3 If you were in charge of marketing a toy based on this device, what would be a suitable name for the toy? Write down your answer and explain why you think the name is suitable.

Prac 2
Focus 3.2

Energy transfer

Purpose

To observe and describe energy transfer in a number of situations.

Requirements

Stations around the laboratory with energy transfer equipment set up at each one.

Procedure

1 Prepare a table to record your observations and inferences. Part of a suitable table is shown below. Your table should have as many rows as there are stations.

Station	Observations	Evidence that energy was transferred

2 Your teacher will organise you into working groups. Go to one of the stations where equipment has been set up. Your teacher will guide you about which group goes to each station. Read the instructions at each station carefully before touching any of the equipment.

3 Carry out the experiment set up at that station. *Record any observations in the table.*

4 Discuss, in your working group, the evidence of energy transfer. When you are sure you understand what has happened at the station, *write down your evidence.*

5 Your teacher will tell you when to move to another station, and the direction in which you will move. When you get to the next station, repeat the procedure. *Write down your observations and evidence at each station.*

6 When you have visited each station, return to your desk. Your teacher will organise you into discussion groups.

7 Show your information to the others in your discussion group, and look at their information. Discuss any differences in your results, or any parts of the activity you found hard to understand. Also, discuss what to write as answers to the questions at the end of this activity.

8 *Write down your answers to the questions.*

Questions

1 Could any of these energy transfers be useful to us in our society or everyday lives? Explain your answer.

2 Which of the stations showed that you can transfer the energy from high-energy chemicals to other objects? Explain your answer.

3 Which of the stations showed that you can transfer energy from high potential energy objects to other objects? Explain your answer.

4 Describe a situation in which you could transfer kinetic energy from one object to another.

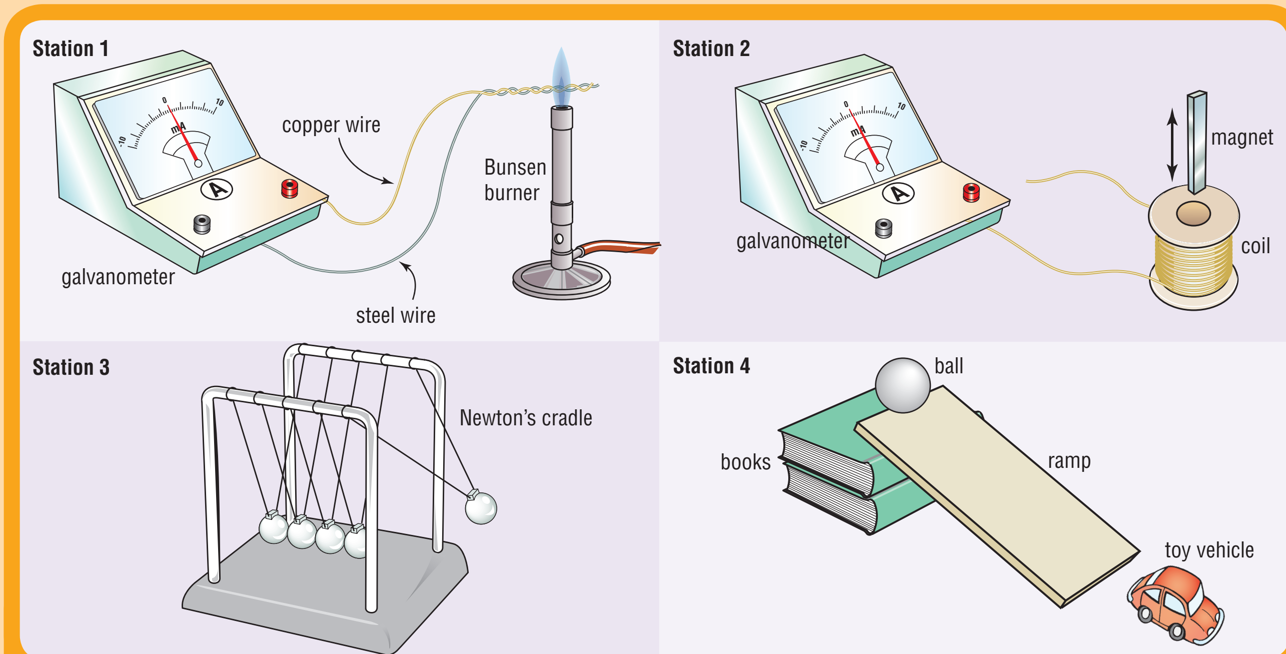


Fig 3.2.10 Stations around the laboratory

FOCUS 3.3

Using energy

Context

Whatever you do, from travelling to sitting still, you use energy all the time. We use energy to get from one place to another, to communicate and to be entertained.

Think back to the last time your suburb experienced a blackout. Even for a short time, you might have found it strange and inconvenient to be without electrical energy.

Energy in our daily lives

We depend on energy to keep our bodies functioning. This is true whether we are just sleeping, or running a race. In our society, we also depend on energy for a huge range of other tasks. These include temperature control, transport, communication and entertainment.

You have seen that humans get energy from the reaction of food and oxygen. Energy needs vary from one person to the next, and depend on age, size and the level of activity. For example, an adult who rides a bicycle to make deliveries needs more energy each day than an adult who works at a computer.

There is a minimum amount of energy we all need just to maintain basic functions such as heartbeat and breathing. This is why we use energy even when we sleep. The average adult minimum energy requirement ranges between about 8 and 13 megajoules (MJ) per day. One megajoule is one million joules. For comparison, burning a litre of petrol produces about 34 megajoules.

Energy converters

Many of the machines and appliances we use to make our lives easier and more comfortable are basically energy converters. Our bodies are energy converters too.

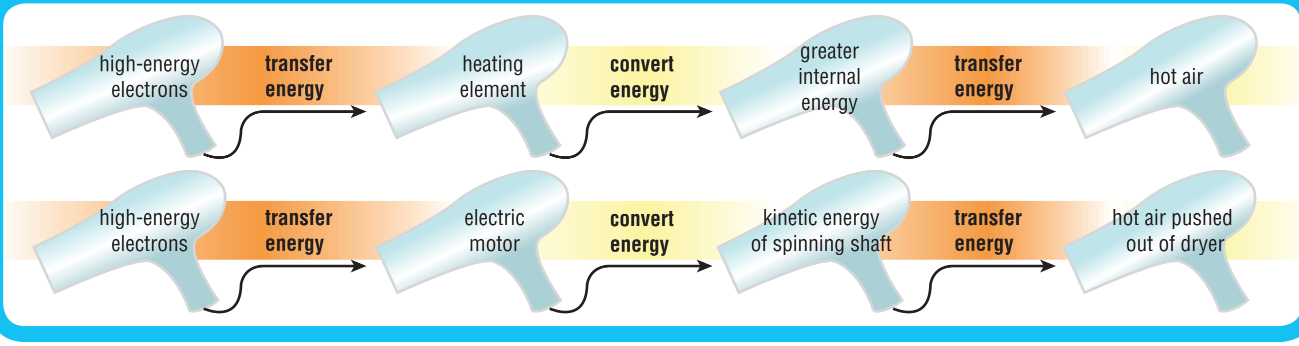
One example of energy conversion is the way a hair dryer works. When you connect the appliance to the electrical mains and turn it on, high-energy electrons from the mains transfer some of their energy into the appliance. Part of the transferred energy goes into a metal wire called a heating element. The energy from the mains makes the atoms in the element vibrate more. This energy conversion raises the temperature of the heating element, making it red-hot.

Another part of the energy from the mains goes into an electric motor. The motor converts this energy into kinetic energy of the motor shaft, so it spins around. A fan attached to the shaft also spins, and its blades push cool air past the heating element. The element transfers some of its internal energy to the air, making it warmer. The kinetic energy of the warm moving air carries it out of the dryer and onto your wet hair.

Some of the internal energy of the warm air transfers to the water in your hair. The water molecules vibrate more, and the water warms up.

Some devices that use energy in our daily lives **Fig 3.3.1**

Fig 3.3.2 How energy is used in a hair dryer



Warm water evaporates faster then cold water, so your hair dries faster. Even a simple everyday occurrence such as using a hair dryer involves a complicated chain of energy transfers and conversions.

Energy receivers

Some devices are designed to receive energy that is being transferred from far away. Our society relies heavily on energy receivers for entertainment and communication. The process of receiving energy also involves chains of energy transfers and conversions.

Consider your television aerial. This is an energy receiver. The process starts at the broadcast tower, where the signal from the station is sent out. The tower radiates energy as a changing pattern, or signal, of electromagnetic radiation. The emr signal carries energy outwards from the tower at the speed of light, 300 000 kilometres per second.

Every television aerial is an energy receiver. Fig 3.3.3

When the emr from the tower passes across a television aerial, it transfers some of its energy to electrons in your television aerial. These electrons move along the aerial in time with the pattern in the signal. Their new kinetic energy is transferred from the aerial, through a cable, to the inside of the television set. Electronic devices in the set use the pattern in the signal to control how the picture and sound are made.

A microwave oven uses the same idea to heat food. A device inside the oven broadcasts microwaves, which transfer energy to water molecules in the food. The water molecules move faster as they receive this

Science Snippet

The ghost in your television

The electrons in a television aerial only vibrate with the signal if the signal is strong and the aerial is pointed in the right direction. Other signals make the electrons vibrate differently. This interference creates unwanted pictures and sound.

Often the signal reflects from nearby buildings. The weaker reflected signal arrives a split second after the main signal. This causes a second, fainter picture to form alongside the real picture. The extra signal is called a 'ghost'. Sometimes ghosts appear when an aeroplane flies past, sending reflections to the aerial. Your television set then acts as a radar receiver!

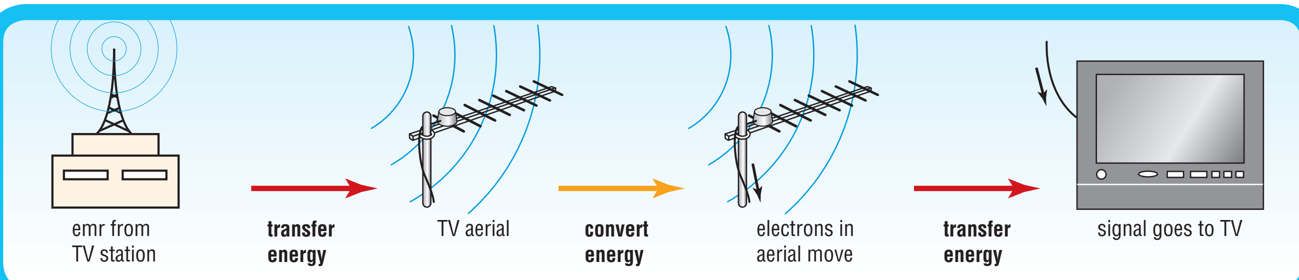


Fig 3.3.4 What happens to the energy when you watch television?

energy, increasing the internal energy of the food. Because microwaves can penetrate the food before being absorbed, the cooking happens inside as well as on the surface of the food.

Prac 1 p. 117

Science Snippet

Power mad

You have more electrical gadgets than your parents did when they were your age. Your parents had more electrical devices than their parents did. Houses built before 1960 rarely had more than a single power point in each room.

Think about all the electrical devices, such as mobile phones, CD players, DVD players, computers, hair dryers, electric toothbrushes and so on, that you own or personally control. These contribute to the amount of energy that you expect to use in a day. What do you think your children might expect to have and use?

Power

In science, we often give special meanings to common words. One example is the word 'power'. In everyday language, power means 'strength'. The science meaning of power is 'how fast energy is being used'. A high-power motor uses energy faster than a low-power motor. This means that the high-powered motor will be able to do the same work in less time.

We measure power in watts. One watt is the amount of energy being transferred and converted, or used, at the rate of one joule every second. You have probably seen power ratings on electrical appliances or machines. For example, the power rating of a light bulb might be 60 watts or 100 watts.

A 100-watt light bulb uses 100 joules of energy every second. A 60-watt bulb uses 60 joules every second. This makes the 100-watt bulb brighter than a 60-watt bulb. It is also more expensive to operate. You have to pay for 100 joules every second instead of 60 joules every second.

The power rating of a car is expressed in kilowatts. This means that the car transfers thousands of joules every second. The higher the rating of an engine, the more energy it uses each second. This also means that higher rated engines cost more to run.

Electrical power stations generate energy in megawatts, or millions of joules every second. Even so, there are 'peak periods' when too many people try to use too many joules every second. The demand for energy each second is more than the power station can supply. This may lead to a 'power failure' or blackout.

We pay for the energy we use, not for power. It costs the same amount to operate each of the following:

- one 100-watt bulb for one hour
- one 25-watt bulb for four hours
- four 25-watt bulbs for one hour.

Prac 2 p. 118

Fig 3.3.5 Which car is cheaper to run? Why?

Homework book 3.3 Energy converters and efficiency

3.3 FOCUS [Questions]

Use your book

Energy in our daily lives

1 Why is the daily energy requirement for humans expressed as a range rather than as a single value?

2 The daily energy requirement for chickens is different from that for humans. How and why is it different?

3 What do we use energy for when we sleep?

Energy converters

4 Why is a hair dryer designed to heat the air before blowing it onto your wet hair?

5 All the energy involved in drying your hair begins as energy that electrons have when they are in the mains. How and where does all this energy end up?

6 In what way is a human body an energy converter?

Energy receivers

7 What is the energy receiver when you warm some pizza in a microwave oven?

8 Why might the picture on a television set change if someone changes the position of the aerial?

9 If you tune your television set to a particular channel, then disconnect the aerial cable, the picture and sound disappear. Why is this?

Power

10 Which is more expensive to run for one hour, a 100-watt light bulb or a 2000-watt heater?

11 How many watts are there in a kilowatt?

12 How many watts are there in a megawatt?

Use your head

13 **a** If you were petrol-powered, how many days could you run on a litre of petrol?

b The value you worked out above is an over-estimate—that is, it is too big. Why is this?

14 Make a flow chart showing the energy transfers and conversions involved in running to catch a train.

15 A mobile phone is both an energy receiver and an energy transmitter. Explain when each of these processes occurs.

16 The door and casing of a microwave oven block the microwaves so they cannot escape from the oven. Why is the oven made so that it turns off when you open the door?

17 To work out how much energy an appliance uses, you can multiply the power in watts by the time in seconds. For example, using a 100-watt light bulb for 10 seconds uses (100 × 10) joules, or 1000 joules. You could also express 1000 joules as one kilojoule.

a If you run a 2000-watt heater for 1000 seconds (a bit less than 17 minutes) how many joules do you use?

b What is this expressed in kilojoules?

c What is this expressed in megajoules?

d Electrical energy costs a bit less than 5 cents per megajoule. About how much would it cost to run a 2000-watt heater for 1000 seconds?

Investigating questions

18 There is some controversy about the regular and frequent use of mobile phones. The problem is that a mobile phone broadcasts microwaves when sending a signal.

a Why is this a problem?

b What are the possible bad effects of using a mobile phone a lot?

c Is there a safer way to use a mobile phone?

19 One of the ways in which farmers attempt to make their farms energy-efficient is by carefully working out how much feed is needed to keep the livestock healthy, without having too much or too little. What information would a farmer have to know or find out in order to work out how much livestock food to buy each month?

3·3 FOCUS [Practical activities]

Prac 1 Focus 3.3

Detecting energy conversion

Purpose

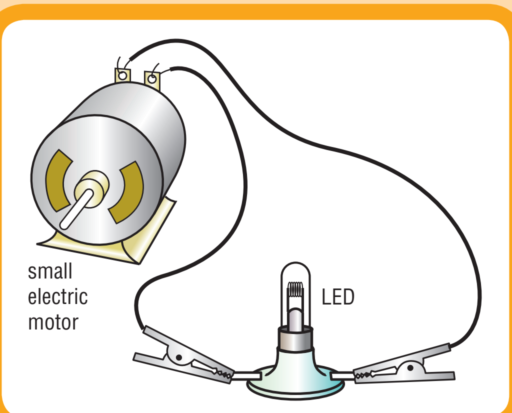
To investigate ways to convert kinetic energy into potential energy of electrons.

Requirements

Small electric motor, energy detector (torch bulb, light-emitting diode or voltmeter), connecting wires.

Procedure

1. Use the connectors to attach the torch bulb, LED or voltmeter to the motor input terminals, as shown in Figure 3.3.6.
2. Turn the shaft by hand and see if the detector can pick up any energy output from the motor. You will probably have to turn the shaft quite sharply to get a response.
3. Design a different way to make the shaft turn, and if you have the equipment, test it to see if it works. For example, you could use a mousetrap, a weight or another motor to turn the shaft.
4. *Draw what your alternative energy-conversion method would look like.*
5. Using whiteboards or large sheets of paper to display your design, compare your way of powering the energy converter with those of other groups. Make a decision as a class about which method would work best, and why. *Write down the details about the design that is the best for the job, and the reasons for choosing that design.*



Connecting the energy detector to the motor **Fig 3.3.6**

Questions

1. In what way does a light bulb, LED or voltmeter detect energy?
2. If you were going to manufacture and sell the final design of energy converter, what would you call it?
3. As a group, make a poster, electronic presentation or web page explaining or advertising the final design.

Converting energy

Prac 2
Focus 3.3

Purpose

To observe and describe energy conversion in a number of situations.

Requirements

Stations around the laboratory with energy-conversion equipment set up at each one.

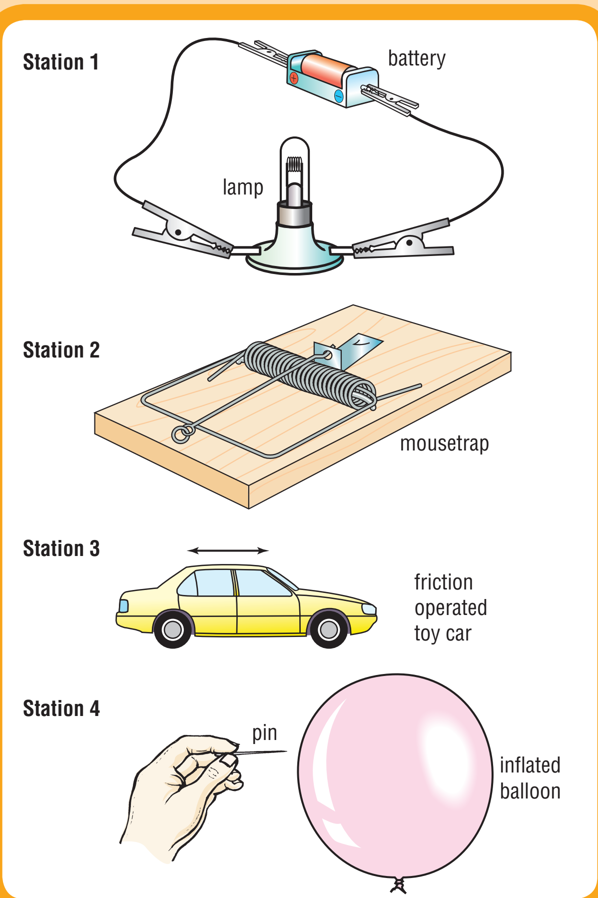


Fig 3.3.7 Stations around the laboratory

Procedure

1 Prepare a table to record your observations and inferences. Part of a suitable table is shown below. Your table should have as many rows as there are stations.

2 Your teacher will organise you into working groups. Go to one of the stations where equipment has been set up. Your teacher will tell you which group goes to each station. Read the instructions at each station carefully before touching any of the equipment.

3 Carry out the experiment set up at that station. *Record any observations in the table.*

4 Discuss, in your working group, the evidence for the energy conversion. When you are sure you understand what has happened at the station, *write down your evidence.*

5 Your teacher will tell you when to move to another station, and the direction you will move. When you get to the next station, repeat the procedure. *Write down your observations and evidence at each station.*

6 When you have visited each station, return to your desk. Your teacher will now organise you into new groups to discuss your findings.

7 Show your information to the others in your discussion group, and look at their information. Discuss any differences in your results, or any parts of the activity you found hard to understand. Also, discuss what to write as answers to the questions at the end of this activity.

8 *Write down your answers to the questions.*

Questions

1 Could any of these energy conversions be useful to us in our society or everyday lives? Explain your answer.

2 Which of the stations showed that you might be able to convert the energy from high-energy chemicals to do useful things? Explain your answer.

3 Which of the stations showed that you might be able to convert energy from high potential energy objects to do useful things? Explain your answer.

4 Describe a situation in which you could convert kinetic energy to do useful things.

5 Describe a situation in which you could convert internal energy to do useful things.

Station	Was the energy initially stored as kinetic, potential or internal energy?	Observations	What is the evidence that energy was converted?

FOCUS 3.4 Heating and cooling

Context

You probably use the word 'heat' many times in everyday life but have you ever wondered what heat actually is? What is it that makes something hot? Why is it that that in winter we put on what we think of as warm clothes, while in summer we look for different types of clothes to wear? Why do roads get very hot during the day while the grass at the side of the road doesn't? Why does the handle of a metal soup-spoon get hot very quickly during cooking yet a similar spoon made of wood does not? Why do hot air balloons rise and how do thermometers work? All these questions can be answered if you understand the nature of heat.

Fig 3.4.1 Thermometers are used for measuring temperature.

What does heat do?

When we add heat to a body we increase the internal energy of that body. When you heat a cup of water, for instance, the particles of water move faster. The water in the cup has become hotter. In everyday language, we use the word 'hotter' to mean a higher temperature.

Temperature

Temperature is a measure of how fast the particles within a body move. To understand the difference between heat and temperature, imagine two saucepans, identical in every way. One saucepan is full of water but the other is only half full. If you heat them both on a stove, which saucepan do you think will reach a higher temperature more quickly? If you said the one with less water, you are correct. Both saucepans are heated for the same time so they both absorb the same amount of heat.

The saucepan with less water, however, has fewer particles, which means that the energy absorbed is spread out over fewer particles. The particles of water in the saucepan with less water move faster, making the temperature higher. We measure temperature in units of degrees Celsius (°C) by using a thermometer.

Fig 3.4.2 A red-hot iron nail might be at a much higher temperature than the water in a bath but might contain less internal energy.

Transferring heat

Heat will flow from an area that is at a higher temperature to any other area at a lower temperature. If you touch something that is at a lower temperature than you are, heat will flow from you to whatever it is that you are touching. It will feel cool or even cold to touch because your fingers will be losing heat.

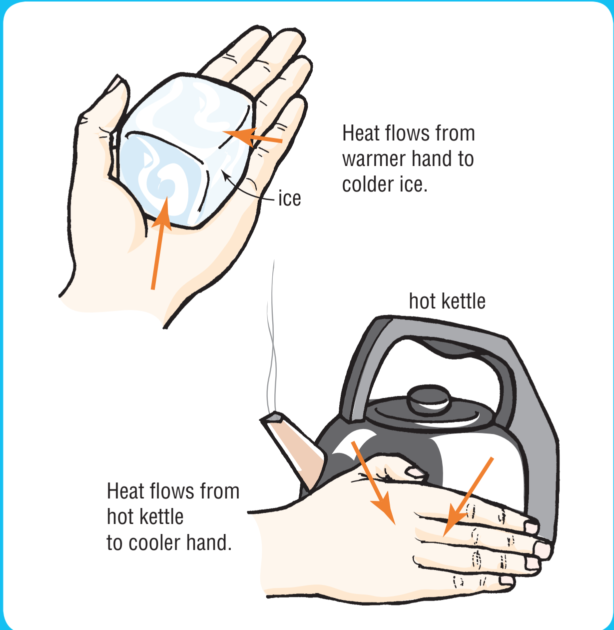
Science Snippet

Hot baths

Think of the energy contained within a bathtub of lukewarm water and within a red-hot iron nail. Because the bath has far more particles than the nail, the total energy contained within the bath is actually greater than the total amount of energy contained in the nail, even though the nail is at a much higher temperature.

Heat always flows from a body at a higher temperature to a body at a lower temperature.

Fig 3.4.3



If, however, you touch something that is at a higher temperature than you are, heat will flow from it to you. It will feel warmer or hot because your fingers are gaining heat. The transfer of heat can occur in three ways—by conduction, convection or radiation.

Conduction

Why is it that spoons used for stirring soup, or for mixing food being cooked, are often made of wood or plastic rather than metal? The reason relates to the transfer of heat by **conduction**. You already know that when you add heat energy to a body the particles within that body start to move faster. If you are making some soup in a saucepan on the stove, then the temperature of the soup might be close to 100°Celsius. This means that the particles within the saucepan are moving very fast. If you stir the food with a metal soup-spoon, the particles that make up the part of the spoon in the hot soup start to vibrate faster and faster. These vibrating particles then pass on their vibrations to the particles next to them and so on, all the way up the handle of the spoon. You will feel this extra kinetic energy as an increase in the temperature of the handle.

You may have noticed that some objects or materials feel colder than others. A metal door handle, for instance, feels colder than the surface of

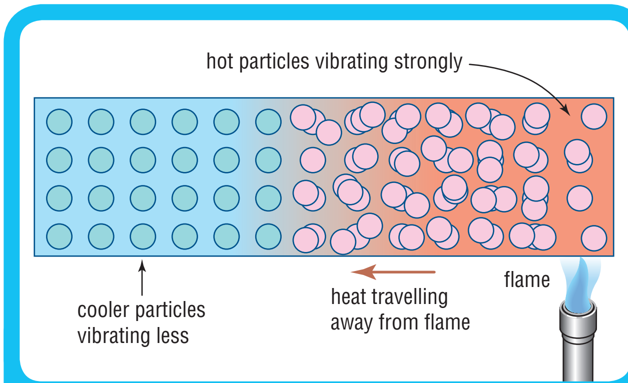
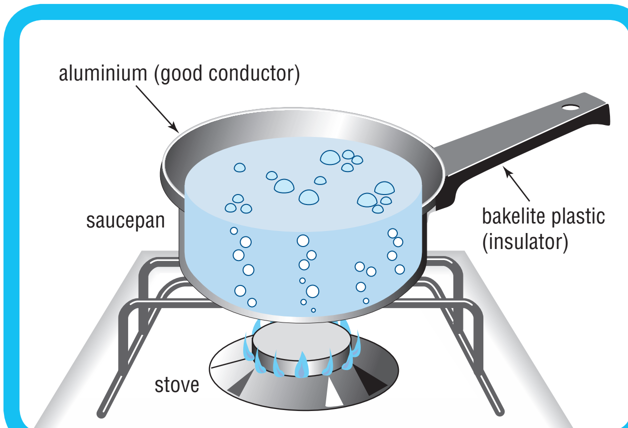


Fig 3.4.4 The particles of a solid gain more kinetic energy and vibrate faster as they are heated.

a wooden table. Metals are much better conductors of heat than wood. The metal door handle will therefore conduct heat away from your fingers, making your fingers feel colder. The wood, however, is not as good a conductor of heat and therefore will not conduct heat away from your fingers as well as metal. The wooden table therefore does not feel as cold to the touch. As a general rule, metals are better conductors of heat than non-metals, such as plastic, wood or cardboard. Solids are also better conductors than gases because in gases the particles are spread out and are not able to carry vibrations efficiently from particle to particle.



The aluminium in a saucepan is a good heat conductor.

Fig 3.4.5

Poor conductors of heat are called **insulators**. Woollen jumpers, for instance, are good insulators of heat. The air that is trapped between the fibres of wool reduces the speed at which the heat is conducted away from the jumper and so keeps you warm.

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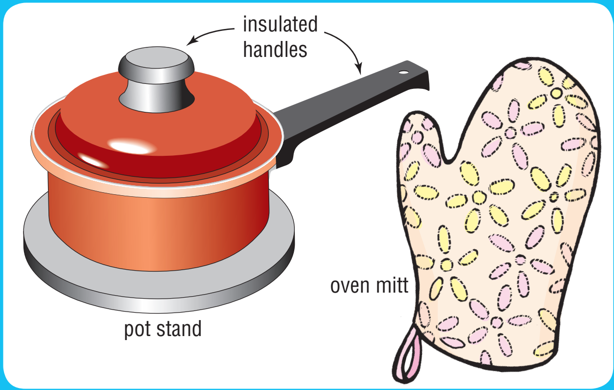
Fig 3.4.6 You find many examples around the home of insulators in use.



Convection

If you put a saucepan of water on a hotplate the particles of water closer to the base of the saucepan start to get hot first. When a liquid is heated, its particles gain kinetic energy. Unlike the particles of a solid, however, which can only vibrate, the particles of a liquid can vibrate and move around in the liquid. These more energetic particles will now spread out to take up more space. Because the particles of water at the base of the saucepan are more spaced out, a volume of water near the base of the saucepan will contain fewer particles than the same volume of cooler water near the surface of water in the saucepan. This volume of water nearer the base of the pan is therefore lighter, or less dense, than the water above it. The hotter, less dense water will be pushed upwards by the cooler, more dense water from above. This process of cold liquids sinking and warmer liquids rising is called **convection** and the movement is called a convection current. Liquids and gases can transfer heat through convection.

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Science Snippet

What a breeze

Land and sea breezes occur as a result of convection. During the day the land heats up faster than the ocean. When this happens the air above the land becomes warmer and less dense than the cooler air above the ocean. The cooler air above the ocean rushes inland as a cool **sea breeze**. In the early evening, the land cools down faster than the ocean. The air above the land becomes cooler and more dense than the air above the ocean. The cooler, more dense air over the land then rushes out to sea as a land breeze.

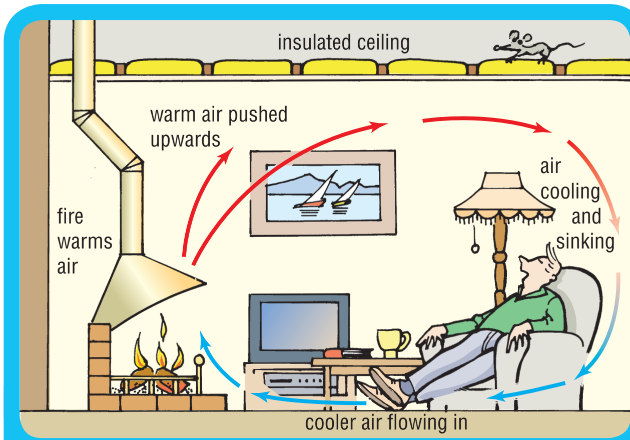
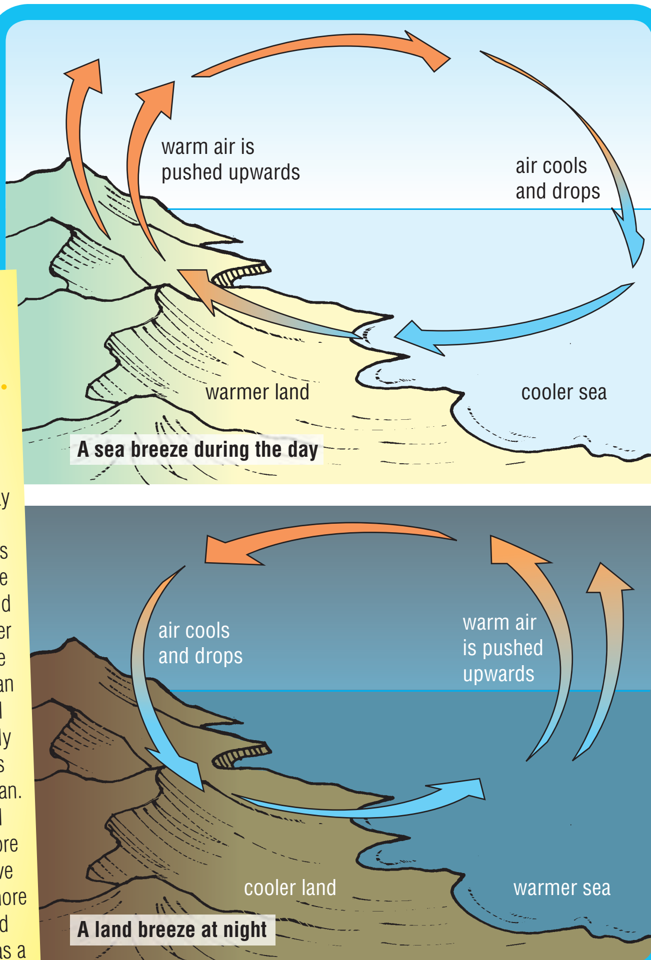


Fig 3.4.7 A fire heating a room



Land and sea breezes are a result of convection currents. Fig 3.4.8

Radiation

When you stand outside you can feel the heat from the Sun on your skin. Heat reaches the Earth through the vacuum of space, even though there are no particles in space for conduction and convection of heat to occur. Heat can do this in the form of **radiation**. Radiation travels at the speed of light (about 300 000 kilometres per second) in the form of waves and is always around us in one form or another. Microwave ovens, televisions, radios, our eyes and X-ray machines all rely on radiation in order to work. You will learn more about radiation and other waves later on in this book. The radiation that your skin senses as heat is called infrared radiation. Infrared radiation is given off by warm and hot bodies.

Absorption and reflection of radiation

Radiation can be absorbed, reflected or transmitted through objects or surfaces that it hits. Figure 3.4.9 shows that infrared or heat radiation is absorbed better by darker surfaces and reflected by lighter coloured surfaces. It is for this reason that, in Western Australia with its warm climate, people tend to driver lighter coloured cars. Lighter coloured cars reflect heat better than darker cars and so stay cooler for longer. Cooler cars are more energy-efficient in summer because they do not require as much air-conditioning.

Interactive CW Animation

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Homework book 3.4 Insulating methods in the home

Light-coloured cars reflect heat radiation better than dark-coloured cars and stay cooler in summer. *Fig 3.4.9*

FOCUS 3·4 [Questions]

Use your book

Temperature

1. When you say that one thing is hotter than another, what can you say about their temperatures?
2. If the particles in a nail are moving much faster than the particles in the water in your bath, which is hotter?
3. If you heated two cups of water for the same length of time, why might one become hotter?

Conduction

4. Why do metal objects in a room usually feel colder than wooden objects when you touch them, even though they are both at the same temperature?
5. Describe why a woollen jumper is able to keep you warm in winter.
6. Why are saucepans generally made of metal while their handles are made of plastic?

Convection

7. Describe what happens in a liquid to form a convection current.
8. Why do land breezes often occur in the late afternoon?

Absorption and reflection of radiation

9. Why are light-coloured cars more sensible in our climate than darker coloured cars?

Use your head

10. Describe the different ways in which a room is heated by a log fire
11. What colour clothes should you wear in winter? Why?
12. When you go on a picnic you might place hot or cold food and drink into a styrofoam container called an Esky. What does this tell you about styrofoam?

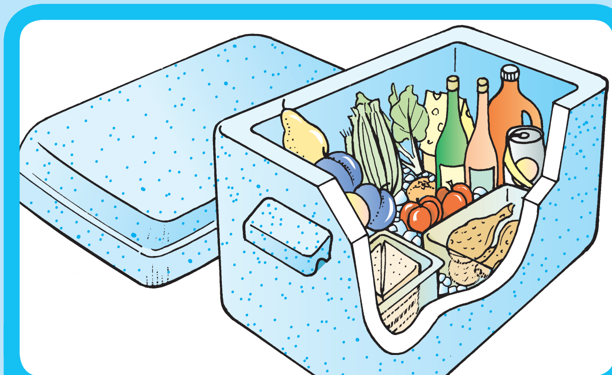


Fig 3.4.10 An Esky

13. Use an example to describe the difference between heat and temperature

>>

14 Describe why a piece of paper held 5 centimetres above a candle flame will catch fire quickly while a similar piece of paper held 5 centimetres alongside the same flame will not.

15 Why is the roof cavity of a home almost always warmer than the rest of the house?

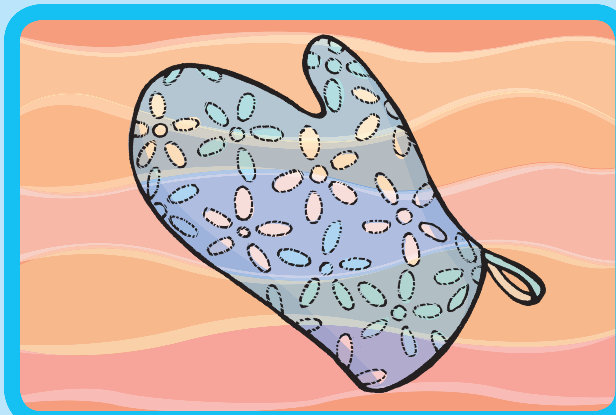
16 Describe one feature of a modern home or car that ensures that occupants are not too warm in summer or too cold in winter.

17 A friend of yours insists that the metal tap in your kitchen must be at a lower temperature than your kitchen benchtop because it feels colder to touch. What would you say to your friend to help them understand the real reason?

18 Why does a cook insert a metal skewer through the centre of a roast before placing it in an oven?

19 In trying to find the location of thermals (rising air streams that provide extra 'lift'), glider pilots often look for rocky areas on the ground. Why do you think they do this?

20 Why can you use an oven mitt, like the one in Figure 3.4.11, to safely take a hot casserole out of the oven?



An oven mitt *Fig 3.4.11*

Investigating questions

DYO

21 Design an experiment to test the insulation properties of different fabrics.

22 Construct a table to record 10 ways in which heat transfer occurs or is prevented in the home.

23 Investigate how radiation is involved in a greenhouse.

3·4 FOCUS [Practical activities]

Prac 1 Focus 3.4

Insulator materials

Purpose

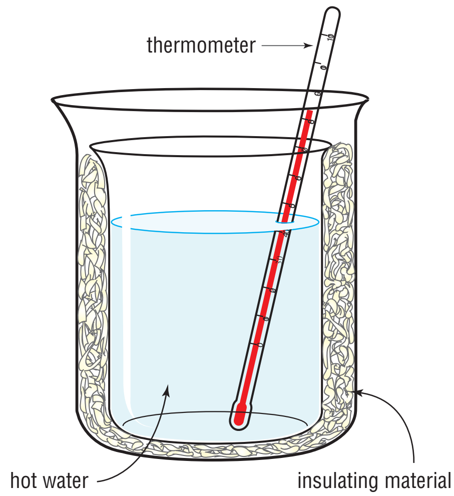
To compare the insulating properties of different materials.

Requirements

Two 100 mL beakers, two 250 mL beakers, choice of different materials (eg foam pieces, small strips of paper, strips of cloth, cotton wool, foam, rubber), thermometer, timer, a source of hot water.

Procedure

1. Set up two sets of the apparatus shown in Figure 3.4.12. You can select any of your insulating materials as the 'filling' between the large and small beakers.
2. When you are ready carefully pour an equal amount of hot water into each of the inner beakers. After one minute start recording the temperatures of each thermometer at one-minute intervals for 10 minutes.
3. *Record your results in a table like the one opposite. You need to record for about 10 minutes. Draw 11 rows.*



How to set up your equipment *Fig 3.4.12*

Time (minutes)	Insulating material	
0		
1		
2		

Questions

1. Describe your results.
2. What variables did you keep the same in this investigation?
3. Can you compare your results to those of other groups. Why or why not?

Prac 2

The thermal motor

Purpose

To construct a thermal motor.

Requirements

Paper or light card, scissors, Bunsen burner or candle.

Procedure

1. Use the shape shown in Figure 3.4.13 to design a thermal motor.
2. Draw the shape in heavy paper and cut it out.
3. Attach a length of thread to the thin end of the motor and suspend it at least 30 cm above a Bunsen flame. Do not allow the motor any closer to the Bunsen flame.

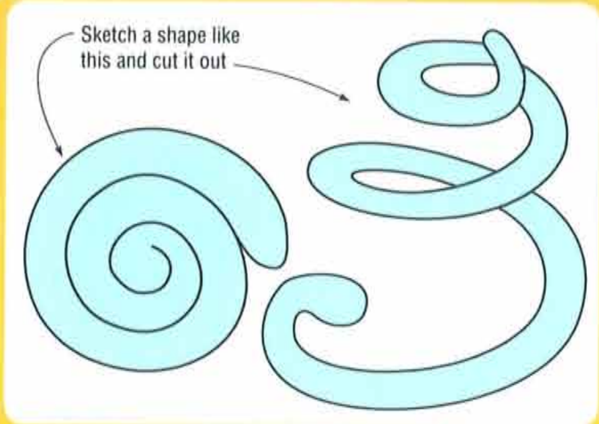


Fig 3.4.13 A thermal motor

Questions

1. Describe the behaviour of the motor when held above the flame.
2. Try to use some scientific words you have learnt to explain the behaviour of the motor.

Prac 3

Keeping cool in summer

Purpose

To find out what colours absorb heat best.

Requirements

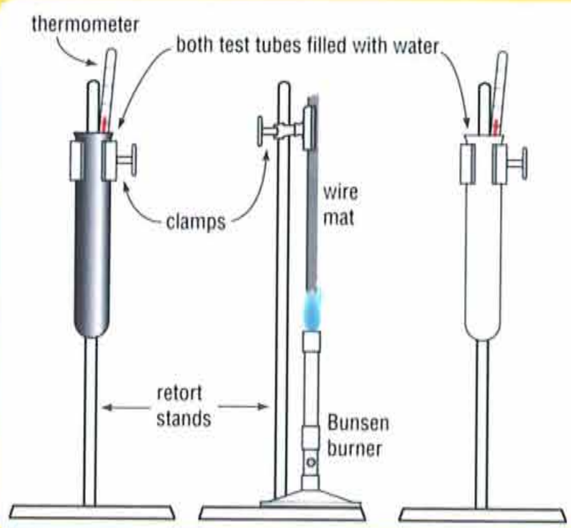
Wire mat, test tube painted black, test tube painted silver or white, timer, thermometer, two retort stands, bosses and clamps.

Procedure

1. Set up the equipment as in Figure 3.4.14.
2. Fill each of the test tubes with water and insert a thermometer in each.
3. After a minute, record the temperature in each of the test tubes. *Record this as the temperature for the time 0 seconds in a table like the one below. You need ten rows to record all your results.*

Time (minutes)	Temperature of black test tube (°C)	Temperature of silver or white test tube (°C)
0		
1		
2		

4. Light the Bunsen burner and heat up the wire mat. In your table record the temperature in each test tube every minute for 10 minutes.



How to set up your equipment Fig 3.4.14

5. *Draw a line graph of your results.*

Questions

1. Describe your findings.
2. Write a statement about the graphs for each of your test tubes.
3. Which variables did you keep the same in this experiment?
4. Write down one example of science in everyday life that supports your conclusions from this experiment.

FOCUS 3.5 Light

Context

Most of our everyday lives involve light in some way. Imagine how different your life would be without light. Without light, green plants which need light from the Sun to produce plant food would not be able to make food for themselves and would die. Animals which in turn eat these plants would not survive. In fact, almost all life on Earth would eventually cease to exist. In this focus you will learn about light and some of the ways in which it affects our lives.

Sources of light

Have you ever tried to describe light? It is easy to describe the colours of different objects. You can describe the glow of a light bulb, a fire or even the Sun. But how would you describe the light given off from these things? Like sound and heat, light is a form of energy and is very hard to describe on its own. It is much easier to describe what you see when light falls on a surface.

We call objects **luminous** if they give off their own light. **Non-luminous** objects reflect light coming from other sources. The Sun, a torch and a light bulb are examples of luminous objects. The Sun is a very important luminous object, because light from the Sun is required for green plants to make their own food through the process called **photosynthesis**. Although the Moon looks as though it is a light source it is actually a *non-luminous* object because it only reflects light from the Sun. Light sources can be classified in several ways, as shown in Figure 3.5.1.

Electroluminescence usually occurs when electricity produces heat as it is passed through a conductor. In a light bulb the conductor is called a **filament**. The hot filament gives off light as well as heat. The giving off of heat and light is called **incandescence**. This is why light bulbs like the one in Figure 3.5.2 are called incandescent bulbs.

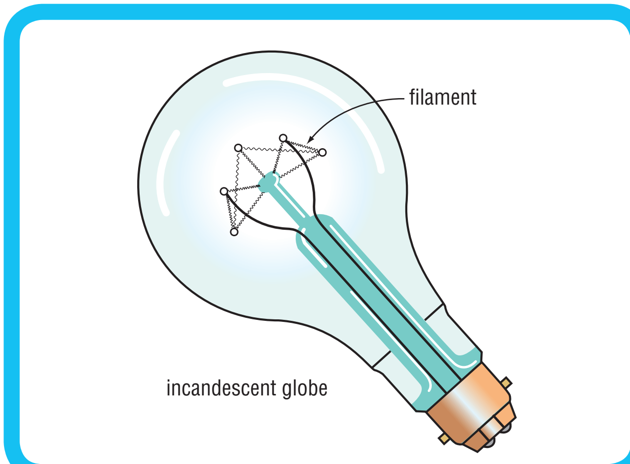
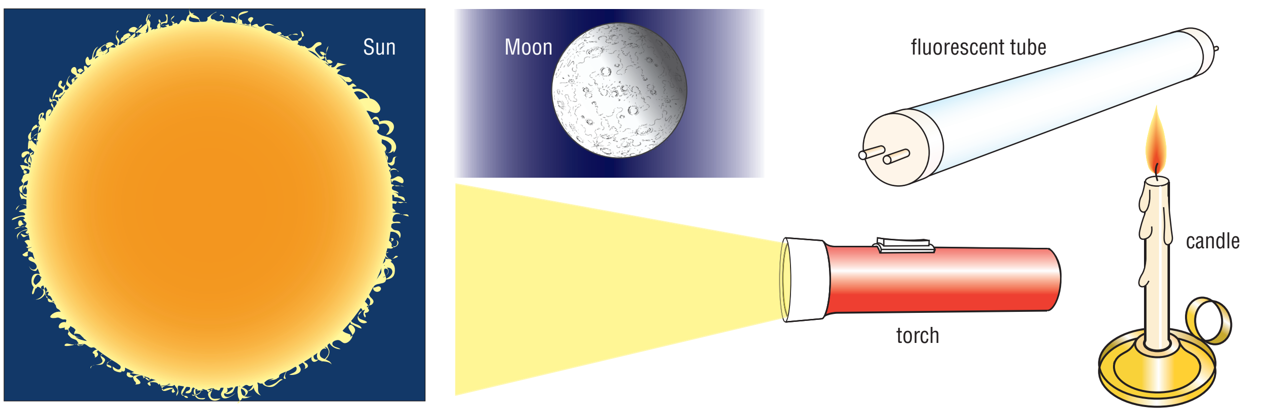


Fig 3.5.2 The light from a light bulb is due to heat produced when electricity flows through a very thin wire called a filament.

Fig 3.5.1 Light can come to us from different sources.



Bioluminescence occurs when living things produce light. Organisms that are bioluminescent include fireflies, some jellyfish and the deep sea angler fish.

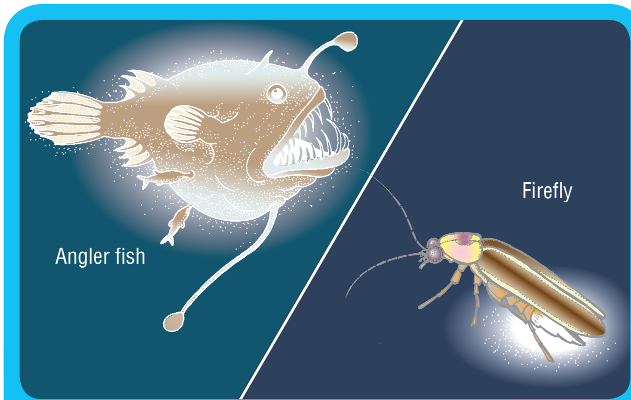
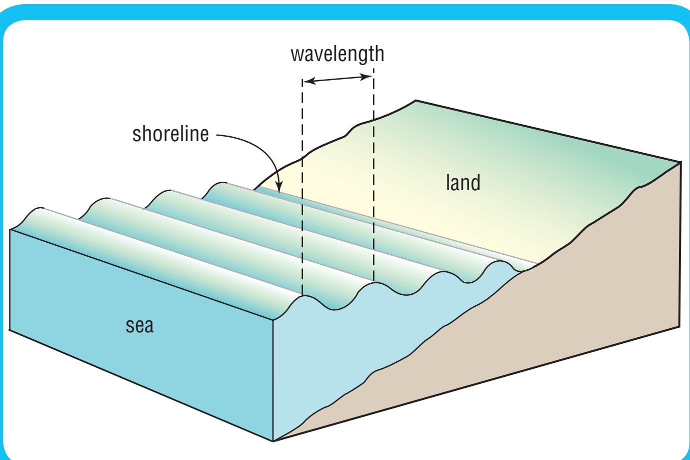


Fig 3.5.3 Living things can sometimes produce their own light.

The nature of light

Light does not travel by particles colliding with each other. This explains how sunlight can travel through the near-vacuum of space to get to our planet. A **vacuum** is a region in which there are few, or no particles. So how does light energy travel through space if there are no particles to carry that energy? Scientists use their understanding of waves to help explain this.

Imagine you are looking at waves rolling along the ocean. Sometimes the crests between two waves will be very far apart. Other times they will be close together. When two waves are far apart the waves are said to have a long wavelength and when the waves are close together the waves are said to have a smaller **wavelength**. Light energy is also carried as waves, but whereas energy carried by water waves requires a medium, light, like other forms of radiation, does not. This is why light can reach us from the Sun through empty space.



Some energy travels by waves. Fig 3.5.4

Colour

Why does a stop sign looks red? Why is the sky blue? Why are the leaves of most trees green? We can see things as different colours because normal white light (like the light coming from sources such as the Sun or an electric light bulb) is itself actually made of different colours. All these colours mixed together produce what we see as white light.

The colours of light differ because each colour has a different wavelength. What our brain detects as red light is a longer wavelength than violet. A prism can be used to separate white light into its different colours. This process is called **dispersion**. The pattern of colours is called a **spectrum**.

> **Science Snippet**
>
> **Colour mnemonic**
>
> A mnemonic is a memory aid. Often you can use a phrase as a mnemonic to help you to remember the order of something. The order of the planets in our Solar System from the Sun can be remembered with the phrase 'My very earnest mother just served us nine pizzas. In this mnemonic the first letters of each word is the first letter for the planets. Try to make a mnemonic to help you remember the order of the main colours of the rainbow. The colours are red, orange, yellow, green, blue, indigo and violet. Your mnemonic can read from red to violet or from violet to red.

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White light can by split into its different colours by using a prism. Fig 3.5.5

The speed of light

Have you ever wondered how long it takes for the light to leave a light bulb and get to your eyes? Try turning a light on at home to find out how long this takes. It turns out that you see the light from a light bulb almost as soon as the light bulb glows. This is because light travels very, very fast. Today we know that light travels at about 300 000 kilometres per second. This speed would allow light to travel almost eight times around the Earth in a second. Imagine being able to travel around the Earth and see the world in one-eighth of a second. Travelling at this speed, light from the Sun takes about 8.3 minutes to reach the Earth.

Science Snippet

Galileo's experiment

About 350 years ago Galileo attempted to measure the speed of light. He stood on one hill a few kilometres distance from his assistant on top of another hill. Galileo shone a lamp in the direction of his assistant, who knew that as soon as he saw the light from Galileo's lamp he was to turn his lamp on also. Galileo timed the time difference from when he turned on his lamp to when he saw the light from his assistant's lamp. Knowing the distance between the two hills then allowed Galileo to work out the speed that light travels. However, he failed because light travelled too fast for there to be a noticeable time difference.

Interactive CW Animation

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The reflection of light

Reflection is the bouncing of light off a surface. Some surfaces appear shiny, like a mirror and you can see an image in them. This type of reflection is called **regular reflection** and occurs because the reflecting surface is very smooth. You cannot see an image on a dull surface because the surface is not smooth enough. Even if it appears smooth, magnifying it many times will show many bumps and imperfections. These cause the light to reflect in different directions rather than mostly towards your eye. Light is still reflected from these surfaces but the type of reflection is called **diffuse reflection**.

You can see an image in a smooth surface because of the regular reflection of light from that surface. **Fig 3.5.7**

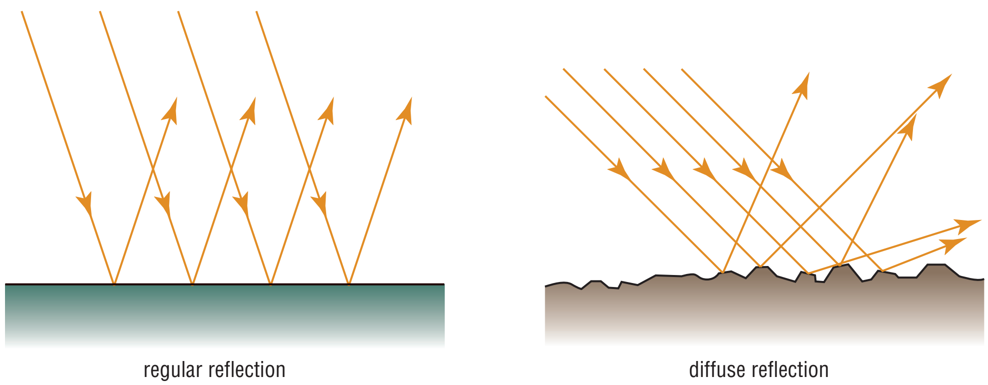
When light from a luminous source such as the Sun falls on a non-luminous object such as your teacher, the light is reflected in all directions. If you can see your teacher then some of this reflected light must be entering your eyes.

The absorption of light

When you look at a tree during the day the leaves of the tree look green because the leaves are absorbing every other colour from which white light is made, and reflecting only the green colour. A red jumper appears red because the jumper is absorbing every other colour except red, which is reflected into your eyes.

The refraction of light

Refraction is the bending of light that sometimes happens as light passes through one substance and into another. You have probably noticed how objects



Regular reflection of light occurs off smooth surfaces, while rough surfaces reflect light irregularly. **Fig 3.5.6**

Homework book 3.5 Applications of laser light

in water sometimes appear shallower than they appear to be and how a spoon in a glass of water appears to be bent. These observations result from light being bent as it passes from an object in water into air.

Refraction is the bending of light as it passes through different substances. Refraction causes the pen in this glass to appear bent.

Fig 3.5.8

Science Snippet

Rainbows

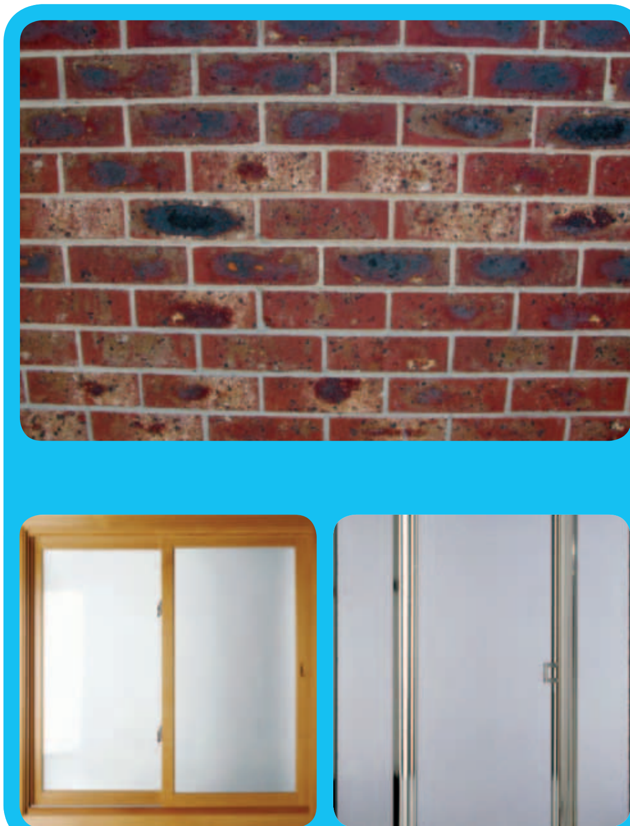
Sometimes you see a rainbow after rain. A rainbow occurs because each drop of rain behaves in the same way as the prism shown in Figure 3.5.5. Many thousands of little water prisms acting together produce a rainbow. Did you know that the rainbow you see is different from the rainbow somebody else sees? The only way for two people to see exactly the same rainbow is for both to stand in exactly the same spot.

Fig 3.5.9 The bending of light by water droplets in the air produces a rainbow.

Transparent, translucent and opaque objects

Light does not need a medium through which to travel but it can travel through different substances. Windows with clear or coloured glass, clear plastics and water, for instance, are **transparent** because they let light through and you can see clearly through them.

Substances that let some light through but don't allow you to see clearly through them are called **translucent**. Some types of glass used in shower doors or in bathroom windows are good examples of translucent substances. **Opaque** substances such as brick, metal and wood do not let light through.



Objects are transparent, translucent or opaque because of how light behaves when it falls on those objects.

Fig 3.5.10

Interactive CW Animation

Shadows

A shadow is produced on a surface when an opaque object blocks light going to it. You cast a shadow during the day because you are blocking sunlight from reaching the ground. A shadow is a good way of realising that light must travel in straight lines.

3•5 FOCUS [Questions]

Use your book

Sources of light

1 Give three examples of luminous objects.

2 What is photosynthesis?

3 How does the bulb of a torch produce light?

The nature of light

4 Draw a diagram showing how a long wavelength wave is different from a wave with a shorter wavelength.

Colour

5 Describe what you see when a prism causes dispersion.

The reflection of light

6 What is the difference between regular and diffuse reflection? Draw a diagram to illustrate your answer.

The absorption of light

7 Using the terms ‘absorption’ and ‘reflection’, explain why a red jumper with a blue stripe appears these colours.

The refraction of light

8 When is refraction likely to happen?

Transparent, translucent and opaque objects

9 What is the difference between an opaque, a translucent and a transparent object?

Use your head

10 The nearest star after the Sun is 4.3 light years away. A light year is the distance light travels in a year. How far is the star in kilometres?

11 Cameras or optical instruments often have colour filters, which are thin coloured transparent material placed over the lens. These make the object being observed look a particular colour. How do you think a filter would work?

12 On a clear night, if you know where to look, you can sometimes see planets, such as Venus, Mars and Jupiter, as bright star-like objects in the sky. Does this mean that these planets are luminous objects? Why or why not?

13 In terms of the way energy is transferred, how is light as a source of energy different from other energy sources such as sound and heat?

14 Often the surface of metals such as brass, copper and iron become tarnished when exposed to moisture and air. This gives them a dull appearance. How does polishing transform the surfaces of these metals from dull to shiny?

15 Why does the paper from which this page is made appear white, while the diagrams appear as different colours?

16 Look at Figure 3.5.11. Draw a table that will allow you to classify the materials as opaque, transparent or translucent.

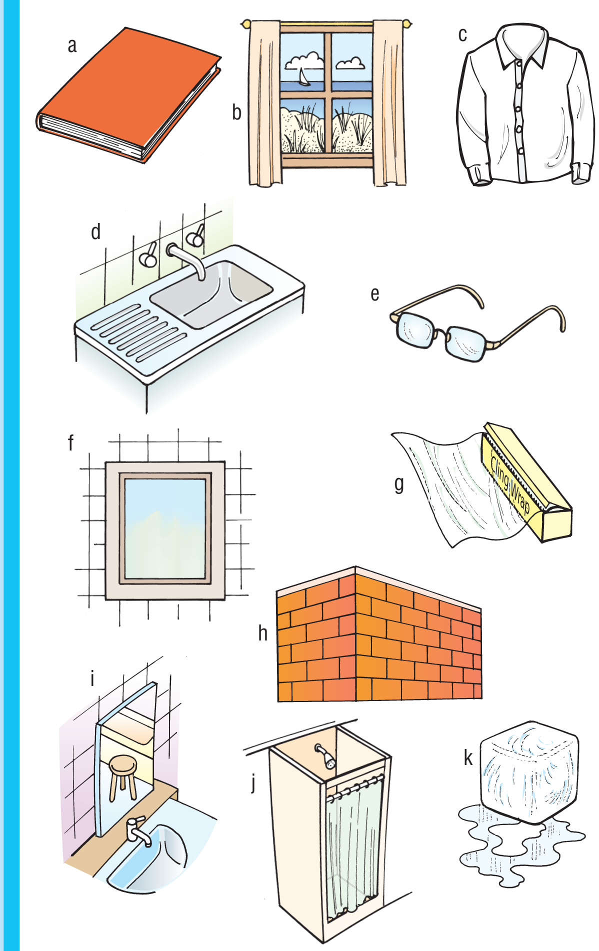


Fig 3.5.11 Objects to classify

17 How might light filters be used at home or in industry?

Investigating questions

18 Investigate the difference between solar eclipses and lunar eclipses. Write about 10 lines. Diagrams may help.

19 Research how the terms ‘umbra’ and ‘penumbra’ are used in relation to shadows.

20 Design an investigation to find out how well plants grow under light of different colours.
Ask your teacher to help you carry out the investigation.

DYO

FOCUS 3.5 [Practical activities]

Prac 1 Focus 3.5

Make a colour wheel

Purpose

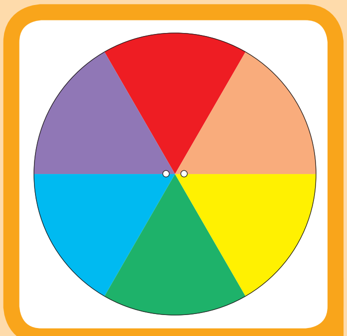
To confirm that light is a combination of different colours.

Requirements

Scissors, cardboard, white paper, sharp pencil, coloured pencils, string, glue.

Procedure

1. Cut a circle out of thick cardboard. The circle should have a diameter of about 12 cm.
2. Cut a circular piece of white paper to fit over the cardboard disc. Glue the two together.



Layout of the colour wheel Fig 3.5.12

3. Divide the white disc into segments as shown in Figure 3.5.12 and colour in each segment with the colours shown in the diagram.
4. Make two small holes about 0.5 cm apart as shown and thread about 1 metre of string through the holes and tie the ends together.
5. Hold the ends of the string in each of your hands and then rotate the disc a few times, so that the string starts to wind up. With some practice you should be able to get the cardboard disc to rotate very fast backwards and forwards. Observe the colour of the disc.

Questions

1. What did you observe when the wheel was spun very fast?
2. Was there a difference between the colour observed when the wheel was spun slowly and the colour observed when the wheel was spun fast?
3. What does this experiment illustrate?

Prac 2 Focus 3.5

Reflection

Purpose

To examine how light is reflected from a plane mirror.

Requirements

Light box or torch, paper, protractor, plane mirror, ruler and pencil.

Procedure

1. Using Figure 3.5.13 as a guide, draw a line MN near one edge of a page in your notebook. Place a mark X at a point between points M and N.
2. Use the protractor to draw a dotted line from point X and 90° to the line MN. This line is called the normal.
3. Place the mirror along the line MN.
4. Use the light box to project a single thin ray of light at an angle to the mirror so that it falls on the mirror at point X.
5. Mark in the positions of the incident and reflected ray.
6. Measure the angles of incidence and reflection using the protractor. *Record your results in a two-column table with the headings 'Angle of incidence' and 'Angle of reflection'. Have as many rows as you think you will need.*
7. Do this for several angles of incidence.

Questions

1. What conclusions can you make about the angle of incidence and reflection for each of your trials?
2. Using these results, predict what will happen if you use your light box and the three-slit 'ray former' to shine rays on the two types of curved mirror in the box.
3. Try out your predictions from Question 2.

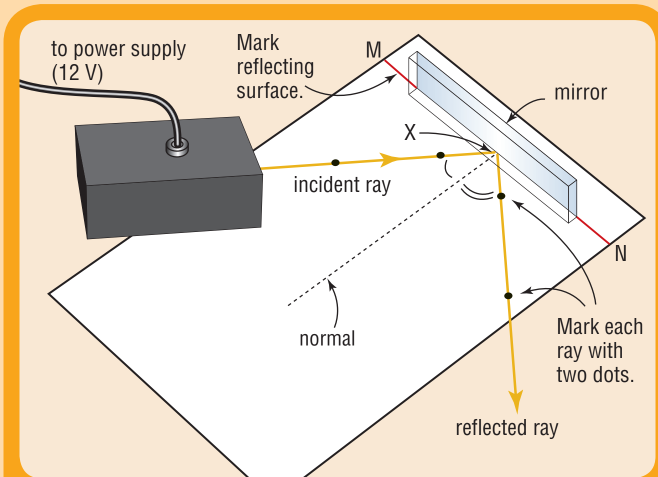


Fig 3.5.13 How to set up the experiment

FOCUS 3·6 Sound

Context

Sound is a vital part of life. We use sound in order to communicate. To do this we need to be able to send and receive sounds. Other animals also use sounds for communication but many animals use sounds for other purposes. Many species of bats, for instance, are almost blind and rely on sound to hunt and find their way around obstacles. Dolphins use sound to see inside things, like an ultrasound machine. What is sound? Read on and find out.

The table below shows the speed at which sound travels through different substances.

Material	Approximate speed of sound (metres per second)
Air	340
Water	1400
Wood	4500
Metal	5000

Prac 2 p. 135

The source of sound energy

Clap your hands together, listen to music coming from your CD player, hear the sound from a car as you stand on the side of a road, listen to the roll of thunder or the ring of a bell in the distance. What is common to these and all other sounds? They are all the result of vibrations. These vibrations usually come to you through air, but sound can also travel through liquids and solids.

The source of all sound is a **disturbance**. Often it is a vibrating object. Place your fingers on the front of your throat and make a deep sound with your voice. Can you feel the vibration that produces the sound? Sometimes you can even feel the vibrations in the air just after you have heard thunder. These vibrations are caused by the disturbance at the source of the thunder.

Prac 1 p. 135

Transmitting sound

Like heat, sounds are transmitted by the vibrations of particles in a medium. Generally, sound travels better in solids and liquids, because the particles in solids and liquids are closer together than the particles of a gas. This means that the vibrations can be passed on more efficiently from particle to particle. You can easily test how good solids are in transmitting sound. Put your ear to the surface of a wooden table. Now get your partner to scratch the bottom of the other end of the table with a nail or other hard object. You will hear the scratching sound clearly. Sounds do not travel as well in gases because the particles of a gas are more spread out.

Sound waves

If you could see the vibrations of air particles that are produced when someone is talking you would see areas in which the air particles are bunched up followed by areas in which the air is more spread out. The regions in which the air is bunched up are called **compressions**, while the more spread-out areas are called **rarefactions**. This pattern is repeated over and over around a source of sound. This repeating pattern of compressions and rarefactions is called a wave and it is waves that carry sound energy from one place to another. Your teacher may demonstrate this with a slinky spring.

Homework book 3.6 A sonic shockwave generator

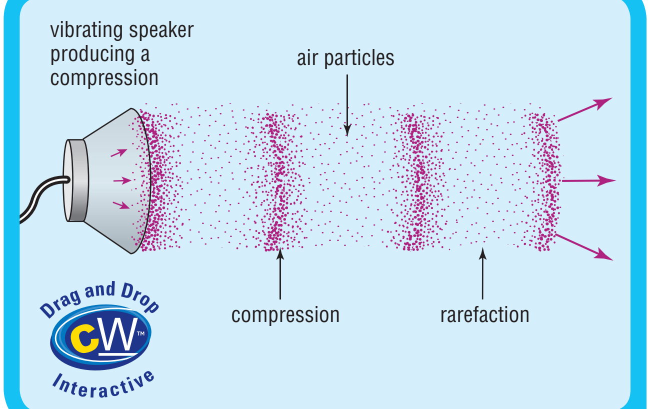


Fig 3.6.1 Sound waves travel through the air as a series of compressions and rarefactions, known as longitudial wave.

The ear

When sound vibrations reach your ears, the vibrations are collected and concentrated by your outer ear. Your outer ear is called the auricle and the ridges and channels of your auricles transfer the sound waves to your middle ear, most of which is called your ear canal. About halfway down the middle ear is a thin section of skin stretched tightly across the canal. This skin is called the eardrum and it vibrates whenever a sound wave falls on it. The vibrations of the eardrum then cause other parts of the middle and inner ear to vibrate. Finally, these vibrations are converted to electrical messages which your brain recognises as a sound.

Very loud sounds can damage different parts of the middle and inner ear and this damage can sometimes be permanent. If music is so loud that you need to shout to be heard by someone next to you, then that music is loud enough to be damaging your ears.

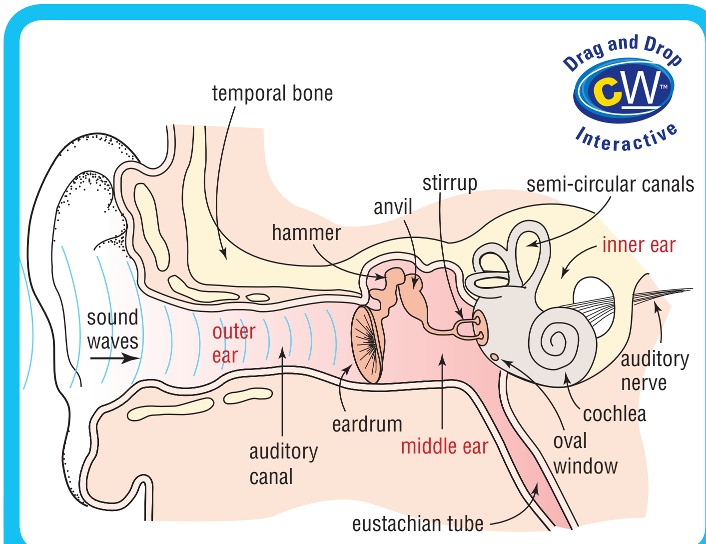
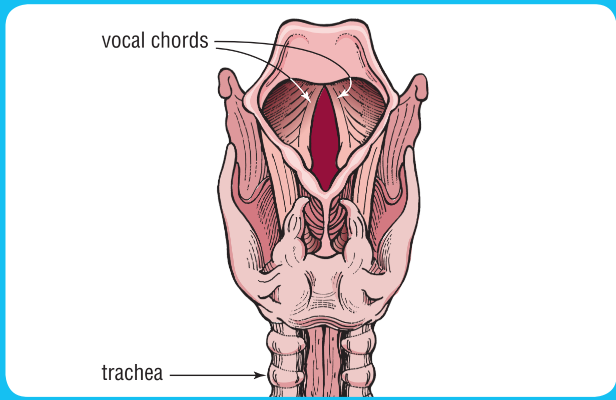


Fig 3.6.2 The ear transmits and converts sound waves to the brain.

Homework book 3.7 The ear

Sounds and speech

Try breathing in and out without making a sound with your voice. Now try the same thing but this time make a sound. Could you feel your throat vibrating when you made a sound? When you breathe out, air moves from your lungs, up your trachea (wind-pipe), through your voice box, over your vocal chords and out through your mouth and nose.



Vibrating vocal chords in your larynx enable you to produce sounds. Fig 3.6.3

Homework book 3.8 Hear, hear

Homework book 3.9 The sonic spectrum

When you hear your voice your vocal chords are closer together than they would be if no sound was produced. Take two narrow strips of paper about 6 centimetres long. Hold them apart and blow air between them. You will find that if the paper strips are close together then the paper will vibrate and make a sound. If the strips are far apart then they will not vibrate. These paper strips are like your vocal chords, which sit in your voice box.

The scientific name for the voice box is the **larynx**. When you use your voice to make a sound the air also vibrates in your throat (trachea), and your mouth and nasal cavity. In order to convert these sounds into speech you need to use your lips, tongue, teeth and soft palate.

The speed of sound

Prac 3 p. 136

Have you ever been to a cricket match and watched from a distance as a cricket ball is being hit? Have you noticed how you can watch the ball hit the cricket bat but only hear the sound some time after?

Science Snippet

Is the storm getting closer?

You can use your knowledge of the speed of sound and the speed of light to determine whether a storm is coming closer or not. Because light travels so fast, you can make an assumption that the flash from lightning reaches you almost as soon as it happens, no matter how far away it is. But the further away the storm, the longer the thunder takes to reach you. During a thunderstorm wait till you see a lightning flash and then count the time delay (in seconds) between seeing the lightning and hearing the thunder. Remember this time. The next time you see a lightning flash, do the same thing again. If the time delay is becoming longer, the storm is moving away from you. If the time delay is becoming smaller, the storm is getting closer. You can even work out how far away it is. How can you do that?

Why is it that you can see the image of the ball being hit well before you can hear it? Similarly, you can often see lightning in the sky as a flash a few seconds before you hear the thunder. The lightning and thunder are produced at the same time in the same place, but the sound takes longer to reach you than the light takes. The reason for this is that sound travels much more slowly than light—light travels at a speed of about 300 000 kilometres per second, while sound travels at only 340 metres per second.

Prac 4 p. 136

Fig 3.6.4 When you are watching the cricket you often see the cricket ball being hit before you actually hear the sound.

Echoes (echolocation)

Have you ever heard an echo of your own voice? An echo happens when sound strikes a large, hard surface, such as a wall, and is reflected back. The distance to the wall determines the time difference between the production of the original sound and the echo. Actually, echoes occur more often than you might think—you probably make many echoes a day. Most of the time, however, the time difference between the original sound and the echo is so small that your brain does not register the echo as a separate sound.

Echoes are used by commercial fisherman to locate the depth of shoals of fish. A device on a fishing boat sends out a sound wave through the water. When the sound wave hits a large underwater body or a shoal of fish the wave is reflected back to a receiver on the boat. If the speed of the sound wave through water is known it is possible for the device to calculate the depth at which the shoal can be found. Fishermen can then place nets at this depth to capture the fish. This is called **sonar** or **echolocation**.

Bats are almost blind and rely on natural sonar to find their way about in dark caves. The bat emits a very high sound, which then is reflected off walls or insects back to the bat. The bat is able to avoid walls and also locate its next meal of flying insects.

Science Snippet

Breaking the sound barrier

Before 1947, engineers and pilots were not sure if aircraft could fly faster than the speed of sound. Perhaps the speed of sound formed a barrier—the sound barrier—that no aircraft could exceed. In 1947, however, a test pilot named Chuck Yeager took his X-1 jet plane beyond the sound barrier. When aircraft go faster than the speed of sound a loud boom is heard. This sound is called a sonic boom. Sonic booms are sometimes heard when meteorites enter the Earth's atmosphere from space.

Fig 3.6.5 A jet 'breaking the sound barrier'. The 'cloud' is water condensing.

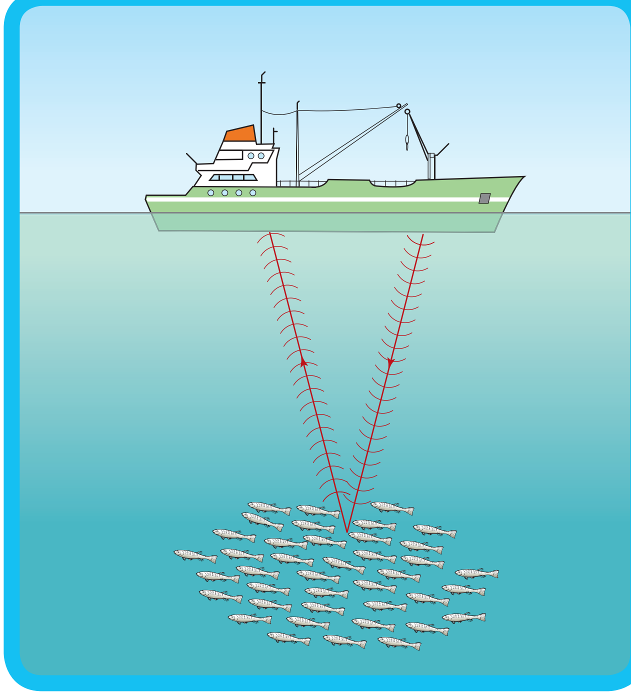


Fig 3.6.6 Echoes can be used to detect the position of fish under water.

FOCUS 3.6 [Questions]

Use your book

Interactive CW Crossword

The source of sound energy

1 What is the source of all sound?

Transmitting sound

2 Which two states of matter do sounds travel better in and why?

3 What conditions are necessary for sound to be produced?

Sound waves

4 What is the difference between a compression and a rarefaction?

The ear

5 What part of the ear collects the sound vibrations from the ear canal and passes them to the inner ear?

Sounds and speech

6 Describe how you make sound with your larynx.

7 What parts of the body enable us to convert sounds into speech?

The speed of sound

8 How much faster than sound does light travel?

Echoes (echolocation)

9 What determines the time delay between your shout in a canyon and your echo?

Use your head

10 How are heat and sound similar?

11 Do you think a sound is produced if no one is there to hear it?

12 In many science fiction movies, you can hear the sound of space craft blowing up. Why is this not scientific?

13 Why can excessively loud sounds damage your ears?

14 Lightning and thunder are produced at the same time. Why then do you usually hear the thunder several seconds after seeing the lightning flash?

15 If you counted 9 seconds between seeing a lightning flash and hearing the thunder, how far away was the lightning?

Investigating questions

16 Investigate why men have deeper voices than women.

17 What produces the vibrations in the following musical instruments: violin, trumpet, drum, clarinet?

18 Investigate echolocation in bats and ultrasound in dolphins. How are they similar and how are they different?

Fig 3.6.7 Bats use echolocation.

19 Make an aluminium-can telephone from two cans, two nails and some string. Your teacher will tell you how. Investigate how to improve its performance.

DYO

3·6 FOCUS [Practical activities]

Prac 1 Focus 3.6

Investigating disturbances

Purpose

To investigate some sound-producing disturbances.

Requirements

Tuning forks, foam cup, rubber band, cardboard, retort stand.

Procedure

1 Set up the apparatus as shown in Figure 3.6.7.

2 Carry out each investigation.

Question

What do the investigations indicate about the source of sound?

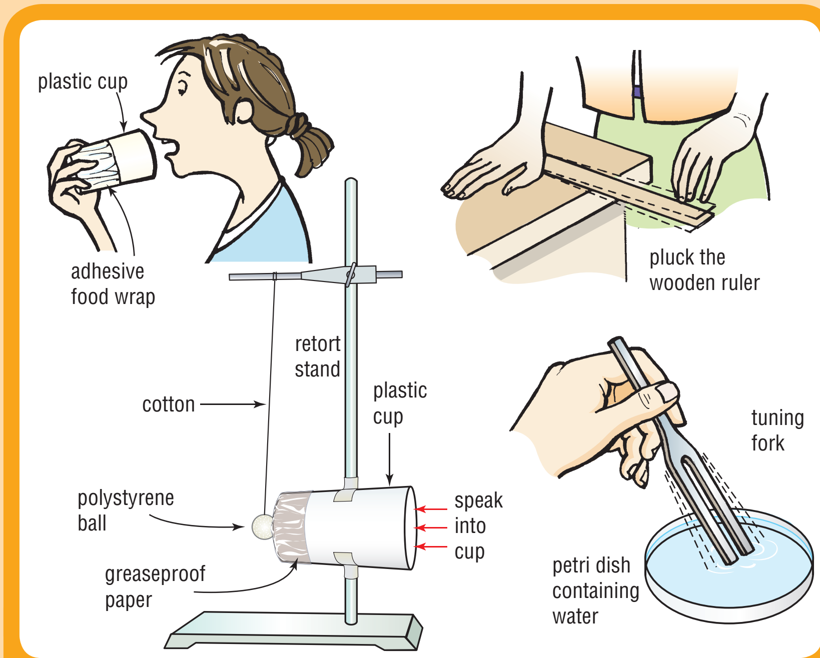


Fig 3.6.7 Some tuning fork experiments

Prac 2 Focus 3.6

Can sound travel through a vacuum?

Purpose

To investigate whether sound can travel through a vacuum.

Requirements

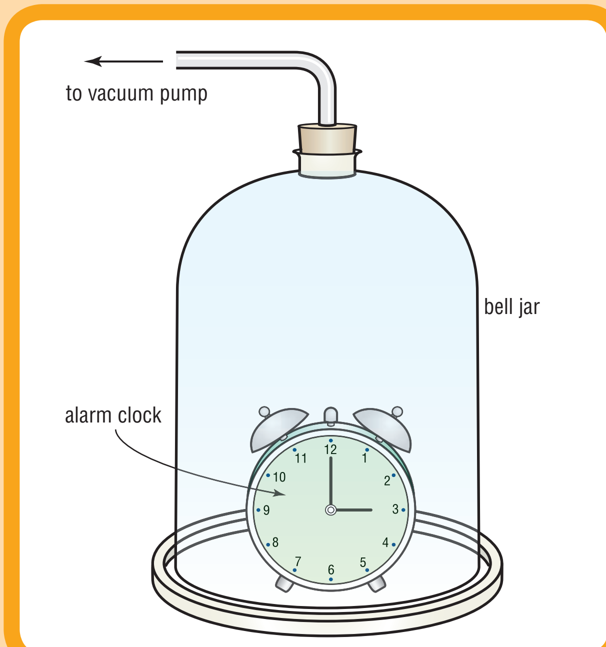
Bell jar, vacuum pump, electric bell or an alarm clock.

Procedure

This activity is best done as a class demonstration by your teacher.

1 The alarm clock should be set on continuous alarm and placed under the bell jar.

2 After ensuring that the bell jar is firmly sealed onto the base (preferably with Vaseline or other sealant), start the vacuum pump to evacuate the air from inside the bell jar.



Set-up to test sound in a vacuum *Fig 3.6.8*

Questions

1 Describe the sound that you heard before, during and after the air was evacuated from the bell jar.

2 What does this tell you about the conditions necessary for sound to be transferred?

3 Why can you see the alarm in the bell jar after the air has been evacuated but not hear it very well?

Speaking

Prac 3 Focus 3.6

Purpose

To investigate the parts of your mouth responsible for turning noise into speech.

Requirements

Nil.

Procedure

1. Pick out six letters of the alphabet.
2. Say each letter clearly. As you do, think about what is happening to your tongue, teeth, lips and palate (your palate is the roof of your mouth). Perhaps a friend could also watch you sound out the letter.
3. *Write down the letter and the parts of your mouth you used in sounding out each letter. Record your observations in a table like the one below.*

Letter	Part of mouth used			
	Lips	Tongue	Palate	Teeth
A				
B				
etc				

4. Extend this prac by replacing letters with words or syllables.

Measuring the speed of sound

Prac 4 Focus 3.6

Purpose

To measure the speed of sound.

Requirements

Trundle wheel or long tape measure, several stop-clocks, a starter's pistol.

Procedure

1. Use the tape measure to measure out a distance of at least 100 metres—the longer the distance, the better.
2. The teacher stands at one end with the starter's pistol, while several students with stop-clocks stand at the other.
3. The teacher firing the starter's pistol begins this experiment. Smoke from the pistol is the sign for student timers to start their clocks.
4. Students stop their clocks when the sound of the pistol reaches them.
5. *Record the distance that the sound travelled and the time difference between seeing the smoke from the pistol and hearing the sound.*
6. *Calculate the speed of sound by using the following formula:*

$$\text{speed (metres per second)} = \frac{\text{distance travelled (metres)}}{\text{time (seconds)}}$$

Questions

1. When using the formula provided to calculate the speed of sound, how did you use the different times recorded by the students?
2. How does this speed compare with the actual value for the speed of sound in air?
3. Why is there a time difference between seeing the smoke and hearing the sound from the starter's pistol?
4. How could your results from this experiment be improved?

FOCUS 3.7 Contact forces

Context

Every day you exert force on objects or have forces exerted upon you. In fact, you could not exist without forces. All life in the universe is held together by forces, but have you ever seen, tasted or smelt a force? You cannot directly see taste or smell forces but you can see the effects of forces. Have you ever wondered what forces are? What are the different types of forces and how do they work? As you begin to investigate and understand forces and how they act and interact with everyday objects you will start to understand the answers to these questions.

What are forces?

Many activities that you do over the course of a typical day require effort. For instance, when you ride a bike, most of the time your legs are pushing down on the pedals. To push you have to make an effort. When you pick up your schoolbag, you have to make an effort in order to lift or pull the bag upwards and off the ground. When you open a door you make an effort to either push the door forward, or pull backwards on the door knob with your hands. In these examples the effort was described as either a push or a pull. The words 'push' and 'pull' are very important words, which you will come across often in studying Energy and Change. Put simply, **force** can be thought of as a push or a pull. Every time you push or pull on something, you are exerting a force.

Effects of forces

Scientists say that when a force acts on something a change occurs. Think about riding a bike again for a moment. What changes could you make to the motion of your bike? If you want to move faster you would have to pedal harder. If you are moving too fast you apply the brakes to slow down. Whether going faster or slowing down you are changing the speed of your bike. When you get to a corner you turn the handle bars in order to change your direction. And if you are unfortunate enough to be moving too fast when you hit a solid barrier such as a wall you might buckle your front wheel and change its shape.

Speeding up, slowing down, changing direction and changing the shape of something are all examples of changes that could be produced by forces. In summary, forces produce:

a an increase in speed (also called an acceleration)
b a decrease in speed (also called a deceleration)
c a change in direction
d a change in shape.

Often more than one of these effects may happen at the same time.

Fig 3.7.1 Forces can be seen to be acting around us every day and in many different situations.

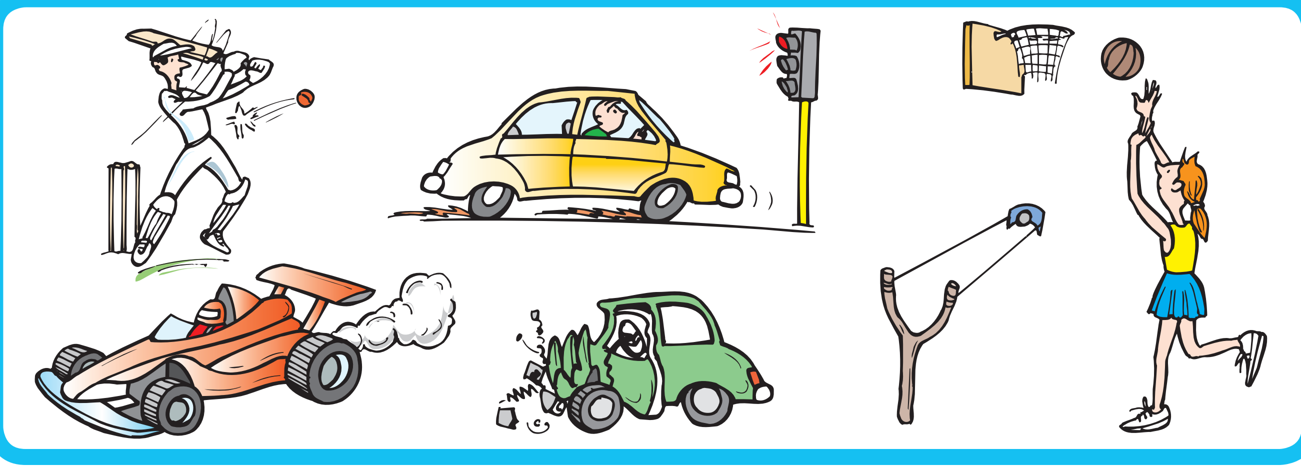


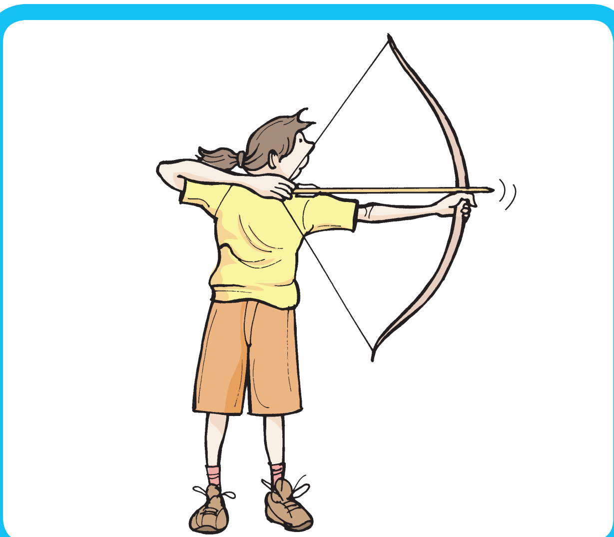
Fig 3.7.2 There are many changes that can be produced by forces you exert when riding a bike.

Analysing forces

Whenever a force is acting, you should be able to tell:

a what is providing the force
b what the force is acting on
c the effect of the force.

For example, look at Figure 3.7.3 and read the analysis of this force situation described in the table below the illustration.



Pulling back on a bow in order to fire an arrow requires force. Fig 3.7.3

What is providing the force?	The girl.
What is the force acting on?	The string attached to the bow.
What is the effect of the force?	The bow bends.

Contact forces

Most of the situations described so far illustrate one object or person exerting a force through contact with another object. For instance, your foot is pushing on the pedal of your bike, causing the bike to move faster (accelerate). Or the contact between the brake pads and the tyres of your bike causes the bike to slow down (decelerate). During an accident your wheel changes shape because it comes into contact with a solid object. These are all examples of **contact forces**. In the next focus you will investigate examples of non-contact forces.

Drawing forces

We can use force diagrams to show some or all the forces acting on an object. Arrows can be drawn to show the direction and size of the forces acting on something.

Look at Figure 3.7.4. Notice that the forces have been labelled with common words that help to describe the forces in action.

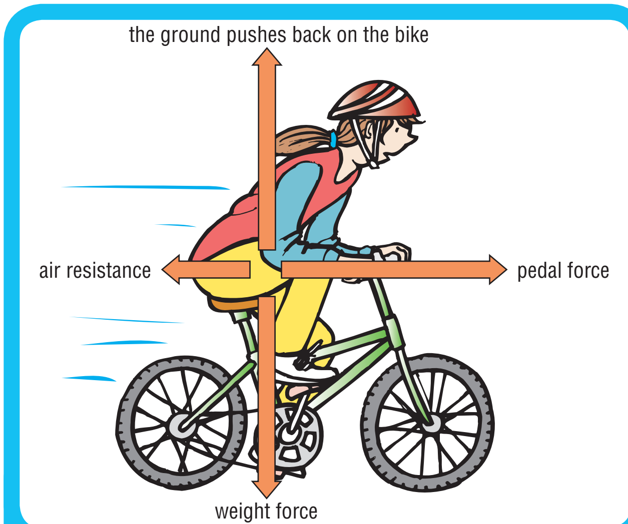


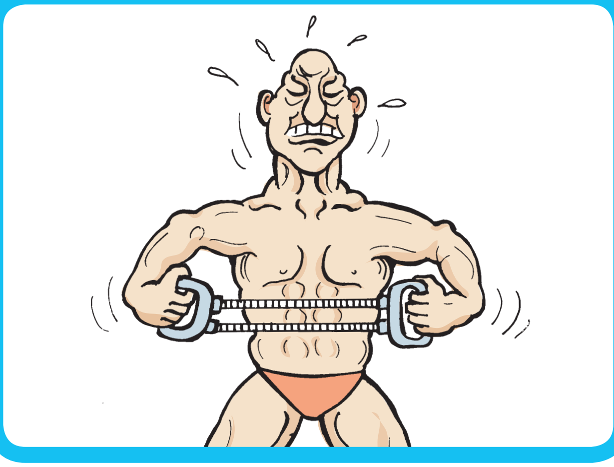
Fig 3.7.4 Forces diagrams can be drawn to show the direction and size of forces acting on objects.

Measuring forces

If you have ever tried stretching rubber bands you will have found that a small force stretches the rubber only a little way. A bigger force stretches the rubber a lot. Once again, you can see how a force has produced a change, in this case a change in the length of the rubber.

Springs can be stretched by applying a force. The bigger the force, the greater the stretch.

Fig 3.7.5



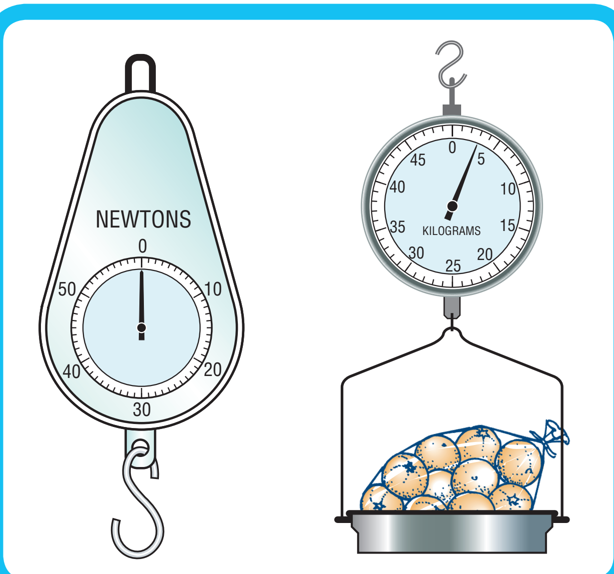
This principle can be used to measure the size of a force. If a pointer and scale are attached to a piece of rubber or a spring, then you can use the change in length of the rubber or spring to measure the size of the force that is producing the change. The spring balance and grocery scales are based on this idea.

Prac 1
p. 142

Science Snippet

Newton

The most common unit of measuring force is the newton (N). This unit is named after the English scientist Sir Isaac Newton (1642–1727). To give you an idea of what a newton of force feels like, if you were to lift a medium-sized calculator or a small apple, you would be exerting a force of about one newton. It is the force needed to lift about 100 grams (more accurately 102 grams).



Spring balances and grocery scales indicate the size of an applied force by the amount of change in the length of a spring.

Fig 3.7.6

Friction

Have you ever wondered why the soles on your favourite joggers wear through, or when you rub your hands together your hands get hot, or even why small brake pads on your bike can stop you very suddenly?

Friction occurs between any two or more surfaces of objects that are in contact. From what you now know about forces, friction is therefore a contact force. Friction occurs on all types of objects and substances, whether they are solid, liquid or gas.

Even though the surface of an object may appear smooth to your eye, an extremely close inspection of an apparently smooth surface with an electron microscope will show that there is no such thing as a perfectly smooth surface. Every surface, even though it appears smooth, has bumps, hills and valleys that can scrape against another surface, preventing the surfaces from sliding over one another. Being a contact force, friction always acts between surfaces that are directly touching. The direction of the frictional forces is normally opposite to the movement of the object. So **friction** is the force that opposes the movement of one body over another.

Fig 3.7.7

Microscopic study reveals many imperfections on surfaces that to the eye seem smooth.

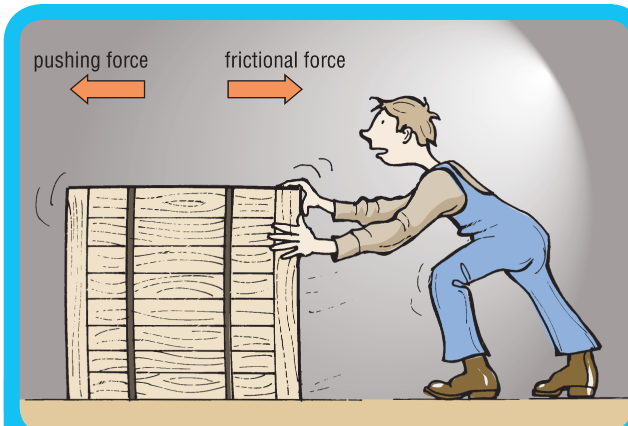
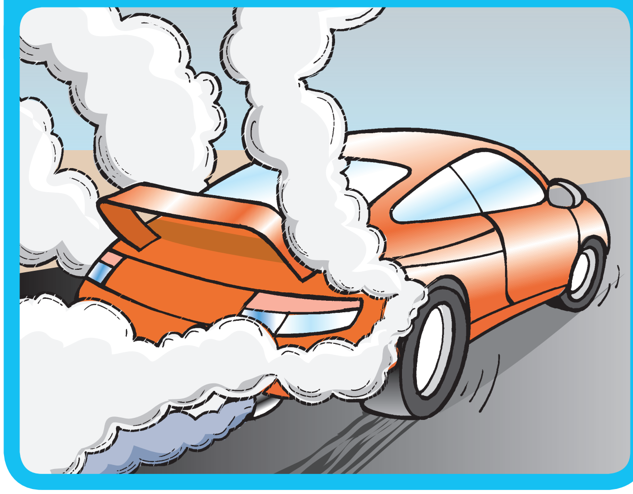


Fig 3.7.8

If the box is moving at a steady (unchanging) speed then the forwards (pushing) and backwards (frictional) force must be equal.

The effects of frictional forces can be an advantage or disadvantage, depending on the situation. Frictional forces can cause **moving parts to wear**, **generate significant amounts of heat**, and cause **moving objects to slow down**. If you rub your hands together for long enough you might feel some of these effects.

Fig 3.7.9 Much friction is acting here.



Try this! Start rubbing your hands together quickly. What do you feel?

Feel the effects of friction. **Fig 3.7.10**

The surfaces of hands in contact are actually quite rough and when you rub them together the friction causes heat.

Rub your hands together except, this time, force your hands more tightly together. What do you feel? It won't be too long before you can start feeling your hands becoming warmer. If you continued this for the whole day you might rub away a few layers of your skin.

Prac 2 p. 143

After rubbing your hands together for a few moments, you may experience two of the main disadvantages of friction—that it generates heat and causes wear. Some ways to reduce the effects of friction are:

- add a lubricant—this is a thick liquid such as oil that is placed between the surfaces in contact, for example adding oil to a motor allows the moving parts inside the engine to slide over one another more easily
- make the surface smooth as possible, for example sports cars are shaped with smooth surfaces and curves so that air flows easily over them
- reduce the force pushing the two objects together, for example unloading a box before pushing it across the floor.

Prac 3 p. 143

Prac 4 p. 144

Drag and Drop CW Interactive

Homework book 3.10 Friction

FOCUS 3.7 [Questions]

Use your book

What are forces?

1 What is a force?

Effects of forces

2 What changes can be produced by forces?

Analysing forces

3 When a force acts, what three things should you be able to identify?

Contact forces

4 What is common to all contact forces?

5 List three different contact forces and give an everyday example of each.

Drawing forces

6 In a diagram showing forces, what do the arrows show?

Measuring forces

7 What units are used to measure forces?

8 What method can you use to measure a contact force?

Friction

9 What is friction?

10 How does a lubricant such as oil help to reduce friction?

11 Provide two situations in which friction is an advantage.

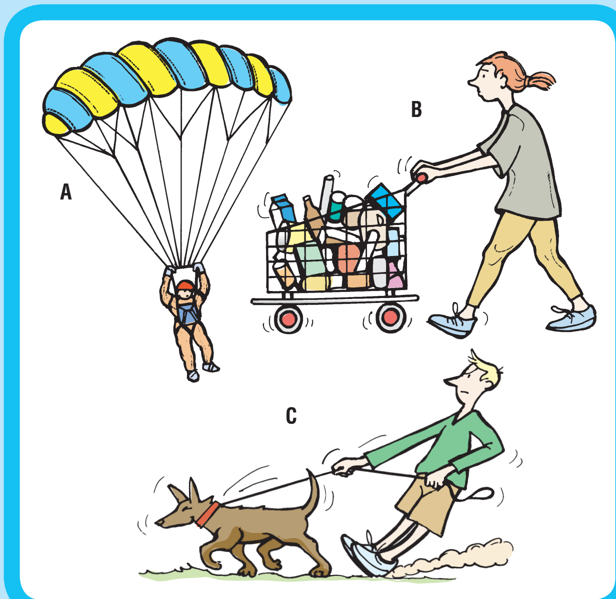
>>

Use your head

12 Identify an example of a situation in which a force:
- **a** changes the speed of an object
- **b** changes the shape of an object
- **c** changes the direction of an object.

13 Look at Figure 3.7.11. For each situation identify:
- **a** what is providing the force
- **b** what the is force acting on
- **c** what the effect of the force is.

Present your answer in a table.

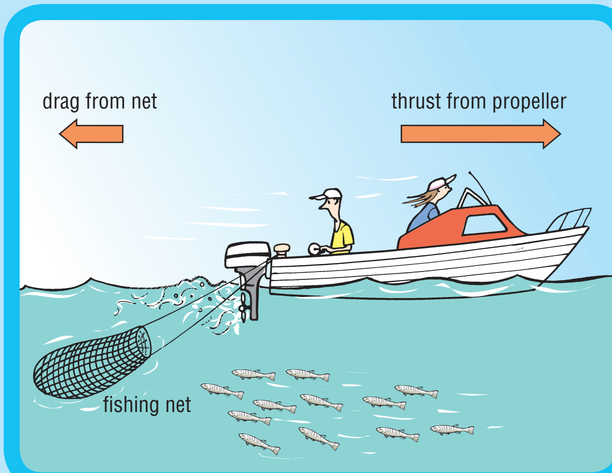


Some forces are acting here. *Fig 3.7.11*

14 Look carefully at Figure 3.7.12. James pulls hard against the mast of his boat but the boat does not move. Is James applying a force to the boat? Explain your answer.

Fig 3.7.12 Is there a force here?

15 Look at Figure 3.7.13. The two forces shown are acting on the boat. Look at the force arrows and determine which direction the boat will move.



Forces on a boat *Fig 3.7.13*

16 A person walking across an icy surface may find the lack of friction between the ice and soles of their shoes to be a disadvantage. Yet for a competitive sprint cyclist in a velodrome friction is a disadvantage. Explain why this is so for each case.

17 In each of the following situations, decide whether the frictional forces should be high or low:
- **a** car tyres in contact with the road
- **b** hands of a trapeze artist holding onto the bar of the trapeze
- **c** a jet fighter flying through the air
- **d** a person abseiling down a cliff face.

18 The three types of friction are:
- sliding friction—occurs when two solid surfaces slide over each other
- rolling friction—occurs when an object rolls over a surface
- fluid friction—occurs when an object moves through a fluid.

Provide one everyday example of each friction type.

Investigating questions

19 In this focus you have read a little about a scientist named Isaac Newton who lived in the 17th century. Newton is famous for many discoveries. Newton framed three laws of motion that help us to understand how forces influence the motion of objects. With two other partners, investigate each of Newton's Three Laws of Motion. Write them down and say how they apply to our everyday life.

FOCUS 3.7

[Practical activities]

Prac 1 Focus 3.7

Make a force measurer

Purpose

To make a device that will allow you to measure forces.

Requirements

Rule, rubber band, paper clips, white cardboard (cut to 2.5 cm × 25 cm), adhesive tape, 500 g slotted masses, scissors, Newton spring balance.

Procedure

1. Prepare two paper-clip hooks and attach a length of rubber to them.
2. Assemble the force measurer as shown in Figure 3.7.14.

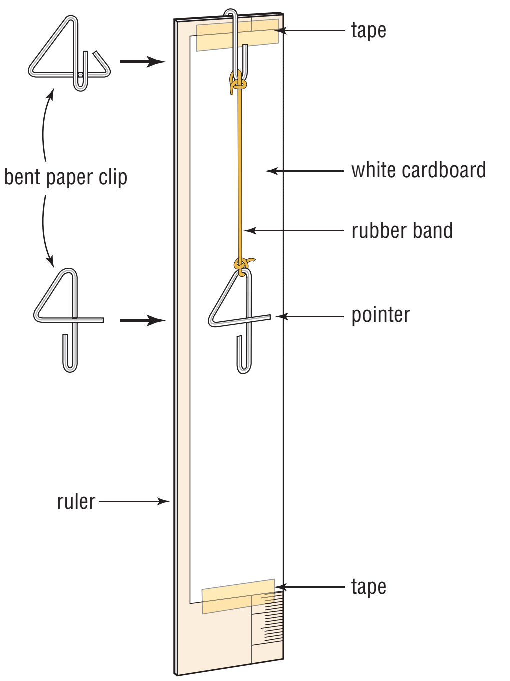
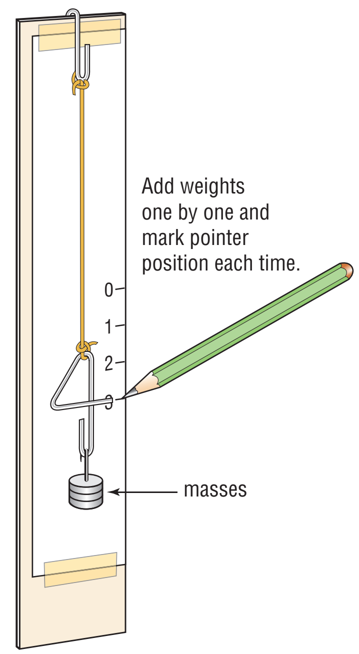


Fig 3.7.14 A force measurer

3. Test your force measurer.
4. Slide the cardboard piece up under the clip. Tape it in position.
5. Mark a '0' on the cardboard level with the tip of the pointer, as in Figure 3.7.15.
6. Hang 100 g of slotted masses onto the lower clip. Mark a '1' at the new position of the pointer.



The scale for your force measurer Fig 3.7.15

7. Add another 100 g to the hook and mark position '2'.
8. Continue to add masses until a scale of 1 to 5 has been prepared.
9. Use your force measurer to measure the force required to do some common activities around your classroom like lifting or pulling on things. After measuring each object by using your force measurer, use a spring balance to record the force in newtons of each object. *Record your results in your notebook using a table like the one below.* You will need to add more rows in your table.

Object	Force using force measurer (1–5)	Force in Newton (N)

Questions

1. Which object required the greatest force? Why do you think this was the case?
2. Compare your force with the force recorded for the same object by other groups with their own force measurers. Are the results the same? Why or why not?
3. How did the spring balance and your force measurer compare in the readings they gave?
4. How could you improve your force measurer?

Testing adhesives

Prac 2 Focus 3.7

DYO

Purpose

The purpose of this activity is to determine which adhesive tape works best.

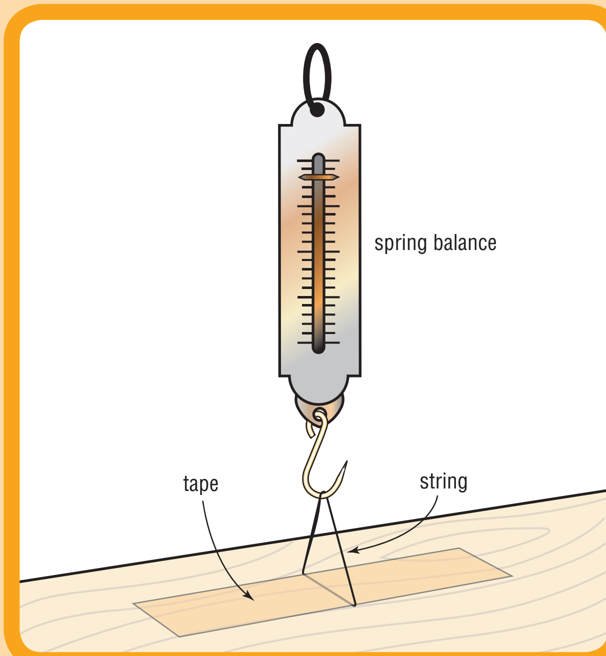
Requirements

Your force measurer from Prac 1 or a Newton spring balance, four different types of adhesive tape, scissors, four 15 cm lengths of string, bench mat.

Procedure

1. Use Figure 3.7.16 to help you design an investigation into which type of adhesive tape works best.
2. *Write down the steps you went through to do this experiment.*
3. Record your results in your notebook using a table like the one below. You will need to add more rows.

Type of tape	Force required in newtons (N)



One way of testing tape strength *Fig 3.7.16*

Questions

1. Which tape required the greatest force to lift it off the bench mat? Explain what this means in terms of the adhesive forces of the tape.
2. What factors do you think may have affected your results?
3. What steps did you take to ensure your test was fair?
4. What improvements can you make to your experiment?

Friction

Prac 3 Focus 3.7

Purpose

To determine if the surface of a material affects the force of friction.

Requirements (per group)

A 0–20 N Newton meter spring balance, a wooden block, 60 cm of string, several different surfaces (sandpaper, fabric, concrete, wood, wax paper, carpet etc).

Procedure

1. Copy the data table on the following page and include additional rows, depending on the number of surfaces you have.
2. Select at least three different types of surfaces near your classroom.
3. Place the wooden block on the first surface and attach the block to the Newton meter.

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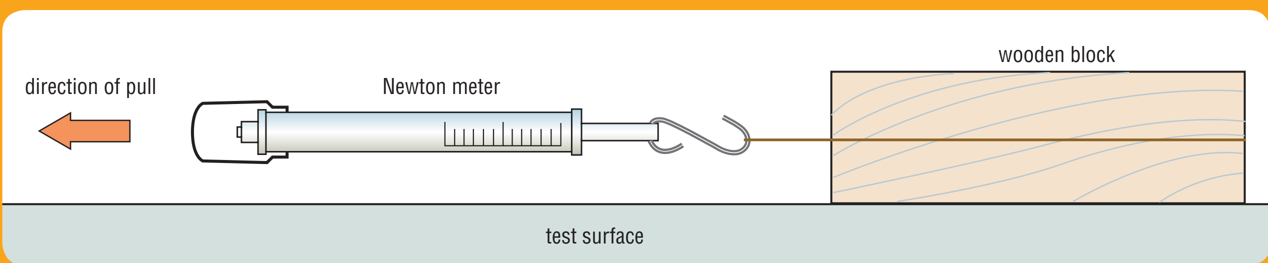
Fig 3.7.17 How to test the force required to move the block



4. Pull the Newton meter at a steady pace horizontally so that the block moves slowly.
5. From the Newton meter read the force required to move the block and *record the reading in your copy of the data table*. What does this reading represent?
6. Repeat this measurement until you get a consistent result (at least three times might be required). Why do you need to repeat the number of measurements?
7. From your data, calculate the average frictional force for each surface.
8. Complete your data table by recording each reading in the appropriate place.

Questions

1. How does the surface of a material affect movement on that surface?
2. What happened to the force of friction as surface roughness was changed?
3. In which direction was the force of friction acting in each case?
4. What factors do you think may have affected your results?
5. What steps did you take to ensure that your test was fair?

Data table

Type of surface	Trial 1 (N)	Trial 2 (N)	Trial 3 (N)	Trial 4 (N)	Average (N)

Prac 4
Focus 3.7

DYO

Investigating friction

You have a choice of experiments investigating friction.

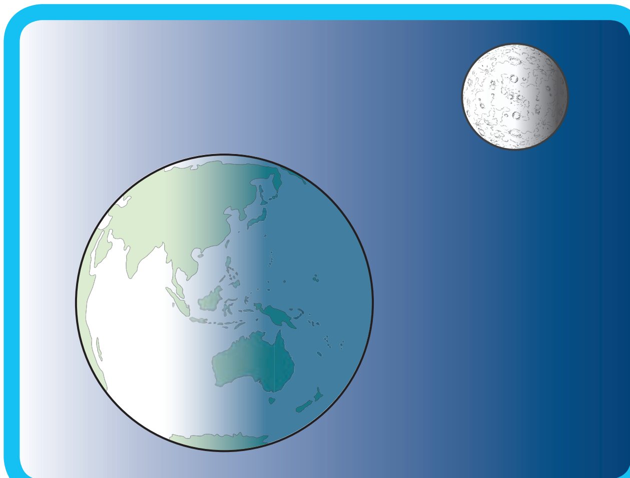
1. Design and conduct an experiment that investigates the hypothesis that the weight of a sliding object affects the force of friction.
2. Design and conduct an experiment to test some ways in which friction can be reduced.

FOCUS 3.8 Gravitational force

Context

Isaac Newton is said to have been sitting under an apple tree one day, when an apple fell down beside him. He is claimed to have said 'What goes up, must come down'. Whether Newton actually sat under the apple tree and said these words we don't know, but the important point is that Newton's thoughts helped us to understand more about a very important force that affects our lives every day. This force is of course gravity, the force that keeps us on the Earth, the force that keeps the Moon orbiting around the Earth, and the force that keeps the Earth orbiting around the Sun. Imagine how different our lives would be without gravity. What might be the difference between gravity and the forces you read about in the last focus (clue—look at the title of the last focus).

Fig 3.8.1 Isaac Newton helped us to understand the nature of gravity.



Gravity keeps the Moon orbiting the Earth. *Fig 3.8.2*

Forces that act at a distance

The answer to the question above is that the last focus dealt with contact forces. If you hold up a pen and then release it, it will fall under the influence of gravity. The pen will fall even though there is no other body or object in contact with it, pushing or pulling it. Gravity is a force that acts over a distance. Forces that act over a distance are called **non-contact forces**.

Gravity

Why is it that things fall when you lift them up above the ground and then release them? Why will a rock fall back to the ground when you throw it into the air? The reason is the force of gravity that exists between them and the Earth. **Gravity** is a 'pulling' force that exists between things that have mass. The Earth has mass and the rock has mass. Therefore both the rock and the Earth have the force of gravity 'pulling' them together. Gravity does not act just between the Earth and objects close to it. There is a strong gravitational force between the Earth and the Moon. This force keeps the Moon orbiting the Earth.

There is a gravitational force between the Earth and the Sun, which is why the Earth retains its orbit around the Sun. Without gravity the Moon would not continue to orbit the Earth but would fly off away from the Earth. The Earth would fly away from the Sun.

The strength of the force of gravity between bodies is determined by the mass of the bodies. Because the Earth is a huge mass it exerts a big gravitational pull on objects close to it, such as pencils, books, apples and you. There is a gravitational force between you and the person sitting next to you. You and the person closest to you, however, do not have a large mass (in astronomical terms) and so there is not a big gravitational force of attraction between you.

The gravitational force of attraction increases as:

- the mass of either or both objects increases
- the distance between the objects decreases.

The difference between mass and weight

What is your weight? When most people are asked this question they often express their answer in kilos (short for kilograms). In fact, the kilogram is the unit for mass, not weight.

Let's review your understanding of mass.

- **Mass** can be defined as the amount of matter that makes up a body or object.
- Mass is usually expressed in units of **grams (g)** or **kilograms (kg)** (although there are other units for describing the mass of something).
- Mass is measured by using some sort of balance like a triple beam balance or a set of weighing scales.

Now let's review our understanding of weight.

- **Weight** can be defined as the amount by which something is pulled downwards (towards the Earth's centre, actually) by gravity.
- Weight is usually expressed in units of **newtons (N)**.
- Weight is measured by using a **spring balance** (see Figure 3.7.6).

Science Snippet

Apple moves the Earth!

Gravity acts equally between an apple and the Earth. This is surprising, since we always see the apple falling towards the Earth and never the Earth falling towards the apple. Actually, the Earth and the apple 'fall' towards each other. Because the Earth has a much greater mass than the apple, the apple moves much more than the Earth. Ask your teacher to explain this to you in more detail.

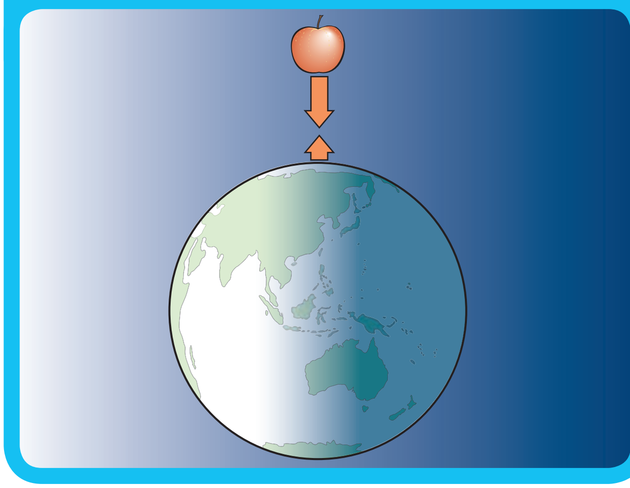
Prac 1 p.147

Prac 2 p. 147

Homework book 3.11 Pressure

Interactive CW Animation

Fig 3.8.3 When you let an apple go, the Earth and the apple fall towards one another.



FOCUS 3.8 [Questions]

Use your book

Forces that act at a distance

1 What is another name for forces that act over a distance?

Gravity

2 What is the name of the force that causes all objects thrown into the air to return to Earth?

3 Is gravity a pushing or a pulling force?

4 Why is a gravitational force considered to be a non-contact force?

5 What two factors affect the strength of a gravitational force?

The difference between mass and weight

6 What are the common units used to measure mass and weight?

7 When you stand on a set of bathroom scales what does the number on the scales tell you?

Use your head

8 How is the mass of a pencil different from its weight?

9 Why is a spring balance an appropriate device to measure the weight of a cup?

10 How would your weight compare at 1 kilometre, 100 kilometres and 1000 kilometres above the Earth's surface?

11 Is a kilogram of rock heavier that a kilogram of feathers? Why or why not?

12 In space does an astronaut have less mass or weight? Explain your answer.

13 How would your weight on the Moon compare with your weight on Earth, and why?

14 The first astronauts on the Moon hit a golf ball for fun. What do you think would have happened and why?

Investigating questions

15 Things fall because of gravity. But Gravity is not the only force that affects falling objects. Design an investigation to find some factors that affect how long it takes a sheet of paper to fall from a given height. Alternatively, your

DYO

>>

teacher may ask you to try the helicopter from Prac 1 in Focus 1.7. You should already have done the helicopter prac.

16 Use the Internet to compare the mass of each of the planets in our Solar System, with the gravitational force at their surface.

17 Use the NASA website to investigate how gravity was used to help send space probes to the planets.

18 The orbits of comets illustrate a striking effect of gravity on objects. Find out what happens.

FOCUS 3·8

[Practical activities]

Prac 1 Focus 3.8

Mass and weight

Purpose

To measure and compare the mass and weight of different objects.

Requirements

Beam balance, spring balance, balance pan, a variety of objects from around the class.

Procedure

1 Use the beam balance to record the mass in grams of several objects around the class, such as whiteboard eraser, pencil, beaker and test tube holder.

2 Use the spring balance and balance pan to record the weight in newtons for the same objects.

3 *Record your results in a table like the one below.* Add more rows for the number of observations you will make.

Object	Mass (grams)	Weight (newtons)

Optional

4 Plot your results on a graph.

Question

Is there a relationship between the mass of objects and their weight. Explain this result.

Prac 2 Focus 3.8

Falling objects

Purpose

To compare the falling times of objects with different masses.

Requirements

Metre rule, sticky tape, objects of different masses, sheet of foam or rubber, stop-watch or stop-clock.

Procedure

1 Use the ruler to measure a height of about 1.5 metres up a wall.

2 Place a sticky tape marker at this height.

3 Collect a variety of unbreakable objects from around the class, such as brass weight, pencil, rubber ball, pencil case.

4 As in the last Prac, measure the mass and weight of each object by using a triple beam balance and spring balance.

5 Work with a partner to drop each object from the sticky tape marker onto the foam or rubber base (a carpet surface would also be suitable), while timing the fall of each object.

6 *Record your results in a table like the one below.* Add more rows for the number of observations you make.

Object	Mass (g)	Weight (N)	Time (s)

Questions

1 What did you discover in the experiment?

2 What factors might have affected your results in this experiment?

3 Which variables did you attempt to keep the same in this investigation?

4 How could you have improved your investigation?

5 Explain your observations.

FOCUS 3.9 Electric and magnetic forces

Context

Like gravity, electric and magnetic forces can act over distances and so are non-contact forces. Electric forces can explain many everyday occurrences, from lightning to the static shocks you can get when touching something metallic like a door handle. Magnetic forces also have much application in our everyday lives. Magnets are used in electric motors, and some pillows and beds, too, because some people believe that magnets help to reduce pain.

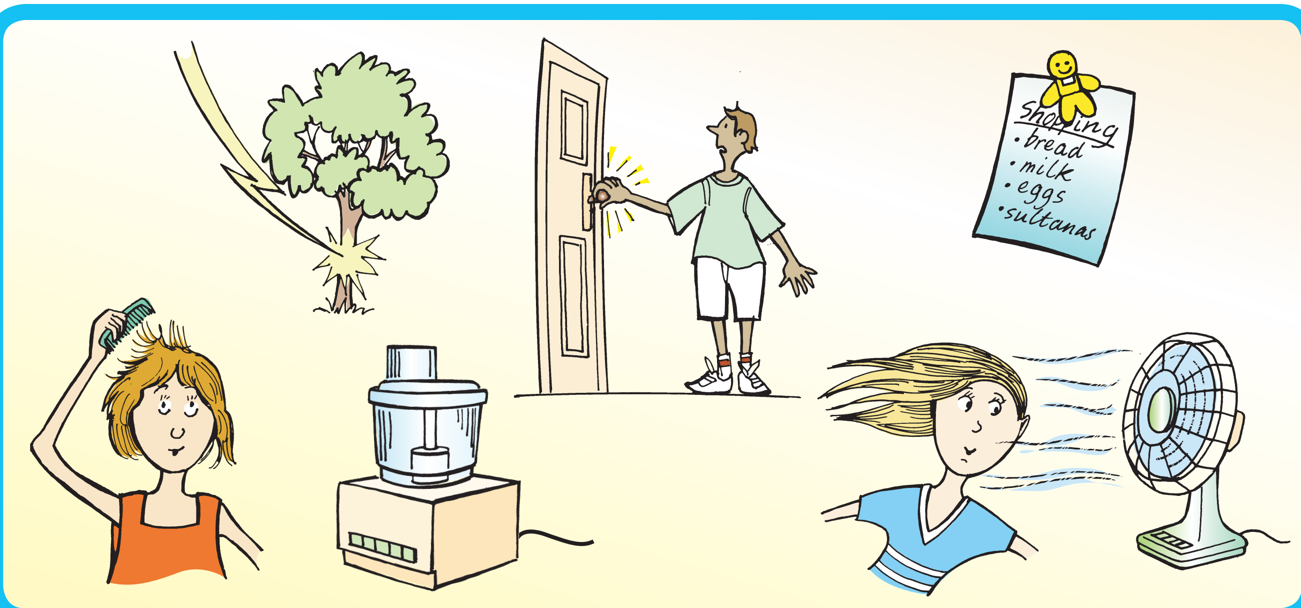
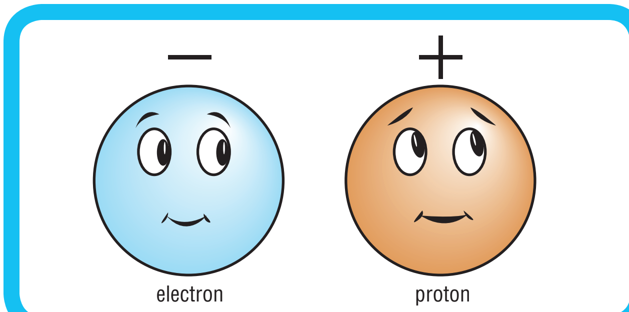


Fig 3.9.1 Magnetic and electric forces play an important part in our everyday lives.

Electric forces

Electric forces result from the pulling or pushing effects of electric charges. There are two different electric charges that you need to know about. These are called **positive charges** (+) and **negative charges** (-). Charges are the result of two very tiny particles existing within atoms. They are called **protons** and **electrons**. Protons are tiny positive-charge carriers and each proton carries one single positive charge. Electrons are tiny negative-charge carriers and each electron carries one single negative charge.

When the number of protons and electrons in an atom are equal the atom has no charge. We say the atom is electrically **neutral**. If an atom has more electrons than protons the atom has a negative charge.



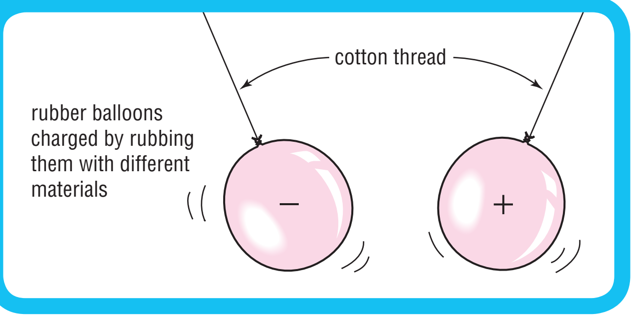
Electrons and protons have opposite charges. *Fig 3.9.2*

If an atom has more protons than electrons, the atom has a positive charge. Objects have a positive or negative charge because the atoms on their surface have either an overall positive or negative charge. How charged bodies affect one another is governed by the **charge law**.

Charge law

According to the charge law, objects that have opposite charges exert pulling forces on each other. These objects attract one another.

Fig 3.9.3 Oppositely charged objects attract one another.



Objects that have the same type of charge exert pushing forces on each other. These objects repel one another.

Electric forces can also be called **electrostatic forces**.

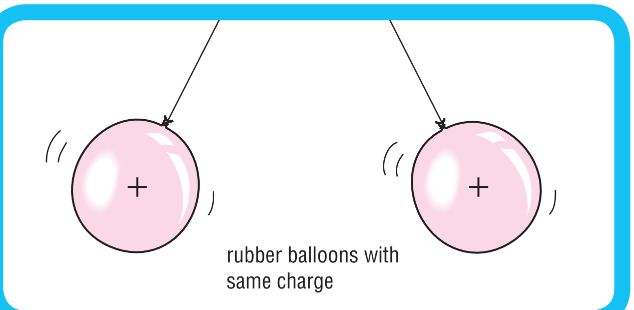


Fig 3.9.4 Objects with the same charge repel one another.

Homework book 3.12 Zapping car doors

Prac 1 p. xx

Interactive CW Animation

Science Snippet

How photocopiers work

Each time you make a photocopy, a spinning drum is charged with electricity with a negative charge, similar to rubbing a balloon on a woollen jumper. A fine black powder called toner is then attracted to the drum. The toner in the machine is negatively charged. The paper that is fed through is positively charged. Since the toner and paper are oppositely charged the negatively charged toner ink particles are attracted to the positively charged paper.

Magnetic forces

Magnets can affect one another or attract certain metals without being anywhere near them. This means that the magnetic force, like electrostatic force and gravitational force, is a non-contact force. All magnets contain one or more of the metals **iron**, **nickel** or **cobalt**, and magnets will only affect materials containing one or more of these metals.

You have many magnets around your home, for example in the latches and seals in the doors of cupboards and fridges to keep them closed. Magnetic forces are also used in devices such as compasses, radios and the speakers of your radios, TV and CD players. The electricity used in homes and in industry is produced by power station generators that contain large magnets.

The simplest type of magnet is called a bar magnet. Each end of a bar magnet is called a **pole**. You can think of each pole as an opposite. One pole is called north and the other is called south. Another common type of magnet is a horseshoe magnet.

Bar magnets and horseshoe magnets are the two most common types of magnets. *Fig 3.9.6*

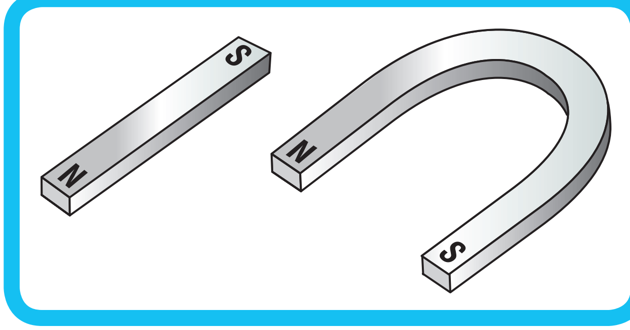


Fig 3.9.5 Photocopiers work because of electrostatic forces.

Magnetic fields

Like gravity and electrical charges magnets also affect the area of space around them. Magnets can do this by producing a **magnetic field** around them. You can see the effect of this invisible magnetic field if you were to place a bar magnet under a piece of paper and sprinkle iron filings (fine iron powder) onto the paper.

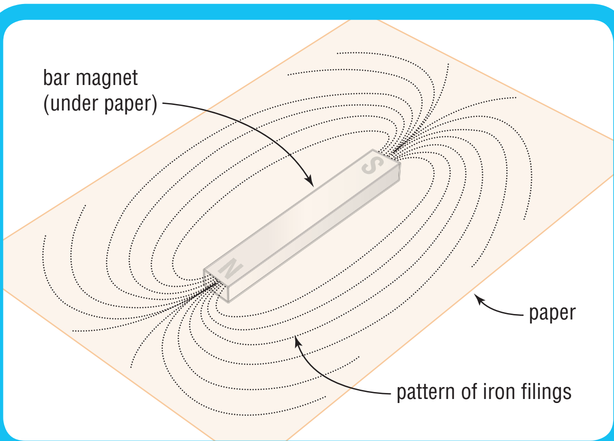


Fig 3.9.7 Iron filings allow you to see the pattern produced by the magnet's field.

> **Science Snippet**
>
> **Animal compass**
>
> A compass has a magnet in the pointer. We use compasses to navigate from place to place. Amazingly, many animals (such as whales and birds) seem to be able to detect the Earth's magnetic field to help them migrate north and south.

The Earth's magnetic field

Our planet Earth, along with some of the other planets in our Solar System, has its own magnetic field. The Earth's magnetic field behaves as though there is a giant bar magnet through the centre of the Earth.

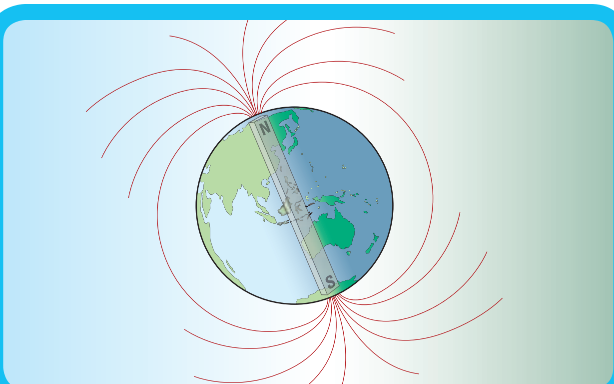


Fig 3.9.8 The Earth has a magnetic field much like that of a bar magnet.

The pole law

When the pole of one magnet is brought close to the pole of another magnet the two poles either repel or attract one another. Magnetic poles follow similar rules to those for electric charges. Opposite poles attract and like poles repel. This is called the **pole law**. For instance, if the north pole of one magnet is brought close to the south pole of another magnet, each pole will attract the other.

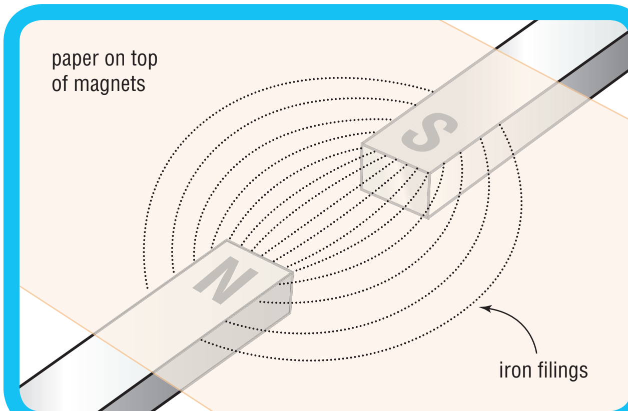


Fig 3.9.9 Iron filings showing the field around a north and a south pole

If two similar poles, for instance two north poles, are brought close together, they will repel one another.

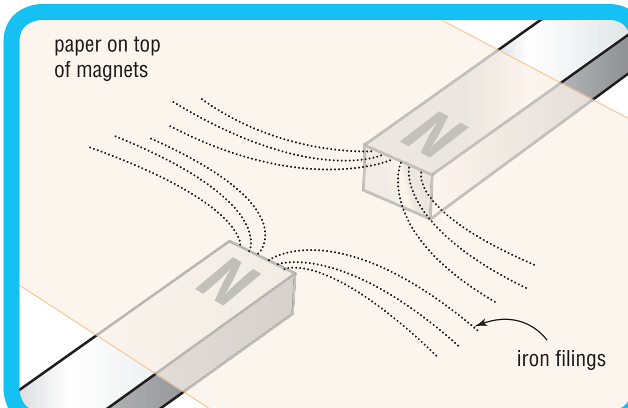


Fig 3.9.10 Iron filings showing the field around two north poles

Either the north or the south pole of a magnet will attract any non-magnetised material, provided that the material contains the metals, iron, nickel or cobalt.

Prac 2
p. 152

Homework book 3.13 Magnets

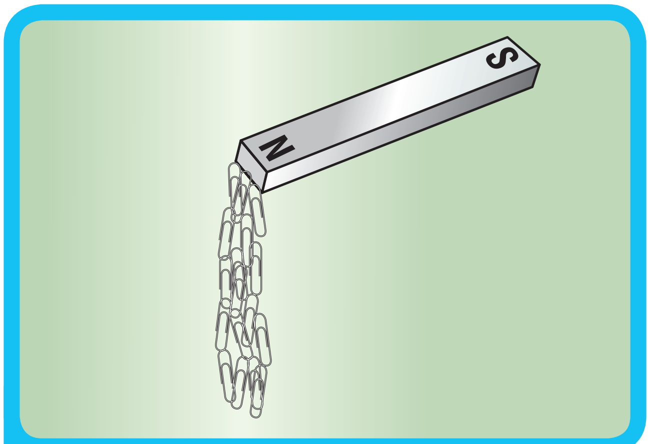


Fig 3.9.11 Magnets will attract metals containing iron, nickel or cobalt.

3·9 FOCUS [Questions]

Use your book

Electric charges

1 Why are electrical and magnetic forces considered non-contact forces?

2 How do objects become charged so that they then exert an electrostatic force on another object?

Charge law

3 What is the charge law?

Magnetic forces

4 List three different metals that have magnetic properties.

5 What are magnetic poles?

6 Draw a picture showing the field around a bar magnet.

Use your head

7 What are some ways that charges and poles are similar and some ways that they are different?

8 Make a list of some of the uses of magnets around your home.

9 Why do you sometimes get a shock when touching a door knob?

10 Look at Figure 3.9.12.

a Which pairs (A, B, C, or D) of bar magnets would repel each other?

b Which pairs (A, B, C, or D) of bar magnets would attract each other?

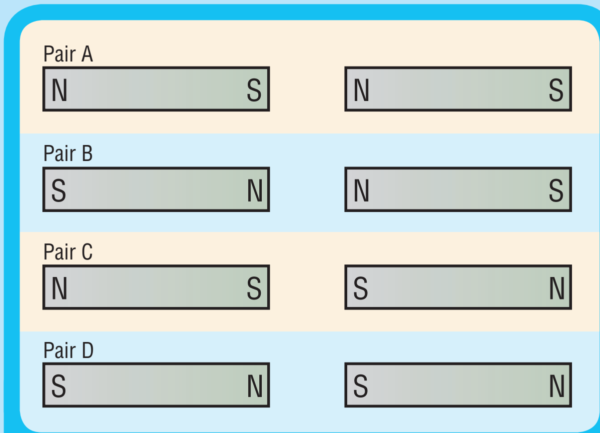


Fig 3.9.12 Arranging the magnets for Question 10

11 Explain why a blown-up balloon when rubbed with a piece of cloth sometimes clings to a wall or ceiling.

Investigate

12 The Earth has its own magnetic field. Scientists believe the Earth's field is the result of moving electrical charges deep within the Earth's molten metal core. Use the Internet to find out:

a what the Earth's magnetic field might look like

b some ways in which the Earth's magnetic field might be important to life on Earth.

3·9 FOCUS [Practical activities]

Prac 1 Focus 3.9

Charging up

Purpose

To produce electric charges and observe their effects.

Requirements

Plastic rod or plastic comb, glass rod, ebonite rod, samples of materials such as silk, cotton, wool, fur.

Procedure

Part A

1 You will be rubbing the different rods with the different materials to see if you can charge them. Figure 3.9.13 shows how to detect if you have charged the rod.

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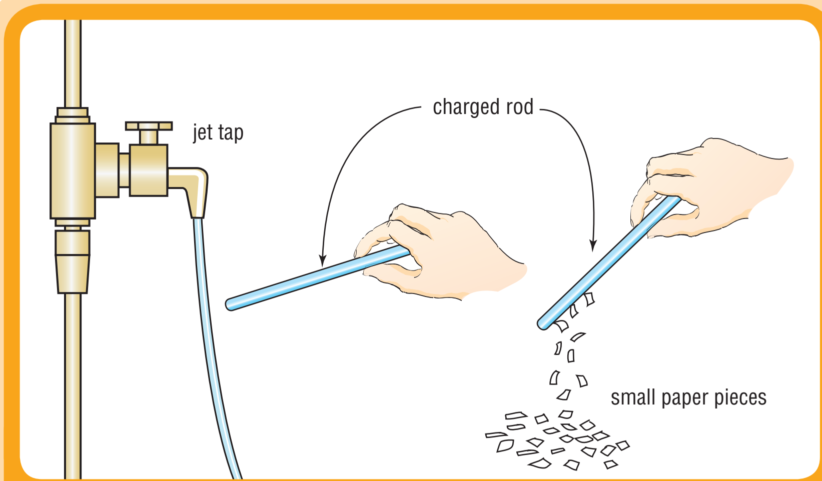


Fig 3.9.13 **a** Using the rod to attract a thin stream of water
b Using small pieces of paper to detect charge

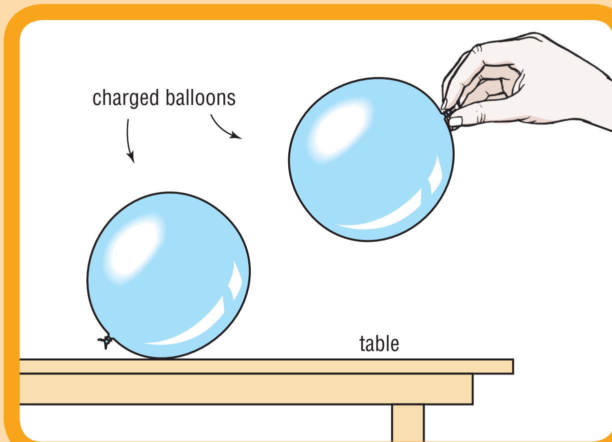
Questions

1. What did all objects you managed to charge in this activity have in common?
2. Why do you think you were able to charge certain rods and not others?
3. Explain your observations of Part B of this activity.

2. Rub the rods with the materials and see if they become charged or not. *Record your observations in your notebook. You could describe the results in a table or draw diagrams.*

Part B

3. Rub an inflated balloon on your hair and then try to get it to stick on a wall. *Describe or draw pictures in your notebook to illustrate your observations.*
4. Try to make the charged side of one balloon touch the charged side of another balloon, like in Figure 3.9.14.



Touch two charged balloons together. Fig 3.9.14

Prac 2 Focus 3.9

Invisible fields

Purpose

To observe the fields around different magnet combinations.

Requirements

Two bar magnets covered in plastic wrap (to keep iron filings off the magnet), iron filings in salt shaker, stiff white paper.

Procedure

1. Start with a single magnet under the paper in the centre.
2. Gently sprinkle iron filings over the paper. Observe the patterns you see, as in Figure 3.9.7.
3. *Draw the field pattern you observe.*
4. Tip the iron filings back into the shaker.
5. Repeat steps 1–4, but this time try the investigation with two magnets with poles close enough together so that they neither attract nor repel each other. Try N and N, S and S, N and S combinations.
6. *Draw the patterns surrounding each combination.*

Question

Describe the similarities and differences between each of the diagrams you have drawn.

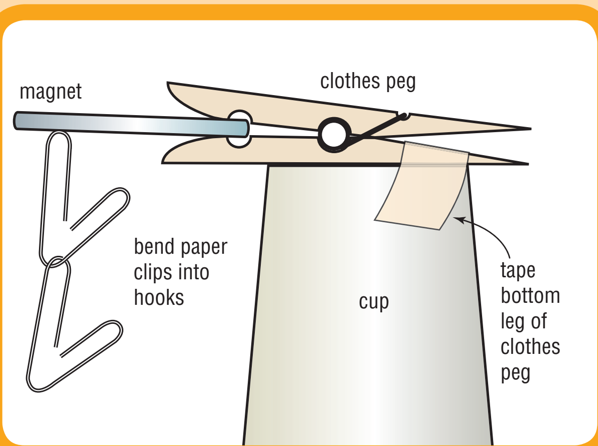
Prac 3
Focus 3.9

How strong is your magnet?

Purpose
To find out how strong your magnet is.

Requirements
Bar magnet, wooden clothes peg, masking tape (2.5 cm wide), 20 paper clips, scissors, foam cup or retort stand.

Procedure
1 Assemble the magnet, clothes peg and cup as shown in Figure 3.9.15.



Equipment set-up for Prac 3 *Fig 3.9.15*

2 Make a hook out of one of the paper clips.

3 Touch the paper clip hook to the magnet. It should be held to the magnet.

4 *Draw up a table like the one below in your notebook.* Your table will need eight rows in total.

Layers of tape	Number of paper clips
0	
3	
6	

5 Carefully add paper clips one by one onto the hook. Count the total number of paper clips that can hang before the paper clips fall off.

6 Record, in the 0 row of your table, the number of paper clips that hold onto the magnet before they fall.

7 Cut approximately 21 squares of masking tape (2.5 cm × 2.5 cm).

8 Stick three pieces of masking tape, one on top of the other, to the bottom of the magnet, as shown in Figure 3.9.16.

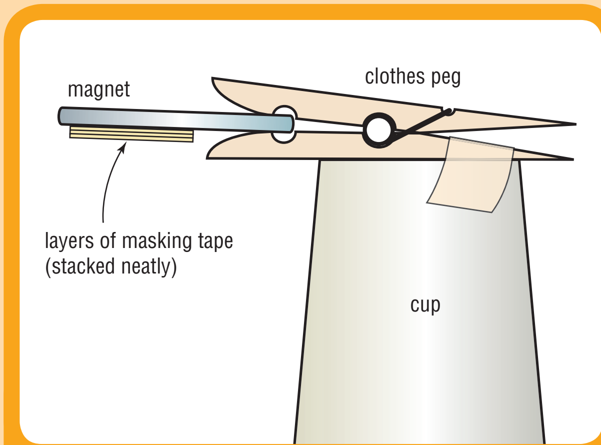


Fig 3.9.16 How to attach the tape

9 Hold the paper clip hook to the magnet to see if it is held by the force of the magnet. Make sure the hook touches only the tape and not the magnet directly. If it is held there, add more paper clips to the hook as before. *Record the result in your table.*

10 Add another three squares of masking tape to the layer of tape already on the magnet, and repeat step 9. Keep doing this until the magnet will not hold the hook, or until you use all 21 paper squares.

Questions

1 At step 5, the paper clip eventually fell. Why does this occur? When this happens, what force is greater than the magnetic force?

2 What happened to the number of paper clips held as you added more pieces of tape?

3 What do you think was the purpose of the tape?

4 What does this experiment tell you about the force holding the paper clips?

5 Try to write a summary of what this experiment has told you about magnetic force.

6 Did you have any problems that you think may have affected your results?

7 What steps did you take to ensure your test was fair?

FOCUS 3.10

Balancing forces

Context

As you are sitting there reading this book, what forces are acting on you? The force of gravity acts on you all the time and at the moment is pulling you down to the chair. You learnt that forces produce a change in speed, shape or direction. Gravity is a force, so why aren't you changing speed, shape or direction? Why is it that you can remain seated in the chair? Read on to find out.

Equal forces in opposite directions are said to be balanced. Fig 3.10.1

Balanced forces

In previous work you learnt that forces change the speed, shape or direction of an object. This is true, but you need a little more information to complete your understanding of forces.

To remain sitting on your chair, the downwards force that you exert on the seat is exactly matched by an upward force that the seat exerts back on you. This upward force is called a **reaction force**. If this reaction force was less than the force you exert on the base of the chair, you would be 'pulled' through the chair. If this reaction force was bigger you would find yourself being 'pushed' off the chair. These two forces are said to be equal in size but each acts in totally opposite directions. The forces are said to be **balanced**.

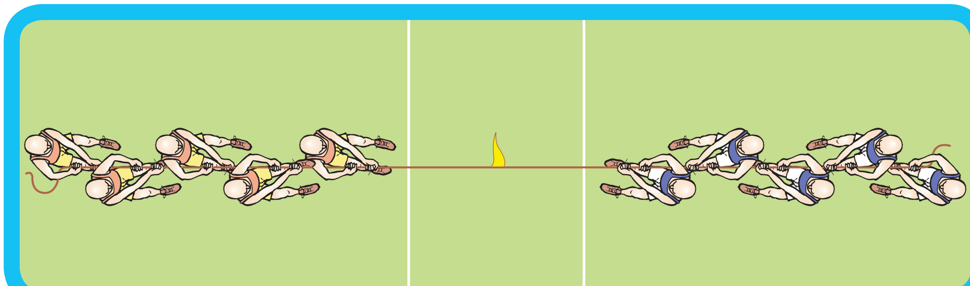
The tug of war is a good example to further illustrate balanced forces. Imagine two teams of five competitors pulling on a rope in opposite directions. The team that can pull the centre marker over the dotted line wins the tug of war.

If all the competitors are of equal strength then it is easy to see that neither team can win because the force exerted by one team in one direction will exactly balance the force exerted by the other team in the opposite direction. Once again, we have a case of balanced forces. When all forces are balanced the situation is described as one of **equilibrium**.

Unbalanced forces

If, in the tug of war, an extra person joins one of the teams, the forces are no longer balanced. The stronger team causes a change of speed in the direction of the bigger force. In this example, the forces in either direction are not balanced any more. They are said to be **unbalanced**.

Now you can modify your previous definition of a force. It is not enough to say that the presence of a force is enough to cause a change of speed, shape or direction. You need to say that an **unbalanced force** causes a change in speed, shape or direction.



Equal forces in opposite directions produce a state of equilibrium. Fig 3.10.2

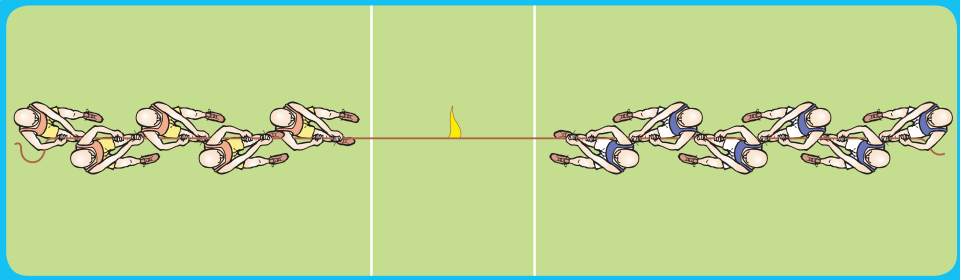


Fig 3.10.3 This is not a situation of equilibrium.

If a car is travelling along the road at a steady speed (say 60 kilometres per hour), then its speed is *not* changing. If the shape of the car is not changing and its direction is not changing then no unbalanced force acts on the car. You therefore can deduce that the overall forward force acting on the car is exactly matched by the overall backward force acting on the car. If both forward and backward forces are equal then there is no unbalanced force acting on the car to cause a change.

If, however, the driver steps on the accelerator then the forward force acting on the car will become bigger then the backward force acting on the car and the car will increase its forward speed. A change occurs (change of speed) because the forward and backward forces are no longer balanced, and the car accelerates. There is no longer an equilibrium between the forces acting on the car.

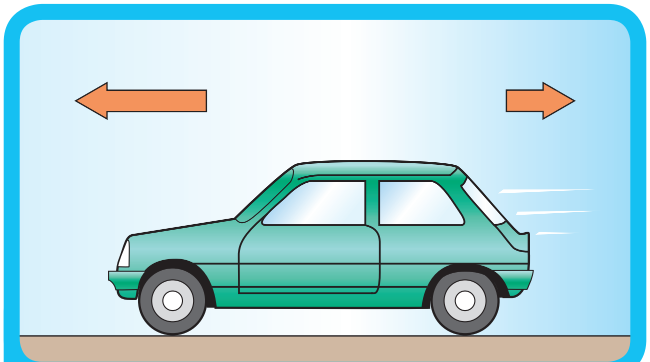


Fig 3.10.4 The car accelerates because the forward forces are bigger than the backwards forces.

Homework book 3.14 Skateboarding forces — the Ollie

Balanced or unbalanced?

Look at the aeroplane in Figure 3.10.6. It is flying at a steady speed in a straight line. It is not changing speed, shape or direction horizontally or vertically. Explain to a classmate why the airliner is flying at a steady speed in a straight line. Use the terms 'lift', 'weight', and 'thrust and drag' in your explanation. Ask your teacher if you cannot work it out.

Science Snippet

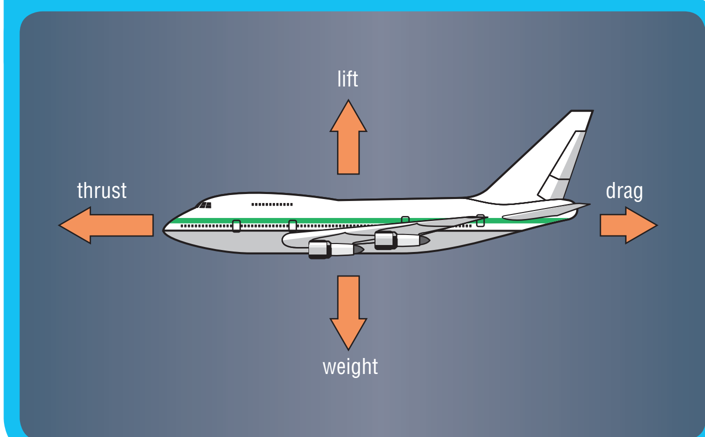
Which is pushy?

You might find it difficult to believe that when a book is lying on a table, the table is actually pushing upwards on the book. You can prove that the table is exerting an upward force on the book by substituting your arm for the table. Find a book with a reasonable weight (like a dictionary or an encyclopedia). Instead of putting it on the table, straighten your arm to one side, palm up, and hold the book in your open palm for one minute.

Fig 3.10.5 Like you, a table also has to exert an upwards force to balance the downwards force the book exerts on the table.

Prac 1 p. 157

Fig 3.10.6 What will this aircraft do?



Homework book 3.15 Flight forces

3.10 Questions

FOCUS

Use your book

Interactive CW Animation

Balanced forces

1 In your own words, what does the term 'balanced force' mean?

2 What is a reaction force?

3 Which of the following statements about balanced forces are false?

- **a** Balanced forces cause an object to remain stationary.
- **b** Balanced forces acting on an object can cause it to wear down.
- **c** Balanced forces cause an object to travel at a constant speed
- **d** Balanced forces cause an object to twist and distort.

4 In terms of forces, what does the phrase 'state of equilibrium' mean?

Unbalanced forces

5 What do we mean by 'unbalanced force'?

6 If the forces acting on an object are unbalanced, list three things you might observe.

7 Provide an example of unbalanced forces acting on an object.

9 What forces might be acting on a stationary book in the middle of a desk?

10 As a sky diver falls towards the Earth she experiences a downwards force and an upwards force acting on her. What is the cause of each of these forces?

A sky diver **Fig 3.10.8**

Use your head

8 In Figure 3.10.7, which tug-of-war teams do you think will win if all people are of the same strength?

11 Look at the picture of the aeroplane flying at a steady speed in a straight line (Figure 3.10.6). Use your knowledge of balanced and unbalanced forces to copy and complete the table on page 157 in order to describe the effect of an unbalanced force on the plane.

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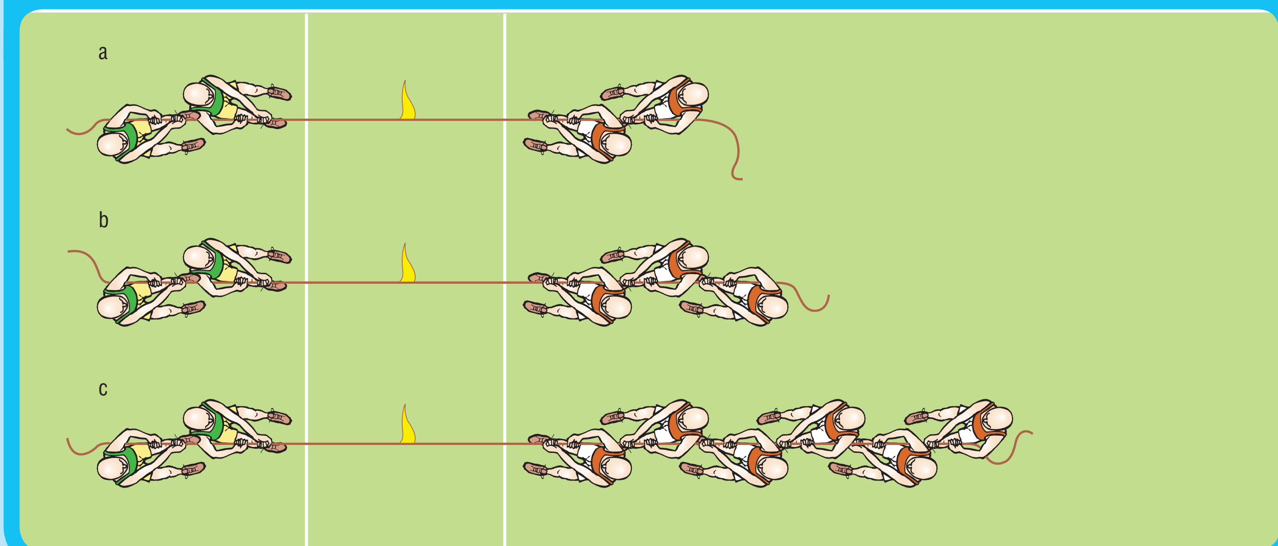
Fig 3.10.7 Tug-of-war teams



Flight condition	Effect
Thrust become greater than the drag	Increase in speed (acceleration)
Drag becomes greater than the thrust	
Weight becomes greater than the lift	
Lift becomes greater than the weight	

Investigating questions

12 In this focus you looked at balanced and unbalanced forces. In Focus 3.7 you studied friction. Use these concepts to explain the phenomenon of terminal speed that sky divers experience as they fall back towards Earth. Include diagrams to aid your explanation.

3·10 FOCUS [Practical activities]

Tower competition

Prac 1 Focus 3.10

Purpose

To learn about forces by participating in a class competition to construct a tower that can carry the heaviest load.

Requirements

20 plastic drinking straws, 100 straight pins, 1 pop stick, a set of slotted masses, scissors.

Procedure

1 Read through the following four rules A to E before attempting to build the tower.

- **A** You must work with a partner to construct a tower that will be tested by your teacher for height, and structural strength.
- **B** You can use up to 30 straws that can be cut and joined with pins. A 50 g mass will be added one at time until your tower collapses under the load.
- **C** The tower must be able to stand on its own and the straws may be bent or folded; however, the pins must be kept straight. A pop stick needs to be placed across the top of your tower so that the 50 g masses can hang from it.
- **D** The last tower that remains standing will be the winner. If there is a tie with the amount of mass added then the tallest tower will win.
- **E** Your teacher will tell you before you start how long you have before the testing begins. You must take the tower to the test area when the teacher says time is up.

2 Discuss and plan with your partner how you will build the tower. *Write down your plan in your notebook. A sketch and notes on how you fitted pieces together will help.*

3 Build your tower. You may have to try several designs if the first does not appear to be working. Remember you have a time limit to finish the tower.

4 Once you have completed the tower, move it to the test area so that your teacher can add weights and test your design.

Questions

1 What was the overall height of your tower?

2 What was the mass that your tower was able to support?

3 What features did the winning design have that allowed it to support a greater mass?

4 What was the main non-contact force acting on your tower?

5 Each straw and join on your tower had forces acting on it. Describe what forces were acting.

6 While your tower survived the weights, were the forces balanced? Why do you think this so?

7 When did the forces become unbalanced, and why did you think this?

8 How would you improve the design of your tower?

Build a bridge

Prac 2 Focus 3.10

DYO

Purpose

To design and build a paper bridge across a 15-cm gap that can hold the greatest weight added to its centre without collapsing. This challenge has two parts.

The first part is to use only one A4 sheet with no cuts or any other substance added to it, such as tape or glue. You are allowed to change only the shape of the paper.

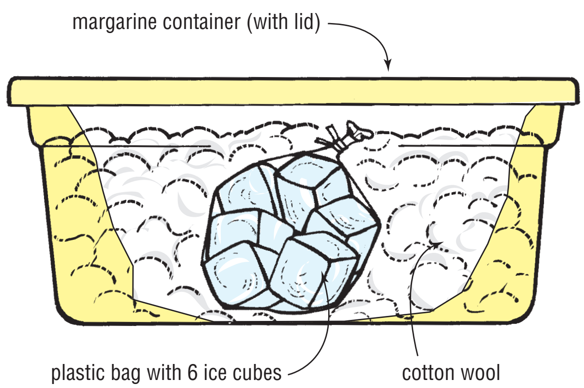
The second part is to use no more than 10 A4 sheets, which can be cut. You can use tape or glue for this one.

Review questions

Second-hand data

Interactive CW Crossword

1 A science class did an experiment on the insulating ability of different materials. One group took a margarine container and placed in it some cotton wool. Then they took six ice cubes enclosed in a plastic bag. The bag was placed in the margarine container, covered by the cotton wool, and the lid was placed on the container. The set-up is shown in Figure 3.11.1.



Set-up for the insulation experiment *Fig 3.11.1*

They then left the container at room temperature for one hour. The melted water was poured into a measuring cylinder to measure its volume. Other groups tried other materials. The results are shown in the table below.

Insulating material	Volume of melted water (mL)
Cotton wool	50
Plastic	40
Newspaper	60
Styrofoam	25
Foam rubber	30

a What was the source of the energy received in this experiment and what was the receiver?

b What was used as a measure of the transfer of heat energy in this experiment?

c Which was the best insulating material?

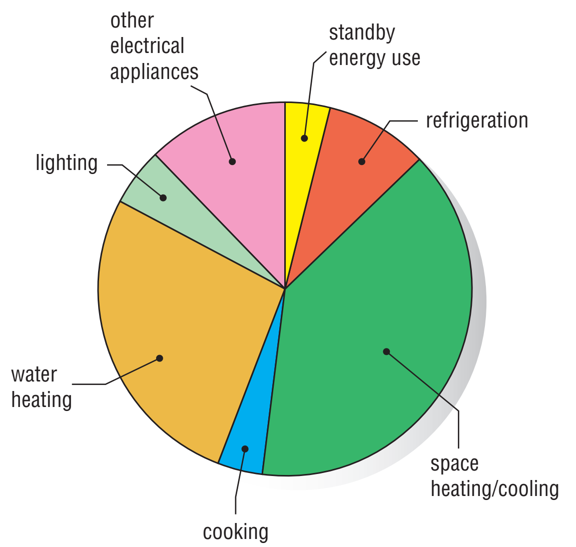
d Write a paragraph justifying your choice in c.

e Explain how the insulating material probably acts. You must discuss the three methods of heat transfer.

f For this experiment to be a fair test, give four variables which must be controlled.

2 The pie graph in Figure 3.11.2 shows how an average Australian family uses energy. Refer to the graph when answering the questions that follow.

Fig 3.11.2 How an average Australian family uses energy



a Discuss how you could work out the percentage of energy use represented by each segment of the pie graph. Show your values in a table.

b If you wanted to reduce your family's energy use, which type of energy use do you think you could change to make the most difference?

c What could you do to persuade other family members to do this?

d What would you have to measure or check in order to find out if your household has a similar energy usage to this average?

[Open-ended questions/experimental design]

3 Study the design of a halogen lamp, shown in Figure 3.11.3.

a How does the design of the body of the lamp help it do its job?

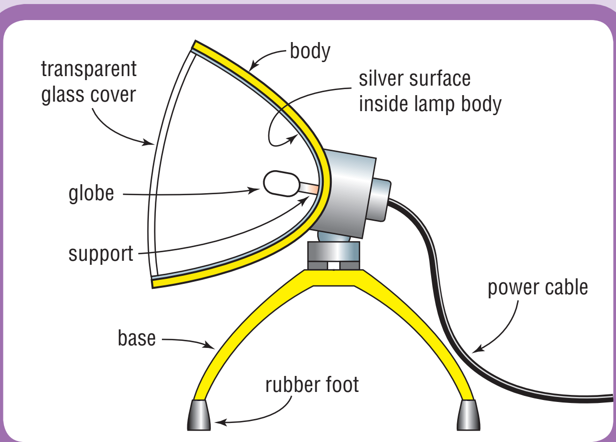


Fig 3.11.3 A halogen lamp shown in cross-section

b How has a knowledge of balancing forces been used in the design of the lamp base?

c How has a knowledge of friction been used in the design of the base of the lamp?

d What energy changes (transformations) would happen in this lamp?

e Why was a glass cover used in the lamp (consider safety)?

f What energy losses would occur in using this as an energy converter?

4 It has been suggested that instead of income taxes, goods and services taxes and so on, there should be just one tax, worldwide: a tax on energy use. Think about the ways in which you, your friends and your family use energy, such as for heating, travel, entertainment and communication. In what ways would an energy-use tax be fairer than an income tax or a consumption tax? In what ways would it be less fair? Would Australia be better off or worse off under such a tax scheme?

[Extended investigation/research]

5 Energy efficiency is an important aspect of housing design and construction. The energy efficiency of housing is an important consideration in the electricity supply for cities, as people use air-conditioning to overcome faults in the design of their houses. For example, a recent trend to reduce the size of eaves to give houses larger rooms has resulted in an enormous rise in electricity demand in peak periods in summer, as people have had to install evaporative air conditioners to cope with the heat load.

Explain the effect of each of the following factors on the heating of a house, and decide on the most suitable choice for the climate in which you live:

a the positioning of the house on the block

b the amount of overhang of the eaves

c the sizes and positions of windows

d the colour of the exterior brick or paint

e the type of building materials used in the roof and walls

f the window treatments such as curtains, tinting etc.

You can present your research any way you wish, for example as PowerPoint presentation, or as a handwritten or typed report. Use suitable diagrams where possible if they make it easier to explain your point.

Your answers must include basic science facts that you have learnt in this outcome, such as the methods of heat transfer, energy transformations, insulation, energy conservation, etc.

6 Increasing numbers of new homes are being designed to be energy-efficient.

a Find out what features make a house energy-efficient.

b Design a house that includes two or more such features. You should draw a plan showing the locations and relative sizes of rooms, windows and so on. Remember that Australia is in the Southern Hemisphere, but the information you obtain from many websites and books will apply to the Northern Hemisphere.

c Write brief notes explaining what you have done, and why this makes the design energy-efficient.

Homework book 3.16 Energy and Change crossword

Homework book 3.17 Sci-words

Life and living

4

Curriculum guide learning focus

- the features of organisms that enable them to survive in the environment
- classification and how this shows that organisms are related
- the processes in organisms, such as respiration, which sustain life
- the different structures of plants and animals to suit their different functions
- differences between unicellular and multicellular organisms
- the more complex structures and levels of organisation of multicellular organisms
- body systems and how they work together to provide the needs for survival
- methods of reproduction in organisms
- methods of classifying, identifying and investigating organisms

This section on Life and Living also contains information which will help students with the outcomes of Investigating Scientifically, Communicating Scientifically, Science in Daily Life, Acting Responsibly and Science in Society.

Outcome level descriptions

The outcome level descriptions covered by this part of the book are LL 2, LL 3 and LL 4.

FOCUS 4.1 Cells

Context

Scientists have been dissecting animals for centuries to try to find out how they work, and answer some of the many questions we have about living things and, more specifically, ourselves. Over 300 years ago a scientist, Robert Hooke, first used the term 'cell' to describe the tiny building blocks observed in a piece of cork. We now know that cells are the basic units of all living things, and although their appearance, shape, size and purpose may vary, they are responsible for the functions that keep all organisms alive. So a cell is the smallest part that we can call life.

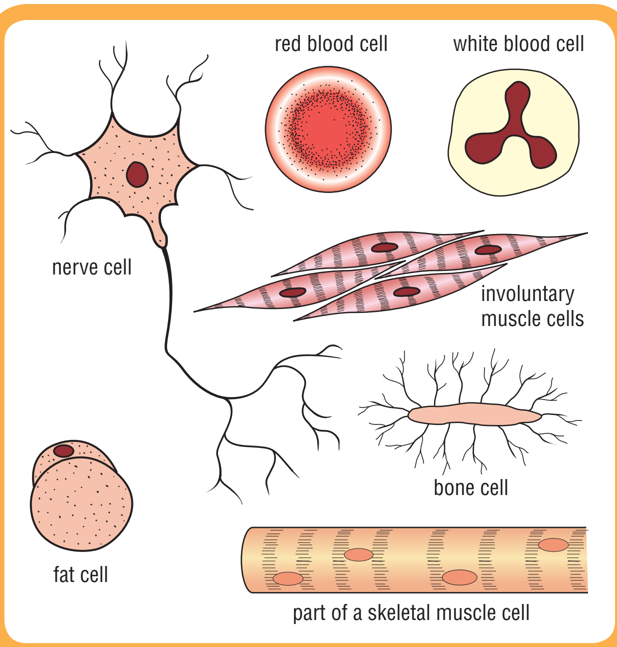


Fig 4.1.1 Some types of cells found in the human body

Cell structure

Early microscopes opened up a whole new world that had never been seen before. When scientists used microscopes (micro = very small, scope = to view) to observe living things they found that all these living things were made of tiny basic units, now commonly known as **cells**. As microscopes developed so did our understanding of cells and their structure. Scientists discovered that although the basic structures of cells were similar, there were many differences. Not only did different organisms have various types of cells, but also different cells could be found within the same organism. An **organism** is a living thing.

Although the first microscope was invented in 1590 it was not until 1824 that a scientist, Rene Dutrochet, claimed that all plants and animals were made up of cells. In the 1830s scientists began to study cells in more detail. In 1839, German biologist Theodor Schwann proposed the cell theory of life after making many observations of different types of cells and considering the work of other scientists. The cell theory states that:

1 All organisms are made up of one or more cells.
2 Cells are the basic units of structure and function in living things.

Science Snippet

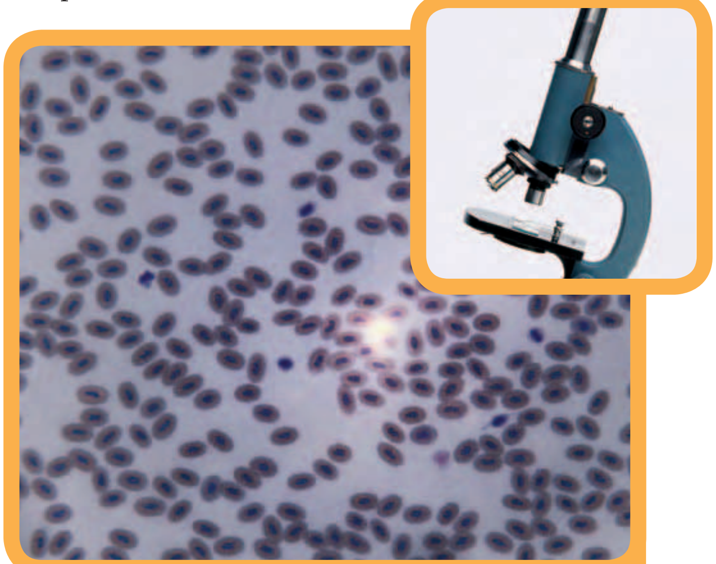
A career in the cells

Scientists who study the structure and function of cells are called microbiologists. They work in many places, such as hospitals, food manufacturing companies and drug companies.

Less than 20 years later a third principle was added by Rudolf Virchow, a German physiologist, after concluding that cells arose in only one way–by the division of other cells. This is now the third part of the modern cell theory:

3 New cells are produced by the division of other living cells.

Therefore the cell is not only the basic unit of structure for all organisms but also the basic unit of reproduction.



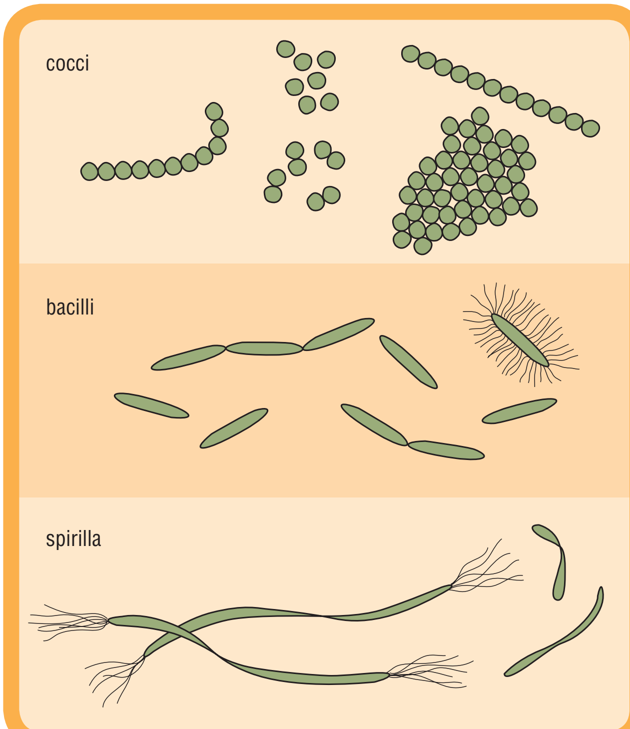
Some cells in the blood of a reptile as seen with a microscope. *Fig 4.1.2*

What do cells do?

Everything a living thing can do is a result of the activities of its cells. Cells are like little chemical factories, constantly making new substances and breaking down others.

Your skin, muscles, blood and brain are all made up of different types of cells. Most are so small that hundreds would fit on the head of a pin. Some cells are very simple such as a bacterial cell, and others are more complex such as a hen's egg.

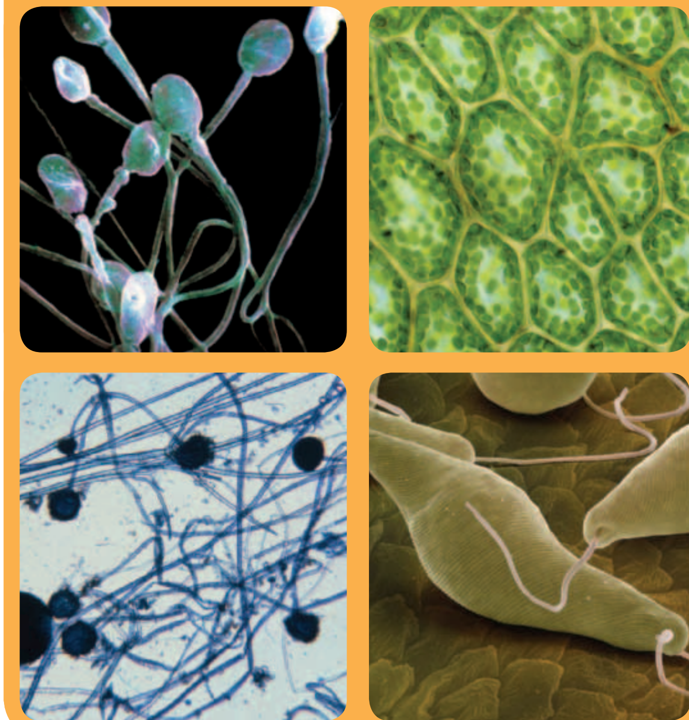
Fig 4.1.3 An egg is a very large cell.

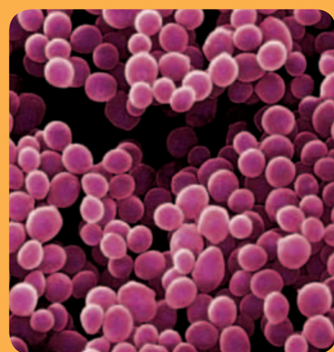


Different types of bacteria *Fig 4.1.4*

Although the cells of all organisms have similar characteristics, variations are used to classify organisms into five main groups or **kingdoms**: **animals**, **plants**, **fungi**, **prokaryotes** and **protists**.

Fig 4.1.5 Some differences in the basic cells in the five kingdoms





Each of these cells performs basic functions, and has three main parts or structures that can be clearly seen using a compound microscope. These parts are the cell membrane, the nucleus and the cytoplasm. These cell parts have different functions (a function is a role or task that must be done to sustain life).

The **cell membrane** is the thin layer that surrounds each cell. It has two functions: it protects the contents of the cell and controls what enters and leaves the cell.

The **nucleus** is the 'control room' of the cell. Inside the nucleus there are chromosomes, made up of the genes composed of DNA. The genes carry the inherited information that is needed by both the cell and the whole organism. The nucleus controls the chemistry of the cell.

Cytoplasm is a jelly-like liquid that fills up most of the space in a cell and contains hundreds of different chemicals. New substances are made and energy is released and stored there. All this activity within the cell is called its **metabolism**. The cytoplasm also contains many smaller structures that carry out special functions in the cell. **Ribosomes** manufacture complex substances called **proteins**. Storage areas for food, water and wastes in the cytoplasm are called **vacuoles**. The **mitochondria** are the parts of the cell where energy is produced in a process known as **respiration**.

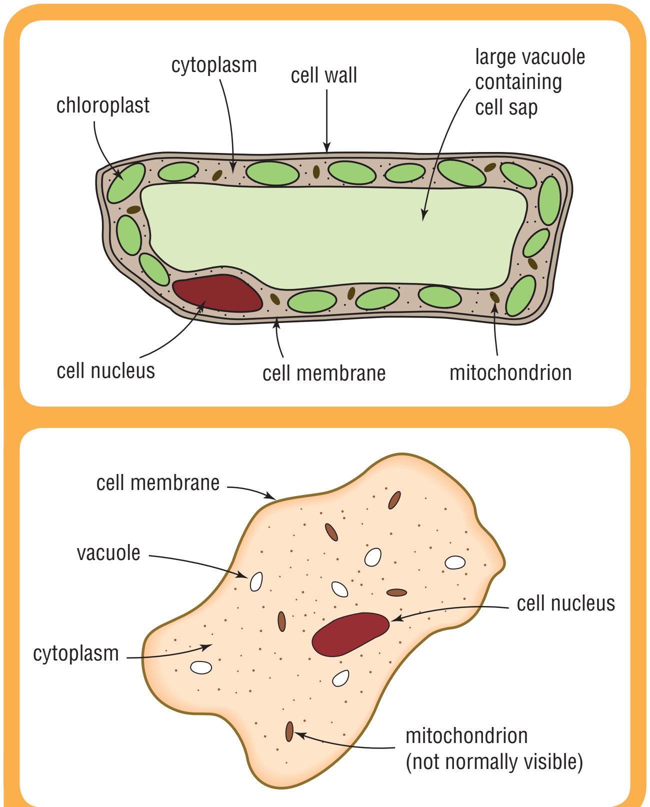


Fig 4.1.6 A typical plant cell and a typical animal cell contain many of the same structures. The parts of the cell that can be clearly seen using a compound microscope are the nucleus, cytoplasm and the cell membrane. In the plant cell the cell wall, chloroplasts and vacuoles may also be seen.

Drag and Drop CW Interactive

Drag and Drop CW Interactive

Microscopes

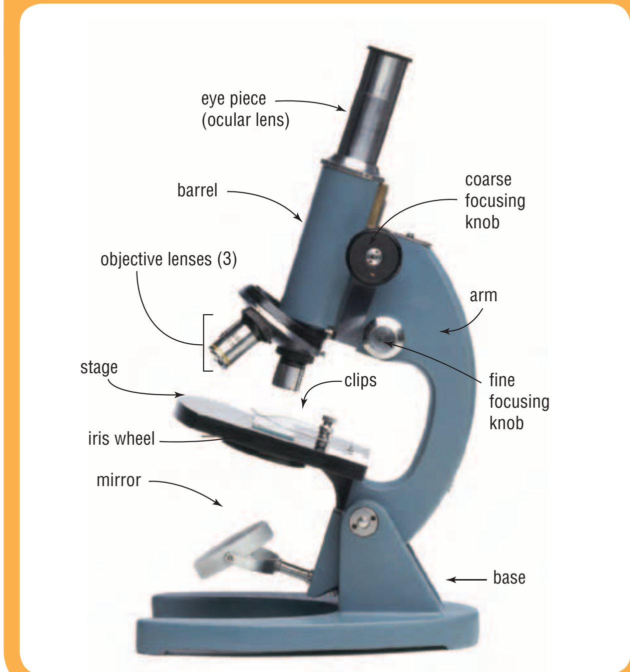
Using a microscope, you can see things that are too small to be seen with the naked eye or things you may want to look at in more detail. The microscope you use at school is called a **compound microscope**. It makes use of light and lenses to magnify objects and you use it by looking through an eyepiece at the object. The most common microscope has only one eyepiece. This is called a **monocular microscope**. Light passes through the object from below, where there may be a built-in light or, more commonly, a mirror, which is used to reflect light through the specimen.

The **binocular microscope** is another type of compound microscope, used for looking at small objects with both eyes. A binocular microscope has a separate set of lenses for each eye, so you can see the object in 3D. This allows you to judge depth and distance, which you cannot do with only one eye open.

> **Science Snippet**
>
> **Secret worlds**
>
> Things that we can see only with a **microscope** are said to be **microscopic**. Microscopes can let you into the amazing secret world of tiny creatures. One drop of pond water is all it takes.

Drag and Drop CW Interactive

Fig 4.1.7 A monocular compound light microscope



Caring for a microscope

There are some rules that you must follow when using your microscope.

1. Always carry the microscope with two hands: one under the base and the other holding the arm.
2. Never tip the microscope upside down.
3. Replace the dustproof cover or place the microscope back in its box when you are not using it.

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4 Always check with your teacher before trying to clean the microscope. You might damage or scratch the lenses. Only use lens tissue to touch a lens.

5 Check that the microscope is working and all its pieces (such as mirror and lenses) are attached. Check when you start using it and before returning it to your teacher.

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Homework book 4.1 Using a monocular microscope

Cell specialisation

As you can see in Figure 4.1.1 the human body is made up of many different types of cells. Each cell type performs a specific function, but all work together to help you carry out your daily activities. All animals are made up of similar types of cells, as you can see in Figure 4.1.8. These types of cells vary greatly from each other and each type is suited to a particular function. The special shape and function of these cells is called **cell specialisation**.

Plants are made up of many cell types, each with their own specific function, as in animals. As you have already seen in animal cells, plant cells too have **cytoplasm**, a membrane and a **nucleus**. Some differences in plant cells are the presence of a cellulose **cell wall** and large **vacuoles**, and some cells contain **chloroplasts** that enable the plant to make its own food.

The types of cells in plants are quite different from those in animals. For example, leaves have palisade cells that are used to produce food. Leaves also have several specialised cells such as guard cells and stomata. The stem and roots also contain specialised cells to carry water through 'veins' and hairs to increase surface area and to assist water absorption, as is illustrated in Figure 4.1.9.

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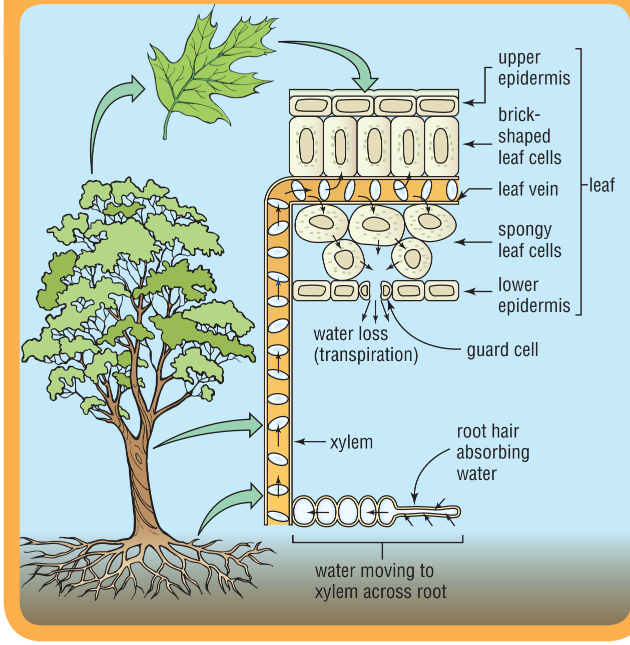
Fig 4.1.9 All plants have similar types of cells, each type performing specific functions.



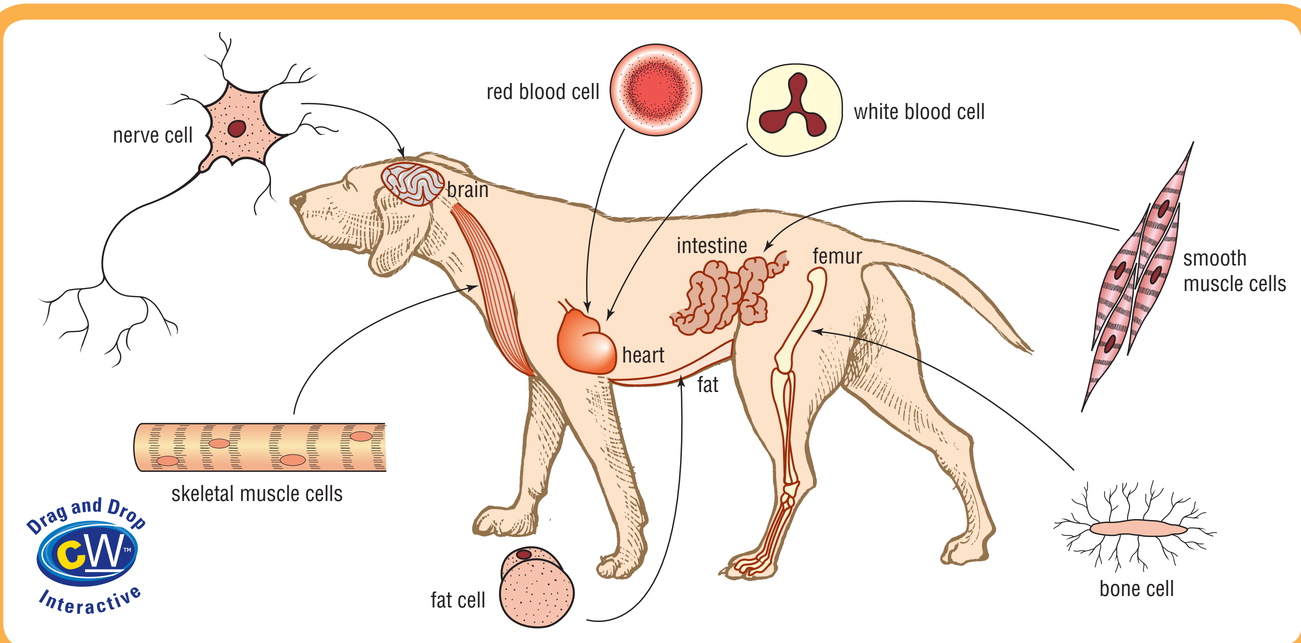


Fig 4.1.8 All animals have similar types of cells, each type performing specific functions around the body.

4•1 FOCUS Questions

Use your book

Cells

1 What do we mean by the term 'cell'?

2 Is an individual cell a living thing? Explain your answer.

Cell structure

3 What does a microbiologist do?

What do cells do?

4 Identify three structures found within a cell that can be seen with a compound microscope.

5 List the functions of three structures found within the cytoplasm.

Microscopes

6 Explain the terms 'microscope' and 'microscopic'.

7 List any two rules for safe handling of a microscope.

Cell specialisation

8 Name six different types of cells and describe the function of each.

9 Identify three differences between plant and animal cells.

Use your head

10 Explain why the cells specialising in photosynthesis are mainly found on the upper surface of the leaf.

11 Look at Figure 4.1.1. What do you think these cells do in your body?

12 A theory is an idea or explanation that is supported by a great deal of evidence. It is not a fact. Why do you think the Cell Theory may be referred to as a theory and not a fact?

13 Prepare a cartoon or instruction sheet that will show other students how to safely prepare a slide or specimen for viewing under the monocular microscope.

Investigating questions

DYO

14 Ask your teacher if you can make slides of different types of cell and swap them with those made by another group. Try to guess where they may be from.

15 How many different microorganisms can you identify in a sample of pond water? Draw and group these according to their features.

4•1 FOCUS Practical activities

Prac 1 Focus 4.1

Using a microscope

Purpose

To set up the microscope and prepare slides.

Requirements

Compound microscope, microscope lamp, magazine cuttings, cover slips, sticky tape.

Procedure:

PART A Setting up the microscope

1 Place the microscope on a flat surface.

2 Check that your microscope has all its pieces attached—if there is anything missing report this to your teacher.

3 Set up the microscope lamp in front of the microscope with the light shining onto the mirror. If your microscope has a built-in light source you will not need a lamp.

4 Adjust your mirror so that the light is reflected up into the body tube of the microscope.

5 Rotate the objective lenses until the low-power lens (this is usually the shortest one with the lowest number on the side of it, for example 4×) clicks into position directly above the hole in the stage.

PART B Using the microscope

6 Place a small cut-out from a magazine on a microscope slide. This is a good specimen to start with as it should be easier to focus on than a normal slide.

7 While looking at the microscope from the side use the coarse focus knob to carefully lower the objective towards the slide.

8 To find the object in your view, look into the eyepiece and carefully wind the lenses back up, using the coarse focus knob. When the object is in view, although still a little blurry, stop turning the focus knob. Never just wind up and down looking for your specimen, as you may accidentally smash through the slide—this is how microscopes and equipment are damaged! If you cannot find what you are looking for, try repeating the steps. If you are still having trouble, ask your teacher.

>>

9 Once you have found your image, to bring this into sharper focus use the fine focus knob—it moves the lenses only a small amount, but it can make a big difference to the image you are trying to look at.

10 *What do you notice about the printed page you are looking at?*

11 Move the slide around. *What happens when you move the slide left to right or up and down?*

12 Try closing the iris diaphragm or turning the iris wheel. *What does this do to your image?*

13 With your image still in focus and while watching from the side, turn the nosepiece until the 40x objective lens is clicked into place. Make sure the objective will not hit the slide.

14 Use only the fine focus to try to sharpen the image under higher magnification.

15 *What do you notice now about the print you are looking at? Did the size increase or decrease when you went from high power to low power*?

Prac 2 Focus 4.1

DYO

Observing prepared slides

Purpose

To investigate differences between different specialised animal cells.

Requirements

Assorted prepared slides, microscope, lamp.

Procedure

1 Set up your microscope.

2 Using the appropriate method, observe a prepared animal slide under the microscope.

3 *Sketch what you can see, labelling your work. Include the date, the label from your slide and the magnification used.*

4 Repeat with different slides, *recording what you observe each time*.

Questions

1 Choose two of the slides you observed and make comparisons, outlining any similarities and differences between the two specimens.

2 Choose one slide that you were able to clearly label and describe the features that you were able to label.

3 Are there any advantages in using prepared slides rather than making your own each time?

Prac 3 Focus 4.1

Preparing a wet mount

Purpose

To investigate the animal and plant life in pond water, creek water or water from a fish tank by preparing a wet mount.

Requirements

Water sample, pipette, microscope, lamp, microscope slides, cover slips.

Procedure

1 Set up your microscope.

2 Place 2 drops of water onto your glass microscope slide and carefully cover it with a cover slip by placing the edge of the cover slip onto the edge of the water then gently lowering it down. (This will help to stop air bubbles forming under your slide.)

3 Using the appropriate method, observe your prepared slide under the microscope.

4 *Sketch what you can see, labelling your work. Include the date, the name of your specimen and the magnification used.*

5 *Sketch as many organisms as you can then repeat by making another slide, recording what you observe each time.*

Questions

1 How many organisms did you see? Can you name any of them?

2 How did using the microscope assist you in examining what was in the pond water?

3 Using two of the different organisms you observed. make comparisons, outlining any similarities and differences between the two specimens.

FOCUS 4.2 Nutrition

Context

Organisms are capable of carrying out seven basic life activities, called life processes. These are respiration, reproduction, growth, movement, response to stimuli, excretion and nutrition. In this focus you will study nutrition, which is concerned with foods. Animals, fungi and bacteria obtain their food from consuming other organisms but plants and algae make their own food.

Fig 4.2.1 Types of food matter required for the human body

Diet

When people use the term **diet** they are normally referring to what they eat while trying to lose weight. But the term 'diet' in fact refers to everything that a person eats. The food you eat affects your health and fitness.

Food provides the energy and materials for your cells to maintain their chemical activity and for growth and repair. The important substances your body needs are called **nutrients**. A balanced diet, which includes all essential nutrients, and regular exercise will ensure your long-term health and well-being.

The energy in food

Within your body food is broken down in a number of steps by chemical reactions in the cells. The process of obtaining energy from food in your body is called **respiration**. Chemical energy is released from food molecules. This energy is used for all of the activities your body does in a day. You can measure the energy in food in kilojoules (kJ) and from this you can work out how much energy you use in a day. The largest amount of energy is used up in muscle activity, such as running, walking or even sitting in class. In all the changes the energy goes through, the final product is heat. This heat keeps your body warm and is eventually given off to your surroundings.

Food types

Each day you should eat a variety of foods, as there are various chemicals in the foods you eat. Water is contained in all food.

The dry matter of food is made of:

- carbohydrates (sugars, starch and cellulose)
- proteins
- fats and oils
- vitamins and minerals.

Carbohydrates

The main role of carbohydrates is to provide you with energy. The food groups that contain carbohydrates are breads, cereals, fruits, honey and vegetables. These foods have sugars and starches that break down into a simple sugar called glucose during digestion. Glucose is easily absorbed into your cells and is used in respiration to provide cells with energy to do work. Cellulose is also called fibre and is found mostly in fruits, vegetables and cereals. Fibre helps to keep the food moving in your gut.

Proteins

The foods that contain proteins include meats, dairy, nuts, eggs, cereals and vegetables. Proteins provide the materials needed for growth and repair of cells. As your body cannot store proteins, you need to eat protein foods regularly so that your body can build its own protein for cellular growth and repair.

Fats and oils

The greasy foods we all enjoy eating, such as hot chips and hamburgers, contain a lot of fats and oils. Fats are high in energy, containing more than double the energy produced by carbohydrates. Fats such as butter are usually produced by animals, and oils such as olive oil are usually produced by plants. This group of nutrients are called lipids. Lipids are stored by your body as an energy reserve and when deposited under your skin they provide good insulation for keeping in the heat.

Vitamins and minerals

Vitamins and minerals are found in very small quantities in foods, but are as important as the other food types. Vitamins are found in all fresh fruit, beans, nuts, meats and vegetables. They are used in various cell reactions in the body, cannot be stored and must be provided daily. Minerals are also needed in small amounts for healthy bones, muscles and nerves. Minerals are found in meats and dairy products, and fruits and vegetables.

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Homework book 4.2 Analyse this!

Plant foods

Like animals, plants need nutrients and oxygen for maintenance, growth and repair of their cells and tissues. Unlike animals, however, most plants make their own food from simple substances they absorb from the air water and soil. This process of food production is called **photosynthesis** and can be shown in the following word equation:

$$\text{Carbon dioxide} + \text{water} \xrightarrow{\text{Sunlight}} \text{sugar (carbohydrate)} + \text{oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Fig 4.2.2 Carbohydrates are made from carbon dioxide and water in the process of photosynthesis.

The green colour of leaves is due to a substance called chlorophyll, which can absorb energy from sunlight. Because sunlight is needed for the process, plants can only photosynthesise in the daytime.

The sugars that are formed during photosynthesis may be converted to starch and stored, though some plants, such as grasses, actually store the sugar.

As we have already discussed, both plants and animals need energy to survive and carry out their daily activities. The energy contained in animal and plant food is released in a process called respiration. In plants, the sugars that are made during photosynthesis combine with the oxygen in the air in the process of **respiration**, producing carbon dioxide, water and energy. Although plants can only photosynthesise at night they carry out the process of respiration all the time, as we do. Respiration is expressed as the following equation.

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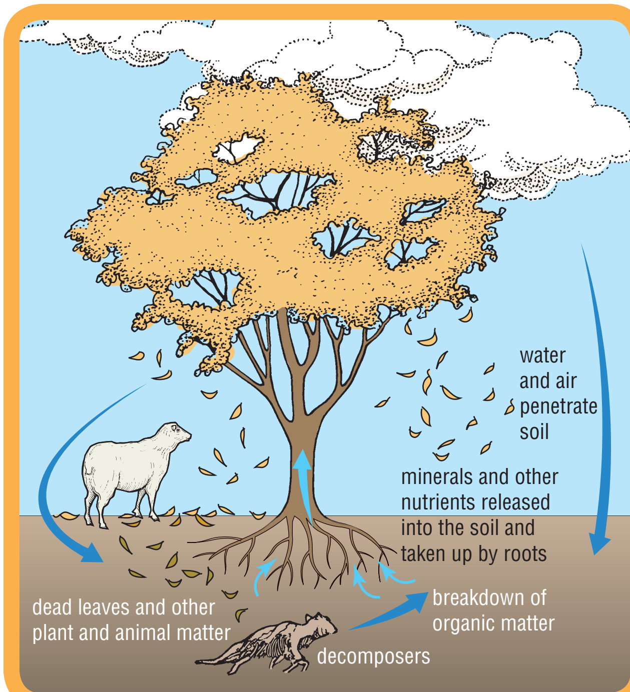
$$\text{carbohydrate} + \text{oxygen} \rightarrow \text{energy} + \text{carbon dioxide} + \text{water}$$

Plants also require other elements, such as nitrogen, phosphorus, calcium, potassium and magnesium, which are absorbed by the plants' roots. If the soil is poor, these nutrients need to be added in the form of fertilisers. In a natural environment plants and animals die and are recycled into the soil by bacteria and fungi, after which the nutrients are dissolved into water and improve the fertility of the soil. Farmers, however, harvest crops before they die, so plants are not broken down and there is no recycling of nutrients.



In natural environments all nutrients are recycled. *Fig 4.2.3*

4·2 FOCUS [Questions]

Use your book

Diet

1 What does the term 'diet' mean?

The energy in food

2 Can we measure the energy in food? What unit do we use?

Food types

3 Identify three types of chemicals in food matter.

4 Draw a table outlining the main types of chemicals in food matter, their function in the body and foods that are high in these substances.

Plant foods

5 Outline the process by which plants obtain food.

6 Do plants respire? If so, when does this process occur?

Use your head

7 Predict the effects on your body of an unbalanced diet.

8 Describe the process by which a plant obtains its energy from the beginning to the point at which the energy is used by the plant.

9 Which of the nutrients needed by animals are made by plants?

10 Consider the experiment in Figure 4.2.4. A scientists set out to test the hypothesis that carbon dioxide and light are needed by plants to make oxygen. After a day or so in the Sun the test tube in Flask A is full of a gas that is shown by the burning splint test to be oxygen.. Test tubes B and C have no gas.

a Why did the experimenter use flask B?

b Why did the experimenter include flask C?

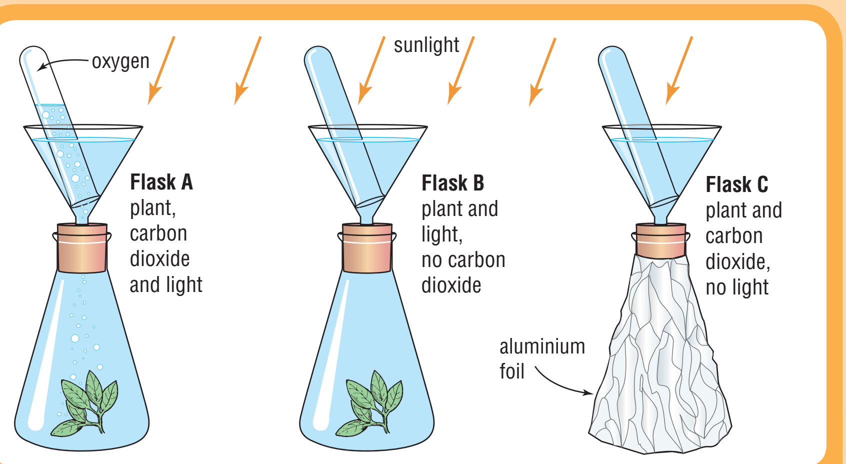
c What can you conclude from the results of this experiment?

Investigating questions

11 If a seed was planted in nutrient poor soil how would this affect it's growth and development? Design a fair test to investigate this statement.

DYO

12 Set up an experiment like in Figure 4.2.4. Collect your results and write a conclusion about the hypothesis.



An experiment to investigate whether light and carbon dioxide are needed for photosynthesis *Fig 4.2.4*

4·2 FOCUS [Practical activities]

Prac 1 Focus 4.2

Testing for nutrients

Purpose

To test a range of foods for fats, carbohydrates and protein.

Requirements

Test tubes, labels, test tube rack, sugar solution (10 per cent glucose), water, Benedict's solution, brown paper, olive oil, butter, protein solution (10 per cent gelatine or egg white), 0.1 M copper (II) sulfate solution, 2 M potassium hydroxide solution, starch solution, iodine solution, four food samples, Bunsen burner, gauze mat, tripod, 10 mL measuring cylinder, 250 mL beakers, Pasteur pipette, an unknown solution.

Procedure

Read through this whole prac first and then *draw a table to record your results*.

PART A Testing for sugars

1 Label three test tubes and place them in a test tube rack.

2 Add 5 mL of glucose solution to test tubes A and B.

>>

3 Add 5 mL of water to test tube C.
4 To test tubes A, B and C add five drops of Benedict's solution.
5 Place the three test tubes in a 250 mL beaker containing about 150 mL of water. Make sure the test tubes do not float. Place the beaker on a wire mat over a tripod and heat with a Bunsen burner. Bring the water to the boil. Leave the tubes in the bath until a change occurs.
6 *Record your results.*

PART B Testing for fats

1 Label three pieces of brown paper A, B and C.
2 Add two drops of oil to the centre of A.
3 Add two drops of water to the centre of B.
4 Rub a small amount of butter on C.
5 Hold the three pieces of paper up to the light. Lipids leave a transparent mark on the paper.
6 *Record your results.*

PART C Testing for protein

1 Label two test tubes A and B and place them in a test tube rack.
2 Add 10 mL of protein solution to test tube A.
3 Add 10 mL of water to test tube B.
4 To each test tube add about 10 drops of potassium hydroxide solution. Tilt the test tube and dribble two or three drops of copper sulfate solution down inside of the tube. A violet ring at the surface indicates protein.
5 *Record your results.*

PART D Testing for starch

1 Label two test tubes A and B and place them in a test tube rack.
2 Add 10 mL of starch solution to test tube A.
3 Add 10 mL of water to test tube B.
4 Add three drops of iodine solution to test tubes A and B.
5 *Record your results.*

PART E Testing an unknown

Use the steps outlined in parts A–D to identify the unknown solution. *Record your results in the table.*

PART F Testing foods

Use the steps outlined in parts A–D to identify the presence of different nutrients in the four food samples. *Record your results in the table.*

Questions

1 What did you learn in this activity?
2 What was the purpose of testing water? Give the reasons for your answer.
3 In which industries might food testing be used?

Prac 2
Focus 4.2

DYO

Plant growth

Purpose

To investigate the affect of sunlight on plant growth.

Requirements

Six bean seeds, six test tubes, two test tube racks, tweezers, potting mix.

Procedure

Read through this whole prac first and then *draw a table to record your results*.

PART A Preparing seeds

1 Label six test tubes and place them in a test tube rack.
2 Place potting mix in each test tube. Leave 10 cm at the top of each test tube.
3 Take tweezers and gently add one seed to each test tube. (Some bean seeds are treated with fungicide—if you touch the seeds, wash your hands with soap and water afterwards.)
4 Place another 5 cm of potting mix over each seed and gently water until the soil is moist.
5 Place three test tubes in a test tube rack and put them in a sunny place to germinate.
6 Place three test tubes in a rack in a dark cupboard and leave them for two days.
7 Check seeds every second day until they begin to germinate.

PART B Recording growth

8 Check seeds every 1–2 days over at least two weeks and record growth and any other changes you may notice. Make sure the soil does not dry out.
9 *Record your results in your table.*

Questions

1 What did you learn in this activity?
2 What was the variable being tested in this experiment?
3 Mushrooms are grown in the dark. Use your library and the Internet to research the differences in the growth requirements of mushrooms and beans. Present your results as a report, poster or presentation.

FOCUS 4.3 Movement and response

Context

All living things need to move and respond to changes around them. Movements are usually made in response to something in the environment. Animals move to obtain food, escape predators, find a mate, search for shelter or just play. Plant movements are much less obvious than animal movements. Plants don't need to move to find food as the nutrients they need for survival can be found in the soil, air and water around them. Plants do, however, make very subtle movements towards the Sun or by sending out tendrils, in the instance of vines.

Movement in animals

You have over 200 bones in your body, which not only provide you with your shape but also support, protection and, most important, the ability to move. Your skeleton does this by working with pairs of muscles to enable to you walk, swim, ride a bike or even breathe.

The need to find food and avoid enemies (predators) has resulted in many animals developing different types of movement. Features or adaptations have developed in some animals to enable them to move very fast.

A variety of methods of movement have evolved in animals, such as gliding, hopping, leaping and running. Fast-moving animals have more streamlined bodies, such as cheetahs, sharks and dolphins, while other animals, such as elephants, pigs and jellyfish, are shaped for slower, controlled movements. Spiders are not streamlined but can move very fast and have long legs to enable them to walk delicately across their webs.

Some animals change their body shapes when they need to increase speed, such as the falcons, octopuses and horses. Many animals need to push on something, such as emus, with their large wide feet, and kangaroos, with their long thin feet and muscular tails pushing off the ground. A shark uses its long tail to push on the water as it glides through. A small child may use the edge of a couch to pull herself along and a monkey

Fig 4.3.1 Different types of animals use a variety of methods of movement.





may use the branches in the forest to grasp onto and pull itself along. All these methods are effective for the animals that use them because of the special features that they have developed over many generations. These features improve their chances of being successful in life by obtaining food and avoiding predators.

Response in animals

If a kangaroo comes across some fresh grass on the side of the road it will eat it; if the kangaroo then hears a car coming on the road it will hop away. These actions are **responses** and help the kangaroo to survive. A response is a change in an organism's behaviour or actions. The factor that causes the organism to respond is called a **stimulus**. In the case of the kangaroo, the stimulus was the smell of grass or hearing the car come towards it. Animals detect a stimulus through the senses of hearing, sight, smell, taste or touch. These senses can be very acute in some animals, enabling them to respond to stimuli and ensure their survival.

A lion is 10 km/h faster at full speed than a kangaroo. If they were to race, who do you think would win?

Fig 4.3.2

Science Snippet

Fast movers

Did you know the kangaroo can move up to 70 kilometres per hour (km/h)? This is only 43 km/h slower than the fastest creature on Earth, the cheetah, which can run at 113 km/h. The lion is number 5 on the world's fastest animals list, moving at 80 km/h at full speed.

Drag and Drop Interactive

Movement and response in plants

Plants do not have to move from place to place to find nutrients, and consequently plant movements are much more subtle than animal movements. As discussed in Focus 4.2, plants obtain most of their nutrients from the air, water and soil around where they grow. Roots grow through the soil in search of nutrients such as water and minerals found in the soil. Many vegetable crops have taproots, which are the swollen storage organs for the plants. Some examples of such vegetables are carrots and parsnips. Some large Australian trees, such as the jarrah, also have taproots, which enable them to travel to great depths in search of water.

As with animals, plants respond to many different things, such as light, water and temperature. Scientists have special names for each of these responses. The response to light begins with the prefix 'photo' (meaning light) and the suffix is 'tropism'. For animals, the suffix is 'taxis'. Therefore in plants, movement in response to light is called **phototropism** and in animals this same response is called **phototaxis**. Other names of responses are shown in the table below.

These prefixes can tell us a lot about a particular plant. For example, a heliophyte is a plant that requires full sunlight, whereas a daisy displays heliotropism by turning its flowers towards the Sun during the day. In plants displaying stereotropism, the plant responds to contact, for example a passionfruit vine climbing with tendrils towards a contact surface. Plants called trigger plants display thigmotropism—a trigger mechanism catapults pollen onto bees and other insects that will carry it to other plants, passing on the pollen and depositing it, therefore achieving pollination.

Prac 1 p. 174

Response	Prefix	An animal's response	A plant's response
Response to light	Photo-	Phototaxis	Phototropism
Response to chemicals	Chemo-	Chemotaxis	Chemotropism
Response to cold	Thermo-	Thermotaxis	Thermotropism
Response to sunlight	Helio-	Heliotaxis	Heliotropism
Response to gravity	Geo-	Geotaxis	Geotropism
Response to touch	Thigmo-	Thigmotaxis	Thigmotropism
Response to water	Hydro-	Hydrotaxis	Hydrotropism
Response to contact	Stereo-	Stereotaxis	Stereotropism

A sweet pea climbs by twisting its tendrils around supports to hold up the plant. *Fig 4.3.3*

A field of daisies, opening their petals to the sunlight *Fig 4.3.4*

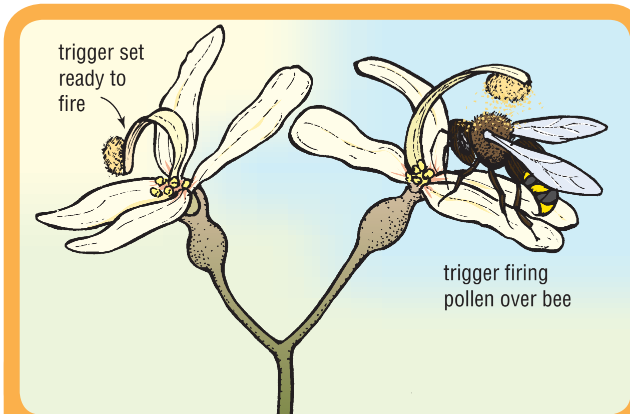


Fig 4.3.5 A Western Australian trigger plant

Homework book 4.3 Plant phototropism

4·3 FOCUS [Questions]

Use your book

Movement in animals

1 Name the two main reasons why animals move.

Response in animals

2 What is a stimulus?

3 What is a response?

4 Give three examples of structures that help animals to detect stimuli.

Movement and response in plants

5 Why are plant movements less obvious than animal movements?

6 List three types of stimuli to which a plant may respond.

7 Describe three types of plant responses.

Use your head

8 Why do animals and plants need to respond to stimuli in the environment?

9 Using the library or the Internet, investigate one animal and one plant, outlining the structures used for movement and detailing at least two stimulus–response examples for each.

Investigating questions

10 In this experiment you use slaters, which are small animals that live under stones and pieces of wood. Slaters are common, do not carry diseases and cannot bite you. Design an experiment to test their responses to different stimuli, such as light, temperature and water. DYO

11 Using bean seeds, design your own experiment to test the responses of plants to a stimulus of your choice.

12 Many plants bend towards the light if light is shone on them from one side over several days. Wheat plants that have germinated and still have the sheath (coleoptile) over the first leaf will respond like this. You need to put the seedlings in a box and allow light in only from the side. Design an experiment to test this response of wheat seedlings.

FOCUS 4.3

[Practical activity]

Prac 1 Focus 4.3

Responses in plants

Purpose

To determine if bean seeds respond more to sunlight or gravity.

Requirements

Bean seeds, cotton wool, petri dish, test tubes, tweezers, water, test tube rack, potting mix.

Procedure

Read through this experiment first then *draw a table to record your results in your notebook*.

PART A Preparing seeds

1. Label and place some moist cotton wool in a petri dish.
2. Add six seeds to the dish.
3. Cover the seeds with more moist cotton wool.
4. Check the seeds each day until they begin to germinate.

PART B Changing direction of growth

1. Place six test tubes in a test tube rack and label each test tube.
2. Place potting mix in each test tube, up to 10 cm from the top.
3. Using tweezers, gently add one of the germinated seeds to each test tube.
4. Place another 5 cm of potting mix over the bean seedlings and gently water until the soil is moist.
5. Place all test tubes in a sunny place to germinate, leaving three in the test tube rack and laying down three test tubes next to the rack.

PART C Recording growth

1. Check seeds every 1–2 days. *Record growth and any other changes you may notice.*
2. *Record your results in your table.*

Questions

1. What did you learn in this activity?
2. What was the variable being tested in this experiment?
3. From your results in this experiment and using what you have learnt from Focus 4.2 about nutrients, design packaging for bean seeds, providing instructions to help people wanting quick-growing, healthy bean plants.

FOCUS 4.4 Respiration and excretion

Context

Breathing is the process of taking air into the lungs (inspiration) and expelling gas from the lungs (expiration). In humans this process takes place using your lungs and other structures in your chest. Once the air is inside your body after inspiration, the oxygen is transferred to your cells and is used to release energy in a process called respiration. All living things respire to provide cells with the energy they need to carry out the functions necessary for survival. During the process of respiration, in addition to the other processes your body carries out, wastes are produced. These unwanted products must be removed from the body in a process called excretion.

Respiration

Oxygen is needed for your cells to carry out the process of **respiration**, which produces energy for survival. Glucose comes from food that has been digested and then absorbed by the cells. This glucose is then combined with oxygen to release energy for cell processes. Carbon dioxide and water are also produced in this process. The carbon dioxide is a waste. It is removed from the body by carrying it back to the lungs where it can be breathed out. The process of respiration can be represented by the following equation:

glucose + oxygen → energy + carbon dioxide + water

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p. 178

Breathing

To obtain the oxygen for respiration we have to breathe. This involves the structures shown in Figure 4.4.1. Keep checking back to this diagram when reading the following description of breathing.

Breathing begins with contraction of the muscles of the diaphragm and ribs. This causes air to rush into your nose and mouth. Air taken in through the nose is warmed and moistened. Tiny hairs and mucus trap dust particles before the air travels down the trachea. This is a ringed tube and is very flexible. The rings are made from cartilage. You may be able to feel them by following down from your chin with the top of your finger and gently feeling your throat. Cartilage stops your trachea from collapsing when you breathe in. At the lower end the trachea branches into two tubes called bronchi.

The bronchi branch into smaller and smaller tubes, finally ending with a small cluster of air sacs, called alveoli. The alveoli are surrounded by small blood vessels called capillaries, where the exchange of gas occurs. Oxygen moves from the alveoli into the blood capillaries and carbon dioxide moves from the capillaries

Science Snippet

Breathing facts

What happens to your body when you are winded? What about a sneeze, or a cough? Are hiccups related to breathing? You may like to find out the answers.

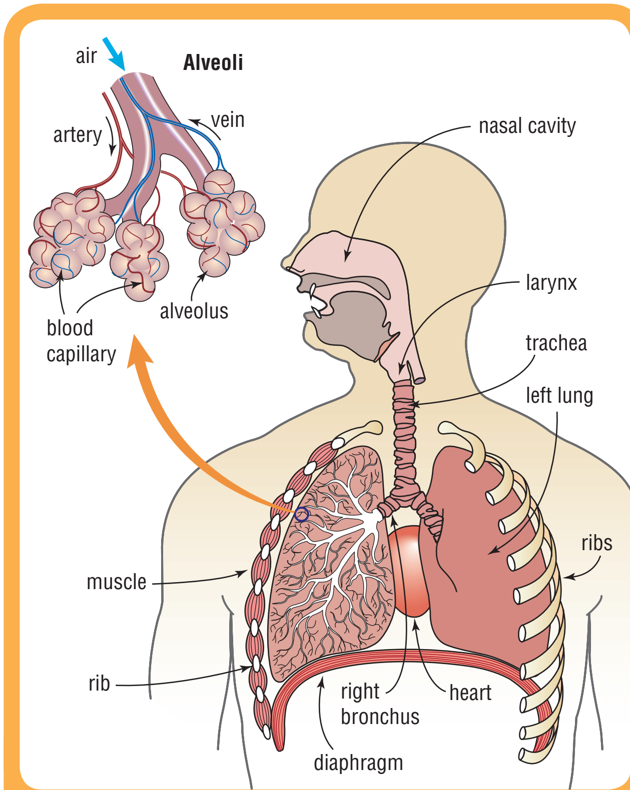


Fig 4.4.1 Structures for breathing.

into the alveoli and is breathed out. You breathe out when your diaphragm relaxes and other rib muscles contract, squeezing on the air in your lungs. This forces it out.

Homework book 4.4 Photosynthesis and respiration

Resuscitation

You may have heard about **resuscitation**, or even seen it being carried out. This process is undertaken when someone is injured or has stopped breathing for some reason. Resuscitation can save lives. This process involves breathing into the mouth or nose of the patient to keep up the oxygen supply to their cells. This process works because the air you breathe out still contains a lot of oxygen.

Sometimes, after a very bad accident the patient's heart stops beating. When this happens the rescuer must push down on the patient's chest to start their heart beating, as well as breathe into their mouth or nose to start their breathing again. When both the heart and lungs have failed, resuscitation is called cardio-pulmonary resuscitation (CPR) or, more simply, heart–lung resuscitation.

Fig 4.4.2 Doctors perform heart-lung resuscitation every day. This can save the life of somebody who has stopped breathing or whose heart has stopped beating.

Resuscitation is a process that everybody should know in case of emergencies. One day you might need to save one of your family or friends. If you ever find yourself in a position of having to undertake resuscitation, it is recommended that you follow the following DRABC of resuscitation.

D is for Danger	Always check that you and the patient are not in any further danger.
R is for Response	Check for a response by shaking the person and shouting.
A is for Airway	Turn the patient on their side and check the airway is clear.
B is for Breathing	Listen, look and feel for breathing.
C is for Circulation	Check for a pulse at the neck or wrist.

Excretion

Earlier in this focus you learnt that your lungs remove the waste carbon dioxide produced by your cells during respiration. Your cells also produce other wastes, which will build up and can become quite toxic if they are not removed. Wastes are removed from your body through sweating, urinating, breathing out and defecation. The process of removing wastes from the body is called **excretion**.

Your body has two kidneys, one either side of your spine, just below your rib cage (see Figure 4.4.3). The waste from your body cells is carried by the bloodstream and your kidneys work like a filtration system, removing wastes such as urea from your blood. Each kidney is about 10 centimetres long, is shaped like a bean and contains approximately 1 250 000 nephrons, which filter the blood. They remove waste such as urea, salt and excess water. The waste travels through the small tubes in your kidneys, then into your ureters, which lead from the kidneys to the bladder. The bladder is a small muscular organ that stores the liquid waste called urine.

Science Snippet

No sweat

A typical human has about 2.5 million sweat glands. You can design a test to determine if your sweat glands are spread evenly over your body using cobalt chloride paper. Dogs, cats and rabbits do not sweat as we do—they breathe heavily or pant to remove excess body heat.

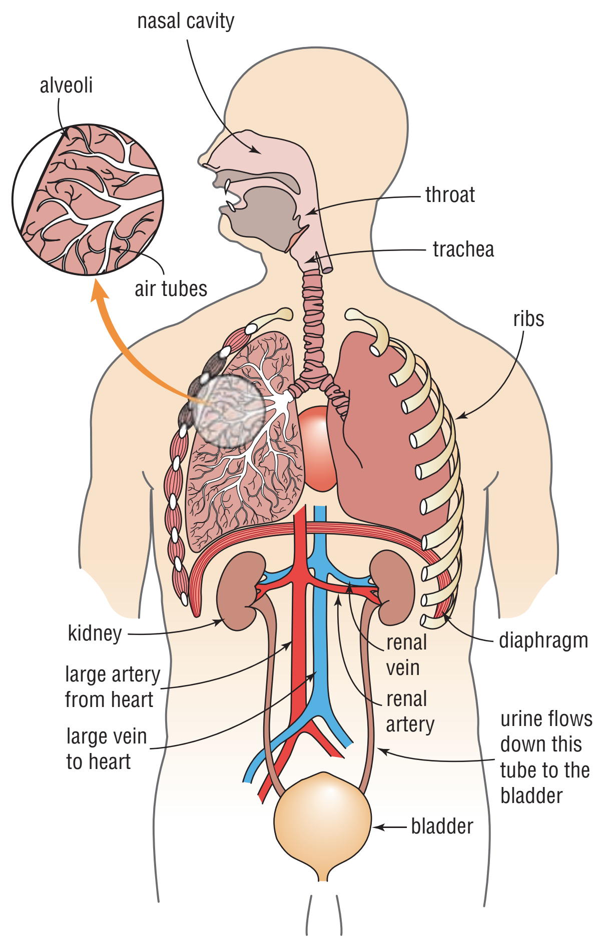
When your bladder becomes full you relax a muscle in your lower abdomen and expel the urine through a process called urination.

Sweating performs two functions in your body: it helps to control your body temperature and it removes waste water containing salts.

Defecation removes some wastes but the undigested food is not actually the waste. The brown colour of faeces is due to wastes from dead red blood cells. These are excreted by the liver and enter the intestines, where they mix with the faeces. The great majority of your faeces is not waste.

The excretory system involves your kidneys, lungs and skin.

Fig 4.4.3



4•4 FOCUS [Questions]

Drag and Drop CW Interactive

Use your book

Respiration

1 What do we mean by the term ‘respiration’?

2 How is respiration different from breathing?

Resuscitation

3 What is resuscitation, and is all resuscitation CPR?

4 What is the ‘DRABC’ of resuscitation?

Excretion

5 What is the function of the bladder?

6 Name three wastes produced by the human body.

7 What process do the nephrons undertake in the kidney?

Use your head

8 What is the advantage of having lungs made up of many small alveoli instead of just two large air sacs?

9 For what purpose do you breathe harder and faster when you exercise?

10 What would happen to your urine if you did not drink much water, and how would this change if you drank a lot of water?

11 When a young American man called Aron Ralston was hiking, a boulder fell on his hand, trapping him for five days. He ran out of water and finally had to drink his own urine for two days to survive. He finally managed to break his by-then dead hand off to get away. He wrote about his experiences in a book called *Between a Rock and a Hard Place*. What do you think would be the problem with drinking your own urine for a long time (apart from the probably horrible taste and the thought of what you are doing)?

Investigating questions

12 Design an experiment to test how your breathing rate may change after exercise. Show your teacher and then conduct the experiment. Then answer the following questions.

DYO

- **a** Are your results different from others in the class?
- **b** Graph your results and say whether your breathing rate is above or below the class average.
- **c** Explain why there is a difference between your breathing rate and the rates of other students in the class.

13 Use your library and the Internet to investigate why the fungus yeast is useful to beer producers, wine makers and bakers.

FOCUS 4•4 [Practical activity]

Prac 1 Focus 4.4

Respiration

Purpose

To investigate respiration in yeast and to infer how it may be useful in bread making.

Requirements

Four 250 mL conical flasks, labels, warm water, bromothymol blue, teaspoons, dry yeast, glucose, stoppers, 100 mL measuring cylinder.

For teacher demonstration: half teaspoon marble chips, 2 mL of 4M hydrochloric acid, test tube with delivery tube and stopper, test tube with bromothymol blue in it.

Procedure

Read through this prac then draw a table to record your results.

1. Label four conical flasks A to D.
2. Add 50 mL of warm water (about 35°C) to all flasks.
3. Add 1 mL of bromothymol blue to all flasks.
4. Add about 1 teaspoon of yeast to each of flasks A and B.
5. Add half a teaspoon of glucose to each of flasks A and C.
6. Swirl all flasks to mix them well. Place the stoppers in.
7. Leave flasks overnight in a warm place. Check them the next day.
8. The chemical changes colour according to how much carbon dioxide has been produced. When there is little carbon dioxide it is blue and it turns yellow at high carbon dioxide levels. Your teacher will demonstrate this to you by bubbling some carbon dioxide gas through some bromothymol blue.
9. *Record your results.*

Questions

1. What was the manipulated variable (independent variable) in this experiment?
2. What was the responding variable (dependent variable)?
3. What changes occurred in the flasks?
4. Why do you think a change occurred in the colour of the flask?
5. What did comparing flasks A and B tell you about yeast?
6. Why did you use flasks C and D?
7. Use these results to find out how this feature of yeast is useful in bread making.

FOCUS 4.5 Reproduction and development

Context

When you plant a seed you can watch it grow. Over time the small seed becomes a plant, produces seeds of its own and in time dies. No living things live forever. They may repair themselves if they are injured and maintain life processes for a long time, but they will eventually die. Different species have different lifespans (live for longer or shorter periods of time), for example the karri tree may live for hundreds of years while a butterfly may live only two weeks. It is essential that all living things have a method to reproduce or produce new members of their species, so they may grow and continue to exist in the environment.

Reproduction

All organisms reproduce to make more of their own kind. Reproduction can occur by sexual or asexual methods of reproduction. **Sexual reproduction** occurs when two 'sex cells', one male and one female, come together to produce a new individual. This should not be confused with **sexual behaviour**, which is the behaviour associated with intercourse and reproduction. The offspring from sexual reproduction usually look a bit like both parents but also have many differences from them.

Fig 4.5.1 The beautiful and sometimes scary jellyfish

Science Snippet

Making jellyfish

Have you ever wondered how jellyfish reproduce? Individual jellyfish are either male or female. The eggs and sperm develop in special areas called gonads, inside the body wall. The gonads are frequently very colourful and add greatly to the beauty of the living jellyfish. When all the eggs and sperm are fully developed in the male and female jellyfish, they are released into the stomach and then through the mouth into the sea. Some of the eggs stick to the frilly mouth lips that surround the mouth of the jellyfish, where they are fertilised in the ocean.

The other method of reproduction is **asexual reproduction**, which is the process by which individuals reproduce without the production of specialised 'sex cells'. The new individual develops from part of the parent. There is only one parent involved in asexual reproduction, and offspring are genetically identical to the parent and can be referred to as **clones**.

Sexual reproduction

Many plants and most animals reproduce sexually. Individuals produce two different types of sex cells, which must join together to form a new individual. This joining of sex cells is called **fertilisation**.

In plants, flowers produce the sex cells in the anther and ovary. Figure 4.5.2 shows the **ovary**, where the female sex cells, called **ovules**, are made. In Figure 4.5.2 you can also identify the **anther**, where the male sex cells can be seen contained in the **pollen**. For sexual reproduction to take place, the pollen from the anther of one flower must travel to the **stigma** of another flower. At the base of the stigma there is a small tube called the **style**, through which the pollen travels to the ovary where the pollen and the ovules join to become a **seed**.

When this seed is placed in the correct conditions of oxygen, temperature and moisture, the plant will begin to grow by sprouting out of the seed. This process is called **germination**. The small plant uses the nutrients stored in the seed to obtain the energy needed for growth until it has leaves and photosynthesis can take place.

Other plants also reproduce sexually but without flowers. Pine trees produce pine cones that hold their little seeds. Ferns, mosses, moulds and mushrooms all produce spores as a result of the sex cells joining in sexual reproduction. Almost all plants, however, can reproduce both sexually and asexually.

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As most animals can only reproduce sexually there is usually a female and a male parent. The male sex cells are called **sperm** and the female sex cells are called **ova**. These sex cells must join together for a new individual to develop. Figure 4.5.3 shows this process in dogs.

Fertilisation occurs in many ways, depending on the environmental conditions in which the animal lives. Fertilisation may occur inside or outside the female's body. Fertilisation inside the body is known as **internal fertilisation**. This occurs in most land animals to prevent the sperm from drying out and dying. The ovum of these animals is very small because the young will receive nourishment from the mother within a couple of days from fertilisation.

Fertilisation outside the body is called **external fertilisation**. This occurs in many water animals, such as fish and frogs. The male deposits his sperm into the water. The ovum of these animals is considerably larger than is the case with internal fertilisation, as it must contain all of the nourishment for the entire period of growth until the young hatches and finds another source of food.

Homework book 4.5 Strange plant sex

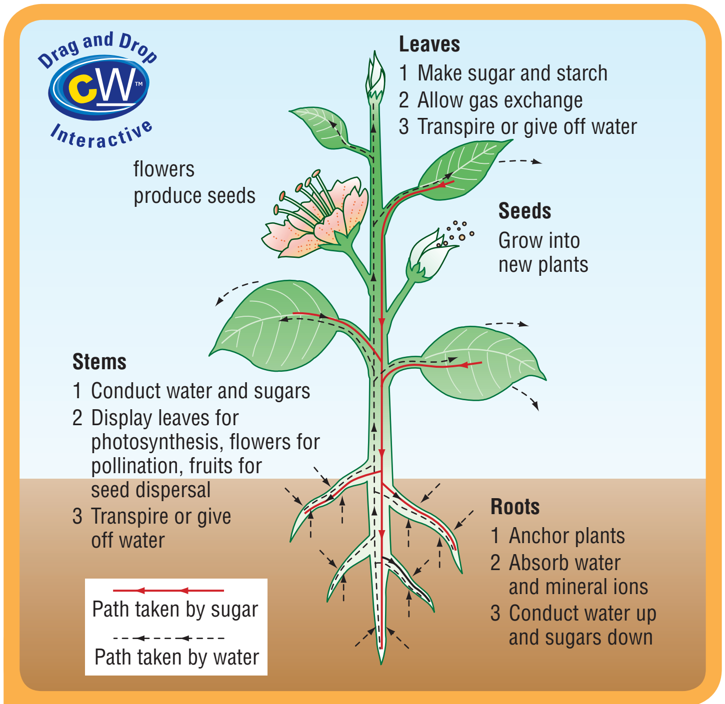
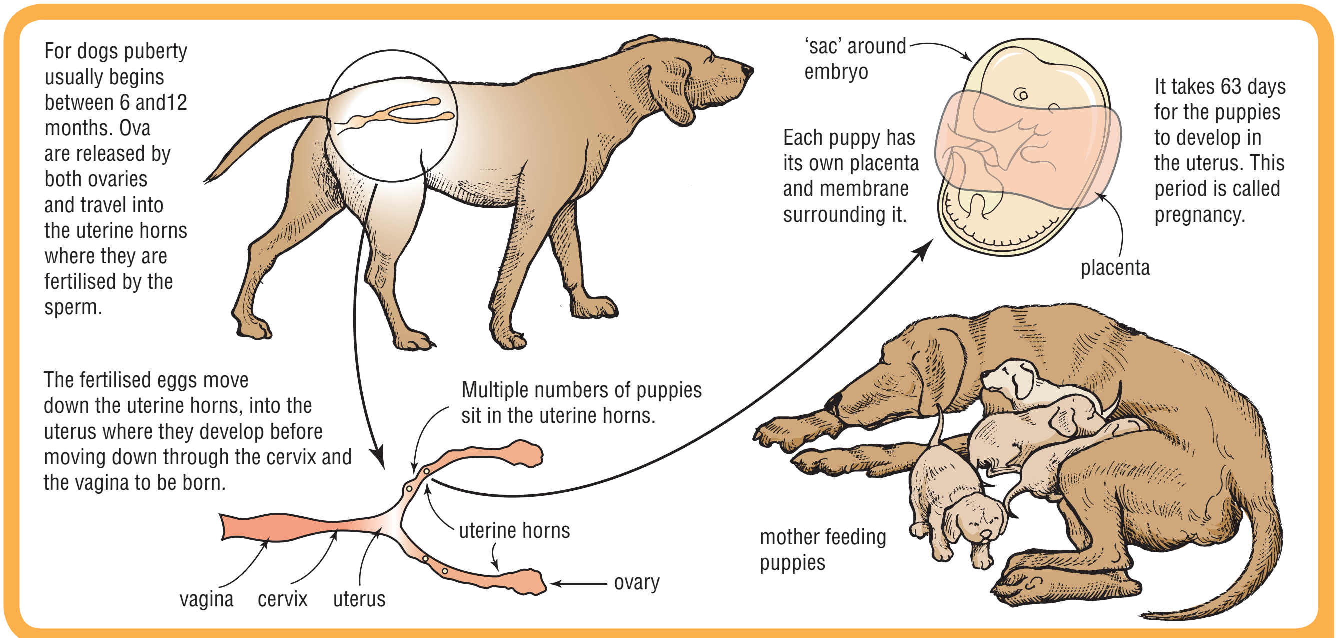


Fig 4.5.2 The reproductive parts of a flower



The reproductive cycle of a dog Fig 4.5.3

Asexual reproduction

There are many different types of asexual reproduction, such as underground stems and spores. Each of these types of asexual reproduction produces new plants from part of the parent.

Buffalo grass stems grow along the ground and are called **runners**. They grow out from the plant and send roots down periodically. If the runner between two plants is cut both plants would survive as two separate plants. You can grow a new lawn with shredded runners from another lawn. When planted just under the surface of the soil and watered the runners will grow leaves and spread across the area where they have been planted. Many other plants also reproduce in this way.

Bulbs, underground stems and tap roots all contain large stores of food for the growing plant. Spores are used by ferns, mushrooms, mosses and moulds to reproduce. These spores are very small and are easily carried by the wind or on passing animals. They need to find warm, moist soil to grow.

A few animals can reproduce asexually. They are often only very simple animals such as protozoa, which can simply divide into two. Another animal that reproduces asexually without 'sex cells' is the hydra, a member of the same group as corals and jellyfish. The hydra develops a bud on the side of the organism, which eventually breaks away. These animals are only a few millimetres in length and live by attaching themselves to vegetation in freshwater lakes and streams.

Fig 4.5.6 Mushrooms grow in warm, moist and often dark areas, and reproduce by spores.

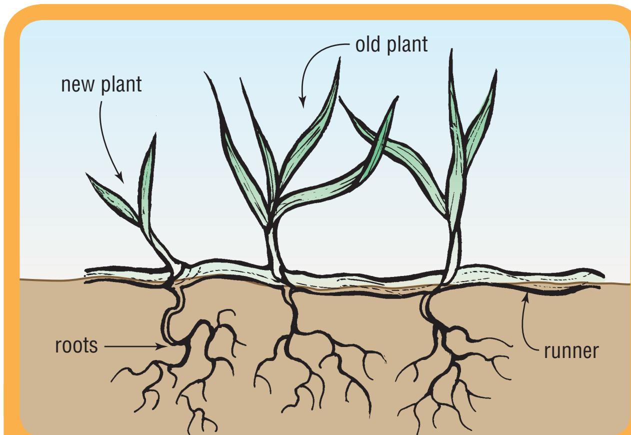


Fig 4.5.4 Many household lawns are developed by using runners.

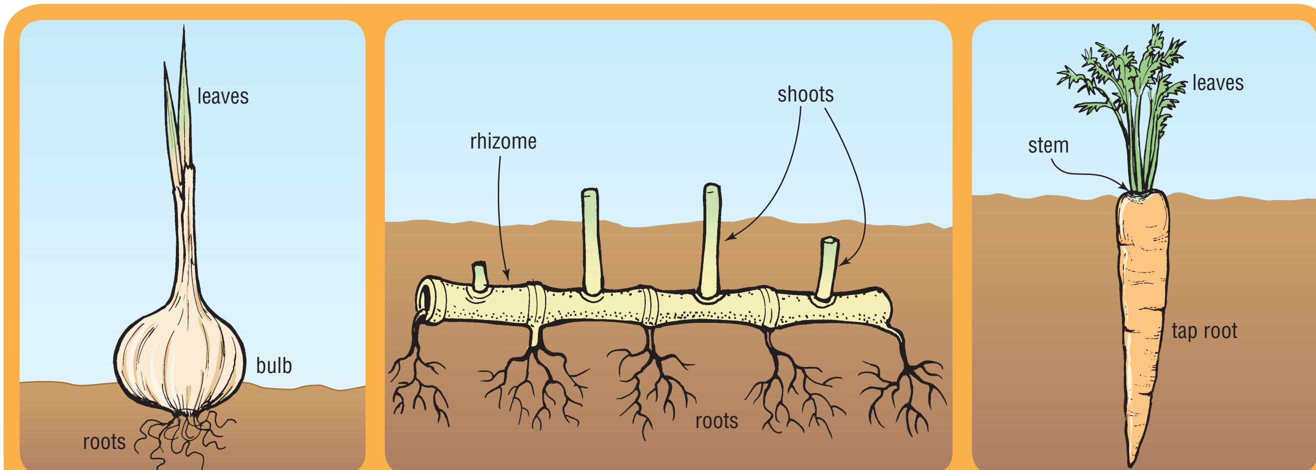
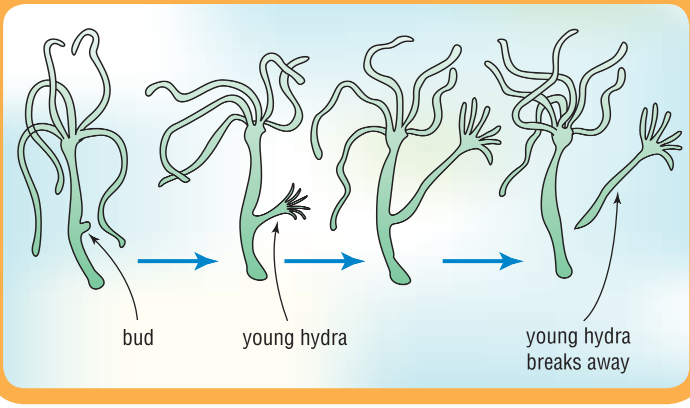


Fig 4.5.5 Many plants use different methods of asexual reproduction, including bulbs, underground stems and tap roots.

Fig 4.5.7 Hydra budding



Development and caring for offspring

Many animals do not care for their offspring. The young of egg-laying animals, such as some snakes, crocodiles, most frogs, turtles and some fish, develop in the egg after being laid and left by the female. There is no parental care after she lays her eggs. The young are completely independent of each other and their parents, finding their own food and protecting themselves from predators.

Science Snippet

A caring dad

Birds of prey parents both look after the offspring. The offspring of the peregrine falcon will stay in the nest for approximately 50 days. They receive over 80 per cent of their prey from the father, and the more chicks there are, the more often he will bring prey back to the nest.

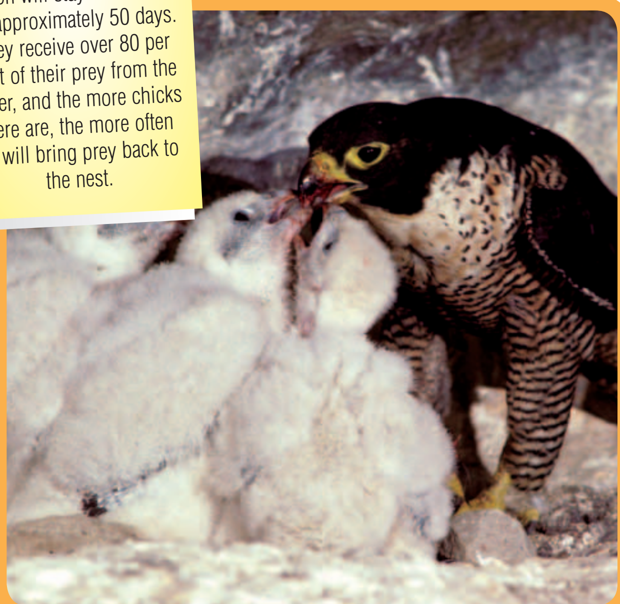


Fig 4.5.8 Falcons provide food, warmth and protection for their hatchlings until they are ready to leave the nest.

Some animals, such as humans, care for their offspring over long periods of time. Some female egg-laying animals such as birds will care for their young until they leave the nest.

Some offspring are born in a very undeveloped state and need special care from the mother for a period of time. In Australia we have many of these animals, which are called marsupials. When a small marsupial is born it attaches itself to a nipple in the mother's pouch. It stays there until it is ready to look after itself. A mother marsupial may have several young in her pouch at different stages of development.

Birds and mammals that care for their offspring produce considerably fewer eggs than those parents that provide no care for their offspring after birth. Young birds and mammals are completely dependent on their parents for warmth, food and protection. The parental care considerably increases the offspring's chances of survival after birth

Fig 4.5.9 Inside the pouch of a marsupial mouse

4•5 FOCUS [Questions]

Use your book

Reproduction

1 What is reproduction?
2 Is there more than one type of reproduction? Explain.
3 a How similar are the parents and their offspring produced by asexual reproduction?
  b Comment on the similarity of parent and offspring produced by sexual reproduction?

>>

Sexual reproduction

4 What is fertilisation and where does it occur in a flower?

5 Why do land animals usually have internal fertilisation?

Asexual reproduction

6 Describe three different ways in which organisms may reproduce asexually.

Development and caring for offspring

7 List two animals that are cared for by one or both parents after birth and two animals that receive little or no parental care after birth.

8 Which type of parental care do humans receive?

Use your head

9 What type of reproduction are you the result of? Give a reason for your answer.

10 Some plants, such as the strawberry, can reproduce sexually by seeds and asexually by sending out runners. What do you think could be some advantages and disadvantages of each type of reproduction?

11 What do you think may be the advantages and disadvantages to the survival of a species if the young require extended periods of parental care? Consider the effect on the parents as well as the offspring.

12 Suggest why some types of animals need to lay thousands of eggs rather than just a few. You need to think about the survival of the species.

Investigating questions

DYO

13 In arctic regions many baby penguins die from the icy conditions. Design an experiment to test how important parental care is for the baby penguin in keeping it warm in the first stages of life after birth. Your experiment should be as humane as possible.

14 Explain why the reproductive methods of the 'gastric brooding frog' of Australia, 'mouth breeder fish' and male 'seahorses' are unusual.

15 The platypus and echidna are two very strange mammals. What is unusual about their reproduction?

16 **a** Why do some animals have courtship displays?
b What is the difference between this sexual behaviour and sexual reproduction?

4•5 FOCUS [Practical activities]

Prac 1 Focus 4.5

Reproductive parts of a flower

Purpose

To identify the reproductive parts of a flower.

Requirements

Assorted flowers, razor blade or scalpel and handle, cutting board, tweezers, dissecting microscope, microscope slides, petri dish, small paintbrush.

Procedure:

1 *Draw your flower.*

2 Touch the end of the stigma. How does it feel? *Record your observations.*

3 Use tweezers to hold the flower while you cut it down the centre from the stem.

4 Try to identify the reproductive parts of the flower—anther, stigma, style, ovary, ovules and pollen.

5 Use the microscope to observe the ovary. Try to remove one of the ovules.

6 Brush some of the pollen onto a slide, using the paintbrush.

7 Observe the pollen under the microscope.

8 *Draw and label the flower you have dissected.*

9 Repeat with a different type of flower.

Questions

1 Describe how the stigma felt and how this may aid the reproduction of this plant species.

2 Suggest an advantage to the plant of having different sizes and shapes of pollen for each type of plant.

3 Is there an advantage for most flowers in being brightly coloured?

4 Suggest some advantages to these flowers of being different shapes and having different arrangements of their flower parts. You need to think about the role of flowers.

FOCUS 4·6

Working together

Context

Most of us can achieve more when we have others around to assist us. Our bodies work in a similar way, with all our cells organised into groups that work together to perform tasks more effectively. The organised structures that form part of a system in living things, such as the breathing and circulatory systems, are called organs.

Body systems

An organism that is made up of many different cells is called a **multicellular** organism. In these organisms, cells group together to perform tasks. If the cells all have a similar structure and appearance they are called a **tissue**. In the human body you have tissues such as muscle tissue, nerve tissue and epithelial tissue, such as skin.

Different tissues that work together are called **organs**. An organ usually has layers of different tissue. The brain, heart and stomach are examples of organs. Arteries, for example, are built of smooth muscle tissue, epithelium and connective tissue. You can see this is Figure 4.6.1.

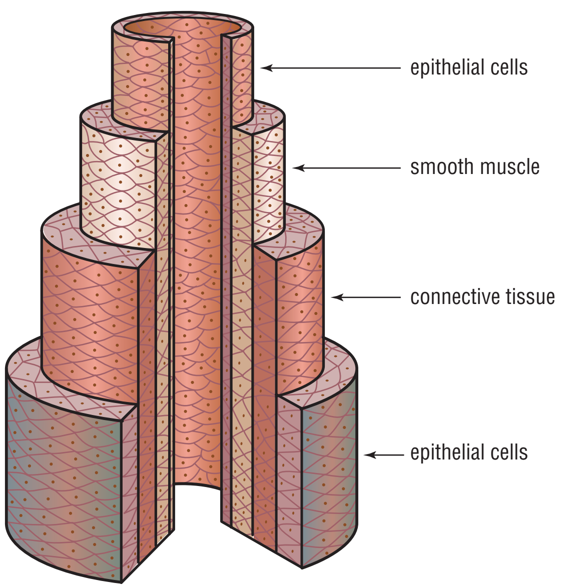


Fig 4.6.1 Smooth muscle tissue in an artery

A **body system** is a group of organs working together to perform a particular function. An example of a system is your circulatory system. The heart arteries, veins and other organs all cooperate to deliver blood. You can see these organs in Figure 4.6.3.

The systems within your body carry out the major functions needed for survival, as they do in all animals. The stomach is part of your digestive system, your lungs are part of your respiratory system and your heart is part of the circulatory system with a network of blood vessels to carry blood around your body. Many systems working together form an **organism** such as you.

Science Snippet

Recycled waste

Some animals use the waste from their excretory system to help treat digestive system disorders. Rabbits recolonise their gut with 'good' bacteria by eating their own faeces!

Human body systems

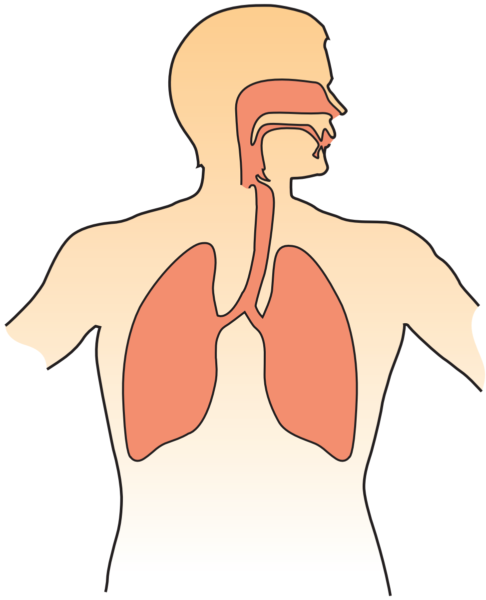
Some important human body systems are shown in Figure 4.6.3.

Science Snippet

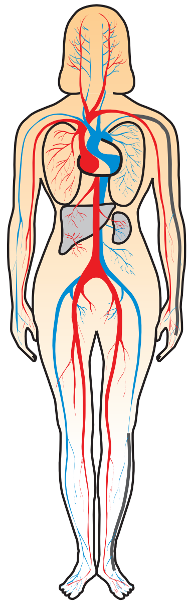
Bony feet

Did you know one quarter of all the bones in your body can be found in your feet?

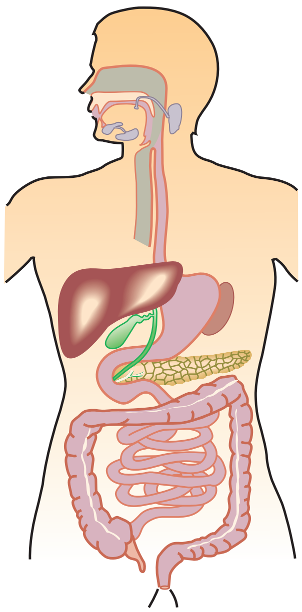
The bones of the human foot *Fig 4.6.2*



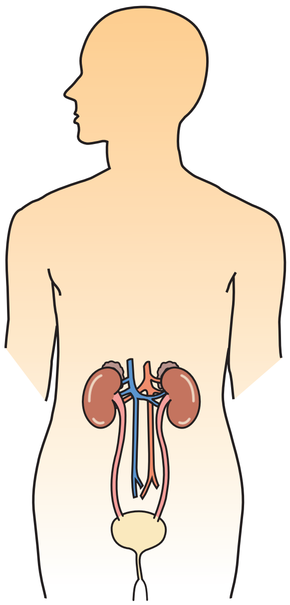
RESPIRATORY SYSTEM
Main organs: Trachea, lungs and diaphragm.
Main functions: Where oxygen is transferred to the blood for circulation to other parts of the body. The waste product carbon dioxide is expelled from the lungs as we breathe out.



CIRCULATORY SYSTEM
Main organs: Heart and blood vessels.
Main functions: Carries nutrients and oxygen to cells. Cellular waste is carried in the blood to other organs for separation before being removed from the body.

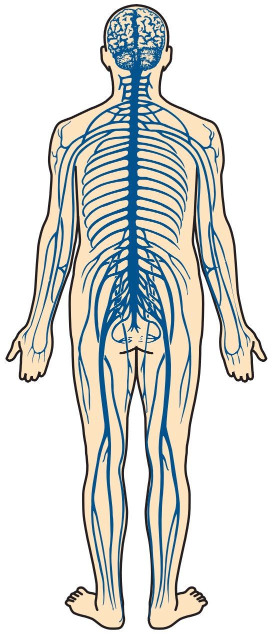


DIGESTIVE SYSTEM
Main organs: Stomach and intestines.
Main functions: Breaks food down into molecules small enough to be absorbed into the bloodstream. Separation of some waste materials occurs here.

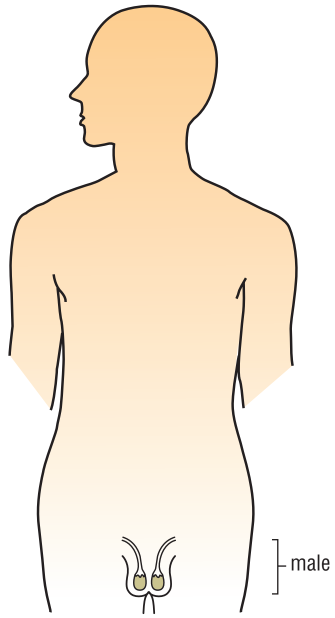


URINARY SYSTEM
Main organs: Kidneys, bladder, ureters and urethra.
Main functions: The urinary system is the main body system involved in excretion—removing liquid waste from the body. The kidneys filter out wastes and control the amount and contents of body fluid. The respiratory system and skin also remove carbon dioxide and sweat.

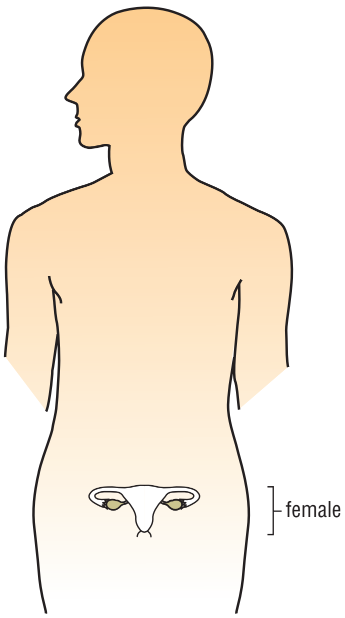
Some human body systems *Fig 4.6.3*



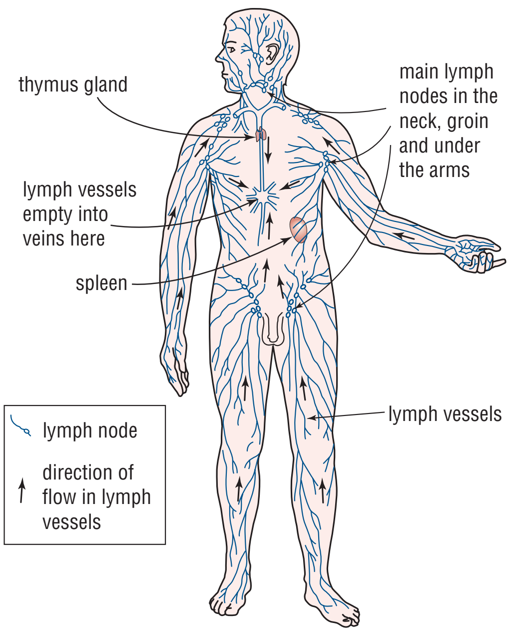
NERVOUS SYSTEM
Main organs: Brain, spinal cord and nerves.
Main functions: Sends and receives messages carried by the nerves. The messages are carried by chemicals and electrical signals.



MALE REPRODUCTIVE SYSTEM
Main organs: Testes, penis
Main function: Produces sex cells and transfers them to female.

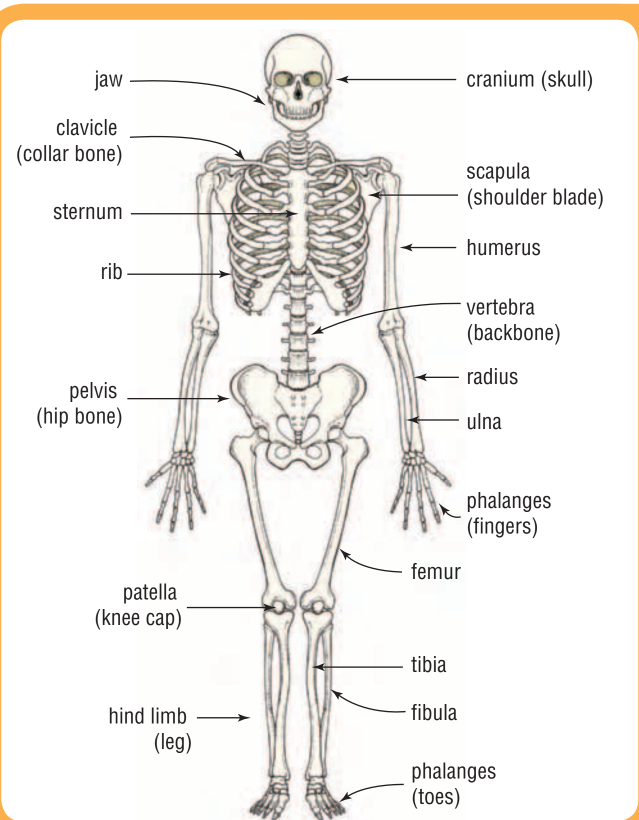


FEMALE REPRODUCTIVE SYSTEM
Main organs: Ovaries, uterus, vagina.
Main function: Produces sex cells and carries offspring.

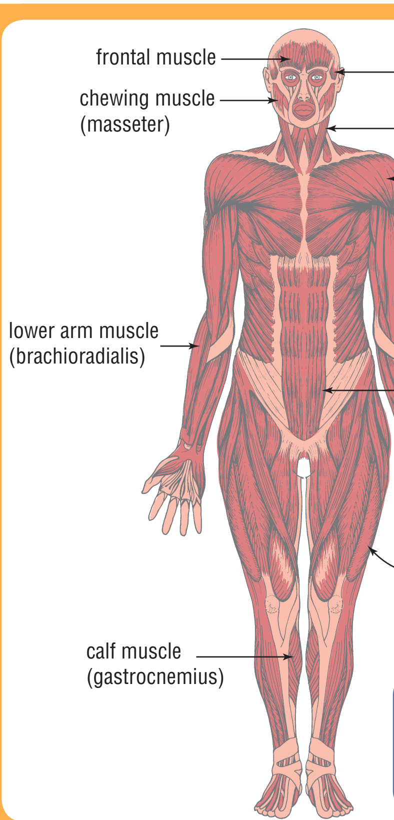


LYMPHATIC SYSTEM
Main organs: Lymph vessels and glands, spleen, thymus.
Main functions: Defends against infection, recycles fluid to the blood.

Some human body systems (continued) *Fig 4.6.3*



SKELETAL SYSTEM
Main organs: The skeleton.
Main functions: Protects the soft internal organs, supports the body, makes blood and helps you to move.



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Drag and Drop CW Interactive

MUSCULAR SYSTEM
Main organs: Groups of muscles.
Main functions: Muscle pairs work with bones attached by tendons, contracting and relaxing to move your body.

Some human body systems (continued) *Fig 4.6.3*

Fig 4.6.4 The endocrine system

Fig 4.6.5 Systems combine to form a functioning leg. (From left) skin surface with vein visible; the next limb shows smaller veins (blue) and the nerves under the skin (yellow); the next two show the muscles attached to bones via tendons; the next shows artery and ligaments of the foot and the final dissection shows the bones.

Plant systems

Plants also contain systems that carry out the functions they need to survive. You can see some of them in Figure 4.6.4. Leaf cells group together to form a leaf, which is an organ. Leaves contain the cells which photosynthesise, providing the food for the plant. The leaves and the stem combine to form the shoot system, which helps make food for the plant.

Another plant system is the reproductive system, which in many plants consists of flowers. The transport system consists of a network of veins, called vascular bundles, moving nutrients and water around the plant. The root system secures the plant in the ground and obtains water and nutrients.

Homework book 4.6 Systems

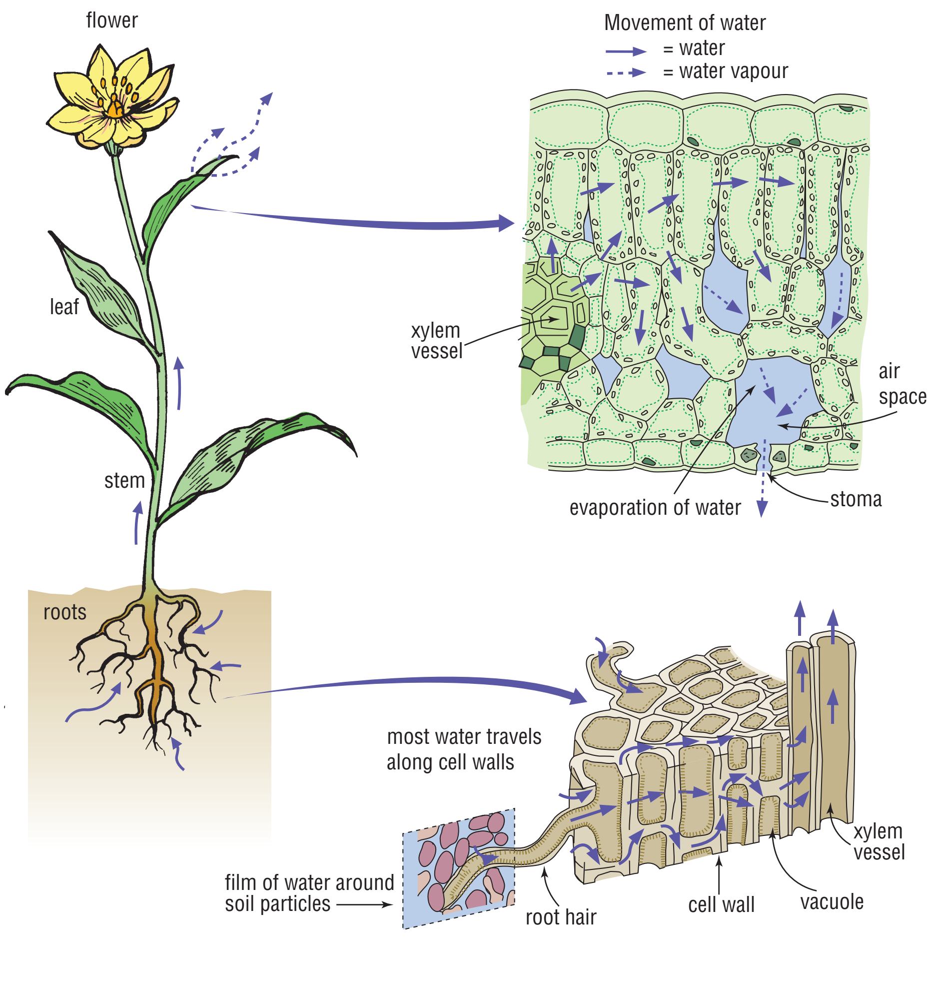

Fig 4.6.6 Some organs and systems in plants

Interactions between systems

Systems do not work on their own. They depend on other systems in the body to function. For example, consider breathing. The lungs absorb oxygen from the air and release carbon dioxide wastes to the air. How does the oxygen get from the lungs to every living cell in your body? It is carried there by another system, the circulatory system. That is why the lungs have a very good blood supply.

Another example is the digestive system. How does digested food reach all your cells? Again, the circulatory system carries it. But the circulatory system also depends on the digestive system. Every cell in the heart and blood vessels needs food. Without the digestive system the circulatory system cells would die. Without the circulatory system the digestive system cells would die. So these systems depend on each other. This dependence is called **interdependence**. Every system in your body is dependent on all the other systems. You, of course, depend on all of them.

FOCUS 4·6

Questions

Use your book

Interactive CW Crossword

Body systems

1 What is meant by the terms ‘tissue’ and ‘organ’? Give examples.

2 What is meant by the term ‘system’? Give five examples.

Human body systems

3 List the function of any two systems in your body, naming the main organs involved.

Plant systems

4 Name five plant parts that are organs, and three systems.

5 Draw and label a diagram of an external view of a plant. Explain the function of each part of the plant and use arrows to show direction and flow of nutrients.

Interactions between systems

6 Describe how the digestive and circulatory systems depend on each other.

Use your head

7 Describe the process of breathing in as much detail as possible.

8 Can you link the process of breathing to any other body system?

9 How do the skeletal system and the muscular system interact to perform their functions?

10 How does the digestive system depend on the respiratory system?

Investigating questions

11 Research a body system of an animal other than a human. Describe its structure and function compared with the equivalent system in your own body. Some diagrams of the system will help you. You could also use a Venn diagram to show the features of both and outline where they are similar.

12 Research the systems of grasses and woody trees such as eucalypts. Outline the features of each and explain how these features may help the plant to survive in its environment.

13 Compare the structure and function of *either* the circulatory or respiratory systems in any *two* of the following: fish, insect, frog or dog.

FOCUS 4·6

Practical activity

Prac 1 Focus 4.6

DYO

Model of body systems

Purpose

To produce a model of the human body and the systems within it.

Requirements

You can use any medium you think will produce the most life-like insides. Some things you may like to consider using are stockings for intestines, a freezer bag containing jelly or slime with assorted disgusting ‘food like’ bits in it, red snakes for veins, etc.

Procedure

1 Draw an outline of the human body and systems you want to create.

2 Label each part of your body and some ideas you could use for creating those parts (remember to make it as life-like as you can).

3 Begin work on an accompanying booklet which will describe your body’s functions and how they relate to each other.

4 Bring in anything you may want to use to create your masterpiece.

5 Imagination overtime—create your work of art!

6 Your teacher may ask you to take some photos of your model if you have access to a digital camera. Perhaps you can put them on a school web page or display them on a class computer.

Questions

1 What did you learn in this activity?

2 Did your human body look as you had imagined it would?

3 What would you change now that you have seen your creation?

FOCUS 4.7

Environments

Context

All living things have particular needs which enable them to survive in their environment. Most young animals rely on their parents to provide the basic needs for survival and teach them what they will need to know to ensure they are successful in life. The community around you will try to provide you with the necessary skills you require to survive on your own so you can be a successful and contributing member of society. There are organisms that require a lot less care and guidance in the environment than humans. These organisms generally have many offspring so only the strongest and fittest will survive. However, very few organisms live alone. Living things in an environment are interdependent, meaning that they depend on each other and their environment for survival.

The place where I live

The place in which a plant or animal lives is called its **habitat**. Every living thing has a habitat, where it can find the requirements for survival. A habitat may need to provide food, shelter and space to live, water, partners for reproduction, and gas for respiration for an animal or plant to survive. A group of organisms of the same species living in the same area is called a **population**. The size of a population in an area changes over time as is it dependent on the availability of food, water, shelter, living space and mating partners.

Fig 4.7.1 A population of sheep.

The different groups of organisms that live together in a particular habitat are called a **community**. Organisms living within a community rely on each other for food and protection. Communities are generally named after the type of habitat in which they are found, such as a coral reef community, or may be named after the most common type of organism, such as a eucalypt community.

All living things have special characteristics that help them to survive in their habitat and obtain the things they need to survive. How well an animal or plant survives in its habitat will depend on how well suited it is to that habitat. Ringtail possums, for example, are well suited to their tree habitat. They can move easily from tree to tree, have large eyes to help

Fig 4.7.2 This is called a eucalypt community because eucalypts are the most common organism to be found in the community.

them see at night, carry their young in pouches or on their back and are coloured to match the branches and trunks of trees. Look closely at the features of the kangaroo in Figure 4.7.3. For each feature, think how it helps the kangaroo to survive in its habitat.

Fig 4.7.3 Kangaroos are well adapted to their habitat.

The environment we live in

In a habitat there are many conditions that plants or animals need to cope with to ensure their survival. The term **environment** is used to describe all the conditions in a habitat that affect the survival of an organism. There are many factors which shape an environment, including living (**biotic**) and non-living (**abiotic**) factors. Living factors include predators and parasites. Non-living factors include temperature, water and wind. **Ecology** is the study of the interactions between living things and their environment.

Organisms rely on both the abiotic factors in their environment, such as water, soil minerals and temperature, and the biotic factors, such as other living organisms, for their survival. The complex system of feeding relationships and interactions with the abiotic factors is called an **ecosystem**. Any animal or plant in an ecosystem will have connections with other living things and the environment. For example, dead trees are important to animals such as numbats or cockatoos for nesting sites and as sources of food. Some animals, such as ants, change their behaviour, depending upon the weather or other physical conditions.

Fig 4.7.4 An aquatic environment, the Great Barrier Reef. To live in an environment each organism needs to find the basic requirements for life.

Any animal can be food for another animal. To survive in a particular ecosystem, animals have to find enough food and have features that will enable it to avoid being eaten. Some features that will enable animals to do this include having keen senses, such as sight, hearing and smell. The numbat has a very keen sense of smell and a long snout, which enables it to find termites in and under dead logs.

Fast muscle reactions are also an advantage in helping animals to catch their prey, for example a cat chasing a mouse. Both animals have fast muscle reactions—the cat moves quickly to catch its prey and the mouse moves quickly to avoid being caught. Claws or sharp mouth parts are also an advantage and help animals to hold and eat their prey. Spines may protect them from being eaten, such as with a sea urchin.

Adaptations

Characteristics that assist organisms to survive are given a special name—adaptations. An **adaptation** is any feature of an organism which helps it to survive and reproduce in its environment.

Fig 4.7.5 Describe some adaptations of this animal.

Types of physical environment

Animals that live in different environments need characteristics that will help them to survive in that environment. That is, they must be adapted to these environments. An organism can live in one of two basic types of physical environment—a land environment or an aquatic environment—which require very different characteristics for survival.

Aquatic environments

Of all abiotic or physical factors that affect animal survival, water is the most important. Aquatic animals do not have to find water, but living in water presents a range of factors that affect survival, such as:

- the amount of dissolved gases in the water
- the temperature of the water
- the amount and intensity of light available
- the effect of currents and waves
- the effect of buoyancy.

All organisms that live in these conditions need to have features that will help them to compensate for each of these factors. For example, small rock pools heat up very quickly and organisms that live in them can be faced with long periods without fresh water flushing through. Organisms that live in rock pools face one of the harshest environments in which to live.

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Fig 4.7.6 Why is the seaside rock pool one of the harshest environments?

Land environments

In land environments water is scarce but air is in abundance. The physical environment also presents a range of factors that affect survival, such as the need:

- for structures to obtain the gases needed for respiration, for example lungs or air sacs
- for a supporting structure such as a skeleton
- to avoid excessive water loss and obtain water
- to regulate temperature.

The organisms that live in these conditions need to have features that will help them to compensate for each of these factors. For example, the spinifex hopping mouse lives in a harsh environment where water is scarce and there is a need to reduce water loss. The spinifex hopping mouse obtains all the water it needs from its food and reduces water loss by looking for food at night, and having very concentrated urine and no sweat glands. Organisms that live in deserts face one of the harshest land environments.

Science Snippet

The vital resource

You can live for several weeks without food. However, without water you would die within 3–4 days.

Fig 4.7.7 The spinifex hopping mouse lives in a harsh environment.

Problems in the Australian environment

Many specialised features have developed in our native animals to enable them to survive in the harsh Australian environment. However, the effects of change such as fire or land clearing on Australian ecosystems can be devastating. These greatly affect food availability and shelter for animals.

Fire has generally been a natural occurrence in the Australian outback, with fires starting from lightning strikes and Aboriginal land use. For thousands of years Aboriginals used regular small fires to manage the plants and animals they needed for food. However, since European settlement low-heat and low-intensity fires have been replaced by severe fires that are

Fig 4.7.8 The Canberra bushfires in 2003 were devastating to the environment.

devastating to the natural environment, such as the Canberra bushfires in 2003. 'Controlled burning' is a government response aimed at reducing the intensity of these fires.

Drought is something regularly experienced by Australian farmers, and is partly caused by climatic changes. These cause major damage to agricultural ecosystems. However, drought and flood were part of the natural Australian landscape long before humans arrived in Australia. Many of our native species have adaptations to cope with these conditions. The pattern can, however, be devastating for introduced species and farming communities.

Our needs are closely linked with those of the environment and the effect that humans have on the ecosystem can be seen each year in the algal blooms that plague the Swan River. The waste fertiliser that runs off gardens and into drains is poisonous to some living things and can harm the environment by promoting excessive algal growth. Many of the activities that humans participate in produce waste materials that can harm the environment. Heavy metals, oil, pesticides and litter all affect the environment and can be introduced by humans. Recycling of wastes, using natural fertilisers and pesticides, can help reduce our impact on the environment.

Fig 4.7.9 The Swan River often suffers from fertiliser run-off, causing algal blooms.

Homework book 4.7 Environment and adaptations

4•7 FOCUS [Questions]

Drag and Drop CW Interactive

Use your book

The place where I live

1 Name five things organisms need to survive.
2 What is a habitat? Name two different habitats.
3 What is a population? Name two different populations.
4 What is a community? Name two different communities.

The environment we live in

5 What do we mean by 'the environment'?
6 What are abiotic factors? Give examples.
7 What are biotic factors? Give examples.
8 What is an ecosystem?

Adaptations

9 What are adaptations?

Types of physical environment

10 What are the main environmental factors affecting aquatic organisms?
11 What are the main environmental factors affecting land organisms?

Problems in the Australian environment

12 List three problems humans have caused in the Australian environment and ways that these problems may be overcome.

Use your head

13 Can you predict what might happen if an animal's habitat was destroyed through clearing? Give as much detail as you can.

>>

14 What advantage would an organism have if it was the same colour as its environment? Would there be any further advantage in it being able to change its colour? Alternatively, would there be any advantage in being brightly coloured?

15 Name an environment that has each of these factors:

- **a** is very hot
- **b** contains many predators
- **c** is very cold
- **d** would be particularly harsh to live in.

16 Draw an animal and label five adaptations, writing a brief note next to each one about how it helps the organism survive in its particular environment. If you can't think of one, choose from shark, whale, eagle, kangaroo, echidna, cheetah, dingo, praying mantis.

17 List three effects fire has on the environment and indicate whether these effects are beneficial or not.

Investigating questions

DYO

18 Investigate the consequences of clearing, toxic waste spill or fill in a local area. Detail the project or problem and the effect it had on the habitat of the marsupials or birds that were present there. Your teacher will tell you how much to write.

19 Design an investigation to test the factors that would affect the organisms living in a seaside rock pool. These organisms face many conditions that are particularly harsh and affect their survival. Some factors you may like to test include the temperature, or increasing salinity of the water. You may also like to test how dark algae in the bottom of the pool would change the conditions in the pool.

20 Choose a group of animals, such as dinosaurs, trilobites, flying reptiles, amphibians, fish or birds, that lived in the past but are now extinct. Describe three features that probably helped organisms in the group to survive in their environment. You can choose several different species from the group if you like. An example of one feature would be how different plant-eating dinosaurs protected themselves from predators. You may also predict how some features may not help survival in a particular environment, causing the group to become extinct. Your teacher will tell you how much to write.

FOCUS 4•7 [Practical activity]

Prac 1 Focus 4.7

Living in a rock pool

Purpose

To determine if the temperature in a rock pool would change more than that of a sand environment.

Requirements

Two small takeaway containers or similar, 250 mL beaker, 250 mL dry sand, 250 mL tap water, labels, heat lamp, thermometer.

Teacher note: Fill a couple of buckets with water the day before conducting this experiment to ensure the water is at room temperature for student use.

Procedure

Read through this experiment first then draw a table to record your results in your notebook.

1. Label two containers, one sand and one water.
2. Pour 250 mL of sand into the container labelled sand.
3. Pour 250 mL of water (at room temperature) into the container labelled water. (Your teacher may have water for you to use here.)
4. *Record the initial temperature of the sand and the water.*
5. Place both containers in the sun or under a heat lamp for 20 minutes.
6. Carefully push the thermometer bulb into the sand just below the surface to record the temperature. *Record the temperature of each container.*

Questions

1. Which container showed the greatest temperature change?
2. What would this mean for the organisms that live in this environment?
3. From your results in this experiment and using what you have learnt from Focus 4.7 about environmental conditions, predict what would happen if the surrounding environment cooled down. You may like to test your prediction by putting your containers in the refrigerator and then test them after a time period you think is appropriate.

FOCUS 4•8 Classifying animals

Context

All around you things are classified. A method of classification helps us to locate the things we want and need in an organised manner. When you go to the shop you would expect all lollies, frozen items and toilet paper to be grouped separately. If you were given some ice-cream, frozen peas, marshmallows, kitchen wipes and toilet paper, you would have no problem sorting these items using their features into groups. All living things are grouped according to similar characteristics or the features they possess. The practice of putting things into groups with similar characteristics is called classification.

Classification

You learnt about classification when you did Focus 1.4. If not, it would be a good idea to read through that first.

You have seen examples of classification all around you and use classification to make life a lot easier. Around your home things are classified according to their use. When you go to a friend's house, even if you have never been there before, you probably know where things are kept. This is the same if you visit your local library, deli or supermarket. Goods are usually arranged according to their purpose or, in the case of the library books, by subject and possibly author.

Science Snippet

A taxing job

Did you know the person who sorts living things into groups is called a taxonomist and the process is called taxonomy? So far there have been almost 2 million species described by scientists. But with an estimated 14 million species living on Earth there is still a lot of work to do!

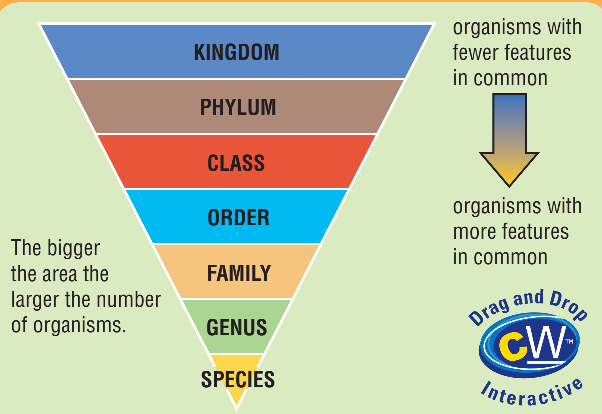
Classifying living things

Scientists use a similar procedure when classifying living things. Organisms with similar characteristics are grouped together so that all living things within that group will have a common feature. A system of classifying living things has been developed for organisms. It consists of a series of levels. Most scientists agree on the major groups.

A rainforest is home to many diverse species, some of which may have not been identified by scientists yet! *Fig 4.8.1*

When scientists approach the task of identifying organisms they first determine which kingdom it belongs to. This is the largest group and it is divided into five areas: animals (for example dolphin), plants (for example daisy), fungi (for example mushroom), prokaryotes (for example bacteria) and protists (for example algae). As can be seen from Figure 4.8.2, after each division the grouping gets smaller and the features become more similar until the animal is classified to a species. Imagine the width of the line indicating the number of different kinds of organism in that level.

Fig 4.8.2 The organisation of living things



All members of a **species** have very similar characteristics. Looking at different breeds of dogs you can see this: a chihuahua and a great dane belong to the same species and could reproduce to produce fertile offspring. Even if they would look a little strange, they have very similar characteristics but are not identical. Members of the same species can reproduce to create fertile young of their own. Members of different species such as a bird and a bat cannot mate to produce offspring. Sometimes similar members of different species mate, such as a tiger and a lion, but their offspring would not be able to mate as it would be sterile.

Each species has a scientific name by which it is known throughout the world. The scientific names of two common animals found around the world are *Canis familiaris* (the dog) and the *Felis catus* (household cat). These names are known as binomial names, as they have two parts. The first part of the name is the genus and is always spelt with a capital. The second part of the name is the species name or more specific grouping.

The dolphin has the following classification:
Kingdom: Animal
Phylum: Chordata
Class: Mammalia
Order: Cetacea
Family: Delphinidae
Genus and species: *Tursiops truncatus*

The offspring of a female tiger and a male lion is called a 'liger', which is sterile. Are there any other animals that you know of like this? *Fig 4.8.3*

Fig 4.8.4 The common bottlenose dolphin or *Tursiops truncatus*

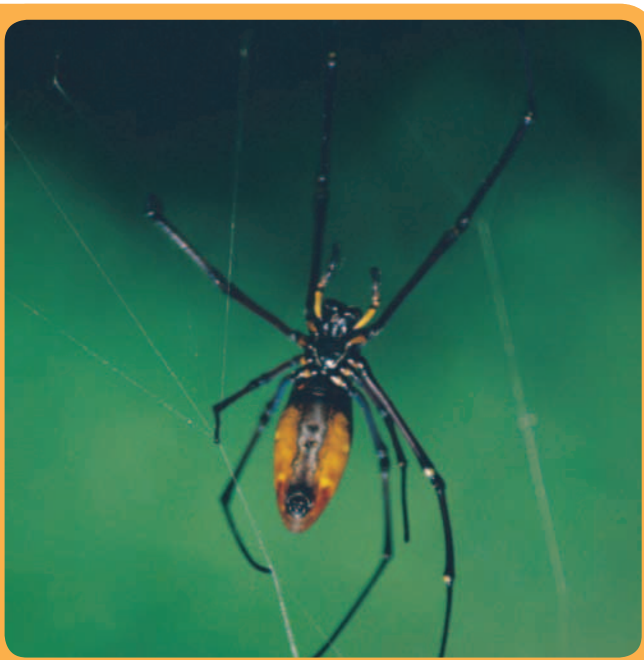
Homework book 4.8 Scientific naming

Animal classification

Many of the animals that have been identified by scientists are insects; very few are the furry animals you know as mammals. To study the diverse ranges of animals that live on Earth scientists classify things into very large groups with similar characteristics. After the division into animals, there are ten groups, or phyla, into which all animals are grouped. This is based on the animals' structures. Figure 4.8.5 shows the major groups of animals identified by scientists.

Homework book 4.9 Sifting and sorting

CHORDATES/VERTEBRATES
Description: The main feature is a nerve chord running down the back. Most animals in this group develop a 'backbone' (vertebral column) as they grow and develop. The vertebrates are divided into five main classes: birds, mammals, fish, amphibians and reptiles.



ARTHROPODS
Description: This is the largest animal phylum. Animals in this group possess an exoskeleton, jointed legs and segmented bodies. The major classes are Insecta, Chilopoda, Diplopoda, Arachnida and Crustacea.

MOLLUSCS
Description: Most molluscs live in water but a few types live on land. They have soft bodies, a muscular 'foot' for movement and some possess a shell.

ECHINODERMS
Description: All echinoderms are marine animals living in coastal areas. They possess spiny skin and are said to have radial symmetry (one side is identical to the other if cut anywhere in half).

The major groups of animals classified by scientists *Fig 4.8.5*

NEMATODES
Description: Animals within this phylum are often parasitic. This means they live off other animals. They have long unsegmented bodies.

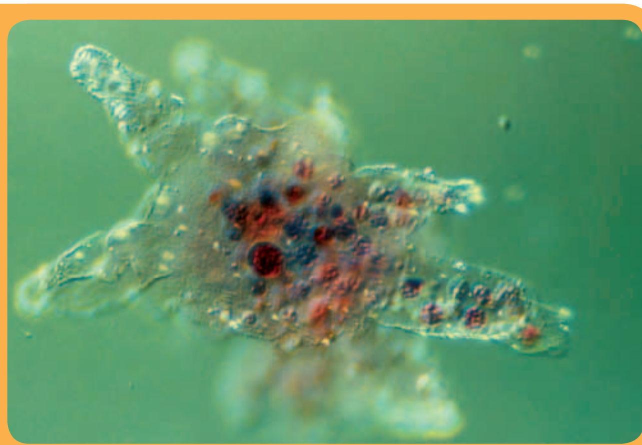
PLATYHELMINTHES
Description: Animals of this phylum can also be parasitic. They differ from roundworms as they have flat bodies instead of rounded ones.

ANNELIDS
Description: Annelids are known as segmented worms. They are found both on land and in water.

CNIDARIANS
Description: All cnidarians have stinging cells and a 'bag like' body surrounded by tentacles. They live mostly in sea water but some live in fresh water.

The major groups of animals classified by scientists (continued) *Fig 4.8.5*

PORIFERANS
Description: More commonly called sponges, poriferans have pores throughout their body and depend on water for survival. When alive they feel soft and rubbery and may be many different colours.



PROTOZOANS
Description: These animals consist of a single cell only and most are microscopic. Although some may be parasites, most are free-living in moist environments such as rivers, lakes, oceans and damp soil.

Fig 4.8.5 The major groups of animals classified by scientists (continued)

Homework book 4.10 Sorting animals

The basis for animal classification

Animals are classified into the levels of classification using many features. The main features used are:

- cell and body structure
- reproduction
- body covering
- movement
- food gathering methods
- body temperature
- methods for obtaining oxygen
- special senses
- where an animal lives.

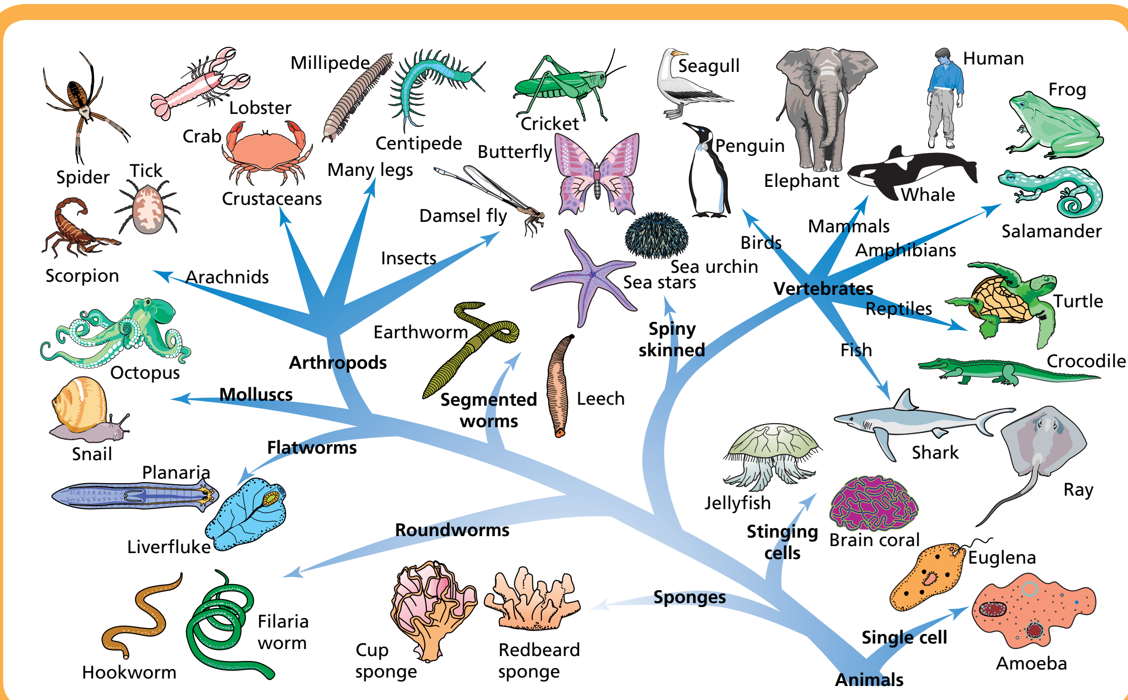


Fig 4.8.6 A simple animal classification key

FOCUS 4•8 Questions

Drag and Drop CW Interactive

Drag and Drop CW Interactive

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Use your book

Classification

1 What is classification? Give two examples where classification may be used.

Classifying living things

2 Why do we classify living things?

3 List the following in order from the group that contains the greatest number of organisms to the group that contains the smallest number of organisms.

Kingdom	Species
Family	Phylum
Genus	Class
Order	Subphylum

4 Explain what we mean by a species. Give an example of a species name.

Animal classification

5 List the ten phyla of animals, then choose two phyla and name three animals from each.

6 List the features that may be used to classify an animal into a group.

7 Explain why a scientist may use a classification key.

Use your head

8 Explain the difference between a class, a species and a phylum.

9 a Using a Venn diagram, write down the similarities and differences between a dog and a crab.

b Which of the features listed in your Venn diagram would be useful in classifying these animals?

Investigating questions

DYO

10 Use your library or the Internet to investigate different methods of classification. Choose one type of classification key to design your own, using types of food, shoes, computer games or anything else you choose.

FOCUS 4•8 Practical activity

Prac 1 Focus 4.8

Classifying animals

Purpose

To construct a classification key for a range of animals.

Requirements

Assorted animal pictures (students could also design their own creatures), pen and paper (you may also be able to do this on the computer using a program called Inspiration).

Procedure

1 Sort your animal pictures into two groups, according to one characteristic that each animal either has or doesn't have. Remember to use only the features listed in the section of this focus headed 'The basis for animal classification', and in Figures 4.8.5 and 4.8.6. *Write down the characteristic you used to split up your animal pictures.*

2 Using a different characteristic each time, repeat this process, splitting each group of animals again and again until you have the animals by themselves. You will need a large area to separate them each time. Then you can name them. *Make sure you write down the characteristic you used to split up your animals each time.*

3 Use each of your identified characteristics in steps 1 and 2 to design a key for other students to use to identify your animals. Use Figure 4.8.7 as an example of how to do this.

Questions

1 What did you learn about using keys?

2 Were some features easier to use than others for identifying animals?

3 Use the classification key in Figure 4.8.7 to classify an elephant, a dolphin, a crab and an earthworm. Was this key easier to use than the one you designed? Why?

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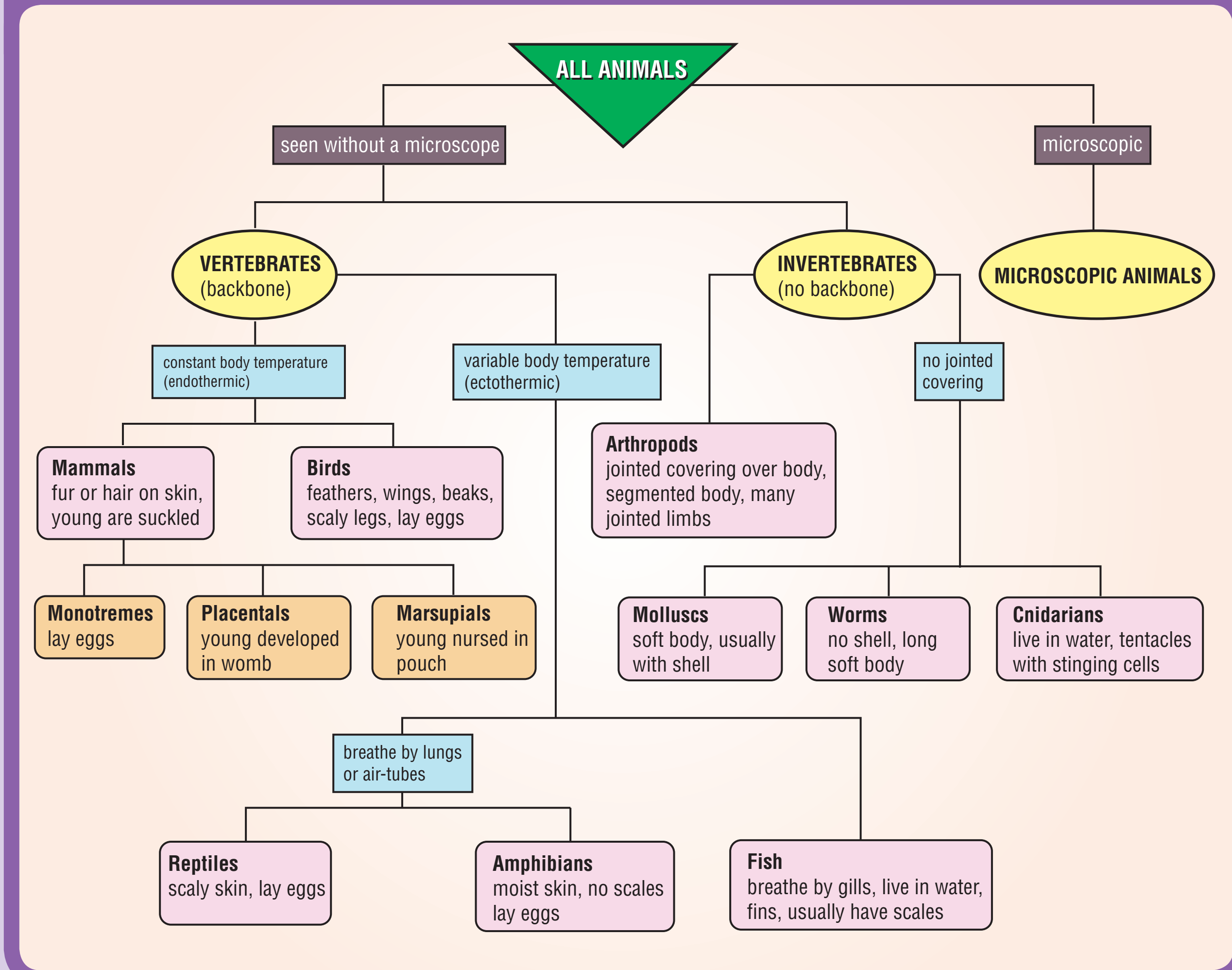
Fig 4.8.7 A classification key constructed by a student to classify animals according to their structure and function



FOCUS 4.9

Other kingdoms

Context

As you walk through a garden you will notice the variety of different plants that exist there. If you look carefully you may also notice fungi and possibly some mosses. As you have learnt so far, scientists use techniques of classification to separate and name different organisms. In addition to the animal kingdom there are four other kingdoms: plants, fungi, prokaryotes and protists. These four kingdoms include the organisms other than animals found on Earth. There is sometimes a difference of opinion among scientists about how to group organisms at these higher levels of classification.

Plants

All plants require sunlight and chlorophyll for the process of photosynthesis to convert simpler substances to sugars to power and build their bodies. Plants also have cells with cell walls.

Scientists classify the diverse range of plants that live on Earth into very large groups that have similar characteristics. After the division into plants, there are four groups into which all plants can be grouped, based on the plant's structures. Figure 4.9.2 shows the groups of plants identified by scientists. Many of the plants that have been identified are part of the class called Angiospermae, more commonly known as the flowering plants.

As can be seen from Figure 4.9.2 plants can be simple or complex. The larger plants have more complex cells and a transport system that enables them to grow taller.

The flowering plants are usually called the higher plants because of their well-developed systems and diversity in structure and function. Flowering plants range from very small grasses to bushes and very tall trees. Flowering plants have the ability to live in a variety of climatic conditions. They have well-developed roots, stems and leaves but their most important part and striking feature is the flower. The flower is the part of the plant where fertilisation occurs and seeds are formed.

A flowering plant. This is a protea. *Fig 4.9.1*

Basis of plant classification

Classification of plants is based on their complexity, which means how many different types of cells they have and how they are arranged and used. The features used are cell structure and function, strength of the rigid cell wall made of cellulose, presence or absence of an internal transport system and the way they reproduce. In some simple classification systems you may see fungi included as a plant, but most scientists don't really consider them to be true plants. A simple plant classification key is shown in Figure 4.9.3.

CONIFERS AND CYCADS
Description: Produce seeds on the scales of a woody cone. Contain cells that transport food and water around the plant.

FLOWERING PLANTS
Description: Develop seeds inside a flower that later becomes the fruit. Contain cells that transport food and water around the plant.

FERNS
Description: Ferns do not produce seeds. They reproduce through spores which develop on cases under their leaves. Contain cells that transport food and water around the plant.

MOSSES AND LIVERWORTS
Description: These plants do not have a well-developed transport system or true roots and are generally found in cooler moist environments.

The features of the four groups of plants *Fig 4.9.2*

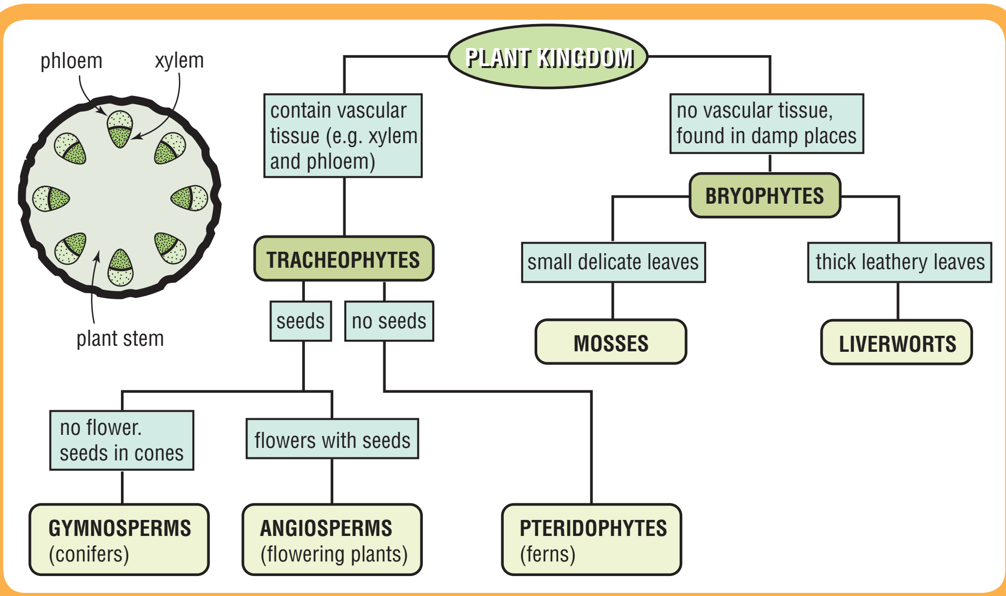


Fig 4.9.3 Classification key for plants

Science Snippet

Partners

Lichen is a special plant that is a combination of an alga and a fungus. The alga and fungus need each other to survive, with the alga producing food for survival through photosynthesis and the fungus absorbing moisture to support the alga. Lichens can reproduce sexually and asexually, though most often asexual reproduction occurs through small parts of the lichen breaking off and settling in another place.

Fungi

Fungi do not fit easily into either the plant or the animal division, and therefore have their own division. In some ways they are like plants and in other ways they are like animals. They have cell walls like plants, but they have no chlorophyll and are unable to make their own food, using photosynthesis. Like animals, they are **heterotrophs**, which means they feed on other animals and plants for nutrients to survive. Some fungi live on living organisms, for example ringworm, which lives on the skin of animals, including humans. Some fungi are microscopic and others are quite large. Some examples of the kingdom fungi include mushrooms, mould, mildew and yeast.

Lichen is often found covering rocks, tree trunks and roofing. *Fig 4.9.5*

Don't be fooled by the name—ringworm is a fungus! *Fig 4.9.4*

Prokaryotes

The kingdom prokaryota includes all the bacteria. Bacteria are found everywhere, from the depths of the ocean to the skin on your arms. Bacteria can be helpful or harmful. For example, the bacteria normally found in your intestines help to digest your food, but other bacteria introduced to your gut can make you very ill. They can produce poisonous chemicals that can break down your body cells. Some, such as tetanus, can kill you by paralysing your breathing. Others, such as tuberculosis, kill you by destroying lung cells. Some cause blood vessels to burst, leading to death.

E coli, a common bacterium found in poorly cleaned food preparation areas or on food kept at an incorrect temperature

Fig 4.9.6

Protists

Members of the kingdom protista include slime moulds, amoeba and seaweeds. Organisms in this kingdom don't fit anywhere else. There are two groups, algae, commonly called seaweeds, and protozoa.

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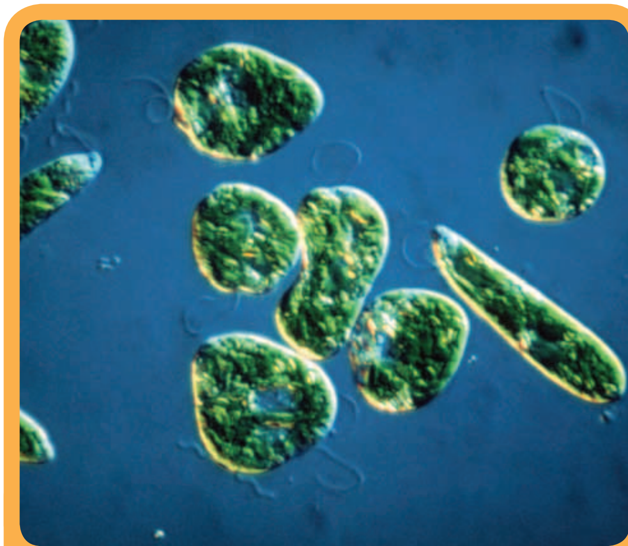


Fig 4.9.7 The kingdom protista embraces many strange and wonderful organisms, such as this euglena.

4·9 FOCUS [Questions]

Use your book

Plants

1 List the differences between simple and complex plants.

2 Explain some of the special features of Angiosperms.

3 Where are the seeds of a conifer produced?

Basis of plant classification

4 List the features which are used to classify plants.

Fungi

5 Explain how fungi are similar to plants and animals.

6 Give an example of a parasitic fungus.

Prokaryotes

7 Explain where in your body bacteria may be useful.

8 Describe how some bacteria may be harmful.

Protists

9 Some protists are 'animal like' and others are 'plant like'. Give an example of each.

Use your head

10 On a biology field trip a new plant was discovered. What features would need to be detailed for it to be classified back at the lab?

11 Make a list of plants from around the school and try to identify to which kingdom they belong.

Investigating questions

12 Use your library or the Internet to investigate one type of plant detailing the structures used for reproduction. Represent your information as a diagram.

13 Investigate the symptoms and treatment for two different types of fungal infection.

FOCUS 4·9

[Practical activity]

Prac 1
Focus 4.9

Classifying plants

Purpose

To construct a classification key for assorted plants from around the school.

Requirements

Assorted plant samples to observe or samples brought from home, pen and paper (you may also be able to do this on the computer using a programme called Inspiration).

Procedure

1 Sort your plants into two groups, according to one characteristic that each plant either has or doesn't have. Remember to use only the features listed in the sections of this focus headed 'Plants' and 'Basis for plant classification'. *Write down the characteristic you used to split up your plants.*

2 Using a different characteristic each time, repeat this process, splitting each group of plants again and again until you have each plant on its own in a separate group. You will need a large area to separate them each time. Then you can name them, or give them a letter. *Make sure you write down the characteristic you used to split up your plants each time.*

3 Use each of your identified characteristics in steps 1 and 2 to design a key for other students to use to identify your plants. Figure 4.9.3 provides an example of how to do this.

Questions

1 Give your samples and key to one of your classmates who did not work on the key with you. They have to try to identify each plant from your key. It would be a good idea to hide the name or letter at this stage. They should be able to tell you the letter or name after they have used the key.

2 How easy was your key to use in identifying the plants?

3 Were some features easier to use than others for identifying plants?

4 Use the information gathered to improve your key, and then ask another classmate to use it for you. Is your key more effective this time?

Fig 4.9.8

Review questions

Second-hand data

1 When organisms grow, they increase in size because they make more cells. Each cell divides into two smaller cells. These then absorb the materials they need and swell up to the normal size for that cell. The materials these new cells need are supplied by the body. This process of making new cells is called cell division.

Your body uses this process of cell division for growth and repair. For example, when you cut yourself, the new skin cells that join your skin together come from cells on the edges of the cut.

The results below show how a boy's mass changed as he grew older.

a Draw a graph of the changes in the boy's mass. Use graph paper.

b Why would cell division have to result in growth? Explain in several sentences.

c Would unicellular organisms grow in the same way that this boy did? Explain your answer.

c Explain why nutrients are needed for cell division.

d In about five sentences explain how the boy's method of obtaining food (heterotrophic nutrition) is different from the method used by a plant (autotrophic nutrition).

e The boy's growing body needs energy. Name and explain in several sentences the chemical process taking place in his cells which gives him the energy he needs.

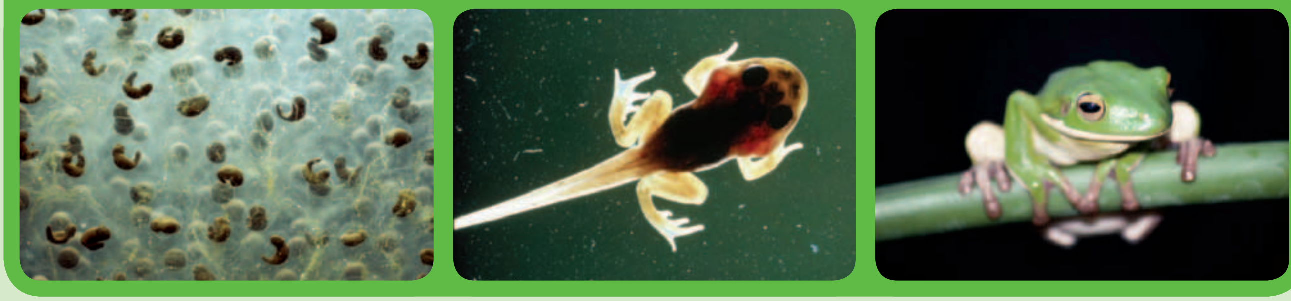
Age (years)	0	1	2	3	4	6	7	8	9	10	11	12	13
Mass (kilograms)	2.5	4	5	7	11	15	19	25	27	30	33	35	36

Open-ended questions/experimental design

2 You have found an object which you think might be alive. Describe eight different experiments or methods you could use to decide if the object is alive or not. These experiments or methods should be based on what you have learnt about the life processes and characteristics of organisms. You must say what observations or results would enable you to clearly decide if it is alive or not alive. Your answer should be about one A4 page in length. Diagrams may be used if they help your answer.

3 As we grow, develop and reproduce, our bodies are continually changing. This is caused by interactions between our systems and the environment. While the body grows and develops it maintains all the processes needed for survival in the environment. Your task is to give a detailed account of changes that occur over time in the life cycle of an animal. Make sure you give a detailed account of changes that occur. Your answer should be about one A4 page in length, including any diagrams needed. You may also use PowerPoint, cartoons or a photographic display to organise your information.

Fig 4.10.1 The life cycle of a frog



Review questions

Extended investigation/research

4 You are a fitness trainer and are interested in the question: 'How does your heart respond during and after exercise?' You decide you are going to investigate how exercise will affect heart rate.

To find the answer you realise you will need to investigate how long it takes for your heart rate to decrease and at what rate after exercise. In your planning you decide you need to be part of a team to help find the answer. So you decide that you will join other fitness trainers. The team decides it needs the following people, and so must decide who will do each job:

- an accurate supervisor to take the heart rate
- an exercise volunteer
- a recorder to take down the information
- a stop-watch, student wrist watch or clock (with a second hand) to record how long you exercise for.

To do the experiment a partner has to measure the volunteer's resting pulse. Your chief fitness trainer, who looks a lot like your Year 8 science teacher, will show you how to do this. The volunteer should be sitting down and relaxed when the measurement is taken.

You need to plan how your team will find the answer to the question. Submit your plan to the chief fitness adviser so they can give you company permission to try the experiment. In your plan you need to specify the equipment you require, where you will conduct the experiment and what you will do, including the measurements you will make. Each member of the team must have their own written copy of this plan in their notebooks.

Once you are ready, carry out your experiment. In your notebook, following your plan, record your results. Then decide what you have discovered about the original problem. Write out what you think you discovered.

At the conclusion of your report you need to answer the following questions.

a Did you wait between pulse measurements? Why?

b Did you repeat your measurements? Why?

c How did you know when to stop taking measurements?

d Why does your heart beat faster during exercise?

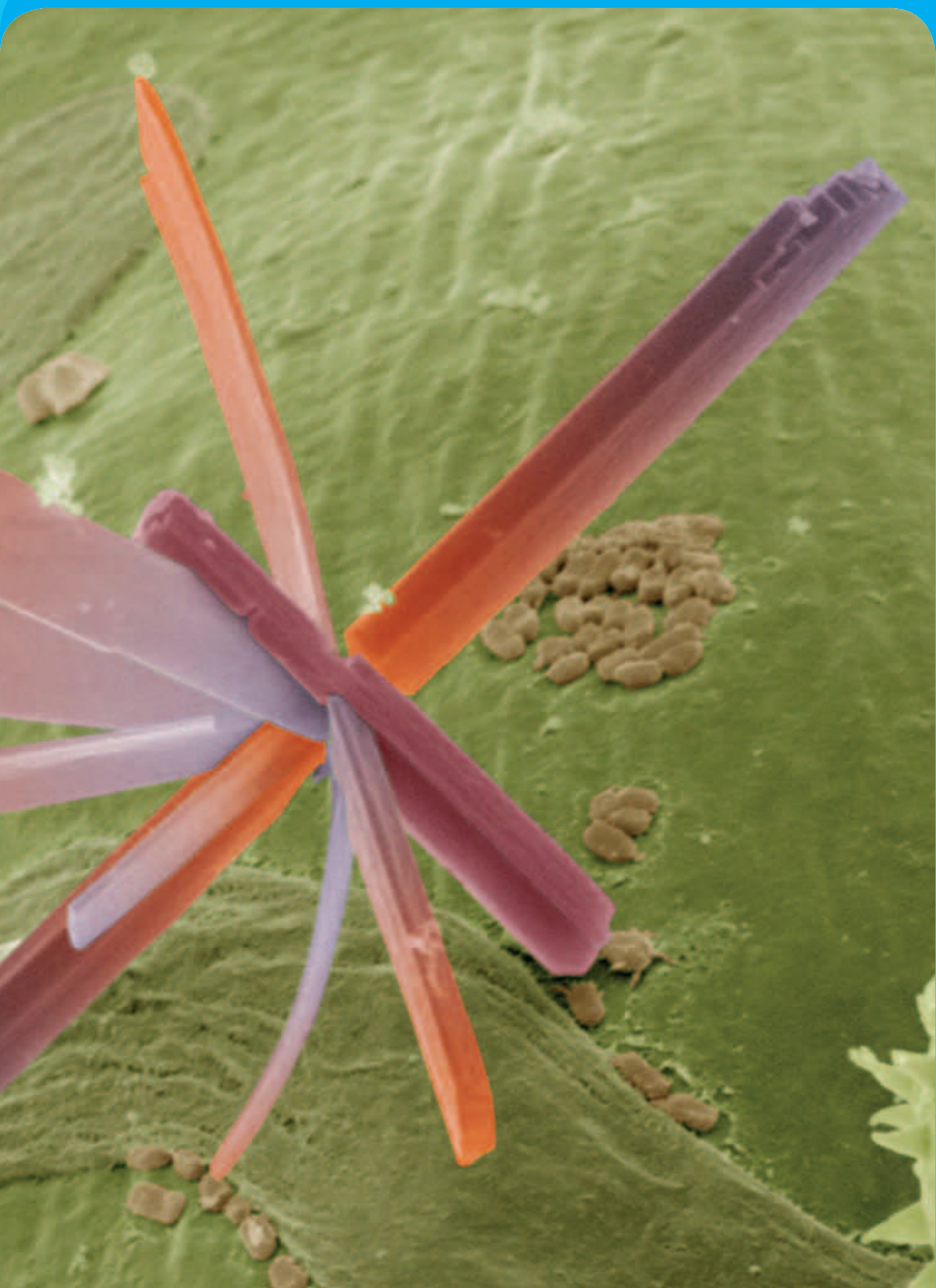
If you repeated this experiment would you expect the results to be different? How?

Taking a person's pulse on the wrist. *Fig 4.10.2*

Homework book 4.11 Life and Living crossword

Homework book 4.12 Sci-words

5 Natural and processed materials



Curriculum guide learning focus

- the nature of chemistry as a materials science
- the states of matter and change of state
- atoms as the basic components of matter
- particle models of solids, liquids and gases
- uses of solids, liquids and gases related to their structure
- differences between elements, compounds and mixtures
- the periodic table and properties of different elements
- symbols for elements and compounds
- classifying changes as chemical or physical
- solutions and other mixtures
- methods of separating mixtures

This section on Natural and Processed Materials also contains information which will help students with the outcomes of Investigating Scientifically, Communicating Scientifically, Science in Daily Life, Acting Responsibly, and Science in Society.

Outcome level descriptions

The outcome level descriptions covered by this part of the book are NPM 2, NPM 3 and NPM 4.

FOCUS 5•1 Living in a material world

Context

We are surrounded by materials. If you look around you right now you can quickly identify many different types of materials. Each of these materials has special features and characteristics which make it useful for a particular purpose. As scientists, we need to be able to select the right material for the job. Scientists who study materials and their uses are called 'materials scientists'. We are all materials scientists because we make decisions about materials every day. In this focus you will explore the range of materials and some of the special properties of these materials that make them suitable for that purpose. You will also be exploring some of the new and exciting materials that are being developed, and the amazing world of nanotechnology, a branch of science that deals with the building of objects and machines so small that we cannot see them.

A material world

Fig 5.1.1 Early humans used the materials around them to make tools to help them perform certain tasks better.

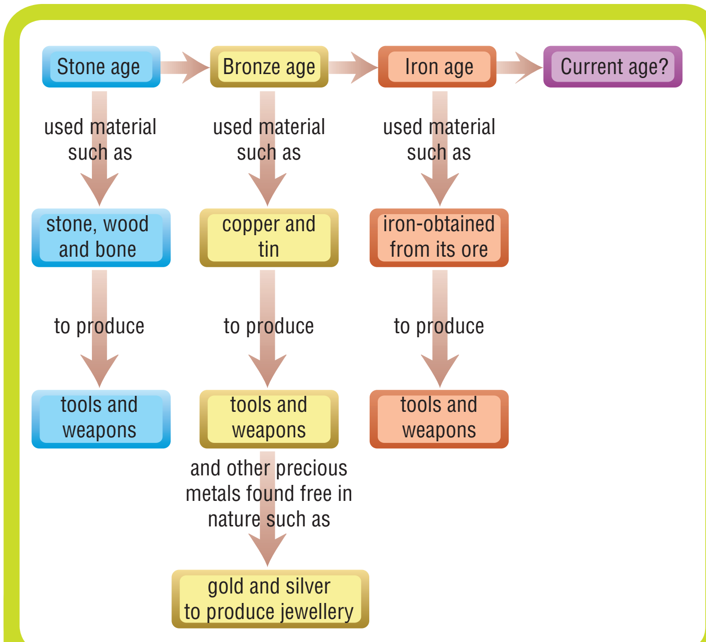


Fig 5.1.2 Materials are used to name some of the major periods in human history.

Materials are so important to humans that whole periods in history have been named after them. These have include the Stone Age, Bronze Age and the Iron Age. As human civilisation has advanced, the type and number of materials have increased.

What name would you give to the time in which we live now? Many people have suggested that we might call it the 'Plastic Age'. However, there have been exciting new materials produced from a range of materials, including new types of metals, ceramics (china) and glass.

Optic fibres are produced from glass and allow digital messages to be transmitted over long distances. *Fig 5.1.3*

What is a 'materials scientist'?

Materials scientists are often known by a variety of names, depending on the type of materials they work with. For example, materials scientists known as metallurgists work with metals, and ceramic and polymer engineers work with ceramics and polymers respectively.

Fig 5.1.4 Polymer engineers explore how plastics and similar materials can be used to replace our existing materials.

In the past, materials scientists used trial and error to improve materials. For example, in medieval times it was found that if iron was heated up and cooled quickly it would become harder. Modern material scientists now try to improve materials by understanding more about the particles that make up the materials and how they are arranged inside the materials. By understanding how these particles are put together to make materials, they are better able to direct their investigations at improving materials rather than relying on chance.

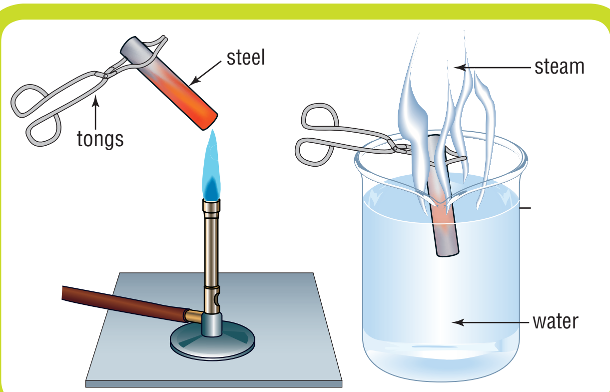


Fig 5.1.5 When steel is heated until it is very hot and then cooled quickly in water or oil, the steel becomes harder and more suitable for making a large number of different materials.

Materials scientists also produce building materials. Can you imagine living without concrete? Concrete was first developed in 1756 but many materials scientists since then have contributed to improving it to the standard of concrete we use today.

Fig 5.1.6 Millions of tonnes of concrete are used every day to produce a large range of building objects. Can you think of any other structures made of concrete?

Properties of materials

Fig 5.1.7 The materials used to make this guitar were chosen because of their particular properties. The strings are elastic, the body neck has strength and the pick guard is hard, and so resists scratching. What other materials can you observe and why were they chosen?

Why are windows made of glass? Why are car bodies made from steel? We make decisions about which materials to use by knowing what special properties these materials have. For example, glass is reasonably strong and hard and, of course, we can see through it. These **properties** make it suitable for use in windows.

The various materials have many different properties. The following table lists some of the main properties.

Science Snippet

Car engines made from ceramics?

Car engines can now be made from new types of ceramics. There are lots of advantages to this. They produce more than twice the power of a petrol engine and use a quarter of the fuel. They are environmentally friendly, producing fewer greenhouse gases. They do not need oil or water and will run forever without servicing! They are at the moment difficult to manufacture and very expensive.

Properties of materials

Property	Explanation	Further information
Ability to transmit light	Some objects allow light to travel through them while others do not. There are special terms used to describe this.	Materials can be **transparent** (you can easily see through them), **translucent** (you cannot easily see through them) or **opaque** (you cannot see through them)
Compression strength	Materials that can support large weights without being crushed are said to have a large compression strength.	There are different types of strength depending on how you apply the force on the material. See tensile strength below.
Conductivity of heat and electricity	Materials that carry heat and electricity well are called **conductors**. Materials that do not conduct heat and electricity are called **insulators**.	Some materials are called **semiconductors**. They carry electricity, but not very well. They are very important in the production of **computer chips**.
Degradability	Materials that break down after being used are said to be **degradable**. Many materials do not break down after use and are said to be **non-degradable**.	Non-degradable materials are difficult to dispose of and will be around for many hundreds of years in landfill.
Ductility	Materials that can be drawn into thin wires are said to be **ductile**.	
Elasticity	Materials that can be stretched and then return to their original shape are said to be elastic.	
Flexibility	Materials that can be bent without breaking are said to be flexible.	
Hardness	Materials that are not easy to scratch or dent are hard.	Hardness is often measured using the Mohs scale. This scale runs from 1–10, with 1 being a very soft material such as talc and 10 being a very hard material such as diamond.
Malleability	Materials that can easily be bent into a different shape are said to be malleable.	
Porosity	Materials that allow air and water to move through them easily (like a sponge) are to be **porous**.	
Solubility	Materials that dissolve when placed in water are said to be soluble.	Water is generally the liquid that is used when exploring solubility, though other liquids will dissolve substances.
State	Materials exist in one of three states—**solid, liquid** or **gas**.	You will be exploring the states of matter in the next focus.
Tensile strength	Materials which require a lot of force pulling on them before they break are said to have a high **tensile strength**.	
Viscosity	Materials which flow easily are said to be less viscous.	Viscosity is generally used when referring to liquids.

Drag and Drop CW Interactive

The materials scientist uses these properties and others when making decisions about which materials to use when building an object. The world of materials science is very exciting as different materials are now replacing more traditional materials such as metals.

One very important job for materials scientists is to find materials that are friendlier to our environment. They have a responsibility to use materials that can be recycled or disposed of safely. We all have a responsibility to the environment. We should try to buy environmentally friendly and recyclable materials.

Fig 5.1.8 Millions of tonnes of plastic are thrown away each day. Materials scientists are developing plastics that will decompose faster.

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Classifying materials

It is estimated that there are about 300 000 different types of materials in use at the moment. This means that if you named a different material every second it would take you three full days just to get through the list. Most materials can be classified into the following main groups: metals, ceramics, semiconductors, polymers, composites, biomaterials and nanomaterials.

Metals

Bronze and iron were among the first metals used by humans. The use of these metals allowed humans to produce a greater range of objects. Metals were also the first materials that early materials scientists experimented with to change their properties.

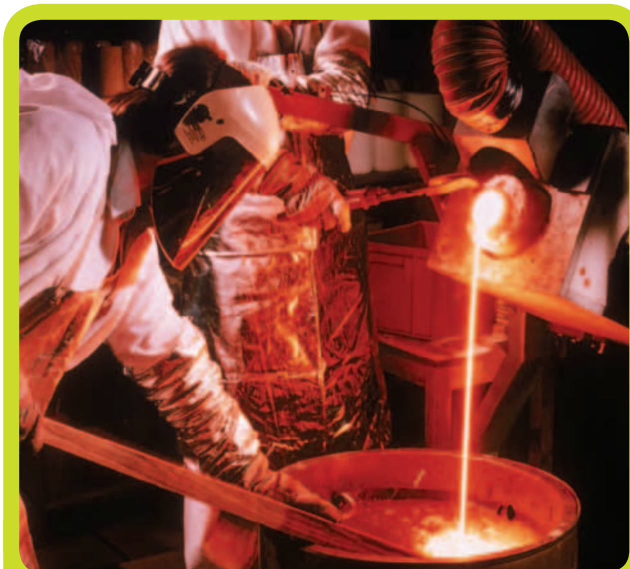

Fig 5.1.9 Metals such as steel can be heated and moulded into a variety of shapes while they are liquid.

Today there are hundreds of different types of metals, many of them formed by mixing different metals together. A mixture of two or more different metals is called an **alloy**.

Ceramics

The china that is used to make a teapot or toilet bowl is one example of a ceramic material. Modern ceramic materials can be used to produce objects such as artificial teeth and bones. Modern ceramics are also being experimented with to replace materials such as metals, for example in car engines, as ceramic materials are often lighter and handle heat very well.

Fig 5.1.10 Many objects in the home are made from ceramic materials.

Prac 2 p. 218

Semiconductors

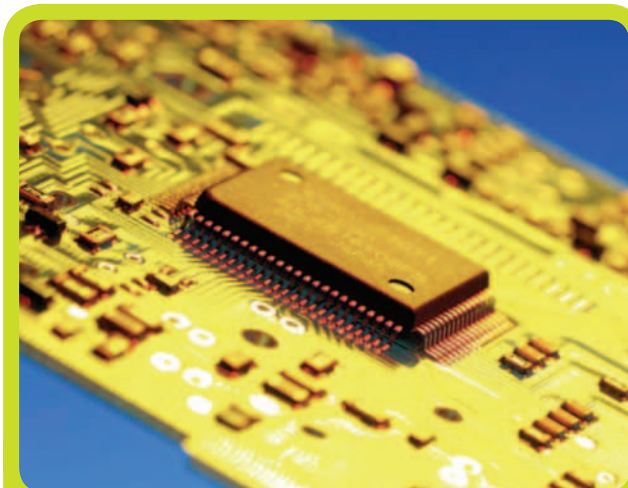

Fig 5.1.11 This circuit board contains a silicon chip made from semiconductors. Circuit boards such as this one are found in all digital devices, such as DVD players, mobile phones, televisions and computers.

Semiconductors are materials that do not conduct electricity very well. The special properties of semiconductors allow them to produce and store digital information. You can only access a website because of the special properties of semiconductors.

Polymers

Fig 5.1.12 Polymers are found everywhere in our homes and schools.

Plastics, paints, rubber and even paper are polymers. Most of the food that you eat is made from natural polymers. Later in this book you will be studying how particles are arranged in materials. In polymers, particles are joined together in long continuous chains which give them their special properties.

Composites

This bike frame is made from a carbon fibre composite. Composites are very strong and light and are often used to replace metals. *Fig 5.1.13*

Composite materials are those produced when different materials are combined. Fibre glass and carbon fibres are common materials for producing boats and sport equipment. They are being experimented with to produce a range of other materials that are typically made of metals. Composites are often just as strong as metals but much lighter, requiring less energy to use.

Biomaterials

Biomaterials are used to replace normal body parts such as this knee joint (shown as the bright colour). *Fig 5.1.14*

Science Snippet

Cyborgs

A cyborg is a human being into whom mechanical and electrical devices have been implanted. Are cyborgs found only in sci-fi movies or do they really exist? Well, we don't have the Terminator just yet, but Australian scientists have invented an implant called a 'bionic ear' to help deaf people hear. Combine the bionic ear with other implants, such as knees, hips, facial reconstruction materials, eye lenses and artificial hearts, and a human–robot combination might be closer than you think!

Your entire body is made from biomaterials. Bones, hair and fingernails are all materials with very special properties. A materials scientists who studies biomaterials will examine the special properties of these naturally occurring biomaterials and try to produce similar materials. Spray-on skin, heart replacement parts, artificial limbs (called prosthetic devices) and teeth are all examples of biomaterials. Biomaterials must be similar to naturally occurring body parts so that the human body does not reject them when they are implanted.

Nanomaterials

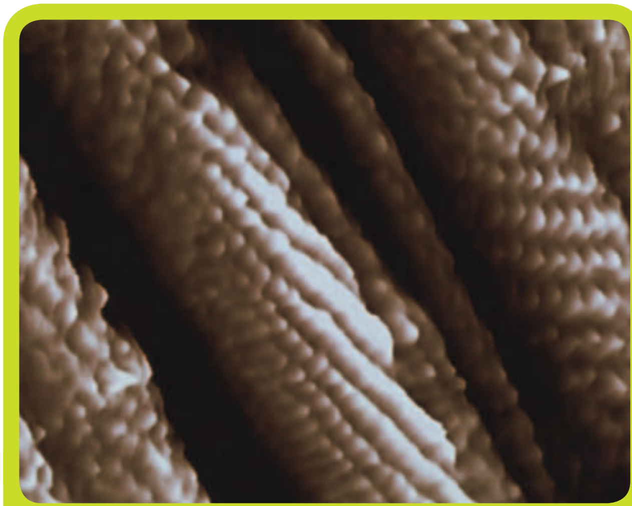

Fig 5.1.15 Carbon nanotubes are built upwards from the smallest possible particles, called 'atoms'. They are very strong and may replace metals as a building materials.

Nanotechnology is a new field in science in which scientists build materials from very small particles. When other materials are produced, large pieces of particles are mixed together but in nanotechnology, the smallest sized particles (called atoms) are joined together first. This technology makes it possible to build much smaller machines from within inside objects, including human body systems. Nanotechnology is nothing new in the plant and animal world. Plant and animal cells have the ability to put materials together from the smallest particles first when they grow or repair themselves. In the future nanotechnology may be used to repair body systems from inside our bodies.

Carbon nanotubes are a new and exciting material produced from single atoms of carbon and formed into very precise structures. They may one day replace metals as a building materials, as they are much stronger and lighter and require less energy to work with.

Homework book 5.1 The properties of materials

5·1 FOCUS [Questions]

Drag and Drop CW Interactive

Use your book

A material world

1 What are the names of the materials that were used to name the periods in history before our current age?

2 What are some of the new types of materials that might be used to name our present age?

What is a materials scientist?

3 What sort of materials do the following materials scientists work with?
   a metallurgist
   b polymer engineer
   c ceramic engineer

4 Why are materials scientists interested in knowing how particles are arranged inside materials?

Properties of materials

5 Why is it important to know the properties of a material before selecting it to make a particular object?

6 List all the properties of materials mentioned in this focus.

7 What responsibility does a materials scientist have to our environment when selecting materials to make objects?

Classifying materials

8 What special properties of metals allowed early humans to produce a greater range of objects during the early Iron Age and Bronze Age than in the Stone Age?

9 Name five objects in your home in which the main material is metal.

10 Name three objects in your home that are made from ceramic materials.

11 What is the special property of a semiconductor material?

12 What are the names of some common polymers around your home?

13 What is a composite material? Give some examples of composite materials.

14 Name three biomaterials found in your body.

15 Name some biomaterials produced by materials scientists.

16 What does 'nano' mean?

17 When an object is manufactured, large pieces of materials are generally used. How is this method different from the method by which nanomaterials will be produced?

Use your head

18 Look at the photographs of the two car interiors in Figure 5.1.16. One was produced in the 1950s while the other is a modern vehicle.
   a Describe how the materials used to produce the dashboard have changed over the years.

The materials used to produce cars have changed considerably over the years. *Fig 5.1.16*

b Why do you think these changes in materials have occurred?

19 The photograph in Figure 5.1.17 shows a bike. To answer the two parts to this question you might like to set up your answer in a table.

a Describe the main materials used to construct the bike.

b Why were these materials chosen to construct the bike?

Fig 5.1.17 A bike

20 Reinforced concrete is produced by pouring wet cement over a framework of steel mesh.

a What property of the cement is improved by this process?

b Explain why you think this occurs.

21 You have been asked to design some packaging to transport a crystal vase from the factory to the shops. The packaging is to be made from a plastic material.

a Describe how you could improve this material to make it a more successful packaging material.

b What should you take into consideration before choosing the plastic you are going to use?

22 You are working in a biomaterials laboratory and have been asked to design artificial teeth. Your first task is to select the best material.

a Make a list of the special properties that you require.

b What are some materials that you could use, based on these properties?

Investigating questions

23 Explain how you would test the electrical conductivity of a material using the following materials—a dry cell, three electric leads and a bulb. Draw a diagram showing how you would set this up. Ask your teacher if you can test the electrical conductivity of a range of materials in your classroom.

24 Research the Mohs scale, which is used to measure hardness. Describe how you would use this scale to measure the hardness of a steel nail.

25 Carbon fibre is a very common composite material for making a range of sporting objects, from squash racquets to bike frames. Use your library or the Internet to research carbon fibre and explain the special properties of this material that make it suitable for these uses.

26 Research more about nanotechnology. Explain why it is predicted that objects made using nanotechnology would be much more precise than objects made from normal processes.

5·1 FOCUS [Practical activities]

Prac 1 Focus 5.1

Testing materials found in a motor car

Purpose

To explore the properties of some common materials found in a motor vehicle.

Requirements

Material samples—rubber, plastics (different types), metals (different types such as copper, iron and aluminium), glass, leather or vinyl, cotton material, water, air (where possible these samples should be cut into very small squares of about the same size), battery (or powerpack), electrical leads, bulb and holder, iron nail, tongs, Bunsen burner (or spirit burner).

Hazard warning: Toxic fumes can be released when objects are burning. Only attempt this activity near an open window and do not inhale any of the fumes produced. A fume hood can be used.

Procedure

1 *Make a copy of the results table shown below.* If you do not have a particular material then do not include it in the table. If you have some different materials then include these in your table.

2 Select one material to test at a time.

3 Test the conductivity of the material using the circuit shown in the diagram. *If the material does conduct, place a tick in the results column of your table.*

4 Test the hardness of the material by trying to mark it with your fingernail. *If it can be marked with your fingernail then record the hardness as soft.* If it cannot be marked with your fingernail then try to scratch it with the iron nail. *If it easy to scratch with the nail then record the hardness as medium. If it is hard to scratch with the nail then record the hardness as hard.*

5 Test the flammability by holding a small piece of material into a Bunsen or spirit burner flame. Give the material a reasonable time to catch a light then pull it out of the flame. *If the material burns easily then record this as flammable. If the material does not burn at all then record it as non-flammable.*

6 Test the state of the material by simple observation. *Record solid, liquid or gas.*

7 Test the tensile strength by trying to stretch the material. *If it does not give at all then record the tensile strength as high. If there is any give at all then record tensile strength as low.*

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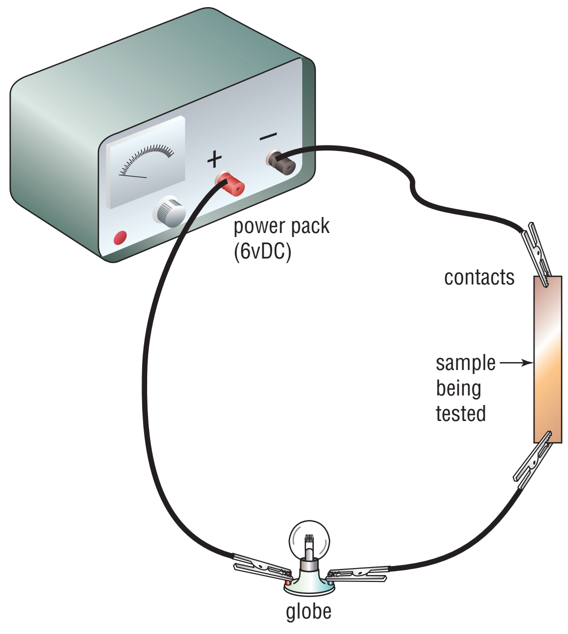


Fig 5.1.18 Use this circuit to test the conductivity of the material you are testing.

Material	Property						
	Conductivity	Hardness	Flammability	State	Tensile strength	Light transmission	Porosity
Plastic							
Vinyl							
Metal							
Glass							
Rubber							
Air							

8 Test the light transmission by holding the material up to the classroom lights and then try to see through it. *If the light is completely blocked then record this as opaque. If you can clearly see through the material then record this as 'transparent'. If some light is let through the material then record this as 'translucent'.*

9 Test the porosity of the material by placing a drop of water on the material. *If it soaks into the material then record this as 'porous'. If the drop sits there then record it as 'non-porous'.*

10 Repeat steps 3 to 9 above for each of the other materials.

Questions

1 For each of the materials you tested, make a list of the objects in a car that are made from this material. What properties of this material make it suitable for this object? You might like to record the answers to this question in a table.

2 Explain why it is important for car manufacturers to know about the flammability of materials.

Prac 2
Focus 5.1

DYO

Making concrete and checking out the hard facts!

Purpose

To produce different types of concrete beams and explore their strengths.

Requirements

Newspaper to work on, cement, clean sand, teaspoon for mixing, fine gravel or stone, small length of wire, water, measuring cylinder, slotted masses, string, plasticine to make a mould.

Procedure

1 Make three moulds for your concrete beams. The moulds should be rectangular and long enough so that the strength of the beams can be tested when you put slotted masses onto them. All your concrete beams should be made to this same size.

2 Make a concrete mix only by mixing cement and sand in a ratio of 2:3 (ie 2 teaspoons of cement to 3 teaspoons of sand). Add a measured amount of water in small amounts at a time until you have a thick paste. *Record how much water you add.*

3 Make your concrete beam by putting cement into one of the moulds. Smooth off your concrete well.

4 Make another concrete beam that contains small pieces of rock or gravel. In concrete this is called aggregate. Use the same ratio of cement to sand and the same volume of water as you did before.

5 Make another concrete beam in the same way, but place a piece of wire at the bottom of the mould, pour in some cement, then place another piece of wire in the middle of the mould.

6 Leave all the mixtures to set for a day before removing them very carefully from their moulds.

7 Now consider a fair test to measure the strength of the concrete beams. Predict which beam you think will be the strongest and record your ideas. *Write down a plan on how to measure the strength.*

8 Show your plan to your teacher and when they give you permission, try your experiment.

9 *Write down your observations and measurements.*

Questions

1 Which of the beams was the strongest? Why do you think this was?

2 Why was it important to use the same ratio of concrete to sand and the same volume of water in each of your beams?

3 What would be some other variables about cement that you could test?

FOCUS 5•2 States of matter

Context

Rain falling on you makes you wet and uncomfortable but it does not hurt or damage solid objects. However, hail storms can cause damage to homes, crops and cars. How can this be when both hail and rain are made from exactly the same substance—water? Water also comes in a gas form or vapour. You can see water vapour changing into small droplets of water when you breathe outside on a cold morning.

Hail, rain and water vapour—solid, liquid and gas—are three different forms of the same substance. All three forms of water must contain the same type of particles but the particles must be arranged very differently. How can these different arrangements be explained? In this focus you will explore the building blocks of matter, atoms and how they are arranged in solids, liquids and gases. You will also explore how scientific models enable you to understand and explain observations in science.

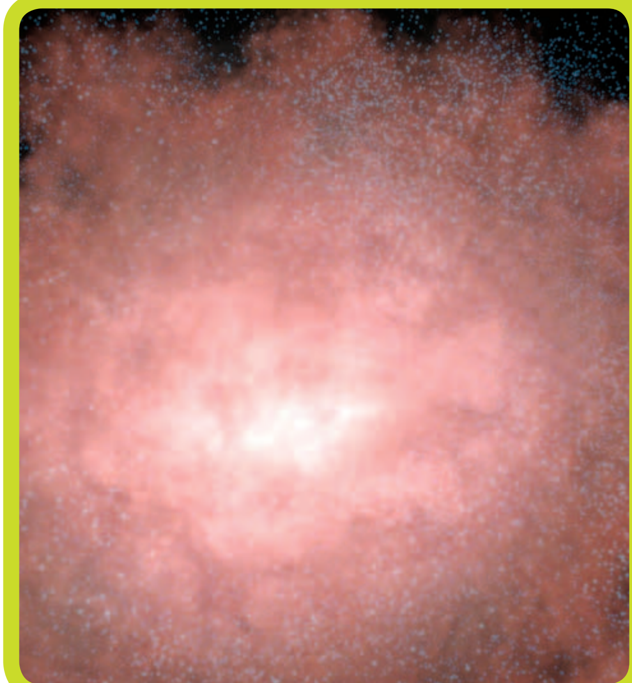
Atoms—things that matter!

In the previous focus you saw that there are thousands of different sorts of materials, all with their own special characteristics that make them suitable for particular uses. While they are all different they all have one thing in common: they are all made of **matter**.

Matter

Matter makes up our Universe. Scientists believe a large explosion, called the 'Big Bang', started our Universe and created matter.

Fig 5.2.1



Most things around us are matter. Matter is simply defined as anything that takes up space and has mass. Objects and materials are matter. Things that are not matter include time, heat and gravity but even these things depend on matter.

A space that does not contain any matter at all is called a **vacuum**. Outer space is very close to a perfect vacuum.

Atoms

Ancient Greek scientists suggested that matter was made up of very small particles called atoms. **Atoms** are the smallest possible piece of matter. They are so small that it is impossible to see them using ordinary microscopes. It has only been in the last 20 years or so that scientists have developed a very special microscope that allows us to view individual atoms.

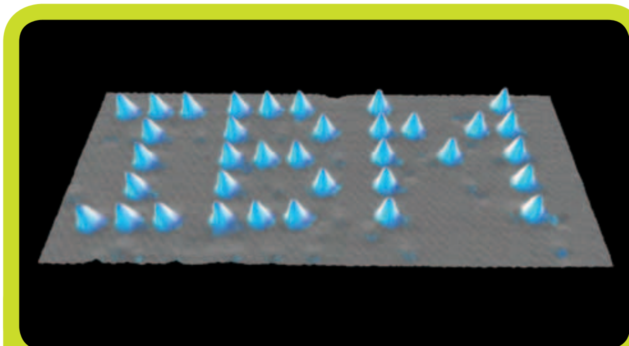


Fig 5.2.2 This famous photograph shows some of our first views of individual atoms. Scientists had arranged these atoms to spell IBM. Computer software is required to help produce the image.

Fig 5.2.3 The periodic table lists all the known types of atoms in a pattern depending on the properties of the different atoms.

	I	II	Transition metals										III	IV	V	VI	VII	VIII
1	H 1																	He 2
2	Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
3	Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
4	K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
5	Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
6	Cs 55	Ba 56	La* 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
7	Fr 87	Ra 88	Ac** 89	Rf 104	Ha 105	Sg 106	Ns 107	Hs 108	Mt 109	Ds 110	Rg 111							

*Lanthanide series	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
**Actinide series	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	L 103

Scientists have identified and named more than 111 different types of atoms. Atoms are the basic building blocks of all matter and are capable of joining with other atoms, both the same and different. This explains why there are so many different types of materials.

Scientists have organised information about atoms into a table called the periodic table. You will learn more about it soon.

While the types of atoms in a material are important, the way in which these atoms are arranged also has a lot to do with the properties of materials.

The particle theory model

For scientists to understand how the atoms and other particles are arranged in materials they have developed a model known as the **particle model**. This model does not rely on us actually having to see the atoms and other particles. Scientists have built up this model by performing investigations and making observations of the behaviour of different types of matter. You will be making similar observations in your practical work about the types of matter.

In the particle model, matter is described as being made of very small particles that are constantly moving. These particles are arranged differently in solids, liquids and gases. The following three sections present some of the evidence for the particle model.

Brownian Motion

Robert Brown first investigated pollen grains in water in 1827. Pollen was selected because it is very light. He observed that the pollen grains were constantly moving around in a random manner. The particle theory model explains these observations in terms of the particles that make up water bumping into the pollen grain. This type of movement was named **Brownian Motion**.

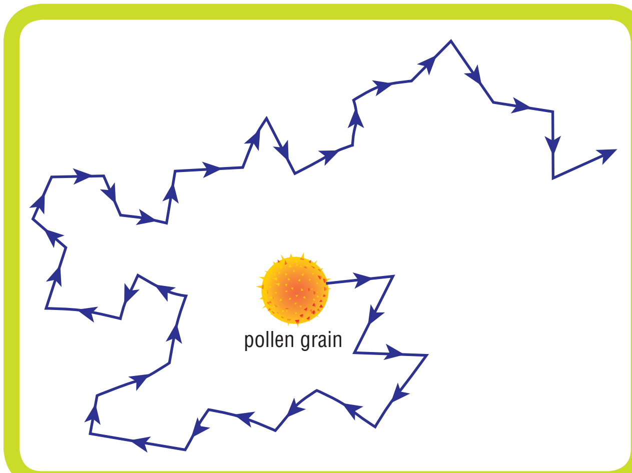


Fig 5.2.4 We cannot see the individual atoms which make up water particles. We can see the effect of these particles on the pollen grain which shows a series of random movements due to being hit by the water particles.

Homework book 5.2 The story of Robert Brown

Smells

Your nose is very sensitive to particles. Your ability to smell can be explained in terms of small particles moving into your nose and dissolving into a layer of mucous in your nasal membrane. The smell of a cooking roast in your house and the smell of someone's perfume from a distance are examples of particles moving through the air into your nose. The movement of these small particles through a substance such as air is known as **diffusion**.

Your teacher may also demonstrate the movement of substances such as ammonia. If a small amount of this liquid is placed at the front of a still and sealed room, the particles (which have a very noticeable smell) will soon spread (diffuse) throughout the whole room, providing further evidence that matter is made of small particles.

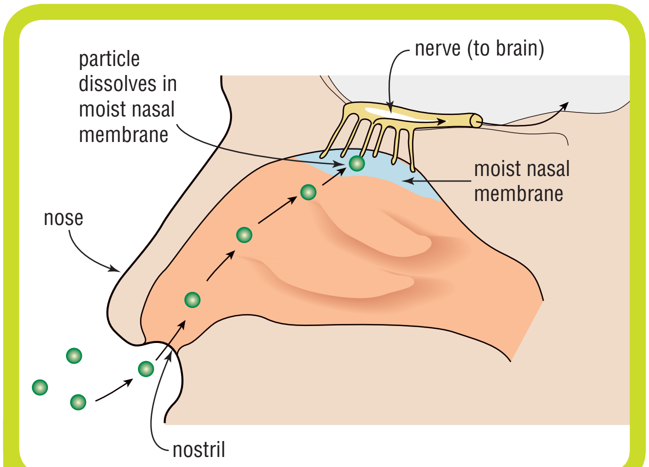
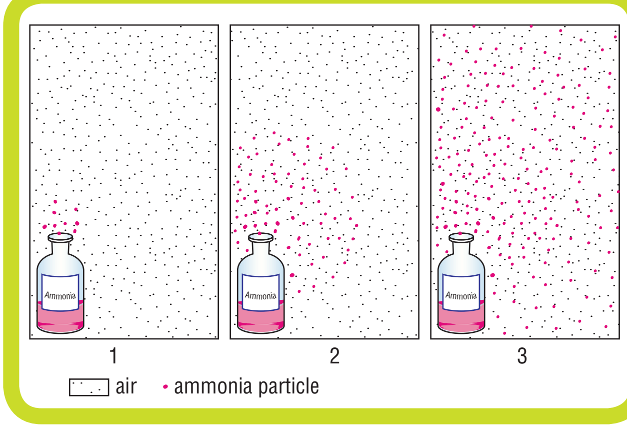


Fig 5.2.5 Only a very small number of particles are required to activate the sense of smell.

Fig 5.2.6 The ammonia particles eventually diffuse through the whole room.



Dissolving

In a similar way to diffusion, substances such as sugar can dissolve when placed in water. Dissolving can be explained in terms of small particles moving through the water particles. You would have noticed that this movement can be sped up by stirring, which forces the particles to move (dissolve) in the water faster.

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Fig 5.2.7 The sugar particles eventually dissolve by moving through the water particles.

States of matter

With an understanding of the particle model you can now explore how these particles are arranged in solids, liquids and gases. Solids, liquids and gases are called the **states** or phases of matter.

Interactive CW Animation

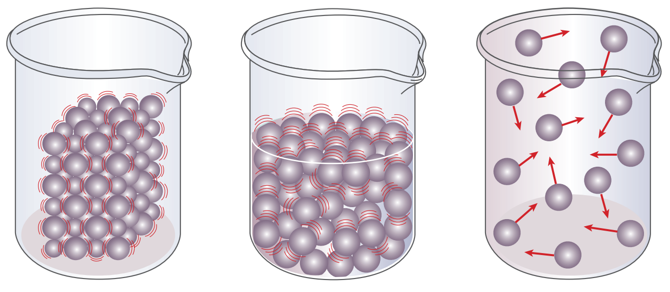

Fig 5.2.8 In solids, particles can vibrate around a fixed position but the particles cannot move within the materials—unlike the particles in liquids and gases.

Solids

If you think of something solid, like a piece of brick or iron, you can imagine the particles as being arranged very tightly. There is very little space between the particles in solids and, as a result, solids cannot be squeezed into a smaller space. Solids are said to be **incompressible**. The particles in solids are strongly joined or **bonded**, and can only move or vibrate around a fixed point. When heated, the particles can vibrate more strongly and, as a result, the solid expands.

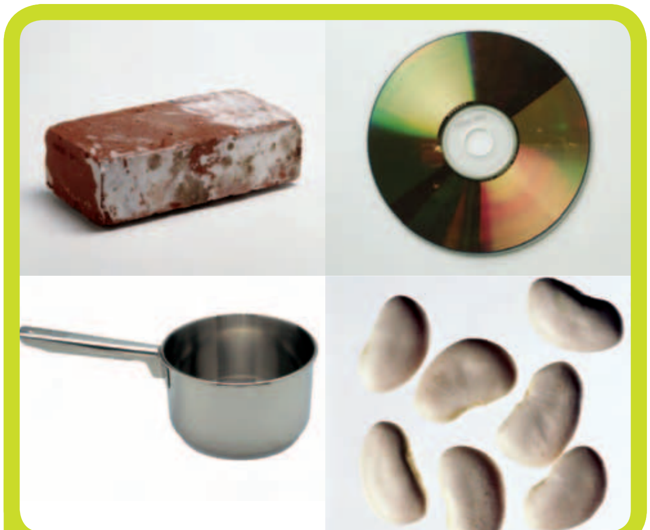

Fig 5.2.9 All these substances are solids.

Liquids

The particles in liquids are still very close together but are not as strongly bonded together as in solids. As a result, the particles in liquids can move over and around each other. This movement of the particles allows liquids to **flow** and consequently liquids will move to take up the shape of any container they are placed in. As with solids, there is very little space between the particles and so liquids are also incompressible. When heated, the particles in liquids move faster.

Science Snippet

Plasma—the fourth state of matter

Not to be confused with 'blood plasma', plasma is said to be the fourth state of matter. When matter is heated to very high temperatures it can lose particles called electrons from the atoms. The resulting material is called plasma and has properties that are different from solids, liquids and gases. Examples of plasma, which occurs commonly in nature, are the stars that make up our Universe, flames and lightning. Scientists are working on a special type of plasma that could be used to supply energy.

Fig 5.2.10 Why are liquids able to take up the shape of their container? What does this tell you about the particles in liquids?

Gases

The particles in gases are much further apart and there is very little attraction at all between the particles. They are able to move around, hitting the walls of their container. The movement of the particles means that gases will always fill up the whole container. Gases are able to be **compressed** because of the space between the particles.

Interactive CW Animation

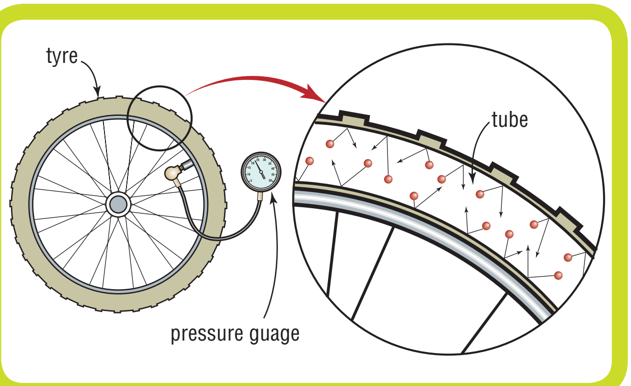

Fig 5.2.11 It is the movement of gas particles striking the wall of their container that gives gases their pressure. This pressure can be measured when you pump up your bike tyre.

Fig 5.2.12 In this experiment you can see the movement of the coloured gas. It moves through the colourless gas air in the upper container after a glass plate separating the two containers is removed. What does this tell you about the particles of a gas?

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5·2 FOCUS [Questions]

Use your book

Matter

1 How would you define matter?

2 What are some examples of things that are *not* matter?

Atoms

3 Who first suggested that atoms existed?

4 What evidence do we have that atoms are very small?

5 What is the periodic table?

The particle theory model

6 How does Brownian Motion show us that particles exist?

7 Why did Robert Brown use pollen grains in his experiment?

8 Some strong perfume is placed at the front of your classroom. Eventually you can smell this perfume at the back of the classroom. What is this movement called?

9 Describe what happens when particles dissolve.

States of matter

10 Describe what is meant by a 'state of matter'.

11 Draw up a table that describes the properties of solids, liquids and gases.

Use your head

12 An image of atoms can be observed only with the aid of a computer-assisted electron microscope. What does this tell you the size of atoms? You might like to use the Internet to find some more examples of how atoms have been viewed.

13 The 'particle theory of matter' is sometimes called the 'kinetic' particle theory. The word 'kinetic' means movement. Explain how the movement of particles is different in solids, liquids and gases.

14 Draw your own diagrams to show how the particles are arranged in solids, liquids and gases. Under each diagram list the major properties of each of the states.

15 In motor vehicles, hydraulic brake systems are often used. In these brake systems pressure is transferred from the brake pedal to the brakes through a liquid brake fluid. Explain what properties of a liquid make it suitable for this purpose.

16 Two students are discussing whether or not solids can be compressed. One student argues that they can be because the kitchen sponge can be squeezed into a smaller space. Does this prove that solids can be compressed? Explain your reasoning.

Investigating questions

17 Research 'plasma' which is described as the 'fourth state of matter'. As part of your research include answers to the following questions:

a How much of the Universe is considered to be plasma?

b What are the special properties of plasma that make it different from the other states of matter?

c What are some examples of plasma in space and on Earth?

18 What is the difference between a fluid and a liquid? Give examples of each.

FOCUS 5.2

[Practical activities]

Prac 1 Focus 5.2

Particle proof

Purpose

To investigate some evidence for the particle theory of matter.

Requirements

Petri dish, water, copper sulfate crystals, spatula, sodium hydrogen carbonate (sodium bicarbonate).

Procedure

1. Fill a petri dish with water and leave it to sit on your bench for a few minutes to make sure that the water is still.
2. Carefully add a copper sulfate crystal to one end of the petri dish, using a spatula.
3. Add a crystal of sodium hydrogen carbonate to the other end of the dish.
4. Leave the crystals to sit quietly. *Record your observations.*

Questions

1. Draw a series of diagrams of your observations over time.
2. Explain your observations using terms such as ‘particles’, ‘dissolving’, ‘movement’, ‘diffusion’.

Prac 2 Focus 5.2

Putting the squeeze on liquids and gases

Purpose

To investigate the compressibility of liquids and gases and relate this to the particle theory of matter.

Requirements

Small syringe, rubber stopper, samples of a variety of liquids.

Procedure

1. Fill the syringe with air.
2. Hold your finger over the nozzle on the syringe, or use the rubber stopper. Predict what is going to happen when you try to squeeze the air. *Record your observation.*
3. Fill the syringe with water. Use the stopper as in Figure 5.2.14. Predict what will happen when you try to squeeze the water. *Record your observation.*
4. Repeat step 3 using a range of different liquids.

Questions

1. Were your predictions correct?
2. Use the ‘particle theory of matter’ to explain your predictions and observations.

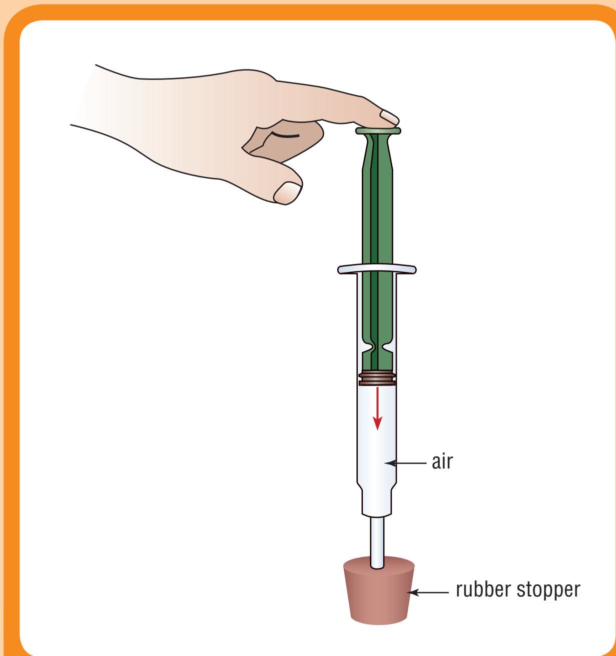


Fig 5.2.13 Use the rubber stopper to block the end of the syringe when testing your liquids.

FOCUS 5.3 Changes of state

Context

An ice-cream melting down your arm, ice-blocks melting into a cool drink, rainfall and fog are all examples of matter changing state or phase. In the last chapter you explored the different states of matter—solids, liquids and gases. Changes of state occur all around us and are an essential part of our environment and everyday life. In this chapter you will explore these changes of state as well as trying to use the particle model to explain these important processes.

Changes of state and the particle theory

Changes of state occur all around us on a daily basis. Solids to liquids, liquids to gases and, in some cases, solids to gases. The reverse can also happen—gases to liquids, liquids to solids and, in some cases, gases to solids. What happens to the particles when these changes occur? How is heat involved in these processes? As scientists we can use our particle model to try to answer these questions. The next two figures explain how these changes occur.

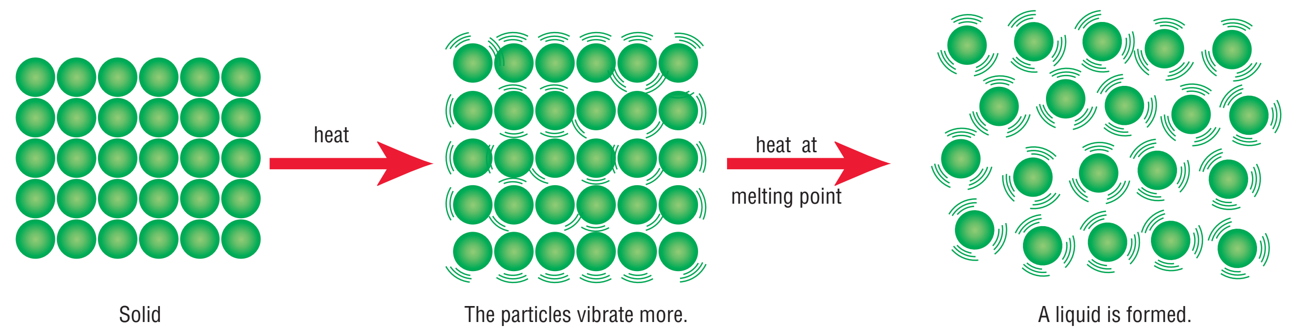
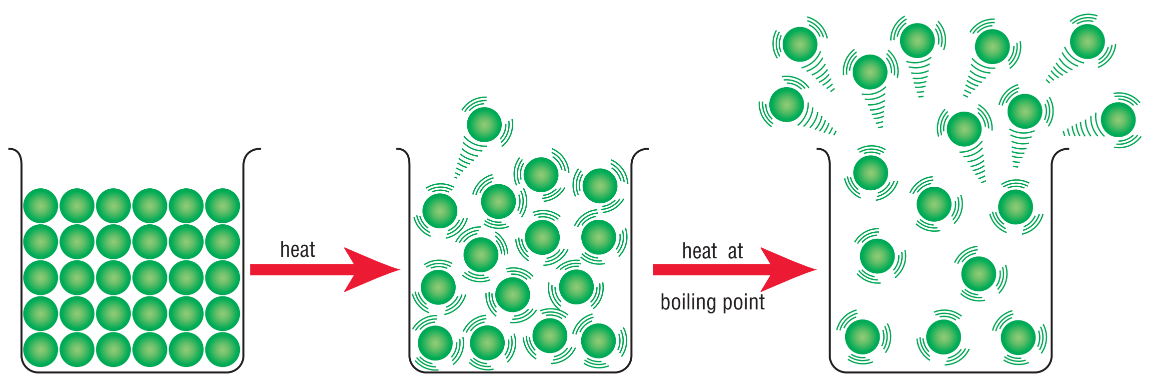


Fig 5.3.1 As the particles in the solid gain heat energy they vibrate faster. It is then possible for them to break out of their fixed positions and move past each other as the substance becomes a liquid. This is called melting. As energy is supplied or absorbed by the liquid, particles gain enough energy to leave the liquid as a gas vapour. This is called evaporation.



As the liquid particles gain heat energy, more and more particles have enough energy to evaporate at the surface. At the boiling point, all the particles have enough energy to evaporate and boiling occurs. *Fig 5.3.2*

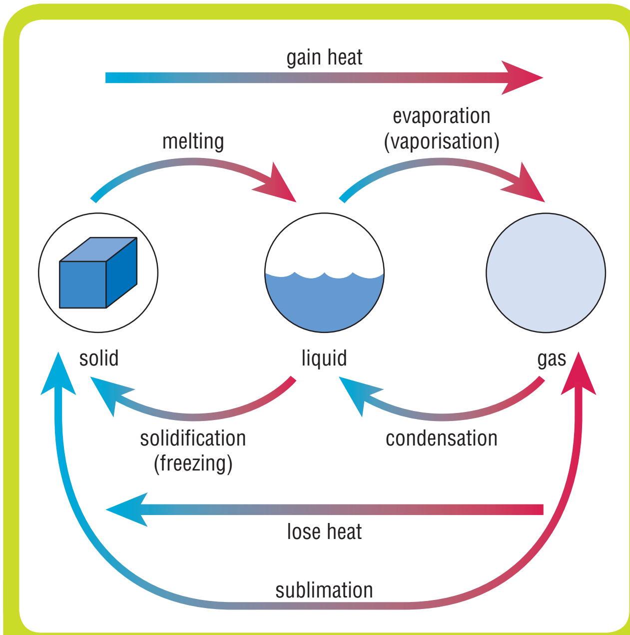


Fig 5.3.3 A summary of changes of state and heat

Changes of state and temperature

Another interesting aspect of phase changes is the temperature of the material as the change of state is occurring. Figure 5.3.4 shows a graph of the temperature against the time as pure water is heated with a Bunsen burner.

The temperature of the water increases steadily as heat energy is supplied to the water from the Bunsen burner. As the water starts to boil at around 100°C, the temperature of the water and gas together stays the same. At this point, all the heat energy being supplied is being used to change the liquid into a gas. Because the heat energy is not causing an increase in temperature it is called **latent** or **hidden heat**. The temperature at which this occurs is called the boiling point.

If you remove heat energy from water, by putting it into the freezer, you will also notice that the temperature becomes constant as the liquid water changes into ice. After the water has turned to ice, the ice itself then gets cooler.

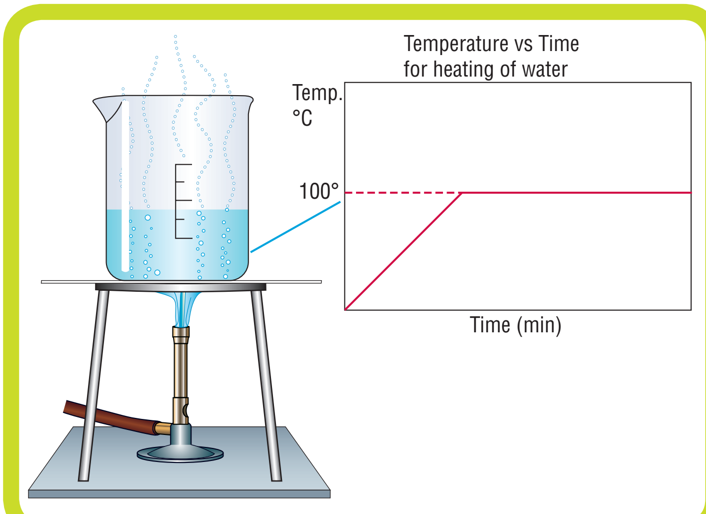


Fig 5.3.4 Can you identify on the graph where the water begins to boil?

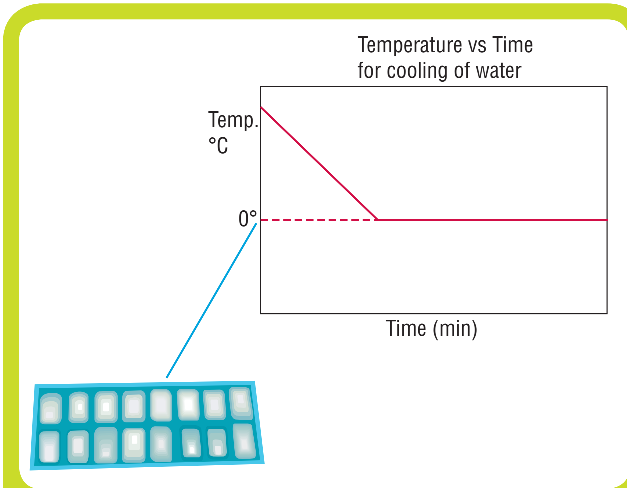


Fig 5.3.5 Can you identify on the graph where freezing occurs?

Solid to liquid

The process of changing a solid to a liquid is known as **melting** and occurs as the particles gain enough energy to loosen the bonds between the particles. The temperature at which a solid changes to a liquid is known as the **melting point**. Melting points vary between different materials as the particles have different amounts of attraction between them.

As solids melt, they absorb heat energy from their surroundings. This can produce a cooling effect, which is why ice-blocks are used in a cool drink or water.

Science Snippet

Ice man

Before the ice-maker was invented by James Harrison (a publisher from Geelong, Victoria) ice had to be imported into Australia. It was often carried in the straw-lined holds of large ships and came from countries as far away as the USA. Harrison's ice-maker machine used a liquid known as ether, which produced a cooling effect as it changed from a liquid to a gas.

Liquid to solid

The process of changing a liquid to a solid is known as **freezing** or **solidification**, and occurs when particles lose heat energy. As they lose heat energy their movement decreases to the point that the attraction between the particles is enough to lock them into fixed positions. Materials generally have a fixed temperature at which this occurs, known as the freezing point for that material. For water this temperature is 0°C. For freezing to occur heat energy must be removed, so the material must be placed somewhere that is cooler than the freezing point. This is why ice-blocks are produced in the freezer compartment of a refrigerator, which is kept at a temperature well below 0°C.

Science Snippet

Cryogenics

Cryogenics is a branch of science that looks at the effect of extreme cold on materials. When applied to organisms it is called cryonics. Some humans who were very ill with a disease have been frozen in the hope that they can be 'thawed out' in a few years when a cure is found. One of the problems with freezing living things is that, because living things contain so much water, ice crystals often form in the cells. These ice crystals can damage the cells as they form.

Liquid to gas

When heat energy is supplied to a liquid, the rate at which the particles move increases and eventually the particles have enough energy to break the bonds between them. At the surface of a liquid this process occurs at all temperatures as the particles absorb heat energy from their surroundings. This process is called **evaporation** or **vaporisation**.

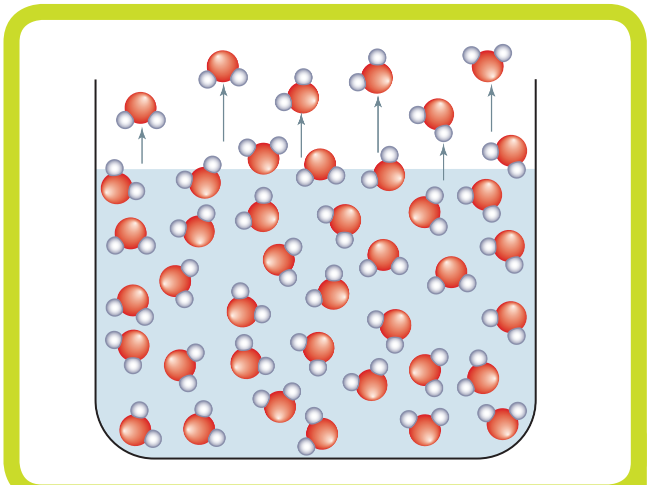


Fig 5.3.6 Evaporation occurs from the surface of the liquid as the particles gain enough heat energy from their surroundings to leave the liquid.

As a liquid evaporates, heat energy is absorbed from the surroundings, producing a cooling effect. This is why sweating is an efficient way of cooling your body when it becomes hot. As the sweat evaporates from your body it absorbs heat energy from the skin, resulting in a cooling effect. This effect is increased if the air movement across your skin is increased. Evaporation also explains why liquid levels fall if a cover is not placed on a liquid.

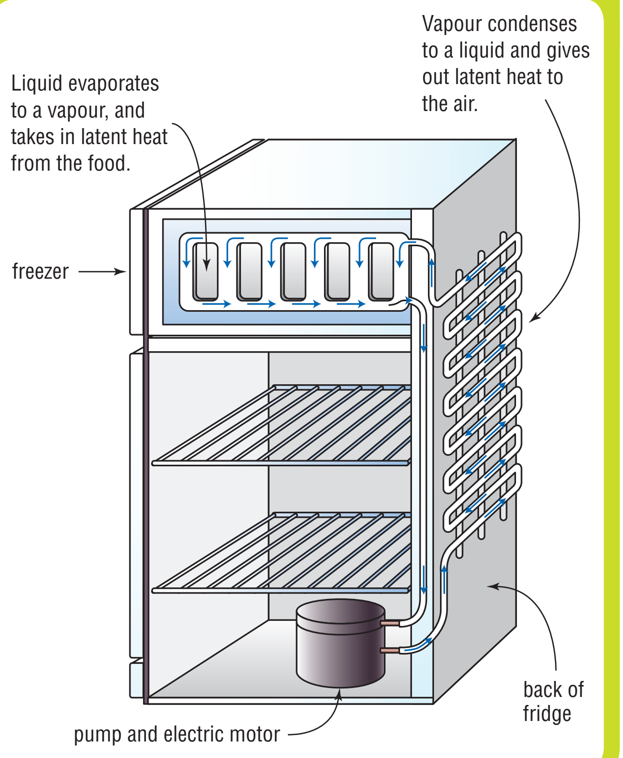
If enough heat energy is supplied to liquid, a temperature is reached at which all the liquid changes to a gas. This gas or vapour is released from within the liquid as bubbles. The temperature at which this occurs is known as the boiling point.

Fig 5.3.7 When a liquid boils, bubbles of vapour form within the liquid and are strong enough to break the surface and escape as vapour.

The liquid-to-gas change of state is very important for the operation of the refrigerator. The box that contains the fridge is **insulated** with a foam-like material to cut down heat movement into the refrigerator. A number of pipes at the back and sides of the fridge are connected into a loop. The pipes contain a gas that can be easily turned into a liquid by squeezing it in a **compressor**. As the liquid flows through the pipes it absorbs heat from the food and the inside of the refrigerator and changes into a gas. The gas is pumped out to the back of the refrigerator and condenses back to a liquid, releasing its heat. The gas is then compressed into a liquid and the cycle continues again.

Refrigerators rely on changes of state to produce a cooling effect inside the fridge.

Fig 5.3.8



Gas to liquid

As gas particles lose heat energy the particles come close enough to each other to form bonds between them and become liquids. This process is called **condensation**. Common examples of condensation include the water droplets that form on the bathroom mirror during a shower or the fog that comes from your mouth as you breathe out on a cold morning.

Fig 5.3.9 Condensation occurs on the outside of the glass as water vapour changes into a liquid.

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Solid to gas

In some cases solids will change directly from a solid to a gas without going through a liquid state. This process is called sublimation and occurs under normal conditions for only a few materials. The 'fog' that is often produced a special-effect in stage productions and movies is actually dry ice subliming from a solid to a gas. The reverse process of a gas changing directly into a solid is also called **sublimation**.

The fog effect often used on stages is often produced by the sublimation of solid carbon dioxide (dry ice) directly into carbon dioxide vapour. It is called dry ice because as the carbon dioxide sublimes it does not leave any liquid.

Interactive CW Animation

Interactive CW Crossword

Homework book 5.3 Changes of state

FOCUS 5·3 [Questions]

Use your book

Change of state and the particle theory

1 Identify whether heat is added or taken away for the following phase changes to occur:

a solid to liquid
b liquid to gas
c gas to liquid
d liquid to solid.

2 The graph in Figure 5.3.10 shows the temperature against time as a solid becomes a liquid and then a gas. Use the graph to answer the following two questions.

a What is the melting point for the wax?
b What is the name given to describe the heat energy at this melting point?

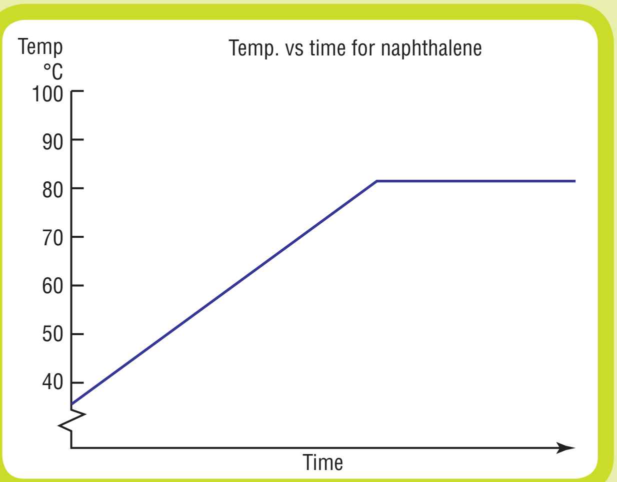
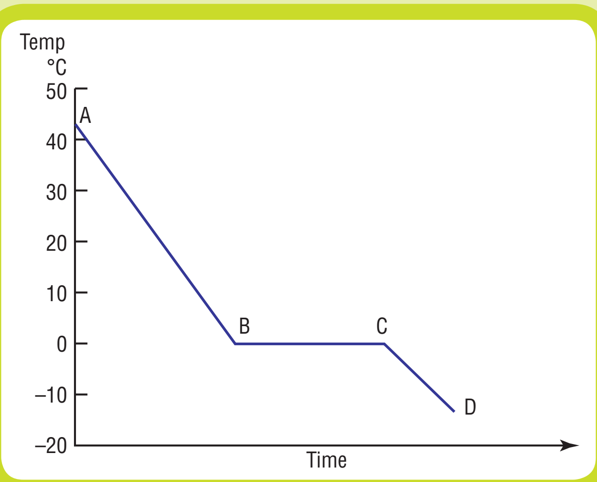


Fig 5.3.10 Graph showing the heating of naphthalene (moth balls) as it changes state to a liquid



Cooling curve for water Fig 5.3.11

Solid to liquid

3 What is the term given to the change of state from a solid to a liquid?

4 Describe what happens to the particles as they change state from a solid to a liquid.

Liquid to solid

5 Give two terms for the change of state from a liquid to a solid.

6 Describe what happens to the particles as they change state from a liquid to a solid.

Liquid to gas

7 Define the terms ‘boiling’ and ‘evaporation’.

Gas to liquid

8 You are drinking a glass of cold water.

- **a** What is the name given to the droplets of water that occur on the outside of the glass?
- **b** Describe how the water came to be there.

Solid to gas

9 What is the term given to the change of state from a solid to a gas and a gas to a solid?

10 What is the unusual feature of solid-to-gas and gas-to-solid phase changes?

Use your head

11 Explain where the heat goes when you continue to heat boiling water but the temperature remains constant.

12 A group of students use a temperature probe to measure the temperature of water. They place the water in a freezer and allow it to cool down. They then measure the temperature of the ice. Figure 5.3.11 shows the graph that is produced.

What is happening to the water/ice at the following points on the graph:

- **a** section A–B?
- **b** section B–C?
- **c** section C–D?

13 Life was very harsh on the goldfields in Western Australia during the 1890s. It was very hot, water was hard to obtain and there were no electrical appliances. To keep food cool, people often used the Coolgardie Safe. Foods such as butter and milk could be kept for a couple of days inside the safe. Figure 5.3.12 shows a simplified Coolgardie Safe.

- **a** Explain how the damp hessian keeps the inside of the safe cool.
- **b** Safes were often located on external verandas, where there was a breeze. Explain why.
- **c** Why did the water tank have to be topped up regularly?

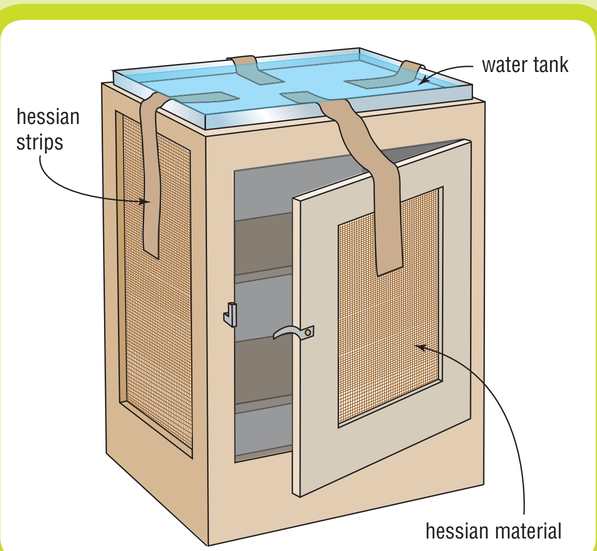


Fig 5.3.12 A Coolgardie Safe

Investigating questions

14 Find out the names of any materials, other than dry ice, that undergo sublimation.

15 There are two main types of air conditioners available for cooling your home: refrigerative and evaporative. Design and construct a table that compares the two different types. Your table should contain the following headings:

- how they work
- changes of state involved
- advantages of each type of air conditioner
- disadvantages of each type of air conditioner.

16 You can change the temperature at which water freezes and boils in a number of ways. One way is to add a material such as salt to water. Another way is to apply pressure to water. Investigate these two different methods of changing the freezing point and boiling point by finding answers to these questions:

a In some European countries and US states, salt is spread on the road during winter. Why?

b How does a 'pressure cooker' help cook food faster?

FOCUS 5.3

[Practical activity]

Prac 2 Focus 5.3

DYO

Test a hypothesis on change of state

Purpose

Below are several hypotheses you could test: Select one of these (or another related idea) to test by experiment. Check with your teacher.

- Hot water cools at a faster rate than cool water.
- Hot water freezes more quickly than cold water.
- Different amounts of water freeze at the same temperature.
- The more salt that is added to water, the cooler the water can be made with ice-cubes.
- Water in which sugar is dissolved will dissolve more slowly than distilled water.
- A breeze will make water evaporate faster.
- The rate at which water evaporates from a container depends on the surface area of the water exposed to the air.

Requirements

These will vary depending on the investigation you have chosen. Keep your requirements simple. You may be required to bring in some materials from home if they are not available in your room.

Procedure

1. *Write out your procedure, clearly indicating the experimental variable.*
2. Discuss in your group what you will have to do to control the other variables that could affect the results.
3. *Draw a diagram that shows how you will conduct your investigation.*
4. Show your teacher and then obtain your equipment after you have permission.
5. Carry out your investigation and record your observations.

Questions

1. What did you learn in this activity?
2. Use a search engine, such as Google, to find any information about the variable you tested. Write a paragraph to summarise what you found from the Internet about this topic.

FOCUS 5•4 Elements, compounds and mixtures

Context

Our world is made up of millions of different materials—from flour to vinegar, paints, plastics and oils—all with different properties and uses. Atoms are the building blocks of all of these different materials. Atoms can join together to form millions of different combinations. When different atoms join together, compounds are formed.

But different materials are not just about atoms joining together. Many of the materials that make up our world involve materials just mixing together without forming permanent connections. These materials are called mixtures.

In this focus you will explore how atoms are arranged in both compounds and mixtures and the special properties of each.

Elements

In Focus 5.2 you learnt about atoms and the **periodic table**, which lists all the known chemical **elements**. Elements such as gold, tin, copper and silver were discovered long ago, while the rest have been discovered relatively recently. Ninety-two of the elements can be found in the Earth's rocks, soil, air and water, while the rest have been made by nuclear scientists.

Chemical elements are said to be **pure substances** because they cannot be broken into simpler substances. If you could look at the atoms in a chemical element you would see that they are all of the same type.

Symbols for chemical elements

The periodic table is universal, which means that the same table is used by science students all over the world. Each element in the table can be represented by a symbol of one or two letters. The letters come from the English, Greek or Latin name for the element. Some of the more common elements and their symbols are shown on page 232. You will note that the first letter of the symbol is always a capital and the second letter of the symbol, if there is one, is lower case. The Latin names for some of the elements are shown in brackets.

Science Snippet

Where do all the chemical elements come from?

Only the first 92 elements occur naturally and can be found in the Earth, air or water of our planet—so where have the rest come from? Nuclear scientists have produced these chemical elements inside nuclear reactors by bombarding existing chemical elements with smaller atoms or pieces of atoms. Many of these new elements do not last very long and often break down by giving off nuclear radiation.

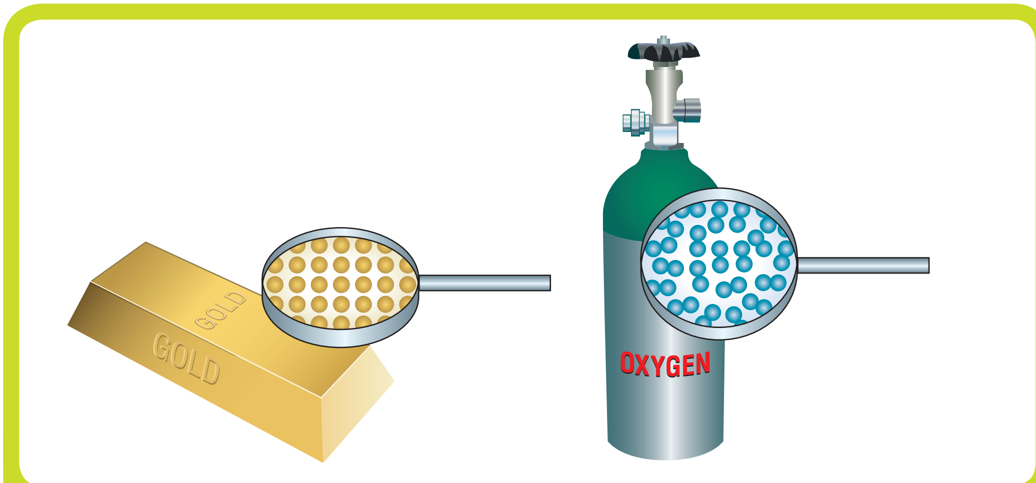


Fig 5.4.1 Gold and oxygen are both chemical elements. All the atoms in a chemical element are the same.

Element	Symbol	Element	Symbol
Aluminium	Al	Mercury (hydrargyrum)	Hg
Calcium	Ca	Nickel	Ni
Carbon	C	Nitrogen	N
Chlorine	Cl	Oxygen	O
Copper (cuprum)	Cu	Silicon	Si
Gold (aurum)	Au	Silver (argentum)	Ag
Hydrogen	H	Sodium (natrium)	Na
Iron (ferrum)	Fe	Sulfur	S
Lead (plumbum)	Pb	Tin (stannous)	Sn
Magnesium	Mg	Tungsten (wolfram)	W
Manganese	Mn	Zinc	Zn

Homework book 5.4 Find the elements

Homework book 5.5 The periodic table

Drag and Drop
Interactive

Compounds, chemical formulas and molecules

How can only 92 naturally occurring chemical elements form millions of different types of materials? One of the major reasons is the ability of elements to join with other chemical elements to form compounds. This joining occurs at the atom level and is often called a chemical reaction. The new compound that is formed has different properties from the original elements.

Compounds are pure substances because the elements that form them join together chemically to form a new material that cannot be separated back into its elements using simple separation methods. You will explore some of these separation methods in a future focus. Compounds contain a fixed ratio of elements. For example, water always contains two atoms of hydrogen to one atom of oxygen. For this reason, water is described by the chemical formula H_2O. Some other common compounds are shown in the table below.

Name of compound	Chemical formula	Contains the elements
Sulfuric acid	H_2SO_4	Hydrogen, sulfur, oxygen
Ammonia gas	NH_3	Nitrogen, hydrogen
Sodium chloride (table salt)	$NaCl$	Sodium, chlorine
Sodium hydrogen carbonate	$NaHCO_3$	Sodium, hydrogen, carbon, oxygen
Acetic acid (vinegar)	CH_3COOH	Carbon, hydrogen, oxygen
Octane (major component of petrol)	C_8H_{18}	Carbon, hydrogen
Ethanol	CH_3CH_2OH	Carbon, hydrogen, oxygen
Salicylic acid (aspirin)	$C_9H_8O_4$	Carbon, hydrogen, oxygen
Natural gas	CH_4	Carbon, hydrogen

Some chemical elements, such as gold, mercury, helium and neon, are found in nature as single atoms while in some elements such as hydrogen, oxygen and nitrogen, more than one atom joins together. When two or more atoms join together (the same or different atoms) a molecule is formed.

Some molecules are elements because the atoms are the same (see Figure 5.4.3).

Molecules can also be compounds if the atoms are different. Figure 5.4.4 shows some molecules from the table above.

From the representation of the molecules, you will notice that the atoms appear to be joined together. These bonds between the atoms in a molecule are called **chemical bonds** and cannot be broken by simple separation methods.

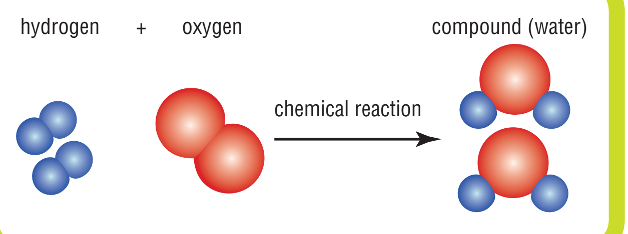


Fig 5.4.2 In this chemical reaction, the elements hydrogen and oxygen are combining to form the compound water.

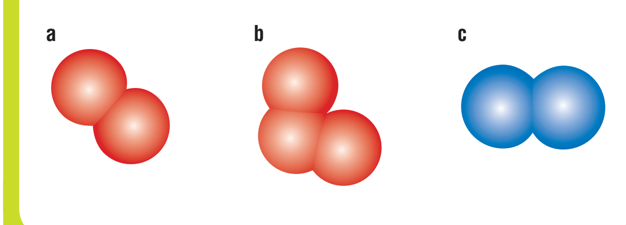


Fig 5.4.3 These molecules are elements, as the atoms within the molecule are all the same—**a** oxygen gas O_2; **b** ozone gas O_3; **c** nitrogen gas N_2.

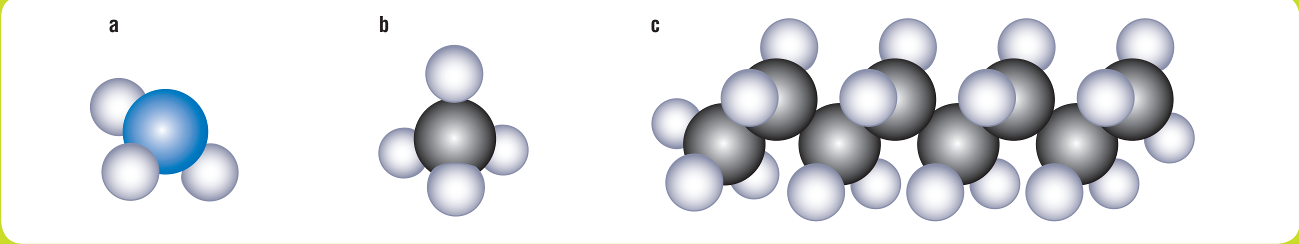


Fig 5.4.4 These molecules are compounds, as the atoms within the molecule are different—**a** A molecule of ammonia consists of one nitrogen and three hydrogen atoms (NH_3); **b** A molecule of methane consists of one carbon and four hydrogen atoms (CH_4); **c** A molecule of octane consists of eight carbon and eighteen hydrogen atoms (C_8H_{18}).

Mixtures

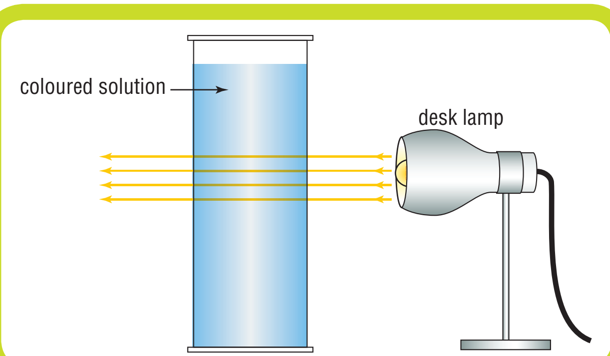
If you stir a teaspoon of table salt (sodium chloride) into a glass of water have you made a new substance? The salt in the water is an example of a mixture. In mixtures, new chemical bonds between the atoms are not formed. You do not get a new substance but instead have a **mixture** of different materials that can be separated using simple methods such as filtration or evaporation. For example, in the case of the salt and water, if you let the mixture sit in the sun, the water evaporates off, leaving the salt. No new substances are produced.

There are three main types of mixtures: solutions, suspensions and colloids.

Solutions

Solutions are a very common type of mixture. The salt dissolved in water is called a salt solution. Other examples of solutions you would come across almost daily include cool drinks and tea. In a solution, the resulting mixture will not settle to the bottom of the container if you leave it, and light will generally pass through it, providing the solution is not too strong.

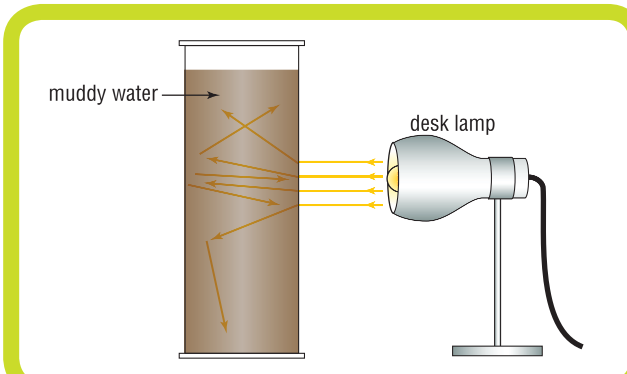
Solutions are always composed of two parts—the material that **dissolves** and the substance that you use to dissolve the material. You will explore solutions in more detail in a focus to follow.



Light will generally travel straight through a solution without being scattered by the particles. Fig 5.4.5

Suspensions

Have you ever noticed, when looking at a dam, that the water is dirty and you cannot see through it? This is often due to the soil and other materials that are in the water. This is an example of a **suspension**. In suspensions, the particles in the liquid are often larger than the liquid particles themselves. You often cannot see through a suspension and light rays will not travel straight through but are scattered by the particles.



Light will not pass through a suspension. Fig 5.4.6

If a suspension is left long enough the particles of materials that are 'suspended' in the liquid will settle to the bottom. The substance that settles out is called the **sediment**.

Prac 1 p. 235
Prac 2 p. 236

Colloids

Colloids are somewhere between solutions and suspensions. The particles in a colloid take a long time to settle out or never settle out fully. Some common examples of colloids include milk and paint. Like a suspension, a colloid will scatter a light ray that is passed through it.

FOCUS 5.4 Questions

Use your book

Elements

1 How many of the chemical elements occur naturally?

2 Elements are said to be 'pure substances'. What does this mean?

Symbols for chemical elements

3 Explain how chemical symbols are represented.

4 Using a copy of the periodic table, write symbols for the following elements—iron, carbon, aluminium, zinc, calcium, magnesium, chlorine, cobalt.

Compounds, chemical formulas and molecules

5 What is a chemical compound? How is it different from a chemical element?

6 How are chemical compounds formed?

7 Give the names of four chemical compounds. What elements do they contain?

8 What is the difference between an atom and a molecule?

9 Give the name and chemical formula for a molecule that is an element.

10 Give the name and chemical formula for a molecule that is a compound.

Mixtures

11 What is the difference between a mixture and a compound?

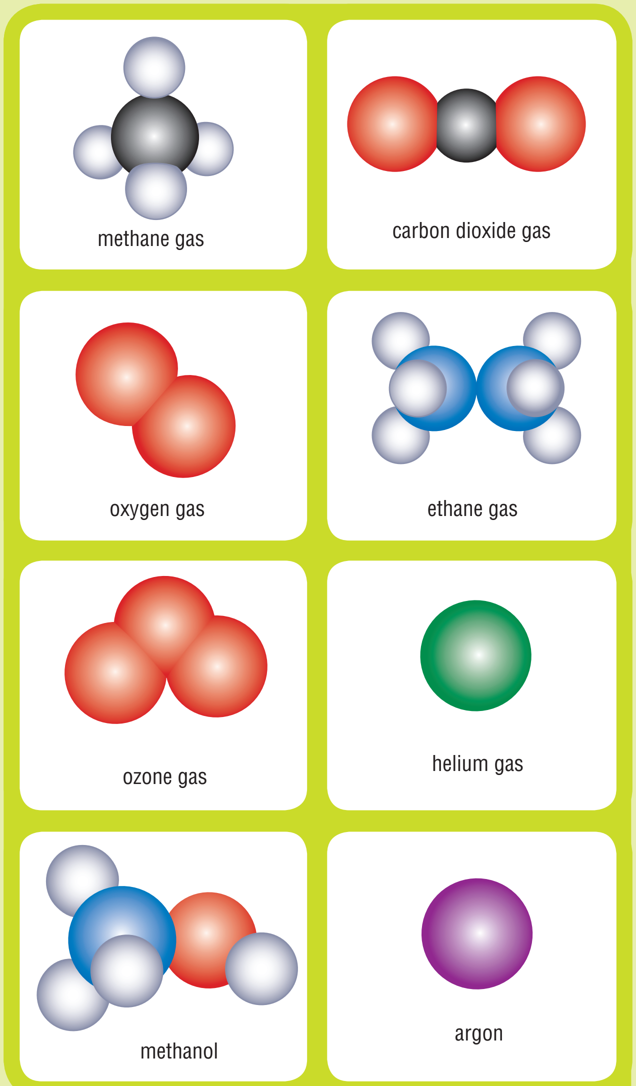
12 What are the three main types of mixture? Give an example of each.

Use your head

13 Below are the formulas and names of some common materials. Copy the table into your notebook and complete the table by identifying whether the materials are elements or compounds.

Name of substance	Chemical formula	Element or compound?
Aluminium	Al	
Carbon monoxide	CO	
Copper	Cu	
Hydrogen sulfide	H_2S	
Mercury	Hg	
Phosphorus	P	
Butane gas	C_4H_{10}	
Hydrochloric acid	HCl	
Manganese	Mn	

14 Figure 5.4.7 shows some common substances that are either elements or compounds.



Representation of atoms and molecules for Question 14 **Fig 5.4.7**

For each of the substances, classify it into one of the following groups:

a atom

b molecule of a compound

c molecule of an element.

15 Benzene is an important chemical used to produce plastics and dyes and is sometimes used as a petrol additive. It can be represented as shown in Figure 5.4.8. The blue spheres represent carbon and the light-grey spheres represent hydrogen.

a Is benzene a compound or an element? Explain.

b What is the chemical formula for benzene?

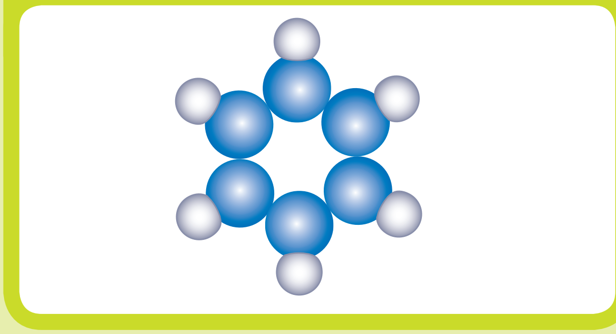


Fig 5.4.8 A graphic representation of benzene

Fig 5.4.9 The electrolysis of water

16 Below are some descriptions of mixtures. Classify each of the situations as being solutions, suspensions or colloids. Explain your decision in each case.

Situation 1: A cola drink is produced by adding sugar and flavouring in water. The resulting mixture then has carbon dioxide gas bubbled through it to give it a fizz. You can see clearly through the mixture from the side of the container.

Situation 2: A student stirs chalk dust into a beaker of water. They cannot see through the resulting mixture. After a couple of hours all of the chalk has sunk to the bottom of the beaker.

Situation 3: A salad-dressing manufacturer adds small amounts of chemicals called 'emulsifiers' to its salad dressings. The oil and water of the dressing do not separate into layers or fall to the bottom of the bottle, even when left for several days.

Investigating questions

17 Use a concept mapping program (such as Inspiration) to map your understandings of elements, compounds and mixtures. If you don't have access to a computer then you can draw a concept map by hand.

18 Your teacher may show you a demonstration called the 'electrolysis of water'. Alternatively you can find information about this process on the Internet.

a In what way does the process show that water is a compound?

b Explain why twice as much hydrogen gas as oxygen gas is produced. Relate this to the chemical formula for water.

19 Go to the *Science Aspects 1* Companion Website at **www.pearsoned.com.au/schools/secondary** to access a copy of the periodic table.

Web Destinations CW

Explore the history of a range of chemical elements that are produced by humans—that is, chemical elements that occur after element number 92 (Uranium) on the periodic table. Where are these chemical elements produced? How are they produced? How are they named?

5·4 FOCUS [Practical activities]

Prac 1 Focus 5.4

To compare a mixture and a compound

Purpose

To produce a mixture and a compound and compare their properties.

Requirements

Sulfur, two teaspoons, watch-glasses, iron filings, magnet, hand lens, iron sulfide.

Saftety note: Smell substances by wafting them toward you.

Procedure

1 Place one teaspoon of sulfur into a watch-glass and one teaspoon of iron filings into another watch-glass.

2 Test the iron and the sulfur for magnetism by holding up each watch-glass and moving the magnet around underneath it. *Record your observations.* Do *not* put the magnet into the iron filings.

>>

3 Carefully smell the iron and then sulfur by wafting any odour towards you. *Record your observations of any noticeable odour.*

4 Examine both the sulfur and the iron filings with the hand lens and *record any observations.*

5 Pour the sulfur and the iron filings into a watch-glass. Mix them together.

6 Test the mixture for magnetism using the magnet. *Record your observations.*

7 Smell the mixture and *record your observations.*

8 Place a teaspoon of iron sulfide onto a clean watch-glass. Iron sulfide is a compound of iron and sulfur.

9 Repeat the tests for magnetism and smell. *Record your result.*

Optional section

10 Your teacher may demonstrate or allow you to make your own iron sulfide by heating iron and sulfur together in an old test tube (it needs to be old, as you often have to break the test tube to get the iron sulfide out). This is best done in a fume hood.

Questions

1 Compare the iron sulfide sample with the iron and sulfur mixture in terms of their magnetism and odour.

2 How would you separate the iron from the sulfur in the iron–sulfur mixture?

3 Did the iron sulfide compound have the same properties as the iron–sulfur mixture? Do you think you could separate the iron sulfide compound back into its separate elements as easily as the mixture?

4 Write the symbols for the following—iron, sulfur, iron sulfur mixture, iron sulfide.

Prac 2
Focus 5.4

What type of mixture is that?

Purpose

To explore a variety of mixtures and to classify them as solutions, suspensions or colloids based on their properties.

Requirements

A variety of substances to test (including salt, sugar, chalk dust, copper sulfate, flour, soil, vegetable oil, milk, detergent and a range of other household materials as provided by the teacher or other students), test tubes, test tube holder, water, rubber stoppers, spatula(s), safety glasses, small light source such as a microscope lamp, small news print.

Procedure

1 Test one substance at a time by placing a small amount of it into a test tube. Use a spatula if the material is a solid. Use a small volume if you are testing a liquid.

2 Half-fill the test tube with water

3 Place a rubber stopper in the top of the test tube and shake it vigorously to try and dissolve the material.

4 Return the shaken test tube to the test tube rack for observations.

5 *Prepare a suitable data table which allows you to classify your substance as solution, suspension or colloid. Use the following steps 6 to 10 to classify each sample and record the result in your table.*

6 If you are unsure if the material has dissolved, shine some light through the mixture. If the light clearly travels through the mixture, and no solid is sitting on the bottom of the test tube, you probably have a solution. You could also try reading some small newsprint through the mixture. If you can read the newsprint clearly through the mixture it is also a solution.

7 If the light does not travel through the mixture and the solid settles out to the bottom of the test tube, classify your mixture as a suspension. Alternatively, you can try reading the newsprint through the test tube. If you cannot see or read the newsprint clearly you may have a suspension.

8 If the light does not travel through the mixture (or you cannot read the newsprint), but the substance does not settle out after a reasonable amount of time, you may have a colloid.

9 Test vegetable oil in water and record your observations. Allow time for the vegetable oil to settle out of the water.

10 Add a few drops of detergent to the vegetable oil and water mixture. Shake the mixture again and *record your observations*. Compare the time it takes for the oil to settle out of the water.

Questions

1 List the substances you tested that were solutions, those that were suspensions and those that were colloids.

2 Were there any materials that you found difficult to classify? Explain.

3 Did the detergent help the vegetable oil form a colloid in step 9? How might this be useful in the production of materials such as salad dressings, which are a mixture of oil and water. (Hint: you may like to research the term ‘emulsifier’.)

FOCUS 5•5

Physical and chemical change

Context

Meat cooking on a barbecue, sugar dissolving in a cup of tea, ice-blocks melting in a glass of soft drink and grass decomposing in your backyard rubbish pile are all examples of change. Change is an essential part of life. Some changes, such as those that occur in the cooking of food, are useful and we often use heat to bring about the change. Other changes, such as the wearing out of your bike tyres, are unwanted and expensive. Either way, change involves particles interacting with each other or their environment. By understanding change you may help the environment, reduce expensive waste or learn how to use different materials in new and exciting ways.

Matter changes

Matter changes around us all the time. Changes in matter, such as the burning of petrol inside the engine of a car, occur very quickly, while other changes, such as the rusting of a car, occur very slowly. Some changes to matter result in new substances being produced while other changes do not. Changes in matter can be divided into two main groups, as shown in Figure 5.5.1.

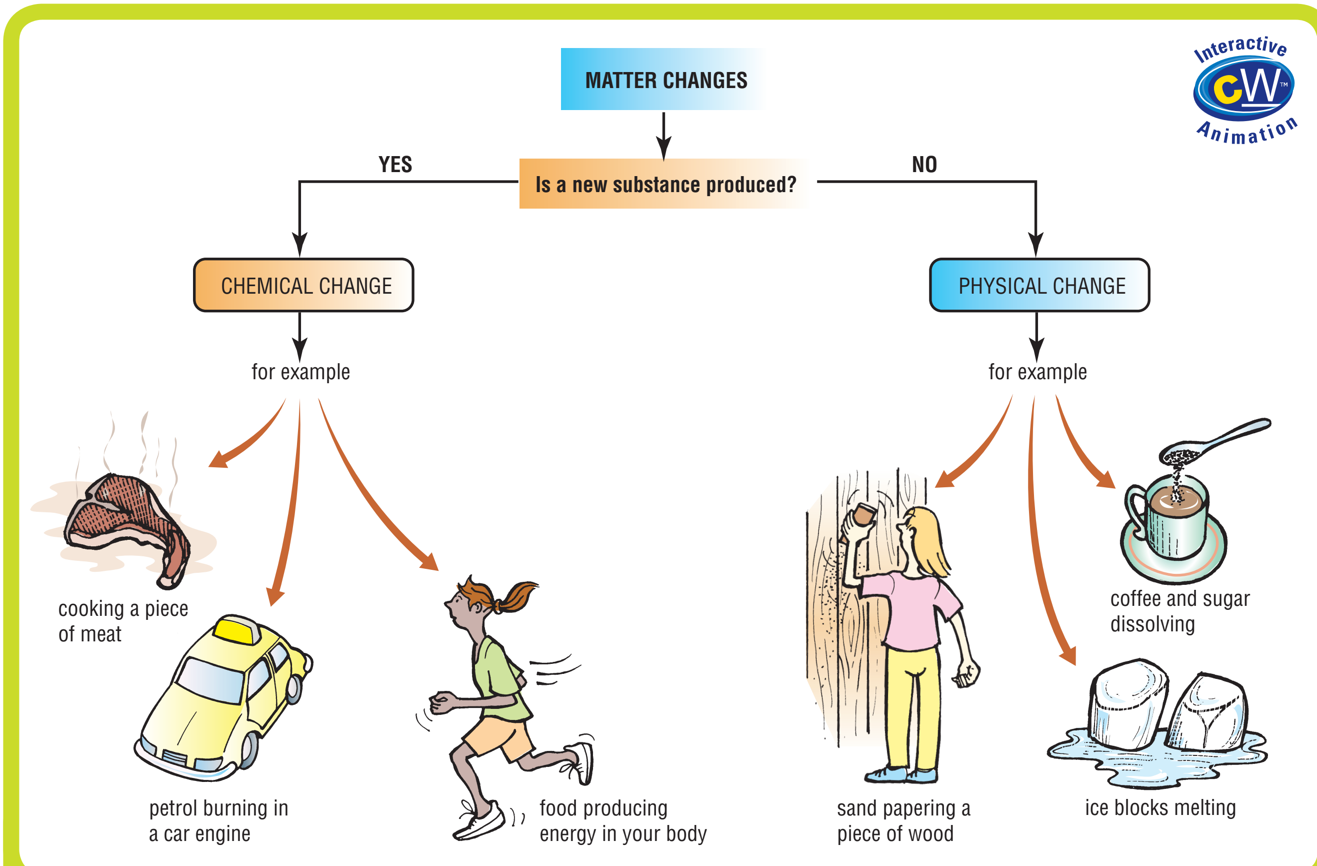
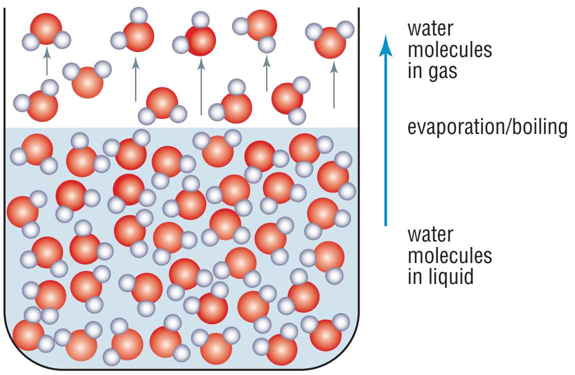


Fig 5.5.1 Changes in matter can be divided up into two main types: physical change and chemical change.

Physical change

When a physical change occurs there are no new materials produced, even though the matter changes in some way. Changes of state (or phase) are examples of this. For example, when water boils it goes from a liquid state to a gaseous state but no new materials are produced.

Water boiling is a physical change, as no new materials are produced. Fig 5.5.2



Physical changes occur all around us and, because they often affect us in some way, it can be helpful if you think of physical change as useful or non-useful.

Useful physical changes

Think of the many useful physical changes you see or feel on a daily basis—clothes drying on the clothes line, sugar dissolving in your cup of tea, or the floorboards in your house being sanded.

Fig 5.5.3 Physical changes occur at a global level. The formation of clouds, for example, is a physical change involving water evaporating and then condensing to form clouds.

Physical changes also occur at a global level and are responsible for our weather patterns. Rainfall and snowfall, for example, involve physical changes.

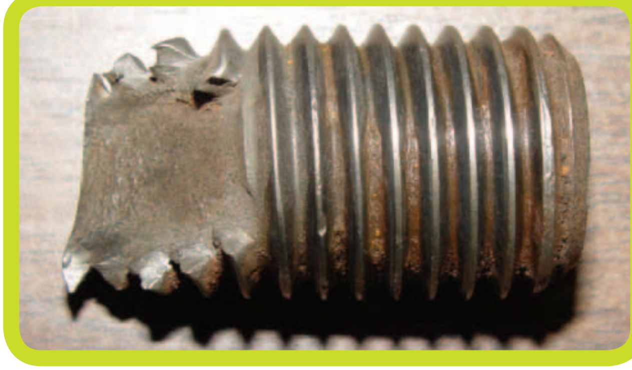
Non-useful physical changes

Most examples of non-useful physical changes involve wearing and breakages. Wearing occurs whenever materials have to move against each other.

Tyre wear is a physical process that can result in dangerous tyres. Fig 5.5.4

Metal fatigue is a physical process that occurs when metals experience strong forces. This can occur in building structures as well as in aeroplane wings and car bodies. It can result in the sudden breakage of the metal through the development of cracks.

Metal fatigue results in the sudden failure of metal, such as this bolt breaking. Fig 5.5.5



On a global level, the wearing of soil through air and water movement can cause change to our landscape and environment.

Chemical change

In the last focus you discovered that in chemical reactions the atoms can rearrange to form new materials or compounds. This is a key feature of chemical change. In chemical change new substances are formed. You can tell when a chemical reaction occurs because one or more of the following occurs:

1 A new substance is formed which is clearly different from the materials you started with.
2 One of the original substances no longer exists or is greatly reduced in size.
3 There is a colour change.
4 A solid or gas is formed.
5 An odour (indicating a new material) is produced.
6 There is a temperature change where the reaction took place–it can become hotter or colder.

These observations don't tell us for sure that it is a chemical reaction, because many of them can also occur during a physical change.

Prac 1 p. 242

Science Snippet

X-rays for aeroplanes

X-rays are not only used in looking for broken bones; they can also be used for looking for broken metals! Metal fatigue in metals can result in disastrous breakages in the wings and bodies of aeroplanes. By using X-rays, technicians can identify metal fatigue in major structural parts before it becomes visible to the eye.

Fig 5.5.6 When two colourless liquids are mixed and there is a colour change (like here to green), we have evidence of a chemical reaction.

Chemical equations describe chemical change

Scientists use chemical equations to describe and summarise what has happened during a chemical change. Your teacher may demonstrate the chemical reaction that occurs between hydrogen gas and oxygen gas.

The chemical reaction that occurs when hydrogen gas and oxygen gas react to produce water Fig 5.5.7

To summarise what has happened during this reaction, you can write a word equation. The substances to the left of the arrow are called the **reactants** and the substances to the right of the arrow are called the **products**. The arrow itself indicates that a change has occurred.

$$\underbrace{\text{hydrogen gas} + \text{oxygen gas}}_{\text{reactants}} \underset{\text{change}}{\rightarrow} \underset{\text{product}}{\text{water}}$$

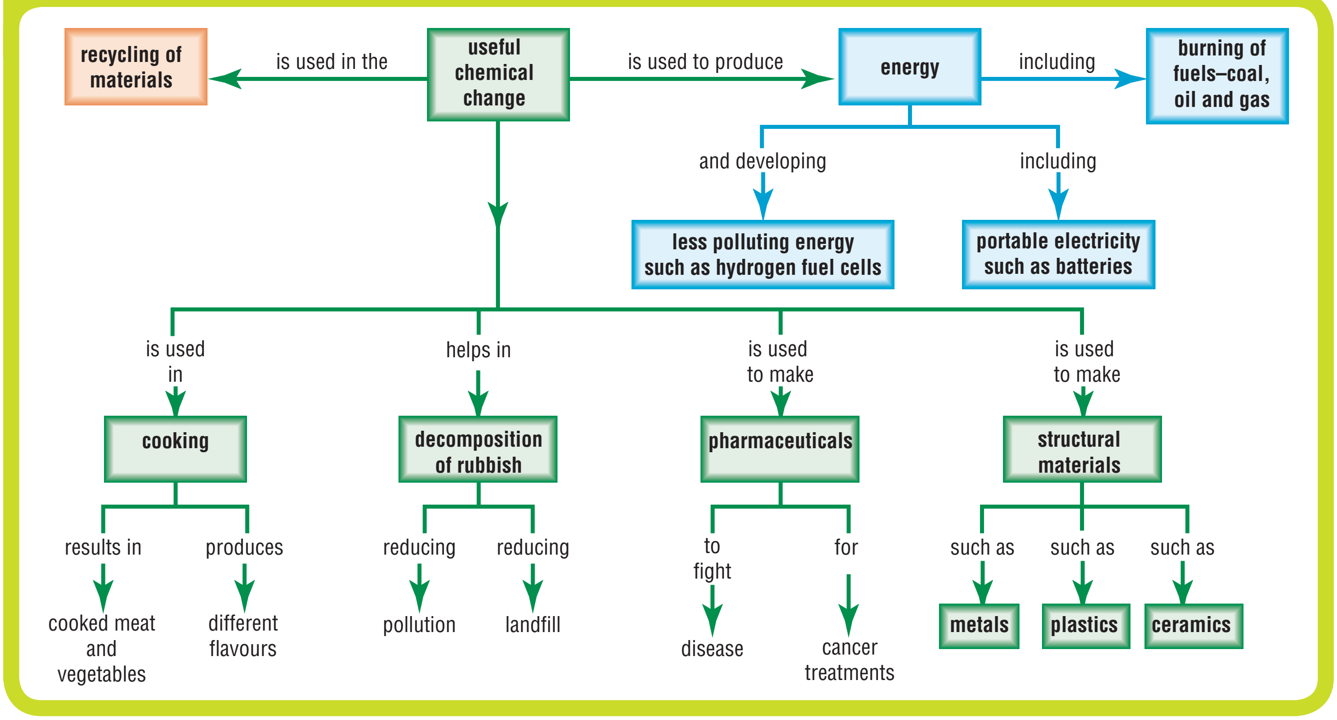
As with physical changes, it is helpful to divide chemical changes up into useful and non-useful chemical changes.

Useful chemical changes

There are many examples of useful chemical change which result in products that benefit our environment or lifestyle. Some of these are summarised in Figure 5.5.8.

Figure 5.5.8 illustrates that chemical change occurs all around us and is essential in the production of pharmaceuticals, structural materials and energy. Chemical change is also essential in food and drink production, for the recycling of materials from plastics and in the decomposition of materials in the soil.

Fig 5.5.8 Some examples of useful chemical changes



Non-useful chemical changes

Not all chemical change is useful. Meat goes bad and milk goes sour, particularly if left out of the refrigerator. In these cases, chemical change is occurring, producing new chemicals that do not taste or smell very nice and can even be dangerous.

Metals such as iron corrode (rust), particularly if the steel is exposed to the air and moisture. The change that occurs with iron when it corrodes is shown in the chemical reaction below:

steel	+	oxygen	+	water	→	iron oxide (rust)
grey metal		colourless gas		colourless liquid		browny-red flaky solid

It is easy to identify that a chemical change has occurred because a new substance (rust) is produced that has different properties from any of the starting materials. Metals other than iron can also corrode by reacting with the oxygen and water in the air.

Chemical changes also occur in our environment, with some nasty side-effects. For example, the burning of fuels produces a number of substances, such as carbon monoxide, carbon dioxide and sulfur dioxide. These materials not only pollute the air, making it difficult for people to breathe, they can also react with the moisture in the air to produce ‘acid rain’, which can damage buildings and vegetation.

How fast can chemical change occur?

Some chemical changes occur very quickly. The burning of petrol in a car engine or an explosion at a mine site are examples of this. In these chemical changes, the new products are produced very quickly, along with large amounts of heat and light.

This chemical change occurs very rapidly. Fig 5.5.9

Other chemical changes, such as the rusting of a car or the breakdown of plastic in the environment, occur very slowly.

The speed (or rate) at which chemical changes occur can sometimes be controlled. Temperature has an effect on all chemical change, which is one reason you store food in a refrigerator. The lower temperature reduces the speed at which the food decomposes.

Science Snippet

Exploding wheat

Chemical reactions can occur very rapidly if the materials in the reaction are ground very finely. For example, although you would not normally regard wheat as explosive, wheat dust can explode in wheat silos if it comes in contact with a flame and plenty of oxygen gas. You can demonstrate the potential for this by sifting flour onto a Bunsen flame.

Homework book 5.6 Physical and chemical changes at home

5·5 FOCUS [Questions]

Drag and Drop CW Interactive

Use your book

Matter changes

1 What is the difference between a physical change and a chemical change?

Physical change

2 Explain why the freezing of water is a physical change.

3 Describe two useful and two non-useful physical changes that occur in your home. In your answer, explain why each is useful or non-useful.

4 Describe two useful and two non-useful physical changes that occur in our environment. In your answer, explain why each is useful or non-useful.

Chemical change

5 Describe how you would recognise if a chemical change had occurred.

6 Use the concept map shown in Figure 5.5.8 to describe six examples of useful chemical changes that occur. You may like to set your answers up in a table which describes the change, why it is useful and the materials that are produced.

7 Describe two non-useful chemical changes that occur in your environment.

8 What does the term 'reactants' mean when describing a chemical reaction? What are the products?

How fast can chemical change occur?

9 Give an example of a chemical reaction that we like to occur very slowly.

10 Give an example of a chemical reaction that occurs very quickly.

Use your head

11 Copy the table below into your notebook. Complete the table in your notes by classifying each change as 'physical' or 'chemical'. You also need to explain your choice.

Change	Physical or chemical	Explanation
A piece of paper being burnt		
A snow flake forming from water drops in a cloud		
Clothes drying out on a clothes line		
A cake baking in your oven		
Grass decomposing in your compost heap		
Sugar dissolving in your cup of coffee		

12 Name three everyday examples of:

a a chemical change being encouraged to occur

b at attempt being made to stop chemical change occurring.

13 Look back at the equation showing the rusting of steel (page 240). Use this chemical equation to explain the following observations.

a Cars in humid climates tend to corrode faster than cars in dry, cool climates.

b Steel objects are often painted to prevent them from rusting.

14 A student carried out the following investigations. She recorded the observations as she went and decided that, based on the observations, they were all examples of chemical changes:

a Vinegar (dilute ethanoic acid) is added to baking soda (sodium hydrogen carbonate). A fizzing sound is heard, the test tube gets warm and lots of bubbles are produced, which pop when they get to the surface.

b Silver nitrate solution is added to salt water and forms a milky, white solid.

c When sodium is added to water it fizzes violently and whizzes around the surface of the water. Bubbles of gas can be seen, along with blue flames.

For each of the reactions above, explain why the student might have considered them to be chemical changes.

>>

15 Kim adds a piece of magnesium to hydrochloric acid. There is some fizzing and a gas is produced. The magnesium disappears. Kim infers that magnesium chloride and hydrogen gas are produced in this chemical reaction.

a What evidence is there that a chemical reaction has occurred?

b What are the reactants for this chemical reaction? What are the products for this chemical reaction?

c Write a word equation for this chemical reaction.

Temperature (°C)	Trial 1 (seconds)	Trial 2 (seconds)	Trial 3 (seconds)	Average (seconds)
20	120	110	132	121
50	72	84	80	79

Investigating questions

16 Ask your teacher if you can try the investigations described in Question 14. Describe all the changes you observe and explain how these support the idea that these are chemical changes.

DYO

17 Josh and Kate set up an investigation where they measured the time that it took for a piece of magnesium ribbon to totally react with hydrochloric acid at both 20°C and 50°C. Their results are summarised in the table above.

a What might have Josh's and Kate's hypothesis for this investigation have been?

b What do the results tell us about the effect of temperature on reaction rate?

c Make a list of the variables that Josh and Kate would have controlled for this to be a 'fair investigation'.

d Why were there three trials for each temperature?

18 Carry out the investigation as described in Question 17. Make sure that you take into account all the controlled variables you suggested.

DYO

FOCUS 5.5

Practical activity

Prac 1
Focus 5.5

Observing chemical reactions

Purpose

To observe chemical reactions and identify the key signs that a chemical change has occurred.

Requirements

Safety note: Make sure you wear safety glasses at all times when you are handling or heating chemicals.

Safety glasses, six test tubes, test tube rack, potassium iodide solution (0.1 M), lead nitrate solution (0.1 M), hydrochloric acid (2M), copper sulfate solution (0.1 M), two pieces of magnesium ribbon, copper (II) carbonate, test tube holder, Bunsen burner, marble chips, granulated zinc.

Procedure

In each of the six reactions, take care to note how the test tubes feel so that you can identify if any of the reactions produce heat or become cooler. Carry out the reactions below in separate test tubes as directed by your teacher. *Draw up a three-column table to record any observations. Label the columns 'Reactants', 'Observations' and 'Evidence of chemical change'.*

1 Add 10 drops of potassium iodide to a test tube. Then add 10 drops of lead nitrate solution.

2 Add 10 drops of hydrochloric acid to one piece of magnesium.

3 Add 10 drops of copper sulfate solution to a piece of cleaned magnesium.

4 Add about 1 cm of copper carbonate to a test tube. Carefully heat the copper carbonate in a blue Bunsen flame using a test tube holder.

5 Place a few marble chips into a test tube. Cover these chips with hydrochloric acid.

6 Add a couple of pieces of granulated zinc to a copper sulfate solution. Let this sit for a few minutes.

Questions

1 Complete your table.

2 Write a summary of the changes that can occur when a chemical change takes place.

FOCUS 5.6

Properties of states and their uses

Context

In this focus you will explore the unique properties of a range of solids, liquids and gases—from hard metals with melting points of many hundreds of degrees to gases such as nitrogen, which must be cooled to below –200°C before it condenses. To understand these special properties we need to expand even further our understanding of particles and how they are arranged.

Properties of solids, liquids and gases

In Focus 5.2 and Focus 5.3 you learnt that many of the properties of materials can be explained in terms of how the particles are arranged in solids, liquids and gases. You learnt a simple particle model. The rest of this focus will be devoted to looking at some of the other special properties of solids, liquids and gases and how these can be explained in terms of the ways that particles are arranged.

Solids

It is the arrangement of the particles within the solid that determine the special properties of some solids compared with others. Solids can be classified into two broad groups called **networks** and **molecular solids**.

Network solids

In a metal, crystal (such as salt) or substance such as diamond the particles are arranged in a large **network** or **lattice**. Because all the particles within the lattice are cross-linked, these materials are often very strong, though crystal substances can also be brittle. They also tend to have high melting points.

Metal lattices have some very special properties, such as their ability to be bent and stretched. This is possible because the bonds within the metal lattice are flexible as well as strong. Other network solids, such as crystals and glass, do not contain the flexible bonds of metals so when forces are applied to them the entire solid is disrupted and the material can shatter.

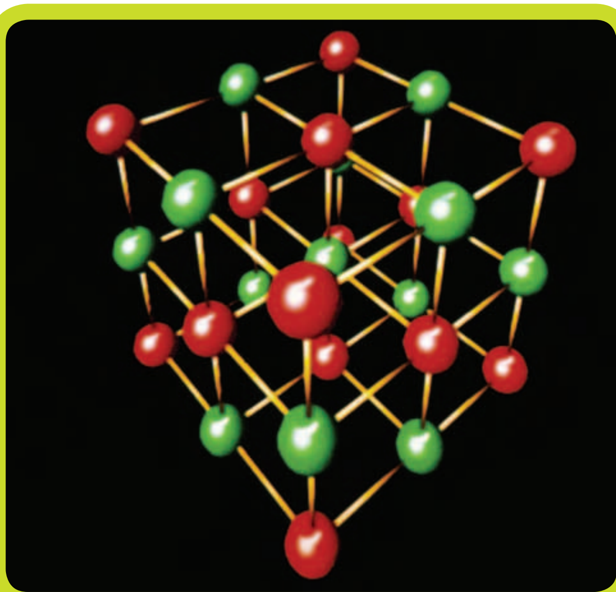


Fig 5.6.1 In solids that are very hard the particles are cross-linked and connected through strong bonds in 'lattices' or 'networks'.

Molecular solids

In many solids, such as wax, soap, foods and plastics, the particles are not arranged in large networks or lattices.

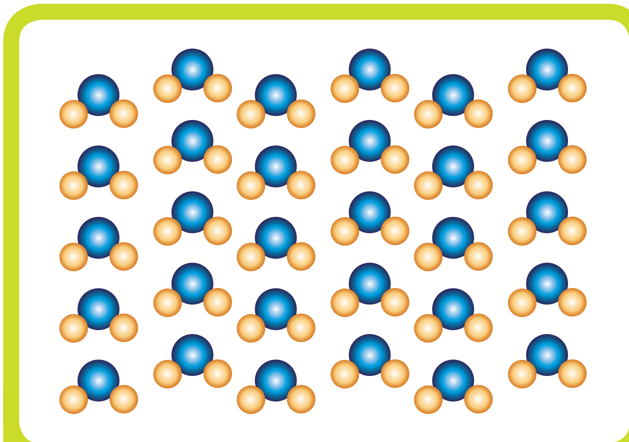


Fig 5.6.2 In molecular solids, the particles (molecules) are not interconnected. As a result, molecular solids are softer than network solids.

The molecules are held in position, but are not strongly joined to other molecules. When a force is applied to a molecular solid, the molecules can move without disrupting the entire solid. These substances tend to be softer and more flexible and often have fairly low melting points.

Science Snippet

Glass—solid or liquid?

Some window panes, hundreds of years old, have been found to be thicker at the bottom than at the top. This led to the idea that glass was in fact a viscous liquid that flowed very, very slowly. So true or false? In actual fact, glass is a solid. It does not flow at all. When glass was first invented, it was difficult to control the thickness of the glass and some of the panes ended up being thicker on one side.

Heating and cooling of solids

All solids expand when heated, but some expand more than others. When particles in a solid are heated, the heat energy causes the particles to vibrate more vigorously and move further apart. This movement is expansion. When the material loses heat energy, the vibration decreases and the particles move closer together and the material takes up less space. This is called contraction.

Solids expand and contract with a lot of force. This has to be taken into account in the construction of bridges, buildings and railway lines.

Homework book 5.7 Expansion graphs

Fig 5.6.3 Engineers have to allow for the expansion and contraction of solids by leaving gaps.

Other properties of solids

In Focus 5.1 you explored a range of properties of materials, including ability to transmit light, compression strength, ability to conduct heat and electricity, degradability, ductility, elasticity, flexibility, hardness, malleability, porosity and tensile strength. Solids display a huge range of these properties. Material scientists make choices and decisions about the use of materials depending on these properties.

Liquids

As with solids, liquids have a large range of properties and uses. The unique properties of liquids allow them to be used for some special applications.

The effect of forces on liquids—hydraulics

Liquids cannot be compressed but the particles are free to move. As a result, liquids can be used to transmit forces from one point to another. This basic principle is used in hydraulics.

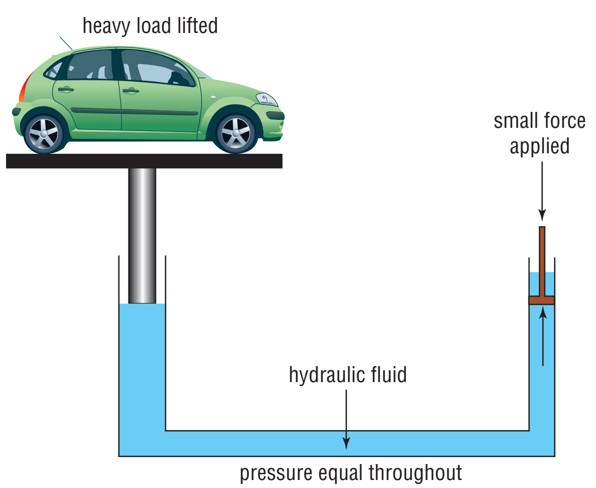


Fig 5.6.4 In hydraulic systems a force is applied at one spot within the liquid and is transmitted to another part of the liquid where it can do useful work.

Hydraulic systems are found in a large range of machines, including back hoes, bulldozers, fork lifts and cranes. Hydraulic systems are also essential in the operating of braking systems within cars, trucks and motorcycles, and for raising and lowering the landing gear of aeroplanes.

The effect of temperature on liquids

As with solids, liquids expand when heated and contract when cooled. Thermometers are based on this principle. A thermometer consists of a bulb of liquid connected to a tube. When the thermometer is heated, the enclosed liquid expands and moves up the tube. The corresponding temperature can be read from the scale. When the thermometer is cooled the liquid contracts and moves down the tube.

Mercury, a liquid metal at room temperature, is used in thermometers because it expands evenly and does not stick to the glass. Alcohol that has been dyed red or green can also be used, as it is cheaper and less poisonous than mercury.

Science Snippet

Glooper computers

Scientists are researching the development of artificial brains (called 'gooware') that work entirely in a liquid format. The replacement of metal and wire brains with liquid brains saves a lot of space and liquid brains can respond more quickly to all sorts of things, such as light and sound. Being liquid, they can also change their shape if required. Robotic scientists are also investigating liquid muscles, so robots of the future will be able to change shape and squeeze into tight places if required.

Pouring liquids—viscosity

Liquids can be poured and, as mentioned in Focus 5.1, **viscosity** is a measure of how easily liquids flow. Liquids such as water are not very viscous, whereas liquids such as honey are very thick and flow very slowly. Honey is said to have a high viscosity. Materials scientists have a scale for measuring viscosity—this can be found most commonly on oil containers. It is called the viscosity grade. A thin oil flows more easily and has a lower number than a thicker oil. For example, a 30-grade oil is used in the engine of a car and is less viscous than the 140-grade oil used in the gear box of a car, which requires a thicker oil.

The viscosity rating of oils is calculated by measuring how long it takes for a certain volume of oil to pass through a standard opening at a particular temperature.

Prac 1 p. 249 Prac 2 p. 249

Fig 5.6.5 The higher the viscosity grade, the thicker the oil

Density of liquids

The amount of mass within a certain volume is known as the **density** of a material. All substances (solid, liquid and gas) have a particular density value. A typical way of measuring density is to determine the mass (in grams) in a fixed volume such as 1 millilitre. Density is measured in units such as grams per millilitre (g per mL). A liquid that is less dense will float on a liquid that is more dense. For this reason, oil will float on the top of water—in the case of an oil spill from a ship, this means that there is some chance of cleaning it up if the water is calm enough.

Fig 5.6.6 Most oil spills occur at sea. The oil is less dense than the water and will float on top.

Gases

Gases, like liquids, are also called fluids, as their particles can flow through a pipe and take on the shape of their containers. As a result of these special properties of gases, they are stored and used in a number of ways.

Compression of gases

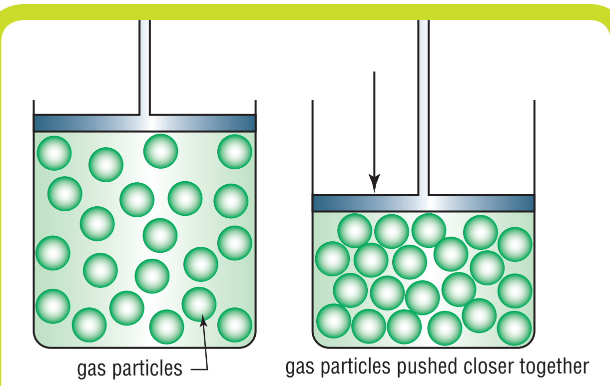


Fig 5.6.7 Compressing a gas

There is a lot of space between the particles of a gas. Gases can be compressed or squeezed into a smaller volume, making them easier to transport and store.

Gases are compressed to save space when they are stored. *Fig 5.6.8*

Elasticity of gases

When gases are squeezed into a smaller volume and then the pressure is released, they return to their original volume. You can feel this if you squeeze air in a syringe with your finger over the end. Because of this, gases are said to be elastic. We make use of this property in a number of ways, for example in tyres. Most bikes and even some types of large earth-moving equipment do not have shock absorbers but rely on the cushioning provided by the air in their tyres.

Heating gases

When gas particles are heated they move faster and with more energy. This results in a number of changes to the way the gases behave.

- Diffusion—the rate at which gases diffuse is increased if you increase the temperature.
- Gas pressure—when gases are heated within a container, the pressure inside the gas increases as the particles move faster and with more energy. The opposite also applies: when the container is cooled, the gas particles move more slowly and the pressure decreases.
- Gas density—when a gas is heated the particles move further apart. Gases become less dense when they are heated and will float on more dense gases, such as cooler air. This property is utilised in hot-air balloons, which will float on the more dense colder air.

The hot air in this balloon becomes less dense when it is heated and will float on the cooler air *Fig 5.6.9*

Uses of gases

Gases have many uses, and like all other substances, their use depends on their properties. Following are some gases and their special properties.

Oxygen

Oxygen gas is sometimes called the gas of life. Almost all living things need oxygen to survive. Oxygen gas is sometimes used in a portable form for people who have trouble breathing or who need an increased concentration of oxygen for their damaged lungs. Oxygen bottles are also used in hospitals for patients requiring breathing support.

Ammonia

Ammonia is a gas that is used by the millions of tonnes to make fertiliser, textiles, explosives and detergents. In its pure form it i s a poisonous gas with a very irritating odour. It can be made by a chemical reaction between nitrogen and hydrogen gas, or produced from coal and natural gas.

Hydrogen

Hydrogen is a very light and flammable gas. It can be used to fill weather balloons. It is used as a rocket fuel and is stored in large tanks, along with other tanks for oxygen gas, in space shuttles and other rockets. Its use as a fuel to replace fossil (oil) fuels is being explored, as it burns very cleanly, producing only water vapour. Fuel cell cars and buses use hydrogen gas.

Inert gases

This is a group of gases that includes helium, neon, argon and krypton, which are all found in the air in very small amounts. They are special in that they are very unreactive gases and are used in situations where a gas is required that does not react or burn. Helium is a low-density gas that can be used to fill balloons, and has largely replaced hydrogen gas. Neon is used to produce bright electronic signs, as it glows very brightly when a high voltage is applied to it. Argon is used to fill electric light bulbs to prevent the filament from burning out too early.

Fig 5.6.10 This sign is filled with the inert gas neon, which glows very brightly when a high voltage is applied to it.

Nitrogen

Nitrogen gas makes up nearly 80 per cent of our atmosphere. It is a largely unreactive gas and its pure form is pumped over tanks of flammable material to help prevent explosions. Nitrogen is very important to some plants in the production of protein. Nitrogen from the atmosphere is used to produce ammonia gas. Nitrogen gas from the atmosphere can also be liquefied by cooling to about −210°C. It is used to snap-freeze foods for storage and to store biological samples, such as sperm and eggs used in artificial breeding programs. It is also used to 'burn off' warts and skin cancers from human skin.

5·6 FOCUS [Questions]

Use your book

Solids

1. Why are network solids, such as diamond and metals, often very hard?
2. Give examples of some molecular solids. Explain why these solids are generally softer than network solids.
3. Explain why a solid will expand when heated and contract when cooled. You could use a diagram to help you.

Liquids

4. In hydraulic systems, a force at one point in the liquid is transferred to another point in the liquid and can cause movement. What property of liquid particles allows this to happen?
5. What is meant by the viscosity of a liquid?

Gases

6. Explain why both gases and liquids are called fluids.
7. What causes the pressure inside a gas?
8. Explain what property of a gas makes it suitable for car tyres.

Use your head

9. Figure 5.6.11 is a representation of how we believe the carbon atoms in diamond are arranged.

Fig 5.6.11 The arrangement of carbon atoms inside diamond

a Is diamond a network or a molecular solid?

b Why is diamond so hard?

10 Describe the properties of the following solids that make them suitable for use in the situations described.

a Aluminium beams are used in the frame of a roof.

b Windows are made of glass.

c Car tyres are made of rubber.

d Baby cups and bowls are made of plastic.

e Small boats are build from fibreglass.

f Large ships are built from steel.

11 In hydraulic systems, such as the braking system on cars and motorcycles, the brake system sometimes needs to be 'bled'. This involves opening up the hydraulic system and applying a force to get rid of any air bubbles. Explain why it is important to remove air from hydraulic systems.

12 The table below shows the mass of 100 mL of various liquids.

Liquid	Mass of 100 mL (grams)
petrol	70
fresh water	100
salt water	103
blood	105
glycerin	126

a Which of the liquids is the most dense? Which of the liquids is the least dense? Explain your answer.

b Draw a column graph that shows the mass of each liquid, starting with the lightest liquid and finishing with the heaviest liquid.

c The density of any substance can be determined using the formula:

$$\text{density (g per mL)} = \frac{\text{mass (g)}}{\text{volume (mL)}}$$

Find the density, in g per mL, for all the liquids listed.

d Which of the liquids would float on water? Explain why you made this decision.

13 Of all the gases, hydrogen diffuses the fastest. Why is this?

14 Miners and cavers have to be aware that some poisonous gases tend to gather at lower levels in caves and mines. What does this tell you about these gases compared with air?

15 Gases are chosen for particular purposes, depending on their properties. For each of the uses below, explain why the gas indicated was chosen for that purpose:

a Argon gas is often used in arc welding by blowing the gas over the surface being welded.

b Baking powder is added to flour to produce self-raising flour. When baking with self-raising flour, carbon dioxide is produced, which bubbles up through the cake mixture during cooking.

c Helium gas is used to fill weather balloons and blimps even though hydrogen gas is a lighter gas.

d Oxygen gas is used together with acetylene gas in welding. The amount of oxygen gas being added can be increased or decreased.

Investigating questions

Web Destinations CW

16 Bimetallic strips can be used to control the temperature of devices such as ovens. Explain how they work. What do they demonstrate about the expansion of solids? Describe how they can be used to control the temperature of a device. Go to the *Science Aspects 1* Companion Website at **www.pearsoned.com.au/schools/secondary** for a link.

17 Research surface tension and answer the following questions:

a What is meant by surface tension?

b How does surface tension help insects walk on water?

c How does surface tension stop water from wetting objects?

d How can surface tension be reduced to help clean objects?

e What is so special about the surface tension of mercury metal and why does this make it suitable for use in thermometers?

18 Petrol companies have researched the effect that temperature has on the volume and mass of petrol in different parts of Australia. On average, 1 litre of petrol in Hobart is heavier than 1 litre of petrol in Darwin. There is an average difference of 15°C between the maximum temperatures of the two cities.

a What property of liquids would cause this difference? Explain your answer fully.

b Why would petrol companies be interested in this type of research?

5·6 FOCUS [Practical activities]

Prac 1 Focus 5.6

Viscosity

Purpose

To measure and compare the viscosity of a number of different liquids.

Requirements

Four funnels or beakers for pouring, 50-cm (or taller) glass tubes, metre rule, engine oil, 16 ball bearings (small enough to fit in glass tubes), timer, olive oil, water, kerosene.

Procedure

1. Fill one of the tubes to the 50-cm mark with engine oil.
2. Record the time it takes for the ball bearing to fall through the 50 cm of oil.
3. Repeat the procedure three more times with more ball bearings and *record the average result in a suitable table*.
4. Repeat this procedure for the other liquids, *recording your results as you go*.

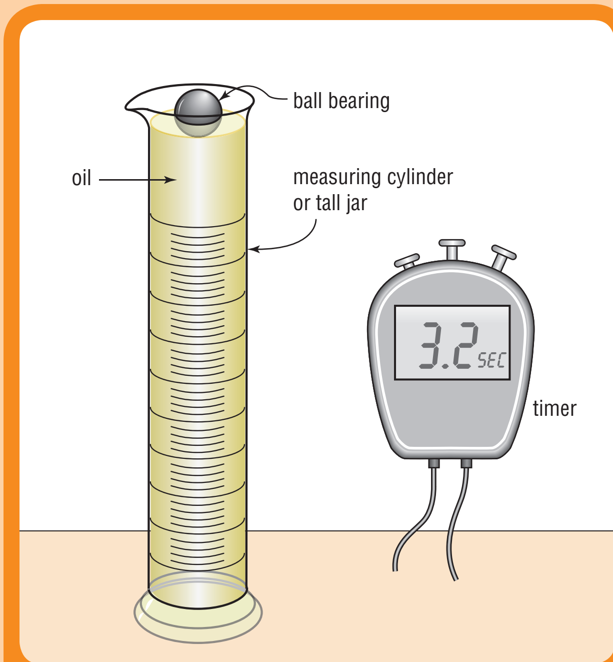


Fig 5.6.12 Set up this equipment to measure the viscosity of the different liquids. The most viscous liquid will be the one in which the ball bearing takes the longest to reach the bottom.

Questions

1. List the liquids from the least viscous to the most viscous.
2. Explain why you used an average time to compare the viscosities of the liquids.
3. What variables did you control in this investigation to ensure that it was a fair test?
4. Explain why engine oil is the most suitable liquid to provide protection on moving gears in terms of its viscosity.

Prac 2 Focus 5.6

DYO

How does temperature affect viscosity?

Purpose

To conduct an investigation to test the effect of temperature on the viscosity of engine oil.

Requirements

Glass tubes from Prac 1, metre rule, engine oil, hot water bath or electric hot plate, funnel or beaker, thermometer.

Procedure

You are to design your own investigation to test the effect of temperature on the viscosity of engine oil. You cannot heat engine oil directly with a Bunsen flame, as oil is flammable. Do not heat the oil to a temperature greater than 80°C. For this reason you can either heat the engine oil in a hot water bath or by using an electric hot plate. Discuss this with your teacher before proceeding.

1. Plan your procedure, making sure that the investigation is fair and controlled.
2. Show your teacher your plans and have them approved before you commence.
3. *Record your results in a suitable table.*

Questions

1. Does temperature make a difference to the viscosity of engine oil?
2. How did you ensure that your investigation was fair?
3. The SAE weight designation system is used to grade oils. For example, the oil used in the engine of the family car would be about SAE 30 while the oil used in the gear box would be SAE 140. Which of these two oils is the thicker? Why do we need different grades of oils?

FOCUS 5•7 Solutions and separation

Context

Why are solutions so important to us? Without water, the chemical reactions that make up life itself cannot occur. This focus explores many aspects of solutions, solubility and separation. Clean water is vital to our survival.

Understanding how and what things dissolve in water is very important in maintaining a supply of clean drinking water. We also need to understand how things dissolve to supply chemicals, grow crops, clean materials, extract minerals, prevent pollution and even catch criminals!

Solutions

In Focus 5.4 you learnt that a substance is a solution if it allows light to travel straight through and if the substance dissolves in water—that is, does not settle to the bottom if left, like a suspension does. These observations suggest that substances that dissolve break up into very small pieces when placed in water. When talking about solutions we use the terms ‘solute’, ‘solvent’ and ‘solution’.

Interactive CW Animation

Interactive CW Animation

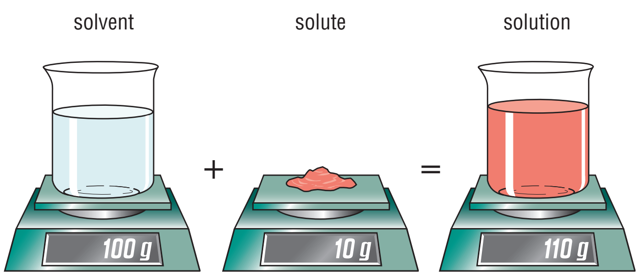


Fig 5.7.1 The solute is dissolved in the solvent to form a solution. The solute does not disappear, as you can see from the mass. The mass is ‘preserved’.

Substances that dissolve in other substances are said to be **soluble**. The solute does not have to be a solid. An example of this is the dissolving of carbon dioxide gas and flavouring in water to produce carbonated drinks, or ‘cool drinks’. When the can or bottle is opened, the dissolved gas comes out of solution, which is the ‘whooshing’ sound you hear. In the same way, the solvent does not always have to be water. For example, alcohol is used as the solvent in some medicines. In two-stroke engines petrol is used as the solvent to dissolve lubrication oil.

Not all substances dissolve in water. Those that do not are called **insoluble** and are identified because they either settle to the bottom or, in the case of suspensions and emulsions, will not allow light to travel through them. Some substances do not dissolve very much in water and are called **sparingly soluble**.

Concentration

If a solvent (such as water) contains a large amount of solute, it is said to be a **concentrated** solution. A solution that contains only a small amount of solute is called a **dilute** solution.

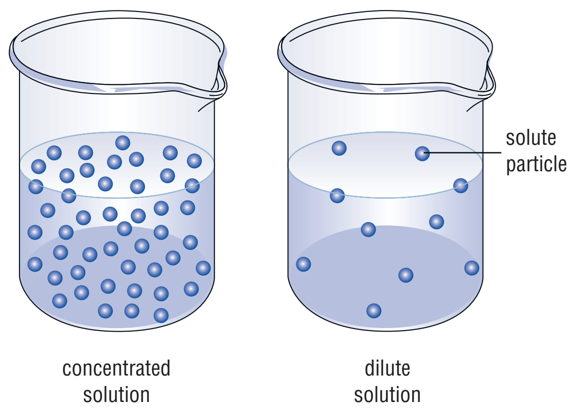


Fig 5.7.2 In a concentrated solution there are more solute particles in a certain volume of solvent compared with a dilute solution.

Separation techniques

There are many situations in which you may need to separate substances out of a mixture. The method that you choose to separate mixtures depends on the solubility of the materials involved.

Insoluble substances

The separation of insoluble materials occurs in many different situations in our homes, in industry and even within our bodies.

Decantation

This is a very simple process used for separating insoluble materials that settle to the bottom of the liquids. Decantation can be as simple as pouring boiling water off the cooked potatoes through to pouring wine off the sediment that has settled to the bottom of the bottle. While decanting is a simple and quick process it is difficult to obtain a perfect separation and often you need to leave some of the material unseparated towards the end of the process.

Fig 5.7.3 The wine is being decanted—that is, separated from the sediment at the bottom of the bottle.

Sieving

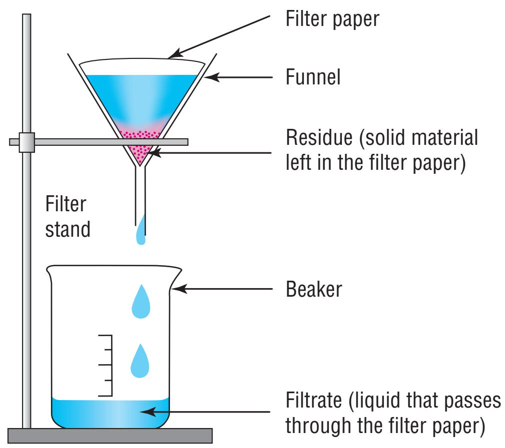
Have you ever used a sieve? They are great if you need to remove the hot water from spaghetti or if you need flour free from lumps. When you pass a material through a sieve you remove materials that cannot fit through the sieve holes. Sieves are also used in mining in a range of processes where only crushed rock of a certain size can be used.

> **Science Snippet**
>
> **Panning for gold**
>
> In the early gold rush days, separation was a very important part of the miners' daily work. If a mixture containing particles of different weights is stirred and shaken, the heavier particles fall towards the bottom. Gold is a very dense metal and specks and nuggets would always work towards the bottom, allowing the lighter dirt and gravel to be washed off. This type of separation is called **gravity separation**.

Filtration

There are many applications of filtration in the home and in industry. Filtration involves passing the insoluble materials through a very fine paper that contains millions of holes small enough to allow the solvent through but not the larger insoluble materials. The material caught in the filter paper is called the **residue**, while the filtered liquid is called the **filtrate**.

This filtration equipment can be used to remove insoluble solids from the liquid. *Fig 5.7.4*



Where have you seen filters in action at home?—perhaps dust masks, coffee plungers and bags, swimming pool filters or air and petrol filters in cars. Filters are very efficient in removing residue from liquids and gases, but they need to be cleaned or replaced regularly so that they function efficiently.

Air filters have many applications, such as filtering air in vehicles and air conditioners. *Fig 5.7.5*

Homework book 5.8 Applications of filtering at home

Centrifuging

Have you ever seen your clothes centrifuged? This occurs in your washing machine during the spin cycle, when the drum spins at many hundreds of revolutions per minute. This forces the clothes and water to the outside of the drum. The drum contains holes that allow the water to move out and fall to the bottom of the machine, where it is pumped out.

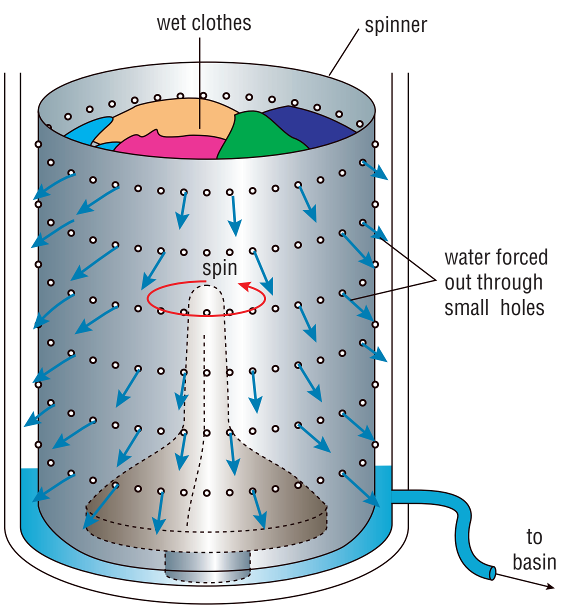


Fig 5.7.6 The spin dryer on a washing machine spin dries the clothes by a centrifuge action.

Centrifuges have many other applications in medicine and industry. In medicine they can be used to separate blood into its cells and liquid (plasma).

Electrostatic precipitation

Electrostatic precipitation is a method of separation used to remove impurities from smoke released from large industrial chimneys. As the smoke moves up the chimney it receives an electric charge, which attracts the particles to the collecting plates at the side of the chimney. The impurities can then be collected from the plates rather than being released into the atmosphere.

Froth flotation

Froth flotation is a separation process used to remove metals from minerals. The metal-containing mineral is finely crushed to release the metal and mixed with water and special chemicals called 'frothing agents'. When air bubbles are blown through the mixture, the metal particles cling to the bubbles and come to the surface.

Soluble substances

Separating soluble substances from the solution is a little more complicated than separating insoluble materials. The process that you use also depends on which part of the solution (solute or solvent) you are trying to recover. Separating soluble materials has many applications, from obtaining fresh water from sea water (desalination) to producing petrol from crude oil, to producing a DNA fingerprint in a crime lab!

Evaporation

In the process of evaporation the solvent is allowed to evaporate off or is boiled off, leaving the solute. It is a simple process but, of course, the solvent is lost in the process. It can be used on a small scale, such as in your science laboratory to remove soluble copper sulfate from water. On a large scale it results in thousands of tonnes of salt from sea water, using sunlight to evaporate the water.

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p. 255

Distillation

Distillation also involves providing heat energy to evaporate the solvent as in evaporation, but in distillation the evaporated liquid (called the distillate) is trapped, cooled and collected. In the case of water, this collected liquid is called distilled water. Insoluble materials are left behind in the original container. Figure 5.7.7 shows a typical laboratory distillation apparatus.

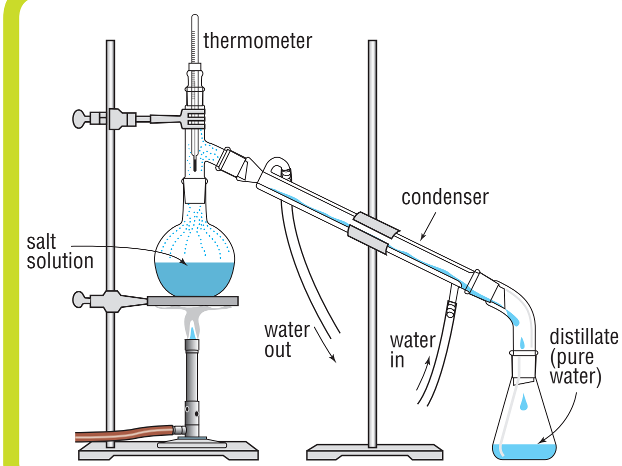

Fig 5.7.7 Laboratory distillation equipment. Cold water to cool the condenser circulates through a jacket around the condenser.

Distillation is used in a range of commercial processes to produce substances such as perfume and a huge range of alcoholic drinks such as whisky. It is also used to produce all the different oil products (called fractions) from crude oil in a process known as fractional distillation.

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Desalination

Fast expanding cities such as Perth are experiencing difficulties in supplying large amounts of fresh water. Desalination is the name given to the process of removing salt and other impurities from salt water. There are two main desalination processes. The first is thermal desalination, which is essentially the distillation process described previously. The second is reverse osmosis, a method that involves ‘pushing’ water through a special membrane which does not allow salt and other impurities to travel through it. Dry salt is not produced, but slightly ‘saltier’ water is returned to the ocean, while freshly desalinated water is produced for the water supply.

Absorption

Have you ever used a kitchen sponge to clean up a water or milk spill? If you have, you have used the process of absorption, whereby liquids are taken up or absorbed by a material, such as a sponge, or by special chemicals, such as charcoal or silica gel. You may have seen pouches of silica gel in supermarket-packaged fresh meat and other materials that need to be kept dry. Silica gel can absorb half its weight in water.

Science Snippet

DNA profiling

DNA fingerprinting can be used at crime scenes if there are samples of blood, saliva, skin or any other tissue. The DNA has to be cleaned up and separated using the separation techniques you have been exploring. The DNA sample is then placed in a gel and an electric field is supplied. The different DNA fragments move within the gel, producing a characteristic pattern for each individual. X-ray photography is generally used to produce a photographic record of the DNA.

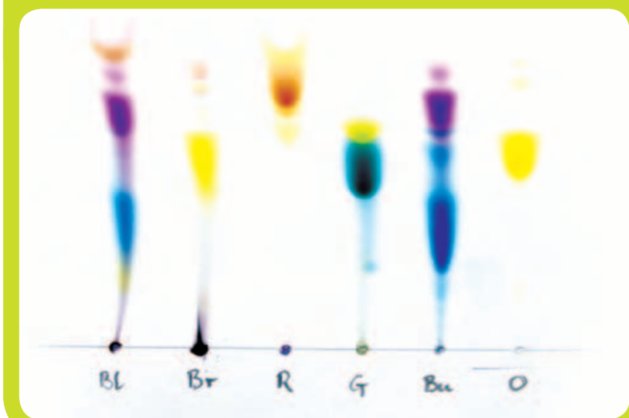
Chromatography

Chromatography is a method of separation that is generally used for small amounts of dissolved materials. It can, for example, be used to separate the different colours found in ink and food dyes. A material such as paper or a special gel (called a medium) is brought in contact with the solution to be separated. Because the materials in solution contain different-sized particles they move at different rates up the medium.

Chromatography also has many applications in forensic science, for example for identifying and separating drugs in blood samples, or identifying the inks used in forged documents.

QuickTime CW Video

Fig 5.7.8 Paper chromatography is used to separate the colours in ink.



Homework book 5.9 Using chomatography

5•7 FOCUS [Questions]

Drag and Drop CW Interactive

Use your book

Solutions

1 Define in your own words what is meant by the following terms: ‘solution’, ‘solute’ and ‘solvent’.

2 A teaspoon of coffee granules is dissolved in some boiling water to make the morning cup of coffee. Give the correct term for each of the following: the coffee granules, the boiling water and the final cup of coffee.

3 Your 7-year-old sister is watching you put a teaspoon of sugar into a glass of water. She makes a comment that the sugar has disappeared. How would you explain the ‘disappearance’ of the sugar to her?

4 Give an example of a solvent that is not water in a solution.

Concentration

5 Draw a simple diagram to explain the difference between a ‘concentrated’ and a ‘dilute’ solution.

Decantation

6 Describe how you would decant water from a mixture of sand and water.

Sieving

7 Give an example of a mixture that you would use a kitchen sieve to separate. Describe how you would do this.

>>

Filtration

8 Draw a diagram that shows how you would use the process of filtration to separate sand from water. In your diagram label where the 'residue' and the 'filtrate' would be located.

Centrifuging

9 Explain where and how a centrifuge could be used to separate a mixture.

Evaporation

10 Draw a diagram to explain how you would use the process of evaporation to remove salt from sea water.

Distillation

11 Sketch a diagram to describe the process of distillation. In your sketch label the following: solution being separated, condenser, distillate.

12 Give three examples of the use of distillation.

Desalination

13 What does the term 'desalination' mean?

14 What are the names of the two processes that are used to desalinate sea water?

Absorption

15 Describe a use of the process of absorption in your home.

Chromatography

16 In what situation would chromatography be used to separate a mixture?

Use your head

17 Filters are used in a number of parts of a vehicle engine, for example air and oil filters. A feature of these filters is the way that they are folded within their container, as shown in Figure 5.7.9. Explain why they are folded this way.

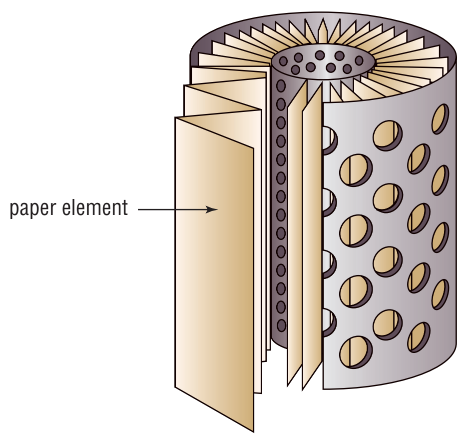


Fig 5.7.9 The inside of a car oil filter

18 You are given a mixture of iron filings, copper sulfate and chalk. Draw a flow chart to describe how you will separate this mixture. You are free to use a range of materials that would be typically found in a science laboratory. In preparation for your investigation, you tested the solubility of copper sulfate and chalk and found that the chalk was insoluble while the copper sulfate was soluble.

19 Explain which separation method would be used for the following situations. For each situation briefly outline how the process works.

- **a** Large rocks need to be separated from sand and very small rocks in a limestone quarry.
- **b** An industrial factory is belching out large amounts of black smoke into the atmosphere.
- **c** Plasma (fluid) needs to be separated from the cells in a blood sample.
- **d** A whisky manufacturer wishes to separate alcohol from a mixture of water and other fermentation products.
- **e** You are trying to make sure that your video camera stays free of any moisture in the air while it is being stored in its bag.
- **f** A mining company needs to remove silver metal from its crushed ore.

Investigating questions

20 Design an investigation to test your ideas of how to separate the mixture of iron filings, copper sulfate and chalk from Question 18. Check with your teacher before proceeding with this investigation.

21 Investigate how a desalination plant would work. Outline the two processes that can be used in these plants, including thermal desalination and reverse osmosis. Describe the process that will be used in Perth and explain why this decision was made. You can visit the *Science Aspects 1* Companion Website on **www.pearsoned.com.au/schools/secondary**. Select Focus 5.7, then Destinations for a suitable website.

Practical activities

Prac 1 Focus 5.7

Magnetic separation and filtration

Purpose

To explore the processes of magnetic separation and filtration to separate a mixture of iron filings, copper sulfate and sand.

Requirements

Newspaper, iron filings, copper sulfate, sand mixture (you can also used coloured crushed chalk), bar magnet wrapped in plastic wrap or inside small plastic bag, container, 100-mL beaker, water, stirring rod, filter paper, evaporating basin, Bunsen burner, conical flask, funnel, safety glasses

Safety note: Wear safety glasses at all times. When heating the copper sulfate take care that the solution does not 'spit', particularly when you get towards the end of the process. Remove the heat before all the water has evaporated. Your teacher should show you what to watch for.

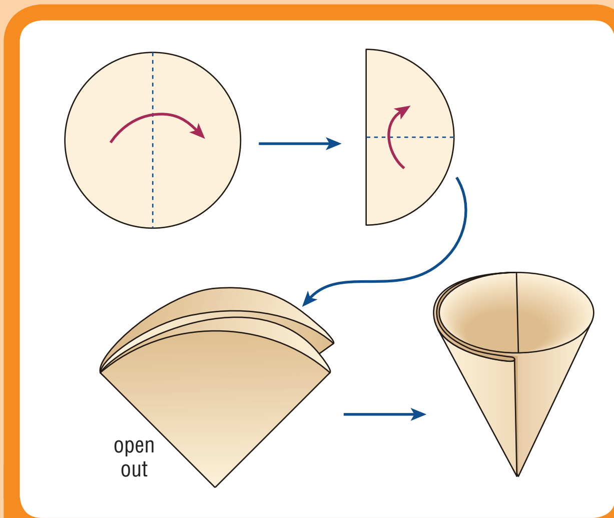
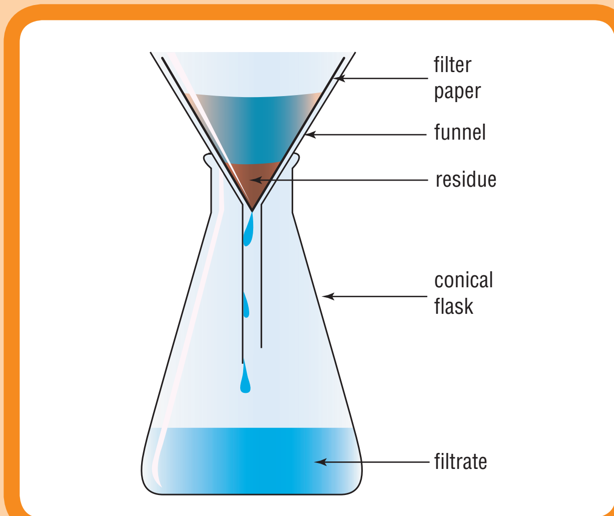


Fig 5.7.10 Method for folding a filter paper



Set up your filtering apparatus as shown. *Fig 5.7.11*

Procedure

1. Before reading this procedure, discuss in your group the process that you think would work. Compare your ideas with the rest of the procedure to follow.
2. Place a sheet of newspaper onto your bench and then place a small pile of the iron filings, copper sulfate and sand mixture on top.
3. Spread the mixture as flat as possible and place the magnet (which should be enclosed in a plastic bag) over the top of the mixture. Collect all of the iron filings that you can from the mixture and place them in a clean, dry container for collection.
4. Put the remainder of the mixture into a beaker and add 50 mL of water. Stir the mixture well. If after stirring, the copper sulfate does not appear to have dissolved, add a little more water.
5. Fold a filter paper as shown as shown in Figure 5.7.10. Place the filter paper into the funnel and tip the mixture through the filter paper.
6. Separate the copper sulfate by placing the solution in an evaporating basin and heating with a Bunsen burner. Remember to follow your teacher's instructions to remove the heat just before all of the water has evaporated.

Questions

1. Write a summary of your investigation, giving the names of the processes that you used in each step.
2. What was the difference in the properties of the copper sulfate and the sand (or chalk) that allowed you to separate the mixture by filtration?

Prac 2
Focus 5.7

Distillation of salt water

Purpose

To explore the process of distillation and how it can be used to produce pure water from a salt water solution.

Requirements

Bunsen burner, wire mat, bench protector, conical flask, tripod, watch-glass, wooden peg, test tube holder, salt solution, beaker, three paper clips, water, safety glasses.

Safety note: Wear safety glasses at all times, avoid the steam by using a wooden test tube holder to hold the watch-glass above the boiling salt solution otherwise you may be scalded.

Procedure

PART A Producing the distillate (distilled water)

1 Assemble the equipment as shown in Figure 5.7.12.

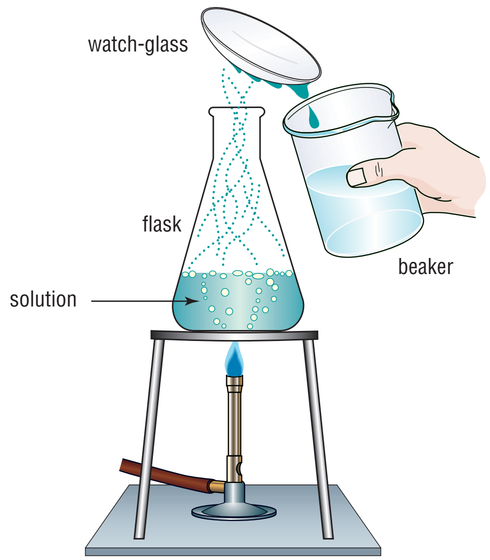


Fig 5.7.12 Set up your equipment as shown. Check with your teacher before you commence and work safely.

2 Use the test tube holder to hold the watch-glass above the boiling solution. Collect your 'distillate' into a beaker. Save the distillate for the next part of this activity.

PART B Testing the distillate

In this next section of the activity you will test the 'distilled water' to see how successful your separation has been.

3 Unfold the three paper clips.

4 Dip one of the ends of the paper clip into the original salt solution and then place this into the blue flame of the Bunsen burner for only a few seconds. This is called a 'flame test'. Observe the colour of the flame.

5 Use another paper clip to repeat the flame test for plain water.

6 Use another paper clip to repeat the flame test for your 'distilled' water.

Questions

1 Were you successful in producing distilled water? Explain using the results of your flame test.

2 Explain why you did not use the same paper clip for the three tests.

3 Think of a modification you could make to your equipment to produce more distillate or prevent the loss of so much steam. Discuss your modifications with your teacher and try it if you are given permission.

FOCUS 5.8

Properties and uses of air

Context

Air is all around us. We can feel it but can't see it and we often just take it for granted. Take it away from us for a short time and we are quickly reminded just how important it is to us. Air is one of the most important mixtures we have on Earth. In this focus you are going to explore this important mixture. What is air a mixture of? What are the special properties of air that make it so useful to us? We also need to reflect on air pollution so that we can work on improving air quality for all our planet's inhabitants, who are also very attached to this very important substance.

The composition of air

Air is a mixture of several gases. The most important of these are oxygen, nitrogen and carbon dioxide but there are many others that occur in measurable amounts, as shown in Focus 2.6. This mixture of gases is called our atmosphere. It lies around the Earth like a blanket, held in place by the effect of gravity.

It is important that you note that percentage of each gas in the atmosphere is only approximate and that there are gases in our atmosphere that are not included in the table shown in Focus 2.6. These can be found at various time during the day, year or at points of local pollution. Some of these gases in the atmosphere include water vapour (which can vary from 0 per cent to nearly 4 per cent in tropical regions), methane gas (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and fluorocarbon 12 (CF_2C_{12}). There are also materials called 'aerosols', which include solid materials such as smoke and dust.

Properties of air

Air has many special properties, most of which you are aware of already from your everyday life. Every breath you take is evidence of the importance of this amazing substance.

Chemical properties of air

Air is a mixture of gases, each with their own special properties. Two of the most important ones are oxygen and carbon dioxide.

Oxygen

When many substances are put in a flame or high temperature in air they react with oxygen. They join to the oxygen atoms in a process called **oxidation**. For example, if you light coal or charcoal in air, the oxygen gas joins to the carbon atoms and makes carbon dioxide gas. If you heat magnesium with a flame in air it ignites and forms magnesium oxide. Burning sulfur in air forms sulfur dioxide.

So all burning reactions must remove oxygen from the air; that is, oxygen supports combustion.

When magnesium burns in air it uses up oxygen. *Fig 5.8.1*

When materials rust, the oxygen reacts with iron, although there is no burning. The oxygen combines with iron and causes it to form a compound of iron and oxygen called rust.

Fig 5.8.2 Rusting is a chemical process that occurs when wet iron comes in contact with oxygen.

To prevent rusting you can paint the surface or coat it in some substance that forms a barrier between the oxygen and the metal.

Fig 5.8.3 Rusting can be prevented by the introduction of a barrier between iron and the oxygen in the air.

Fig 5.8.4 Pollutants in our atmosphere include gases and aerosols and can irritate your respiratory system. Do we really want to see people wearing masks in our cities to help them breathe?

While there are many forms of air pollution, one that you should understand is the **greenhouse effect**. The greenhouse effect has resulted in global warming. It has now been established that average temperatures are increasing due to the increased production of certain gases such as carbon dioxide. The increased amounts of these gases in the atmosphere have resulted in solar radiation being trapped in the atmosphere. These increased temperatures result in a number of effects, including changes to weather patterns.

A summary of the sources and effects of some other major air pollutants is given in the table below.

Carbon dioxide

Carbon dioxide is used by plants in the chemical process of photosynthesis. This was explained in Focus 4.2.

Photosynthesis is probably the most important chemical process on Earth. What an amazing process it is, to provide food, but also replace the oxygen gas in the air. The chemical property of carbon dioxide that makes it useful is that it is the only substance which can react with a compound in plants to start the process of sugar making.

Prac 1 p. 262

Air pollution

Some of the chemical properties of air are due to pollutants. Pollutants are gases or aerosols that have been put into the air because of human activity and are often harmful to our health.

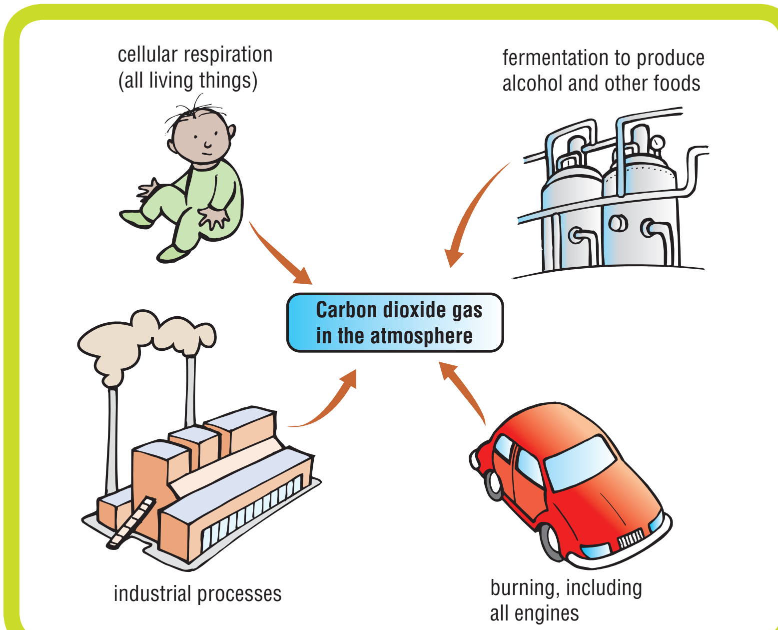


Fig 5.8.5 The increase in carbon dioxide in the atmosphere comes from many sources, including respiration, fermentation, combustion and many different industrial processes.

Pollutant	Sources	Effects
Ozone (lower atmosphere)	Formed when nitrogen oxides from cars and other compounds react with sunlight.	While essential in the upper atmosphere, close to the ground it can irritate the respiratory system and cause asthma attacks.
Carbon monoxide	Engines burning fossil fuels—particularly if they are not tuned correctly.	Breathing difficulty, dizziness, lack of breath, headaches
Nitrogen dioxide	Power plants and cars.	Coughing, shortness of breath
Sulfur dioxide	Burning coal and oil in power plants.	Breathing difficulty, asthma, can harm trees and crops
Lead	Burning unleaded fuel. Power plants and industrial sources.	Can cause decrease in IQ in young children
Particulate matter	Solids or particles, including smoke, dust, sea spray and dandruff.	Skin and eye irritation, cancer
Toxic air pollutants	A range of materials from asbestos, dioxins and formaldehyde (methanal)	Cancer, birth defects, irritation to eyes and nose

Physical properties of air

Air is a real substance. This means it takes up space and has mass. You can prove this simply by turning a glass upside down and then pushing it into water. The water will not enter the glass as the glass is already full of air. Air is a gas and its physical properties are all related to this.

Prac 2 p. 263

Elastic nature of air

Like all gases, air can be compressed into a smaller volume. When the compression force is removed from the air it returns to its original volume. This 'elastic property' of air can be used to drive machines known as pneumatic devices, such as jack hammers, drills and air guns used to remove wheel nut tyres.

Fig 5.8.6 The energy in the air is being used in this jack hammer device.

Moving air

Moving air has energy. While this energy can sometimes be destructive, it can also be used to turn windmills to pump water, produce electricity and push yachts and windsurfers through water. Wind energy is being explored in many countries, including Australia, as an 'alternative energy'. This will produce pollution-free electricity and decrease the amount of greenhouse gases being pumped into the atmosphere.

Science Snippet

Who puts the bubbles in bread?

Bread rises because of carbon dioxide rising through the mixture prior to it being baked. The carbon dioxide is produced by living cells called yeast. Yeast is added to the bread mixture before baking. The dough is kept covered and warm as the yeast multiplies and causes the sugars in the bread mixture to ferment to produce carbon dioxide. A similar effect can be caused in cakes by adding baking powder (sodium bicarbonate), which decomposes during cooking to produce carbon dioxide and so causes the cake to rise during cooking.

Fig 5.8.7 The energy in moving air can be used to produce electricity, reducing greenhouse gases.

Heating air

When air is heated it expands. As the particles move further apart it becomes less dense and rises. This rising hot air is the cause of air turbulence you might have noticed when you've been flying in a plane. On a larger scale, hot air above large land masses will rise, creating a low pressure region. Cooler air from above the ocean will move into this area, creating a sea breeze. On a smaller scale, a hot-air balloon uses a propane gas burner to control the production of hot air.

Warmer rising air can also be removed from homes and buildings by placing a ventilation fans or vents near the ceiling. The warmer air rises and moves out through the vents and is replaced by cooler air that flows in through the windows or under doors.

Fig 5.8.8 A propane gas burner is used to heat the air in this balloon, causing it to rise. As the air in the balloon cools it will become more dense and the balloon will fall.

Air as an insulator

Air is an effective insulator against heat, cold and noise. Double-glazed windows consist of two panes of glass separated by a layer of air and are very effective in reducing noise.

Clothing also makes use of the insulating effects of air. Loose-fitting clothing, in particular, traps a layer of air between the clothing and your skin, reducing heat loss to the environment and keeping you warm.

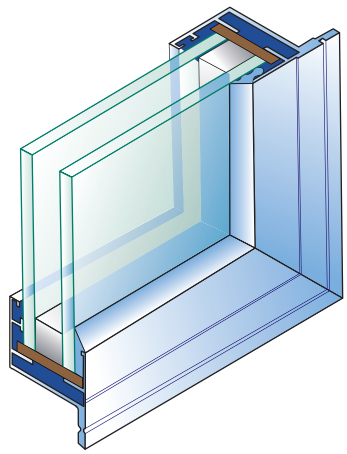


Fig 5.8.9 Double-glazed windows provide insulation for the movement of heat as well as reducing noise levels between the outside and inside of the home or office.

Homework book 5.10 Home experiments on air

FOCUS 5•8 [Questions]

Use your book

The composition of air

1 Why is air called a mixture and not a compound?

2 Which atmospheric gas best fits the description below?

- **a** The most abundant gas in the atmosphere.
- **b** A gas used by plants in the process of photosynthesis; also the best known greenhouse gas.
- **c** A gas used by all living things in the process of chemical respiration that produces energy for cells.

Properties of air

3 Explain why a flame will burn much brighter in pure oxygen gas than air.

4 Explain why a coating of paint or plastic will reduce rusting.

5 Describe three gases that contribute to air pollution.

6 'Air is a real substance'. Describe what is meant by this statement and explain how you would prove this to a fellow student.

7 Moving air has energy. Describe three situations in which this energy is useful and three in which it is not useful.

8 What is meant by the 'elastic nature' of air. How can this property be used?

9 Explain how a hot-air balloon works.

10 Describe why a jumper is more effective if it is loose and baggy rather than tight-fitting.

Use your head

11 A tennis ball bounces to a reasonable height when dropped onto hard ground, but if the ball has a hole or split in it, it does not. Use the properties of air to explain why.

12 Ozone was mentioned in this focus as both an important gas in our atmosphere and a pollutant. Explain how this is possible.

13 The partially completed concept map in Figure 5.8.10 shows the important balance between oxygen and carbon dioxide in the atmosphere.

Use this concept map to explain the importance of maintaining the balance between oxygen and carbon dioxide gas in the atmosphere.

14 In 1967 a fire onboard a NASA experimental space capsule killed all three astronauts. Their capsule was using a 100 per cent oxygen environment and a small electrical fault caused a spark. Soon after, NASA stopped using pure oxygen in their capsules and switched to a 60 per cent oxygen, 40 per cent nitrogen mix. Explain why this gas mixture is a safer combination to use.

Investigating questions

15 Investigate the issue of global warming. You could use a concept mapping program such as Inspiration to store and organise your information. Your investigation should include the answers to the following questions:

- What are some greenhouse gases other than carbon dioxide that are contributing to the problem?
- What are the possible consequences of global warming?
- Explain some of the ways that governments are trying to deal with the problem. In your answer outline what the Kyoto Protocol is about and how this would help with greenhouse gas emissions.

You could also make a PowerPoint presentation that summarises what you have discovered as well as provides some suggestions for doing something about global warming.

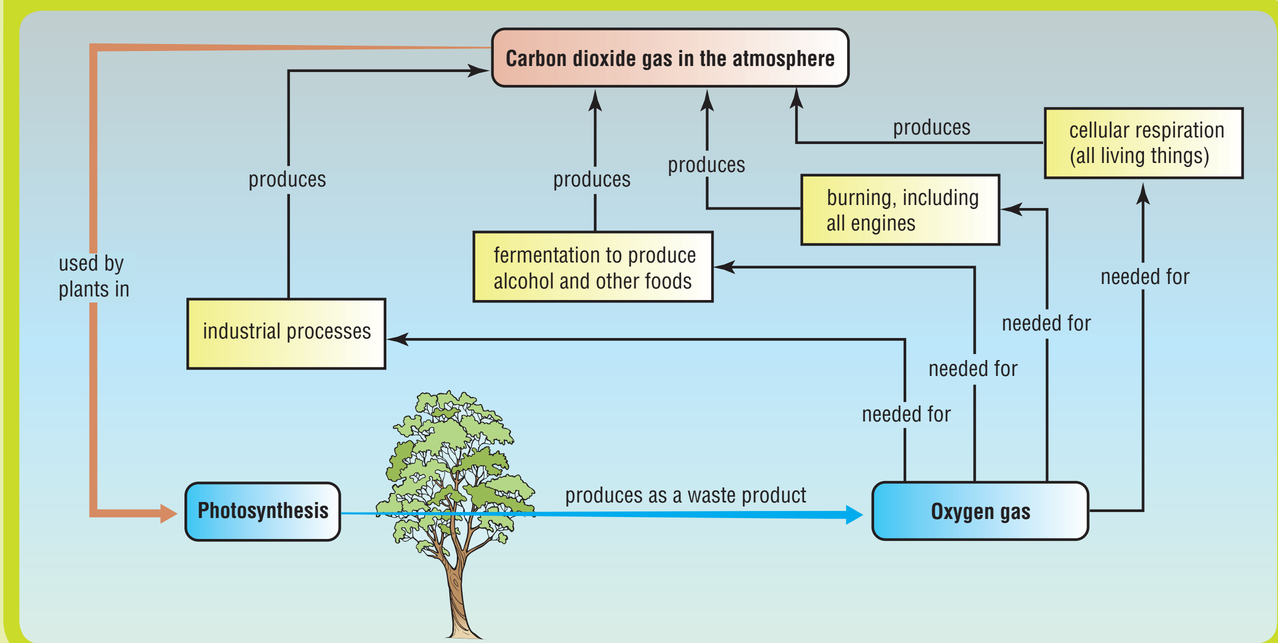
16 Glider pilots have to know about 'thermals' if they wish to stay in the air for extended periods of time. Research thermals and find out:

- what they are
- why they are important to glider pilots
- where are they most likely to be found and why.

17 Find out how to design your own model hot-air balloons. They can be made using inexpensive items such as garbage bags and wire. You can use cotton wool and firelighters to provide the heating flame. Show your design to your teacher before proceeding. Find out about fire restrictions before flying your balloon.

DYO

Fig 5.8.10 The balance between oxygen and carbon dioxide gas is very important.



5·8 FOCUS [Practical activities]

Prac 1 Focus 5.8

Preparation and properties of oxygen and carbon dioxide gas

Purpose

To prepare and compare the properties of oxygen and carbon dioxide gas.

Requirements

Safety note: Safety glasses must be worn at all times.

Conical flask with stopper and gas delivery tube, manganese dioxide (several pieces), hydrogen peroxide (40 mL of 2M), ice-cream container or pneumatic trough, two gas jars, water, wooden splint for burning (popstick), steel wool, Bunsen burner, marble chips (teaspoon), hydrochloric acid (1M), round-bottomed flask, thistle funnel, blue litmus paper, small candle in a beaker, matches, plastic teaspoon.

Procedure

PART A Production and properties of oxygen gas

1 Collect and set up the equipment as shown in Figure 5.8.11. Do not add any chemicals yet.

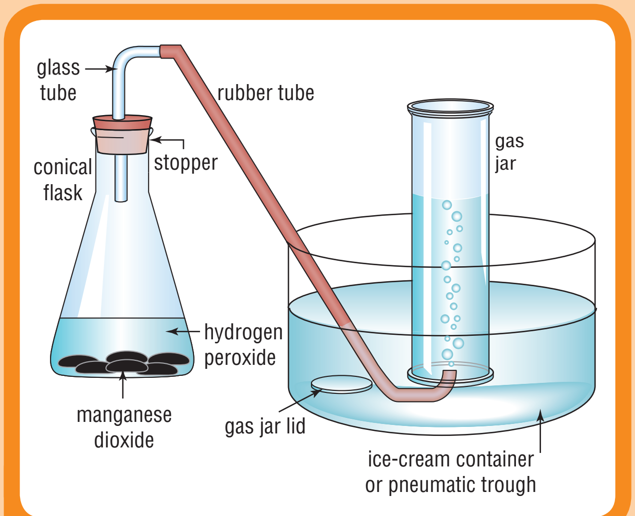


Fig 5.8.11 Set-up required for the production of oxygen gas

2 Place a few pieces of manganese dioxide (MnO_2) into the conical flask.

3 Carefully add 80 mL of hydrogen peroxide to the flask.

4 Place the stopper with the gas delivery tube attached into the conical flask. Allow the first few bubbles to escape, as this is mostly air.

5 Fill two gas jars with water and turn them upside down into the glass trough. Collect two gas jars of oxygen gas. You know they are filled as the water is displaced by the oxygen gas.

You can store the oxygen gas for a few minutes by placing a glass lid over the mouth of the gas jar before you get it out of the water trough.

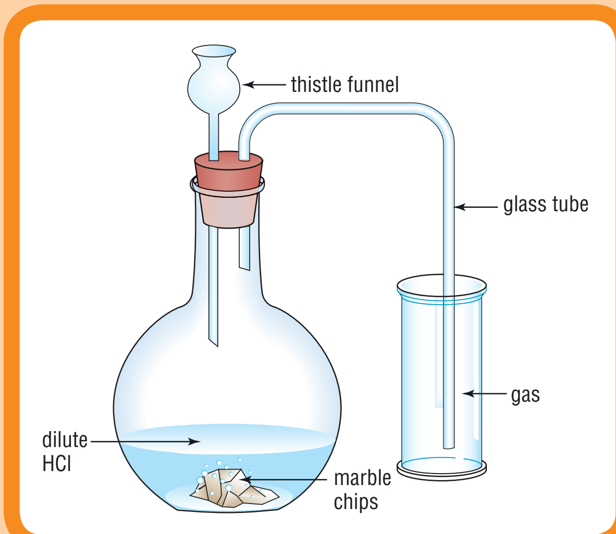
6 *Observe and record the colour of the oxygen gas.*

7 Light a thin piece of wood (a pop stick will do) and blow on it until is just glowing. Plunge the glowing splint into the gas jar and observe. *Record what you observe.*

8 Hold a small piece of steel wool in some metal tongs. Heat the steel wool in a blue Bunsen flame until it is glowing red. Observe how well it burns in air. Heat another piece of steel wool and plunge it into a jar of oxygen gas. Observe and record what happens.

PART B Production and properties of carbon dioxide gas

1 Collect and set up the equipment as shown in Figure 5.8.12. Do not add any chemicals yet.



Set-up required for the production of carbon dioxide gas *Fig 5.8.12*

2 Place a teaspoon of marble chips into the bottom of the round-bottomed flask. Cover this with dilute hydrochloric acid and let it bubble for 30 seconds or so.

3 Collect 2 gas jars of carbon dioxide as shown in Figure 5.8.12. You can check that the jar is filled with carbon dioxide by placing some damp blue litmus paper on the top lip of the gas jar. When it starts to turn red, the jar is filled with carbon dioxide.
4 Light a splint and get it burning well. Plunge the burning splint into one of the jars. *Observe and record what happens.*
5 Light a candle that is secured upright by plasticine on the bottom of a beaker. 'Pour' one of the jars of carbon dioxide over the top of the burning candle. *Observe and record what happens.*

Questions

1 Which of the two gases supports burning? Explain your answer.
2 Explain how the burning changed for the steel wool in air compared with pure oxygen.
3 Carbon dioxide is a dense gas that is 'heavier than air'. Do your observations support this? Explain your answer.
4 Carbon dioxide gas can be tested for by using limewater. If you have time and permission you might like to try this by bubbling a small amount of carbon dioxide through a solution of limewater. You should also try bubbling oxygen gas through limewater as well for a comparison. You could also try exhaling some of your breath through the limewater as well.

Prac 2
Focus 5.8

Air is a real substance

Purpose

To investigate the properties of air that make it a 'real substance'.

Requirements

Two 250 mL beakers, large trough of water, glass funnel, small glass bottle, plasticine, drinking straw.

Procedure

PART A Air can be transferred from place to place

1 Place one beaker into the trough so that if fills with water as shown in Figure 5.8.13.
2 Push the second beaker, open end down, into the trough of water. *Record what you see and feel as you do this.*

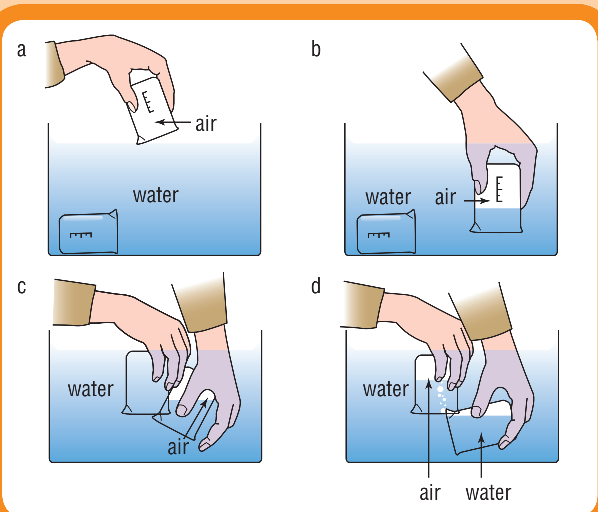
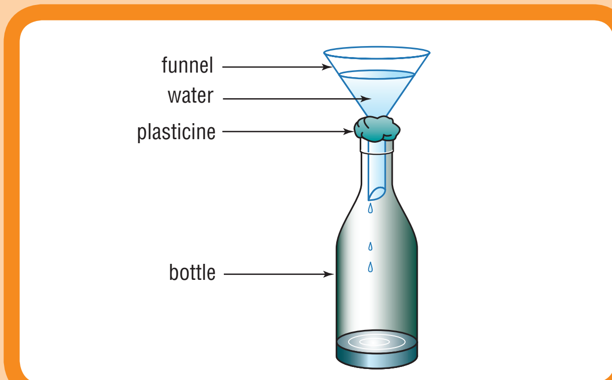


Fig 5.8.13 Investigating air

3 Hold the beaker filled with water above the beaker filled with air as shown in Figure 5.8.13.
4 Tilt the lower beaker so that the air flows from the bottom beaker to the top beaker and *record your observations*.

PART B Showing air occupies space

1 Place a funnel into the neck of the bottle and seal it with plasticine as shown in Figure 5.8.14.



Air is a real substance. *Fig 5.8.14*

2 Pour water into the funnel and *record your observations*.
3 Poke the drinking straw through the funnel into the bottle and *record what happens*.

Questions

1 What evidence is there that air is a real substance?
2 Explain your observations in Parts A and B of this investigation, including the purpose of the straw in Part B.

Review questions

Second-hand data

1 A group of students do an experiment to test the hypothesis that: 'As the solvent temperature increases, so does the solubility of the solute'.

To test their hypothesis, the students select three different solutes and then measure how much of each solute will dissolve in 100 mL of water at different temperatures.

Their results are shown in the table opposite:

a Construct a graph that summarises your results. Put all the results on the one graph.

b List as many factors as you can that would have to be controlled in this investigation to make sure that it was a 'fair test'.

c For each solute, write a sentence to describe the solubility of the solute as the temperature is increased.

d Was the students' hypothesis correct? Explain your answer.

Temperature	Amount of solute (g) dissolving in 100 mL of water		
	Solute A	Solute B	Solute C
10	1.5	4.2	0.2
20	2.0	3.6	0.4
30	2.3	3.3	0.6
50	2.9	2.8	1.3
60	3.3	2.5	1.8
70	3.4	2.3	4.2
80	3.5	2.1	3.0
100	3.5	1.8	5.5

Open-ended questions/experimental design

2 The second-hand brick market is big business as home builders try to reduce costs. Home restorers also often prefer to use older style bricks. You own a brick cleaning business. You are just setting up and you are exploring how to best remove the old cement from the bricks. Your research uncovers that hydrochloric acid (HCl) is very effective in reacting with the old cement and dissolving it from the brick.

You are to design an investigation which explores the most effective conditions to dissolve the cement from the bricks. You should follow these steps:

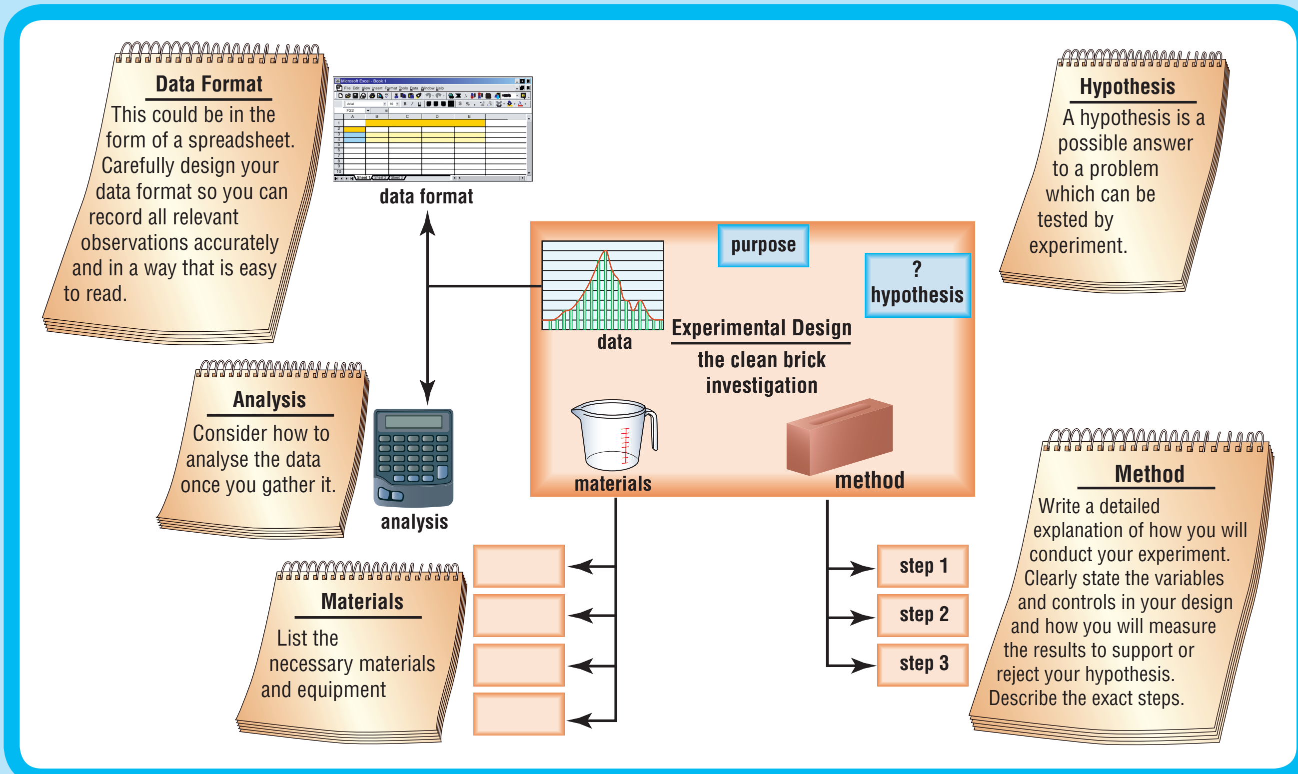
a Brainstorm with your research team some potential experimental (independent) variables that you could test. You may have time to test a couple of variables.

You might like to use a concept mapping program to prepare your investigation. Figure 5.9.1 will give you an idea as to how to set up your investigation.

b Your teacher may provide you with a scaffolding sheet to help you with your experimental design.

c Chalk is very similar in composition to cement and will react with hydrochloric acid in a very similar way. You can use chalk in place of old cement during your investigation.

d Check with your teacher before you commence the investigation.



You might like to use a concept mapping program to design your investigation. *Fig 5.9.1*

[Extended investigation/research]

3 You are to prepare a concept map that summarises all the special characteristics and relationships of matter that you have been studying—but don't panic yet, it has been started for you! The concept map in Figure 5.9.2 has been partially completed but needs you to finish it off. You are also required to add some joining statements.

You should use a concept mapping program if you can, but alternatively you could create this on a piece of butchers papers to hang up in your classroom.

4 As a result of climate change, countries such as Australia are turning to new ways of producing fresh water from salt water using the process of desalination. As outlined in Focus 5.7, there are two main desalination processes. These are thermal desalination and reverse osmosis. You are to prepare a report which compares and contrasts these two methods. The following questions need to be answered in your report:

a How do the two processes work?

b What are the advantages of each method?

c What are the disadvantages of each method?

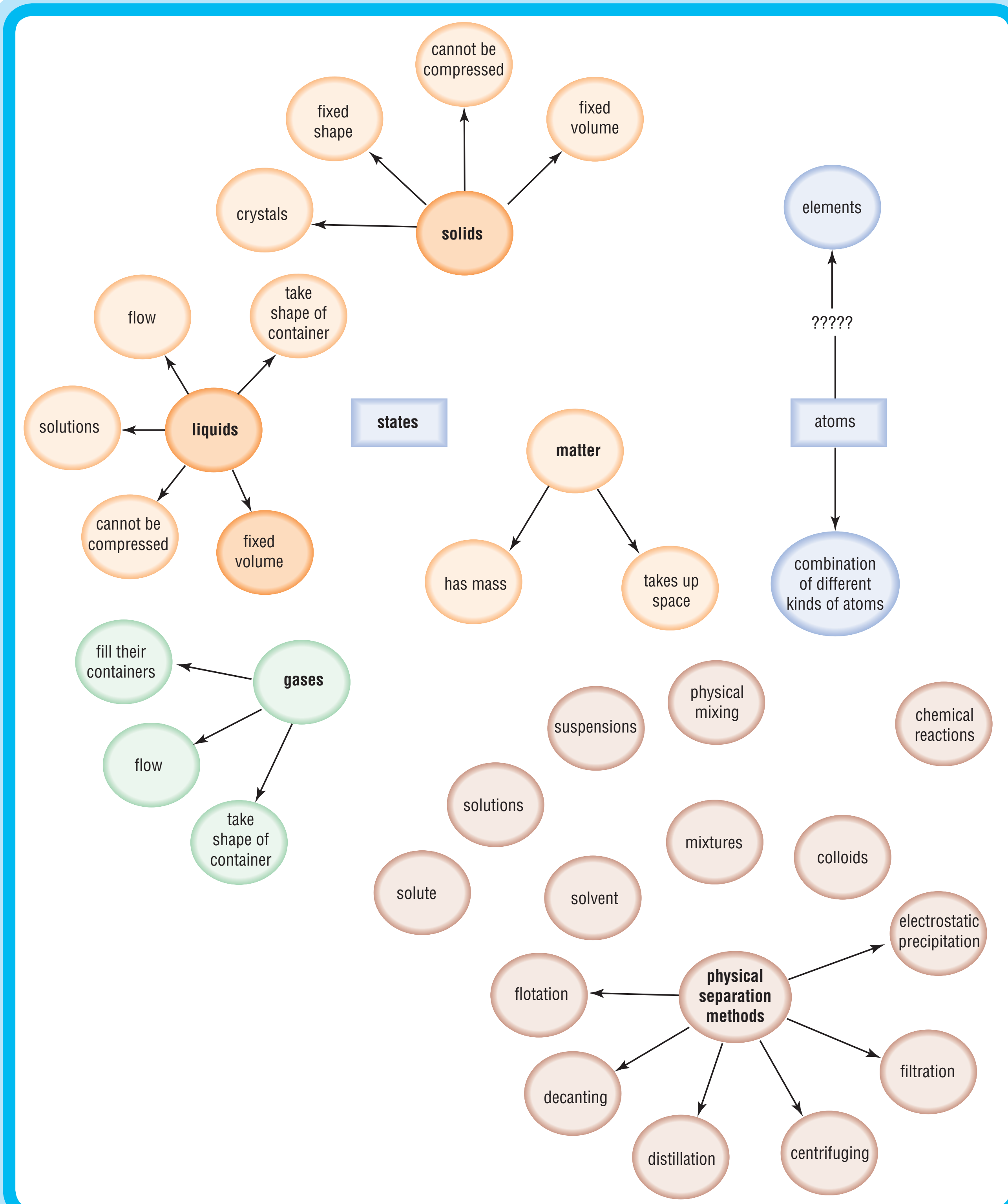
d Where else in the world are major desalination plants located? What type are they?

e If you are living in Perth, you should consult the Water Corporation website (go to *Science Aspects 1* Companion Website at **www.pearsoned.com.au/schools/secondary** for a link to their website) and find out where the desalination plant is going to be located.

f A major criticism of desalination plants is that they produce considerable greenhouse gases. The Water Corporation in Perth talks about 'offsetting' greenhouse gas production. What does this mean and how could they do it?

You might like to consider presenting your report in a number of ways. Your teacher will discuss this with you. These could include:

- a presentation to your class using presentation software
- a wall chart
- a TV or radio interview where one member of your group can take on the part of 'desalination expert'. You could use a digital video camera to record and prepare your interview.



Complete this concept map, which shows the special characteristics and relationships of matter. *Fig 5.9.2*

Homework book 5.13 Natural and Processed Materials crossword

Homework book 5.14 Sci-words

Index

Numbers in **bold** refer to definition terms in **bold** type in the text

NOTES

NOTES

Navigating *Science Aspects 1* Student CD

To launch *Science Aspects 1* Student CD, place the CD in your CD drive. It should launch automatically. If not, double click on 'Setup'. If you have problems consult the 'ReadMe' file on this CD. If you opt to copy the files to your hard drive, subsequently launch the program by selecting Start/Programs/ScienceAspects1/Start.pdf (Windows), or double click the 'ScienceAspects1' icon on your desktop (Mac OS X).

Buttons on the CD Home page

- Click on the coursebook button to enter the book. Use the Bookmarks in the sidebar to find the content you want. Use the arrows and page numbers at the bottom of the screen to page through the book.

- Click on the 'Companion Website–on CD' button to go to an offline copy of the Companion Website. No Internet connection is required.

- Click on the 'Companion Website–live button' to go to the live Companion Website. An Internet connection is required.

- Click on the 'How to' button if you need more information on how to use this package.

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Minimum system requirements

Windows

- An Intel Pentium processor-based PC
- Microsoft Windows 98 Second Edition or greater
- At least 128 MB of RAM
- 700 MB of available hard disk space
- Internet Explorer 5.01, 5.5, 6.0 or 6.1

Macintosh

- A 400 MHz PowerPC G3 or better
- Mac OS X v.10.2.6–10.3
- At least 128 MB of RAM
- 700 MB of available hard disk space
- Internet Explorer 5.2.3

Software requirements

- Adobe Reader 6 or greater (provided on this CD)
- QuickTime 6.5 or greater (provided on this CD)
- Internet Explorer 5.x or greater (free download)
- Flash Player 6 or greater (free download)
- Microsoft Office Suite

Quick guide to Adobe Reader

For a more detailed guide, open Adobe Reader, click the 'Help' menu and click 'Adobe Reader Help…'.

Click the Open button and choose the desired filename to open a PDF document. (PDF documents usually have the extension .pdf.)

Select the Hand tool. When the pointer is over a linked area on the page it changes to a hand with a pointing finger. Click the link. (The hand has a plus sign in it if the link points to the Web.)

Click the arrow next to the magnifying glass to see the zoom-in and zoom-out tools—or use the plus and minus icons.

Rotate view 90° clockwise

Rotate view 90° counter-clockwise

Click the Print button, specify options, and click OK. (Most of the options are the same as they are for other applications.)

Top toolbar

To copy and paste text or graphics, click the arrow next to the icon and choose between the Text tool and the Image tool. Select the desired text or graphic. Click your right mouse button while pointing at the selected graphic or text and select 'Copy to clipboard'. You can paste your selection into a document in another application such as MS Word.

Click these icons to zoom to preset page views.

Click the camera icon then drag your mouse to frame the image and simultaneously copy it to the clipboard. You can then paste it into a document in another application such as MS Word.

Side tabs
(click to show or hide)

Bookmarks can mark parts of a document for quick access, or link to page views in other documents.

Pages shows thumbnails of pages, which you can use to move quickly around the document.

First page

Previous page

Current page in a document

Next page

Bottom toolbar

Last page

Previous view

Next view

You can use four page layouts when viewing PDF documents:

- **Single Page layout** displays one page in the document pane at a time.
- **Continuous layout** arranges the pages in a continuous vertical column.
- **Continuous-facing layout** arranges the pages side by side. This configuration accommodates a two-page spread display and multi-page viewing.
- **Facing layout** arranges two pages side by side.

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