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Australian Curriculum

Science Essentials 7

Australian Curriculum edition

Ken Williamson Anne Garton

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Ken Williamson Anne Garton

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Internet addresses
At the time of printing, the internet addresses appearing in this book were correct. Owing to the dynamic nature of the internet, however, we cannot guarantee that all these addresses will remain correct.

Warning: It is recommended that Aboriginal and Torres Strait Islander peoples exercise caution when viewing this publication as it may contain images of deceased persons.

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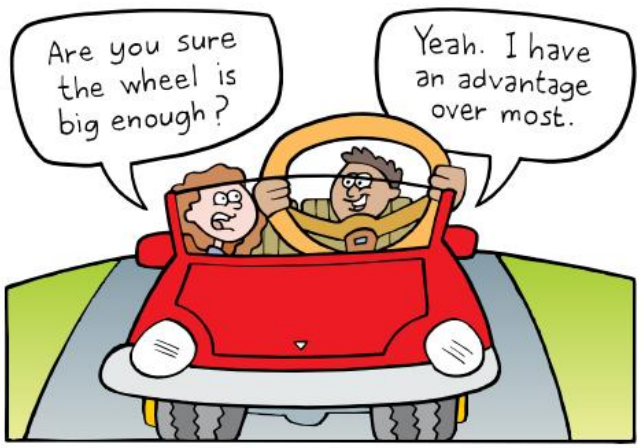

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Getting to know the book

In writing this book we have tried to make science enjoyable by talking about things in your everyday life and making them easy to understand. To get to know the book we suggest you work through the questions on this page and the next. You may want to do this in a small group.

Focus for learning

At the beginning of each chapter there is a short section which explains how the chapter is relevant to you and the world around you. There is also a list of what you will do in the chapter and important words.

At the start of each chapter there is also a problem for you to work on over several weeks. You will often work with other students on this problem. Sometimes you will design your own experiments, sometimes you will prepare a presentation for the class, and sometimes you will make something. For example, in Chapter 3 page 46 you have to purify some dirty water to make it safe to drink. As you work through the chapter you will learn things that will help you with your problem.

Throughout the chapter you will find *Problem-solving* reminders and suggestions to help you complete your problem.

- Find the *Problem-solving* tasks in each of the 12 chapters. Which one of these looks the most interesting to you?

Inquiries and investigations

Most chapters have five short sections. In most lessons there are activities called *Inquiries* — to help you understand things better. There are also about three *Investigations* per chapter, where you will work in a science laboratory and write a report.

- Look through the book. What differences do you notice between *Inquiries* and *Investigations?*

At the beginning of each *Investigation* there is a section called *Risk assessment and planning*. It is essential that you read the investigation carefully before you start. You then discuss with your teacher any risks involved and how to reduce these risks. If necessary you also prepare data tables or spreadsheets where you can record your results.

- Have a look at *Investigation* 1 on page 13.

In each chapter there is a page where you learn science skills such as handling chemicals safely. You also learn communication skills such as reading scientific articles, and science inquiry skills such as predicting.

- Use the Contents on the previous pages to find some of the *Skills*.

In Chapter 3 your problem is to purify some dirty water.

SCIENTISTS AT WORK

In each chapter there is a page where you can find out about the work done by scientists now and in the past.

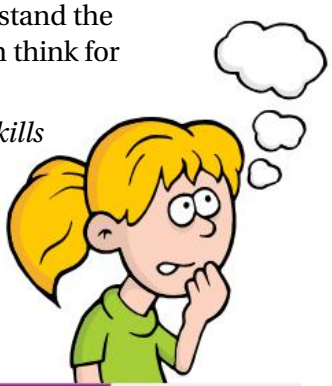
- Make a list of the scientists featured in *Scientists at work*. There are also special pages called *Science as a human endeavour* which are designed to show how science is used in everyday life.

THINKING SKILLS

At the end of each section there is a set of exercises called *Over to you*. These are designed to test your science knowledge and understanding.

Towards the end of each chapter there is a section called *Thinking skills*. The exercises here are more difficult than those in *Over to you* and are designed to check how well you understand the chapter and whether you can think for yourself.

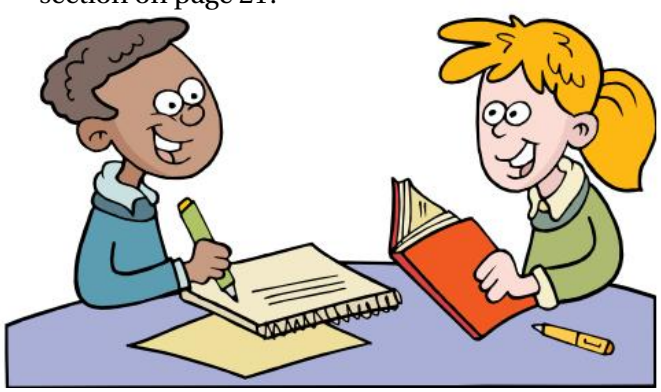
- Have a look at *Thinking skills* for Chapter 3 on page 64. Could any of these exercises be turned into a science project? Which ones?



Self-management

At the end of each chapter there is a page to help you summarise and revise the chapter.

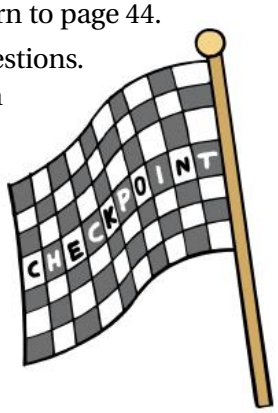
- Turn to page 21. Check the *Knowing and Understanding* where you use the words on the right to fill in the gaps. See if you can do any of them.
- What is the purpose of the *Self-management* section on page 21?



Checkpoint

Checkpoint is where you can check your knowledge, understanding and skills from the chapter before any tests your teacher gives you. Turn to page 44.

- Try one or more of these questions. Then check your answers on page 269.
- What should you do if you can't do the *Checkpoint* questions?



Glossary and Index

- Important new words are in bold in the text and their meanings are in the Glossary starting on page 276. Look through it and find a word you haven't seen before. Read its meaning and then find where the word is used in the book.
- Use the index to find out which page you would find information on
  - the Newcastle earthquake
  - Emma Cooney
  - recycling of plastics.

Check the page to see what information there is.

We hope you enjoy *Science Essentials*.

Ken Williamson
and Anne Garton

Links to the Australian Curriculum

The content elaborations in the right-hand column are listed at the beginning of each chapter. They indicate *some* of the ways in which the Australian Curriculum content descriptions have been elaborated in *Science Essentials 7*.

Science Understanding	*Science Essentials 7* Elaborations
Science Understanding is fully integrated with Science Inquiry Skills, as indicated in the elaborations.	
Biological sciences There are differences within and between groups of organisms; classification helps organise this diversity (ACSSU111)	**Chapter 4 Biological classification** group a variety of organisms on the basis of similarities and differences in particular features use keys to identify, sort and name organisms describe the classification system introduced by Carolus Linnaeus identify problems in the classification of lichens, corals, viruses and carnivorous plants
Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions (ASSSU112)	**Chapter 5 Survival** use food chains to show feeding relationships in a habitat describe how cane toads have affected the other organisms in an existing food web
Chemical sciences Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)	**Chapter 3 Separating mixtures** recognise the differences between pure substances and mixtures, and identify examples of each identify the solvent and solution in a variety of solutions investigate a range of separation techniques such as filtration, distillation and chromatography
Earth and space sciences Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)	**Chapter 12 Earth, moon and sun** compare times for the rotations and orbits of the Earth, moon and sun model the relative movements of the Earth, sun and moon to show how phases of the moon and eclipses occur relate the tides to the positions of the Earth, moon and sun
Some of the Earth's resources are renewable, but others are non-renewable (ACSSU116)	**Chapter 10 Using our resources** give examples of renewable and non-renewable resources discuss how resources such as forests and plastics can be used sustainably
Water is an important resource that cycles through the environment (ACSSU222)	**Chapter 2 Kitchen chemistry** consider the water cycle in terms of changes of state **Chapter 9 Planet Earth** apply a knowledge of the water cycle to explain the formation of clouds and rain describe how the presence of water vapour in the atmosphere affects the weather **Chapter 10 Using our resources** pages 207–209 discuss ways of saving water around the house

continued >>>

Physical sciences Change to an object's motion is caused by unbalanced forces acting on the object (ACSSU117)	**Chapter 6 Forces** distinguish between contact forces (such as pushing) and non-contact forces (such as gravity) investigate common situations where forces are balanced (such as stationary objects) and unbalanced (such as falling objects) **Chapter 7 Simple machines** give examples of how a simple machine can magnify the force you use, change the direction of the force, speed things up or transform energy give examples of different types of levers and pulleys in everyday devices **Chapter 9 Planet Earth** apply a knowledge of balance and unbalanced forces to everyday situations such as drinking through a straw or floating in salt water
Earth's gravity pulls objects towards the centre of the Earth (ACSSU118)	**Chapter 6 Forces** explore how gravity affects objects on the surface of the Earth and in orbit around the sun **Chapter 12 Earth, moon and sun**

Science as a Human Endeavour	*Science Essentials 7* Elaborations
Science as a Human Endeavour is integrated with Science Understanding.	
Nature and development of science Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world (ACSHE119)	**Chapter 6 Self-management** page 131 demonstrate an understanding of the first compass—invented by the ancient Chinese civilisation **Chapter 7 Scientists at work** page 151 appreciate the contributions made by Archimedes to scientific knowledge, engineering and technology **Chapter 11 *Jurassic Park*** recognise the significance of fossils in the development of the geological time scale **Chapter 12 Earth, moon and sun** pages 248–249, 257 examine Aboriginal and Chinese stories about eclipses and day/night
Science knowledge can develop through collaboration and connecting ideas across the disciplines of science (ACSHE223)	**Chapter 4 Inquiry 7** page 80 investigate plants used as food by Aboriginal people **Chapter 8 Didgeridoo** page 172 explain in simple terms how a didgeridoo works
Use and influence of science Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations (ACSHE120)	**Chapter 6 Boomerangs** page 116 investigate how boomerangs used by Aboriginal people were designed to make tasks easier to perform **Chapter 7 Woomera** page 142 discuss the woomera as an example of Aboriginal technology **Chapter 8 Sound** pages 167–168 describe how the reflection of sound is used in ultrasound imaging and echolocation **Chapter 11 Should we create a *Jurassic Park*?** page 243 discuss in a small group whether scientists should bring dinosaurs back to life

Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management (ACSHE121)	**Chapter 5 Scientists at work** page 104 describe the contribution of an Australian scientist working to protect the environment **Chapter 10 Aboriginal bush medicines** page 218 research the use of bush medicines by Aboriginal people
People use understanding and skills from across the disciplines of science in their occupations (ACSHE224)	**Chapter 3 Scientists at work** page 54 investigate a career in water treatment **Scientists at work** page 238

Science Inquiry Skills	*Science Essentials 7* Elaborations
Science Inquiry Skills are fully integrated with Science Understanding and can be developed through the various learning activities in *Science Essentials*—Problem Solving, Inquiry, Investigation, Skill, Over to you, Thinking Skills and Self-management.	
Questioning and predicting Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)	**Chapter 2 Problem solving** page 23 **Chapter 2 Kitchen chemistry** explain observations and make predictions
Planning and conducting Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)	**Chapter 1 Nature of science** use equipment and chemicals safely, including a Bunsen burner make accurate observations and measurements **Chapter 2 Kitchen chemistry** observe physical and chemical changes **Chapter 3 Separating mixtures** use scientific equipment correctly and handle chemicals safely **Chapter 5 Problem solving** pages 89, 105 research an Australian animal that is extinct or in danger of becoming extinct **Chapter 7 Problem solving** pages 133, 141, 152 work in a group to make an everyday gadget and explain how it uses simple machines **Chapter 8 Sound** investigate a range of musical instruments to compare the frequency, quality and intensity of the sounds produced do simple demonstrations of how sound travels through different materials **Chapter 9 Making gases** page 186 use laboratory equipment to make the gases hydrogen, oxygen and carbon dioxide
In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS126)	**Chapter 5 Investigation 3** page 102 design an experiment to investigate how plants are affected by factors in the environment such as light and temperature **Chapter 7 Simple machines** conduct investigations into the mechanical advantage of levers, pulleys and bicycle gears **Chapter 10 Nasty nappies** page 217

continued >>>

Processing and analysing data and information Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS129)	**Chapter 2 Investigation 2** page 29 record measurements in a table and draw a graph **Chapter 9 Skill** page 197 distinguish between dependent and independent variables and interpret line graphs **Chapter 12 Skill** page 253 accurately map the positions of objects in the sky
Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS130)	**Chapter 2 Kitchen chemistry** give examples of how different materials have different uses, depending on their properties **Chapter 4 Inquiry 9** page 83 use a table to summarise differences between the five kingdoms of living things **Chapter 8 Sound** pages 173–175 use a diagram to explain how the human ear works **Chapter 10 Using our resources** use flow diagrams to describe manufacturing processes **Chapter 11 *Jurassic Park*** pages 226–227, 232, 237 use a knowledge of modern animals to reconstruct an ancient animal from fossil bones investigate the dinosaur footprints at Lark Quarry, near Winton in central Queensland
Evaluating Reflect on the method used to investigate a question or solve a problem, including evaluating the data collected, and identify improvements to the method (ACSIS131)	**Chapter 3 Problem solving** pages 46, 53, 58, 65 discuss the success of a water purification project and suggest possible improvements **Chapter 6 Thinking skills** page 130 reflect on the method used to investigate a question or solve a problem **Chapter 11 Making fossils** page 225 simulate the formation of plant and animal fossils and suggest modifications to your methods to improve them
Use scientific knowledge and findings from investigations to evaluate claims (ACSIS132)	**Chapter 11 *Jurassic Park*** pages 239–243 evaluate from a scientific perspective the idea of bringing dinosaurs back to life **Chapter 12 Moon landing hoax** page 264 evaluate the claim that the *Apollo 11* landing was a hoax
Communicating Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133)	**Chapter 1 Nature of science** draw science equipment correctly write a report of a science experiment **Chapter 9 Problem solving** page 180 write a report on Earth by aliens from the imaginary planet Dork

Source: Australian Curriculum, Assessment and Reporting Authority (ACARA)

1

Nature of science

The beginning of each chapter in this book starts with a problem for you to do. The information in the chapter will help you. The task is presented first so that you are able to plan ahead and know what to look for in the chapter.

PROBLEM SOLVING

Headline news

Your task here is to find an amazing piece of information about science. Go to the library and locate the science books, science articles, science reference material and listed science internet addresses. Reading this chapter will also help.

1. Present your information in no more than 200 words on an A4 page.
2. Decorate the page and use the heading *Headline news*.
3. Write down the sources of your information:
   - For books, include the book title, author's name, publisher, place and date of publication and the page number where you found the information.
   - For articles, include the magazine title, publisher, place and date of publication, the page number, article title and author.
   - For the internet, include the full web address, the author and title of what you found.

Pluto has not been visited by a spacecraft because it is so far away from Earth.

The Himalayas grow 5 mm each year. Everest, the tallest mountain in the Himalayas, is $\frac{1}{2}$ metre taller today than when it was first climbed in 1953. There were no Himalayas when the dinosaurs lived.

Some female insects like mantids eat the male after mating.

Honey is nectar from flowers that bees have vomited back up.

The fastest train, the Maglev train, can reach speeds up to 552 km/h. It uses a magnetic field rather than bumpy wheels.

The human brain takes up 2% of body weight, but uses 20% of all oxygen taken in.

Focus for learning

Science is the study of the world around us. Scientists question what they find around them and carry out carefully planned tests to find answers to their questions.

Why study science? Almost all areas of your life are affected by science. What you know about the world and your place in it comes from science. So does your understanding of the materials and objects you use and the animals and plants that live on this planet.

There is often something about science on the television, in the paper or a magazine. So studying this subject can give you a better awareness of current events. Science helps you to solve problems both for today and in the future. It gives you skills that you can use throughout your life.

This chapter will introduce you to science and this book will help you learn the essentials of science.

By the end of this chapter you will be able to …

Science Inquiry Skills

- use equipment and chemicals safely, including a Bunsen burner
- make accurate observations and measurements
- draw science equipment correctly
- write a report of a science experiment

LITERACY FOCUS

In a notebook, write the meaning of each of the following terms, in your own words. If you aren't sure of their meaning, check the glossary at the back of the book, or in a dictionary. This way, as you work through the book, you can build up your own alphabetical glossary. You should also be able to spell the words correctly.

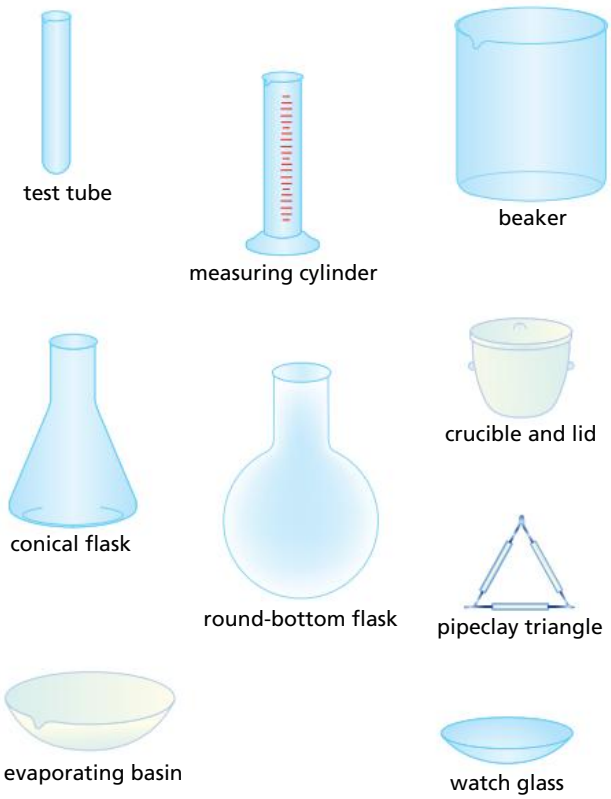
aim
apparatus
biodegradable
Bunsen burner
conclusion
corrosive
disposal
evaporating basin
filter funnel
flammable
generalisation
hazardous
hydrochloric acid
laboratory
Material Safety Data Sheet (MSDS)
method
qualitative
quantitative
risk assessment
science

1.1 Science is observing and using equipment

Scientists are people who observe or notice the world around them. They use their senses to help them collect information. They listen, look, smell, touch and taste, but only when it is safe and sensible to do so. They then ask questions or inquire about what they observe and try to find answers to these questions.

You probably inquire about your world in the same way. Let's say your bicycle has a wobbly wheel. You might ask why, and then think of some possible answers. There might be a nut missing or the tyre might be punctured. Then of course the next step is to investigate or test your ideas. You would probably need a spanner or some sort of tool to help you investigate. Scientists also have tools to help them investigate their questions. Scientists call these tools equipment.

Science equipment is found in a **laboratory**. This is a room where experiments can be carried out properly and in safety. It also has the necessary equipment and other resources such as chemicals, electricity and gas.



Students working in a science laboratory

How good are you at observing?

INQUIRY 1 **Candle burning bright**

You will need: jam jar lid with candle stuck to it, box of matches

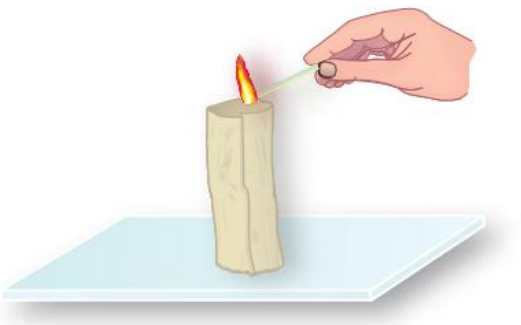
1. Place the jam jar lid and candle on the bench.
2. Light the candle and observe it carefully.
3. Record all the observations you can make.
4. Compare your observations with others. How many observations did you make?

The scientist Michael Faraday, who wrote The Chemical History of a Candle, *was able to make 100 observations of a burning candle.*

INQUIRY 2 Tea bag burner

You will need: tea bag, white tile, box of matches

1. Take the string, staple and tea carefully from the tea bag and put them in the bin.
2. Open the empty tea bag so it forms a tube.
3. Stand this tube on the white tile on your bench.
4. Light the top of the tea bag with a match. Do this away from curtains and mobiles in an open, cleared space on your bench.
5. Record your observations.



The air inside the tea bag warms up. Warm air rises and the tea bag becomes lighter, taking off like a hot-air balloon.

INQUIRY 3 In an egg spin

You will need: hard-boiled egg, raw egg

1. Place a raw egg on the bench and spin it. Observe it carefully as it spins.
2. Place one finger on the egg to stop it spinning and then lift your finger off. Observe the egg carefully.
3. Repeat this procedure with the boiled egg. Can you tell the difference between the two eggs?

When you stop a raw egg from spinning and take your finger away, the egg keeps spinning because the liquid inside it is still moving. With a hard-boiled egg, the egg stops spinning because the contents of the egg are solid.

INQUIRY 4 Stuck tight

You will need: wine glass, thin piece of card

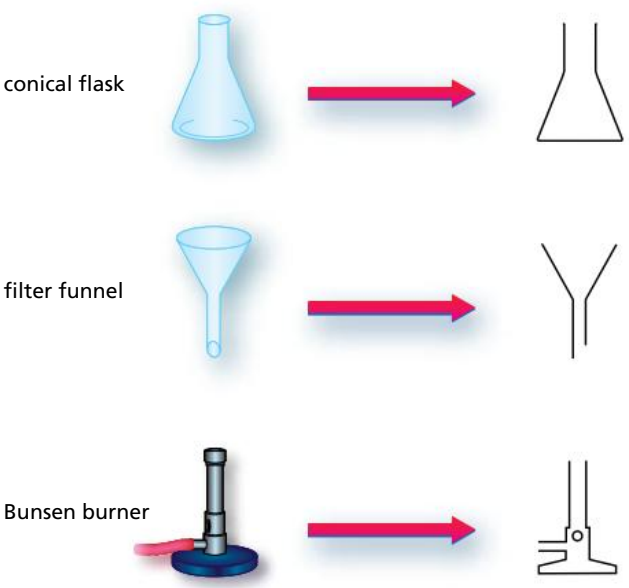
1. Fill the glass with water until the water is running over the sides.
2. Slide the piece of card across the surface of the glass.
3. Hold the card on the glass and turn the glass upside down over a sink or outside.
4. Remove your hand from the card. What happens?

The air pushes against the glass and the card, keeping it in place. The push of the air on the card is greater than the push of the water. So the card stays against the glass.

Drawing science equipment correctly

Scientists draw equipment in two dimensions only, not three dimensions. This makes the drawings much simpler and quicker to draw. When drawing in this way you need to follow these rules.

1. Draw the item as if it is cut in half, drawing just the outline.
2. Use a pencil so you can correct mistakes.
3. Never use colour, shading or coloured pens.
4. Use a ruler for all straight lines.
5. Add labels where necessary.



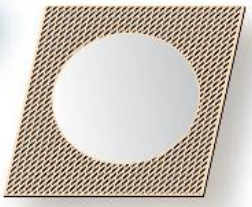
INQUIRY 5

Which piece of equipment is it?

Collect or have access to the equipment below.

beaker (50 mL, 250 mL)

filter funnel


gauze mat

test tube

conical flask

tripod

measuring cylinder (10 mL, 100 mL)

watch-glass

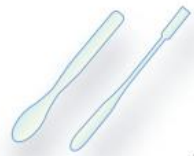
round-bottom flask

flat-bottom flask

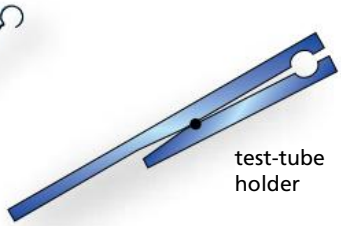
crucible

Bunsen burner

evaporating basin


spatulas

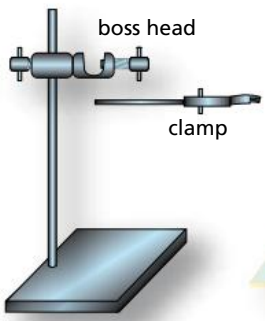
test-tube brush


test-tube holder

tongs

eye dropper

glass stirring rod


boss head

clamp

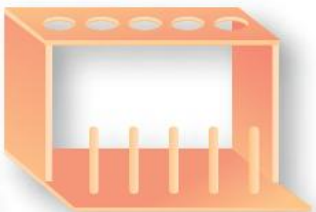
retort stand

heatproof mat

mortar

pestle

pipeclay triangle


test-tube rack

1 Draw a diagram or map of your laboratory as it would look from above. For each of the pieces of equipment listed here show where they are located on the map. You could use a symbol key or colour code.

2 Match the pictures of each piece of equipment shown above to the descriptions on the next page. Once you have found the correct description, write it in your book with a picture of the equipment next to the description. You will need to carefully observe the equipment you have collected. Here's an example of what to do.

Beaker

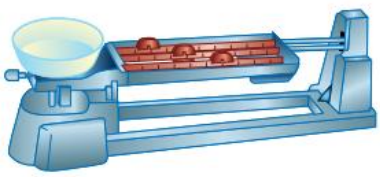
A glass container for holding, mixing and heating chemicals. It looks like a glass with a pouring lip. It comes in different shapes and has a scale with numbers written on the side.

INQUIRY 5

Which piece of equipment is it?

A A glass container for holding, mixing and heating chemicals. It is almost round with a flat bottom and long neck.	**B** This item is for heating. It sits underneath a Bunsen burner to protect the bench.	**C** This is used for holding test tubes. It looks like a peg.
D This rack supports and holds test tubes. The pegs are used for drying wet test tubes.	**E** A glass container for holding, mixing and heating chemicals. It is round and does not stand up easily. It has a long neck.	**F** This is used for cleaning inside a test tube. It is a long thin brush.
G This item is for measuring liquids. It is tall and thin, glass or plastic. It has a scale on the side.	**H** This item is for heating. It is metal and it has a hole for letting air in. It has a hose to attach it to a gas tap.	**I** A glass container for holding, mixing and heating small amounts of chemicals. It looks like a thin tube.
J This stand is made of three different pieces. Together they hold and clamp things in place.	**Which piece of equipment is it?**	**K** This item is for heating and it sits on top of a tripod. It looks like a piece of mesh. It stops items dropping into the Bunsen burner.
L A ceramic container for holding and heating small amounts of chemicals strongly. It looks like a dish with a pouring lip.	**M** A small glass or plastic tube with a squeeze bulb on one end for moving small amounts of liquids from one place to another.	**N** A ceramic container with a lid for heating chemicals to a very high temperature.
O This is used for transferring large amounts of liquids and for filtering liquids. It has a wide mouth, and a narrow opening at the bottom.	**P** This item is for heating. It has the shape of a triangle. It is made of clay and sits on top of a tripod.	**Q** A small solid glass rod used for stirring liquids.
R These two items are used for grinding chemicals. One is the bowl and the other does the grinding.	**S** This item is for heating. It has three legs, *tri* meaning three and *pod* feet. It sits over a Bunsen burner.	**T** A glass container for holding small amounts of chemicals. It is sometimes placed over the top of a beaker.
U These items are used to transfer small amounts of chemicals into test tubes. They are long and thin and can have different shapes. They can be plastic or metal.	**V** A container for holding, mixing and heating chemicals. It is cone-shaped. If you turn it upside down and hold the neck it looks like an ice-cream cone.	**W** This piece of equipment is used for holding very hot equipment. It is metal with rough, flat ends.

3 Find out what the following pieces of equipment are used for and write your own descriptions.



INQUIRY

5 Which piece of equipment is it?

4 Classify the equipment you have investigated into the following groups.

A items for holding, mixing and heating

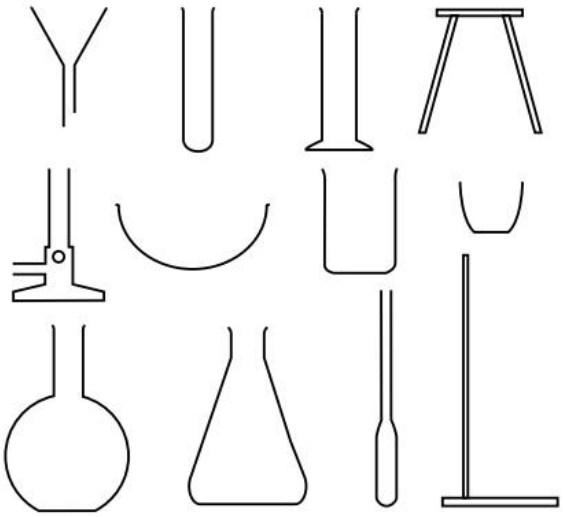
B items for just heating

C items for transferring chemicals

D items for just holding

E other

5 Here are some correctly drawn pieces of equipment. Copy these diagrams into your book and label them. Check with your teacher to see if you are correct.



6 When science equipment is set up or assembled for an experiment it is called **apparatus**. Draw this apparatus correctly in two dimensions.

Over to you

1 Why is it important to study science?

2 Describe what science is using the words *scientist, observe, inquire, investigate.*

3 Copy and complete the sentences below to summarise your observations from the previous activities.

a As the candle burnt we made _____ observations to decide what happened. The class together made _____ observations.

b As the tea bag burnt, it started to _____ because …

c It is possible to tell the difference between a boiled egg and a raw egg because …

d The card stuck to the glass because …

4 List all the equipment you would need to boil 500 mL of water.

5 State the best piece of equipment for

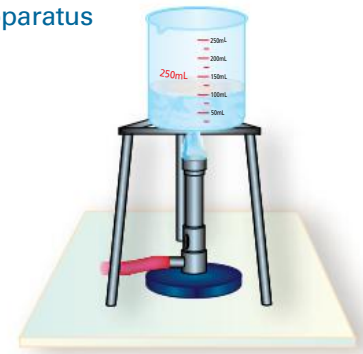
a measuring a small quantity of liquid.

b holding a long piece of glass tubing in place.

c supporting a beaker over a Bunsen burner.

d heating a small amount of solid.

6 Correctly draw the apparatus shown and label it.



INQUIRY

6 Test your memory

You will need: tray with 20 pieces of science equipment on it, cloth

1 Get into groups of about four.

2 You have 1 minute to memorise the items on the tray once the tray is uncovered.

3 After 1 minute cover the tray again.

4 Each person in the group must then write down all the equipment that they can remember from the tray using their correct names. Draw the items scientifically.

5 Compare your list with others in your group. How many items did you remember that were spelt and drawn correctly?

1.2 Science is working safely

The science laboratory can be a dangerous place. To protect yourself and others you must always know what you are doing, follow instructions carefully and think of the safety of everybody in the laboratory, including yourself. Each practical in this book will remind you of some safety rules, steps or points you need to follow. Here are some of these:

1. Never enter the laboratory or preparation areas by yourself.
2. Never touch any equipment unless you are told to.
3. Do not eat or drink in the laboratory.
4. Report any accidents or broken items to your teacher.
5. Always ask your teacher for help if you are not sure what to do.
6. Keep chemicals and equipment in their correct place.
7. Never run or do foolish things in the science laboratory.
8. Place broken glass in the glass bin.
9. Never taste chemicals. Never smell chemicals unless your teacher tells you it is safe to do so.
10. Listen carefully to everything you are told to do.
11. Dispose of chemicals as instructed.
12. Wear enclosed leather shoes.

As well as safety rules to be followed, there is safety equipment located in every laboratory. There will be first-aid kits, fire extinguishers, solutions for acid and alkali burns, and buttons or taps to disconnect the gas or electricity. It is important that you know where these are in case of an accident.

First aid

The most common accidents in the laboratory are cuts from broken glass, burns from hot equipment, splashes from chemicals (especially on the skin and in the eyes) and poisoning when students breathe in, taste or smell chemicals.

A second-degree burn

If there is an accident, you must let the teacher know what has happened. They may advise you to follow some simple first-aid techniques summarised in the table on the opposite page. Always follow your teacher's directions and review your first-aid procedures regularly.

First aid for common problems in the laboratory

Problem	First aid
Burn	Flush the area immediately with cold water and keep running water on it until the teacher gets to you.
Fire	Turn off all gas taps and electricity. Use the fire blanket, fire bucket or fire extinguisher if safe to do so. Calmly start to leave the laboratory.
Foreign objects	If glass or any foreign object is stuck in the eye, hand etc., do not try to remove it.
Cuts	Cover the cut with a clean dressing and if necessary gently apply pressure to stop the bleeding. Elevate the body part.
Spills on the skin, splashes to the eye	Use Material Safety Data Sheets (see below).
Poisoning	Use Material Safety Data Sheets or your teacher will contact the Poisons Information Centre.

Material Safety Data Sheets

To know which chemical you are using requires a **Material Safety Data Sheet** or **MSDS** for short. There is an example below. This sheet will tell you the following about the chemical:

- how the chemical should be stored
- how the chemical reacts with other substances
- what the chemical looks like
- how the chemical behaves, e.g. its boiling point and melting point
- the first aid that is needed for the chemical
- the hazardous symbol and the storage rating.

On each chemical container there must be a hazardous symbol and storage rating. These symbols warn you of the dangers associated with using a particular chemical. Some of these symbols are shown in Inquiry 8. The number and symbol tell the user how to store the chemical in the laboratory. For example, hydrochloric acid will have a corrosive substances label on it and the number 8. This means it must be stored in zone 8 in the laboratory, usually a corrosives cabinet.

MSDS Heavy Metals

Acute health effects

SWALLOWED

The material is moderately discomforting to the gastrointestinal tract and may be harmful if swallowed.

EYE

The material is moderately discomforting to the eyes and may be harmful following absorption.

SKIN

The material is moderately discomforting to the skin. Open cuts or irritated skin should not be exposed to this material. Toxic effects may result from skin absorption.

First aid

SWALLOWED

If poisoning occurs, contact a doctor or Poisons Information Centre.

If swallowed, and if more than 15 minutes from a hospital, induce vomiting, preferably using Ipecac Syrup APF.

Note: Do not induce vomiting in an unconscious person.

EYE

Immediately hold the eye open and wash with freshly running water. Ensure irrigation under the eyelid by occasionally lifting upper and lower lids. If pain persists or recurs seek medical attention. Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

SKIN

Immediately remove all contaminated clothing, including footwear (after rinsing with water). Wash affected areas thoroughly with water (and soap if available).

Seek medical attention in event of irritation.

Safe handling

STORAGE

Keep containers securely sealed.

Store in a cool, dry, well-ventilated area.

Store away from incompatible materials and foodstuff containers. Protect containers against physical damage and check regularly for leaks.

INQUIRY 7 What's unsafe in this laboratory?

Look at the illustration below. List all the safety rules that are being broken.

INQUIRY 8 Hazardous symbols

1 Look at the hazardous symbols below. You may need to use a dictionary to find out what each symbol means.

2 Find an example of a chemical container with these symbols on them. (Your teacher may have a collection of chemicals for you to look at or allow you into the preparation area to find examples of these chemicals.)

3 Look through the chemicals you have at home. Find three examples of items with these labels. Hint: Look at aerosol cans.

4 Hazardous symbols are also found on tankers and at industrial sites. Find an example of one of these symbols in these places and say where you found it.

1	EXPLOSIVES	3	FLAMMABLE LIQUIDS	5.2	ORGANIC PEROXIDES
2.1	FLAMMABLE GASES	4.1	FLAMMABLE SOLIDS	6.1	TOXIC SUBSTANCES
2.2	NON-FLAMMABLE NON-TOXIC GASES	4.2	SUBSTANCES LIABLE TO SPONTANEOUS COMBUSTION	7	RADIOACTIVE MATERIALS
2.2	OXIDISING GASES	4.3	SUBSTANCES THAT IN CONTACT WITH WATER EMIT FLAMMABLE GASES	8	CORROSIVE SUBSTANCES
2.3	TOXIC GASES	5.1	OXIDISING SUBSTANCES	9	MISCELLANEOUS DANGEROUS GOODS AND ARTICLES

INQUIRY 9 Safety equipment

1 You have already drawn a map of the science laboratory showing where the equipment is located. Add the following items to your map. (You may have to walk around and find them.)
   - **a** gas taps
   - **b** first-aid kit
   - **c** gas supply tap
   - **d** fire extinguishers
   - **e** sand bucket
   - **f** water sinks
   - **g** fire blanket
   - **h** glass bin
   - **i** preparation room
   - **j** waste paper bins
   - **k** electricity cut-off button
   - **l** safety shower and eye wash
   - **m** solutions for alkali and acid burns

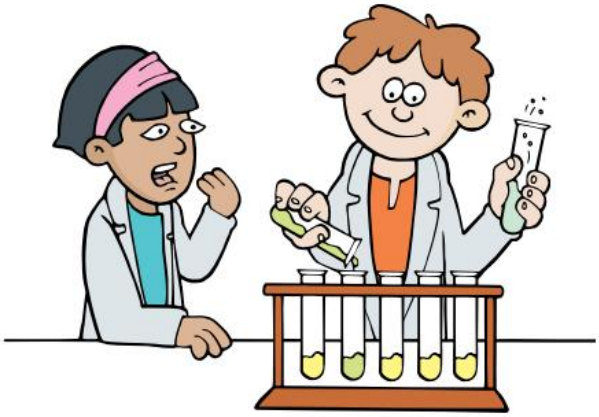
2 Explain why each of these items is necessary in a science laboratory.

3 List any safety signs and rules displayed in your laboratory.

Over to you

1 Design an A4 poster showing a safety rule to put up in the science laboratory.

2 Sue-lin and Jake have just carried out an experiment that involved mixing various chemicals in different test tubes. Jake suggests to Sue-lin that they should mix all the chemicals together to see what happens.
   - **a** What is wrong with Jake's idea?
   - **b** What should Sue-lin do?



3 Explain why the following rules in a school laboratory are important.
   - **a** Do not bring food and drink into the laboratory.
   - **b** Do not enter the laboratory without a teacher.
   - **c** Leave school bags outside.
   - **d** Wear leather shoes.
   - **e** Tie hair and loose clothing back.
   - **f** Do not enter the preparation room.

4 Look back at the extract of an MSDS on page 9 for heavy metals. What effect do heavy metals have on the skin? What first aid should be followed? How should they be stored?

5 The picture shows a hazardous symbol on a tanker.
   - **a** What is the chemical being carried?
   - **b** What is the hazardous symbol saying?
   - **c** What other information is written on the hazardous sign?
   - **d** Explain why all the information on the sign is necessary.

PROBLEM SOLVING

Remember your task for the chapter? What interesting information have you discovered so far that you can write about? What research have you done in the library? Don't leave it to the last minute!

1.3 Science is carrying out experiments

Scientists make very careful notes about what they are doing and record their observations. This is important so that other people can read what was done and discovered. These are the main sections that form a report:

- **Title and date**
- **Aim:** This says what you are trying to find out or why you are doing the experiment.
- **Risk assessment and planning:** In this section you identify any risks you might face and get ready to record what you find out.
- **Apparatus:** This is a list of all the materials and equipment used in the experiment.
- **Method:** This section explains what has to be done in the experiment. It includes diagrams of how the experiment should be set up.
- **Results:** In this section all the *data* (information) is recorded. Observations in words are said to be **qualitative** (KWAL-i-tat-ive). Observations in numbers are said to be **quantitative** (KWONT-i-tat-ive). Graphs and tables are used wherever necessary.
- **Conclusion:** This is a statement to explain what the findings were. Sometimes a general statement or summary can be made that is true for most cases. This is called a **generalisation**. For example, a student wanted to find out what difference a wet road made to the stopping distance of a bicycle. She concluded that 'the wetter the road, the longer it takes to stop a bicycle'. This may not be true all the time, but in general it is.

In this book you will be provided with guided questions to help you write your own reports. Eventually you will be able to write a report yourself. When you are asked to write the aim, apparatus and method you can usually write a reference to the page number from your text instead of writing all these out again. Later when you are designing your own reports you will need to work out and write down your own method.

Examining the risks

Scientists start an experiment by assessing the risks of what they are about to do. This means that they think about possible accidents that could happen with the equipment, chemicals and procedures they are using.

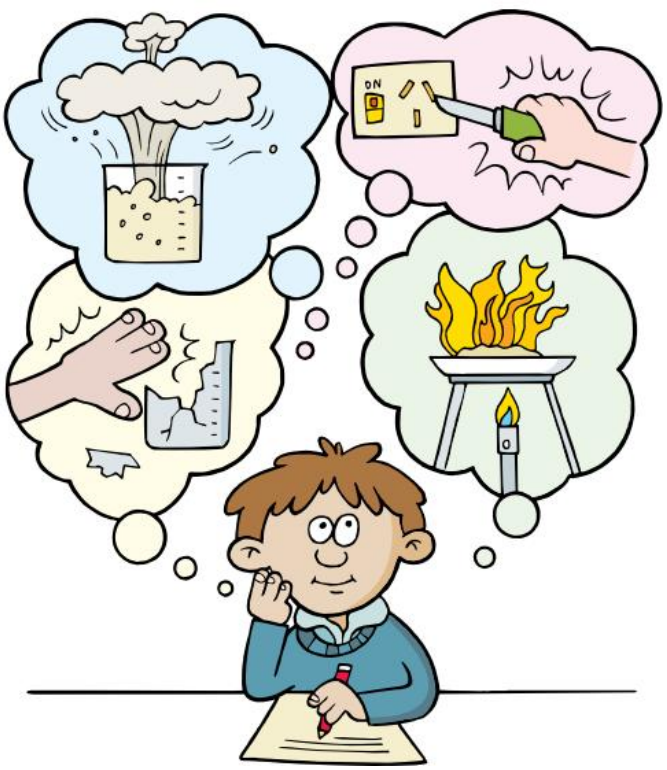
The risks could involve chemicals being absorbed through the skin or inhalation when chemicals are breathed in. Chemicals, of course, must not be eaten.

In a laboratory scientists use electricity, so there is a risk of electrocution if it is not handled properly. There is also the risk of exposure to hot and cold things, explosions, spills and splashes, and sharp objects or moving parts.

Assessing the risks could also involve thinking about what effect your tests will have on the environment. It may also involve deciding whether it is right to carry out the tests you intend to do. For example, will it harm other animals?

By examining the risks, scientists can plan their experiment and know what personal protective equipment, such as safety glasses and gloves, should be used.

At the beginning of each experiment in this book you will be asked to carry out a risk assessment, so that you are fully aware of the possible dangers you could face.



INVESTIGATION

1 Safe clothes in science

Aim

To investigate the clothing you wear in science.

Risk assessment and planning

Read this experiment carefully before starting.

1 Explain why you must follow these rules.
   - **a** Only burn what you are instructed to burn.
   - **b** Leave hot equipment on the bench to cool.
   - **c** Put any used matches in the bin.

2 Some materials melt, drip and give off fumes when they burn. What are the risks to you? How can you minimise these risks?

3 Do not inhale any fumes from this experiment.

4 Draw up a table or spreadsheet with the following headings:

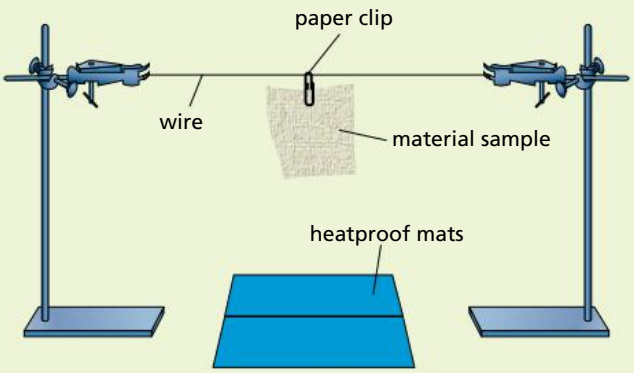
- Type of material
- Time taken to burn
- Observations

This will be used to record your results and should be included in that section.

PART A

Apparatus

- 5 sample materials (10 cm × 10 cm) from unwanted clothes
- material from an old laboratory coat
- 1 m length of wire
- paper clips, box of matches
- 2 heatproof mats
- 2 retort stands
- stopwatch



Method

1 Set up the items as shown near an open window or in a fume cupboard.

2 Attach 1 piece of material to the wire.

3 Light a match and hold it to the edge of the material until it ignites.

4 Time how long it takes the material to burn.

5 Repeat this for each material sample you have.

Results

Answer these questions.

1 Which material took the longest to burn? The shortest? Did any material not burn?

2 Find out what each material is made of. Which materials are synthetic, e.g. polyester, nylon or blends of these? Which materials are natural, e.g. wool or cotton?

3 Which material is the safest to use? Why?

4 What does this experiment tell you about safety when doing practical work in science?

5 How long did it take the laboratory coat to burn compared to the other materials?

6 Why do you think it is important to wear a laboratory coat when heating things in science?

PART B

If there is time, you might like to investigate flameproof materials or the materials used in heat-resistant gloves sometimes used in science. You may also like to investigate the effects of acids on the clothing you wear in science. Do not proceed without assistance from your teacher.

Conclusion

Copy and complete these sentences.

The aim of this experiment was to see if …

It was found that it takes synthetic or manufactured materials a _____ time to burn. Natural materials take _____ to burn. It is important to wear a laboratory coat when heating in science because …

Write your report

For the *Aim*, *Apparatus* and *Method* you can simply give the page number of this investigation. For the *Risk assessment and planning*, *Results* and *Conclusion* you need to answer the questions on this page.

Over to you

1 Place these words in their correct order: *conclusion*, *aim*, *apparatus*, *results*, *method*.

2 In which section of a practical report would you put the following?

- **a** a list of your observations
- **b** a list of what to do, like a recipe
- **c** a general statement about the findings
- **d** a drawing of the apparatus
- **e** a statement saying what the experiment is about.

3 Look back at pages 3 and 4. For each of the four inquiries write a conclusion in the following format.

The aim of the activity was to …

It was found that …

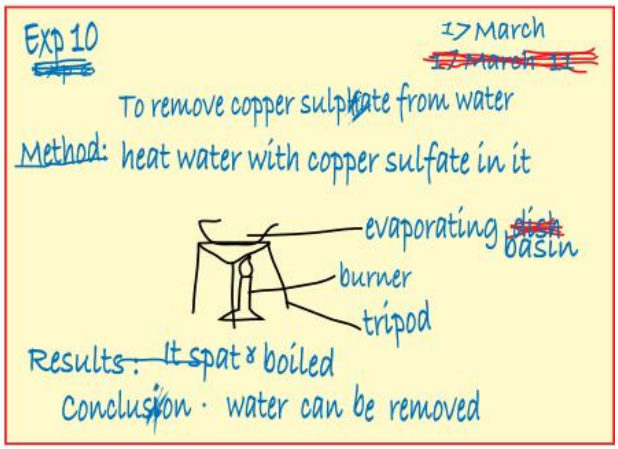
4 Why do scientists write practical reports?

5 Look at the two experiments presented here: state which report you prefer and why.

6 What is a risk assessment? Make a list of risks that could occur in a science laboratory.

7 Find out what the following words mean: *absorption*, *ingestion*, *corrosive*. Explain how these could be risks in a science laboratory.

8 Imagine you are going camping for a week in the bush. Complete a risk assessment that you would need to do before going.



Experiment 10 — 17 March 11

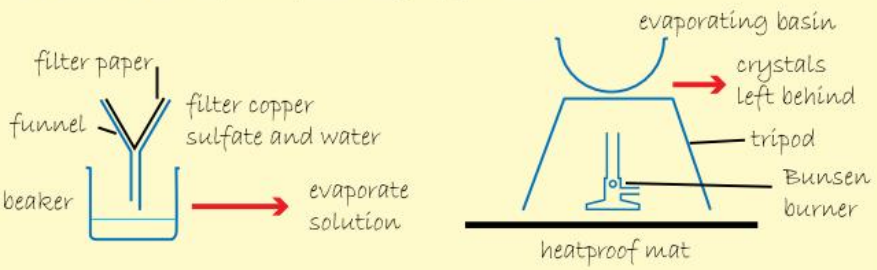
Separating Copper Sulfate from water

Partner: Greg Bloom

Aim: To remove copper sulfate from water

Risk Assessment and Planning: The evaporating basin must not boil dry, otherwise the copper sulfate crystals could spit out and burn your skin.

Method: Set up the following apparatus.



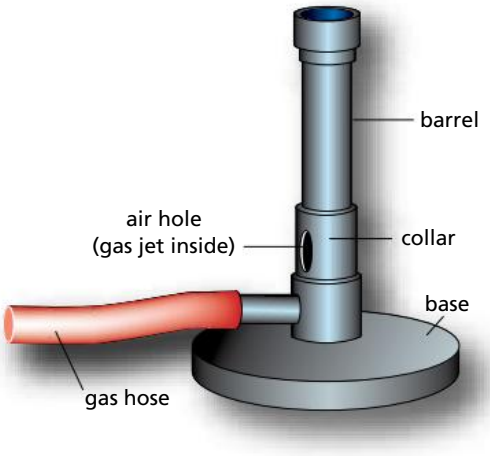
Results: The water evaporated from the basin leaving the copper sulfate behind.

Conclusion: It is possible to separate copper sulfate from water using evaporation techniques.

1.4 The Bunsen burner

The Bunsen burner is used to heat things. The gas hose of the burner is fixed to the gas tap in the laboratory and gas flows into the burner. The air hole allows the oxygen in air to mix with the gas. The amount of air can be changed by turning the collar which opens or closes the air hole. When the air hole is open, the gas reacts completely with the oxygen producing a clean, very hot, noisy, almost invisible, blue flame with an inner lighter blue centre. Parts of this flame reach about 1500 °C. Very dangerous! This blue flame is used for heating.

When the air hole is closed, very little air mixes with the gas. The gas does not react completely with the air, so it produces a yellow, flickering, quiet, visible flame. It is a dirty, sooty flame. This flame is still dangerous, but it is safer than the blue flame because it can be seen.



SCIENTISTS AT WORK

Robert Wilhelm Bunsen (1811–1899)

The Bunsen burner is named after Robert Wilhelm Bunsen, a German chemist. He did not invent the burner. A technician called Peter Desaga designed it. However Bunsen needed a hot, non-luminous flame for his experiments, so he redesigned it to mix gas and air (oxygen) together before it was burnt. This gave him a cleaner, hotter, more useful flame. This led to huge improvements in the use of gas burners, which is why the burner was named after him.

Bunsen discovered that iron oxide could cure arsenic poisoning. However, he nearly killed himself with arsenic poisoning finding this out. He also lost the sight in one eye when a piece of glass flew into it during an explosion.

Bunsen improved charcoal furnaces by finding a way to capture waste gases and recycle them through the furnace. He also introduced the use of carbon electrodes in batteries, produced pure metals such as aluminium and magnesium, and made magnesium wire which was used for lights because it burnt so brightly. Bunsen even studied volcanic rocks, vents and geysers.

Using his new technique of spectroscopy, Bunsen discovered the element rubidium by studying colours produced when light is passed through a vaporised chemical and then through a prism.

Questions

1. Why is the Bunsen burner named after R. W. Bunsen if he didn't invent it?
2. Name three other things that Bunsen is known for.
3. What risks did Bunsen face in his laboratory?
4. In what ways could Bunsen have reduced the risks he faced?

INVESTIGATION

2 Using the Bunsen burner

Aim

To learn how to light a Bunsen burner and use it.

Risk assessment and planning

Read through the steps below on how to light a Bunsen burner then answer these questions.

1 Explain why the following rules are important.
- Do not light the Bunsen burner until told to.
- Set up the Bunsen burner away from books and the edge of the bench.
- Use a heatproof mat under the burner.
- Tie back your hair and tuck in loose clothing.
- Never light a Bunsen burner with paper.
- Never leave the burner unattended.

2 Why do you think it is necessary to light the match before you turn the gas on?

3 Why do you think it is important to light the Bunsen burner on a yellow flame? Is the air hole open or closed to get a yellow flame?

Apparatus

- Bunsen burner
- gauze mat
- heatproof mat
- pair of tongs
- broken piece of crucible

Method

1 Place the heatproof mat underneath the burner.

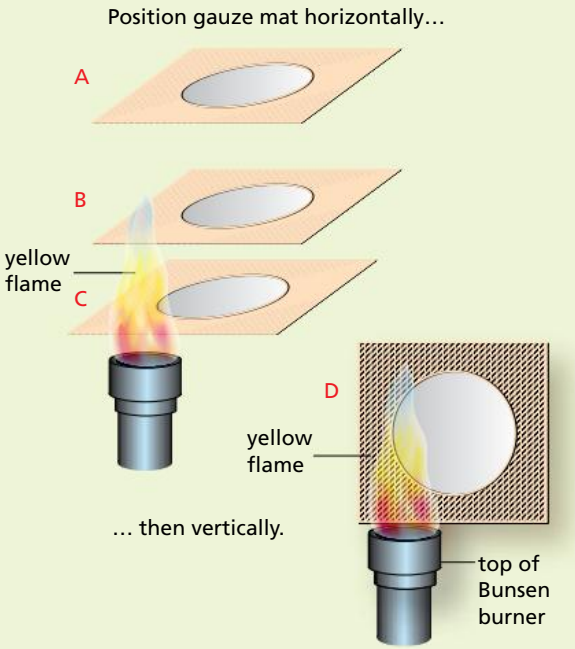
2 Attach the gas hose to the gas tap. Don't force the hose onto the tap too far.

3 Light the Bunsen burner in the following way:
- **a** Close the air hole.
- **b** Light the match.
- **c** Switch on the gas.
- **d** Hold the match close to the top of the burner, but not over the top of it.
- **e** Remove the match from the burner when it is lit.

4 Hold the piece of crucible in the yellow flame. Record your observations.

5 Place the gauze mat in the flame at points A, B, C and D using tongs as shown top right. Observe and record any differences you notice.

6 Turn the collar until you have a blue flame and repeat Step 5. Observe carefully.



Results

1 Draw a large labelled diagram of the Bunsen burner in your notebook.

2 Copy and complete this table about the Bunsen burner.

Features of Bunsen burner flames					
Flame	Clean?	Visible?	Hot?	Safe?	Sound?
Yellow	No		Cool		
Blue		No			Noisy

3 Describe the differences between the blue and yellow flames, including what the differences are within each flame.

Conclusion

Copy and complete these sentences.

The aim was to learn how to ...

The yellow flame of a Bunsen burner is a _____ flame. The blue flame is a _____ flame. The safest flame to use is the _____ flame. When heating it is important to use the _____ flame. It would take a _____ time to heat things using a yellow flame and the beaker or apparatus would be covered in _____.

Write your report

Give the page number for the *Aim*, *Apparatus* and *Method*, but complete the *Risk assessment and planning*, *Results* and *Conclusion* by answering any set questions.

1.5 Chemical use and disposal

Proper disposal of chemical waste is important. The following hazardous wastes should not go down the sink whether you are in the science laboratory or at home.

paints
acids
glue
furniture polish
disinfectants
bleach
weed killer
pool chlorine
insecticides
oil
fat
turpentine
kerosene
ammonia
varnish
grease
oven cleaner
paint stripper
drain cleaner
brake fluid
cooking oil
fuels, e.g. petrol
thinners (used to thin thickened chemicals)

Wastes from the sink are carried in the water through drains to a sewage plant. Many of these wastes are not **biodegradable** so they can't be broken down by the action of living things. For this reason these wastes must be removed before the water is released back into the environment.

Wastes such as chemicals, litter and rubbish that run off driveways, roads and gardens enter the water in stormwater drains. This water is not cleaned, so the wastes empty straight into our waterways.

Paints, thinners, glue and fuels in our waterways can kill plant and animal life. Even acrylic or water-based paints that do dissolve in water can cause cloudiness, blocking light entering the water so water plants cannot grow well. Aquatic plants and algae produce some of the oxygen needed for all life in waterways. The waterways will die without this oxygen. Some substances like grease and oil stick to the feathers of birds, and as a result they cannot swim or fly.

To dispose of paints, thinners, glue and fuels put them in a sealed tin or container. Then take them to your local waste disposal centre for proper disposal. Oils, fats and grease from the kitchen can be disposed of in the same way.

Paint brushes should be cleaned by painting as much paint as possible onto newspaper and then washing the brushes out in a bucket in the garden. The leftover water should be tipped onto the garden so that it doesn't enter the stormwater drains.

Any water containing detergents or bleach that are not biodegradable should also be put on the garden. It is possible to buy biodegradable household products in the supermarket.

The results of careless disposal

Food substances such as food scraps should not be put down the sink. Food breaks down in water to produce chemicals called nitrates, which can cause excess plant growth. This in turn can clog waterways and kill the life there. Food scraps should therefore be put on a compost heap in your garden or placed in a worm farm. Worms break down the food scraps, and you can reuse the soil they make. Food scraps could also be wrapped in newspaper and put in the bin.

In the science laboratory your teacher will tell you how to dispose of chemicals. Chemicals that will not react together can be stored in one container for chemical disposal. Acids, acetone and ammonia must all be stored and disposed of separately. Labelled containers for chemical disposal should be placed in the laboratory for you to use. Do not be tempted to combine chemicals to 'see what happens'. You could be mixing a deadly cocktail!

INQUIRY 10 **Chemical disposal at home**

1 Go through your house and garden. List the items you have that should not be put down the sink or stormwater drain.
2 For these items list how you should dispose of them. Put labels on them to remind you.

INVESTIGATION

3 Handling chemicals

Aim

To practise heating and handling chemicals correctly.

Risk assessment and planning

1 Explain why the following rules are necessary.
- Only use the amount of chemical specified.
- Point the neck of a test tube away from others.
- Hold the test tube on an angle when heating things.
- Always move a test tube in a flame.

2 Write down any extra risks your teacher brings to your attention about the chemicals you are using.

Apparatus

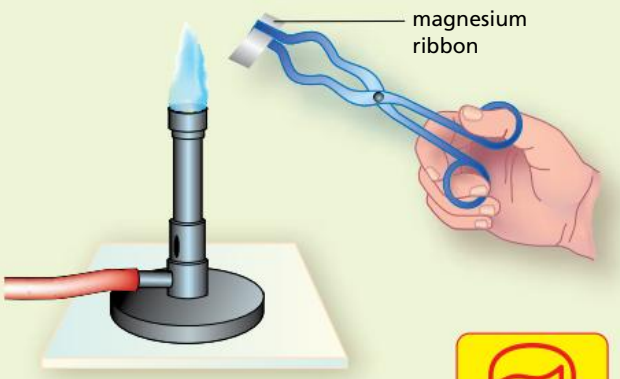
- piece of magnesium ribbon
- tongs
- safety glasses
- sugar
- spatula
- Bunsen burner equipment
- test tubes

Method

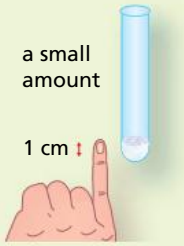
1 Your teacher will burn a piece of magnesium ribbon using a Bunsen burner as shown below.

The light produced is very bright and could damage your eyes. If possible the demonstration should be done behind a special UV protective tinted glass screen. Do not look directly at the burning magnesium—look out of the corner of your eyes.

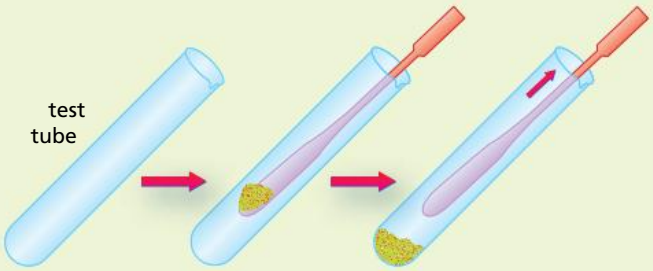
2 Record your observations in your notebook.



3 Place a small amount of sugar into a test tube with a spatula. A small amount is enough chemical to cover the end of your little finger.



4 Slide the spatula down into the test tube before you allow the sugar to fall off the spatula so that the solid falls to the bottom of the test tube, not on the sides.



5 Heat the sugar in the test tube by holding the bottom of the test tube just above the inner blue flame. Move the test tube from side to side. If it is heated in one place it may break.

6 Once the sugar has melted remove it from the flame and place the test tube in the rack.

7 Record your observations.

Results

1 The record of your observations from Step 4 and Step 7 should be written neatly as the first section of your results.

2 What are the similarities and differences in the way you heated the two solids?

Conclusion

Copy and complete these sentences.

The aim was to …

When the magnesium ignited there was a _____ flame.
Sugar _____ when heated.

The important safety points to remember are …

Write your report

Write your report in the usual way. Remember to complete the *Risk assessment and planning*.

INVESTIGATION

4 Heating liquids

Aim

To practise heating and handling liquids correctly.

Risk assessment and planning

1 Why is this safety rule necessary? To mix a liquid, shake the test tube from side to side and swirl the contents. Never put your thumb or finger on the end of the test tube and shake it up and down.

2 If no chemical amounts are specified, how much should you use?

3 Write down any other risks your teacher brings to your attention.

Apparatus

- glucose solution
- test-tube rack
- test tubes and holder
- Bunsen burner equipment
- Benedict's solution in a dropping bottle

Method

1 Place some glucose solution in a test tube.

2 Add 10 drops of Benedict's solution and mix gently.

3 Set up and light the Bunsen burner.

4 Gently heat the contents of the test tube by moving it in a blue flame. Remove the test tube from the flame every few seconds to avoid *bumping*. This is where the contents of the test tube boil violently and suddenly whoosh out of the end.

Results

Record your observations.

Conclusion

Copy and complete these sentences.

The aim was to learn how to heat a _____ using a Bunsen burner. As you heated the solution it changed colour from _____ to _____.

Write your report

Write your report under the usual headings. Remember to complete the *Risk assessment and planning*.

Over to you

1 List five substances that you should not put down the sink or stormwater drain.

2 Where does water from the stormwater drain go?

3 What happens to substances that you put down the sink?

4 What problems do paints, thinners, glue and fuels cause for the environment?

5 Go to the supermarket and find five products that are biodegradable. Hint: Look at washing powders, dishwashing liquids and cleaners.

6 Write a list of dos and don'ts on the disposal of chemicals to be placed in your home for all family members to see. For example, you might put a sign in your laundry to remind family members to tip water containing bleach, e.g. NapiSan, on the garden.

7 Describe two methods for heating solids in a laboratory.

8 Describe how you would safely heat a liquid in a test tube.

PROBLEM SOLVING

Have you started your task yet? What have you found out? Have you designed your A4 page in an interesting way?

Follow the ABBBC rule of poster making; that is, **A**lways check spelling and make your work **Big**, **Bold**, **Bright** and **Colourful**. You should also use the whole of the page.

SKILL

Chemicals safety

Risk assessment and planning

Read through each of the four tests.

For each, list the safety precautions you will have to take.

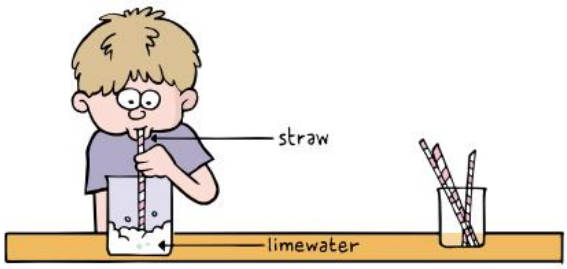
Apparatus

- limewater
- beaker (250 mL)
- 1 M hydrochloric acid
- sodium thiosulfate crystals (hypo)
- solutions of copper sulfate and sodium carbonate in dropping bottles
- 3 test tubes
- drinking straw
- piece of zinc
- spatula

Test 1

Pour 50 mL of limewater into a beaker.

Using the straw, blow into the limewater.



Test 2

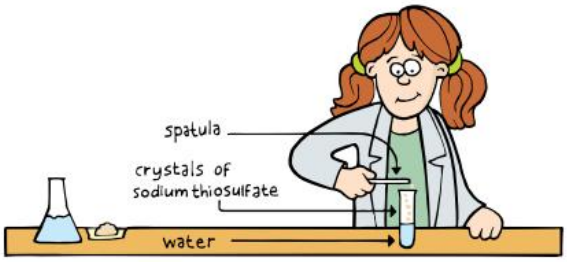
Place a piece of zinc into a test tube.

Add enough hydrochloric acid to cover the zinc.

Test 3

Add some sodium thiosulfate crystals to a test tube and add a small amount of water. Shake the test tube to dissolve the crystals.

Add 10 drops of hydrochloric acid.



Test 4

Add 10 drops of copper sulfate solution to 10 drops of sodium carbonate in a test tube.

Results

Record your observations for the four tests.

THINKING SKILLS

1. Design an A4 poster showing the steps to take when an accident occurs in the laboratory. Include what to do if there is a fire.
2. Imagine you are a fire fighter called out to the local hardware store for a fire. You are told that there are flammable gases, oxidising agents and corrosive substances in the store.
   - **a** What signs would you expect to see on the site to confirm this?
   - **b** What advice would you give your team about these chemicals?
   - **c** What steps would you take when you arrive on site?
3. You are given a clear, colourless liquid in a bottle. What observations could you make to help you decide what it is?
4. Find five similar items such as 5 coins, 5 shells, 5 watches or 5 pencil cases. Write your own description of one item of the five. Ask a friend to read your description and tell you which particular item you were describing. How good were you at observing and recording?
5. Using only the following equipment describe how you would show the difference between the two different Bunsen burner flames: 2 beakers, 2 Bunsen burners, 2 gauze mats, 2 heatproof mats, 2 tripods, measuring cylinder.
6. What safety rules must be followed at your school? Explain why.
7. You are travelling overseas for six weeks on holiday. What risks would you have to consider and how could you plan to minimise these?

Knowing and Understanding

Copy and complete these statements using the words on the right to begin a summary of this chapter.

1 Scientists are people who _____ the world around them and ask _____. They try to find _____ to their questions.

2 Scientists use _____ which is drawn in two _____.

3 To heat things in science a _____ is used. A closed air hole gives a _____ flame. It is important to light a _____ before turning on the gas.

4 There are many hazards or dangers in a science laboratory. These include _____, explosions, _____ and splashes.

5 Chemicals should not be put down a _____ and neither should wastes such as _____, _____ and varnish.

6 We should use products in the home that are _____.

7 You must take special care when handling and _____ chemicals.

answers
biodegradable
Bunsen burner
burns
cuts
dimensions
equipment
fuels
heating
match
observe
paint
questions
sink
yellow

Self-management

An important skill is to be able to review the chapter in preparation for a test.

1 Check back through the chapter and give the page number for each of the main points mentioned above.

2 The main points above do not cover all the chapter. For each page of text in the chapter write down one important point that has not been listed.

3 List the highlighted words in **bold** throughout the chapter and their meanings. The glossary in this book or a dictionary will help you.

4 Think of the types of questions you might be asked about this work on a test. Write yourself a question starting with each of the following.

a Draw ...
b Why was the ...
c Give three examples of ...
d What are the steps ...
e Name the rules for ...
f When would you ...
g What is the difference ...
h How would you ...
i What would you do if ...
j List as many ...

You will of course need to know the answers to your questions.

5 Compare your list of questions with others in the class. Write down any questions you do not know the answer to, and ask your teacher to go through these with you.

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 State whether the following are true or false.

- **a** Test tubes should always be moved in a Bunsen burner flame.
- **b** Science equipment is drawn in two dimensions.
- **c** An evaporating basin is for heating liquid strongly.
- **d** A gauze mat and peg are used to support equipment on top of a tripod.
- **e** MSDS need only be used when something goes wrong in the laboratory.
- **f** Risk assessment and planning in a practical is only needed when a Bunsen burner is used.
- **g** Hot equipment should be put away immediately so that other people don't touch it.
- **h** All containers should be properly labelled.

2 Put these words in their correct order to describe what scientists do: *record*, *observe*, *question*, *experiment*, *collect information*.

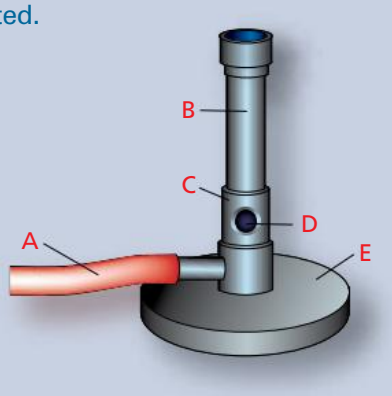
3 List three pieces of information you are likely to find on a Material Safety Data Sheet (MSDS) for a chemical.

4 In which parts of a practical report would you find the following?

- **a** a record of observations
- **b** a list of the equipment used
- **c** a description of what was done
- **d** a sentence explaining what the experiment was about
- **e** a summary of the experiment

5 Name three possible hazards you could face in a science laboratory.

6 Copy the drawing of a Bunsen burner and label the parts indicated.



7 Greg and Emily noticed that the door to the science laboratory had not been shut. It was a cold, wet day and Emily suggested they could go and eat their lunch inside. Greg said no because it would break too many rules. Which rules would they be breaking?

8 Trisha was trying to heat 500 mL of water in a beaker over a Bunsen burner. The water was taking a long time to boil and the beaker was turning black. What was Trisha doing wrong? What should she do differently?

9 These steps show how to light a Bunsen burner. Rewrite the steps in their correct order and make any corrections necessary.

- **a** Make sure the air hole is open.
- **b** Place the Bunsen burner on the bench with a heatproof mat underneath.
- **c** Switch on the gas.
- **d** Light the match and hold it close to the top of the Bunsen burner until the gas ignites.

10 Describe how you would safely dispose of

- **a** acrylic paint.
- **b** water from bleaching clothes.
- **c** oil and grease from the kitchen.
- **d** food scraps.

11 Explain how you would safely heat liquid in a test tube.

12 What equipment would you use for the following?

- **a** holding six test tubes
- **b** heating a small amount of a powder to a very high temperature
- **c** transferring a small amount of solid chemical into a test tube
- **d** grinding a chemical
- **e** measuring a small amount of liquid

13 Suppose you want to hold a thermometer in a conical flask so that you can measure the temperature of the water as it is being heated. Draw a diagram of the apparatus you need.

2

Kitchen chemistry

PROBLEM SOLVING

Experimenting in the kitchen

1 Demonstrate how science is used in the kitchen by performing a practical activity and reporting on what you find. For example, you may choose to show how food decays and then explain your findings using science. This chapter will give you many different ideas.

2 To practise your report writing skills, you must present your findings as an investigation report with these headings:

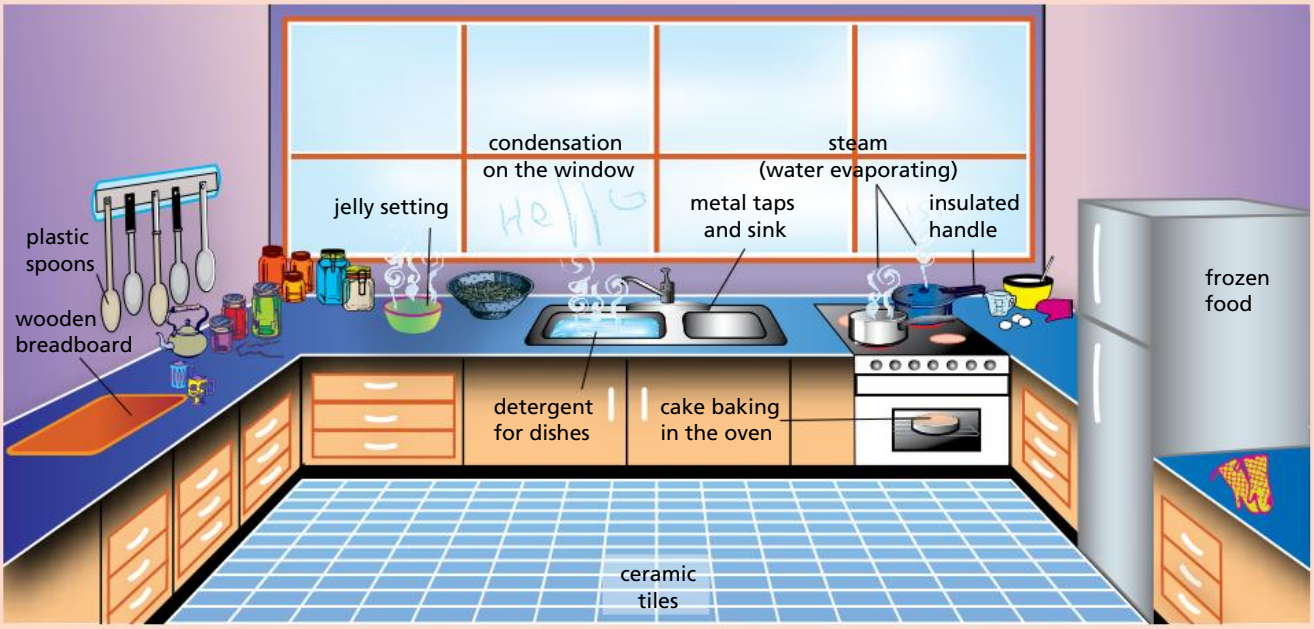
- Aim
- Risk assessment and planning
- Method
- Results
- Conclusion.

Focus for learning

Did you know that just by cooking in the kitchen you are performing a science experiment? A lot of science happens in the kitchen as you can see in the picture below. Science can explain the various things we use in the kitchen and what happens when we mix them. That's what this chapter is all about—kitchen chemistry.

Look at the drawing below.

- What examples of science can you see?
- What are the **properties** (characteristics) of some of the things you can see, for example the insulated handle? How do these properties make them suitable for what they are used for?



By the end of this chapter you will be able to …

Science Understanding

- consider the water cycle in terms of changes of state

Science Inquiry Skills

- observe physical and chemical changes
- record measurements in a table and draw a graph
- explain observations and make predictions
- give examples of how different materials have different uses, depending on their properties

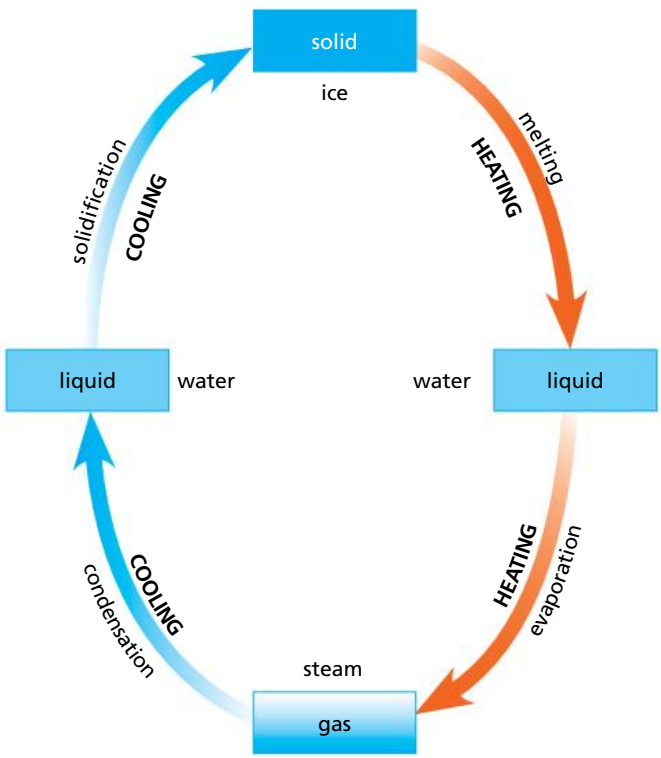
LITERACY FOCUS

change of state
chemical equation
combustion
conductors
data table
energy
enzymes
experimental control
fermentation
inference
insulators
meniscus
parallax error
photosynthesis
prediction
products
properties
reactants
respiration
states of matter

2.1 Physical changes

Changes take place in the kitchen and all around you. Ice melts in a drink, water boils on the stove, jelly sets to make dessert, and milk can curdle.
These changes can either be chemical or physical. In a **chemical change**, such as baking a cake, a completely new substance is formed. You add eggs, milk and flour together and you cannot get these things back again when the cake is made. In a **physical change** no new substance is formed.
Making a mixture is an example of a physical change. If you mix peppercorns and salt, you can still see the peppercorns and the salt. No new substance has been made. A sieve can be used to separate this mixture because the salt is small enough to pass through the sieve leaving the peppercorns behind. Try this and see. So a physical change, like making a mixture, is reversible.

Water can be frozen into ice and ice can melt back to water. Water can boil and form steam which can change back to water. This means water can be a solid (ice), a liquid (water) or a gas (steam). These are the three **states of matter**. A change from one state to another is called a change of state. These changes are physical changes because they are reversible. This is summarised in the **change of state** wheel below.

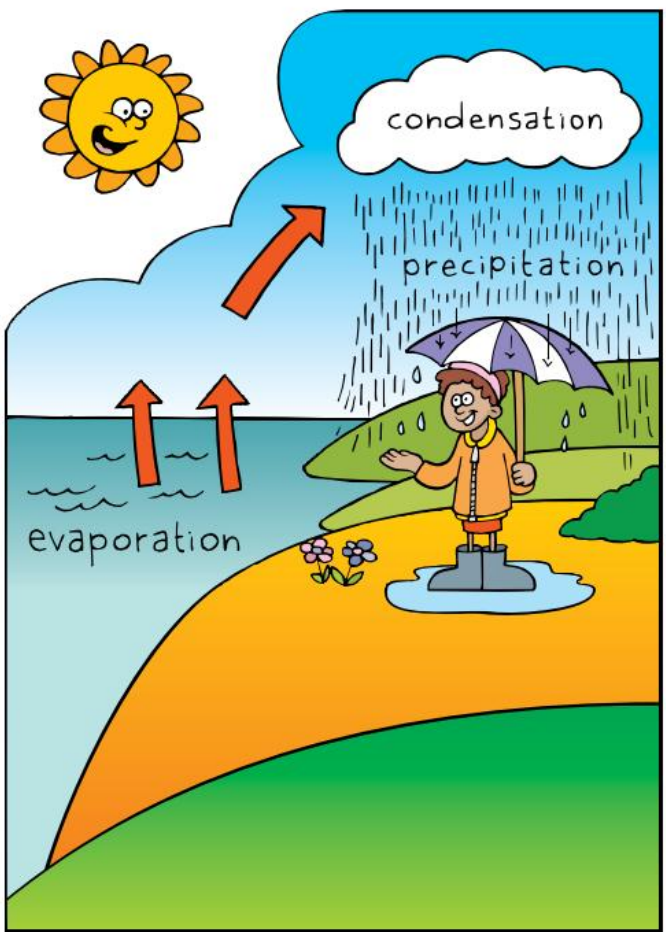


There are many examples of physical changes in the kitchen. For example, milk and cream (liquids) can be frozen to make ice-cream, a solid.

We boil water to cook our food. When the water boils it becomes steam that rises as we cook. If the steam hits a cold pan lid it condenses back to water again. This is why there are often water droplets underneath the lid of a pan when food is cooking. If steam hits the cold kitchen window it condenses too, forming water droplets on the window pane.

The water cycle

The **water cycle** or the movement of water through the air, rivers and seas is an example of a physical change in everyday life. Water evaporates from the surface of rivers, lakes or seas, forming water vapour. This means it changes state from a liquid to a gas. Heat from the sun causes this change. The water remains in the air until the air cools as it moves high into the atmosphere. Here it condenses or changes back from a gas to a liquid to form clouds. If enough water is formed, it starts to fall back to earth as rain or *precipitation*. This water then runs back into the waterways to start the whole process again.



INVESTIGATION

1 Physical changes

Aim

To observe a physical change and demonstrate how to evaporate a solution safely.

Risk assessment and planning

Read through the investigation then answer these questions.

1 Why do you turn off the gas before all the water has evaporated in the evaporating basin?

2 What should you do with the hot heating equipment, evaporating basin and crystals when the investigation is finished?

Apparatus

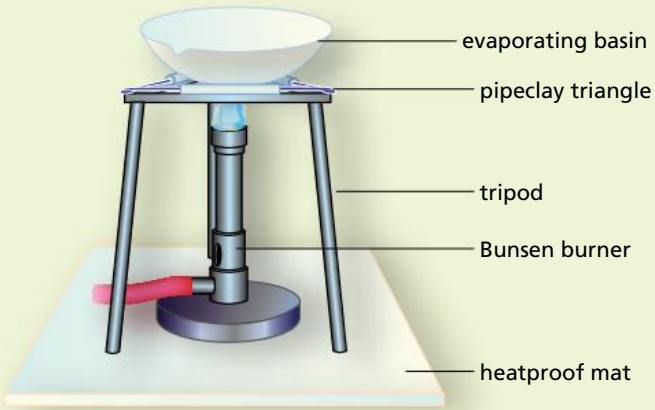
- packet of jelly crystals
- evaporating basin
- pair of tongs
- 250 mL beaker
- Bunsen burner equipment
- pipeclay triangle
- stirring rod
- teaspoon

Method

1 Mix 3 teaspoons of jelly crystals with 100 mL of warm water until the crystals have dissolved.

2 Set up the equipment shown top right.

3 Heat the jelly mixture in the evaporating basin until the water has almost evaporated, then turn off the gas and let the rest of the water evaporate naturally. Otherwise the hot crystals will spit out and could burn you.



Results

1 What happened to the jelly crystals in the water?

2 When the jelly and water mixture was heated, what happened to the water?

3 What formed in the bottom of the evaporating basin as you heated the mixture?

4 If you put the jelly and water mixture in the fridge, what change of state would take place?

Conclusion

Copy and complete these sentences.

It is possible to mix the jelly and water together and then separate the mixture by evaporating the _____ and leaving the jelly crystals behind. This is a _____ change because it can be reversed and the parts of the mixture separated.

Write your report

Write up your report in the usual way.

Over to you

1 What is a physical change? Give two examples.

2 Copy the change of state wheel on the previous page. Give the meaning of these words: *melting*, *evaporation*, *condensation* and *solidification*. Give an example of each of these changes in the kitchen. What conditions are needed for each of the four changes of state on the wheel?

3 Explain how physical changes result in clouds, rain and water.

4 How could you separate a mixture of salt and water?

PROBLEM SOLVING

Remember your chapter task? Can you use an example of a change of state in the kitchen or separate a mixture as your activity?

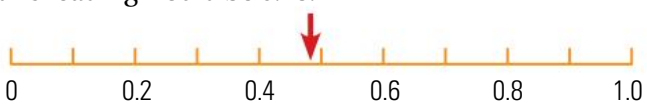
In the next investigation you will need to be able to read a scale on a thermometer and use a measuring cylinder correctly. You will also need to be able to make a data table. Let's learn these skills before continuing.

2.2 Measurement, scales and tables

When you are following a recipe in the kitchen, you must be able to use and accurately read measuring equipment. The recipe may ask for 10 mL of milk. You need to know what this means. This is not only important in the kitchen but in all aspects of our lives. It might be 10 km from your home to your school. Kilometres, in this example, is the unit of measurement. The standard units of measurement are listed in the table on the right. It is essential when you are measuring to use the correct units.

You have already looked at some measuring equipment in science. We measure liquids with a measuring cylinder, weight with a spring balance, time with a stopwatch, and measure temperature with a thermometer. Measuring instruments have a scale that like a ladder is divided into sections or divisions. Each division has a corresponding number. Some instruments have a pointer that moves along the scale. For equipment like a measuring cylinder, the scale is on the side and the water level is the pointer.

It is not always easy to read a scale. Sometimes the pointer or the water level lies between two divisions on the scale. When this happens you have to estimate the reading. On the scale below, the pointer is between 0.4 and 0.5. It is closer to 0.5 than 0.4, so an estimate of this reading would be 0.48.



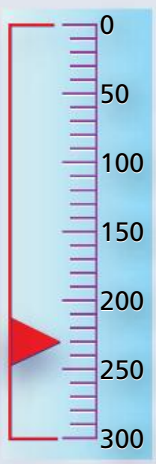
Quantity	Instrument	Common units
Time	watch or clock	second s minute min hour h
Length	metre rule or tape measure	millimetre mm (1/1000 m) centimetre cm (1/100 m) metre m kilometre km (1000 m)
Mass	balance	gram g (1/1000 kg) kilogram kg tonne t (1000 kg)
Temperature	thermometer	degree Celsius °C
Volume (liquids)	measuring cylinder	millilitre mL (1/1000 L) litre L

Notes on table

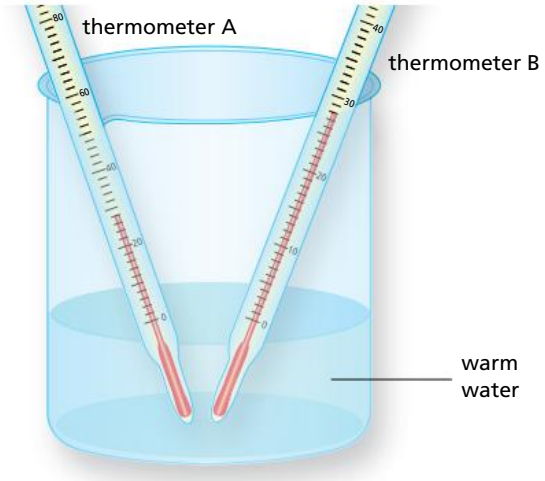
1 Prefixes are used for smaller and larger units.
micro (μ) = one millionth
milli (m) = one thousandth
centi (c) = one hundredth
kilo (k) = one thousand
mega (M) = one million

2 The volume of solids is more commonly measured in cubic centimetres (cm^3) or cubic metres (m^3). 1 cm^3 is the volume of a cube with a side of 1 cm.

3 When measuring the volumes of liquids, 1 cm^3 is the same as 1 mL.

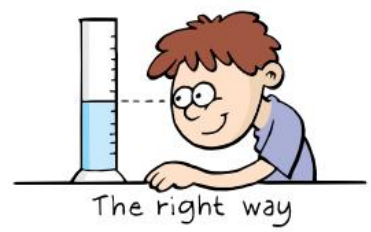
Scale	Steps	Example
	1 Determine how the scale should be read. In other words, do you read the scale from left to right or up and down?	1 Find the lowest number on the scale; in this case it is at the top. The highest number is at the bottom, so the scale must be read from top to bottom.
	2 Decide what each division on the scale means.	2 In this example there are five divisions between 0 and 50, so each division must equal 10 units.
	3 Locate the two numbers before and after the pointer.	3 The number before the pointer is 200 and the number after it is 250. So the pointer is indicating somewhere between these numbers.
	4 Count the number of divisions from the number before the pointer to the pointer.	4 There are three divisions or 30 units.
	5 Add this number to the number of divisions before the pointer.	5 The number before the pointer is 200, and there are three divisions or 30 units to the pointer, so the pointer reads 230.

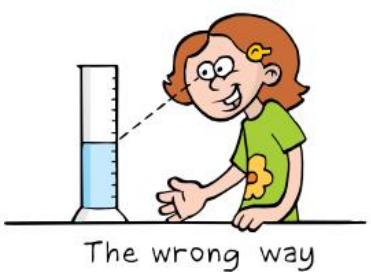
Some scales have few divisions and are not very accurate. The smaller the divisions on a scale, the more accurate the scale is. For example, thermometer B below will give a more accurate measurement than thermometer A because it has smaller divisions and more of them.



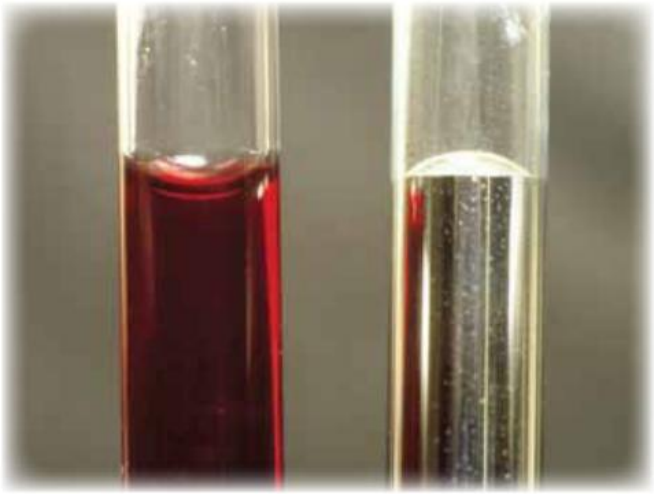
Mistakes can happen when measuring because the instrument is faulty or it is not used properly. For example, failure to look directly over the pointer or look square on to the measuring instrument causes **parallax error**.

If you read the speedometer from the passenger seat of a car, you tend to read a different speed than the driver does, because of parallax error.





If you are using a glass measuring cylinder where the water level is the pointer, you must make sure you are at eye level with the top of the water to avoid parallax error. Also, the water level does not form a straight line but dips in the middle forming a curved surface called a **meniscus** (men-IS-cus). You read the scale from the *bottom* of the meniscus.



With water in a glass tube or measuring cylinder, the meniscus is curved downwards, as on the left. With mecury (right), the meniscus is curved upwards.

For accuracy, scientists usually repeat their measurements and then take an average. All the measurements are added together and this figure is then divided by the total number of measurements taken. Here's an example.

$$\begin{array}{r} 20.4 \\ 19.3 \\ 20.3 \\ \hline 60.0 \end{array} \qquad \text{average} = \frac{60}{3} = 20$$

Accurate measurements rely on accurate recording too. So it is important to record what you do and not rely on your memory. A good way to collect information is to make a **data table**. Let's say you are working in a kitchen and need to keep control of the food you have used over a week. A data table makes this task quick and easy. The columns are the types of food you want to count. The rows show when you do the counting.

Days	Potatoes	Tomatoes	Onions
Mon	|	||	|
Tue	𝍸	𝍸 |	||||
Wed	𝍸	|	|
Thur	||||	||	|

Each food is recorded by drawing a vertical line up to four. When number five is counted you cross out the bundle, forming a group of five. This also makes it easier to add up. This type of table is called a *tally* table. It is one type of data table that can be used in science.

INVESTIGATION

2 Measurement in action

Aim

To practise some measurement skills.

Risk assessment and planning

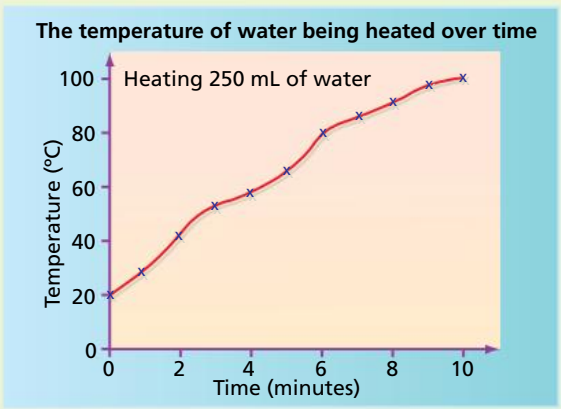
Read this investigation before starting.

1 What precautions do you need to take?

2 To record your findings in Part A, make a data table with three column headings: *Minutes from start*, *Number of drops* and *Temperature*. Your row headings will be minute intervals.

3 Make a data table for Part B with column headings: *Minutes from start*, *Temperature of tea with milk*, *Temperature of tea without milk*. Your row headings will be minute intervals.

4 To display your results you will use line graphs. These show how something, like the temperature of water, rises and falls over a given period. A person's weight, height or temperature over time would be shown on a line graph.



Such a graph has four important features:

- A title to tell you what the graph is about.
- Two scales. In this example time is the scale on the horizontal or x-axis and temperature is the scale on the vertical or y-axis.
- Points are plotted correctly with a smooth curve connecting the points, not a straight line.
- The graph takes up all the space on the paper. A small graph is too hard to read.

PART A

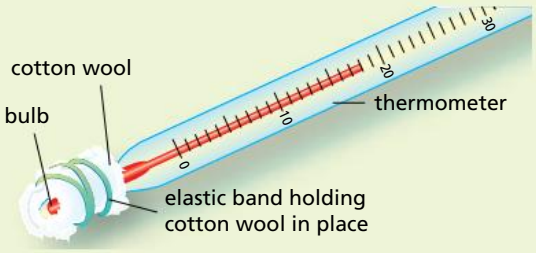
Apparatus

- thermometer
- cotton wool ball
- acetone in a dropping bottle
- retort stand
- elastic band

Method

1 Place the bulb of a thermometer inside a cotton wool ball and secure it with an elastic band.

2 Record the starting temperature.



3 Every 30 seconds place 1 drop of acetone on the cotton ball and record the temperature. Continue until there is no temperature change.

4 Record your results in a data table.

Results

Use your results to draw a line graph.

Conclusion

Copy and complete these sentences.

The acetone changed from a liquid to a gas, cooling the thermometer very _____. This is an example of a _____ change.

PART B

Aim

To find out if milk affects how fast tea cools.

Apparatus

- 250 mL beakers
- 20 mL milk
- hot water from a kettle
- 2 tea bags
- thermometer

Method

1 Using two 250 mL beakers make 2 cups of hot tea with 200 mL of water in each beaker.

2 Measure the starting temperature of each beaker then add 20 mL of milk to 1 beaker only.

3 Measure the temperature of each beaker at minute intervals until the temperature no longer changes.

Results

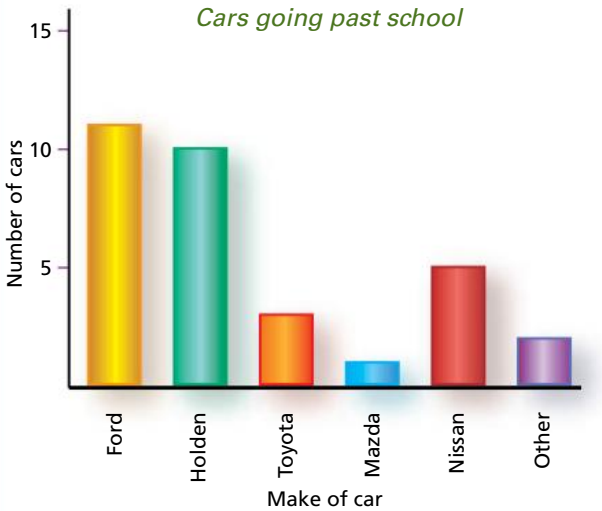
Draw the results for both beakers on one graph.

Investigate whether adding milk makes any difference to how fast the tea cools.

INQUIRY

1 Drawing a column graph

A line graph is not the only type of graph you can use to record results. In a column graph the columns run vertically, or up and down the page. In a bar graph or chart the bars run horizontally, or across the page. These graphs are used to compare groups of things. For example, if you wanted to record the types and numbers of cars that go past the school gate in a half-hour period you would use a column or bar graph.



1 Record the number and make of cars in the teachers' car park (under supervision). Draw a bar or column graph of your results.

2 When Bob was cleaning out the sports shed he counted the following equipment:

cricket bats	10	hockey sticks	44
tennis racquets	20	rounders bats	5
golf clubs	38	lacrosse sticks	24

Draw a column graph of his records.

3 Tennille recorded the amount of stock in her hairdressing salon. Her results were:

hairbrushes	5
shampoo	25
conditioner	21
tint tubes	16
moisturising treatments	8
peroxide bottles	3

Present this information as a bar graph.

Over to you

1 What sort of graph would you use to show the following?

- **a** a person's heart rate as they ran a marathon
- **b** the numbers of different types of book in the library
- **c** the weight of a person from birth until adulthood
- **d** the numbers of different food items in the tuckshop
- **e** the temperature of the air throughout the day

2 If you were to draw the graphs above, what would the x-axis and y-axis on each be?

3 Cailin and Ryan measured the lengths of their young pet rabbits. Here are their results:

Rabbit name	Length (cm)
Flopsy	24
Peter	27
Cotton Tail	21
Bunny	18
Brair	26
Bugs	22

- **a** Draw a graph of their results.
- **b** Flopsy had been measured since birth and her length recorded every week for eight weeks.

Weeks	1	2	3	4	5	6	7	8
Length (cm)	10	11	14	15	18	20	21	24

Which type of graph would you use to display these results? Draw the graph.

4 What are the units of measurement for distance, temperature and time?

5 Helen was pulled over by the police and asked to explain why she was speeding. She said she didn't think she was. The policeman then asked Scott who was sitting next to Helen to state what her speed was. Why wouldn't Scott be able to give Helen's speed accurately?

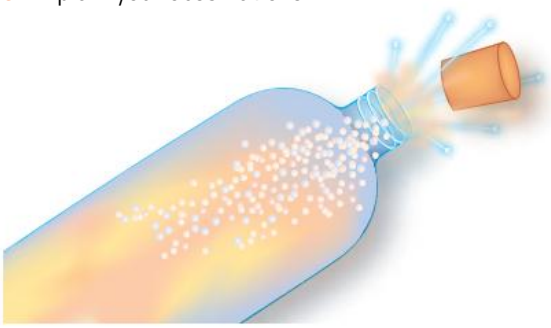
6 Why is a scale with many divisions on it better to use than one with large divisions?

2.3 Chemical changes

INQUIRY 2 Bottle pop

You will need: clear plastic drink bottle with a cork that fits well, baking soda, bottle of vinegar (acetic acid), teaspoon, measuring cylinder

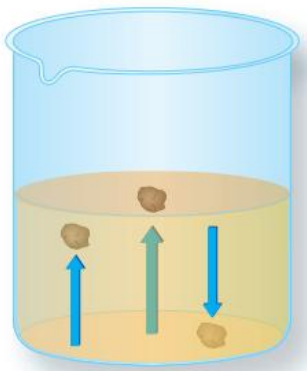
1. Go outside to do this activity.
2. Place two teaspoons of baking soda in the drink bottle.
3. Moisten the cork with water.
4. Add 200 mL of vinegar to the bottle and very quickly put the cork in the top of the bottle (not too tightly).
5. **Do not point the bottle at anybody or anything**. If the cork does not pop out, shake the bottle or add more baking soda or vinegar.
6. Explain your observations.



INQUIRY 3 Dancing sultanas

You will need: can of lemonade, sultanas, 250 mL beaker or glass of the same size

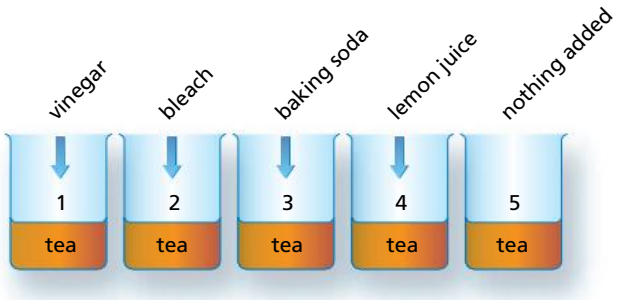
1. Fill the beaker almost to the top with lemonade.
2. Add five sultanas to the lemonade.
3. Try to explain the movement of the sultanas in the lemonade. You may need to check what happens to sultanas in just water.



INQUIRY 4 Tea rainbow

You will need: 5 small beakers (100 mL), a large beaker (500 mL), 2 tea bags, bleach, lemon juice, teaspoon of baking soda, vinegar (acetic acid), hot water (not boiling)

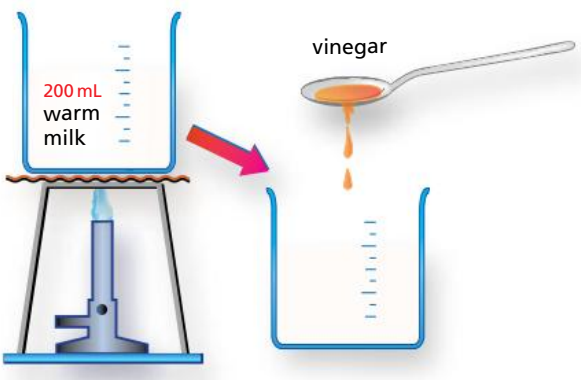
1. Make a cup of tea in the 500 mL beaker with 400 mL of hot water and a tea bag. **Do not drink it.**
2. Divide the tea from the large beaker into five 100 mL beakers so they are filled equally.
3. In beaker 1 place a teaspoon of vinegar.
4. In beaker 2 place a teaspoon of bleach. (Caution: Bleach is corrosive, so try to avoid getting it on your skin.)
5. In beaker 3 place a teaspoon of baking soda.
6. In beaker 4 place a teaspoon of lemon juice.
7. In beaker 5 place nothing but tea.
8. Observe and explain what happens.



INQUIRY 5 Sour milk

You will need: milk, vinegar, Bunsen burner equipment, 250 mL beaker

1. Pour 200 mL of milk into a 250 mL beaker and gently warm it. Do not boil it.
2. Add a teaspoon of vinegar to the milk and stir it.
3. Observe what happens and try to explain your observations.



What is a chemical change?

There are many physical changes that occur in the kitchen. Water boiling, making jelly and making ice blocks are all examples of physical changes.

Changes where one or more new substances are formed also take place in the kitchen. Such changes are called **chemical reactions**. Think of making a cake. You mix all the ingredients together, for example, eggs, milk, sugar and flour. When you place these mixed ingredients in the oven, the heat of the oven causes them to change. You cannot get the ingredients you started with back from the cake once the chemical reaction has taken place. So chemical reactions usually cannot be reversed.

Cooking an egg is another example of a chemical reaction. The cooked egg is very different from the raw egg, and you cannot get the raw egg back again once the egg is cooked.

Signs of a chemical reaction

All of the activities on the previous page were examples of chemical reactions. The end product was very different from the ingredients or reactants you mixed.

In Inquiry 2, you would have observed bubbles being given off as the reaction took place. Vinegar mixed with baking soda reacts to produce carbon dioxide gas that bubbles through the liquid. Carbon dioxide makes soft drinks fizzy.

Baking soda is added to cakes to make them rise in the oven. The baking soda reacts with other ingredients in the cake, releasing carbon dioxide that bubbles through the cake, making it light and fluffy. As a result the cake rises.

In Inquiry 3, the sultanas started to rise because they became lighter. The carbon dioxide bubbles acted like life jackets and carried the sultanas to the surface. The gas escaped at the surface, and the sultanas became heavy and sank again.

In Inquiry 4, you would have observed different colour changes in the tea. Lemon juice and vinegar are acids, whereas bleach and lime are bases. Acids and bases are two different types of chemicals. The tea is called an indicator because it turns a different colour depending on whether an acid or a base is present.

The fifth beaker in Inquiry 4 had nothing added to it. It was used as a point of comparison with the others. You needed to see tea with nothing in it and compare it with the tea that had things added to it to see the colour changes. A point of comparison like this is called a **control**.

In Inquiry 5 the milk curdled. Milk contains tiny particles of protein and other substances. The vinegar reacted with the particles, causing them to form clumps. The clumps are called curd, and the runny leftover liquid is called whey. The curd can be used to make cheese.

In the four activities you observed new substances being formed—colour changes, gases produced, and a solid being produced from a liquid—all indicating that chemical reactions had taken place.

Sometimes a chemical reaction can produce heat, light and sound. This is what happens in an explosion.

To sum up, as new substances are formed in a chemical reaction:

a a gas may be released

b a colour change may occur

c a solid may be formed from a liquid

d the mixture may become hot or cold

e light and sound may be produced.

Some chemical reactions release energy.

When do reactions occur?

You will have noticed that reactions do not usually take place on their own. First, chemical reactions only occur under certain conditions. You have to have the right substances present. For example, it is no use using salt instead of baking soda to make a cake. The cake just won't rise.

Second, you often need a source of energy to cause a reaction. To fry an egg or make a cake rise you need heat. To make the curds and whey in Inquiry 5 you needed to warm the milk. You also need a supply of heat (e.g. a match) to ignite the gas in a Bunsen burner or gas stove. The gas then reacts with the air. This reaction is called **combustion**.

Sometimes the heat needed to cause reactions is produced by electricity. Toasters, hot plates, and waffle and sandwich makers work this way. The electricity runs through coils of wire in these appliances, causing them to heat up, and this causes chemical reactions in the foods they come in contact with.

Reactants and products

To describe a chemical reaction in as few words as possible you can use a **chemical equation**. For example:

water + carbon dioxide → carbonic acid

Water and carbon dioxide are the **reactants** or the substances that react together. Carbonic acid is a **product**—what is produced.

Chemical reactions produce fireworks.

Over to you

1 Which of the following statements are true and which are false? Rewrite the ones that are false.

- **a** In a chemical change one or more new substances are formed.
- **b** Making a cake is an example of a chemical reaction.
- **c** A point of comparison in an experiment is called a control.
- **d** Producing curds and whey from milk is an example of a physical change.

2 The following signs indicate a chemical reaction has occurred. Give an example of a reaction for each sign.

- **a** A gas may be released.
- **b** A colour change may occur.
- **c** A solid may be formed from a liquid.
- **d** The mixture may become hot or cold.
- **e** Light and sound may be produced.

3 Which of the following are chemical changes and which are physical changes? Explain your answers.

- **a** wax melting
- **b** a pear rotting
- **c** yogurt going sour
- **d** an egg being fried
- **e** a fire cracker exploding
- **f** socks drying in the sun
- **g** radiator bars glowing red hot
- **h** gas burning in a hot water system
- **i** coffee dissolving in water

4 Charlie mixed two unknown chemicals in an ice-cream container. The container melted and a strange smelling gas was given off. Had Charlie caused a chemical reaction? Give reasons for your answer. What advice would you give Charlie?

5 Combustion occurs in the engine of a car so that the car can move. What is the energy source for this reaction? What are the reactants, and what are the products?

6 When potassium iodide is added to lead nitrate, potassium nitrate and lead iodide are produced. Write a chemical equation for this reaction.

2.4 Wanted and unwanted chemical reactions

Chemical reactions occur within us and around us. In a car engine, fuel is burnt in air to cause movement. Chemical reactions keep our bodies working. Plastics, detergents, fuel and paints are made in chemical reactions.

Probably the most important chemical reaction of all is **photosynthesis**:

carbon dioxide + water + sunlight → glucose + oxygen

In this reaction, plants use sunlight to make their own food (**glucose**). Animals then eat plants and other animals to survive. So all life depends on this reaction.

Many appliances work because they have batteries in them that provide **energy**. Plants and animals do not have batteries in them. Instead another important reaction, called **respiration**, provides the energy needed for their bodies to work. Energy is released during this reaction.

glucose + oxygen → carbon dioxide + water + energy

Chemical reactions ensure that the materials needed by our bodies are manufactured, and wastes are removed. For example, chemical reactions occur inside us to break down our food so we can use it. Substances called **enzymes** (EN-zimes) make these chemical reactions take place faster than they normally would, so our bodies can function correctly.

The reaction of baking soda with vinegar is a reaction that can be used to make honeycomb. The chemical reaction of milk with acids is how we make cheese.

Yeast is a living organism that changes glucose (sugar) into alcohol and carbon dioxide in a process called **fermentation**. Yeast is added to malt (for beer) and to grape juice (for wine) so that fermentation can take place to make alcohol. Yeast is also added to bread, and the carbon dioxide released makes the bread rise.

Soda–acid fire extinguishers use the following chemical reaction to produce carbon dioxide to extinguish fires. The reaction produces a 'gaseous blanket' that covers the fire and prevents air getting to it, thus making the fire go out.

baking soda + sulfuric acid → sodium sulfate + carbon dioxide + water

Some chemical reactions are unwanted. For example, rusting causes iron and steel to break down and look unsightly.

iron + oxygen → iron oxide (rust)

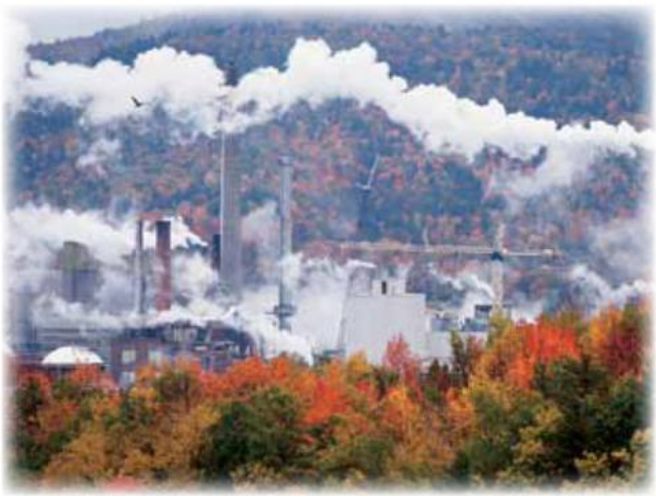
Many metals tarnish or look dirty because of a similar reaction. For example, copper gets a green tarnish of copper oxide. When this happens the copper has to be cleaned.

copper + oxygen → copper oxide

A reaction that occurs between your teeth and acids causes tooth decay. The acids are formed by the action of bacteria on food. This is why you need to clean your teeth after eating.

Chlorofluorocarbons (CFCs) that were used in aerosol cans have reacted with ozone in the atmosphere and converted it to oxygen. This reaction is breaking down the protective layer of ozone around the earth and letting harmful UV light through.

To make toast, a chemical reaction occurs that browns the bread as it reacts with air. However if the toast burns, we end up with black carbon. This same reaction occurs in bushfires and house fires.



Unwanted chemical reactions

INVESTIGATION

3 Chemical reactions

Aim

To observe a range of chemical reactions.

Risk assessment and planning

Read the investigation before you start.

1. What precautions should you take when handling boiling liquids?
2. What should you do if you spill any of the hot liquid on or around you?
3. What should you do with any food items when you have finished?
4. Why shouldn't you eat what you make in science?

PART A: Making honeycomb

Apparatus

- 1 cup of sugar
- ¼ cup of water
- 1 teaspoon of vinegar
- ¼ teaspoon of baking soda (sodium hydrogen carbonate)
- large saucepan
- kitchen spatula
- 1 teaspoon of butter
- stove
- baking tray, lightly greased with butter

Note: Your teacher may be able to arrange to do this in a kitchen.

Method

1. Place the sugar, butter and water in a large saucepan. Do not leave the saucepan unattended at any time.
2. Bring the mixture to the boil gently until it turns a golden yellow colour, then remove it from the stove immediately.
3. Stir in the baking soda and vinegar. The carbon dioxide produced should make the mixture bubble. Watch it does not spill over the edge of the saucepan. It will be very hot.
4. Pour the mixture into the baking tray and stir it several times with a spatula until it sets.

PART B: Yeast action

Apparatus

- 3 plastic drink bottles (1.25 L)
- sugar
- large measuring cylinder
- 3 identical balloons
- yeast
- teaspoon
- string

1. Blow up and stretch each balloon several times.
2. Put 3 teaspoons of sugar in each bottle and label the bottles 1, 2 and 3.
3. Add water to the bottles as follows:
   - 500 mL of cold water to bottle 1
   - 500 mL of slightly warm water to bottle 2
   - 500 mL of hot water to bottle 3.
4. Shake each bottle to dissolve the sugar, then add one sachet of yeast to each. Fit a balloon over the top of each bottle.
5. Put the bottles in an incubator (30–40°C) for 30 minutes.
6. Try to explain your observations.

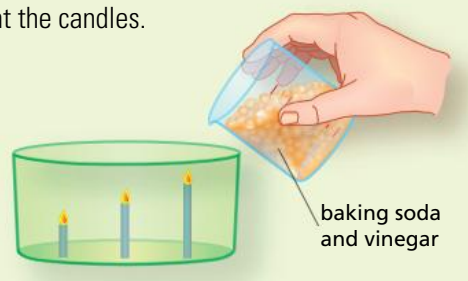
PART C: Fire extinguisher

Apparatus

- baking soda
- beaker or jar
- 3 birthday candles of different lengths
- ice-cream container that is taller than the longest candle
- vinegar (acetic acid)
- teaspoon

Method

1. Set up the apparatus as pictured here. Light the candles.



2. Put 2 teaspoons of baking soda in a beaker. Cover the baking soda with vinegar. Tilt the beaker over the container as shown, but don't pour out any froth or liquid.
3. What do you observe happening? In groups try to explain your observations.

INVESTIGATION

3 continued

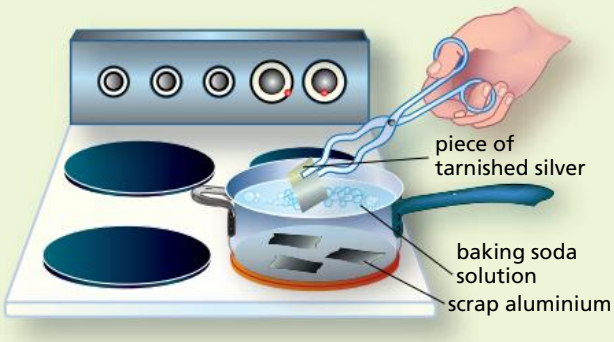
PART D: Silver tarnish

Apparatus

- metal tongs
- saucepan or large beaker
- baking soda (sodium hydrogen carbonate)
- scrap aluminium, e.g. disposable pie plate; piece of silver that has become tarnished (lost its shine), e.g. cutlery or coin
- stove or heating equipment

Method

1. Add 2 teaspoons of baking soda to 500 mL of water in a saucepan or large beaker.
2. Add some scrap aluminium to the solution. (You don't need any scrap aluminium if you use an aluminium saucepan.)
3. Heat the solution, but do not boil it. Then use a pair of metal tongs to place the tarnished silver in the solution. Make sure the silver touches the aluminium.
4. After the silver has been cleaned, remove it from the solution and wash it in running water.



Note: If you hold the piece of silver partway into the solution, you can see the contrast between the cleaned and tarnished parts.

Results

Describe the four chemical reactions that you have observed.

Conclusion

For each reaction, state whether you think it is a wanted or an unwanted reaction, and explain your reasoning.

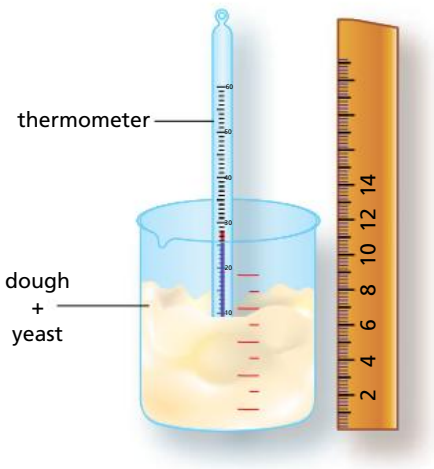
Write your report

Write your report in the usual way.

Over to you

1. **a** Name two wanted and two unwanted chemical reactions that are mentioned in this chapter.
   b Name two other wanted and two other unwanted reactions that are not mentioned in this chapter.
2. Copper and silver need to be cleaned because they tarnish. How could you stop these metals tarnishing?
3. What are enzymes?
4. In your own words explain how a soda–acid fire extinguisher puts out a fire.
5. Greg noticed that when yeast is added to dough, heat is released. He decided to measure the amount of heat given off by placing a thermometer in his dough and taking the temperature every 5 minutes. He also measured how high the yeast had risen. Here are his results.

Time (min)	0	5	10	15	20	25
Temperature (°C)	15	20	25	32	33	33
Dough height (cm)	0	2	6	10	11	11



   a Draw line graphs of these results for Greg. Put time on the *x*-axis and draw both graphs using the same scale.
   b Did a chemical reaction occur? How do you know?
   c How long did it take for the reaction to start? How do you know?
   d At what temperature did the reaction start?
   e Was there a point where the amount of heat given off stopped increasing? What happened to the dough height at this point?
   f Predict what you think would happen to the dough height after 2 minutes.

2.5 Properties of materials

Objects in the kitchen and the home are made of different materials. There are six major groups of materials: metals, ceramics, plastics, fibres, wood and glass. We use these materials in different ways depending on their properties.

Metals

Metals are very useful to us because they can be bent and twisted into shapes. We say metals are *malleable* because of this. We can shape almost anything we want out of them, e.g. pots, pans, cutlery. Metals are also shiny, which is a useful property because they can be easily cleaned.

Metals are good **conductors** of electricity and heat. This means they allow electricity and heat to move through them. This makes metals excellent for pans. Heat from the stove easily passes through the pan and into the substance being cooked. However, pan handles are not made of metal because you would burn your hand as the metal heats up. So handles are usually made of plastic, wood or silicone. These substances are **insulators**. They do not allow the transfer of electricity and heat through them very easily.

Ceramics

Ceramic materials, often called china or porcelain, are made from moulded clay that is heated to very high temperatures in special ovens called kilns. This means that many ceramics, such as casserole dishes, can be heated strongly. Ceramic materials are long wearing and usually glazed so that substances don't affect them (e.g. by staining or absorbing liquids). This is why the ceramic material does not contaminate any food placed in it. They are also hard to scratch and easily cleaned, which is why plates, cups and saucers are made from china. However, ceramics will break if you drop them!

Plastics

Plastics are synthetic or manufactured materials made using chemical reactions. They can be shaped and moulded. They are hard wearing and easy to clean. Some plastics, however, are easily scratched and melt when put near heat.

Plastics are useful because they can be shaped into objects such as chairs, bowls and glasses. They are not easily broken so they are great for children to use. Plastics, however, can be harmful to the environment when burnt. And because they do not decay they are hard to dispose of. This is why it is essential to recycle them.

Fibres

Natural fibres such as wool, cotton and cellulose are made from living things. These fibres are long wearing and useful for making clothing. Natural fibres usually don't burn easily.

Synthetic fibres like nylon or polyester are manufactured. They are often added to natural fibres. This makes the material easier to use and less likely to crease or need ironing. Many synthetic fibres, however, burn or melt easily.

Wood

Wood is made of cellulose, a natural material made by plants. It can be carved and shaped, and has many advantages over plastic. For example, it is completely natural, easily recycled and attractive to look at. However, it can be burnt if over heated and is easily dented.

Glass

Glass is a material that is very useful because it is transparent. Like plastic it can be shaped and moulded to make useful objects and it can be recycled. It does get brittle with time and is easily broken. It can be cleaned and does not affect any food items that are stored in it.

So the properties of materials make them suitable for different uses.

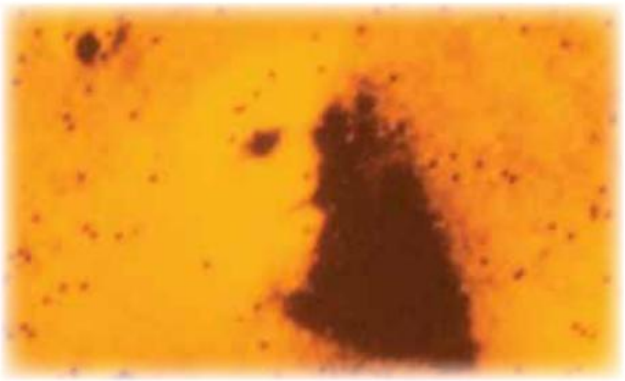
Which of the six major groups of materials are shown here?
Which are not shown?

SKILL

Inferring and predicting

So far, you have been asked to record your observations in practical work and activities. When you make an observation and try to explain it, you are making an **inference**. When you make an observation and then try to tell what future observations will be, you are making a **prediction**.

Look at the photograph of the 'face' on the surface of the planet Mars. It was taken by the unmanned *Viking* spacecraft in 1976 in the late afternoon. The observation is that the landscape of Mars looks like a face. Once you try to explain this observation, for example by saying how it might have been formed, you are making an inference.



You need to remember three things about inferring.

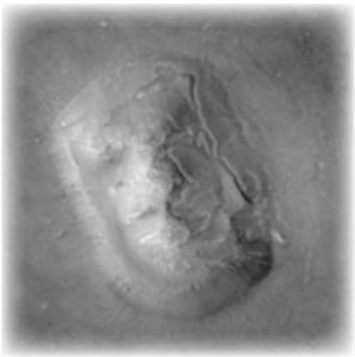
1. *There can be many inferences for the one observation.* For example, the 'face' could have been carved by an ancient Martian civilisation or it may have been formed by land movements. Perhaps it is just a picture formed by shadows from the afternoon sun.
2. *Observations are correct if they are made carefully and honestly.* However, inferences made from the observations are not always correct. But they can be tested by further observations. Suppose the *Viking* spacecraft was able to take another picture the following morning. If the face was caused by afternoon shadows, then morning light would give a different view of the same landscape. If the face was carved by people or made by land movements it would still be much the same.
3. *It is important not to confuse inferences with observations.* An explanation of an observation is very different to the observation itself. For example, a theft occurred at a jewellery shop. A man nearby saw a person run out of the jewellery shop into the carpark. When questioned by the police he said 'I saw the robber run into the carpark. He must have been looking for the getaway car'. The police reported that the robber escaped from the jewellery shop into the carpark where a car was waiting for him. They had both confused an observation with an inference. The observation was that a person ran out of the jewellery shop into the carpark. There can be many inferences to explain who the person was and what he was doing in the carpark.

Predicting or making a forecast of what a future observation may be is another important skill in science. Predictions are based on your observations and what you already know. A weather forecast is an example. Meteorologists are people who study the weather, make careful observations and then, based on their knowledge of weather patterns, make a forecast or prediction for the next day. They may not be right all the time, but for most of the time they are quite accurate.

INQUIRY 6

The face on Mars

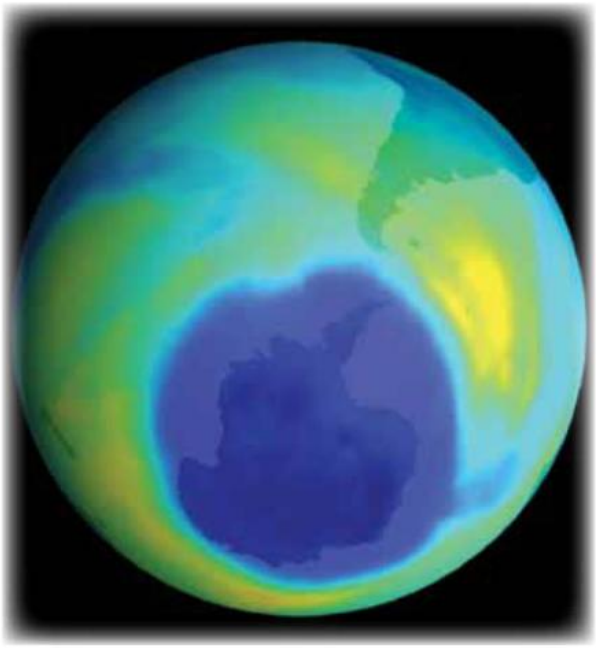
1. Look at the picture of the 'face' on Mars (left). List as many observations as you can about this picture.
2. What inferences have been made on this page to explain the 'face' on Mars? List them.
3. What other inferences could you suggest to explain the 'face'?
4. Look at the photo of the 'face' on Mars taken more recently. What further observations can you make?



5. Based on the new observations you have made, what do you infer is the cause of the 'face'?
6. What do you predict will happen to the 'face' in 10 years' time? What did you base your prediction on?

INQUIRY 7 What am I?

Look at this picture carefully.



In groups answer the following questions.

1 What observations can you make about this picture? List them.

2 What inferences can you make from your observations? List them.

3 List what your group members think the picture is from your discussion.

Now read the following clues about the picture.

- I am now affecting South America.
- I may soon affect Australia.
- I measure 26 million square kilometres.
- I am the result of an unwanted chemical reaction.

4 With these new clues answer questions 1–3 again.

5 Predict what you think this picture will look like in 10 years time.

6 Were you able to make more inferences?

7 Were your inferences correct? (See the correct information on page 42.)

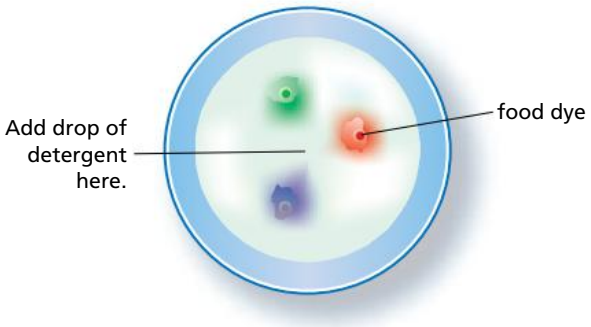
INQUIRY 8 Detergent action

You will need: saucer, 3 different food dyes, detergent, milk

1 Fill the saucer with milk.

2 Place 1 drop of each food colour in the saucer as shown, so that the drops do not touch.

3 Place 1 drop of detergent in the centre of the bowl and observe what happens.



4 Record all your observations.

5 Write an inference to explain your observations.

6 If detergents act this way with drops of food dye, what can you predict will happen with grease and dirt on plates and clothes?

INQUIRY 9 The disappearing cup

You will need: white foam cup for carrying hot liquids, acetone, glass (not plastic) dish

Because of the acetone fumes, this activity could be done in a fume cupboard or as a teacher demonstration.

1 Place the foam cup in the dish.

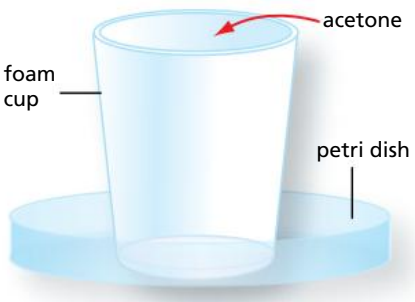
2 Pour some acetone into the cup.

3 Record your observations.

4 Could the cup be recycled by dissolving it in acetone? Explain.

5 Write an inference to explain what has happened.

6 Test whether acetone affects other plastics in the same way.

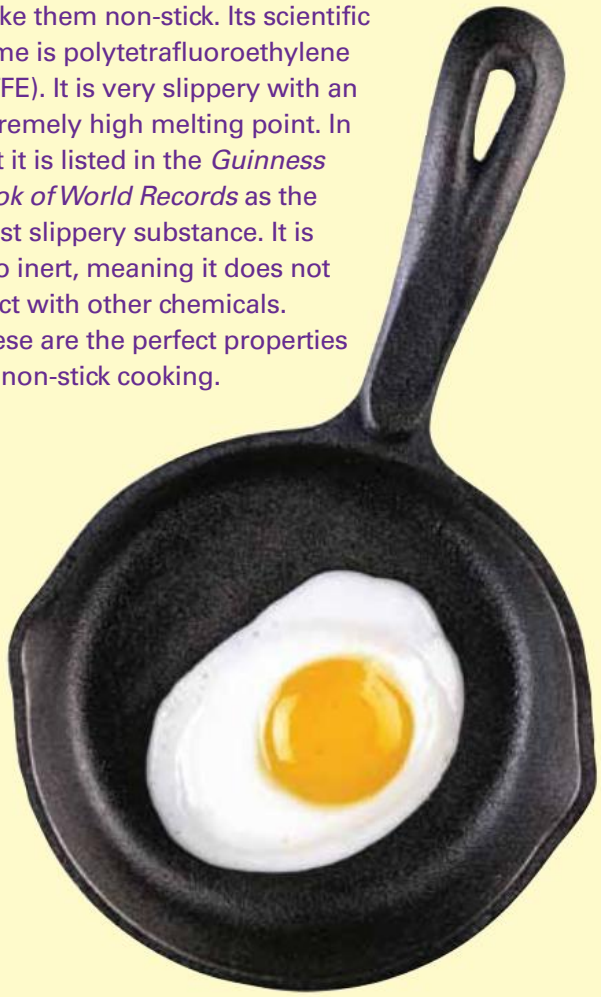


SCIENTISTS AT WORK

Roy J. Plunkett (1911–1994) and Teflon™

The story of Teflon™ shows how it is possible to alter the properties of materials to make them more useful to us.

Teflon™ is the material used to coat frypans to make them non-stick. Its scientific name is polytetrafluoroethylene (PTFE). It is very slippery with an extremely high melting point. In fact it is listed in the *Guinness Book of World Records* as the most slippery substance. It is also inert, meaning it does not react with other chemicals. These are the perfect properties for non-stick cooking.

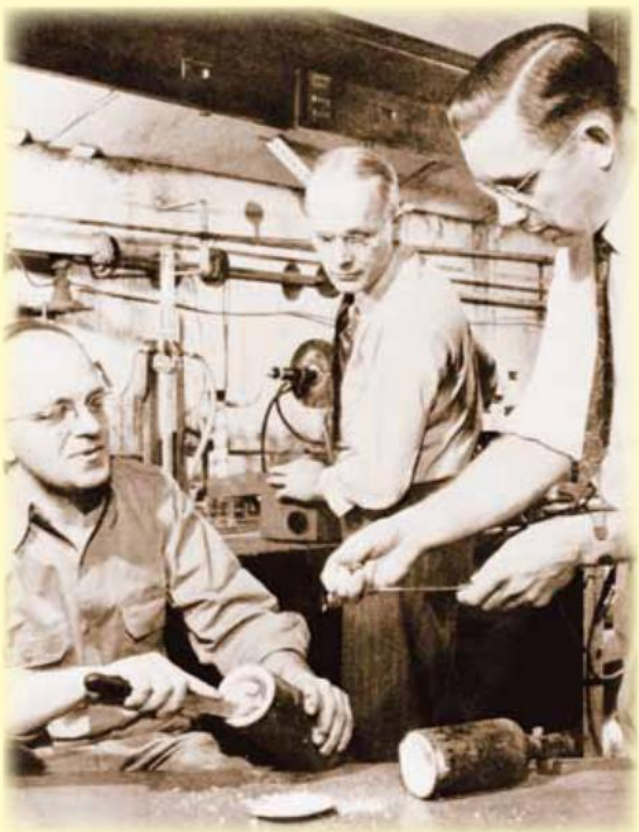


Teflon™ is also used in computer chip development and to protect data communication cables. It is used as a fabric protector on home furniture and uniforms because it repels water and stains from fabrics without changing the colours of the fabrics. The DuPont Stainmaster® carpet is made using technology based on Teflon™, which is why this carpet is stain-resistant. Teflon™ is added to socks to reduce friction and therefore blisters, and in wiper blades on cars, nail enamel (nail polish) and hosiery. It is also used in the space program for heat shields, space suits and blankets, and to insulate cargo holds.

This amazing material was found by accident by chemist Dr Roy J. Plunkett, working at DuPont in the United States. In 1938 Plunkett was testing the chemical reactions of tetrafluroethylene (TFE)—a refrigerant gas. He noticed that no gas came out of a cylinder that had been filled earlier with TFE. The cylinder was too heavy to be empty, so Plunkett and his assistant Jack Rebok decided to investigate what had happened to it. They cut it open, and discovered that the gas had changed to form a white powder. When Plunkett investigated this powder he found that it was a new substance with amazing properties. DuPont registered the name of this powder as Teflon™ in 1945.

A common question asked is that if teflon doesn't stick to surfaces, how can it stick to cookware? The surface of the pan is roughened and then a special primer or first coat is put on. The Teflon is then placed in layers on top of the primer to make sure it sticks to the pan.

So the story of Teflon™ shows us how mistakes or unplanned events can lead to wonderful discoveries in science.



Roy Plunkett (seated) removes some of the white Teflon™ powder from the cylinder he cut open.

Over to you

1 Copy and complete the following table.

Material	Properties	Objects made of this material	Why has this material been used?
Metals	malleable, shiny, conductors		
Plastics			
Glass			
Ceramics			
Fibres			

2 Which material would be best if you wanted to

a hold water in a container that was transparent and recyclable?

b give a child some food or drink in a container that wouldn't break?

c heat a casserole in the oven in a clean, sturdy container?

d make a utensil that looked shiny and was easy to clean?

e knit a jumper?

3 What is the difference between a conductor and an insulator?

4 Give three examples of insulators and three examples of conductors in your home.

5 State whether the following are true or false.

a A forecast of a future observation is called a prediction.

b Inferences made from observations are always correct.

c Inferences are not the same as observations.

d Explaining what you have observed is called a guess.

e There can be many inferences for one observation.

6 Look at the following situation.

a Which statement is the observation, which is the inference, and which is the prediction?

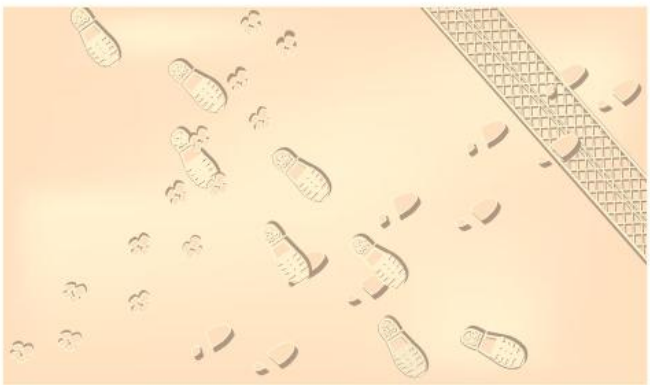
b Write three more examples like this. Check with your teacher that your examples are correct.

c Swap your examples with a partner. See if you can tell the difference between an observation, an inference and a prediction from their examples.

7 **a** What observations can you make about the burning candle below?

b What inferences can you make from these observations?

8 The following tracks were found on a section of deserted beach.



a Infer who or what had been on the beach that day.

b Infer the order in which the tracks were made.

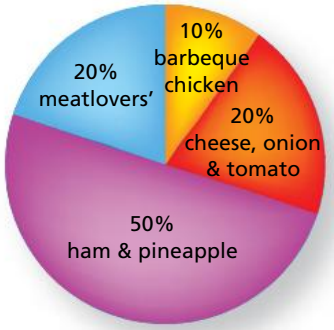
9 The discovery of Teflon™ has been described as *serendipity*, a stroke of good luck and a marvellous accident. It has also been described as a scientist thoroughly checking his findings. Find out what serendipity means. How would you describe the discovery of Teflon™?

10 Do you know of any other scientific inventions that were discovered by accident? Research these.

THINKING SKILLS

1 Some reactions occur very quickly and some very slowly. How could you show that the speed of cooking is altered by the size of the food being cooked, e.g. chopping versus no chopping?

2 This pie chart shows the results from asking 50 people what their favourite pizza is.



a Change this pie chart to a column graph showing the different pizza choices.

b If you surveyed another 50 people what would you predict to be the favourite pizza? Explain your prediction.

3 The table below shows the times when high tide occurs at a local beach.

	Sat	Sun	Mon	Tue	Wed
am	6.20	7.10	8.00	8.50	
pm	6.45	7.35	8.25	9.15	

a What is the difference between each morning tide?

b What is the difference between the morning and afternoon tide?

c Predict what the morning and afternoon tide will be on Wednesday.

4 Some substances easily change state from a liquid to a solid and back again. How would you show that some substances are suitable for freezing and others are not? You will need to see how substances freeze and thaw, e.g. try water and lettuce. Which substances can be frozen and used again?

5 There are many factors that affect the outcome of an experiment. For example, in Inquiry 2 on page 31 (Bottle pop), the following factors affected how far the cork 'popped': amount of vinegar, amount of baking soda, size of bottle, size of cork etc.

List the factors that could affect the following reactions:

a Bouncing balls (page 31)

b Sour milk (page 31)

c Yeast action (page 35)

You may like to carry out some investigations to see which factors make these reactions go the fastest. For example, you could hold a competition to find who can make the cork pop the furthest (under supervision) or who can make the sultanas bounce the most.

6 Design and carry out an experiment to show how parallax error can affect the speed that passengers sitting in different places in a car will read on the speedometer.

7 Liquids change state at different rates. For example, methylated spirits evaporates faster than water. Design and carry out an experiment to measure the evaporation rates of the following liquids:

water, methylated spirits, acetone, kerosene, turpentine.

8 Today beeswax candles are popular to make at home. Investigate whether beeswax candles last as long as candles that are made commercially.

Explanation of Inquiry 7

The picture shows the hole in the ozone layer above Antarctica. The picture was taken by a NASA satellite.

PROBLEM SOLVING

For your chapter task you could find an example of a wanted or unwanted chemical change or demonstrate why we use a particular material in the kitchen.

You could demonstrate the properties of solids and liquids using kitchen equipment.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 Changes that take place around us can be _____ changes, where no new substance is formed, or _____ changes, where a completely new product is made.

2 The three states of matter are _____, liquids and gases. Matter can easily change form. For example, a liquid _____ to become a gas.

3 When measuring it is important to always use the correct _____ of measurement. There are errors such as _____ error that can occur when taking measurements.

4 Physical changes can be _____ but chemical changes cannot. In a chemical reaction, the materials that react together are called the _____ and the new substances formed are called the _____.

5 An example of a wanted chemical reaction is _____. An example of an unwanted chemical reaction is _____.

6 When you explain what you have observed, you are making an _____. When you forecast a future observation you are making a _____.

7 The ways in which substances are used depend on their _____.

chemical
evaporates
inference
parallax
photosynthesis
physical
prediction
products
properties
reactants
reversed
rusting
solids
units

Self-management

A data table can be used for revision since it allows you to see at a glance what you have covered. You can then approach your teacher with the problems that you need help with, and make sure you study these areas for a test. A table like this is helpful for revision, no matter which subject you are studying.

Copy and complete this data table to make a summary of Chapter 2.

Summary of Chapter 2 *Science Essentials 7*

Page	Important points covered	New words	Problems I am having
25	*Physical change — reversible mixtures, change of state* *Chemical change — not reversible* *Change of state — solids, liquids and gases* *Water cycle*	*Evaporation* *Condensation* *Precipitation* *Solidification* *Melting*	*I don't understand what the difference is between a physical and a chemical change.*

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Which of the examples below show physical changes and which show chemical changes?

a toast burning

b ice melting

c snow forming

d bread being made

e food rotting

2 Which of the following are true and which are false? Rewrite the ones that are false.

a Heat from the sun causes water to evaporate from the surface of water.

b Precipitation is when a gas forms a solid.

c Physical changes cannot be reversed.

d A qualitative observation requires measurement.

e Water usually forms a meniscus in glass containers.

f Scientists repeat their measurements for accuracy.

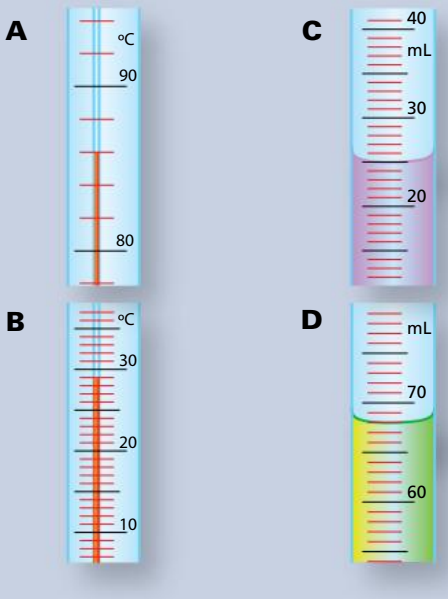
g New substances are formed in chemical reactions.

h Photosynthesis is an unwanted chemical reaction.

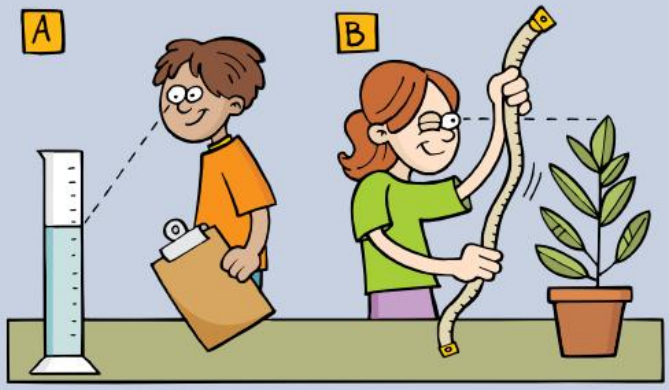
i Metals are conductors of electricity and heat.

j Predicting a future observation is called making an inference.

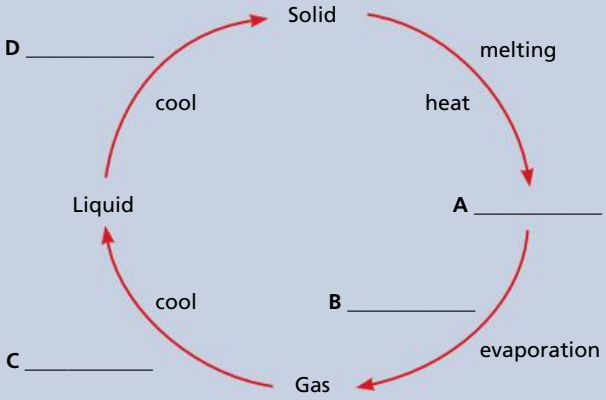
3 What measurement is indicated on each of the scales below?



4 Explain what the error of measurement is in each of the pictures below.



5 Copy and complete the missing words on the change of state wheel.



6 Explain how rain is formed in the water cycle.

7 Put the correct unit of measurement with the instrument used to measure it.

centimetres, grams, seconds, degrees Celsius, millilitres

a balance

b tape measure

c thermometer

d watch

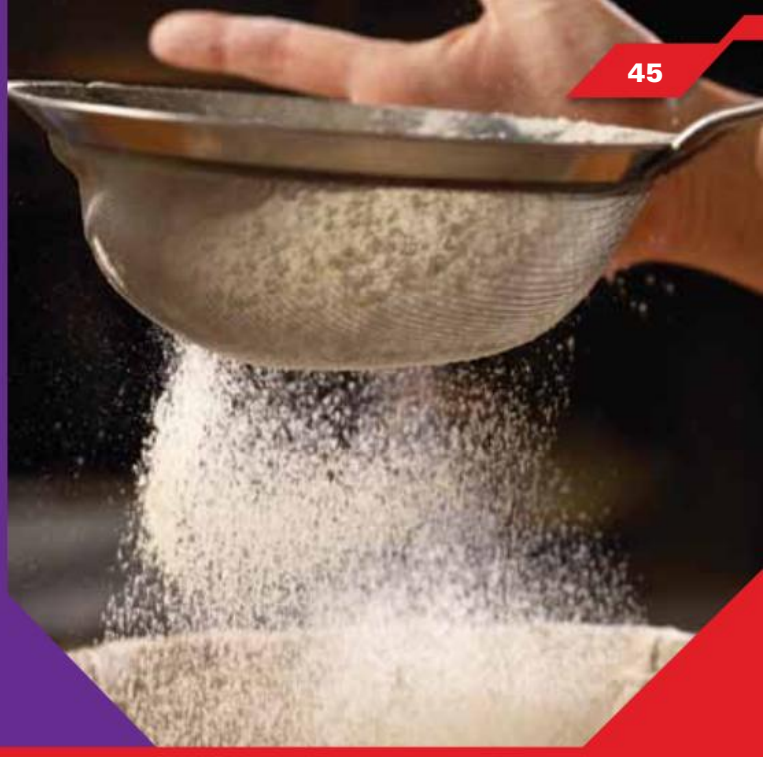
e measuring cylinder

8 Drew counted the books he had in his bedroom. Here are his results:

Books	Number
School texts	15
Novels	25
Dictionaries	3
Sports magazines	28
Comics	10

Draw a graph to display Drew's book count.

3



Separating mixtures

By the end of this chapter you will be able to …

Science Understanding

- recognise the differences between pure substances and mixtures, and identify examples of each
- identify the solvent and solute in a variety of solutions
- investigate a range of separation techniques such as filtration, distillation and chromatography

Science as a Human Endeavour

- investigate a career in water treatment

Science Inquiry Skills

- use scientific equipment correctly and handle chemicals safely
- discuss how successful a water purification project was and suggest possible improvements

Focus for learning

Our water comes from dams and reservoirs. Before we can drink it, however, it needs to be purified to remove any suspended solids, bacteria, colour and odour. We sometimes take pure water for granted.

PROBLEM SOLVING

Purifying water

Imagine the normal water supply has broken down. The only water available is creek water, which is greenish in colour, smells, and has all sorts of things in it, e.g. twigs and mosquito wrigglers. *How can you make this water pure enough to drink?*

1 Form a group with other students. Your task is to purify a sample of about 200 mL of impure creek water.

2 Observe the creek water. What can you see and smell in it?

3 In your group, brainstorm ways of purifying the water. Write down your ideas and keep the list.

You will find lots of different ways of separating mixtures in this chapter, and many of these can be used to purify water. Add these to your list.

4 As a group you will need to decide on these things.

- Which method or combination of methods will you use?
- What equipment will you need?
- Who will do what?
- How much time will you need?

You may need to discuss the problem with your teacher. You may also need to use the library. For example, how is the water for your city or town normally purified?

5 When you and your teacher are happy with your plan, put it into action. Keep a record of everything you do.

You could prepare a poster for presentation to the rest of the class.

Don't drink the water since it may contain harmful bacteria even if you think you have killed them.

6 Discuss how successful your method was.

- What was the water like after you purified it?
- How much purified water did you recover?
- Is your method practical?
- How long did it take?
- How much would it cost?
- Would your method work for larger volumes of water?

7 If you aren't happy with your results, try again. You may need to treat your water again, or try a different method.

LITERACY FOCUS

adsorption
aerosol
capillary action
centrifuge
chromatography
colloid
crystallisation
decanting
dialysis
distillation
emulsion
filtrate
filtration
flocculation
froth flotation
mixture
permeable
pure substances
residue
sedimentation

3.1 Mixtures

The many different substances around us all have different properties. They can be solids, liquids or gases. Each substance has its own characteristic properties that allow you to distinguish it from other substances. For example, sugar has a sweet taste. Petrol has a distinctive *smell*. Glass is *transparent* (you can see through it). Diamond is extremely *hard*. Grass is a green *colour* and lead is very *dense*.

All materials can be classified into one of two groups—pure substances and mixtures. **Pure substances** contain particles that are all exactly the same. They always have the same properties, no matter where you find them. Salt, gold, distilled water and carbon dioxide gas are all pure substances.

However, most materials are **mixtures**—made up of several different substances mixed together. These substances can be solids, liquids or gases. For example, soft drink is a mixture of water and carbon dioxide gas, plus sweetener, flavouring and colouring. Sometimes mixtures are combinations of solids, liquids and gases, as shown in the table top right.

Soft drink is a mixture of five different substances, but it looks and behaves like a single substance.

Mixtures made of the same substances can have different properties. The amount of each part of the mixture (called their proportions) can vary widely. This changes the properties of the mixture. For example, concrete is a mixture of cement, sand, gravel and water. The properties of the concrete, for example, its strength, depend on the proportions of cement, sand and gravel.

Examples	Type of mixture	Main parts of mixture
Black coffee	solid in liquid	Coffee powder in water
Smoke	solid in gas	Tiny bits of soot, dust etc. in air
Sterling silver	solid with solid	Silver and copper
Soft drink	gas in liquid	Carbon dioxide in water
Air	gas with gas	Nitrogen and oxygen
Wine	liquid in liquid	Alcohol in water

Solutions

Most of the mixtures in the table above are **solutions**. When a teaspoon of sugar is added to a glass of water and the mixture stirred, the sugar **dissolves** to produce a sweet-tasting, clear, colourless liquid. Even though it is a mixture, it looks as though it is one substance only. This is because its properties are the same everywhere throughout the solution. The water is the solvent and the sugar is the solute. Water is called the *universal solvent* because so many substances dissolve well in it.

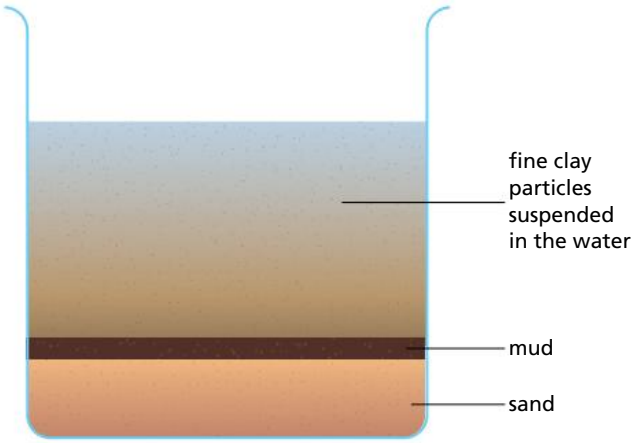
Solutions can be solids as well as liquids. For example, sterling silver is made by melting and mixing silver and copper (7½%) and allowing the mixture to cool. Solutions can even be gases. For example, pure air is a mixture of mostly nitrogen and oxygen. Its composition is always the same.

Some solutions involve mixtures of all three states of matter. For example, urine is a solution in which water is the **solvent** and urea (a solid) and ammonia (a gas) are two of the many solutes.

Suspensions

A **suspension** is a mixture that has tiny bits of insoluble solid suspended in it, like muddy water. Suspensions are cloudy because light rays are scattered by the tiny suspended bits of solid.

When a suspension is left to stand the large, heavy particles settle faster than the smaller, lighter ones. The solid that collects on the bottom of the container is the sediment. When flooded rivers wash away the soil from their banks, they carry suspended solids down to a calmer area where the mud and sand settle to the bottom. This natural process is called **sedimentation**.



Muddy water is a suspension. When it is left to settle, sediment forms on the bottom of the container.

Colloids

The Yarra River in Melbourne is well known for its brown colour. This is because the clay in the water is so fine that it will not settle, as it would normally do in a suspension. Instead the clay particles are spread evenly throughout the water, forming what is called a **colloid** (COL-oyd). A colloid has properties in between a solution and a suspension.

The particles in a colloid may be tiny bits of solid, liquid droplets or gas bubbles. The substance containing these particles may also be a solid, a liquid or a gas. The table on the right shows the common types of colloids.

Many of the things you eat are colloids. This meringue and the whipped cream inside it are both colloid foams.

A liquid-in-liquid colloid is called an **emulsion** (ee-MULL-shun). A common example is ordinary homogenised milk, where tiny globules of butterfat are spread throughout water. It is processed by forcing the milk through small holes to break up the larger fat globules in the cow's milk. This is why the cream (the fat) doesn't come to the top on standing.

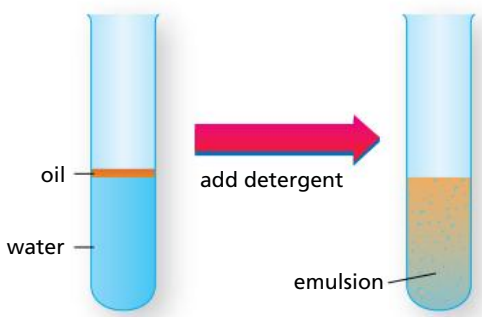
Colloid	Type	Examples
Liquid emulsion	liquid in liquid	mayonnaise, milk, ice-cream
Solid emulsion	liquid in solid	cheese, butter, face cream, bitumen
Liquid aerosol	liquid in gas	fog, clouds, household sprays
Gel or sol	solid in liquid	most paints, blood, toothpaste, mud, jelly
Foam	gas in liquid	whipped cream, beer froth, soap suds
Solid foam	gas in solid	marshmallows, pavlova, pumice, polystyrene foam

INQUIRY 1

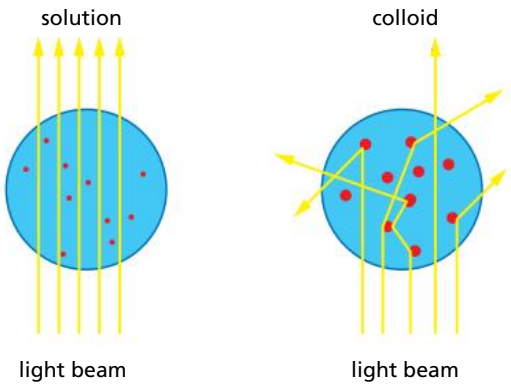
Forming an emulsion

You will need: used engine oil or vegetable oil, liquid detergent, test tube and stopper

1. Add water to the test tube to a depth of about 2 cm. Then add a few drops of oil. Do the oil and water mix? What happens if you stopper the tube, shake the mixture and let it settle?
2. Add a drop of detergent, shake vigorously and allow to settle. What do you observe?
   - Write an inference to explain your observations.
   - How do you think detergents get dishes and clothes clean?



Although it is easy to see fogs, foams and emulsions, it is often hard to tell the difference between solutions and some types of colloids. One way to do this is to shine a beam of light through both. In the solution you can't see the beam because the dissolved particles are too small to scatter the light. But the beam can be seen in the colloid because it is scattered by the larger particles. This is why you can see the headlights of a car in fog.



INQUIRY 2 Solution or colloid?

You will need: large flask, hypo (sodium thiosulfate), dilute hydrochloric acid, measuring cylinder, projector

1. Dissolve a large spoonful of sodium thiosulfate in a litre of water in a large flask or beaker.
2. Arrange a projector so that its beam shines through the flask. Can you see the beam in the solution when looking from the side?
3. Add about 20 mL of dilute hydrochloric acid to the flask and stir. What happens now?
   - Write an inference to explain your observations.

Over to you

1. Which of the following are mixtures, and which are pure substances?
   - **a** air
   - **b** concrete
   - **c** gold
   - **d** orange juice
   - **e** oxygen gas
   - **f** petrol
   - **g** polluted water
   - **h** salt
2. Which of the following are true, and which are false?
   - **a** Water dissolves everything.
   - **b** Solutions are always coloured.
   - **c** Oxygen gas dissolves in water.
   - **d** Emulsions settle out on standing.
   - **e** Lime cordial is a solution.
   - **f** A solute can be a solid, a liquid or a gas.
3. In your notebook, match up the following types of mixtures with the examples.

a mixture of gases	muddy water
b mixture of solids	air
c mixture of gas in liquid	soil
d mixture of solids in liquid	smoke
e mixture of solids and gases	lemonade

4. Complete this table in your notebook by writing *yes* or *no* in the three columns for each question.

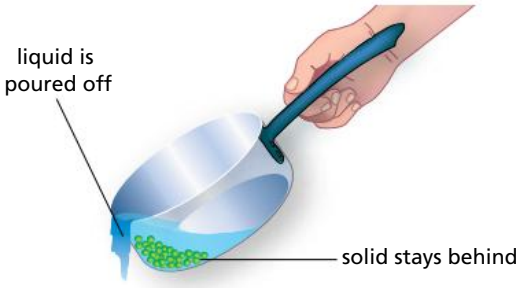
	Solutions	Suspensions	Colloids
Is the mixture clear?			
Can you see the solid bits?			
Do the parts dissolve?			
Do the solid bits settle?			
Does the mixture stay evenly mixed?			
Can you see a beam of light in it?			

5. For each of the following, decide whether it is a solution or a suspension.
   - **a** plastic paint
   - **b** salt water
   - **c** sand mixed wih water
   - **d** sugar mixed with water
6. You have a jar containing pebbles, sand and clay mixed with water. You shake the jar and let it stand. Predict what will happen and say why.
7. You cannot see the beam of light from a projector unless there is smoke or dust in the air. Why is this? You could try this for yourself.

3.2 Separating suspensions

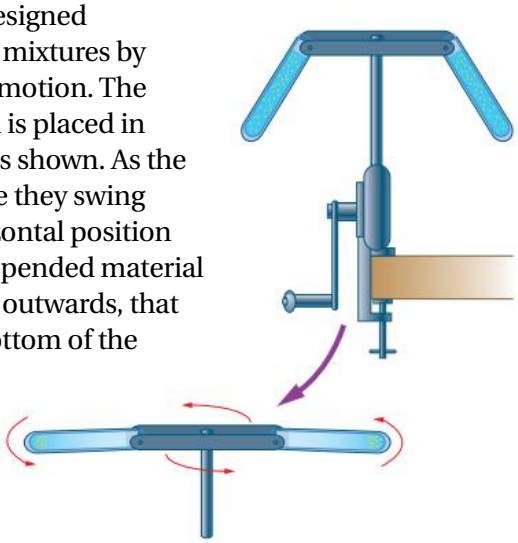
Decanting

Suppose you are in the kitchen and have boiled some peas in water, but you don't want the water. You gently tip the saucepan so that the water runs out, leaving the peas in the saucepan. Pouring off the liquid like this, while keeping the solid in the container, is called **decanting**. It is a way of separating the liquid part of a suspension from the solid part, once it has settled.



Using a centrifuge

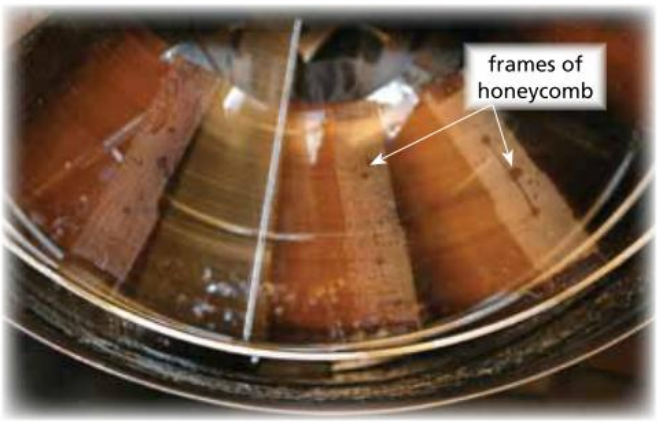
If a suspended solid settles very slowly you can speed up the separation by using a **centrifuge**. This is a machine designed to separate mixtures by a spinning motion. The suspension is placed in test tubes as shown. As the tubes rotate they swing into a horizontal position and the suspended material also moves outwards, that is, to the bottom of the test tubes.



Centrifuges are used to separate red blood cells from plasma at the blood bank. When test tubes of blood are spun in a centrifuge the heavier red blood cells settle to the bottom, leaving the pale yellow liquid plasma on top. The plasma and red blood cells can then be separated by decanting.

Blood, before and after being centrifuged

Centrifuges are used to separate cream from milk, and honey from honeycomb. A spin-dryer is also a type of centrifuge. The clothes are forced to the sides of the tub and the water passes out through the holes in the tub.



When this drum is spun the honey is forced out of the honeycomb and collects in the bottom of the drum.

INQUIRY 3 Homemade centrifuge

You will need: empty 4 L paint tin with a handle, 2 test tubes, newspaper, muddy water

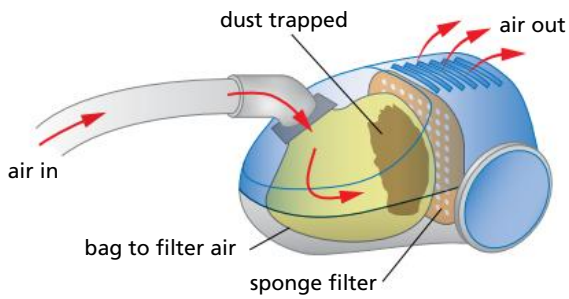
1. Pour some muddy water into 2 test tubes.
2. Put one of the test tubes into the paint tin and hold it upright by packing newspaper tightly around it.
3. Find a clear space outside where you can rapidly whirl the tin around your head without endangering anybody. When you stop whirling make sure the tin is the right way up or you will spill it.
4. Compare your 'centrifuged' tube with the other tube. What do you observe?

Filtration

Decanting is not a very good method for complete separation. Some liquid is usually left behind. Also, unless you are very careful, you are likely to pour off some solid with the liquid. A better way of separating suspensions is by **filtration**, where a suspension is poured through a *filter* and the solid is left behind.

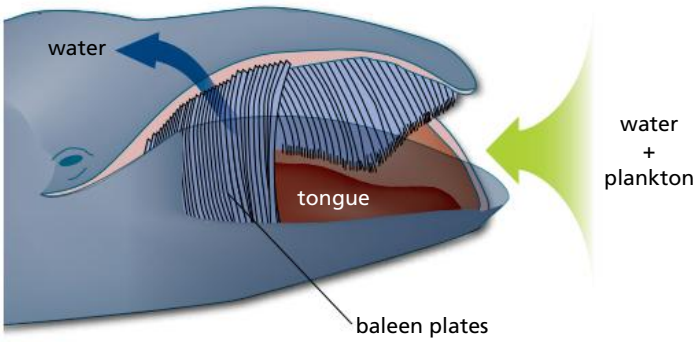
In our day-to-day life we use filters to separate solids from liquids and gases. For example, in the kitchen a colander or sieve is used to filter spaghetti from the water it was boiled in.

A teabag also acts as a filter. It allows the tea solution through the bag but not the tea leaves. Vacuum cleaners have a special bag that filters dust and dirt from the air drawn in.



There are filters in a car to clean the petrol, air and oil. Filters are used to purify the water we drink, and to clean the water in swimming pools.

Animals also use filters. For example, the hairs in your nose are used to filter the dust from the air you breathe. Baleen whales have comb-like plates called baleen along each side of their jaw. When the whale takes a mouthful of water its tongue forces water through the baleen and the plankton in the water are caught in the baleen.

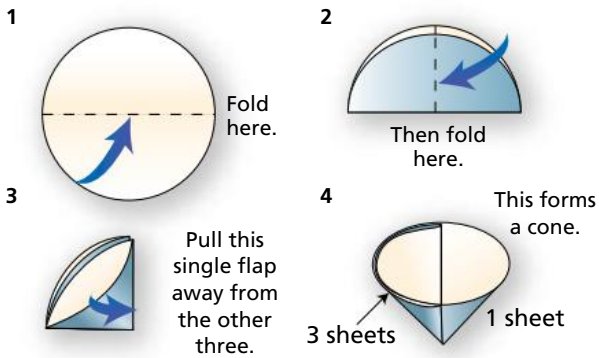


How a baleen whale filters food out of the water

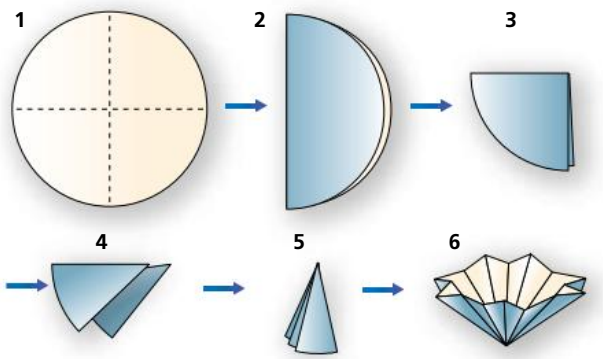
In the laboratory, filter paper is used to filter suspensions. It has tiny holes or pores that allow water to pass through it but not bits of solid. The liquid that passes through the filter paper is called the **filtrate**. The solid material that is left in the filter paper is the **residue**.

INQUIRY 4 Folding filter paper

For Investigation 1 on the next page you will need to be able to fold filter paper. To do this follow the steps below, then open out the paper into a cone as shown, to fit into a filter funnel.



To make *fluted* filter paper you keep folding the paper in half until you have folded it four times. Then you unfold it to form a fluted cone as shown.



INVESTIGATION

1 Filtering a suspension

Aim

To separate a suspension by filtering it.

Risk assessment and planning

1 Read through the investigation and describe to your partner what you have to do.

2 Are there any possible hazards to be aware of? Explain.

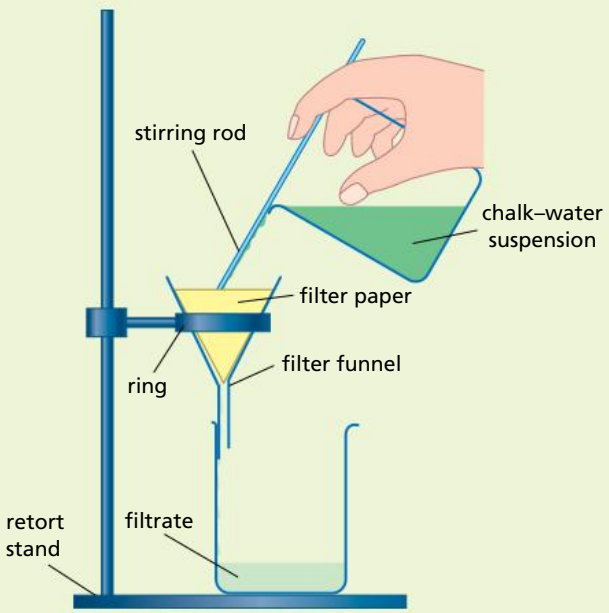
Apparatus

- crushed coloured chalk
- three 250 mL beakers
- 2 or 3 pieces of filter paper
- filter funnel
- retort stand and ring
- glass stirring rod
- teaspoon
- wash bottle

Method

1 Make a suspension by mixing about 4 teaspoons of crushed coloured chalk in about 200 mL of water in a beaker.

2 Set up the filtration apparatus as shown below. Adjust the height of the stand so that the spout of the funnel touches the inside of the beaker. This allows the water to flow out evenly, preventing splashing.



3 Fold the filter paper and put it into the filter funnel. Use the wash bottle to wet the paper so that it sticks to the sides of the funnel. (You don't need to do this with fluted filter paper.)

4 Stir up your suspension. Then hold the stirring rod as shown with its lower end *almost* touching the filter paper. This will allow the water to flow gently into the filter paper.

Carefully pour some of the suspension down the rod into the funnel. *Don't let the water reach the top of the filter paper.*

5 Use the wash bottle to rinse the remaining chalk from the beaker into the filter funnel.

✻ Is there any solid left in the filtrate? How do you know?

6 Investigate one or more of the following questions.

- What is the advantage of using fluted filter paper instead of a filter cone? Are there any disadvantages?
- There are different grades of filter paper. What difference does this make?
- Can you filter colloids? You could try starch, jelly crystals or clay mixed with water. You could also try milk (an emulsion).

Write your report

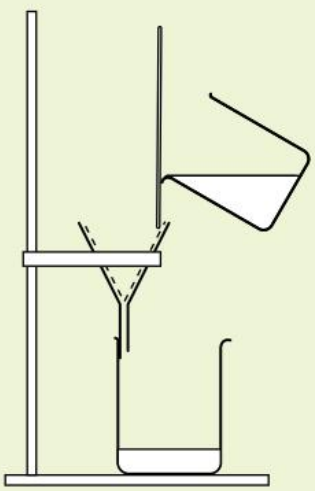
1 Explain why you:

a adjusted the filter funnel as shown in Step 2

b wet the filter paper in Step 3

c poured the suspension down a stirring rod in Step 4.

2 Copy this simple two-dimensional view of the filtration apparatus. Neatly add the following labels: *filter funnel*, *filter paper*, *stirring rod*, *filtrate*, *residue*.

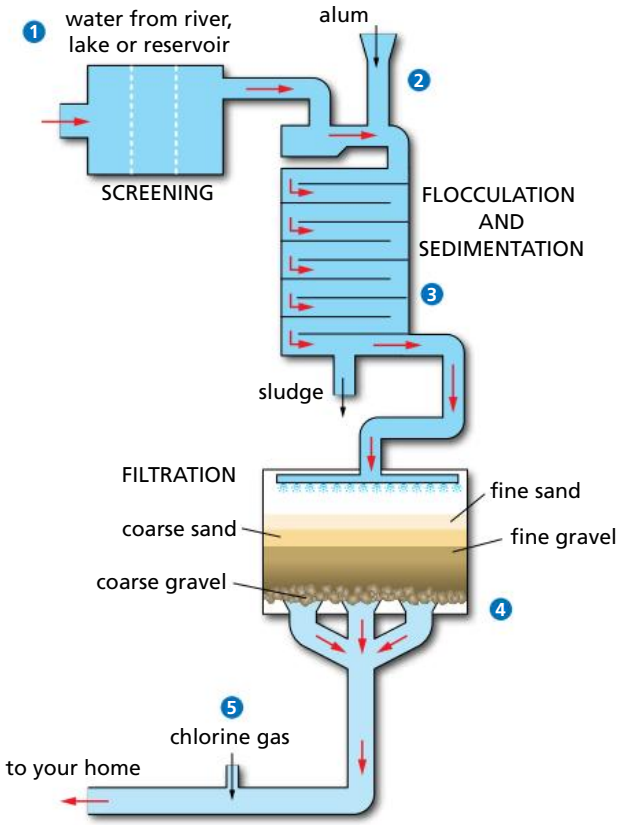


3 Record and explain your findings from Step 6.

Water treatment

There are normally five steps in the purification of water for towns and cities.

1. In the first stage the water is passed through a screen (a wire mesh filter) where large solids such as sticks are removed.
2. If there is clay in the water it forms a colloid which cannot be separated by filtration. Instead special chemicals, e.g. alum, have to be added. These cause the colloidal particles of clay to clump together and settle out. This process is called **flocculation** (FLOK-you-LAY-shun).
3. The clumps of clay in the water eventually settle to the bottom as sludge. This is the sedimentation process.
4. The mixture is then filtered through beds of sand and gravel to remove any solids that are left after flocculation and sedimentation.
5. Finally chlorine gas is added to destroy bacteria.



PROBLEM SOLVING

Which methods in this section could you use to purify your creek water from page 46? Explain.

INQUIRY 5 Clay and water

You will need: 2 test tubes, beaker, clay-based soil, alum

1. Mix the soil with water in the beaker and allow it to settle.
2. Decant some of the clay and water mixture into two test tubes.
3. To one of the tubes add a small amount of alum, shake and leave to settle.
   - Compare the two test tubes. Did the alum cause flocculation in the second tube?

Over to you

1. Work with a partner and give each other a spelling test of these words. Correct any mistakes.

apparatus	filtration
beaker	laboratory
centrifuge	sedimentation
colloid	solution
filter funnel	suspension

2. List at least four ways of separating the solid from the liquid in a suspension.
3. What is a centrifuge? Where is a centrifuge found in most homes?
4. Use a diagram to explain how a spin-dryer works.
5. Look at this household filter. Explain how it works.

6. Why is filtering usually a better method of separation than decanting?
7. Why is it important to regularly replace the filters used in cars, water purifiers and pools?
8. Suppose you use filter paper to filter river water that contains mud, sand, dissolved salt and some plant materials. Which of these materials will be present in:
   a the sediment? **b** the filtrate?
9. What happens in the sedimentation tank at a water treatment plant?
10. How could you get rid of the brown colour from a sample of Yarra River water?

SCIENTISTS AT WORK

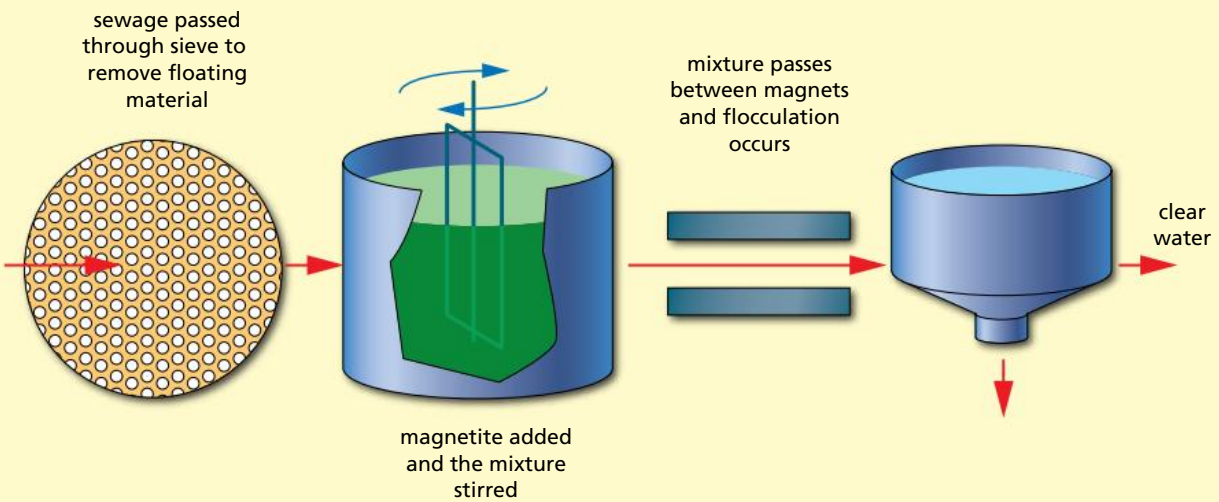
Emma Cooney and sewage treatment

At school Emma was excited by science—especially chemistry and physics. She decided to go to university and become a chemical engineer so that she could apply what she had learnt. In her first job after university Emma became interested in ways of treating the waste water from industry and so decided to join the CSIRO team working on the new SIROFLOC process.

SIROFLOC was a water treatment technology developed by CSIRO in 1977. It uses small particles of magnetite (magnetic iron oxide) to remove colour, murkiness and other impurities from water. The magnetite has a positive charge, and because the impurities have a negative charge they stick to the magnetite, causing flocculation. The magnetite, with the impurities stuck to it, is easily separated from the mixture using a magnet, leaving the treated water clean and suitable for drinking. The magnetite can then be recovered and used again.

In 1986 CSIRO scientists decided to apply the SIROFLOC process to the treatment of sewage and industrial wastes. In 1993 a pilot plant was built at Malabar in Sydney. It was able to process 5000 m^3 of raw sewage per day—what a city of 20000 people would produce. The process is so fast that what normally took 15 hours was completed in 15 minutes. However the plant cost too much to operate and is no longer used. The SIROFLOC process is still being investigated and scientists in Bulgaria have found that black sand containing a large quantity of magnetite works better than pure magnetite

Emma did a doctorate at Melbourne University to study the use of special minerals to remove smelly ammonia from sewage. She loves to know that her work designing new treatment processes for waste water is making our rivers and beaches much cleaner and safer places for us all to enjoy.



How the SIROFLOC process works

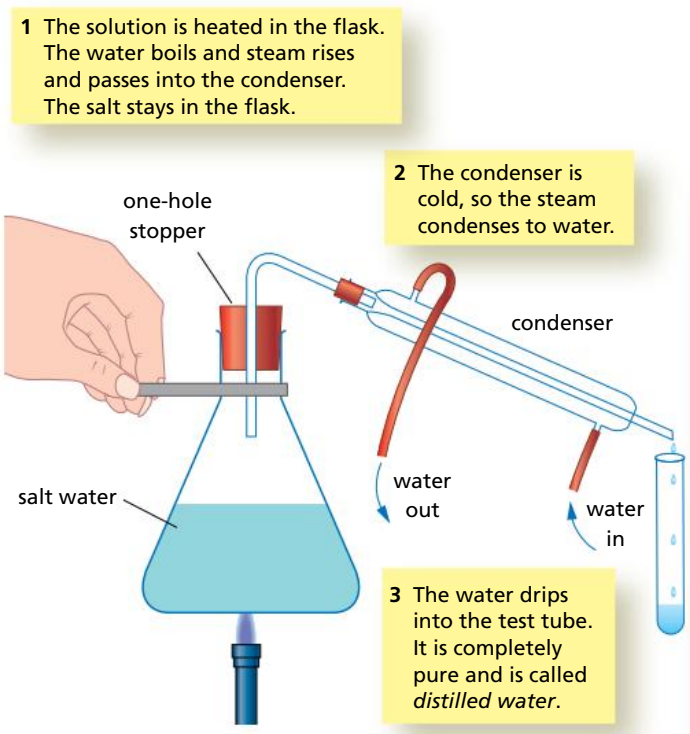
3.3 Separating solutions

Evaporation and crystallisation

If you want to separate the solid dissolved in a solution, you can heat the solution. The solvent then evaporates, leaving the solute behind. For example, if you heat soft drink, the water evaporates and the sugar and other substances that were dissolved in it are left behind. Rapid evaporation produces a powder containing microscopic crystals. Slow evaporation produces larger crystals. This process is called **crystallisation**.

Condensation and distillation

Distillation is a way of getting pure solvent from a solution. It is the same process as evaporation except that you condense the solvent after it evaporates. The apparatus below could be used to obtain pure water from salt water for example. This is what happens.



In Investigation 2 you will use a similar method to distil eucalyptus oil or plant perfume. If you boil the plant with water in the flask, the oil is extracted by the steam and can be condensed.

Salt is made by running sea water into large ponds and letting the sun evaporate the water, leaving salt crystals behind.

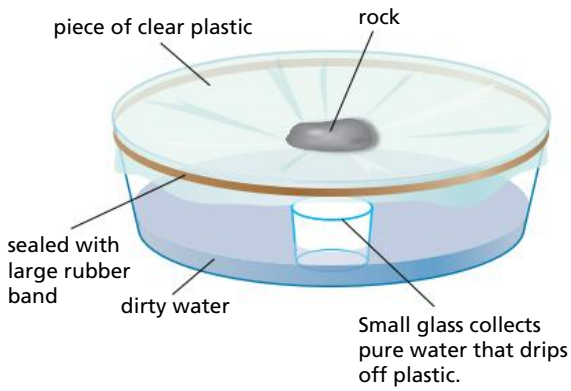
Distillation can be used to separate pure water from salty water (see Inquiry 6 below). It can also be used to separate two or more liquids with different boiling points, e.g. water and alcohol. This process is used in the making of whisky and brandy, and in the separation of crude oil into petrol, kerosene, diesel fuel and lubricating oil.

INQUIRY 6 Survival water

If you need water to survive it is possible to obtain pure drinking water from dirty water.

Design and build your own solar distillation unit. One possible design is shown below. Test it to see if it works.

- Explain how your solar distillation unit works.



INVESTIGATION

2 Oil or perfume by distillation

Aim

To use the process of distillation to make eucalyptus oil or plant perfume.

Risk assessment and planning

Read the method carefully.

1 There are a number of safety hazards in this investgation. Make a list of these hazards and for each one say how you will minimise the risk.

2 Study the diagram of the distillation apparatus. How does the condenser work?

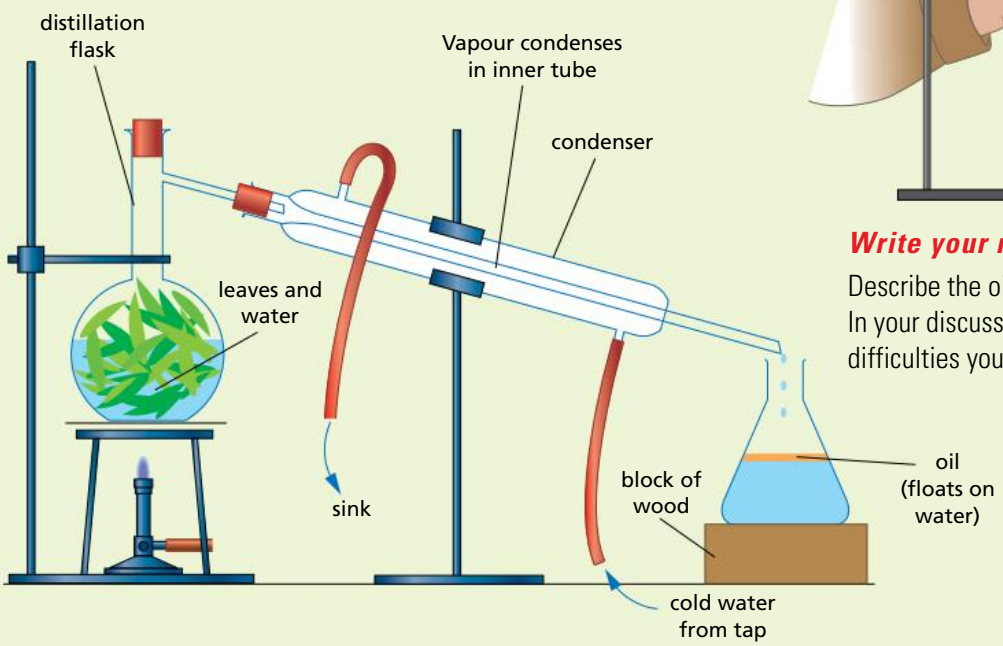
Apparatus

- eucalyptus leaves, orange peel or sweet-smelling petals
- distillation flask and condenser
- burner, tripod and gauze mat
- 2 retort stands and clamps
- 2 small flasks (250 mL)
- boiling chips
- separating funnel

Method

1 Set up the distillation apparatus as shown below. Your teacher must check it before you start.

2 Pour about 200 mL of water into the flask. Add some boiling chips to prevent bumping (violent eruption of bubbles from the bottom of the flask).



3 Add some crushed or cut up leaves, peel or petals to the flask. Put as many leaves as you can into the flask without them being too tightly packed.

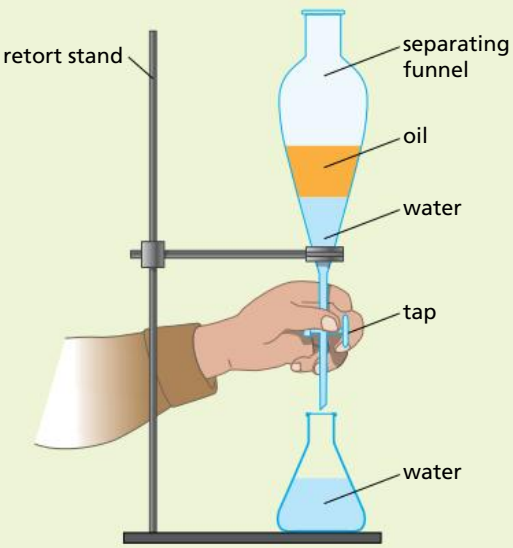
4 Turn on the water through the condenser and boil the water in the flask. Observe the steam condensing along the central tube of the condenser.

5 Collect the water and oil that come out of the condenser in a small flask. When you have collected enough oil, turn off the burner.

6 Smell the oil floating on top of the water. Rub some on your finger. Does it feel oily?

7 You can separate the oil from the water using a separating funnel. You simply pour the mixture into the separating funnel, then *carefully* turn the tap to let the bottom layer of water run into a second flask as shown. If you don't have enough oil, you could mix some commercially made oil with water.

✻ Is the oil more dense than water or less dense? Explain.



Write your report

Describe the oil or perfume you made. In your discussion describe any difficulties you had making it.

Adsorption

Adsorption is used to remove unwanted colours, flavours and odours. In this process the unwanted substance coats the surface of another substance. Adsorption is different from absorption. If you eat a pie you absorb it, but if someone throws a pie and it sticks to your face, that's adsorption. One important use of adsorption is in gas masks. Some of the first gas masks were invented during World War I. As the wearer breathed in, the air passed through a container of charcoal. This charcoal adsorbed any poisonous gases. Many modern gas masks work in much the same way.

Charcoal is good at adsorbing things because it contains a huge network of fine holes or pores. Each gram of specially purified charcoal has a surface area of about 1000 m^2. So it has plenty of surface where unwanted substances can be adsorbed. Charcoal is also used in water purifiers and to adsorb drugs from the blood of people who have overdosed.

INQUIRY 7 Removing the colour

You will need: beaker, blue litmus solution, activated charcoal, heating equipment

1. Half-fill a beaker with water. Add just enough blue litmus solution to colour the water.
2. Add a small amount of activated charcoal and boil for 5 minutes.
3. Filter the mixture and collect the filtrate. What colour is it now?
   - Try to explain what has happened.

Silica gel is another substance used in adsorption. If you look around at home you may find some silica gel in little cloth bags in bottles of tablets, camera equipment and other places where things need to be kept dry. Silica gel can adsorb as much as 40% of its own mass in water.

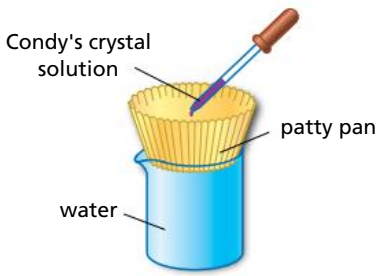
Dialysis

Dialysis (die-AL-a-sis) is a way of separating large molecules from small molecules. It is used to purify blood and to separate pollutants from drinking water. Inquiry 8 will help you understand how it works.

INQUIRY 8 Through the patty pan

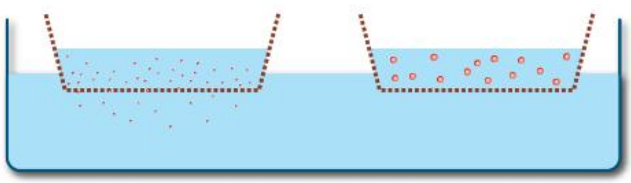
You will need: non-waxed patty pans, beaker, Condy's crystal solution, ink, 2 droppers

1. Fill the beaker with water and float one of the patty pans in it.



2. Using the dropper, place 10 drops of Condy's crystal solution in the patty pan. What happens?
3. Repeat the test with clean water, a new patty pan and ink.
   - Did the ink take more or less time than the Condy's crystal solution to pass through the patty pan?
   - Try to explain the difference between Condy's crystal solution and ink.

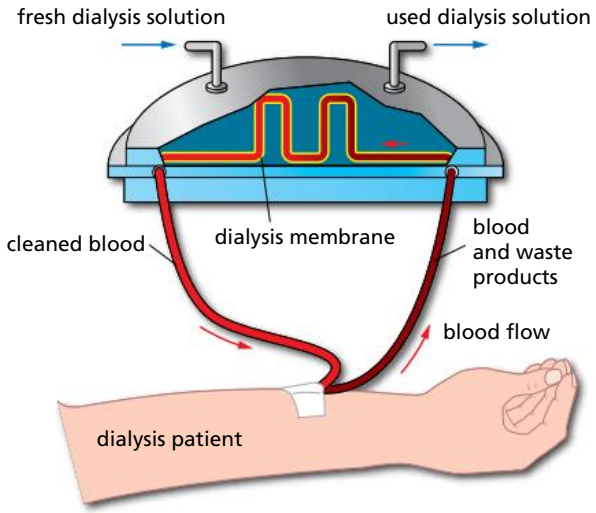
What is happening in Inquiry 8 is that the patty pan is acting as a *semi-permeable membrane*. A *membrane* is a thin sheet of material, and *permeable* means particles can pass through it. So a semi-permeable membrane lets some particles through and not others. The dissolved particles of Condy's crystals are only small. The ink is a colloid and its particles are much larger, so they do not pass through the patty pan.



Patty pans act like sieves, letting through only the smallest particles.

If your kidneys fail they stop removing waste products like urea from your blood. These toxic wastes build up and will eventually kill you. In dialysis, a patient's blood is passed through a dialysis machine which takes over the job of the kidneys, removing waste products from the blood.

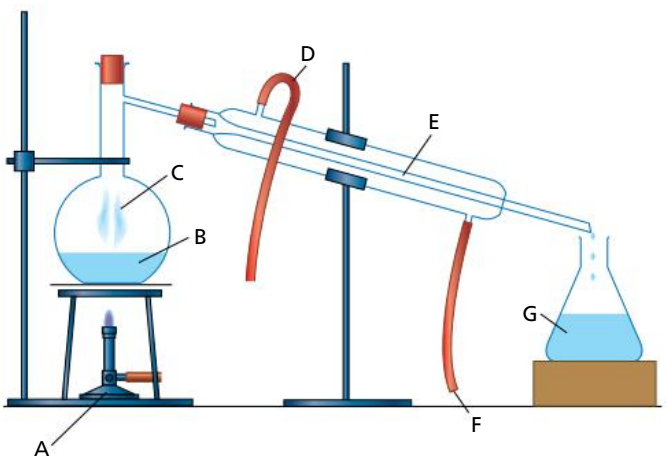
In a dialysis machine blood from the patient passes through tubes made of a semi-permeable membrane. Surrounding these tubes is a special dialysis solution that contains chemicals in amounts similar to normal blood. Blood cells are too large to fit through the holes in the membrane but urea and salt pass through it into the solution and are removed.



How a dialysis machine works

Over to you

1 The diagram shows the apparatus used to distil salt water. Write down the correct letter for each of the following:



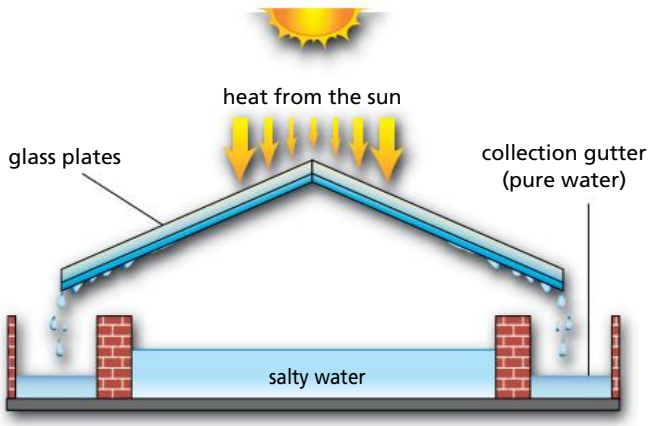
a Bunsen burner
b distilled water
c where cold water enters
d where cold water leaves
e where evaporation takes place
f where the vapour changes to a liquid
g where the salt stays

2 Which two changes of state are involved in distillation?

3 Write a sentence or sentences using these words correctly: condensation, distillation, evaporation.

4 You dissolve some blue copper sulfate in water and leave it in a basin in a warm place for a few days. Predict what will happen.

5 Describe how this solar distillation unit works.



6 Gran finds a little bag with clear crystals in it in her bottle of tablets. What is the purpose of these crystals?

7 Gas masks often contain specially prepared charcoal. Air that is breathed in must pass through the charcoal. How does the mask remove poisonous gases that are breathed in?

8 When Liam went to mow the lawn he found that there was water mixed with the petrol in the can. How could he use a separating funnel to get rid of the water?

9 After a while the fluid used in dry cleaning becomes contaminated with suspended dirt and dissolved material. Suggest a way of purifying it.

PROBLEM SOLVING

Have you started your water purification task from page 46? If not, check to see what you have to do. Are there any methods in this section you could use?

3.4 Separating solids

Sometimes we need to separate a mixture of solids from each other. The five methods in this section all depend on differences in the properties of the solids.

Flotation

If one insoluble solid floats on water and the other sinks, you can add water to the mixture and skim off the floating solid. Sand and sawdust can be separated this way.

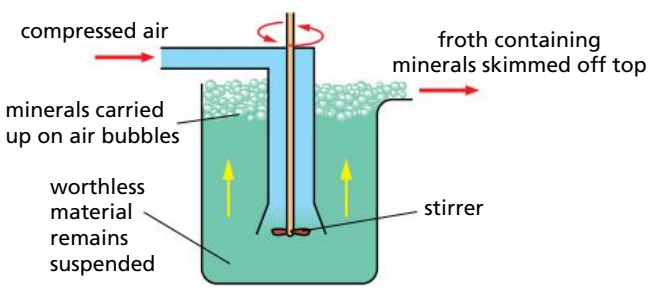
INQUIRY 9 Sand and sawdust

You will need: jar with lid, teaspoon, sand, sawdust

1. Half-fill the jar with water and add a teaspoon of sand and a teaspoon of sawdust.
2. Put the lid on the jar firmly and shake vigorously.
3. Let the jar stand for a while, then use the spoon to remove the sawdust.

- How could you separate the sand and water?

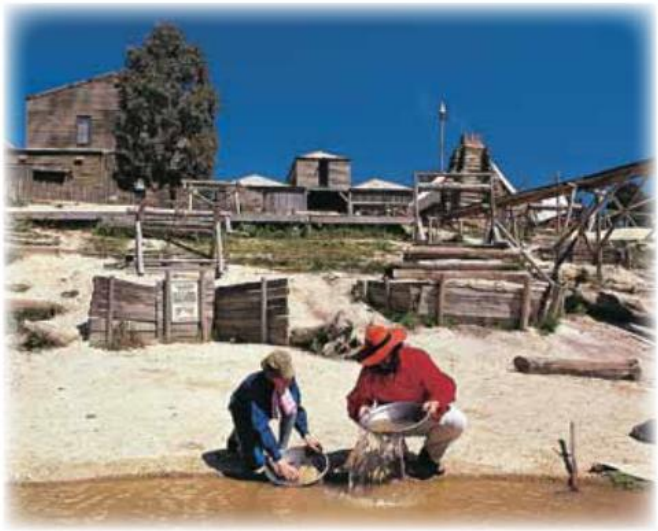
Sometimes flotation can be used even if both solids normally sink in water. A special chemical is dissolved in the water, and air is bubbled into it. A froth of bubbles floats to the top, taking one of the solids with it. This method is called *froth flotation*. It was invented in Australia, at Broken Hill, and is often used to separate valuable minerals from rock.



How froth flotation works

Gravity separation

If one solid is heavier than the other, you can use gravity separation. A good example of this is gold panning. Here the water is swirled about in the pan, allowing the heavy gold to sink and the lighter mud and sand to be washed off the top. This is like decanting.



When you pan for gold you use gravity to separate heavy gold particles from 'lighter' sand.

INQUIRY 10 Sand and lead shot

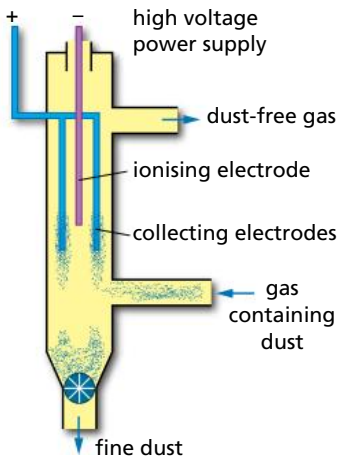
You will need: fine sand, lead shot, small bowl or dish similar in shape to a gold pan

1. Mix some sand and lead shot in the bowl.
2. Run a small stream of water from an outside tap into the mixture as you move the bowl from side to side. Can you separate the sand and the lead shot?

- How does this separation method work?

Electrostatic separation

If one solid is attracted to an electric charge and the other is not, you can use electrostatic separation. In industry, electrostatic precipitators are used to separate the dust particles from chimney gases. As the dust particles move rapidly through the precipitator they become negatively charged and are attracted to a positive electrode. Here they lose their charge and fall out as fine dust. Similar methods are used to clean the air in large air conditioners.



INQUIRY

11 Salt and pepper

You will need: mixture of salt and pepper, plastic rod, nylon cloth

1. Spread out the mixture of salt and pepper on a piece of paper.
2. Rub the plastic rod with a nylon cloth to charge it, then pass it over the mixture. What happens?

- Try to explain what happened.

Magnetic separation

If one solid is attracted to a magnet and the other is not, you can use magnetic separation.

INQUIRY

12 Sand and iron filings

You will need: bar magnet, small plastic bag, sand, iron filings

Put the magnet in the plastic bag and use it to separate the sand and iron filings.

- Why do you think you put the magnet in a plastic bag?

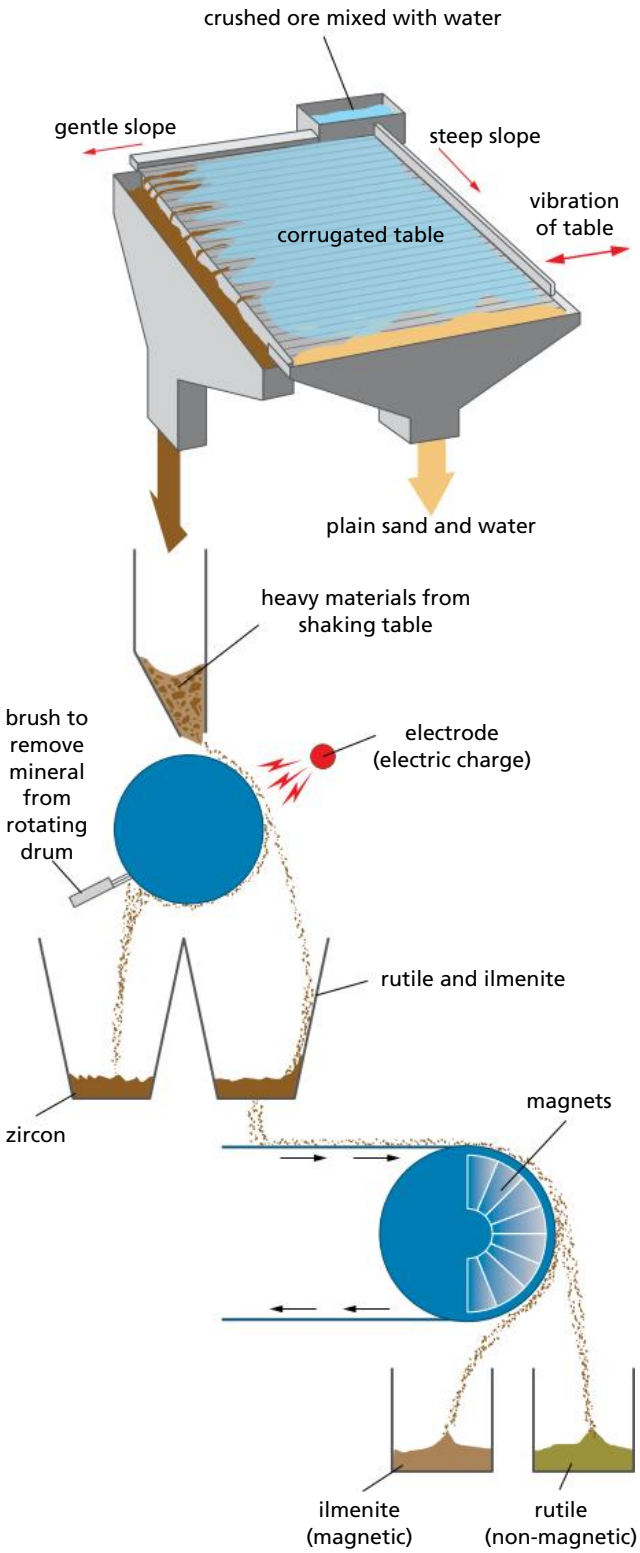
When scrap metal is collected, metals such as copper, iron and aluminium are often mixed together. If this mixture is passed near a magnet the iron can be removed. Many agricultural products are crushed during processing, but they sometimes contain broken pieces of machinery or fencing wire that could damage the crusher. This is why crops such as sugar cane and wheat are often carried by conveyor belts past a magnet to remove such iron and steel objects before they can damage processing machinery. Magnetic sweepers have also been made that can be towed behind a vehicle to pick up any iron or steel objects. This is very important at airports to prevent flat tyres on aircraft.

Separating mineral sands

Several different processes are used to separate the minerals in mineral sand. These separating processes rely on the fact that the minerals in mineral sand have different properties.

In the first stage the mineral sand is mixed with water and fed onto a sloping, vibrating table. The less dense minerals like plain sand (silica) are easily washed down the table by the water, as shown below. The jiggling motion of the table tends to move the more dense minerals, mainly zircon, rutile and ilmenite, to one side of the table.

In the second stage the heavy minerals are passed close to a large electric charge where they all become charged.



The rutile and ilmenite lose this charge quickly and fall off the rotating drum. The zircon keeps its charge and sticks to the drum until it is removed by a brush. In this way the zircon is separated.

In the third stage the rutile and ilmenite are fed onto a moving belt that passes a large magnet. The ilmenite is magnetic and is attracted to the drum. The rutile is not magnetic and falls straight down into a separate collecting bin. In this way the two minerals are separated.

Filtration

If one solid is soluble in water and the other is insoluble, you can add water. When you filter the mixture, the residue is the insoluble solid. The filtrate contains the soluble solid in solution. It can be recovered by evaporation. Look at the flow diagram on the right.

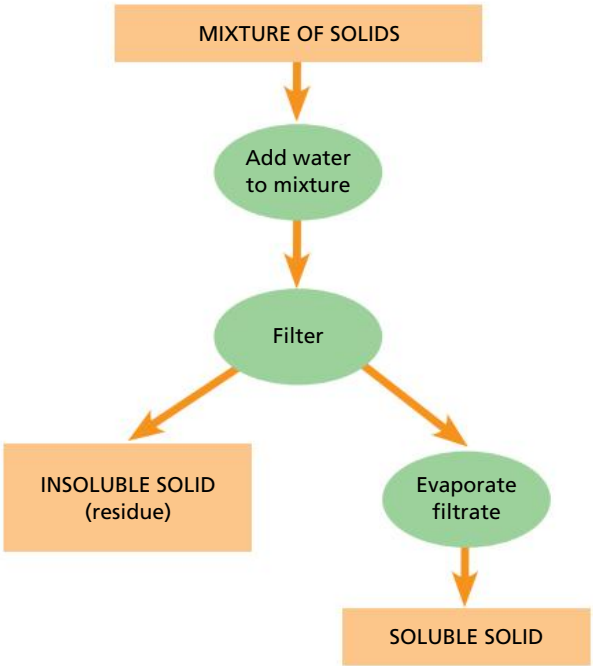
Over to you

1. How could you separate a mixture of salt and aluminium filings?
2. You suspect a bag of sulfate of ammonia (a common lawn fertiliser) contains some sand. What simple test could you carry out at home to check this?
3. Describe in your own words the process of froth flotation.
4. How does gold panning work?
5. Look at the diagram bottom right on page 59 of an electrostatic precipitator used to remove dust from chimney gases. In your own words, describe how it works.
6. A company wants to recycle the rubber in car tyres, but the tyres contain steel wire. Design a process to separate the steel from the tyres.
7. Look at the diagram on the previous page showing how mineral sand is processed.
   - **a** What are the four different minerals in mineral sand?
   - **b** Which mineral is separated at the first stage because of its low density?
   - **c** How is zircon separated?
   - **d** Which mineral is magnetic?
8. Imagine you are a waste management engineer. You have been supplied with a mixture that contains sand, sawdust, iron filings and lead shot. Your task is to separate as much of each material as you can, so that they can be recycled. How are you going to do this? Draw a flow diagram to show this. The Skill box will help you.

SKILL

Using flow diagrams

Flow diagrams (or flow charts) are used to show the steps that make up a process. A complicated process can be described simply by breaking it into small steps with connecting arrows. For example, the process of separating a mixture of solids by filtration can be shown like this. The orange rectangles show what you started with (the inputs) and what you finished with (the outputs). The green ovals show the steps in the process.



1. Draw a simple flow diagram to show how a magnet can be used to separate a mixture of sand and iron filings (Inquiry 12 on the previous page).
2. Look at the diagram on page 53 showing how water is purified. Draw a flow diagram showing the five steps in the process. Make sure you show the inputs and outputs.
3. Draw a flow diagram showing the processes used to separate the minerals in mineral sands (this page and opposite).
4. Read through Investigation 1 on page 52. Draw a flow diagram to summarise what you did in this investigation, starting with the water and the chalk.

   Suppose you found there was still some chalk in the filtrate and you decided to filter it again. How could you show this on the flow diagram?
5. Choose your own example of a process and draw a flow diagram for it.

3.5 Chromatography

Chromatography (CROW-ma-TOG-ra-fee) is a method of separating substances that occur in small amounts in a mixture.

Suppose you dip the end of a piece of chalk into water-soluble black ink and then stand the chalk in a beaker containing a small amount of water. As the water carries the ink up the chalk by **capillary action**, the ink separates into bands of different colours. Each band contains one of the substances that is present in the ink.

The rate at which each part of the mixture moves depends on two of their properties:

a how strongly it adsorbs to the chalk

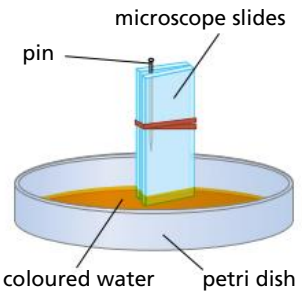
b how well it dissolves in the water.

INQUIRY 13 Capillary action

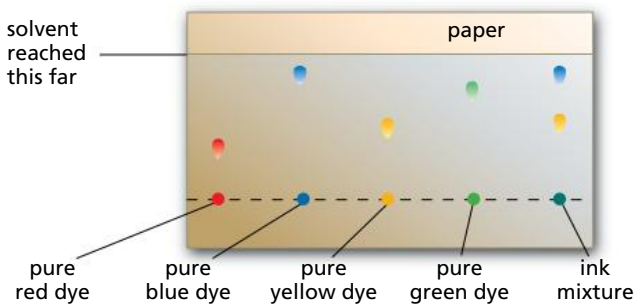
Capillary action is where a liquid rises up a narrow tube. You can demonstrate capillary action like this.

You will need: petri dish, coloured water, pin, rubber band, 2 glass microscope slides

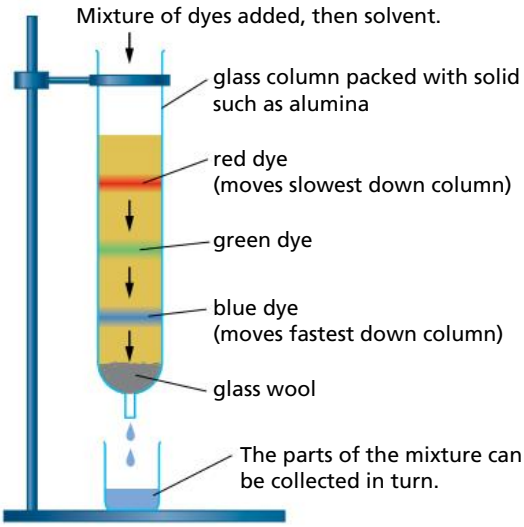
How can you explain what happened?



In *paper chromatography* the mixture is allowed to soak up through special paper, like filter paper. Suppose you have some green ink that is a mixture of different dyes. You put a spot of ink on a piece of paper, along with each of the pure dyes, and let the solvent soak up the paper. The ink produces a yellow spot and a blue one, and from this you can infer that it is a mixture of yellow and blue dyes.

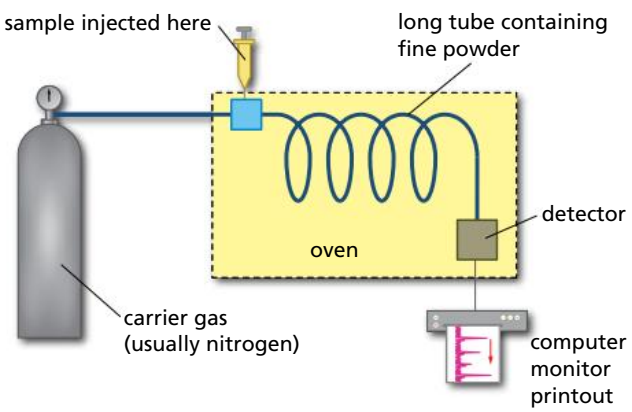


In *column chromatography* the mixture to be separated is poured onto the top of a column of adsorbent material, followed by more solvent. The different parts of the mixture move down the column at different rates. If the parts are coloured they appear as different coloured bands. As the parts come out of the bottom of the column they can be collected separately.



Gas chromatography is used in industry and in scientific research to detect very small amounts of chemicals in mixtures. For example, it is used by forensic scientists to detect poisons and drugs in blood. It is used to test the purity of medicines and to see if harmful pollutants are being released into the air.

The diagram below shows how gas chromatography works. A carrier gas is used to push the sample through a long tube containing a fine powder. The different chemicals in the sample come out of the end of the tube at different times, as indicated by the peaks on the computer monitor.



INVESTIGATION

3 Paper chromatography

Aim

To use paper chromatography to separate the coloured substances in inks and food colourings.

Risk assessment

Read the investigation carefully and do a risk assessment.

Apparatus

- various coloured inks from biros, felt pens or marking pens
- food colourings
- 250 mL beaker or petri dish
- filter paper or blotting paper
- dropper
- scissors
- adhesive tape
- Smarties, jelly beans, or similar

Planning

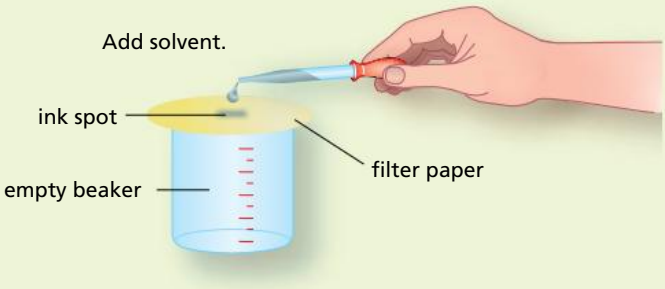
- You can use any of the methods on this page.
- Dark colours usually give good results.
- For inks (e.g. biro) that won't dissolve in water you need to use alcohol or methylated spirits.
- To extract the colour from a Smartie or similar, put it in a watch glass and add a drop or two of water until the colour starts to run. Then use the wet Smartie to put a spot of colour on the filter paper.
- Once the filter papers have dried you can label them and put them in your notebook.
- When you have finished the investigation, describe your results and write a suitable conclusion. For example, which was the best method and which substance contained the most colours?

FILTER PAPER METHOD

1 Put a spot of ink in the centre of a piece of filter paper. Put the filter paper on top of a beaker or petri dish as shown top right.

2 Use a dropper to carefully add a single drop of solvent to the ink spot. Watch what happens. Once the first drop has spread, add a second drop.

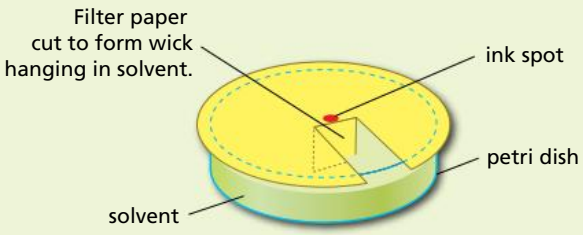
3 Keep adding solvent until the colours have spread at least halfway across the filter paper. You will get coloured rings.



WICK METHOD

1 Make two cuts in the filter paper to create a flap, as shown below.

2 Bend the flap downwards and put the filter paper on top of a petri dish so that the flap dips into the solvent.

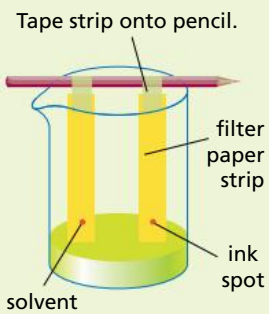


HANGING STRIP METHOD

1 Cut a strip out of filter paper.

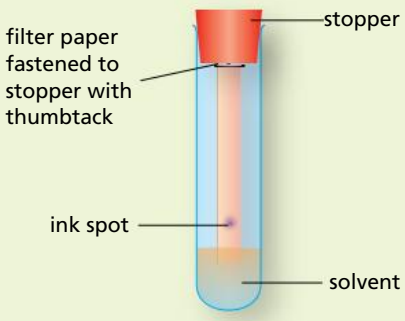
2 Put an ink spot about 2 cm from the end of the strip.

3 Add some solvent to the beaker. Then suspend the strip as shown, so that the solvent is about 1 cm below the spot.



4 You can add other strips to the same beaker, or you can put more than one spot on a wide strip of paper.

5 You can also use a test tube as shown.

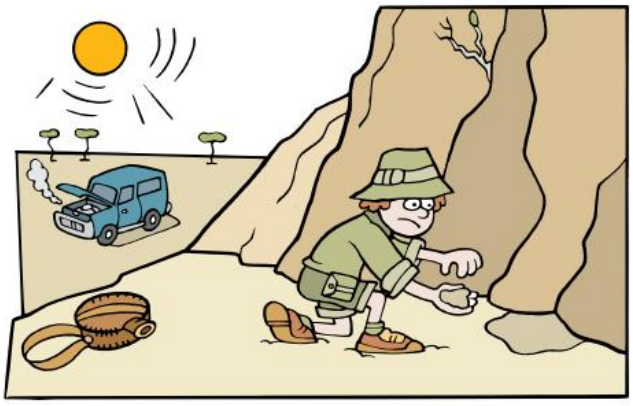


THINKING SKILLS

1 Hayley has two beakers. In one she has water and in the other salt solution, but she doesn't know which is which. How can she tell which is which *without tasting them*?

2 Your science teacher is furious with the class. Someone has mixed the sand, salt and iron filings in a large jar! Until they are separated, no one can go to lunch. How can you separate this mixture?

3 Your car has broken down in the desert in central Australia and you have no water to drink. You find a damp patch of sand near the bottom of a cliff. Design a way of getting drinking water from this damp sand.



4 Which method would you use to do each of the following?

a remove small pieces of glass from soup

b separate the coloured dyes in an ink

c make cloudy tap water clear

d separate flecks of gold from river gravel

e obtain copper sulfate crystals from a solution of copper sulfate in water

f separate olive oil from water

g remove the dust from the smoke in a factory chimney

h obtain pure alcohol from beer

i extract perfume from rose petals

j separate cream from milk

k separate pebbles and sand

5 Alyx shone a beam of light through some muddy water. She could see the beam. When she tried this again the next day she could not see the beam. Explain her observations.

6 Three coloured liquids were tested to get an idea of the size of the particles in them. The data in the table shows what happened. Which liquid probably contained the smallest particles? Explain.

Liquid	Did the colour pass through a filter paper?	Did the colour pass through a patty pan?
A	yes	no
B	yes	yes
C	no	no

7 You sometimes find dark patches of mineral sand on the beach. If you can obtain some, try to separate it from the normal sand.

8 Design an experiment to find out how much sugar there is in soft drink. You will need to evaporate the water. Which soft drink contains the most sugar?

9 Obtain some silica gel from the packets that come with things that need to be kept dry, e.g. tablets and camera equipment. Design and carry out an experiment to find out how much water silica gel can adsorb on its surface.

10 Green plants contain a chemical called *chlorophyll*. This can be separated from the leaves of plants by crushing them up with a small amount of alcohol or methylated spirits. Is the chlorophyll a pure substance? Is it the same in different plants? Design and carry out an experiment to find out, using paper chromatography.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 The materials around us are either pure substances or _____. Separation methods depend on differences in the _____ of the substances in the mixture.

2 In a _____ (e.g. muddy water), the _____ settles to the bottom when left standing. Solutions do not settle.

3 Many everyday substances are _____, with properties in between solutions and suspensions.

4 Suspensions can be separated by _____, using a centrifuge or by filtering.

5 A solute can be separated from a solution by evaporation followed by _____. Distillation is the process where you _____ the solvent after it evaporates.

6 A mixture of solids can be separated by using differences in their properties, e.g. _____, density, whether they float in water, are attracted by an electric charge or a _____.

7 In chromatography a mixture is dissolved in a _____ and the parts separate as they are soaked up by special _____ or move through adsorbent material in a column.

colloids
condense
crystallisation
decanting
magnet
mixtures
paper
properties
sediment
solubility
solvent
suspension

Self-management

You should now have finished your water purification project. A good way to present your group report is to do an interview. Imagine one of you is a chemical engineer whose task was to purify the dirty creek water. Think of an interesting name for yourself. Another person (or persons) in the group interviews the chemical engineer. You could record the interview or do it live.

The interview should start with an introduction to the problem of purifying water, and introduce the chemical engineer. You then need to ask a series of questions such as:

- Which method did you use? If you have prepared a poster you could display it here.
  A flow diagram would be helpful.
- Why did you choose this method? Why didn't you use ...?
- How successful were you? How pure was your water?

- Do you think you could improve your method? How?
- Do you think your method would work for larger volumes of water?
- How expensive do you think it would be to purify water this way?

Finish the interview by thanking the chemical engineer and perhaps making some conclusion about the problem of purifying water.

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 A mixture of sand and salt has to be separated. Which is the correct sequence of steps for doing this?

A evaporate → dissolve → filter

B dissolve → filter → evaporate

C dissolve → evaporate → filter

D filter → dissolve → evaporate

2 For each description below, choose one of these words.

centrifuge	distillation	filtration
chromatography	evaporation	flotation
condensation	decanting	sedimentation

a method of separating an insoluble solid from a liquid

b method of getting pure solvent from a solution

c device used to separate red blood cells from plasma

d process in which a liquid turns to a vapour

e process in which a vapour turns into a liquid

f gently pouring off a liquid, leaving the solid behind

g allowing the solid in a suspension to settle

h method of separating the different coloured substances in ink

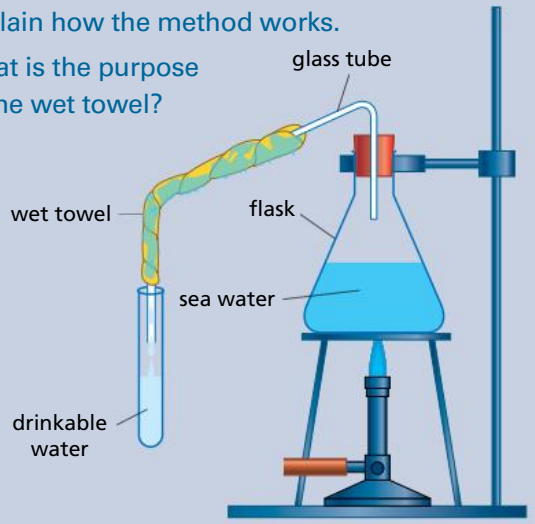
i method used in the mining industry to separate minerals from rock

3 The apparatus below was used to obtain drinkable water from sea water.

a What is this method of separation called?

b Explain how the method works.

c What is the purpose of the wet towel?



4 Each of the following is a mixture of a solid in a liquid.

- muddy water
- sugar solution

a In which mixture are the bits of solid smallest?

b Which could be separated by filtration?

c Which could be separated using a centrifuge?

d Suppose you passed a beam of light through the two liquids. In which would you see the beam?

5 Explain in your own words the difference between a solution and a suspension.

6 Dema tested the solubility of three unknown solids, A, B and C in four different liquids—acetone, ethanol, turpentine and water. She recorded the mass of solid that dissolved in 50 mL of each liquid.

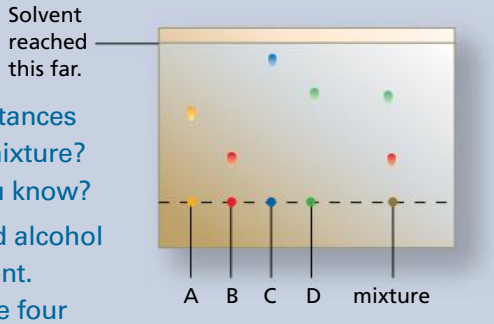
Liquid	Grams of solid that dissolved		
	Solid A	Solid B	Solid C
Acetone	1	0	6
Ethanol	4	3	4
Turpentine	1	1	5
Water	5	6	0

a Which liquid is the best solvent for solid B?

b If you had a mixture of A and C, which liquid could you use to separate them? Explain your answer.

c How could you separate a mixture of A and B?

7 Crystal used paper chromatography to find out which substances were in an unknown mixture. She compared her results with four pure substances A, B, C and D. Her results are shown below.



a Which substances are in the mixture? How do you know?

b Crystal used alcohol as the solvent. Which of the four substances do you think is the most soluble in alcohol? The least soluble?

4 Biological classification

Focus for learning

Classification is placing things into groups. You are classified into year levels at school. Library books are grouped. Objects in your home are classified and placed together. For example, pots may be in one cupboard in the kitchen and cups somewhere else. Classification makes our lives easier. If we know how objects are grouped, then we can find them more quickly.

Scientists classify organisms. Some organisms such as a dog or a cat are easy to group because we know and recognise them easily. But some organisms are hard to group. For example, scientists recently found something that looked like fine, sticky blond hair growing in caves on the Nullarbor Plain, South Australia (see the photos above). The 'hair' was in fact bacteria. It was so different to known groups of bacteria that a new group had to be created for them.

The bacteria obtain their food by breaking down chemicals in the rocks. Originally they must have come from the sea and over time became separated from other organisms, slowly changing or evolving into a new group of bacteria.

Early classification systems separated organisms into two large groups called **kingdoms**—plants and animals. However when bacteria were first identified they did not fit neatly into either group, so a separate kingdom was created.

Many more differences were found between organisms when the electron microscope was invented in 1933. So today there are five kingdoms. However some organisms still don't fit neatly into the groups created, as you will find out when you read the chapter and complete the problem on the next page.

PROBLEM SOLVING

Classification misfits

Your task is to decide whether the present five-kingdom classification system needs to be changed.

You must:

a Describe the features or characteristics of each of the five kingdoms giving five examples of organisms in each.

b Explain why lichens, corals, carnivorous plants and viruses are difficult to classify. You may not know what these organisms are yet; however you will read about them in this chapter.

c Present a new classification system that includes these problem organisms.

Venus flytrap

By the end of this chapter you will be able to ...

Science Understanding

- group a variety of organisms on the basis of similarities and differences in particular features
- use keys to identify, sort and name organisms
- describe the classification system introduced by Carolus Linnaeus
- identify problems in the classification of lichens, corals, viruses and carnivorous plants

Science as a Human Endeavour

- investigate plants used as food by Aboriginal people

Science Inquiry Skills

- use a table to summarise differences between the five kingdoms of living things

LITERACY FOCUS

angiosperms
asexual reproduction
cell membrane
cell nucleus
cell wall
cytoplasm
dicotyledons
fertilisation
fungi
genus
gymnosperms (conifers)
invertebrates
kingdoms
Monera
monocotyledons
non-vascular plants
pollination
protists
sexual reproduction
species
spores
unicellular
vascular plants
vertebrates

4.1 Living or non-living?

INQUIRY 1 Is a motor car living or not?

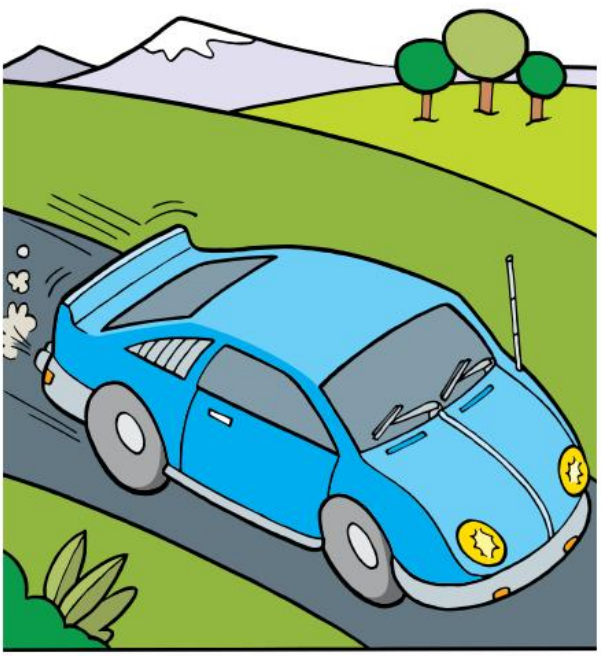
1 In groups, write down the characteristics that you think a living thing has. It is important to spend time on this before you continue.

2 As a class, discuss your characteristics and come to an agreement as to what characteristics a living thing must have.

3 Using your list of characteristics, decide whether a motor car is living or non-living using the description below.

A car can move around. Its wheels rotate and turn. The parts inside it move, but it cannot carry out this movement without fuel. The fuel (food) is combined with oxygen, and this produces waste products such as carbon monoxide and water from the exhaust. It needs oil to keep its parts working.

The car has been reproduced many times, in many different forms. It is easily damaged and can be repaired. New parts can be made and old parts replaced. A car can be made to react to its surroundings. For example, windscreen wipers can be switched on when it is raining, and lights can be activated when it is dark outside. The car has a heater and some have air-conditioners so that a constant temperature can be maintained.



INQUIRY 2 Features used for classification

1 Classify the organisms presented here into at least four groups.

2 Explain what characteristics or features you used to group the organisms.

The seven characteristics of living things

Biologists (scientists who study living things) use seven characteristics to decide if something is living:

- **Movement:** All living things move in some way, although their movements might not be seen.
- **Respiration:** All living things need energy to survive, so they carry out respiration.
- **Sensitivity:** All living things respond to what happens in their environment.
- **Growth:** All living things grow and replace their body parts.
- **Reproduction:** All living things have a way of making copies of their own kind.
- **Excretion:** All living things must eliminate wastes from their bodies.
- **Nutrition:** All living things must take in food or a source of nutrients in order to live.

To remember these think of MRS GREN.
The motor car in Inquiry 1 was not a living thing because it did not have all these characteristics.

Useful and non-useful characteristics

Classification is about identifying patterns of similarities and differences between living things. Some characteristics are useful to help you do this and others are not. In Inquiry 2 you may have used colour to classify your organisms. You might have grouped the soldier crab, butterfly, wren and bluebottle together because they are blue. This is not very useful because these four organisms are very different.

Size is also not a very useful characteristic. An elephant and a giraffe are large, but too different to group together. In the same way, using where an organism lives will not group organisms successfully. For example, starfish, dolphins and lobsters all live in the sea, but have little else in common.

The following features are more useful and reliable to classify animals:

- Body structure, e.g. the number of legs, wings, lungs or gills, and cell structure. **Cells** build together to make living things, like bricks make a house. Cells are so small you need a microscope to see them.
- The way an animal functions or works, e.g. a constant body temperature or a temperature that varies with the surroundings.
- How the animal reproduces, e.g. **sexual reproduction** where male and female parts meet. This can be through internal or external fertilisation (male and female sex cells meeting inside or outside the body), or **asexual reproduction**, without the meeting of sex cells.
- The body covering of the animal, e.g. whether it has fur, feathers or scales.

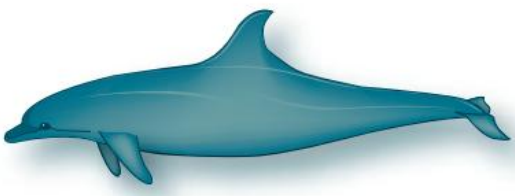
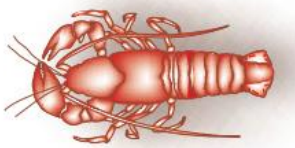
Using keys

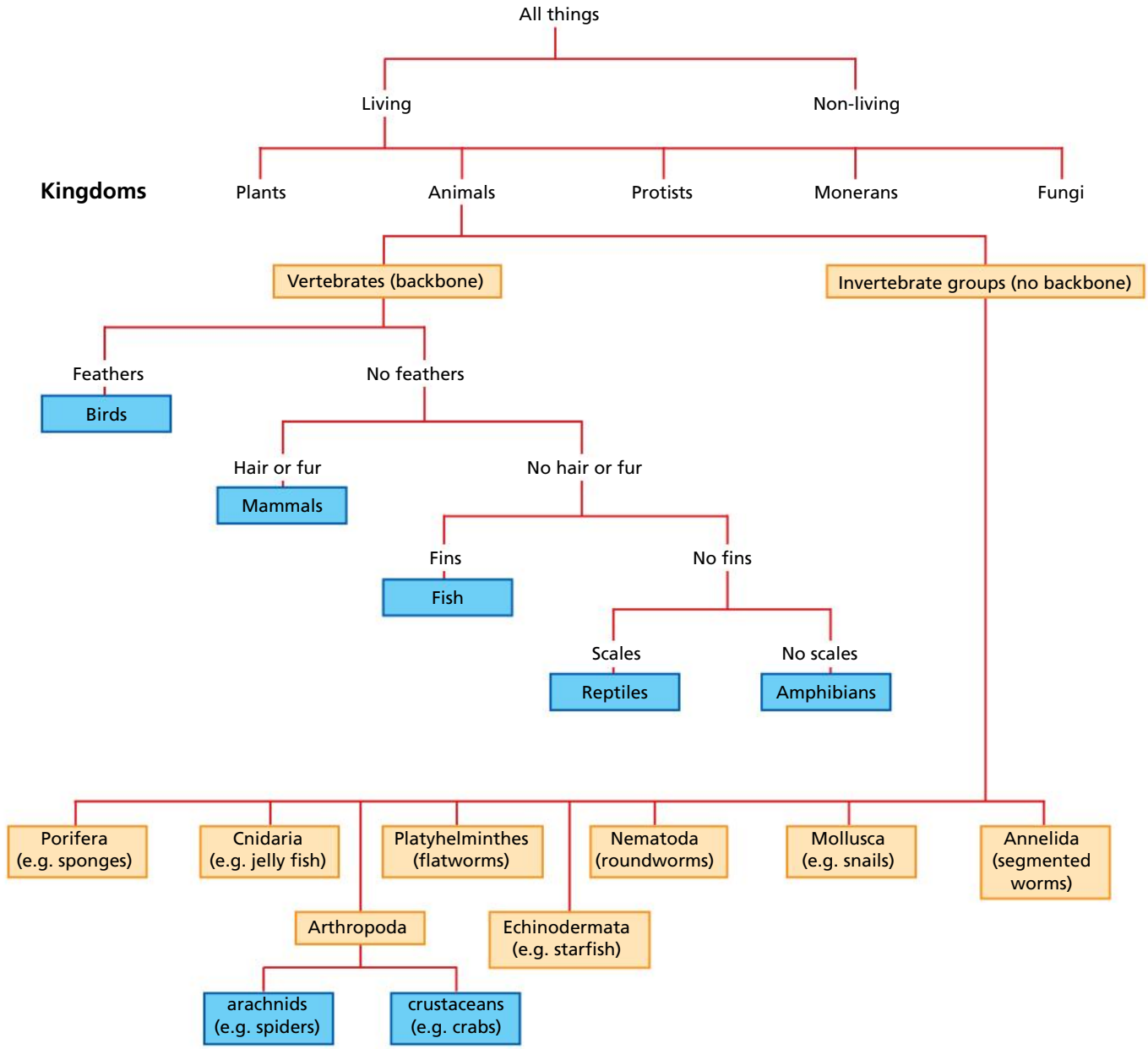
A **key** is a very helpful tool for identifying organisms. Using a key, unknown things can be identified. A key divides a large group into smaller groups. Each smaller group is then divided again and again until the organism is named.

If you look at the key for living things on the next page, you will see that the first branch splits into two alternatives, living and non-living.

Living things are divided into five kingdoms, which are then divided further. For example, the animal kingdom is divided into two—**vertebrates** (animals that have a backbone and **invertebrates** (animals without backbones). The vertebrate group then branches into five smaller groups.

With each branch that is made, the organisms become more alike. The groups also have fewer organisms in them. Eventually the organism can be classified and given a name at the bottom of the key.



Over to you

1. What is classification and why is it useful to us? Use examples in your explanation.
2. What was found in the caves on the Nullarbor Plain and why was this find so exciting?
3. List the seven characteristics of living things.
4. What characteristics are used for classification? Why?
5. What characteristics are *not* useful for classification? Why?
6. What happens to the size of a group as you go further down a key?
7. What can you say about the organisms in each group as you go further down a key?
8. Match the following words with their meanings:
   kingdom, asexual reproduction, biologist, sexual reproduction, vertebrate, structure, function, invertebrate.
   - **a** The first major level of classification
   - **b** The internal workings of an organism
   - **c** An animal that doesn't have a backbone
   - **d** No male and female sex cells are needed
   - **e** An animal that has a backbone
   - **f** A person who studies living things
   - **g** How an animal is put together
   - **h** The meeting of male and female sex cells is needed

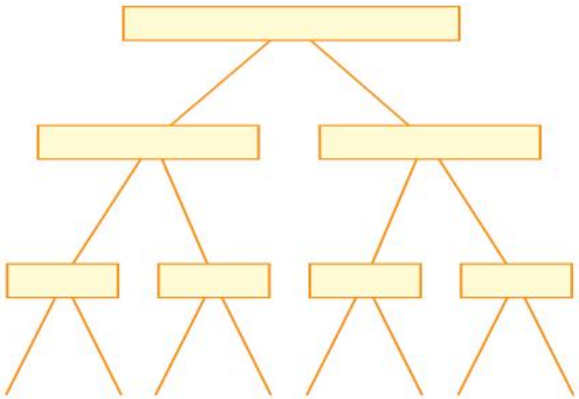
SKILL

Using, making and interpreting keys

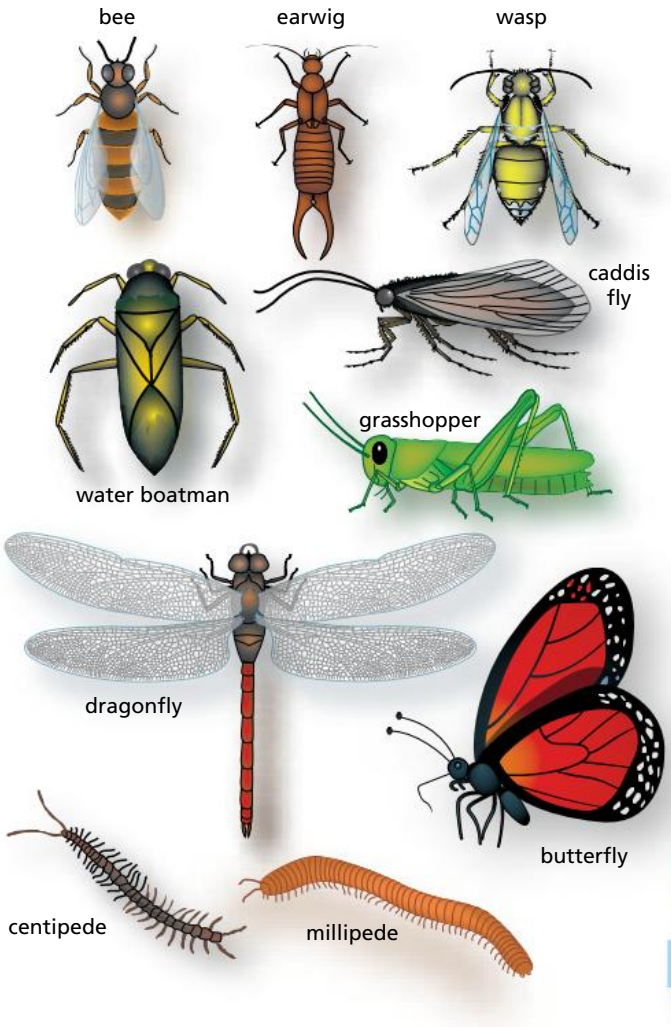
1 Using the outline below, design a key to classify:

a the contents of your pencil case

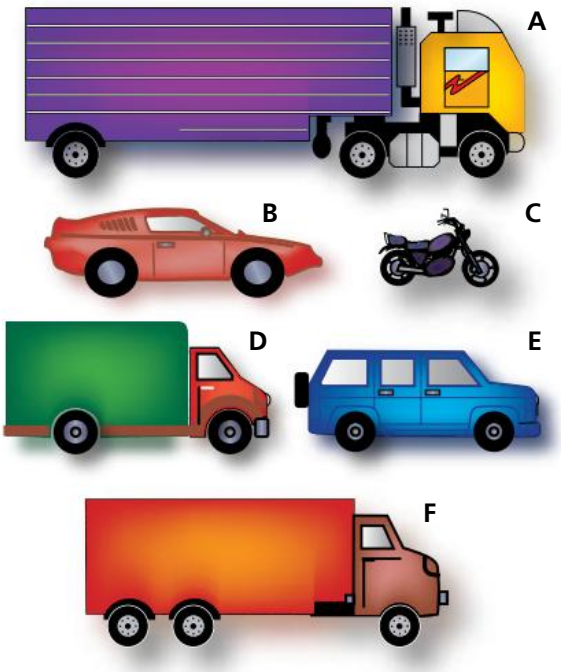
b items in a supermarket



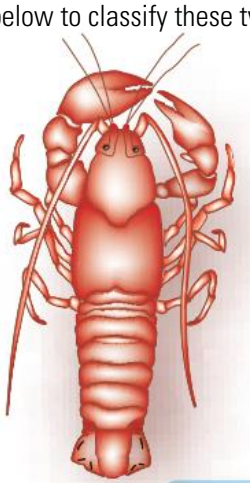
2 Make a key to classify the insects pictured here.

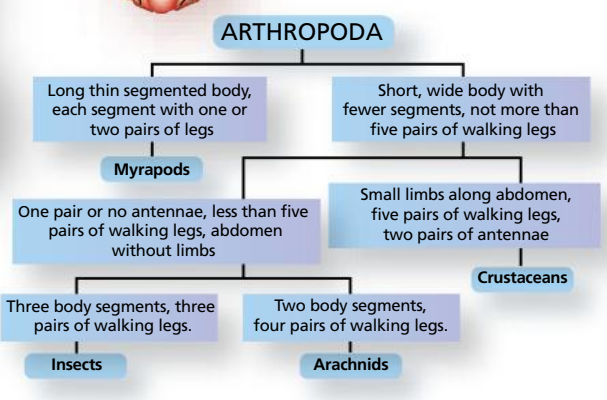


3 Make a key of the vehicles pictured here.



4 Arthropods are animals with jointed legs. Use the key below to classify these two arthropods.

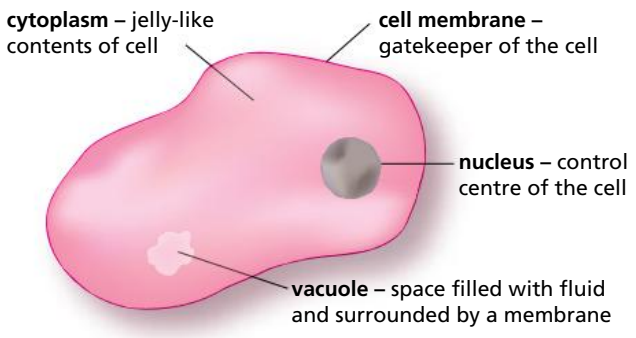




4.2 The animal kingdom

Animals are consumers since they eat other organisms, both plants and animals, for food. They use this food to release energy in respiration and to obtain the materials they need for growth, movement and repair of their bodies.

Animals are multicellular, which means they are made up of many cells. An animal cell has a **cell membrane** to keep the contents of the cell together. It also controls the flow of substances into and out of the cell. A **nucleus** controls the cell's activities. It is also filled with **cytoplasm** (SIGH-toe-PLAZ-um) or the jelly-like substance that fills the inside of a cell.



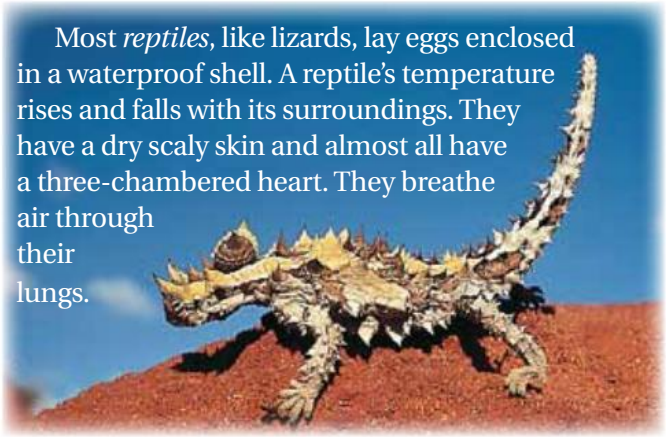
Vertebrates

The animal kingdom is divided into two large groups called the vertebrates (backbone) and invertebrates (no backbone). All large land animals are vertebrates because their skeleton gives them the support they need. The vertebrate group is made up of five smaller groups—mammals, birds, fish, reptiles and amphibians.

Mammals, like humans, cats and dogs, have hair or fur and they feed their young on milk that is secreted from special glands in their body called **mammary glands**. (The word mamma means 'breast'.) Mammals are able to maintain a constant body temperature even if their surroundings change. They have four chambers in their heart and breathe air through lungs.

Birds have feathers, a beak, clawed feet and wings. They have a constant body temperature, lay hard eggs and have a four-chambered heart. They breathe air through their lungs.

Most *reptiles*, like lizards, lay eggs enclosed in a waterproof shell. A reptile's temperature rises and falls with its surroundings. They have a dry scaly skin and almost all have a three-chambered heart. They breathe air through their lungs.

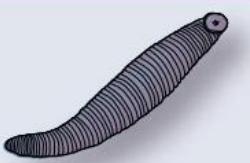


The word *amphibian* means 'double life' because these animals start their life in water and live on land as adults. Amphibians such as frogs do not have any claws or scales. They have a moist skin and a three-chambered heart. The adults do have lungs, but obtain air or oxygen mainly through their skin. They have a changing body temperature.

Fish possess gills and have a body covering of scales. They have a two-chambered heart and a varying body temperature. Some fish have a skeleton of cartilage, the substance that gives your nose and ears shape. Most fish have bones.

Invertebrates

The following table summarises the major invertebrate groups.

Invertebrate group	Characteristics	Examples	Sketch
Porifera (por-RIF-er-a), commonly called sponges	Body wall of two cell layers. Mostly marine. Adults usually attached to a hard surface.	Sponges	
Cnidaria (Coelenterates) (ni-DARE-y-a)	Body wall of two cell layers, jelly-like material in between. Sac-like body with a single opening for the mouth and anus. Tentacles around the mouth with stinging cells.	Corals, sea anemones, jellyfish	
Platyhelminthes (plat-ee-hel-MINTH-ez), commonly called platyhelminths	Flat soft body, no body segments, poorly developed gut–digestive tube with a single opening, or no digestive tube.	Tapeworms, liver flukes, planaria	
Nematoda (nem-a-TOAD-a), commonly called nematodes	Round soft body, no body segments, poorly developed gut–digestive tube with mouth and anus.	Roundworms	
Mollusca (mol-LUSK-ca), commonly called molluscs	Soft body, usually with a shell, body not segmented. Well-developed digestive, circulatory and nervous systems. Large muscular 'foot'.	Snails, oysters, mussels, squid, octopuses, clams, bivalves, nautilus, chitons	
Annelida (an-el-LEAD-a), commonly called annelids	Long round soft body, divided into segments, both internally and externally. Well developed digestive, circulatory and nervous systems.	Earthworms, leeches, beach worms	
Arthropoda (ar-throw-PODE-a), commonly called arthropods	Jointed covering over body and limbs. Body segmented, but can be fused. Open circulatory system.	• Arachnids—spiders • Crustaceans—shrimp, crabs, lobsters, prawns • Insects—beetles, butterflies, moths, grasshoppers • Millipedes • Centipedes	
Echinodermata (ee-KINE-o-der-MATA), commonly called echinoderms	Hard spiny skin, all live in the sea. Internal limy skeleton. Arms, if present, come from a central point. Water-filled tube feet.	Starfish, sea urchins, sea cucumbers, brittle stars, sealilies	

INVESTIGATION

1 Specimen classification

Aim

To classify vertebrate and invertebrate specimens.

Risk assessment and planning

Each specimen is preserved in formalin that is poisonous to breathe in. Discuss with your teacher how to handle preserved specimens.

Apparatus

20 specimens from the key on this page

Method

Use the key here to classify the 20 specimens you have been given.

Results

Present your results as in the following example.

Specimen 1

Name: Starfish

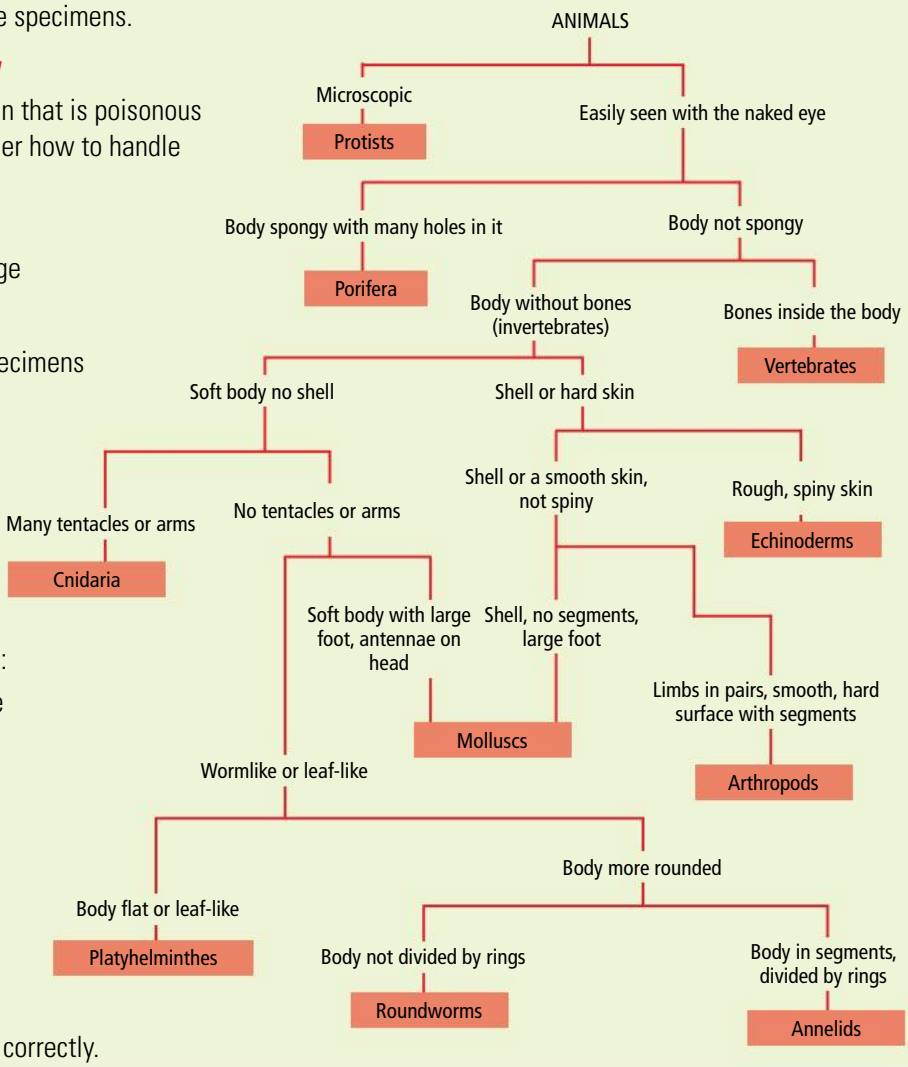
Characteristics used for classification:

1. Easily seen with the naked eye
2. Body not spongy
3. Body without bones
4. Shell or hard skin
5. Rough, spiny skin

Kingdom: Animals

Invertebrate group: Echinodermata

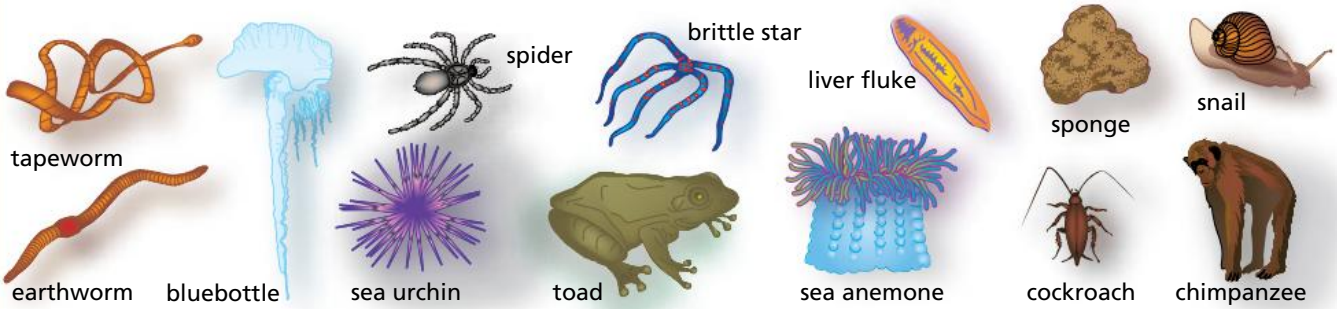
As a group, discuss with your teacher whether you classified the organisms correctly.



INQUIRY

3 Using keys

1. Classify the organisms below using the key above.
2. Did you have any problems classifying these organisms? Explain.
3. Draw up your own key to classify these organisms a different way.



INQUIRY 4 What am I?

1 To which group does this organism belong? List the features that helped you make your decision.

The platypus

I have waterproof hair over my body, and webbing on my front feet that I can fold away to reveal nails to help with digging. The webbing makes me look flat-footed, so I used to be called *Platypus anatinus* (flat-footed, duck-like animal), but today I am called *Ornithorhynchus anatinus* (bird-like snout) because I have a duck-like bill.

I swim with my eyes shut and use my bill to find food. Like birds, I have no teeth. Instead I have grinding pads in my mouth to crush food. My jaw is mammal-like. I can hear, and growl like a dog when threatened. I also have a poisonous spur on my hind legs.

My ribs and kidneys are reptile-like and I use the same body opening to get rid of wastes and to reproduce. I lay eggs too. However, I suckle my young and have a constant body temperature.

2 Write your own 'What am I?' about an organism you know. Swap your description with a partner and see if you can guess each other's organism.

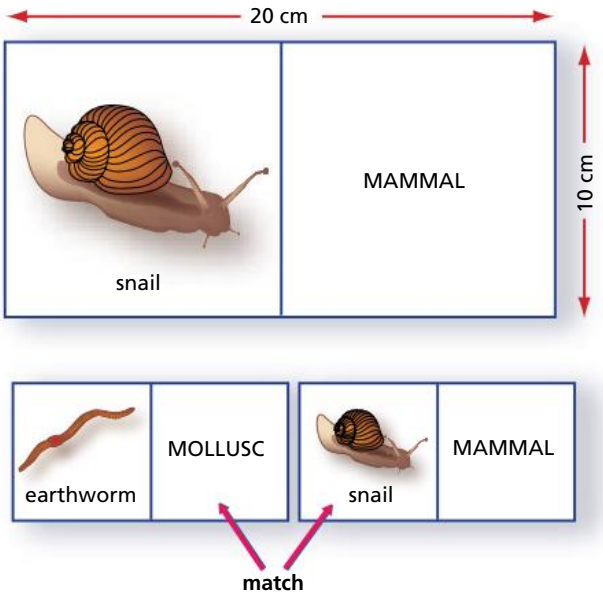
INQUIRY 5 Making dominoes

Group activity

You will need: cardboard, scissors, collection of photographs, drawings or photocopies of animals.

1 Cut the cardboard into a piece 20 cm × 10 cm. On one side of the card stick or draw a picture of an animal. On the other side of the card write the name of an animal group or a feature of a group instead of a name. The picture and name should not match. Make 30 cards like this.

2 Divide your cards or dominoes evenly between the group members. Place one domino in the centre of the group. Take it in turns to match the pictures, group names or descriptions with the other dominoes until one player has none left. That person is the winner.



Over to you

1 Match each of these organisms to its description below: arthropods, mammals, reptiles, porifera, cnidaria.
- **a** The organisms in this group have a constant body temperature.
- **b** Arachnids and crustaceans are in this group.
- **c** These organisms are often called sponges.
- **d** Organisms in this group have a single body tube with one opening for a mouth and anus.
- **e** These organisms lay eggs with waterproof shells.

2 How would you tell the difference between organisms in the following groups?
- **a** platyhelminths and nematodes
- **b** annelids and molluscs
- **c** amphibians and reptiles
- **d** arthropods and echinoderms
- **e** reptiles and annelids

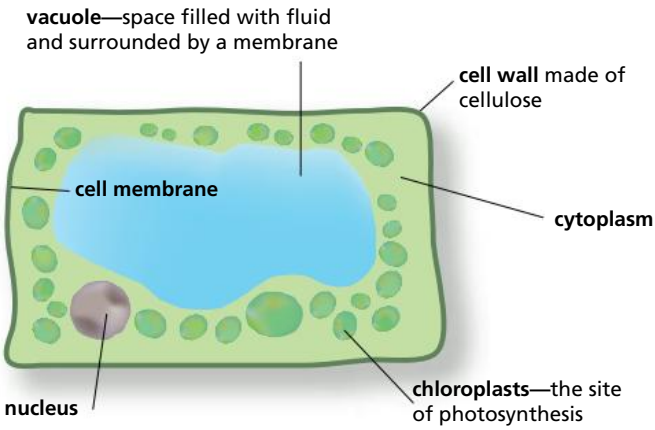
3 What are the major features of organisms in the animal kingdom?

4 Draw up a table to summarise the main features of the vertebrate groups. Use the following headings in your table: body covering, way of breathing, body temperature, reproduction.

4.3 The plant kingdom

Plants are producers because they carry out photosynthesis to make their own food. They use this food for growth and repair of their bodies and to release energy in respiration.

All plants are multicellular. A plant cell has a cell membrane, nucleus and cytoplasm, just like an animal cell. Unlike animal cells however, plant cells have a **cell wall** made of cellulose that encloses the whole cell and provides the plant with support. Plant cells also contain chlorophyll.



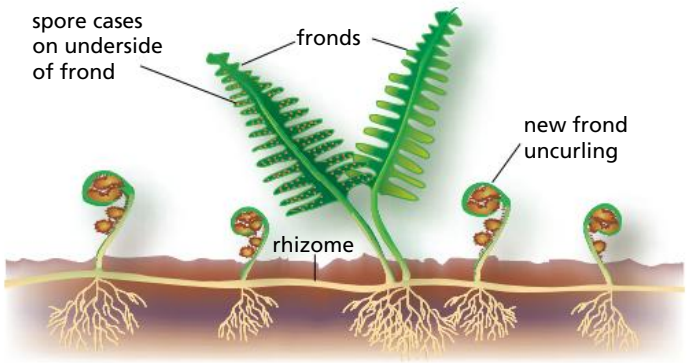
The animal kingdom is divided into two large groups based on support structures—backbone or no backbone. The plant kingdom is divided into two large groups—vascular (plants with tubes) and non-vascular (plants without tubes).

Vascular plants

Vascular plants are ferns, conifers and flowering plants. Vascular means 'containing tubes that have fluid in them' so these plants have phloem and xylem tubes and true roots, stems and veins in their leaves.

Ferns have a stem, leaves and roots. The stem is called a *rhizome* which grows horizontally under the surface of the soil. The leaf or frond you can see is what we recognise as a fern. These grow from several different places along the rhizome.

Ferns reproduce by **spores**. These are cells that are not made by the meeting of male and female parts. At certain times of the year, spores are formed in spore cases on the underside of the leaves. These spore cases break open and spread the spores to reproduce the fern.



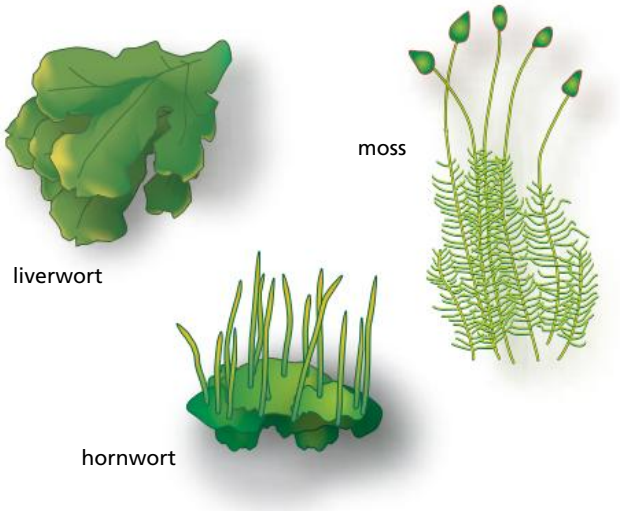
Conifers or **gymnosperms** include pine trees, firs and other evergreen trees and shrubs. They reproduce by seeds enclosed in cones. A seed is different from a spore since it is made from the meeting of male and female parts. The male pine cone releases pollen and the female pine cone produces the ovum or egg. When the pollen meets the egg, fertilisation occurs and a seed is produced. These seeds are scattered when the pine cones containing them fall from the tree.

Cones on a conifer

Flowering plants or **angiosperms** include most trees, water plants such as water lilies, grasses, bushes, shrubs and even bulb plants like daffodils. Angiosperms reproduce by flowers and seeds. The flowers contain both the male and female parts. So when you are admiring a flower you are looking at the sex organs of a plant!

Non-vascular plants

Non-vascular plants are mosses, liverworts and hornworts. They have no true roots, stems or veins in their leaves and are the simplest plants. Most of them only grow to a few millimetres high because their cell walls do not contain strong substances to provide the plant with support. Only a few species have simple tubes for carrying water and food around the plant. Non-vascular plants reproduce from spores. The spores are made inside a round capsule, which is usually on a stalk. Most mosses and some liverworts can grow from pieces that have broken off a plant, or from special parts of the plant.



INQUIRY 6

Examining different plants

You will need: a selection of different plants, e.g. mosses with spore capsules, ferns with spore cases, conifers and pine cones, angiosperms and flowers, hand lens

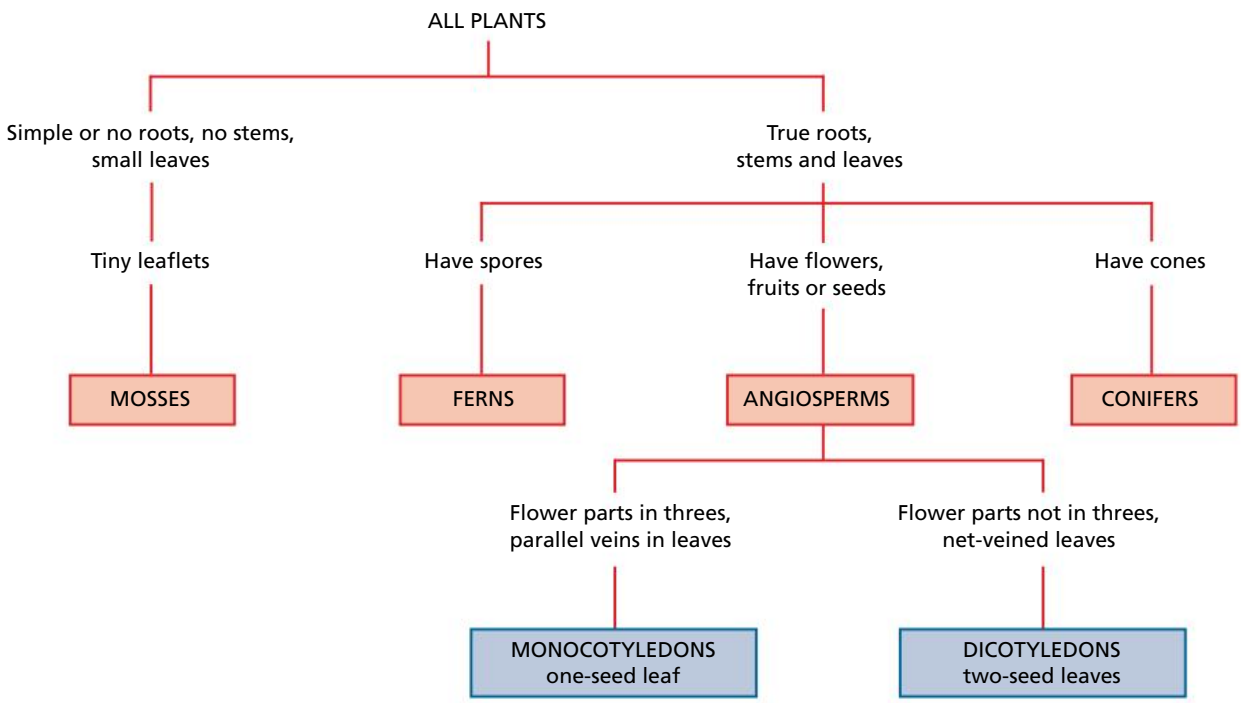
1 Using the plant key provided here, classify the plant specimens that you have been given.

2 What features have been used to classify plants in this key?

3 Now look at the nine photos on the next page and classify the plants pictured. For flowering plants try to say if they are a *monocot* or a *dicot* and why you think so.

Monocots (monocotyledons) have their flower parts in threes and parallel veins in their leaves. There is only one *cotyledon* (COT-el-LEE-don) or first simple leaf that grows from the seed.

Dicots (dicotyledons) have two cotyledons, net-veined leaves and flower parts in fours or fives or multiples of these.



A

B

C

D

E

F

G

H

I

INQUIRY 7 Aboriginal food plants

Australian Aboriginal people traditionally ate a wide variety of bush foods. Different clans or groups ate different foods, depending on the environments in which they lived. Here are just some of the bush foods that were eaten by the Cadigal people in the Sydney area.

a *Xanthorrhoea resinifera*

The flower of this plant produced a long stem which was used for making spears. The resin inside the plant was used for glue and the nectar from the flowers provided food.

b *Lomandra longifolia*

The seeds of this plant were ground up and used to make flour for cakes. The leaves were eaten and tasted like peas.

c *Dianella caerulea*

The fruits of this plant were eaten raw. They have a sweet, nutty taste.

d *Banksia ericifolia*

The nectar of the flowers were collected and mixed with water to produce a sweet drink.

e *Syzigium paniculatum*

The fruit of this plant was eaten raw. It is sweet and fleshy. Early colonists made the fruit into jams and drinks. Today this fruit is still used to make jam.

f *Pteridium esculentum*

The rhizomes of this plant were chewed or the sticky starch inside was beaten out. This was an important food source because the plant could be dug up all year round.

1 From the description of each plant provided above, try to work out which plant group the bush food came from e.g. fern, angiosperm, conifer. What clues helped you group the plants?

2 You have been given the genus species name of each plant. Find out what the common names of each of these are.

SCIENTISTS AT WORK Carolus Linnaeus (1707–1778)

Swedish naturalist Carolus Linnaeus looked at the structure of organisms to group them. He established our present binomial (two-name) classification system. This is where every living thing is given two names—a **genus** name followed by a **species** name. Biologists use the rule that if two animals cannot successfully breed together naturally and produce offspring, then they are different species. Using this system, humans are *Homo sapiens* and the largest tree in Australia is *Eucalyptus regnans*.

Latin or Greek words are usually used to describe the organism. For example, low-growing plants are often called *prostrata* meaning 'close to the ground'. Nice smelling plants are called *odorata* meaning 'sweet scented'. A banksia with saw-like leaves is called *Banksia serrata* since *serrata* means 'like a saw'. *Callistemon citrinus* (pictured) is a lemon-scented bottlebrush. The word *citrinus* tells you this.

Organisms can be accurately named and identified using this binomial system. It is also a system that is used worldwide. So biologists all around the world use the same name to describe a particular organism, even though they speak different languages.

Over to you

1 How would you tell the difference between
- **a** a plant and an animal?
- **b** a fern and a conifer?
- **c** a gymnosperm and an angiosperm?

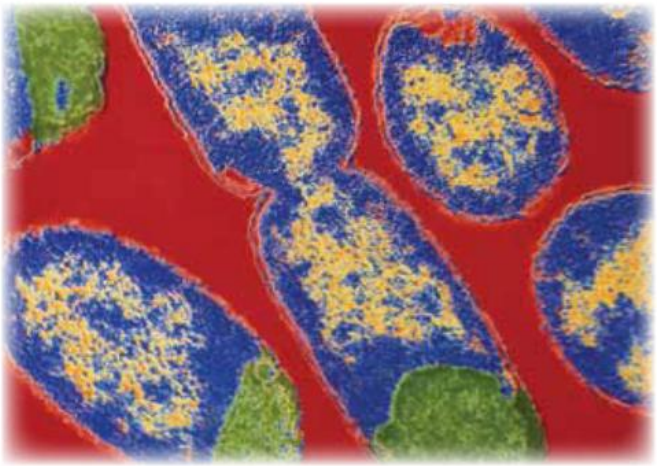
2 Why is Linnaeus' two-name system so useful?

3 Match these species words with their correct meanings: alpina, longiflora, tetraptera, torquata. (You may need to use a dictionary.)
- **a** long flowers
- **b** four-winged
- **c** alpine
- **d** like a collar

4.4 Monerans, protists and fungi

Monerans

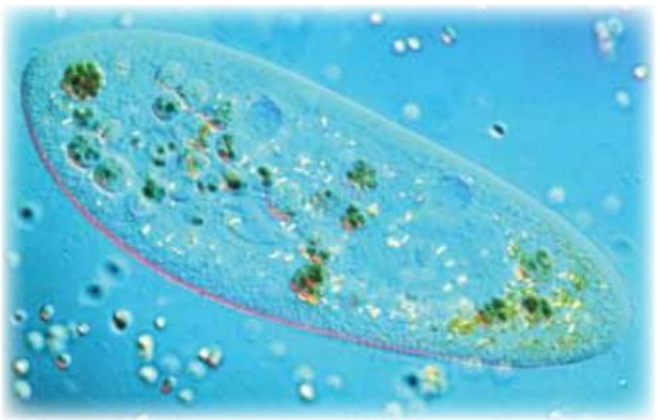
The **Monera** kingdom is made up of the simplest microscopic organisms. They are **unicellular** (made up of only one cell), without an obvious nucleus. Bacteria and blue-green algae (cyanobacteria) are examples. Bacteria are very important to us since they break down or decompose dead organisms. However, they can invade our bodies and make us sick. Tetanus and food poisoning (salmonella) are examples of diseases caused by bacteria.



E. coli bacteria

Protists

Most **protists** are unicellular with a very simple structure. Paramecium and amoeba are examples. Protists live in water and obtain nutrients straight from their surroundings.



A paramecium

Algae are protists. They used to be classified as plants because they contain chlorophyll and carry out photosynthesis. However they have no roots, stems or leaves and have a very simple structure. So they are now classified as protists. We tend to think of algae as seaweed and multicellular, but many algae are unicellular.

Green algae

Fungi

Yeasts, moulds, mushrooms, puffballs and toadstools are classified as **fungi**. Some fungi, like yeasts, are unicellular, but most are multicellular.

Fungi were originally classified as plants because they appeared to have roots like plants, however the roots are in fact fine tubes called *hyphae*. The hyphae are only one cell thick so that food can move into these tubes from the surroundings. Fungi digest their food externally. They secrete enzymes into what they are growing on. The enzymes break down the food to a size that can be taken in through the hyphae. In doing this fungi break down dead plants and animals, so they are also decomposers, like bacteria.

A network of hyphae together is called the *mycelium*. It is often not seen. In a piece of mouldy bread, the furry dark part we see is in fact only a small part of the fungus (singular of fungi). The mycelium is entangled through the bread.

What we can see in mushrooms, toadstools and the furry part of mould, is called the fruiting body. It is in this fruiting body that spores are produced.

Fungi are not considered to be plants because they cannot make their own food and their cells do not contain chlorophyll. They have a cell wall made of chitin—a material that makes up the exoskeletons of insects. Plant cell walls are made of cellulose.

Fungi are important because they decompose dead organisms, and we use them in the food industry. Yeast, for example, is used in the production of bread and alcohol. Some fungi are a benefit to the living organism they grow on. For example, mycorrhizae fungi grow on plant roots. These fungi receive nutrients from the plant, but they also provide the plant with nutrients too, acting as an extended root system. Fungi found in the gut of insects and crustaceans receive food from the animal, but they provide their host with vitamins.

Fungi can be harmful because they can grow on living things. For example, tinea is a fungal infection that affects the skin on feet. Plant rust causes damage to crops.

Spore being released from a puffball

INQUIRY

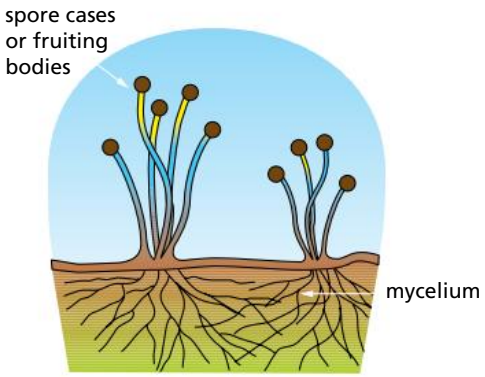
8 Investigating fungi

You will need: microscope, prepared slide of fungi (e.g. bread mould and yeast), large fresh field mushroom, white paper or card.

1 Your teacher will set up the microscope.

2 Examine the different slides provided by your teacher showing different types of fungi. Draw what you see.

3 Examine the slide of bread mould. The furry stalks you can see are the fruiting bodies that contain spores. When released, the spores can land on food and grow into mould again. The mycelium will be hidden growing through the bread.



3 Break off the stem of the field mushroom and place it with the gills face down on a piece of white paper. Leave it for several hours, preferably overnight. When you remove the cap you should see spores on the paper. You can wipe them off with your fingers.

4 See if you can find different examples of fungi in the school yard or your garden, e.g. toadstools.

INQUIRY 9

The differences between the five kingdoms

1 Copy and complete the following table as a summary of the five kingdoms.

	Animals	Plants	Monerans	Protists	Fungi
Number of cells			Unicellular	Mainly unicellular	
Cell wall structure			Cell wall of protein	Some have a cell wall of cellulose	Cell wall of chitin
Chlorophyll in cells			Some have chlorophyll	Some have chlorophyll	
Nucleus present in cell?			No	Yes	Yes
Examples of organisms					

PROBLEM SOLVING

Look back at the problem presented at the beginning of the chapter. At this point you should be able to describe the features of each of the five kingdoms. Now you must decide if lichens, corals, viruses and carnivorous plants fit into any of these groups or whether they need separate groups by reading the rest of this section. Once you have finished you will be able to complete your project with the information you have collected.

Lichens

Lichens (LI-kens) are made up of algae and fungi living together. The algae give nutrients to the fungi by way of photosynthesis, like plants. The fungi can retain water in their cells to help the algae. Lichens are difficult to classify because algae and fungi are classified into different kingdoms.

Corals

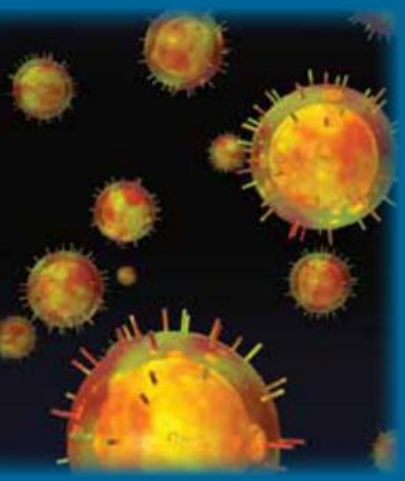
Corals have algae in their bodies that provide them with nutrients by photosynthesis, like plants. However corals have animal features, such as a hollow sac-like body with one opening that is both a mouth and an anus, and stinging tentacles used to catch food.

Corals can exist by themselves or in colonies. Some have soft, jelly-like bodies and others are surrounded by a hard, limy skeleton. Corals can reproduce asexually, so there is no meeting of male and female sex cells. They simply split or bud to produce a second organism. Corals can also reproduce sexually by releasing sex cells (eggs and sperm) into the water.

Corals have both plant and animal characteristics. To which group should they belong?

Viruses

If you have ever had influenza then a virus made you sick. Viruses are not made of cells, so should they be classified as living things? Living things are made up of building blocks called cells. Viruses do have genetic material like cells.



Influenza virus

However a cell is surrounded by a membrane, whereas viruses have a protein coat instead. Viruses lack cytoplasm which fills cells.

Viruses cannot reproduce by themselves. They invade another organism (called the host) by injecting their genetic material into the host cells. The host cells then make new viruses that invade other cells. In the process the host cells are destroyed and the host becomes sick. AIDS (HIV) is a well known disease caused by a virus.

Carnivorous plants

The Venus flytrap (see photo on page 68) and the sundew act as both plants and animals. They carry out photosynthesis and their cells contain chlorophyll. However they also eat organisms as animals do, which is why they are referred to as carnivorous plants.

The Venus flytrap catches flies and mosquitoes by secreting nectar onto a hinged leaf that springs shut when hairs on the surface are touched. A rim of hairs, like teeth, around the leaf stops the insect escaping. Once caught, the insect is digested by enzymes over a week.

The Australian sundew and pitcher plant also catch and digest mosquitoes, ants and flies using sticky nectar and hairs on their leaves. Pitcher plants are shaped like a jug with slippery slides, and teeth on the rim of the jug trap insects inside.

These plants are often found in soils that lack nitrogen. When digested, the insects give the plant the nitrogen they need.

INQUIRY 10 Carnivorous plants

You will need: pitcher plant, sundew and Venus flytrap, hand lens

1. Draw each carnivorous plant.
2. Using a hand lens, view the hinged leaf of the Venus flytrap, and find the nectar and hairs on the sundew and pitcher plant. Describe these in your own words and explain how they trap insects.
3. Describe any other features of these plants that may attract insects to them. For example, the liquid in sundews makes them shine in the sun. This may lure insects to them.
4. Explain why these plants are difficult to classify.

Over to you

1. State whether the following are true or false.
   - **a** Amoeba and paramecium belong in the protist kingdom.
   - **b** Protists get their nutrients from the water environment in which they live.
   - **c** Monerans are simple organisms. They have a nucleus in their cells.
   - **d** The fine tube-like roots of fungi are called hyphae.
   - **e** The fruiting bodies of fungi produce seeds.
2. Explain why algae are included in the protist kingdom rather than the plant kingdom.
3. How would you tell the difference between organisms in the following kingdoms:
   - **a** monerans and fungi
   - **b** protists and animals
4. Give two examples of how fungi are useful and two examples of how they are harmful.
5. An organism was found on a beach. It had no signs of any roots, stems or leaves. However its cells contained chlorophyll and it was able to carry out photosynthesis. What kingdom would you place this organism in? Explain your answer.
6. The organism pictured here was growing on a dead tree. To which kingdom does this organism belong? Explain your answer.

THINKING SKILLS

1 A teacher was listing groups of organisms on the board, as below. The students in the class had to tell their teacher what each group was. What would you say?

Group 1: cat, fish, dog, wombat

Group 2: rose, wattle, eucalypt, fern

Group 3: paramecium, amoeba, seaweed, spirogyra

Group 4: salmonella, blue-green algae

Group 5: mushrooms, puffballs, toadstools, mould

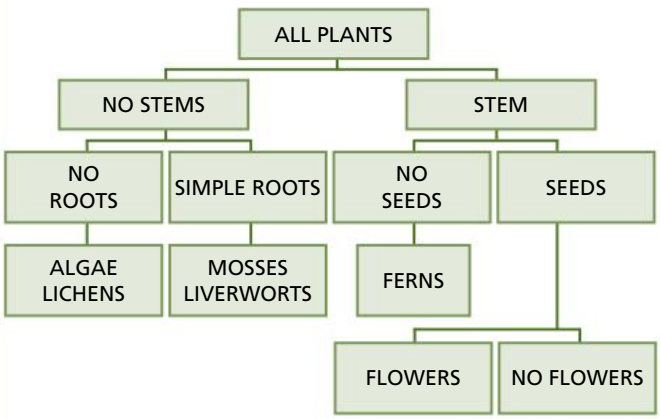
2 Design a way to show the differences between:

a organisms in the vertebrate classes

b organisms in five invertebrate groups.

You could use a list like the one above or think up your own idea.

3 The following key appeared in a textbook which is now outdated.



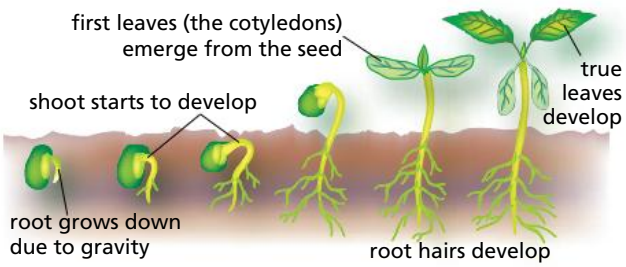
Explain why this key is outdated. Why wouldn't it be used today? Are there any parts of the key that are still correct?

4 Whales are mammals and tuna are fish, yet they both spend all their life in the water.

a Why are they classified in different groups and not together if they both live in the sea?

b What characteristics would be used to distinguish between these two groups of organisms?

5 Gordon started to grow a seed to see how it developed. The diagram below shows his results.



a What type of plant was Gordon growing? Give reasons for your answer.

b Would this plant produce flowers, spore cases or pine cones to reproduce? Explain.

6 Many Australian plants produce flowers without any petals. For example, the wattle has flowers that are a bundle of yellow coloured stamens and banksia flowers are made up of many flowers grouped together with the male and female parts brightly coloured. Why don't some Australian flowers have petals?

INQUIRY 11 Message board

Explain the features of a group of organisms presented in this chapter by posting a question on a message board like the Dolly forum. Imagine you are the organism writing a letter for some personal advice. There is an example on the right.

When you have finished your post, swap it with a partner and see if you can guess which group of organisms they have presented.

I can't make any friends. The plants that I hang out with say that I am different because I eat insects. But I am green just like them and love sitting in the sun! I can't make friends with any animals because they won't come near me. When I put on a morning tea of nectar, only some of my new friends turn up and then I never see them again. I just don't belong in any group! What advice can you give me?

Sensitive Sundew

Knowing and Understanding

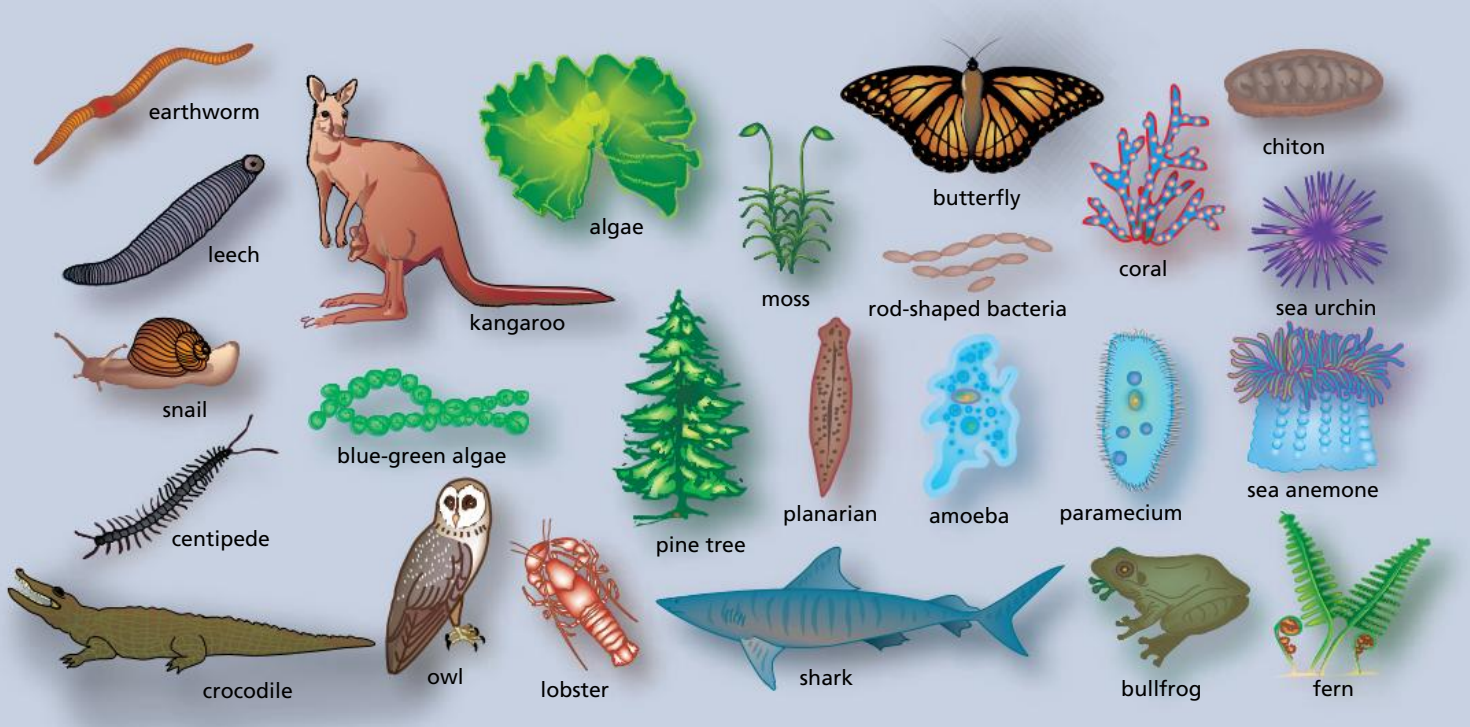
Copy and complete these statements using the words on the right to make a summary of this chapter.

1. Classification is placing organisms into _____. There are five major groups called _____.
2. Some features that are useful for classification are body _____ and structure. Where an organism lives or its _____ are not useful characteristics for classification.
3. The characteristics used to determine whether something is living or not are: movement, _____, sensitivity, _____, reproduction, excretion and nutrition.
4. Animals are consumers. The animal kingdom is divided into two main groups: the vertebrates and the _____. There are five classes of vertebrates. These are mammals, birds, _____, _____ and reptiles. There are many groups of invertebrates.
5. The plant kingdom is divided into two main groups: vascular plants such as _____, and non-vascular plants such as _____.
6. The three remaining kingdoms are the monerans, _____ and fungi. Monerans are simple organisms. Fungi _____ or break down other organisms. The protists are mostly _____.

amphibians
angiosperms
colour
covering
decompose
fish
groups
growth
invertebrates
kingdoms
mosses
protists
respiration
unicellular

Self-management

1. The organisms presented here are all jumbled up. Classify them into kingdoms.
2. Now try to classify these organisms into the smallest possible groups, using the information in this chapter.



Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Which of the following statements are correct?

a All arthropods have jointed legs.

b Roundworms are grouped as platyhelminthes.

c Molluscs and annelids are vertebrates.

d Birds have feathers and mammals have fur.

e Sponges belong to the porifera group.

f A key separates groups of organisms.

2 The five kingdoms of living things are

A fish, porifera, protists, animals, plants.

B protists, fungi, birds, mammals and plants.

C monerans, protists, animals, plants and fungi.

D reptiles, monera, animals, plants and ferns.

3 Give an example of why colour is not used to classify organisms.

4 Match the following words with their meanings.

vacuole, amphibians, spores, classification

a Placing organisms into groups

b Cells that are not made by the meeting of sperm and egg

c Space inside a cell filled with liquid and surrounded by a membrane

d A group of vertebrates with moist skin

5 State one difference between each of the following groups of organisms.

a porifera and platyhelminthes

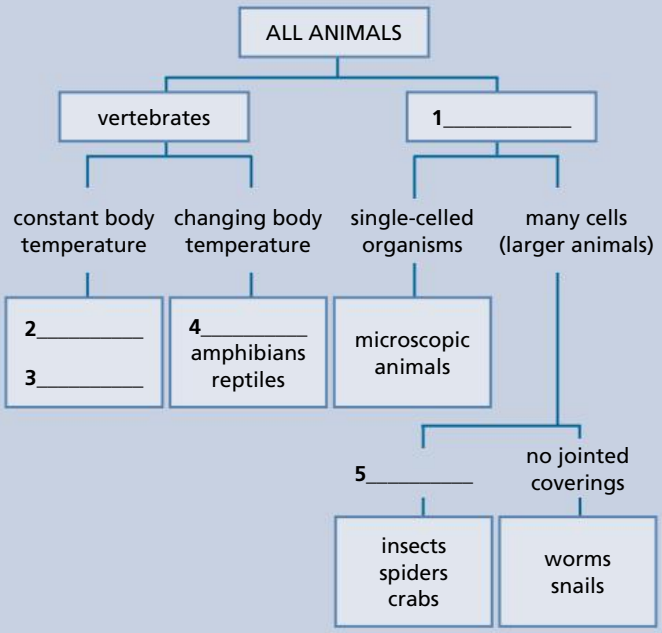
b angiosperms and gymnosperms

c ferns and mosses

d fungi and monerans

6 **a** Fill in the missing words in this key.

b The key is not correct, why?

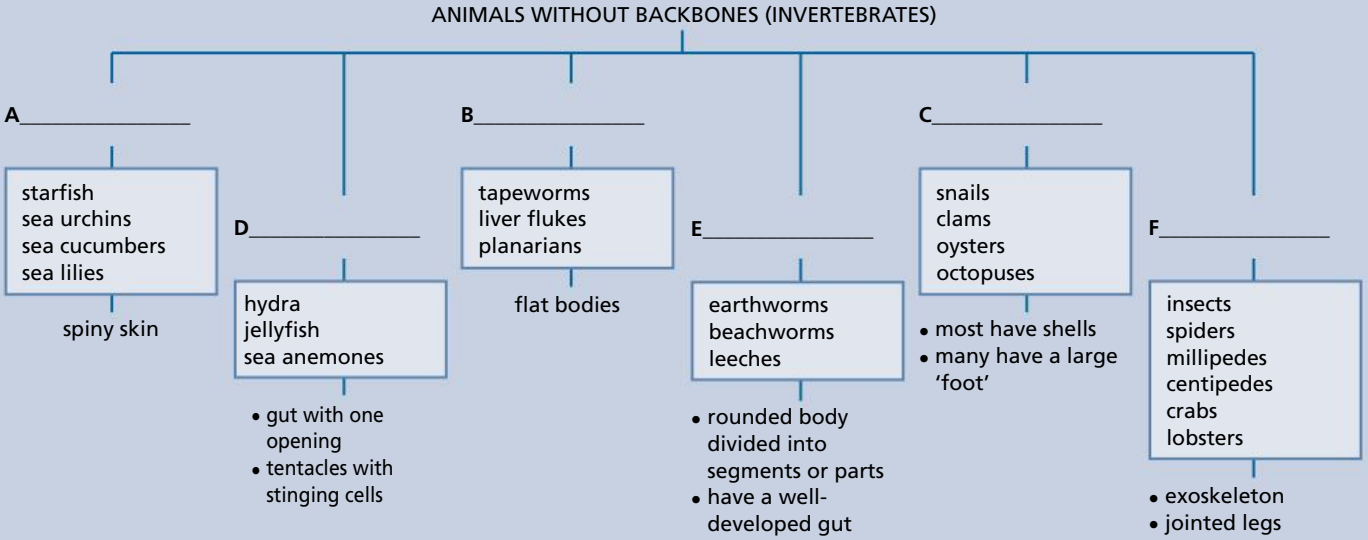


7 Emily found a plant with the following characteristics:

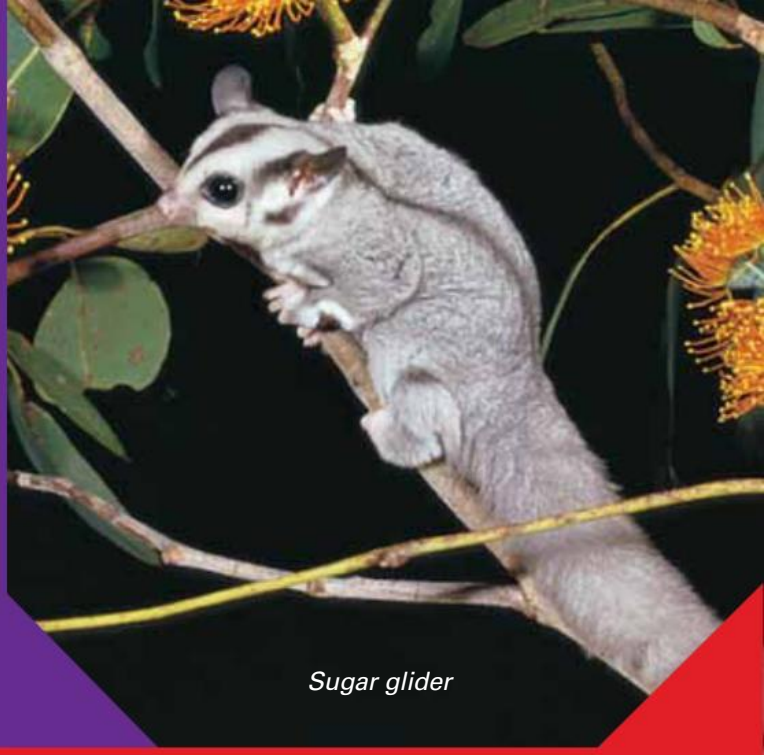
- roots, stems and leaves
- xylem tubes throughout the plant
- evergreen
- seeds and cones.

How would you classify this plant? Explain your answer.

8 Fill in the key below by adding in the missing words.



5



Sugar glider

Survival

By the end of this chapter you will be able to …

Science Understanding

- use food chains to show feeding relationships in a habitat
- describe how cane toads have affected the other organisms in an existing food web

Science as a Human Endeavour

- describe the contribution of an Australian scientist working to protect our environment

Science Inquiry Skills

- research an Australian animal that is extinct or in danger of becoming extinct
- design an experiment to investigate how plants are affected by factors in the environment such as light and temperature

LITERACY FOCUS

abiotic factors
adaptations
aquatic
behavioural
biodiversity
biotic factors
buoyancy
carnivore
characteristics
endangered
environment
eucalypts
extinct
functional
habitat
herbivore
littoral zone
nocturnal
predators
structural

Focus for learning

Why do you live where you do? It might be because your house is close to shops, or because you like the neighbourhood. The place where you live provides your family with the things that they need to survive.

The place where an organism (living thing) lives is called its **habitat**. Like you, organisms live in places that provide them with the things they need to survive. For example, a sugar glider (photo page 88) eats nectar and insects. It is only found in forests that provide this food. The habitat of the Richmond birdwing butterfly is rainforest on the east coast of Australia. Its caterpillars eat a vine that grows there.

These organisms also have special features called **adaptations** that help them survive in their habitat. The sugar glider has a flap of skin that stretches from its ankle to its elbow. It spreads this out to glide between trees. The birdwing butterfly has green velvet-like wings so it can blend into its rainforest surroundings.

This chapter is all about the places where organisms live and the adaptations that help them survive. It also looks at why some organisms survive and others don't.

The Richmond birdwing butterfly lives in rainforests.

INQUIRY 1

What do you need?

1 List all the things that you need to survive. Where do these things come from?

2 Rank the list in order, starting with the most important thing that you need and finishing with the least important.

3 What could you live without? Explain.

4 Divide the list into two groups, under the headings *Living* and *Non-living*. How many other organisms do you rely on to survive?

PROBLEM SOLVING

Gone forever

Choose an Australian animal that is in danger of being wiped out (**endangered**) or one that has already been wiped out (**extinct**).

1 Describe the type of environment that the organism lives in (lived in) and where it is found in Australia. Include two biotic (living) and two abiotic (non-living) factors that affect the organism.

2 Explain how the animal is (was) adapted to its environment

3 Why is this organism in danger or why has it become extinct?

4 Present your findings as an A4 fact sheet in no more than 300 words.

The following organisms could be looked at:

swift parrot, great desert skink, Broom's pygmy possum, northern hairy-nosed wombat, spot-tailed (tiger) quoll, black-footed rock wallaby, Tasmanian tiger

The rest of the chapter will help you.

5.1 Australian environments

In Inquiry 1 you listed your survival needs and then grouped these as living or non-living. Under *living* you may have listed family and friends who are needed for company, or plants and animals that you eat. Other organisms also rely on and interact with their own species. They need to mate, but in turn compete with each other for food and shelter. For example, young Tasmanian devils play and bite one another in practice for possible competition for food.

Organisms also interact with other organisms. An organism may be a predator and hunt its food, or it may be prey and be hunted by other animals. These are examples of **biotic** (living) **factors** that affect an organism where it lives.

Under the heading *non-living* you may have listed water, clothes, a house and weather. These are the **abiotic** (or non-living) **factors** that affect an organism. Light, temperature, humidity, water, soil and air are other examples.

The term **environment** is used to describe all the factors, both living and non-living, that affect an organism where it lives. If one or more of these factors is missing from a particular environment, then the organism may not be found there. For example, the sandhill frog found in Western Australia needs sand to provide it with protection from predators (biotic). The sand also provides moisture and keeps the frog cool (abiotic). The frog feeds at night, then at dawn it burrows down to where the sand is damp. It takes moisture from the sand through its skin. The sandhill frog is only found in places like this where the conditions are right for its survival.

INQUIRY 2

Four different Australian environments

1 Look at the different environments pictured. For each picture infer what the possible abiotic factors are that could affect organisms living there. For example:

- What are the maximum and minimum temperatures likely to be?
- Is this a wet or a dry place?
- Is the air humid (moist) or dry?
- Is there a lot of water available? Is the water salty or fresh?
- How much wind is there?
- How much rain falls?
- Are there tides or currents?

INQUIRY 2

Four different Australian environments

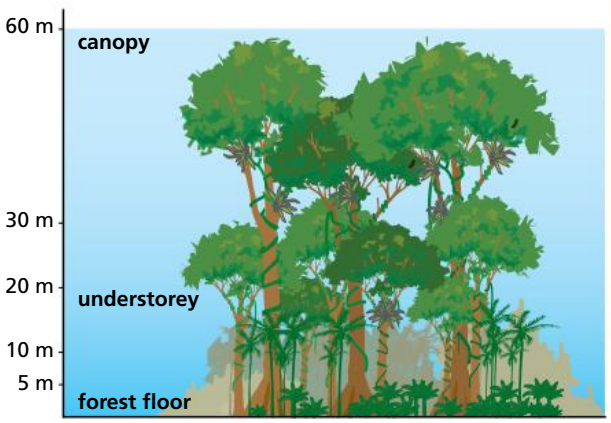
2 Check your inferences in question 1 with the following descriptions.

A desert

In deserts the temperature during the day can reach up to 60°C and fall to almost freezing at night. It is a place of extreme conditions. There is little moisture in the air. The moisture available is trapped below the ground. There is so much sunlight that the soil surface can reach temperatures of over 70°C. Water 1 cm deep can reach a temperature of almost 100°C. In the shade of grasses or dense bushes, the temperature can be over 40°C, yet only 40 cm below the ground it can be as low as 28°C. On the surface there is little shelter from winds and dust storms. Organisms must survive for months without rain.

A rainforest

A rainforest is a tropical forest made up of plants that require high levels of moisture. The largest trees can be well over 30 m high, forming a *canopy* like an umbrella, shading the *understorey* plants below. The light intensity is greatest at the top of the canopy, while the forest floor can be quite dark. The dense vegetation traps water and keeps the air cool and damp. Rainforests are usually found in the tropics where the temperature is, on average, about 27°C and the rainfall is over 1500 mm per year. The forest floor is covered with leaf litter rich in nutrients and decaying matter that takes a long time to break down. The nutrients from this are released very slowly. Therefore the soil does not contain a lot of nutrients.



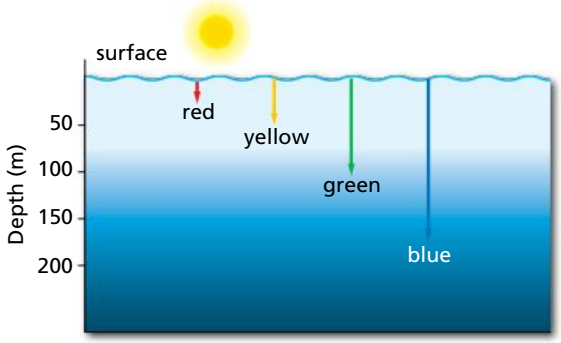
A rock pool (the littoral zone)

The area where water meets the land is called the **littoral zone**. This could be the edge of a lake, sandy beach, mudflat or rock platform. These are places of extremes. For example, a rock pool at low tide is exposed to the weather and sun. On a warm day the temperature of the pool can rise to 35°C. Warm water contains less oxygen than cold water, so there is less oxygen available in the pool at these times. The salt levels in the pool increase as the water from the pool evaporates, but decrease when it rains. As the tide comes in, the pool is battered by waves and eventually goes underwater. When this occurs, the temperature of the water can drop to less than 15°C and the oxygen levels in the pool rise again.

The ocean

The water in the ocean contains a high concentration of dissolved salt, about 3.5 g per 100 mL. Seawater contains 0.004% oxygen, much less than air, which contains 21% oxygen. At the equator, the water temperature can be over 30°C,while at the poles it can be below 0°C. In very deep parts of the ocean the temperature remains at about 0°C.

There is plenty of light from the surface of the ocean to a depth of 200 m. In the twilight zone (between 200 m and 1000 m) the light slowly decreases. Beyond 1000 m it is always dark. As the light disappears, so does the oxygen and the pressure from the water above increases. White light is made up of the different colours that you see in a rainbow. These colours disappear at different depths, so the colour of light in the water changes. Water also supports or pushes upwards any objects in it. This is called **buoyancy**.



INQUIRY

3 Biotic factors

The four pictures here show one organism from each of the environments discussed on the previous page.

A turtle

A variegated limpet

A dunnart

A green tree frog

1 To which environment does each of these organisms belong? Why do you think so?

2 What adaptations do these organisms have to help them survive where they live? For example:
- What can they do to help them survive?
- What type of structures or body parts do they have?
- How would their bodies function or how would their bodies work to help them?

3 Make a list of other types of organisms that would be found in each environment, and the features they would need to help them survive.

4 Choose one of these environments and draw an imaginary organism with all the features you think it needs to survive. Explain your organism to the class.

5 Look back at the organisms pictured on the first two pages of this chapter. What type of environment do they live in? Why do you think these organisms live in the areas they do?

Over to you

1 Describe your back garden, using the words *environment*, *biotic* and *abiotic*.

2 What problems do organisms living in water face? How are these problems similar to and different from those facing land organisms?

3 List two conditions that would be faced by organisms living in a rainforest which would not be experienced by organisms living in a desert.

4 List two conditions that would be faced by organisms living in

a the littoral zone. **b** the ocean.

5 Look at the picture of the eastern bearded dragon. It lives in rainforests, but is also common in gardens in the north of Australia.

What features does it have to help it survive in these environments?

5.2 Food chains and webs

As you have learnt in the previous section, organisms are affected not only by the abiotic factors in their environment such as changing temperatures and oxygen levels, but also by the biotic factors.

Let's look at lorikeets (small brightly-coloured parrots) for example. They need oxygen and water, but they also need food. They eat pollen and nectar and so rely on flowering plants such as eucalypt, Banksia, grevillea and bottlebrush for food. Trees also provide them with shelter and they use tree hollows to make a nest to rear their young. Without these plants the lorikeets could not survive. Lorikeets are also social birds. They live in groups or flocks of many birds and often feed together. They are thought to pair up and mate for life.

Lorikeets are themselves food for other animals such as peregrine falcons, brown falcons, whistling kites and pythons. The lorikeets are the **prey** and the organisms that eat them are called **predators**.

It is easy to show these feeding relationships by drawing a **food chain**. This shows who eats who drawn in a line. For example:

eucalypts → lorikeets → falcons

The arrow points to the organism that does the eating. Food chains are a useful way to show feeding relationships in a habitat.

Cane Toads

Cane toads were brought to Queensland in 1935 in the hope that they would eat beetles that were killing or affecting the growth of sugarcane, and causing millions of dollars damage to the sugarcane industry. The toads bred quickly and then spread across Queensland and into the Northern Territory and New South Wales. They are now considered a pest because there are so many of them.

When the toads were introduced into Queensland many animals that ate frogs started to eat the toads. Quolls (pictured below), snakes, goannas and even crocodiles ate them.

However cane toads are very different from frogs because they are poisonous, so many native animals were killed from eating toads. Even native tadpoles died when they ate cane toad eggs. Some organisms that ate cane toads were not affected, for example, hawks and native rats. Some fish, for example, barramundi, and certain species of frogs ate cane toads but didn't like the taste or felt sick and learnt to avoid them.

If you tried to draw food chains of all these interactions there would be too many. It is better to draw a **food web** which shows all the feeding relationships within a group of organisms, linking many different food chains together. A food web is a more accurate picture of the relationships organisms have in natural environments. A cane toad food web has been drawn below.

By looking at cane toads you can see how living things can cause changes to their environment and affect other living things. When scientists started studying the effect of cane toads on Australian animals they found that in some places 90% of goannas and 10% of quolls were killed within the first year of the cane toads arriving. However native tadpoles did not decrease in numbers because the goannas that ate them had died. Hawks were not affected by the toads and in fact benefited because there were more dead animals around to eat. So the introduction of the toads affected the balance of organisms that previously existed. Affecting one part of a food web affects other parts of it as well.

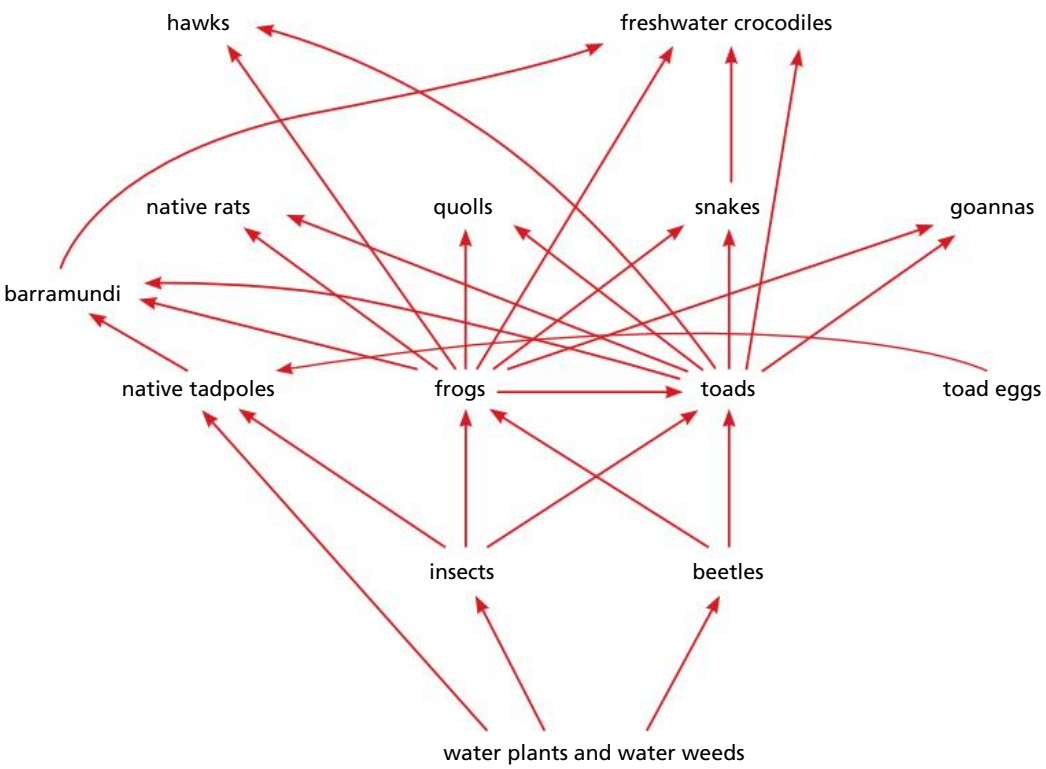
If you look at the cane toad food web there are plants which are at the bottom of the food web. These plants are called **producer** organisms because they make food for the other organisms. The organisms that eat the plants are called **herbivores**, and the organisms that eat the herbivores are called **carnivores**.

Over to you

Use the cane toad food web below to answer these questions.

1. List two producers, two herbivores and three carnivores in the food web.
2. List five food chains, for example:

   water plants → beetles → toads → goannas
3. How many food chains can you find in the food web?
4. Why did goannas, quolls and snakes die when the cane toads were introduced?
5. Do you think cane toads are well adapted to living in Australia? Explain your answer.
6. If all the insects were removed from this food web, what do you think would happen to the rest of the web?
7. What can we learn from the cane toad story about introducing new organisms into Australia?
8. Use the internet to research the eating habits of one Australian organism. Construct your own food web showing the relationships that exist between this organism and others in its environment.



A cane toad food web

5.3 Adaptations

Living on land

Organisms living on land have the following adaptations to help them survive.

1. They need oxygen from the air for respiration. Many animals have lungs. Frogs are able to take in air through their skin. Insects draw air into their body through openings called spiracles.
2. They need water. Animals living on land lose water during breathing, sweating and urinating and this water must be replaced. Animals such as the echidna and the bilby do not drink, but obtain water from their food. Some organisms concentrate their urine and faeces to conserve water. Some plants have needle-shaped leaves so less sunlight hits the leaf surface and water loss is reduced.
3. They need a structure to support their bodies. Animals have either an internal skeleton (endoskeleton) as we do, or an external skeleton (exoskeleton) as insects do. Plants have woody tissue or use water in their cells to keep them upright.
4. Organisms on land must also cope with changing temperatures. For example, in the cold some small animals such as dunnarts go into a state of inactivity. In this state they slow down the reactions in their body. Some organisms grow a thicker coat of hair or fur. To avoid the heat, some organisms seek shelter under trees. Others burrow underground, where the temperature can be 20°C lower than on the surface.

Living in water

Organisms living in water also have adaptations to help them survive.

1. Aquatic organisms (those living in seawater and fresh water) need oxygen. However, as very little of the oxygen in air dissolves in water, most aquatic organisms have structures such as gills to extract oxygen from the water. They must actively pump water across their gills or swim constantly to move water over their gills.
2. The temperature of water affects the organisms living in it. For example, corals in reefs will not live in water colder than 20°C. Also, warm water has less oxygen dissolved in it than cold water.
3. Light is in short supply in water and gradually disappears below 200 m. Photosynthesis occurs only near the surface, so photosynthetic organisms such as algae and seaweed are found only near the surface or in shallow seas. Organisms that live deep in the ocean have special features, such as fluorescent body parts, to survive where there is no light at all.
4. Buoyancy supports organisms in water. For example, when the tide is in, seaweed growing on a rock platform is held upright by the water. When the tide goes out, it lies limp on the rocks because it has no support. Organisms living in water must control buoyancy to move up or down. Fish can move up and down by simply letting air into and out of a swim bladder. To overcome buoyancy divers attach lead weights to their belts to make them sink.
5. Many aquatic organisms live in fast-flowing streams or on the seashore where they are battered by waves. These organisms have ways to overcome these conditions. For example, the variegated limpet (page 92) has a simple saucer-shaped shell for protection against waves and a strong muscular foot to attach it to rocks.

Salinity

Aquatic organisms are affected by *salinity*—the amount of salts such as sodium chloride dissolved in the water. For example, some fish living in seawater have a lower concentration of salts in their body fluids than their surroundings do. So they take in salt and lose water until their body fluids match the environment they are in. These fish can dehydrate (lose water) because of this. So they drink water and get rid of salt from their gills to survive.

Freshwater fish have the opposite problem. They have a higher concentration of salts in their body fluids than their surroundings do. So they take in water and lose salt to their environment. They produce very dilute urine and take in salt through their gills to make up for the loss of salt.

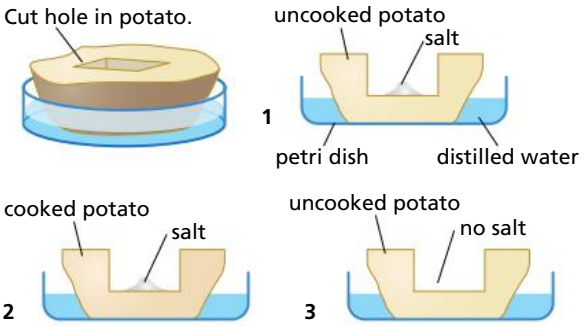
It is for this reason that many saltwater organisms cannot move into brackish (slightly salty) or fresh water. If they do, they have a higher concentration of salts in their body fluids than their surroundings, so they lose salts to the environment and eventually die. Organisms such as shore crabs, that can tolerate salt and brackish water, are able to keep their body fluids constant regardless of the environment.

INQUIRY

4 Salty fish in fresh water

You will need: the equipment pictured

Set up the potatoes as shown and observe what happens to them after 2–3 hours.



1 What does the potato represent?

2 Cooking the potato 'killed' the cells. Why did you need to see what happened to a cooked potato?

3 Why was the uncooked potato with no salt needed?

4 What variables could affect this activity? How were these controlled?

5 Explain why fluid leaked into the cavity of the uncooked potato with salt. How does this explain what happens to organisms in fresh and salty water? What adaptations do they have to overcome this?

INQUIRY

5 Case study of desert dunes

Sand dune deserts cover 950 000 km^2 in Australia. In these deserts, the sand and air temperatures can be extreme. Small bushes and clumps of spinifex grass offer the only shade. The needle-sharp spines of the grass trap pockets of humid air between them, and the ground beneath them is shaded and damp. This is why some lizards such as the blue-lined dragon live inside the clump of grass. The lizard has yellow stripes on its back and belly to blend in with the grass. Australia has 54 species of lizard that live only where the spinifex grows.

The dune is quiet during the day. Ten centimetres below the dune the sand is moist and cool. Further down is where most organisms spend their day. As the day cools, ants appear, and military dragons and thorny devils start to feed. By night the dune is alive with activity. Narrow-banded sand swimmers (skinks) hunt beetles and ant spiders feed on the ants.

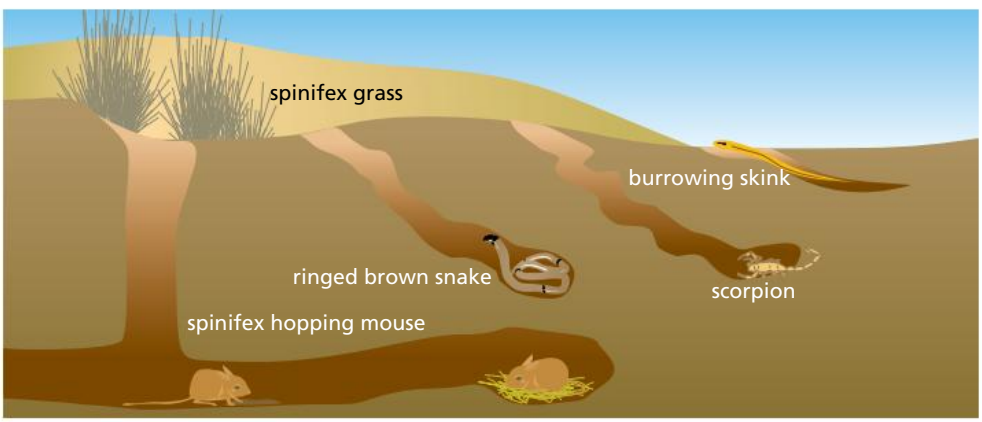
Hairy-footed dunnarts feed on beetles as well as small lizards and flying insects. Scorpions sit and wait at the entrances to their burrows for any passers-by. Spinifex hopping-mice bound across the sand, and knob-tailed geckos hunt for insects. A burrowing ringed brown snake comes out to chase a gecko.

a Explain how being **nocturnal** (active at night), burrowing and living in spinifex are adaptations for desert life.

b Why do you think the dominant plant on these dunes has needle-shaped leaves?

c Draw a simple diagram to show what eats what in this case study.

d Design an experiment to show how the temperature and moisture levels in a burrow can be far less than on the surface.



The blue-lined dragon has stripes on its back and belly to blend in with the spinifex grass.

Types of adaptation

Let's review the different types of adaptation.

Structural adaptations

Geckos have special pads on the end of their toes that help them cling to the smoothest of surfaces and climb. The pads are examples of *structural adaptations*—the way an organism's body parts are built to help it survive.

Functional adaptations

The way an organism's body works can also help it survive. This is a *functional adaptation*. For example a leech attaches to its prey or host with suckers, and then pumps digestive juices into the host. These prevent the blood from clotting and act as a painkiller in the host so that the leech can get the food it needs. The suckers are structural adaptations. The digestive juices produced are a functional adaptation.

Behavioural adaptations

Wraparound spiders from central Australia have thin bodies that enable them to lie close to tree branches. During the day they wrap themselves around a branch and stay hidden, coming out of hiding at night to hunt their prey. This is an example of a *behavioural adaptation*. The way the organism behaves helps it to survive.

A wraparound spider hidden on a branch

INQUIRY 6

Seal or koala?

1 Match the adaptations below with the animals pictured and explain your reasoning.

- **a** The leaves that are the food for this animal contain toxic substances that can be filtered by its liver and excreted in urine.
- **b** This organism has a water-repellent top coat with an under layer of dense fur.
- **c** The blood of this organism can hold three times more oxygen than the blood of a human.
- **d** Water is obtained from dew and from leaves.
- **e** The front paw of this animal has two thumbs to help it grasp and climb.
- **f** This organism has an appendix that can be up to 2 m in length to help digest plants.
- **g** The nipples of the female can be pulled in to lie flat on the body.
- **h** The baby is protected in a pouch.
- **i** This animal has a very reduced tail.
- **j** Hind limbs are used as a rudder or legs.
- **k** The body is streamlined, with a rounded head and almost non-existent ears.
- **l** There is a smooth layer of fat or blubber under the skin.
- **m** The fur has many strands and is waterproof.

2 Group these adaptations as structural, functional or behavioural.

INVESTIGATION

1 Colour adaptation

Aim

To investigate the factors that affect the survival of organisms in different habitats.

Risk assessment and planning

Copy the two tables below to record your observations.

Table 1

Number of counters	Red	White	Black	Green
Game 1				
Game 2				
Game 3				

Table 2

	Number of students with less than five counters	Number of students with red counters	Number of students who survive
Game 1			
Game 2			
Game 3			

Apparatus

- 80 coloured counters or discs, 20 each of red, black, white and green
- stopwatch

Method

1. Your teacher will divide the class into three equal-sized groups.
2. Group 1 (Set-up) will hide the coloured counters in one area of the school grounds. Place some counters on the same coloured ground and others on different coloured ground.
3. Group 2 (Predators) will not see the set-up. They have 1 minutes to find as many counters (prey) as possible. They are not allowed to work together.
4. Group 3 (Observers) will observe Group 2 and record how they behave.
5. At the end of the minute, record the number of counters collected in Table 1.
6. Any students with less than 5 counters are out of the game (not enough food) and any students with red counters are also out (poisonous food). Record how many students survived the activity in Table 2.
7. Now that students know how they can be out of the game, repeat the activity with Group 1 Predators, Group 2 Observers and Group 3 Set-up. You will have to collect all the counters and hide them in the same area.
8. How many students survived this time? Were there any differences in the behaviour of the predators? (The observers answer this.)
9. Repeat the activity for the last time with Group 1 Observers, Group 2 Set-up and Group 3 Predators. This time the predators can collaborate or work with others.
10. How many students survived this time? Were there any differences in the behaviour of the predators?

Discussion of results

1. Let's imagine the counters are real prey and each colour represents a different group of organisms. How does colour affect the survival of the prey?
2. Which colour was the best camouflage to avoid being seen and picked up? Why?
3. What type of adaptation is colour? Give an example of how colour is used as an adaptation in the natural environment.
4. How many organisms (prey) died in each game? Did any become extinct, i.e. no counters of a particular colour left to collect?
5. Did knowing how many counters were needed for survival and which counters not to pick up change the numbers of dead and extinct organisms in Game 2? Did the behaviour of the predators change? Would this happen in the wild?
6. Did the collaboration of organisms (helping each other) make a difference to survival chances in Game 3? What type of adaptation is this? Give a real-life example.
7. If over time the black and white counters (prey) became extinct and only the green and red counters (prey) remained, what would happen to the number of predators? Give a real-life example of this happening.

Conclusion

Write a summary about your findings.

INQUIRY 7 Characteristics to survive

For each animal shown below answer the following.

1 Which characteristics are
- **a** structural adaptations
- **b** functional adaptations
- **c** behavioural adaptations?

2 For each animal, describe the environment that would best suit its characteristics.

Rests under bushes, debris or in other animals' burrows

Mates from July to August

Able to roll into a ball to escape danger

Sleeps during the day and feeds at night

Fur grows between the spines

Long claws for digging and grooming

Very sensitive snout

Termites, ants and soil provide food and water

Abdomen skin folds to make a temporary pouch

Long thin tongue

Does not drink

Produces sticky saliva

Pad at back of mouth for grinding food

Breeds between March and May

Large ears with rich blood supply to help get rid of heat

Excellent sense of smell

Grey fur on top, white fur underneath

Soft fur coat that can fall out in clumps in an attacker's mouth

Pouch opens to the rear

Eight nipples

Nocturnal

Eats larvae, seeds, fruit, fungi and bulbs

Sleeps in burrow during the day

Food provides water; no need to drink

Tail ends in a white crest often held up like a stiff banner

Strong forelimbs and claws for digging; steep spiral burrow up to 3 m long

Over to you

1 Use examples to explain the difference between structural, functional and behavioural adaptations.

2 Sugar ants live together in a large group called a colony. Different individuals in the group have different jobs to perform. What type of adaptation is this and how does this help the ants to survive?

3 Antechinuses (similar to dunnarts) spend so much energy mating that most males do not survive. This leaves few, if any, males alive until the young are born. Explain how this is an adaptation to help antechinuses survive.

4 Organisms living in the littoral zone have many of the following features in common. State whether these features are structural, functional or behavioural adaptations.
- **a** hard outer skeleton
- **b** able to tolerate a wide range of temperatures
- **c** crawl under seaweed or rocks to escape predators
- **d** hide under ledges in the shade of rock pools
- **e** plates or lid on the shell so it can be closed
- **f** use less energy for body reactions if exposed when the tide goes out
- **g** cling to rocks when the tide comes in

5.4 Australian plants

INQUIRY 8 Stomata

You will need: prepared slides of leaf surfaces, microscope

1 Examine the slide of a leaf surface. What do you see? Suggest why a leaf would have these structures.

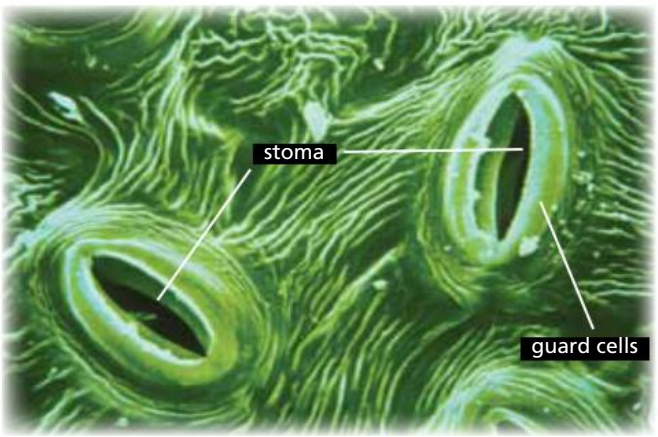
2 Examine the leaf surface of different plants, if you have the slides available. Are all the leaves the same? Explain your observations.

Stomata

In Inquiry 8, you may have noticed that the surface of a leaf is covered with openings called **stomata** (STOW-ma-ta). Plants need carbon dioxide for photosynthesis and oxygen for respiration. They exchange these gases through the stomata. For photosynthesis to occur the stomata must be open during the day.

The problem for a plant is that when the stomata are open, water evaporates from the leaf in the process of transpiration. To replace the lost water, land plants must take up water through their roots. If a plant can't obtain enough water it wilts. This is because the cells of many plants need water to keep them full or *turgid*, pushing out against other cells and making the plant firm. Without water, the plant is no longer turgid, and wilts.

However plants are able to control the opening and closing of the stomata to reduce transpiration. Around each stoma (singular of stomata) are guard cells. When these cells lose water, they close and prevent water escaping through the stoma. The stomata are therefore an excellent adaptation to life on land.



Adapted to fire and drought

In most plants the stomata are open during the day and closed at night. However, in dry conditions some plants such as eucalypts open their stomata at dawn and close them after about 6 hours. Other plants open their stomata in the early morning and late afternoon when there is enough light for photosynthesis. However they close them in the middle of the day when the risk of water loss is greatest.

Eucalypts have other adaptations to help them survive in the dry Australian environment. Their leaves hang vertically so they get less sun. A thick, shiny waterproof layer on the surface of the leaves helps to reduce evaporation from the leaf surface.

Long before humans came to Australia, fires were started naturally by lightning. During periods of rain plants grow quickly, providing fuel for fires in hot weather. When Indigenous Australians arrived here, they used fires to renew the forests and ensure their food plants survived. Today fires are used in forestry and farm management so fuel dosen't build up on the forest floor. Despite this there are uncontrolled fires that start both naturally and unnaturally and which cause damage to property, destroy wildlife and take lives.

Many Australian plants are adapted to fire. For example, wattle seeds germinate quickly after a fire. Heat also causes the seeds to be released from banksia pods. Some plants flower in the presence of smoke and fire. Native animals also benefit, because fire-tolerant plants send out new shoots after a fire, providing food for the animals.

Some eucalypts need fire to survive. Over time leaf litter builds up on the forest floor and the eucalypt seeds cannot grow in this, so other plants take over. A fire clears the forest floor, and removes the plants that compete with eucalypts for space, light and water. If a eucalypt forest does not experience fire within 250 years, the trees die out.

Eucalypts have a thick bark that protects them from fire. Many have lignotubers, which are swellings near the bottom of the stem or under the ground that contain a mass of buds that shoot after a fire. Eucalypts without lignotubers usually produce huge quantities of seed that germinate quickly once a fire has passed. A fire regenerates the bush, allowing plants to flower and fruit and grow new shoots.

Flower adaptations

The shapes and designs of many Australian flowers are an adaptation to life in a dry climate. For example, to conserve water the petals of many Australian flowers are very small or absent. Instead the male and female parts of the flower are brightly coloured to attract pollinators. The flowers of eucalypts, for example, have long, conspicuous stamens, which are the male part of the flower. These surround the pistil—the female part. The petals and sepals are fused together forming a cap over the bud called the operculum. The name *eucalypt* comes from two Greek words, *eu*, meaning 'well' and *calyptos* meaning 'covered'. So *eucalyptus* means 'well-covered bud'.

Bottlebrushes or callistemon flowers also have bright, showy stamens. Individual flowers are clustered together in what looks like a 'brush'. The sepals and petals of grevilleas are fused together in a colourful whorl, and many individual flowers form a large flower head. The colourful yellow wattle flowers are also balls of stamens.

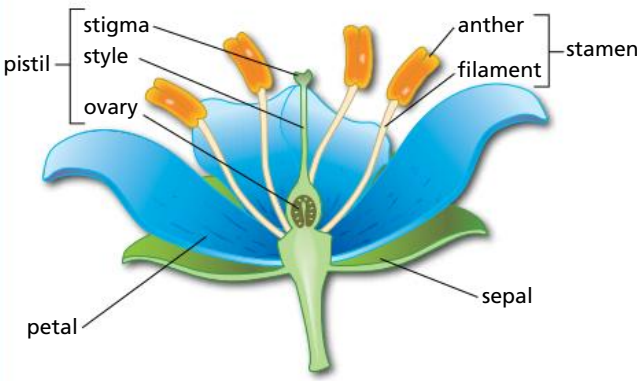
INQUIRY 9 Australian flowers

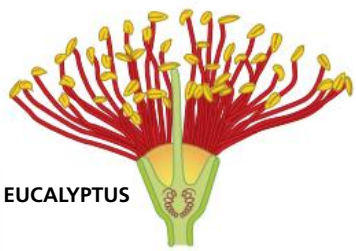
You will need: dissecting equipment, samples of flowers from eucalypts, grevilleas, wattles and bottlebrushes, hand lens

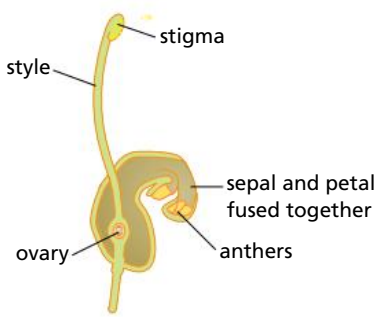
1 The diagram below shows a general flower with the male and female parts labelled. Examine each of the Australian flowers you have. Draw and label the individual flower parts. The diagrams on this page will help you. On a separate drawing show the structure of the flower heads.

2 Explain how Australian flowers are different from the general flower drawn here.

3 Explain how the structures of the flowers you have examined are an adaptation to life in a dry climate.




EUCALYPTUS



GREVILLEA

INVESTIGATION

2 Wattle seeds

Aim

To test the following hypothesis:

Fire makes wattle seeds germinate (sprout from seeds) more quickly.

Apparatus and method

What will you use and what will you do? Try boiling the wattle seeds in water to simulate a fire, rather than actually burning the seeds. Does the type of wattle seeds or the length of time they are boiled in water make a difference to their germination rates?

Risk assessment and planning, Results and Conclusion

Write these sections yourself.

Discussion

1. Did you get the results you expected? Why or why not?
2. What were the variables in this experiment and which of these did you control?
3. Were there any errors in the design of your experiment where some variables were not properly controlled? How could you improve this next time?

INVESTIGATION

3 Design your own

Choose one of the following experiments.

a Impatiens are plants that grow well in the shade. They lose water very quickly and droop in a hot sunny position because their cells lose turgor. Design an experiment to see how long it takes impatiens to droop in the sun compared to in the shade.

b Cobalt chloride paper is pink when dry, but as it absorbs moisture it becomes blue. Using cobalt chloride paper, plastic bags and twist-ties, design an experiment to see if eucalypts lose less water than impatiens, when it is hot.

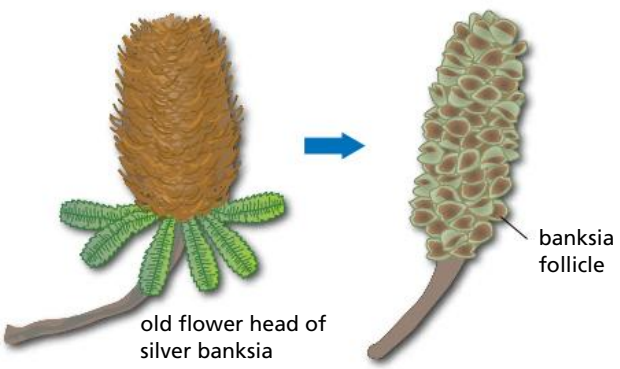
c Design an experiment to see how the angle of a leaf affects its temperature.

d Design an experiment to show whether a shiny leaf surface is cooler than a dull one.

e There are different types of roots. A taproot is one large root that grows straight downwards into the soil. Carrots, turnips and dandelions are examples. The taproot acts as a strong anchor, reaching water well below the surface. Plants such as bamboo and palms have a mass of threadlike roots. In places where water and minerals are in short supply, this allows the plant to reach a greater area of soil. Examine the roots of different plants with a hand lens and explain how the structures you observe help the plant to survive.

Over to you

1. What are stomata? How do they affect the movement of gases and water in a plant?
2. Give three adaptations that eucalypts have to help them live in a dry environment.
3. Why do plants that grow in areas with little sunlight have large, broad, flat leaves whereas trees like eucalypts that experience high levels of sunlight have leaves that are narrow and angled downwards?
4. Explain with examples how eucalypts are adapted to fire.
5. What features do eucalypts, callistemons and wattles have in common?
6. How is a grevillea flower different from a eucalypt flower?
7. Explain in your own words how Australian flowers are unique.
8. The seeds of banksia plants are contained in dry woody pods called follicles on a flower spike. In a fire the flower spike burns but the seeds are protected inside the follicles. The heat splits the follicles. When it rains the follicles open further and the seeds are released.
   a Explain how the follicles are an adaptation to fire.
   b Suggest why the follicles only open after rain.



5.5 Going, going, gone

There are many natural changes in our environment, such as changes in the weather, seasonal changes, movements in the Earth's crust and changes to waterways with movements of sand, silt and tides.

There are other changes that affect the environment that are not natural, such as pollution, destruction of habitat, and climate change from pumping out gases into our atmosphere. The introduction of non-native plants and animals such as lantana, cats, dogs and foxes has also affected the natural Australian environment. These non-native animals prey on our native animals and compete with them for food. Lantana was introduced to gardens and has spread into the bush, competing with native plants for light, space and nutrients from the soil.

Since Europeans arrived in Australia, more than 50 different species of native mammals, birds and trees, as well as hundreds of different species of native plants and invertebrates, have become extinct. More than 100 animals such as frogs, birds and fish and more than 600 different plants are now endangered.

Introduced organisms are just one reason why we are losing **biodiversity**. This word comes from the Greek word *bios* meaning 'life' and diversity, which means 'variety', so it means the variety of life on Earth. As you have seen, variety in organisms is important because if a change occurs, populations of organisms are not wiped out. But biodiversity is also important because each organism interacts with others, for example, in feeding relationships. If one group is wiped out, this can affect many other organisms and cause drastic changes in natural environments.

Biodiversity is also important for our own survival. Think of the variety of organisms you rely on to survive just one day, for example the plants and animals you eat. If these organisms disappeared you might not survive.

The pictures on the right show some of the organisms that are endangered or already extinct. For example, the northern hairy-nosed wombat is estimated to live in a 100 m^2 area in Epping Forest National Park in central Queensland. At the latest count there were 138 individuals left. Another on the list is Broom's pygmy possum, also called the mountain pygmy possum. It has a fragmented population restricted to the mountains of Victoria and NSW. How many individuals are left is unknown.

Western quoll (endangered)

Eastern hare-wallaby (extinct)

Western barred bandicoot (extinct on mainland)

Mountain pygmy possum (endangered)

Northern hairy-nosed wombat (endangered)

SCIENTISTS AT WORK

Dr Louise Morin

Dr Louise Morin at CSIRO in Canberra is one scientist working to protect our unique environment. At present Dr Morin is monitoring the development of a rust fungus released in Australia in June 2000 to control a common weed called bridal creeper. This plant is native to South Africa, and was introduced into Australian gardens in the 1850s. It has invaded the natural bush, because its seeds are very easily spread by birds. Herbicides cannot be used because of their effect on other plants, and there are no natural enemies here to keep bridal creeper under control. In fact it is well adapted to the bush of temperate Australia.

In South Africa, bridal creeper is kept in check by its natural enemies. One of them is the bridal creeper rust fungus. In 1998, this fungus was brought to a quarantine facility in Australia, where tests were carried out to make sure that it infected only bridal creeper and no Australian plants. After 18 months of testing, the fungus was approved for release into the Australian environment. This is an example of **biological control**, using a natural enemy of an unwanted organism to get rid of it.

So far the rust has been very destructive at several of the 550 release sites across Australia. The hope is to achieve a balance between weed numbers and the fungus. There have to be enough weeds for the fungus to survive and infect new plants, but weed numbers need to be small enough so that native plants can regenerate the bush.

Dr Morin studied science and maths at school, obtaining a Bachelor's Degree in Agriculture in Montreal, Canada. At university she took a course that was taught by a well-known scientist who was an expert on diseases of sunflowers. Louise found the course so interesting that she became hooked on the study of plant diseases.

Before and after completing her Master's degree, Dr Morin travelled the world. It was during a scientific conference in Rome that she decided to complete her PhD (doctorate) in Australia.

Dr Morin has travelled to Ireland, Scotland, France, South Africa, Argentina and Hawaii with her work, which she hopes will contribute to making a better world. In the future she wants to work with graduate students and help solve the problems caused by other weeds in Australia.

Louise and her son in a patch of bridal creeper

INVESTIGATION

4 Cress seeds

Aim

Cress seeds respond very quickly to changes in their environment. Use cress seeds to test the following hypothesis:

Pollutants in the environment will affect organisms.

Apparatus and method

What will you use and what will you do? You could use three petri dishes with cress seeds in them. Water the seeds in the first petri dish with distilled water (pure water). This will be your control (e.g. page 72). You can compare the growth of the seeds in the other two dishes with this. Water the second dish with a weak chemical solution and the third dish with a stronger solution. There are many possible chemicals you could use, e.g. detergent, bleach, paint, shampoo, soap. Choose one to test.

Write a prediction about seed growth before starting. For your results you could count the number of germinating seeds and measure their height, then graph this information.

Write your report using the headings listed on page 12.

Save the platypus

In 1995, the Urban Platypus Program began to map the distribution of the platypus and see if platypus numbers were constant or decreasing. The platypus is presently described as *vulnerable*, but not endangered.

A platypus feeds in waterways at night. It spends up to 17 hours a day resting in a burrow located about 1 m above the waterline where plants overhang the water. This gives the platypus protection from predators and it also hides the platypus as it enters and leaves the water.

Platypus numbers are being affected by changes to the natural flow of waterways, pollution in the water (rubbish and chemicals) and the removal of plant life near waterways. Melbourne Water and the Platypus Conservancy are working to improve waterways and educate the public so that the platypus survives.

Cod or carp?

Australia's largest freshwater fish is the Murray cod. It is found in the Murray–Darling River system and was once extremely common. Prior to European settlement, it was a major food source for Aboriginal people in the area. Today cod numbers are declining, and it is listed as vulnerable.

The cod moves upstream to breed and can travel 100 km or more to spawning sites where it lays its eggs. Snags in the river made by fallen trees, stumps and vegetation provide these sites. Fish numbers have been affected by the dams and weirs built along the river, preventing fish migration at breeding times. The removal of fallen trees and other debris has reduced spawning sites. The clearing of vegetation along the river's edge for farming has meant that soil and chemicals have entered the river and altered the quality of the water.

Murray cod

In contrast to this, the numbers of carp in the Murray River are increasing. This fish was introduced into Australia for fishing. It is so well adapted to Australian waterways that its numbers have increased to the point where it is a recognised environmental pest. To control the carp, it has been made illegal to keep live carp, and any that are caught must not be returned to the water.

Over to you

1. List three natural changes that take place in the environment.
2. List three unnatural factors that are affecting organisms.
3. Explain how the platypus and the Murray cod are being affected by unnatural changes.
4. Make a list of five things that you can do at home and in the bush to protect our native plants and animals.
5. What do you think the government should do to save our native organisms?
6. How is Louise Morin working to save our native bush?

PROBLEM SOLVING

In no more than 300 words, present your research.

- Try to use diagrams to summarise information and avoid using unnecessary words. For example, a distribution graph could be used to show where the organism is located. The following Skill section will help you with this.
- Highlight the main points of your research, then simplify your sentences as much as possible before writing them on the fact sheet.
- The wanted poster is one example of how you could present your information.

SKILL

Drawing and interpreting maps

When studying where animals live in Australia, information is often displayed on a map. When you are presented with a map there are clues to tell you what the map is about. Review these clues with your teacher.

- the map title
- any keys that are used
- colours and shading
- the map scale
- places, names and labels

1 Look at the following map and answer the questions below.

a Do you understand the meaning of all the words in the key? If not, use a dictionary.

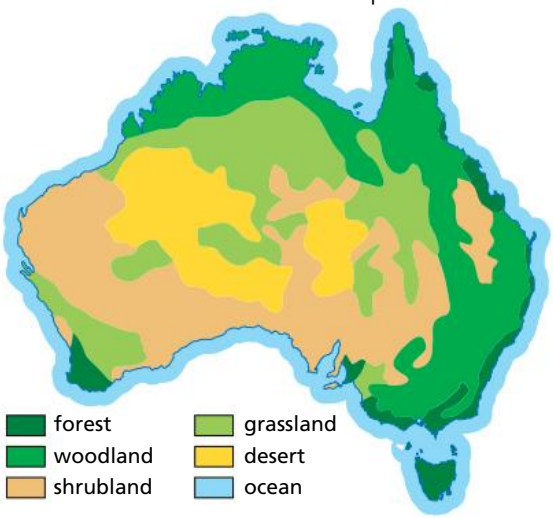
b What do the title of the map and the key tell you?

c What do the colours indicate?

d Is there a scale? Is one needed? Explain.

e How many environments are shown on the map?

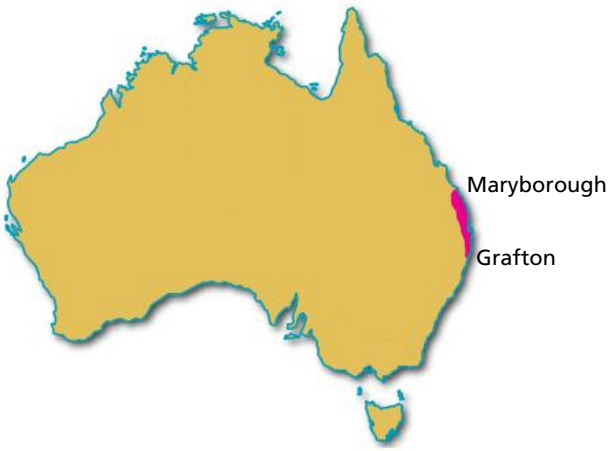
f List three other types of environments that you know of that are not shown on this map.



Different Australian environments

2 The map above is an example of a simple distribution map. It shows the location of different environments and their distribution (how spread out they are). Distribution maps can also show the quantity or amount of whatever is being recorded.

a The map top right shows the distribution of the Richmond birdwing butterfly. Which of the three factors—location, distribution and quantity—are recorded here?



Distribution of the Richmond birdwing butterfly

b What information is missing from this map that could be included?

3 To draw your own detailed map of the present distribution of the platypus in Australia follow these steps.

a From an atlas, trace a map of Australia onto a large sheet of paper, using as much of the paper as possible.

- Trace the outline and state boundaries, include capital cities (in capital letters) and any major towns, e.g. Cairns, Newcastle, Ballarat.
- The names of rivers should be written along the line of the river. All other labels should be horizontal. Spell names correctly.
- Use black pen for all labels and outlines, red pen for boundaries and blue pen for waterways.
- Include a title, a key and a scale (where appropriate).

b Plot the information below onto your graph, showing some of the places where the platypus is located:

Victoria: Goulburn River, Ovens River, Murray River, Yarra River, Plenty River, Maribyrnong River and creeks leading from these such as Dandenong Creek, Olinda Creek, Woori Yallock Creek. Places such as Eltham, Heidelberg, Upper Ferntree Gully, Otway ranges, East Gippsland, Echuca

New South Wales: Rivers throughout the Great Dividing Range

Queensland: Coastal rivers from Cooktown to the border of NSW, Murray–Darling River, Atherton Tablelands

Tasmania: All major waterways and King Island

THINKING SKILLS

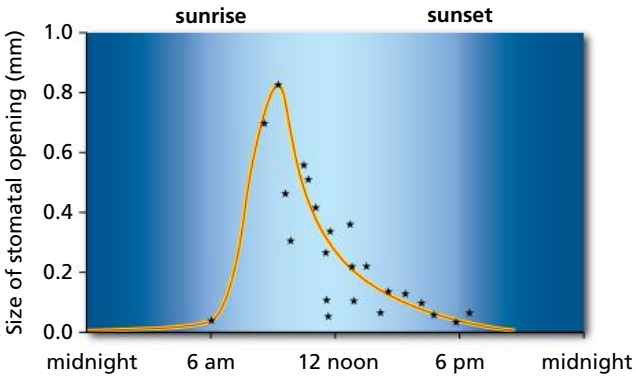
1 *Spirogyra* is a freshwater organism. If irrigated with salty water (given a constant supply), its cells lose water, or turgor. Can you explain why this happens? Irrigate spirogyra cells with salt water and investigate their structure with a light microscope. Draw what you see.

2 Organisms must be able to cope with temperature changes. Investigate an area in the school ground or at home to see the range of temperatures that can occur.

3 The following organisms were introduced into Australia: camel, cane toad, dingo, rabbit, water buffalo, prickly pear. Find out how these organisms have affected our native environments and what is being done to control them. After your research you could write *Who am I?* questions to test your classmates. Here is an example.

> ***Who am I?***
> *I am a native of south and central America. I was introduced in 1935 to control beetles in sugarcane fields in north Queensland. I am poisonous to animals that eat me. I have spread throughout Queensland, into NSW and the Northern Territory. I am . . . the cane toad.*

4 The graph below shows the size of the opening of the stomata of a eucalypt over a 24-hour period in a dry environment. (Fully open = 1.0.) Use what you have learnt in this chapter to infer what was happening to the eucalypt.



5 The Wollemi pine was discovered in 1994. It belongs to an ancient group of plants called Araucaria (primitive conifers). It grows at only two sites, 1 km apart, within the Wollemi National Park in NSW. There are only about 100 adult plants and 200 seedlings left, so it is classified as endangered. It is believed that Wollemi pine numbers have been stable over hundreds of thousands of years. Now it is feared that collectors, fire, present-day plant diseases and weeds could destroy those that are left. The tree grows to 40 m. It reproduces with its cones and has seeds that are brown, papery and flat with a single wing. Seeds can be collected and they do not germinate until after being stored for about 6 months.

The Wollemi pine is found in rainforest in a deep sandstone gorge with rocks that are about 200 million years old. Araucaria plants were common in Australia at this time, but they decreased in numbers over millions of years because of climate change. In recent times, the loss of these plants has increased due to fires started by humans. The Wollemi pine has pollen similar in structure to ancient Araucaria, so it is an important discovery and needs to be protected.

a Why is the Wollemi pine endangered and why is it critical to ensure it survives?

b What reason has been suggested for the decrease in numbers of the Wollemi pine?

c Imagine you are a ranger in the NSW National Park responsible for the Wollemi pine. Put forward an action plan to save the pine.

d A Wollemi pine was planted in a city botanic gardens, but vandals stole it. What would you say to the thieves to convince them of the value of the pine and to return it?

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1. _____ are characteristics that help an organism to survive and reproduce where it lives.
2. The survival of an organism in its environment depends on _____ or living factors such as predators, and _____ or non-living factors such as light, temperature and humidity.
3. Interactions between _____ can be described in terms of food chains and _____ , and human activity can _____ these interactions.
4. There are three different types of adaptations: structural, functional and _____.
5. Organisms living on land or in water have different environments to cope with. Light, temperature, the amounts of dissolved salts and _____ affect organisms in water. Water availability, temperature and _____ are problems on land.
6. Eucalypts are adapted to the Australian environment because they can control the opening and closing of their _____, have leaves with a thick cuticle and can re-grow quickly after a _____.
7. Introduced organisms are causing the loss of _____ in Australia.

abiotic
adaptations
affect
behavioural
biodiversity
biotic
buoyancy
fire
food webs
organisms
stomata
support

Self-management

Finding information

When given some reading to do and then asked questions about it, you often have to hunt back through the text to find what you need. A good way to summarise a chapter and save time is to write down all the headings, and words in *italics* and **bold** with page numbers as you go. For example, here are the first two pages of this chapter:

Page 89 Focus for learning
Inquiry 1: What do you need?
Problem solving: Gone forever
habitat, **adaptations**

Page 90 Australian environments
Inquiry 2: Four different Australian environments
biotic, **abiotic**, **environment**

1. Continue to summarise the chapter in this way.
2. Beside each bold word write down its meaning.
3. Using your summary, state the page number and the heading where the following information could be found:

a a picture of a rainforest
b light levels in the ocean
c biotic and abiotic factors
d three different types of adaptations
e variation and natural selection
f the echidna and bilby
g support structures of animals living on land
h nocturnal animals
i the littoral zone
j adaptations to fire
k the organism pictured below

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Write meanings for the following words:

adaptation, producer, nocturnal, extinct, stomata, turgid

2 Copy and complete the following sentences.

a The place where an organism lives is called its _____.

b The characteristics that suit an organism to the place where it lives are called _____.

c In the food chain *grass → rabbit → hawk*, the hawk is a _____ and the _____ is its prey.

d The area where water meets the land is called the _____.

e It is important to maintain the variety of life on Earth or _____, not only for our own survival, but for the survival of all life.

3 **a** Which of these factors could be a problem for organisms living on land?

dehydration, lack of body support, buoyancy, lack of oxygen, water movement

b Which of these factors could be a problem for organisms living in water?

dehydration, lack of body support, buoyancy, lack of oxygen, water movement

4 Phasmids are leaf or stick insects (see photo below). For self-defence a phasmid may

- freeze.
- spray a chemical on its predator.
- hiss and kick its legs.
- open its bright wings.

a Explain how each of these adaptations helps the phasmid survive.

b Are these all behavioural adaptations? Explain.

5 Ella and Talia were growing cabbages in their garden. They observed that birds were eating caterpillars on the cabbages, and that the caterpillars were eating the cabbages. Draw a food chain for their observations.

6 The drawing below shows a food web for a large pond.

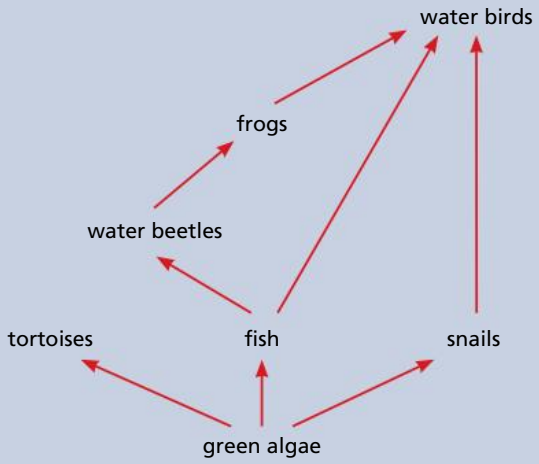
a Which animals are herbivores?

b Which animals are carnivores?

c Which is the producer in the food web?

d Predict what would happen if more water birds came to the pond.

e What would happen to the food web if the green algae started to die?



7 In parts of central Tasmania eucalypts are the dominant forest plants, and beech trees grow beneath them. Over time the forest becomes so dense that the light reaching the forest floor is too low for the eucalypt seeds to grow and survive. Eucalypts are fire-tolerant, but beech trees are not.

a Explain what would happen over time if there were no fires in the forest.

b What would happen to the forest if there were regular fires?

6

Forces

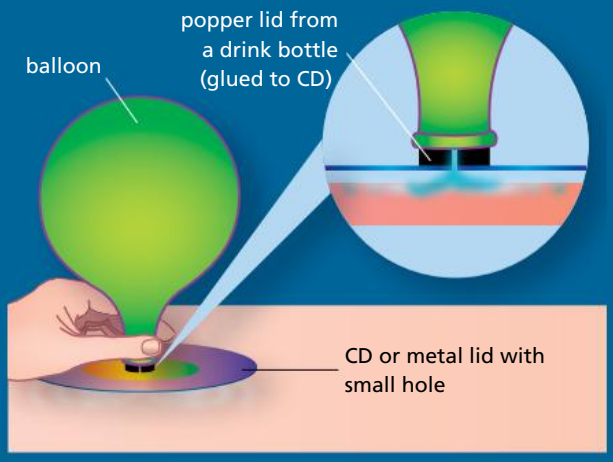
PROBLEM SOLVING

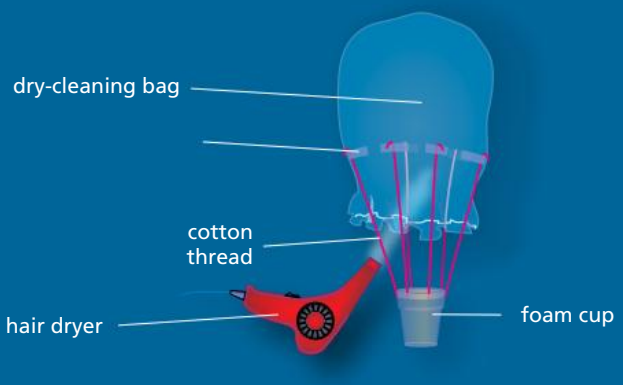
Making a hovercraft or a hot air balloon

Your task is to design a model hovercraft or a hot air balloon. The pictures will give you some clues.

1. Make your model and see how well it works.
2. What are the different variables affecting your model? If you are building the hovercraft, for example, the size of the stopper is one variable that could affect it.
3. Make improvements to your model. What are the variables you changed and why is your model better?
4. Write a report detailing what you did. Explain how your model works using the following headings *Forces acting*, *Balanced and unbalanced forces*, *Contact or non-contact forces*, *Pairs of forces*.

The remainder of the chapter will help you with this task.





Focus for learning

What is a force? A **force** is a push or a pull. Forces can start and stop objects moving. They can make an object change direction, speed up or slow down. They can cause objects to bend, twist and turn.

Many forces are acting on us at any one time. As you read this book, the force of gravity is pulling downwards on you. Gravity is a force of attraction between objects. Objects are heavy or have weight because of the pull of gravity acting on them.

LITERACY FOCUS

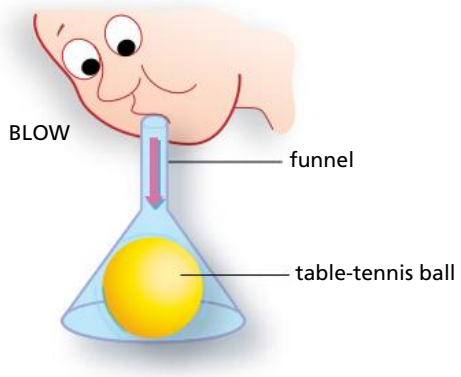
attraction	lubricant
compass	magnetic poles
contact force	magnetised
domains	non-contact force
electrostatic	repulsion
force	satellite
friction	static electricity
gravity	streamlined
ionosphere	thrust
lightning	weight

INQUIRY 1 *Creating lift*

You will need: funnel, table-tennis ball

Place the ball as pictured inside the funnel and blow through the neck of the funnel.

1 Predict what you think will happen.



2 What actually happened?

3 Use the information on the next page to try to explain your results.

By the end of this chapter you will be able to …

Science Understanding

- distinguish between contact forces (such as pushing) and non-contact forces (such as gravity)
- investigate common situations where forces are balanced (e.g. stationary objects) and unbalanced (e.g. falling objects)
- explore how gravity affects objects on the surface of the Earth and in orbit around the sun

Science as a Human Endeavour

- investigate how boomerangs used by Aboriginal people were designed to make tasks easier to perform
- demonstrate an understanding of the first compass—invented by the ancient Chinese civilisation

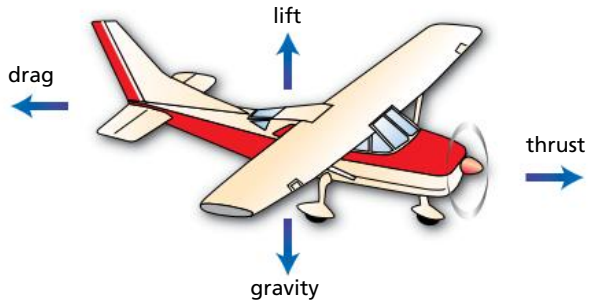
Science Inquiry Skills

- reflect on the method used to investigate a question or solve a problem

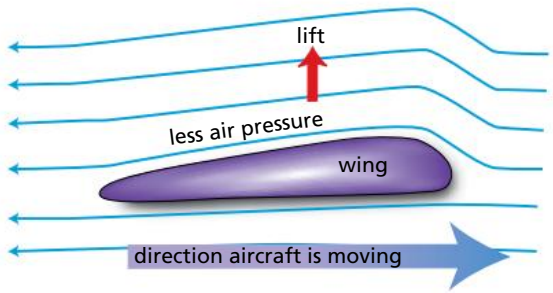
6.1 Forces

How an aeroplane flies

There are four forces working on an aeroplane as shown.



Gravity pulls the aircraft downwards, and lift is the force that pushes it upwards. Lift is created by the shape of the wing. Air rushing quickly over the top of the wing has less air pressure than slow moving air under the wing. This difference in pressure creates an upward force that helps to lift the plane into the air.



Thrust is the force that pushes the plane forwards. Propeller blades are shaped like wings and spin through the air at high speed, so they create thrust in the same way that wings create lift.

Another way to create thrust is to push air or gas backwards at high speed. A jet engine in an aircraft creates thrust by throwing hot air backwards at extremely high speed. The backward force caused by the aircraft on the air is equalled by a forward force caused by the air on the aircraft. These forces are sometimes called 'action and reaction' forces.

Rockets work in a similar way. Chemicals inside the rocket explode and produce huge amounts of gas. The gas is pushed out of the rocket at an enormous speed. The force that pushes the gases out of the rocket is equalled by a force that pushes the rocket in the opposite direction.

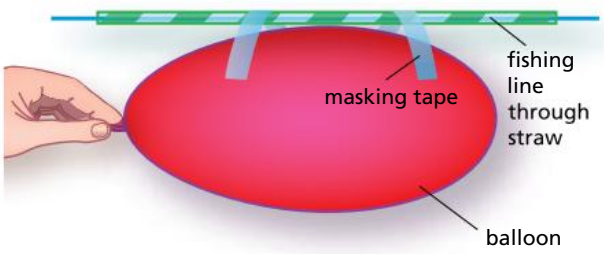
Different forces often act in different directions. For example, drag on an aeroplane acts in the opposite direction to thrust, and gravity acts in the opposite direction to lift. An object such as a plane can change its speed or direction only if the opposing forces are not balanced. It can take off only when lift is greater than gravity, and it can accelerate forwards only when thrust is greater than drag.

The forces acting on a hot air balloon work in a similar way. A burner inside the balloon heats the air, which expands and becomes lighter, creating lift. Gravity pulls downwards. The balloon rises when the lift is greater than gravity—when these forces are unbalanced. To come down, a balloonist limits the amount of hot air produced by the burner, so there is less lift. Gravity is then the stronger force, pulling the balloon back down to Earth.

INQUIRY 2 Line rocket

You will need: balloon, masking tape, drinking straw, 10 m of fishing line

1 Set up your line rocket as pictured here.



2 State which forces are acting on your rocket and why it moves forward.

3 Alter the variables that are affecting your rocket so it shoots down the line in the fastest time. For example, does the size of the balloon, size of the straw, smoothness of the string, amount of tape, etc. make any difference?

4 Can you design a rocket that will travel in a straight line without the use of the fishing line?

So far you have seen that:

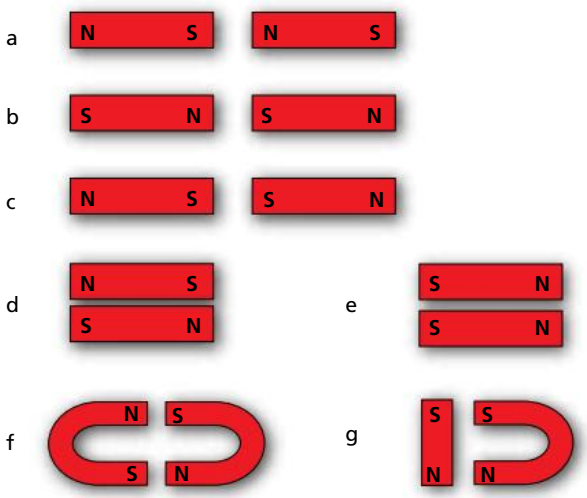
- A force is a push or a pull.
- Different types of forces can act on an object at any one time, e.g. gravity, lift, thrust and drag.
- Forces can act in different directions.
- An object can speed up or change direction only when the forces acting on it are not balanced.
- Action forces in one direction cause reaction forces in the other direction.

Complete the following activities to find out more about forces.

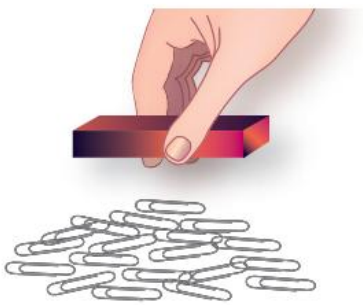
INQUIRY 3 Magnetic force

You will need: bar and horseshoe magnets, paperclips

1 Bring the magnets together in pairs as pictured here. For each pair of magnets that you bring together, describe the forces acting between them.



2 Now bring a magnet near some paperclips. Describe the forces acting here. Does it matter which way you hold the magnet?



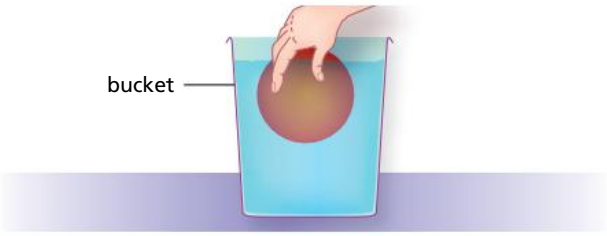
INQUIRY 4 Forces in water

You will need: bucket of water, different types of balls, e.g. golf, tennis, table-tennis, rubber, styrofoam, baseball

1 Fill a bucket with water then push a table-tennis ball into the water right to the bottom. Let the ball go.

2 Explain what happens to the ball. What forces are acting on the ball and in which directions?

3 Repeat the activity with the other balls.



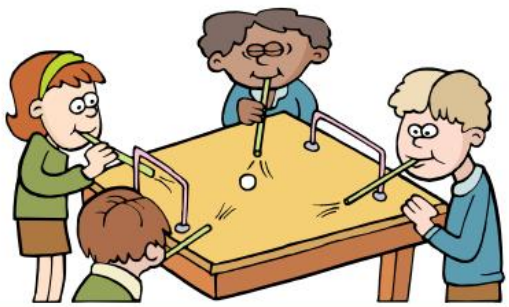
INQUIRY 5 Blowing force

You will need: table-tennis ball, packet of drinking straws, Blu-Tack

1 Use a straw to blow the ball in different directions when the ball is moving:
   - towards you
   - away from you
   - across in front of you.

2 Describe the forces acting and what happens to the ball in each situation.

3 Now play a game of straw soccer. Set up goal posts with the Blu-Tack and straws as shown. Start the game by one student blowing the ball into the centre from their corner. Take it in turns to restart the game like this whenever the ball goes off the table. Do not touch the ball with the straw, your hands or any other part of your body. The winning team is the one that has the most goals in 10 minutes.



INQUIRY 6 Electrostatic force

You will need: plastic pen or perspex rod, small pieces of paper, piece of woollen material or a woollen jumper

1. Place the small pieces of paper on the bench.
2. Rub the pen or rod with the woollen material or your jumper.
3. Bring the pen near the paper. What happens? Describe the forces acting. Does the paper need to touch the rod to stick to it? Explain.

INQUIRY 7 Gravitational force

You will need: 50 cent coin, piece of paper the same shape as the coin but slightly smaller

1. Hold the coin and paper at eye level in front of you. Drop them together.
2. What forces were acting on the coin and paper? How do these forces explain your observations?
3. Test to see if the height you drop the objects from makes any difference.
4. What do you predict will happen if you place the paper underneath the coin? Will they fall together? What do you predict will happen if you place the paper on top of the coin? Will they fall together? Test this.
5. Explain all your observations.

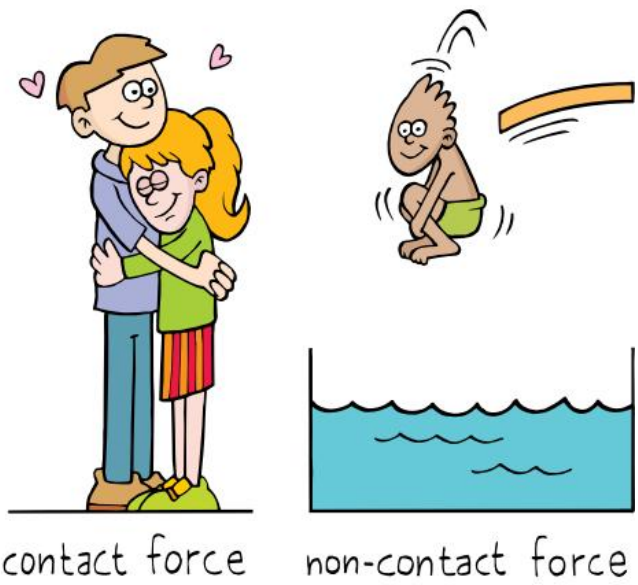
Contact and non-contact forces

There are many different types of forces. Some are touching or **contact forces**. When you push or pull something you are making contact with it. This is a contact force. When you were blowing the table-tennis ball, the air was making contact with the ball and moving it, so it was a contact force. Electrostatic, magnetic and gravitational forces are examples of **non-contact forces**.

The paper did not have to touch the rubbed pen to be pulled to it. This was an electrostatic force. The magnets did not have to touch to be pulled (attracted) or pushed away (repelled) from each other. The coin and paper did not have to touch the ground to be pulled to it by gravity.

When the coin and paper were dropped, both objects were pulled downwards by gravity. However, the force of air resistance pushed up against the paper as it fell, making it float down slowly. The air did not offer much resistance to the coin, so it was pulled downwards much more quickly.

When you tried to push the ball under water in Inquiry 4, you could feel an upwards buoyancy force acting on it. The water was pushing up against the ball as you tried to push it down. Yours was the stronger force, so you were able to push the ball to the bottom of the bucket. When you stopped holding the ball down, the forces were unbalanced. This unbalanced buoyancy force pushed the ball back up.



Over to you

1 For each of the activities that you have completed on pages 113 and 114
- **a** state what forces were acting.
- **b** state whether there was movement and why.
- **c** explain whether the forces were contact forces or non-contact forces.

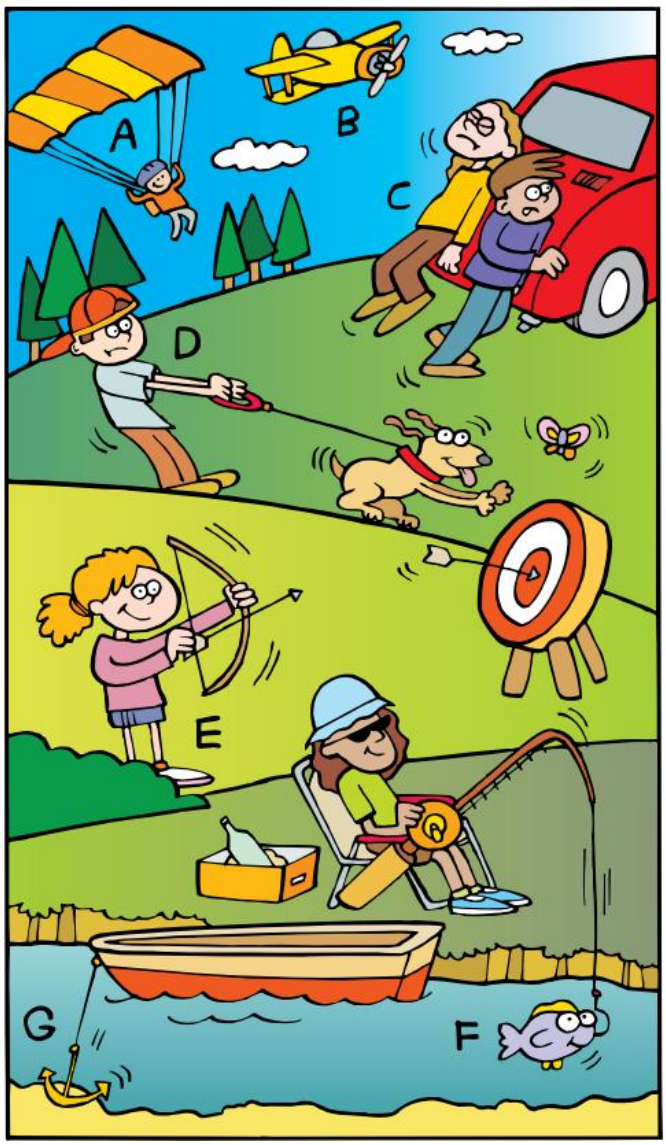
2 Give two examples (other than those presented on the previous pages) for each of these:
- **a** a pushing force
- **b** a pulling force
- **c** movement caused by gravity
- **d** a lifting force
- **e** a force where something bends
- **f** a muscular force
- **g** a frictional force.

3 Which of the following are true and which are false? Rewrite the false ones so that they are true.
- **a** Every action has an equal and opposite reaction.
- **b** Movement occurs when forces are unbalanced.
- **c** In an aeroplane, drag acts in the opposite direction to thrust.
- **d** In an aeroplane, lift acts in the opposite direction to friction.
- **e** When a shotgun is fired, the gun moves backwards because of the action force.
- **f** At any one time several forces can act on an object.

4 You want to make a hot air balloon that rises as fast as possible.
- **a** What forces must you consider?
- **b** How can you change these forces to make the balloon rise as fast as possible?

5 Give at least one example (other than the ones presented in this section) to illustrate each of the following:
- **a** A force is a push or a pull.
- **b** Different forces can act on an object at any one time.
- **c** For every action there is an equal but opposite reaction.
- **d** The speed and direction of an object can change if there are unbalanced forces.
- **e** A stationary object will not move unless the forces acting on it are unbalanced.
- **f** Forces can be contact or non-contact.

6 Look at the picture presented here.



In this picture:
- **A** a parachutist floats to Earth
- **B** a plane flies through the air
- **C** people push a car to move it
- **D** a man holds the dog and there is no movement
- **E** a girl fires arrows
- **F** a fish pulls the woman's fishing line
- **G** a boat is anchored to the bottom of the lake

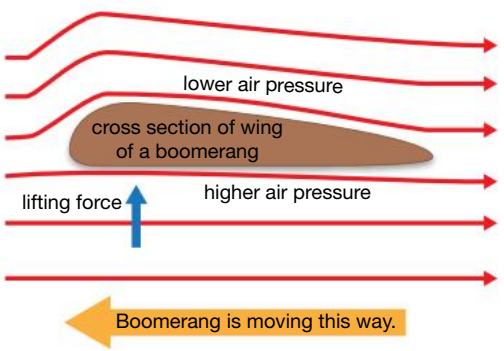
For each of the seven situations say:
- **a** what forces are acting
- **b** whether the forces are balanced or unbalanced
- **c** which forces are actions and which are reactions.

Boomerangs

Boomerangs are throwing sticks used by Australian Aboriginal people, mainly for hunting. They also have social and spiritual importance. Most Aboriginal boomerangs, used for hunting animals such as kangaroos and emus, have a hook shape. They do not return. Returning boomerangs are smaller, with a double wing shape, as shown in the photo. They were used as toys. They were also thrown above long grass in order to frighten flocks of birds into nets that were usually strung between trees. Nowadays boomerangs are popular with tourists. They are also used in international competitions.

How does a boomerang work?

A boomerang uses physics and aerodynamics during its amazing return flight. The boomerang is simply two aeroplane wings joined in the middle, like a propeller. Each wing is more curved on the top side than on the bottom, as shown below. In flight, air rushes over this wing. The air passing over the top of the wing has to travel further, so it moves faster, resulting in a lower air pressure above the wing than below it. This higher pressure underneath the wing causes a lifting force. This effect is called the *Bernoulli effect*.



INQUIRY 8 A model wing

To model how the shape of a boomerang causes lift you will need a sheet of A4 paper.

Hold the two corners of the short side of the sheet of paper, as shown. The paper will curve like the curved surface of a boomerang. Now blow hard across the top of the paper and observe what happens.

- Explain how this demonstrates lift on a boomerang.

You throw a boomerang as shown in the photo, using an arm movement a bit like in a tennis serve. The boomerang should be almost vertical as it leaves your hand with a flick of the wrist. You don't throw it horizontally like a frisbee. Because it is spinning there is more lift on the upper forward-moving half of the boomerang than on the lower backward-moving half. This puts a twisting force or torque on the boomerang. The spinning boomerang acts like a spinning top or a spinning bicycle wheel. The twisting force makes the boomerang lean to one side and turn in a circle. This is a bit like riding a bicycle with no hands on the handlebars. You can turn the bike simply by leaning to one side. The boomerang lies on its side as it circles around and returns to the thrower in a horizontal hover (if you have thrown it correctly).

- How does the shape of a boomerang help it to obtain lift when it is thrown?
- In your own words describe how a returning boomerang circles around when thrown.
- You might like to search the internet to find out how to make your own boomerang. They can even be made out of paper or cardboard.

6.2 Frictional forces

Friction is a contact force that opposes motion. It occurs when two surfaces move against each other, even if one or both surfaces are liquid or gas. Friction can be helpful. For example, on a cold day when you rub your hands together, friction produces heat that warms them up. When you strike a match on the side of a matchbox, friction produces enough heat to light the match. Friction holds knots, nails and nuts and bolts in place.

It is also friction that slows down moving objects. Stop pedalling your bicycle and it stops because of friction between the wheels and the road surface. It is also friction that makes brakes work.

Friction between the brake pad and wheel rim makes the brakes work.

Without friction between your feet and the floor you could not walk, and it would be very hard to even stay standing up. If you have ever tried to walk on ice in normal shoes, where there is little or no friction between your feet and the ice, you will understand.

Friction causes wear and tear.

Friction can also be unwanted. For example, friction in an engine can cause parts to wear out. Oil is used to make these parts slip and slide past each other easily, reducing friction.

Friction occurs because surfaces are never completely smooth. They have little bumps in them that catch on one another. Sports shoes and tyres are designed with a tread that will catch on surfaces to increase friction and prevent slipping. The rougher the surface, the more friction there is. The mass of an object also affects the friction. The heavier the object, the harder it is to start it sliding over a surface.

Friction doesn't only occur between solid surfaces. For example, there is friction between the hull of a boat and the water. The more streamlined the boat is, the less the friction and the more easily the boat slips through the water. Surfboards, speedboats and fast-swimming fish are all streamlined to reduce friction.

Friction between air and objects moving through it is called air resistance or drag. It is important because parachutes and kites rely on it to work. However, planes need to have a streamlined shape to cut through the air more smoothly. When space vehicles re-enter the Earth's atmosphere, the air causes so much friction that the outsides of these crafts heat up. They therefore need to be protected from melting by special ceramic tiles.

Reducing friction

There are four main ways to reduce friction.

1. Reduce the area of contact. For example, a rolling object has less friction than a sliding one, because the contact area is much smaller. This is why we use ball bearings in wheels, and why we can move heavy objects by putting logs under them.
2. Put a thin layer of fluid between the surfaces so that the two surfaces glide easily over each other. Lubricants such as oil and grease work this way.
3. Make the surfaces smooth. For example, knives, forks and spoons are smooth and polished so that they do not catch in your mouth. And modern car shapes are smooth so that air flows around them easily, causing less drag.
4. Reduce the weight of a sliding object. For example, you need more force to start the fifth *Harry Potter* book sliding across a table than you do for the first one!

INVESTIGATION

1 Friction on different surfaces

Aim

To examine forces on rough and smooth surfaces.

Risk assessment and planning

1 Read the investigation and draw up two data tables like the one shown on the right to record your findings.

You will be measuring forces in this practical. Forces are measured in newtons (N) using a spring balance. If your spring balance is in kg not newtons, you will need to convert your results to newtons:

1 kg is the equivalent of 9.8 N.

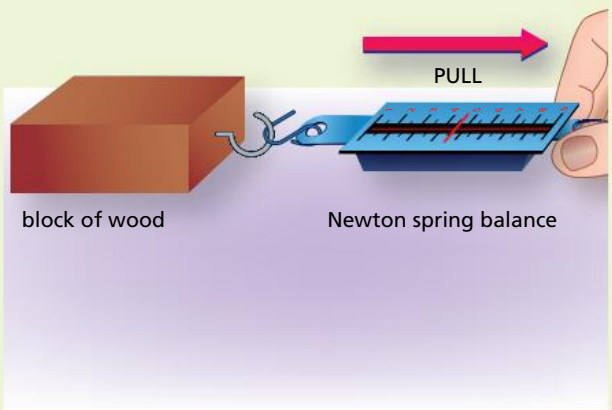
2 Look at the different surfaces you will be testing. Predict which surface will have the most friction and which surface will have the least friction by placing the surfaces in order from the one with the most friction to the one with the least.

Apparatus

- large block of hardwood with a hook
- 5-newton spring balance
- various surfaces (see table)

Method

1 Hook the spring balance onto the block as pictured below and measure the force required to *start the block moving*. It is difficult to read the spring balance when it starts to move, so it is necessary to take an average of three measurements to get more accurate results. Enter the measurements in the data table.



2 Now measure how much force is needed to *keep the block moving*. Again take an average of three trials. Enter the measurements in another copy of the data table and indicate that you are measuring the force needed to keep the block moving.

Start the block moving				
	Force needed (N)			
Surface tested	Trial 1	Trial 2	Trial 3	Average
Desk top				
Vinyl				
Carpet				
Concrete path				
Bitumen path				
Sandpaper				
Sheet of glass				
Ceramic tile				
Heatproof mat				

Results

1 Draw a column graph of your results.

2 Which surface was the hardest to get the block moving on? The easiest? Were your predictions correct?

3 Which surface was the hardest to keep the block moving on? The easiest? Are your answers different from question 2?

4 Design your own experiment to test one of the following hypotheses:

- **a** Oil, grease and rollers reduce the amount of force needed to move the block.
- **b** The greater the mass of the block, the more force is needed to start it moving.
- **c** A large area of contact between the block and the surface increases the force needed to move the block (for the same mass).

Conclusion

Summarise what you have discovered in this investigation.

Writing your report

Write your report in the usual way.

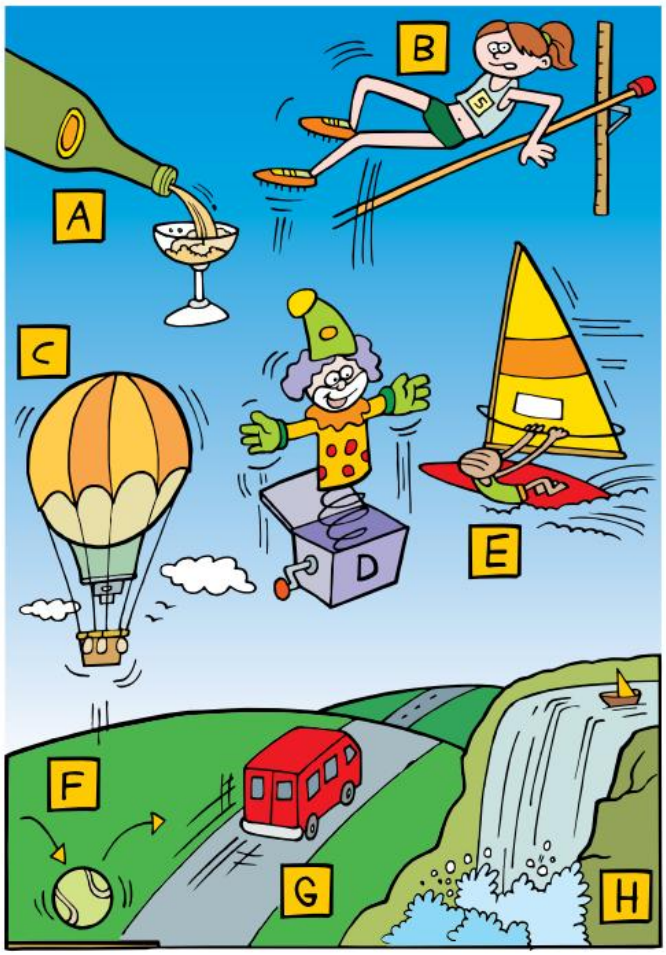
Over to you

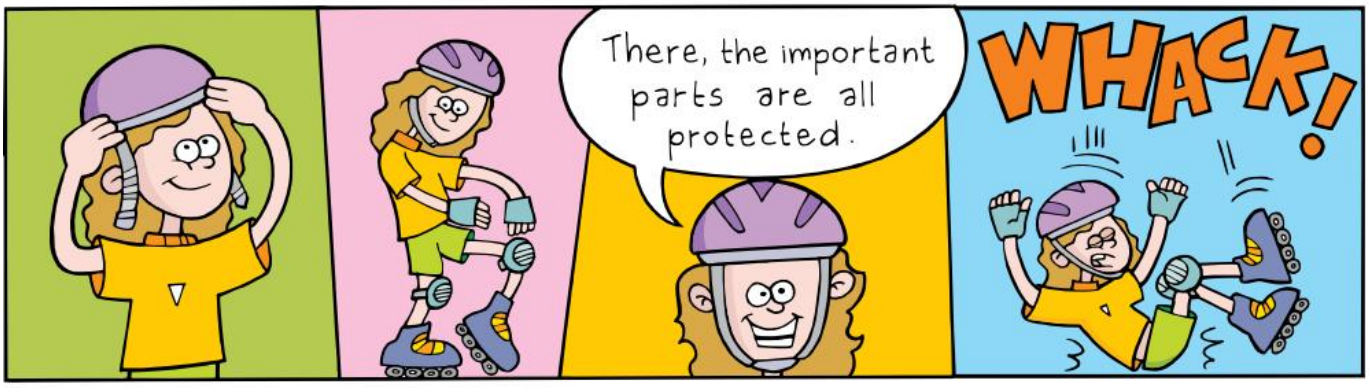
1 What effect do rough and smooth surfaces have on a bicycle and a speed boat?

2 State whether the following are true or false.
- **a** Rolling friction is greater than sliding friction.
- **b** The greater the mass of an object, the greater the force of friction between the object and the surface it rests on.
- **c** Friction can occur without movement.
- **d** If you stop pedalling a bicycle on a flat road, the only way to slow down is to put on the brakes.

3 Use your knowledge of friction to explain the following.
- **a** Ten-pin bowling lanes have smooth, polished surfaces.
- **b** Downhill skiers prefer powdered snow to ice on their course.
- **c** Bald tyres are dangerous.
- **d** Olympic swimmers wear special full-length suits to swim in.
- **e** The engine heats up when a car is driven.
- **f** Car tyres are hot after a long journey.
- **g** If you slide down a rope your hands burn.
- **h** Railway tracks are smooth and shiny.
- **i** A pool player puts chalk on the end of a cue.

4 Look at the cartoon below.
- **a** Explain what forces are acting on the skater.
- **b** How has friction been reduced?
- **c** Explain why some friction is needed to skate.





5 The pictures on the top right show friction in action. For each picture:
- **a** Name two surfaces that the force of friction is acting between.
- **b** State whether friction is useful or a nuisance.
- **c** Explain what would happen if there was suddenly no friction acting.

You may like to discuss your answers in a group.

PROBLEM SOLVING

If you are designing a hovercraft, you need as little friction as possible between the disk or lid and the bench to make your hovercraft slide easily. How are you going to reduce friction?

6.3 Gravitational forces

Have you ever wondered why if you jump up in the air you always come back to Earth? Why don't you float off into space? Why is it that if a branch falls off a tree it comes crashing down to Earth? Why doesn't it just hang in mid-air? The answer of course is **gravity**.

You, everybody and everything are being pulled to Earth by the force of gravity. It was Sir Isaac Newton in the 17th century who came to the conclusion that gravity is the force of attraction between objects, and that the size of the force depends on the mass of the objects.

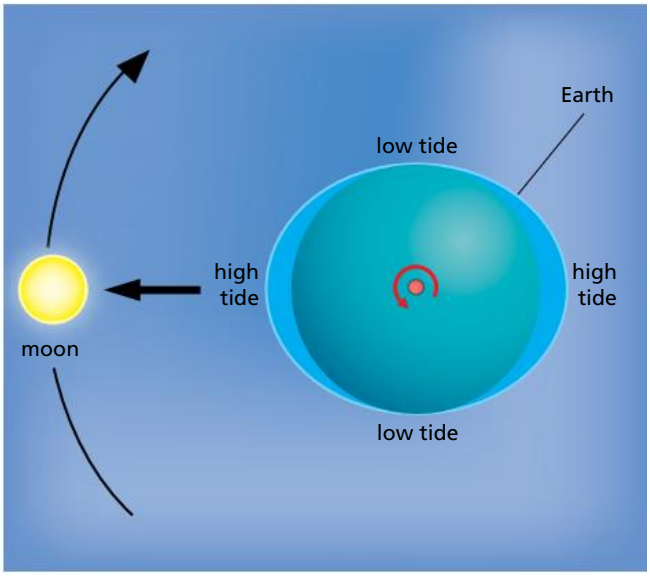
All objects are affected by the pull of the Earth, and they attract each other as well. In fact, all objects exert a force of gravity on all other objects in the universe. We do not notice that we are attracted to other people, objects and things because this gravitational force is very, very small. However, the greater the masses of the objects, the greater the force between them. You are attracted to the Earth and the Earth is attracted to you. This is why when you jump up you are pulled to Earth again. But most of the force of attraction is due to the enormous mass of the Earth. This gravitational force acts towards the centre of the Earth.

An astronaut walks with weighted boots to keep him on the moon's surface.

It is the pull of the Earth that gives us **weight** or makes us heavy. Weight is measured in *newtons* (N) because it is a force. Obviously, the more mass you have the greater your weight is going to be.

The moon has less mass than the Earth, so the moon does not attract bodies or things on it as strongly as the Earth does. Gravity is therefore less on the moon. In fact, the gravity on the moon is only one-sixth of the Earth's gravity. So if you jump on the moon, you do not come down as quickly as you do on Earth. This is why astronauts wear weighted boots to keep them on the moon's surface. Imagine what would happen if you went to a giant planet like Jupiter or Saturn, which has more gravity than Earth. What would your weight be there?

Gravitational force is a non-contact force because it exists between objects even when they are not touching. For example, there is a gravitational force between the Earth and the moon. This keeps the moon in place. It is the pull of the moon that gives us tides.



Satellites are kept in orbit around the Earth because of gravity, and the Earth is kept in orbit around the sun by the same force. In fact, all the planets orbit the sun because of gravity. Gravitational forces also act over the huge distances of space, for example between stars and between galaxies.

INVESTIGATION

2 Gravity and springs

Aim

To investigate whether the extension or stretch of a spring increases as the mass stretching it increases.

Risk assessment and planning

1 How should you correctly handle the masses and springs?

2 Draw up a table to record your results. Your two column headings will be *Load in grams* and *Extension of spring in cm*.

Apparatus

- sheet of A4 card
- spring
- a mass hanger and masses
- retort stand and clamp
- graph paper

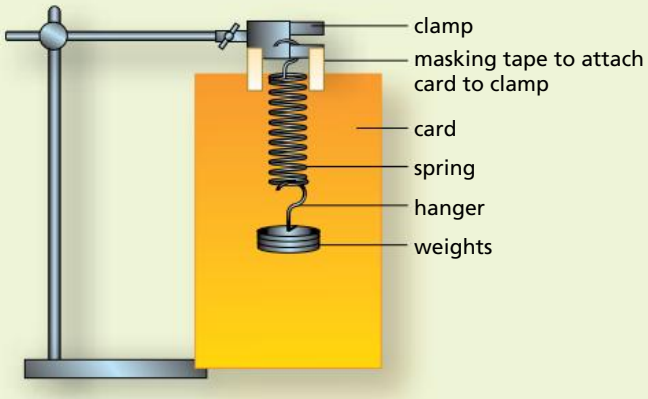
Method

1 Set up the apparatus as shown on the right.

2 On the card, mark where the end of the spring is with the hanger attached but no masses on it.

3 Put a 50 g mass on the hanger. Mark where the spring extends to now.

4 Keep adding 50 g masses and mark where the spring extends to each time.



Results

Draw a graph of your results. The *x*-axis will be load in grams and the *y*-axis will be the extension of the spring in cm.

Conclusion

What happens to the extension of a spring as the mass increases? Explain your observations.

SCIENTISTS AT WORK

Sir Isaac Newton (1642–1727)

When the name Isaac Newton is mentioned people think of gravity. In 1665, fable suggests that while resting under an apple tree on his family's farm in England, he was almost hit by a falling apple. He questioned why the apple fell out of the tree. Did the Earth pull the apple? And does the Earth pull other bodies like the moon? Thus Newton began to develop his theories about motion and forces. He was 23 years old.

The story of Newton's life is an interesting one. At school, Newton was often beaten up by the school bully—the brightest boy in the class. The story goes that Newton grew tired of being picked on and worked hard to become top of the class. He excelled in mathematics, and so at the age of 18 he was sent to Cambridge University to further study this subject. At 27 he became professor of mathematics.

Newton calculated the orbits of planets around the sun and showed that a force of attraction, gravity, held the planets in position. In 1687 he published his theories in a book with the Latin title *Philosophiae Naturalis Principia Mathematica* or *The Mathematical Principles of Natural Philosophy*. In this publication he answered mathematical questions about the motions of everything, including the planets. Newton put forward three laws of motion.

1. A body at rest remains at rest unless acted on by an outside force. And a body in motion remains in motion at a constant speed unless acted on by an outside force.
2. A body affected by an outside force will accelerate in the direction of that force. A large force will produce a large acceleration. The mass of the body will also affect the acceleration.
3. A force exerted by object A on object B is equal in size but opposite in direction to a force exerted by object B on object A. This is sometimes stated as 'For every action there is an equal and opposite reaction'.

Newton was able to work out the masses of the Earth, Jupiter and Saturn. He showed how gravity could keep a satellite in orbit around the Earth, over 200 years before satellites were launched. He demonstrated that light could be split by a prism into different colours and that these colours could be recombined to make white light. He also discovered that a curved mirror instead of a lens in a telescope gave a clearer view of a star or planet.

Newton died in London in 1727, aged 85. His theories changed our thinking about science.

Newton showing how light can be split into a rainbow of colours using a prism

Over to you

1. Which of the following statements are true and which are false? Rewrite the false ones so that they are true.
   - **a** All objects are pulled to Earth by the force of gravity.
   - **b** Gravity is the force of attraction between objects, and the size of this force is not affected by the masses of the objects.
   - **c** We have weight because gravity pulls us to the Earth and makes us heavy.
   - **d** The gravity on the moon is only half that on Earth.
   - **e** Our weight would not change if we were able to visit Jupiter or Saturn.
   - **f** Gravitational force is a contact force.
   - **g** Gravitational force can act over the huge distances of space.
2. The table here shows the gravity of the planets compared with Earth.

Place	Gravity (compared with Earth)
Mercury	0.4
Venus	0.9
Earth	1
outer space	0
moon	0.2
Mars	0.4
Jupiter	2.4
Saturn	0.9
Uranus	0.9
Neptune	1.1

   - **a** On which planet would you weigh the most? The least?
   - **b** On which planet would your weight be similar to what it is on Earth?
   - **c** On which planet would your mass change?
3. Explain how the story of Newton shows that if you really want to do something you can.
4. Name five ways that Newton changed our thinking in science.
5. Explain in your own words the difference between mass and weight.

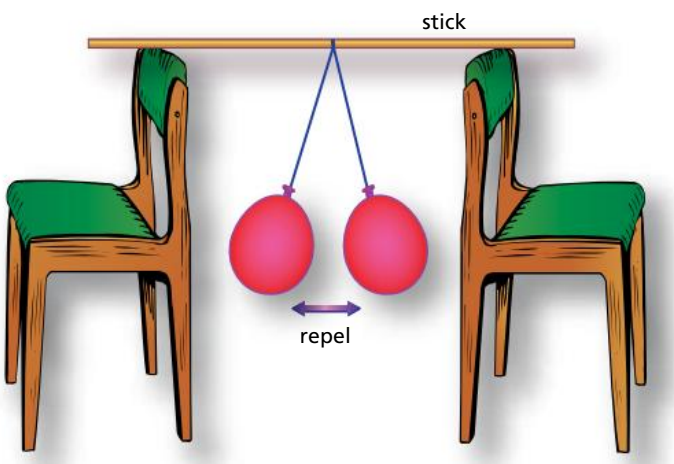
6.4 Electrostatic forces

Have you ever walked across a nylon carpet then touched something metallic and felt a tingle? Or hopped out of a car and touched the metal door handle only to be zapped? These things happen because of electric charges. When objects are rubbed together, the friction between them can cause the build-up of electric charge. This build-up of charge is called **static electricity** because the charge remains stationary.

The build-up of static electricity results in electrostatic forces between objects. These are non-contact forces and can affect objects from a distance. There is an invisible area around charged objects called a field. Anything entering this field is affected.

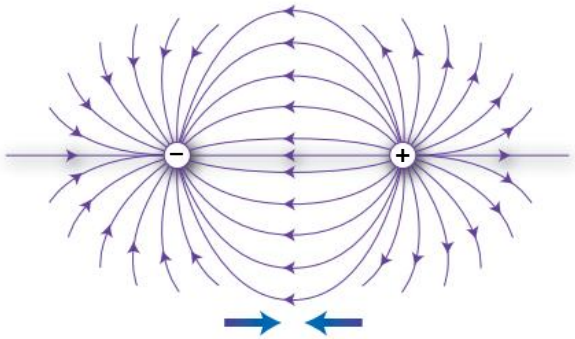
Charged objects behave in certain ways when they are brought together. Earlier in this chapter you observed that a rubbed rod attracted small pieces of paper to it. The rod was charged and the paper was uncharged, *so charged objects can attract uncharged objects*.

If two balloons are both rubbed with the same cloth or charged in the same way and brought together, they don't attract each other. Instead, they push one another away. *So objects that have the same charge repel each other*.



both balloons rubbed in the same way

The attraction and repulsion of charged objects can be explained in terms of the electric field around them. The diagram top right represents how *unlike charges are attracted*.



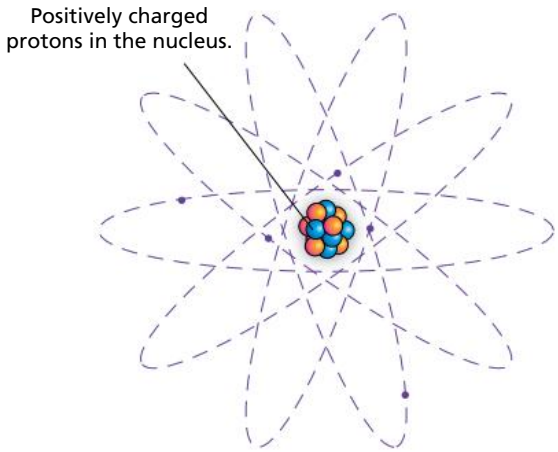
attraction

Objects entering this field behave differently, depending on whether they have a charge and what sort of charge it is. Positively charged objects would be pushed away from the positively charged object and pulled towards the negatively charged object, as the arrows in the force field show.

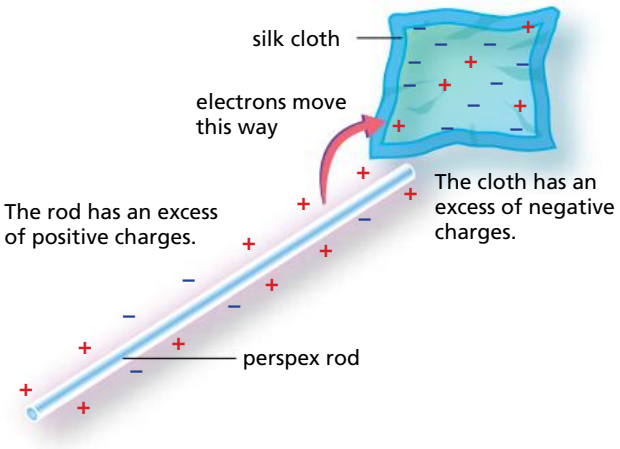
An American scientist, Benjamin Franklin, was able to successfully explain the charging of an object by rubbing. He used the words positive and negative instead of charged and uncharged. Using Franklin's idea:

1. Positively charged objects attract negatively charged objects. In other words, unlike charges attract.
2. Positively charged objects repel other positively charged objects, and negatively charged objects repel other negatively charged objects. So like charges repel.

Franklin was not able to explain how objects became positive or negative. Today scientists can. All material or matter is made up of atoms. These atoms contain electrons (which have a negative charge) and protons (which have a positive charge).



When you rub a perspex rod with a silk cloth, the rubbing causes electrons to move away from the atoms on the rod, leaving positive protons behind. As the rod loses electrons it becomes positively charged. The silk gains the electrons and becomes negatively charged because it has more electrons than it started with.



A different cloth may *give* electrons to the rod, making it negatively charged. The cloth will then have a positive charge.

There are everyday situations where the effects of electrostatic forces can be observed. Positive and negative charges can build up in thunderclouds. If these charges become large enough electrons can suddenly move from one part of the cloud to another, or to the ground, causing a spark that heats the air and causes lightning.

Photocopiers rely on negative and positive charges to produce an image. The paper is positively charged and the toner is negatively charged. The toner is therefore attracted to the positive paper, forming an image.

Electrostatic charges can cause problems. In operating theatres and at petrol pumps electrostatic sparks can ignite the gases in the air. Care is therefore taken to make sure that all equipment is 'earthed'. This is done by giving the static electricity a path to the ground, so that it leaks away and does not build up and cause problems.

INVESTIGATION

3 Electric charges

Aim

To investigate electric charges.

Risk assessment and planning

What safety rules should you keep in mind when you are handling a Van de Graaff machine?

PART A

Apparatus

- 2 balloons and string

Method

1. Blow up and tie a balloon.
2. Rub the balloon on a woollen jumper or cloth. Hold the balloon against the wall, then let it go. What happens?
3. Charge the second balloon in the same way. What happens when you hang the two charged balloons close together?
4. Charge a balloon and hold it just above your hair. What happens? (You need fine, wispy, very clean hair.)
5. Your teacher may demonstrate how to use a Van de Graaff machine (see photo).

PART B

Apparatus

- plastic rod and piece of wool

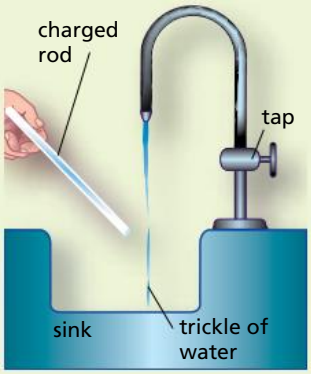
Method

1. Rub the rod with the piece of wool. Then bring the charged rod close to a thin stream of water as shown on the next page.

INVESTIGATION

3 Electric charges

2 Record your observations.



PART C

Apparatus

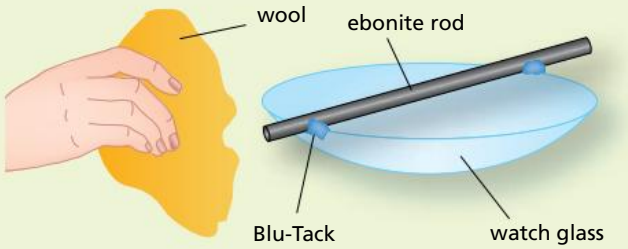
- 2 perspex rods
- piece of wool or fur
- watch glass
- 2 ebonite rods
- piece of silk
- Blu-Tack

Method

1 Rub a black ebonite rod with wool, set it on the watch glass as shown top right, and then bring a piece of wool close to one end of the rod.

2 Record what happens.

3 Repeat this using the perspex rod and the silk. Record what happens.



4 Using only the apparatus you have been provided with, design an experiment to test the following hypotheses:

a Two identical rods charged in the same way (with the same material) will repel one another.

b Two identical rods charged in different ways (with different materials) will attract one another.

c Two different rods charged in the same way (with the same material) will attract one another.

Results

1 Which parts of this investigation show you unlike charges attracting? Like charges repelling? A charged object attracting an uncharged one? Explain.

2 Try to explain each part using positive and negative charges.

3 Which parts show evidence of an electric field? Explain.

Over to you

1 Explain the following using what you have learnt in this section.

a Rubbing your feet on a nylon carpet and then touching something metallic gives you a tingle.

b Touching the metal door handle of a car after it has been moving may give you a zap.

c Nylon items in a clothes dryer crackle when you pull them apart.

d The hair on your hands and arms may stand up when brought close to a TV screen when the TV is on.

e Churches with very large steeples have a metal rod inside them which is connected to the ground.

f Electrical items become dustier than other objects around the house.

2 Explain what an electric field is. Draw a picture of what you think this field would look like around:

a a charged object

b two objects with the same charge

c two objects with different charges.

The diagram on page 123 will help you.

3 Give an example of where static electricity is useful and two examples of where it is a nuisance.

4 Benjamin Franklin used the terms positive and negative instead of charged and uncharged, but he could not explain how objects became positive and negative. Imagine you are talking to Franklin. What would you tell him now?

5 When a perspex rod is rubbed with wool and brought near pieces of paper, the paper is attracted to the wool. Explain why this happens using these words: charged, uncharged, positive, negative, electrons, attract, move.

6.5 Magnetic forces

A magnet can push or pull objects near it, even without touching them. So a magnetic force is a non-contact force. This force is strongest near the magnet and becomes weaker the further away from the magnet an object is moved.

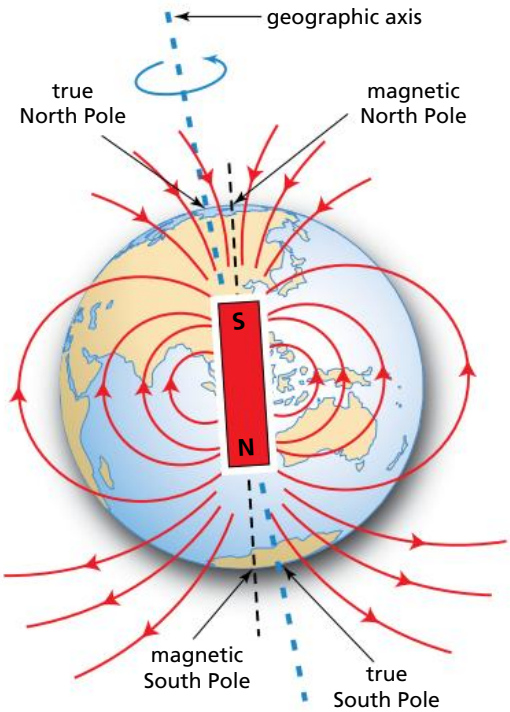
Magnets attract only certain metals—iron, cobalt and nickel. These materials are said to be magnetic. Steel, being an alloy of iron, is also magnetic. Only magnetic materials can be magnetised or made into magnets.

The magnetism of a magnet is concentrated in the ends or **poles**. If you suspend a magnet it will always point north-south. The end that points north is called the north pole. The other end is the south pole. If you bring two magnets together, two north poles will repel one another, and so will two south poles. *So like poles repel.* However, if you bring the north pole of one magnet near the south pole of another they will attract. *So unlike poles attract.*

Magnets do not have to touch for the force of attraction or repulsion to be felt. They have an invisible **magnetic field** around them and any magnetic material in this field will be affected. For example, cupboard doors often have magnetic catches that pull the door shut when the door gets close to the magnet on the cupboard. The door closes because of the magnetic field around the catch. The closer to the magnet the material gets, the stronger the force. Non-magnetic materials are not affected.

A compass needle will always line up in a north-south position. For hundreds of years no one could explain why. Then in 1600, Sir William Gilbert suggested that the Earth behaved as if it had a giant imaginary magnet inside it, surrounded by its own magnetic field. Since the north pole of a compass needle points to the North Pole of the Earth, he inferred that the magnet inside the Earth must be upside down. He also suggested that the magnetic poles of the Earth are not in exactly the same place as the geographic poles of the Earth. So the imaginary magnet must be slightly tilted too, as shown top right.

The Earth's magnetism has other effects as well. It helps trap invisible charged particles in a layer around the Earth known as the ionosphere (eye-ON-os-fear). Radio signals can be bounced off this layer and sent around the world.



The Earth's magnetic field. The north end of a compass needle points in the direction of the arrows on the lines.

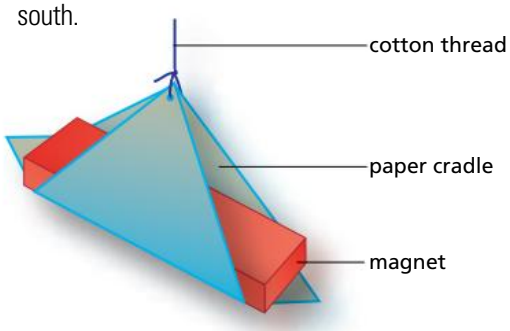
Charged particles from the sun move towards the poles because they are attracted by the Earth's magnetic field. In the process, coloured lights called auroras are produced around the North Pole and South Pole.

The Aurora Australis *in Antarctica*

INQUIRY 9 Investigating magnets

You will need: bar magnet, horseshoe magnet, box of paperclips or pins, paper, retort stand, cotton thread

1 As a group test the following hypotheses.
   - **a** A magnetic force is a non-contact force.
   - **b** The magnetism of a magnet is concentrated at the poles.
   - **c** Like poles of a magnet always repel and unlike poles always attract, no matter what the size and shape of the magnet.
   - **d** A suspended magnet will always line up north-south.



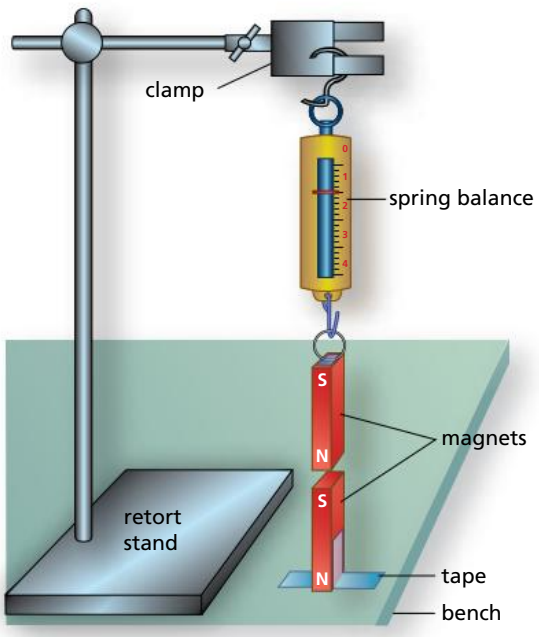
   - **e** The magnetic force becomes weaker the further an object is moved from the magnet.
   - **f** One magnet can be 'floated' on top of another.

2 Explain what you did and what you found out.

INQUIRY 10 The strength of magnets

1 Design an activity to measure the strength of a variety of different magnets. The diagram may give you a clue. Remember to control variables.

2 Explain what you did and what you found.



INQUIRY 11 Can you see a magnetic field?

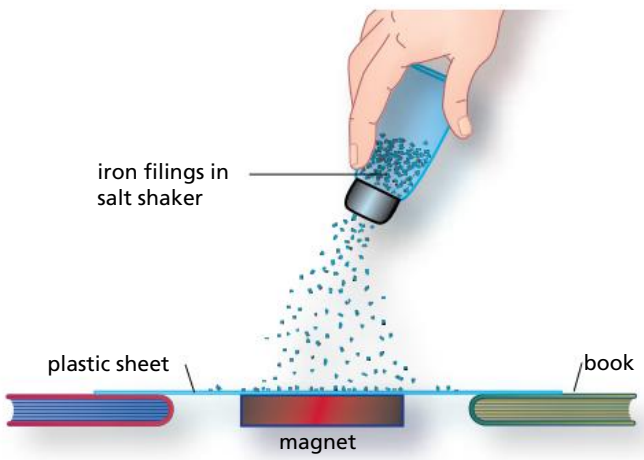
You will need: different sized and shaped magnets, overhead transparency sheet, iron filings in a salt shaker

1 Using the equipment provided, find out what the magnetic field of a bar magnet looks like.

2 Draw diagrams and explain your findings for each of the magnets you test.

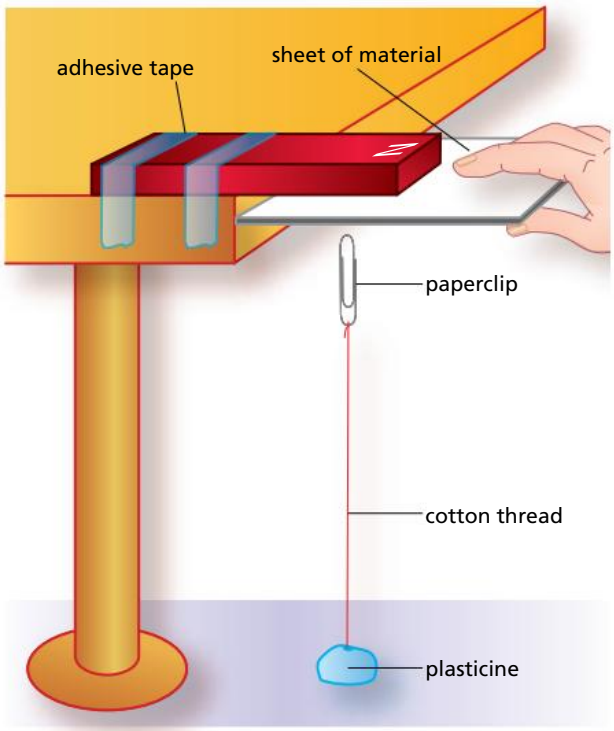
3 Predict what the magnetic field pattern will look like for:
   - **a** two magnets with like poles together
   - **b** two magnets with unlike poles together
   - **c** a magnet near a piece of iron or steel
   - **d** different sized and shaped magnets.

4 Test your predictions and explain your observations.



INQUIRY 12 Blocking magnetic fields

1 Set up the following apparatus.

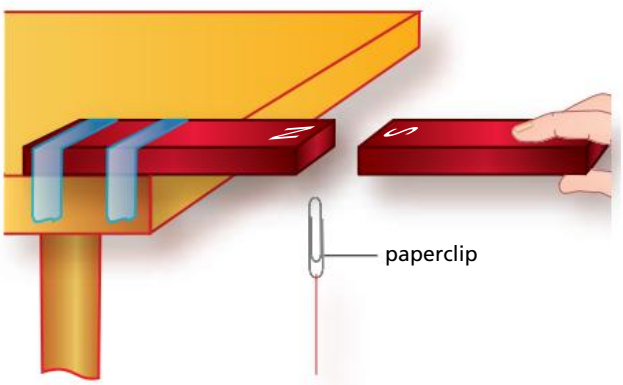


2 Test different materials to see which materials block the magnetic field.

3 Look at the diagram below. Predict what will happen to the paper clip when you bring a second magnet close to the magnet fixed to the bench.

4 Will it make a difference which pole of the second magnet you bring up to the fixed magnet?

5 Test your predictions and explain your observations.



Over to you

1 Which of the following are true and which are false? Rewrite the false ones so that they are true.

a A magnet is strongest at its poles.

b All metal objects are affected by magnets.

c Not all magnets have a magnetic field around them.

d The effect of a magnet decreases the closer an object is to the magnet.

e The imaginary magnet in the Earth has its north pole towards the North Pole.

f Two south poles together will attract.

g A north and a south pole together will attract.

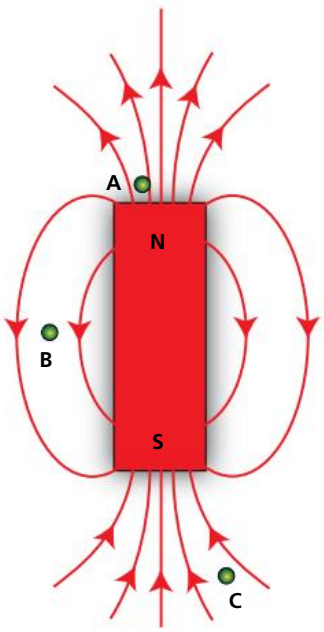
2 A student was asked to place three steel ball bearings next to a magnet so that:

a one would be strongly attracted to a pole of the magnet

b one would be weakly attracted to a pole

c one would be attracted equally by both poles.

Looking at the diagram here, which ball bearing was which?



3 Two magnets were placed end to end and they repelled one another. If they were both turned around so that their opposite ends were now facing one another, what would happen? Explain your prediction.

4 Karen was testing materials to see which metals were affected by a magnetic field. Which of the following metals do you think were *unaffected*?

aluminium, brass, steel, copper, iron, nickel

Explain your answer.

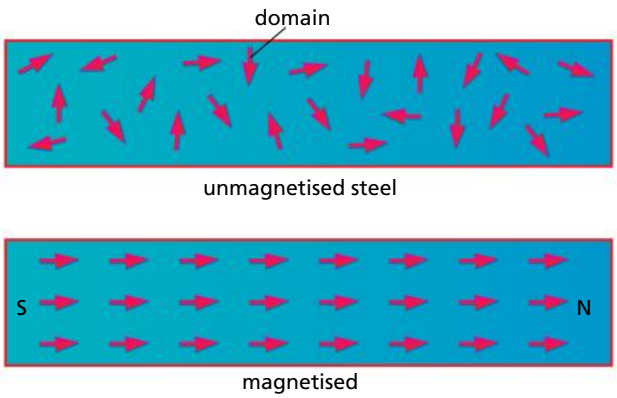
SKILL

Using a model

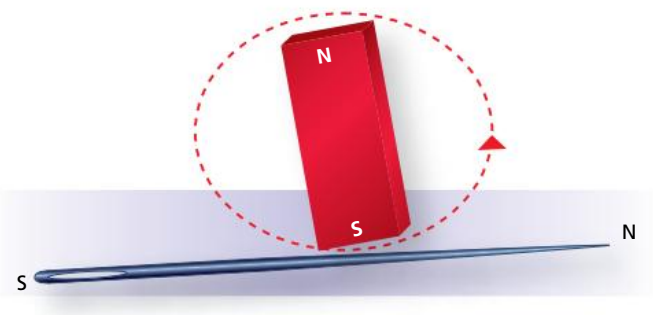
Mention the word 'model' and you might think of building a miniature copy of something like a boat, a castle or a plane. However in science, a **model** is a theory or idea that is used to explain our observations. The model is an example or a representation of what we think something is like. Any observations or findings that are made can then be compared to the model. In Chapter 12 you will use models of the Earth, moon and sun to help you understand day and night, the seasons, moon phases and eclipses.

Scientists have also developed a model to explain magnetism. If you could look inside a piece of steel or a magnet it would be made of small sections or regions called *domains*.

In an unmagnetised piece of steel, the domains all point in different directions so there is no overall magnetic effect.



To magnetise a piece of steel, e.g. a needle or a hacksaw blade, all the domains must be made to point in the one direction. One way to do this is to stroke the piece of steel with a magnet in one direction many times. The more domains there are lined up, the stronger the magnet will be.



1 What is a model? What is the model that scientists use to explain magnetism?

2 Explain what domains are. How are they arranged in a magnet?

3 How can the domains be made to point in the same direction?

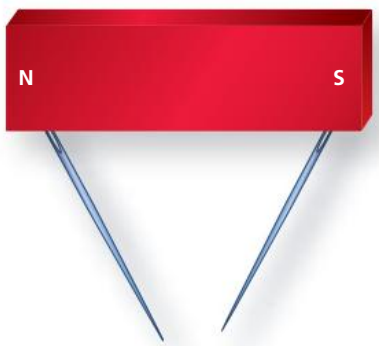
4 How can a magnet be made stronger?

5 What would you predict would happen if you magnetised a piece of metal and then cut it in half?

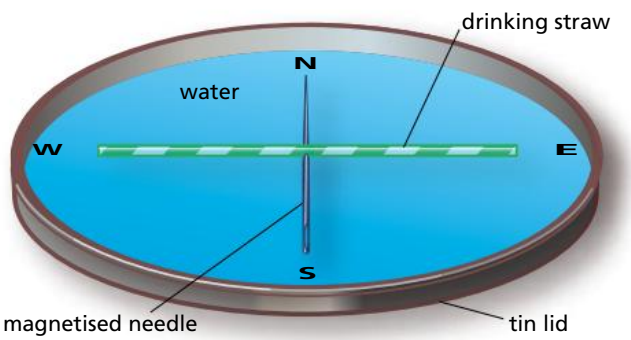
6 Can the domain model explain why repeatedly banging the seals of a magnetised cupboard door weakens them? How?

7 If you keep stroking a needle with a magnet, can you make it more and more magnetic? Explain using domains.

8 A student magnetised two needles and they were attracted to a magnet as shown. Did the student magnetise the needles in the same way? Explain your answer.



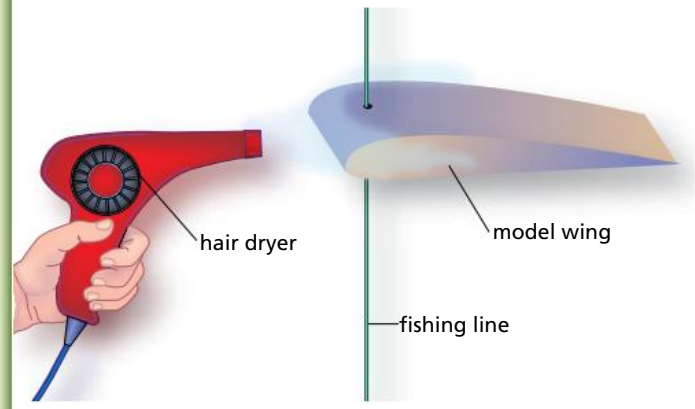
9 Explain how you could make your own compass. This picture may give you a clue.



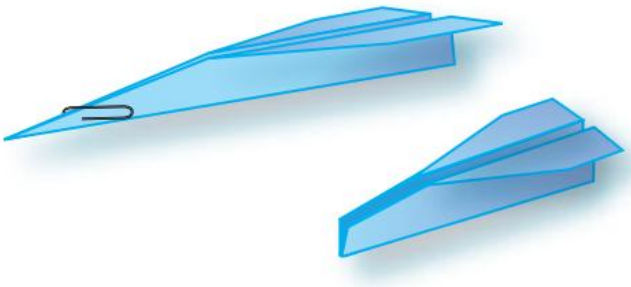
10 Heating a magnet destroys its magnetism. Why do you think this happens?

THINKING SKILLS

1 Design a model to investigate how differently shaped wings create lift. Make sure the wing can move up and down the fishing line. Then use a hairdryer to see how well the wing lifts.

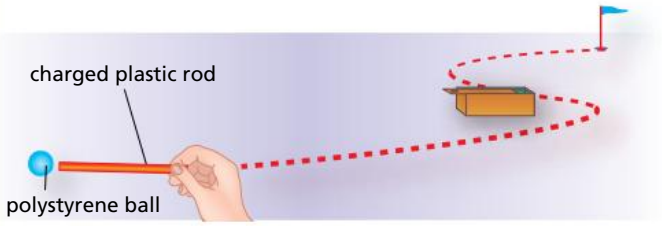


2 Build model planes. Test them to see which flies the furthest. Hold a class competition.

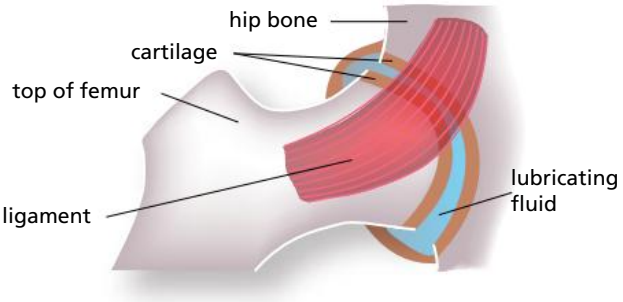


3 For an object to float in water the forces must be balanced. Try to make plasticine float on water. You can choose any shape you like, but you must use all of the plasticine you are given.

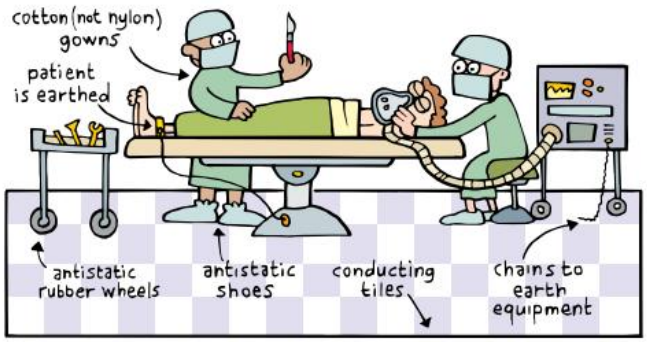
4 Design two different games to show that magnetism and electrostatics involve non-contact forces.



5 Investigate how joints are designed to reduce friction. Find out about arthritis and what happens when a joint doesn't work correctly.



6 The picture below shows an operating theatre. Explain how the parts pictured prevent the build-up of static electricity.



7 It is difficult to separate an individual plastic bag from a bundle of plastic bags.

a Explain why the bags stick together.

b Design an experiment to show how the bags stick to one another.

c Work out a solution to the problem.

8 Design an experiment to show which carpet is the best to use in shops where metal display counters often cause problems for customers wearing rubber-soled shoes.

9 What do you predict will happen if you bring a charged rod near the thin stream of smoke from an incense burner? Test your prediction and explain your findings.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 A force is a push or a _____. Forces can start or stop objects moving or slow them down.

2 There are different types of forces. Some forces like friction are touching or _____ forces. Electrostatic, _____ and gravitational forces are examples of non-contact forces.

3 _____ is a force which opposes motion. It occurs between two surfaces.

4 Movement occurs when forces are _____.

5 Action forces in one direction cause _____ forces in the other direction.

6 _____ is the amount of matter in an object. It is the pull of the Earth on this mass that gives us _____ which is measured in _____ (N) because it is a force.

contact
friction
magnetic
mass
newtons
pull
reaction
unbalanced
weight

Self-management

Read the following article and answer the questions below.

The first compass

The ancient Chinese believed that magnetism was a magical, invisible force. They were the first to invent the magnetic compass in the first century AD. It was called a 'south-pointing spoon' and was used to determine where buildings and important sites should be positioned. The Chinese believed that the Earth had natural lines running through it and that buildings should be positioned according to these lines. So the 'spoon' was used by fortune tellers to point out lucky sites. The spoon contained a piece of lodestone, a naturally occurring magnetic rock that was affected by the Earth's magnetic field. The spoon spun on a highly polished plate when affected by the Earth's magnetism. It was 1000 years later, in the 12th century, that the Chinese actually used a magnetic compass for navigation.

1 What are forces and which force is discussed here?

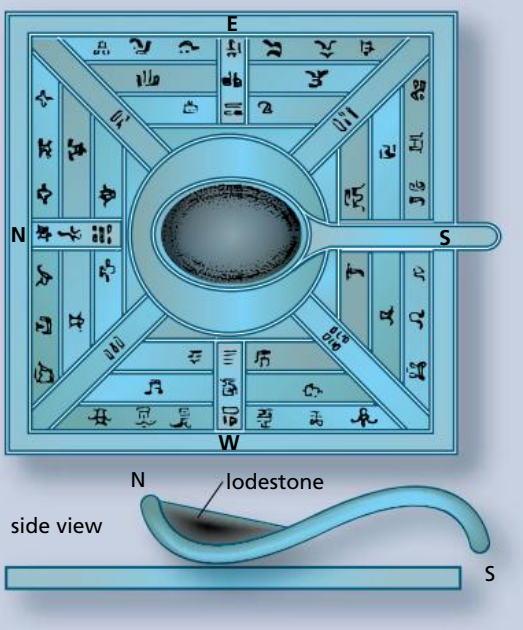
2 Why was this compass called the 'south-pointing spoon'?

3 Explain from your work in this chapter how you think the Chinese compass worked.

4 What model presented in this chapter would explain why the spoon was magnetic?

5 Does the spoon work using contact or non-contact forces? Explain what these are in your answer and give examples.

6 Is the spoon affected by any other forces? Explain your answer.



Chinese south-pointing spoon

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Copy and complete the following.

a A force is a _____ or a _____.

b Forces can act in different _____.

c There is movement when the forces are _____.

d _____ forces in one direction cause _____ forces in the opposite direction.

2 Explain using examples how contact forces are different from non-contact forces.

3 State whether the following are true or false and rewrite the false ones so that they are true.

a Friction opposes motion.

b Thrust is due to friction with the air.

c Rolling friction and sliding friction are the same.

d Oil, grease and streamlining will increase friction.

e Friction is a wanted force when striking a match.

f Friction is an unwanted force when tying a knot.

4 Explain why your hair sometimes sticks to a plastic comb when you comb your hair.

5 Ashleigh does not believe that there is a magnetic field around a magnet. What could you do to convince her that a field does exist?

6 Look at the cartoon below.

a What force is involved in the cartoon?

b Explain why this force is something that 'you can count on'.

c Who first explained this force?

d Explain how this force affects all bodies on Earth and in space.

7 Explain what each of the following are and give an example.

a friction

b static electricity

c magnetism

d gravity

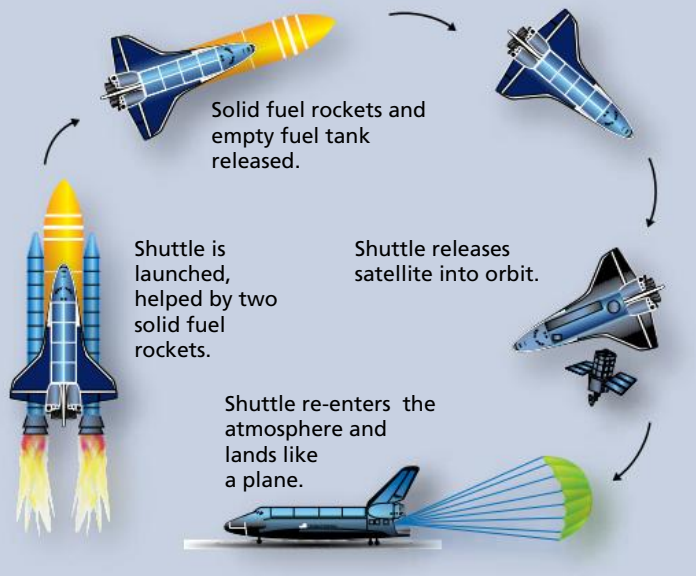
8 Look at the pictures of the flight of a space shuttle.

a Name the forces that would be acting on the shuttle as it is launched. Which is the strongest force? How do you know?

b What features of the shuttle help it escape the Earth's gravity? Explain.

c Name the forces that would be acting on the shuttle as it re-enters the Earth's atmosphere. Which is the strongest force? How do you know?

d Name the forces that would be acting on the shuttle as it lands. Which is the strongest force? How do you know?



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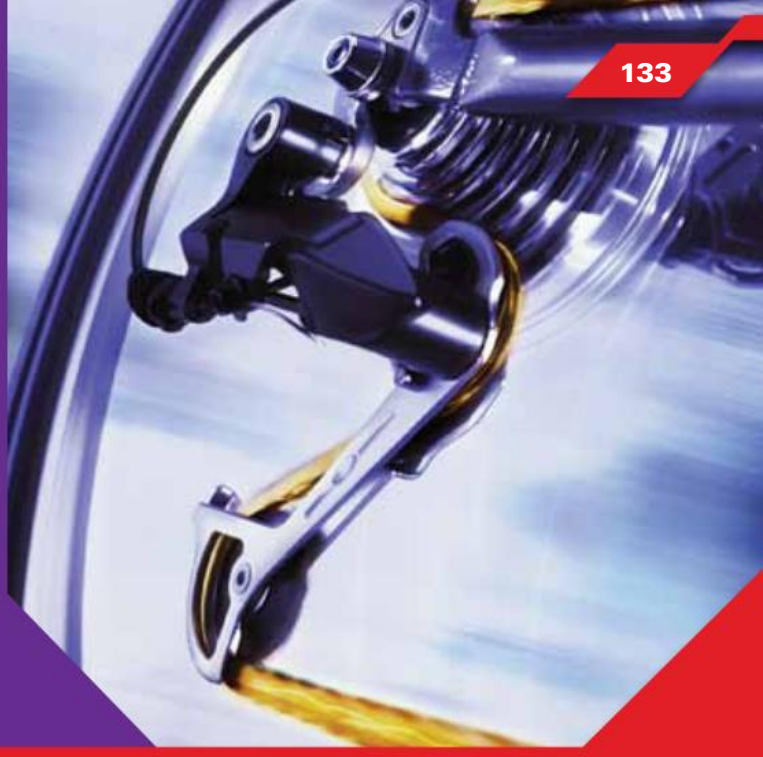


Simple machines

PROBLEM SOLVING

Building a gadget

Choose a non-electrical, everyday gadget in your home to examine. You could look at a hand-held eggbeater, food tongs, stapler, corkscrew or bicycle. For the gadget you choose:

a Identify all the simple machines that are part of the gadget, e.g. gears, levers, pulleys.

b Describe what each part or simple machine does.

c What is the advantage of having each simple machine in your gadget?

d Construct a model to demonstrate how your gadget works.

e Show how the model produces a mechanical advantage. How does the effort needed compare to the load? Do you require a lot of effort to work the machine?

Some of these questions will of course be difficult to answer until you have completed the chapter.

Focus for learning

If you were asked which machines you had used today you might list a car, radio, television or computer. But have you used a pair of scissors, stapler, can-opener or knife? Have you gone up a slope or a ramp? Have you opened a door handle or latch on a window? If you have then, you have used simple machines. In fact we use these machines every day to make our lives easier.

The bicycle system

A bicycle is an amazing machine because it uses far less energy than a car and it is much more energy efficient. Pedalling a bicycle requires only as much energy as walking, but because a bicycle gets you where you want to go three times faster, you only use a third of the energy it would take to walk the same distance. It is also pollution-free.

A bicycle is a **system** of several different machines that work together as a whole. There are gears, wheels-and-axles, and levers too! The pedals are connected to a crank (a lever with a pedal attached). The crank is connected to the chain wheel. When you push down on a pedal, this turns the chain wheel. As the chain wheel turns, it turns the rear wheel and you move forward.

The amount of force you have to use to pedal or move the bicycle is called the **effort**. The **load** is what the machine has to lift or move. Your weight and the weight of the bicycle, friction from the road, bicycle parts moving together, and air resistance as you move through the air together make up the load of the machine.

LITERACY FOCUS

driven gear	inclined plane	pivot	transformation
driving gear	kilogram	pulley	wedge
effort	lever	screw	wheel-and-axle
fulcrum	load	simple machine	wheelbarrow
gear wheel	mechanical advantage	spring balance	work

By the end of this chapter you will be able to …

Science Understanding

- give examples of how a machine can magnify the force you use, change the direction of the force, speed things up or transform energy
- give examples of different types of levers and pulleys in everyday devices

Science as a Human Endeavour

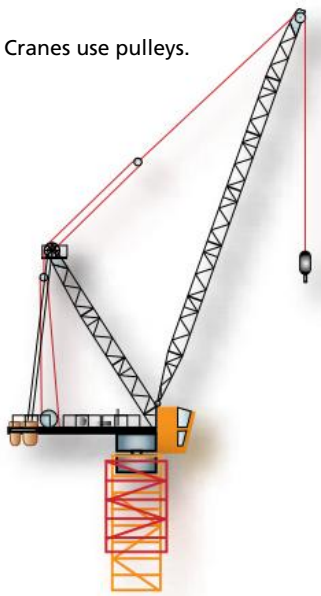
- discuss the woomera as an example of Aboriginal technology
- appreciate the contributions made by Archimedes to scientific knowledge, engineering and technology

Science Inquiry Skills

- work in a group to make an everyday gadget and explain how it uses simple machines
- conduct investigations into the mechanical advantage of levers, pulleys and bicycle gears

7.1 What is a machine?

A machine is anything that helps you do things more easily. The most common **simple machines** are levers, pulleys, inclined planes (ramps), screws and gears. Complex machines such as cranes, winches, clocks and bicycles contain many simple machines.



Cranes use pulleys.

Clocks have gear wheels inside.

Planes have wheels and axles.

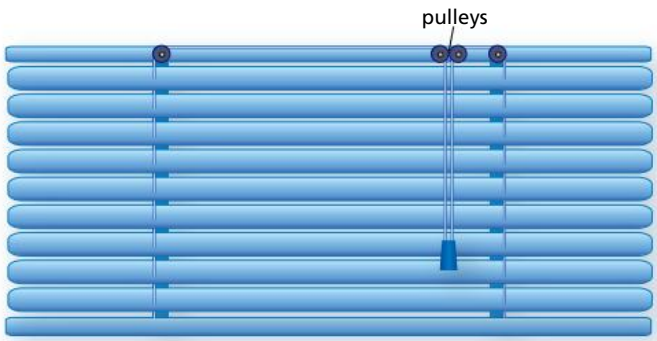
There are four ways simple machines help us do things more easily.

1 Machines can magnify the force you use

Think of a can-opener where you usually turn a big knob, handle or wheel. The effort you put into turning the handle or wheel moves a smaller wheel which in turn moves a circular blade that pierces and slices open the can as it moves. You are turning a large wheel or knob and this requires much less effort than turning the little wheel by itself. In this way the can opener has magnified the force you use. In other words, you have a greater force for less effort. When a machine does this it gives the user a *force advantage*.

2 Machines can change the direction of the force

When you pull the cord on a venetian blind at a window, the cord is attached to a pulley wheel. From the pulley, the cord then threads through the slats of the blind. You pull the cord down and the slats of the blind go up. The pulley has changed the direction of the force. It is much easier to pull something down than to push and hold something up. So the pulley helps you move the blind.



3 Machines can speed things up

When you ride a bicycle and push down on the pedals, the pedals don't turn as fast as the back wheel does. A few turns of the pedals can make you go very fast. A machine like the bicycle that does this is said to have a *speed advantage* or a *distance advantage*. The higher the gear you use, the faster you go and the more distance you cover.

To go up a hill you put a bicycle into low gear, so that less effort is needed to move the load (you and the bike) up the hill. The bicycle in this case gives you a *force advantage*.

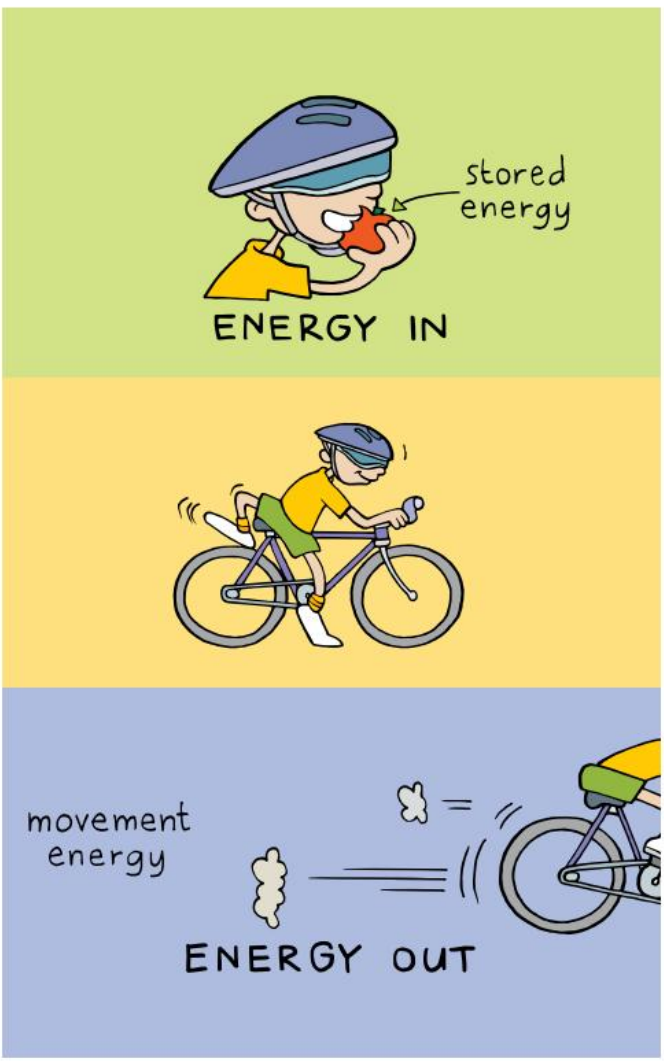
A machine like a bicycle can give you a speed–distance advantage or a force advantage, but not both. You can't have the bicycle in low and high gear at the same time.

4 Machines can transform energy

You do work when you use a force to move something. Energy is the ability to do work. In most simple machines, like a can opener, you are applying a force to move the machine. So you are doing work or providing the energy to get the machine working. Machines reduce the amount of work or effort required to get a job done.

Machines are energy transformers. They take the initial or starting energy and transform or change it into a different form. Let's look at a television set. The starting energy is electrical energy. This is transformed to light and sound in the television set, and also heat.

If you are playing hockey, your body is the energy transformer. The stored energy in the food you eat is transferred to your muscles, where respiration occurs and energy is made. This energy is then changed to kinetic energy in your legs and arms when you move. This energy is also changed to heat that makes your body warm because your muscles are working.

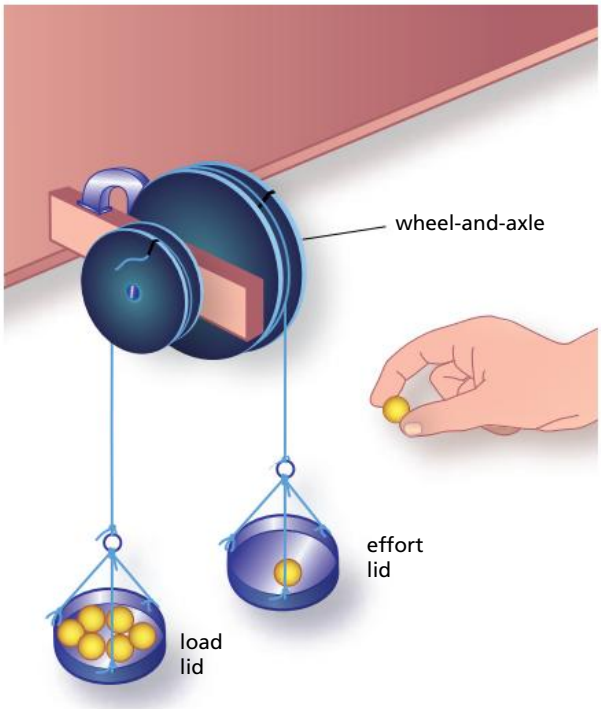


INQUIRY

1 Load and effort

You will need: apparatus pictured

1 Set up the wheel and axle with lids attached as pictured here. (Your teacher may have this set up already as a demonstration.)



2 Add marbles to the load lid until it moves downwards and the effort lid is as high as it can go.

3 Now slowly add marbles to the effort lid until it starts to move downwards, needing no further marbles.

Questions

1 How many marbles did you need in the effort lid compared to the load lid?

2 Is there a force or distance advantage in this machine? Explain.

3 Did this machine change the direction of the force? Explain.

4 Using the same equipment, how could you show that:

- **a** the two lids do not travel the same distance?
- **b** the two lids do not travel at the same speed? (Hint: If both lids move at the same time, the lid that covers more distance moves faster.)

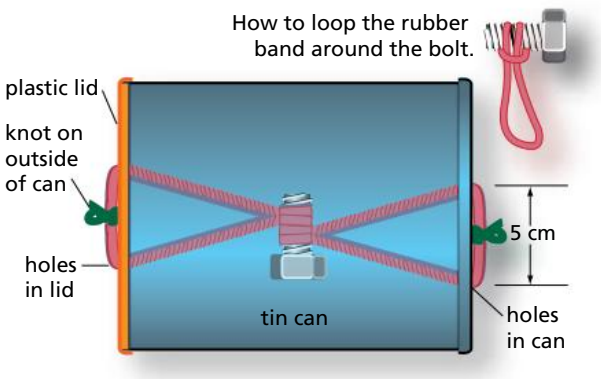
INQUIRY

2 An energy transformer

Machines can be energy transformers. They can take the initial energy and transform it into a different form.

You will need: a container or can at least 10 cm in diameter with a lid (e.g. 1 L paint tin or a baby's formula tin), nail, hammer, scissors, 1 or 2 large rubber bands, medium-sized bolt

1 Make sure your can has no rough edges and that you can get your hand inside it.



2 Punch two holes in the bottom of the can about 5 cm apart. Do the same with the lid.

3 Loop one of the rubber bands around the bolt as shown. Cut the rubber band and thread it through the holes in the bottom of the can. Then tie the two ends together on the outside of the can.

4 Loop the second rubber band around the bolt and attach this one through the lid of the can. Then put the lid on the can and tie the two ends together on the outside of the lid.

5 Roll the can and observe what happens.

6 Make an inference to explain your observations.

7 How did your can store energy?

8 How did your can transform the stored energy?

9 Consider the design of your can. What variables could you change to make it store more energy and transform this energy more efficiently?

You may want to have a competition to see whose machine can roll back the furthest.

Over to you

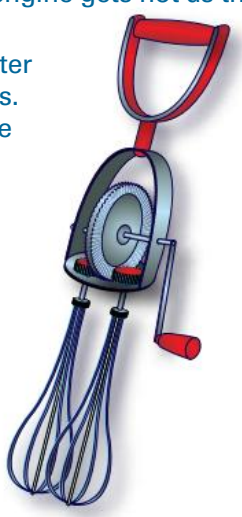
1 Copy and complete the following sentences.
- **a** The _____ is the force you put into a simple machine.
- **b** Some machines help you by changing the _____ of the force.
- **c** Some machines _____ the force you use.

2 The following statements are false. Rewrite them to make them true.
- **a** A simple machine can give you a bigger force and make things go faster as well.
- **b** When the effort is larger than the load, the machine has a force advantage.
- **c** The effort is what the machine has to work against to move.
- **d** A high gear on a bicycle will provide a force advantage.
- **e** Another name for the crank on a bicycle is a gear wheel.

3 Give your own examples (different from those in the text) of how a machine:
- **a** magnifies the force used
- **b** changes the direction of a force
- **c** makes things go faster
- **d** transforms energy.

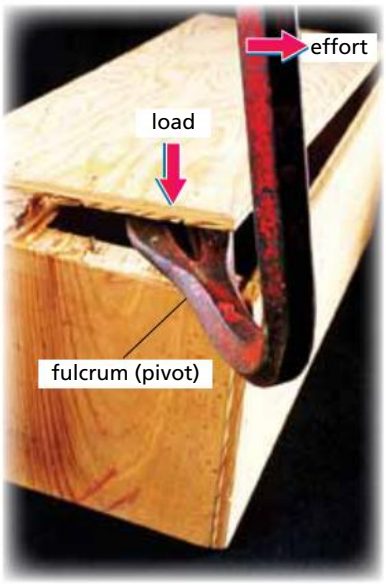
4 Describe in your own words the difference between effort and load.

5 Explain what the following examples show about machines.
- **a** John pulled up the sails on his boat. The pulley at the top of the mast made it easier. As he pulled the rope down the sail went up.
- **b** Allison's car had a flat tyre. Using a jack, she was able to lift the car and change the wheel using very little effort.
- **c** A car battery has the energy in it to start the engine moving. The engine gets hot as the parts in it move.
- **d** A hand-held egg-beater has three gear wheels. These gears make the beaters turn faster than the handle used to turn them.



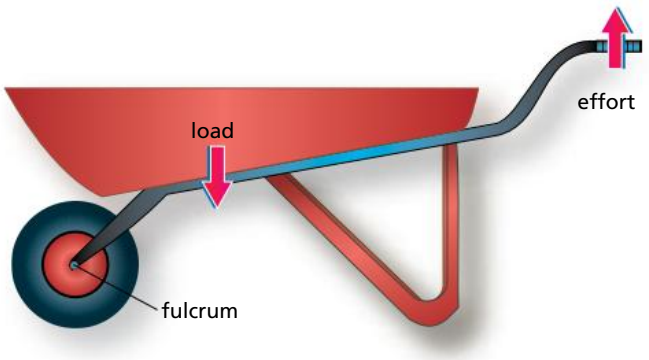
7.2 Levers

It is difficult to get the lid off a wooden packing case, but you can do it easily with the right tool—a pinch-bar. You simply work the claw end of the bar under the lid and pull back on the other end of the bar, as in the photo. A pinch-bar is a common simple machine called a **lever**.



A lever is made up of a long bar or handle that moves around a fixed point called the **fulcrum** or pivot. For example with a wheelbarrow, the fulcrum is the wheel axle. This connects to a tray and then the handles extend from the tray.

Whatever you want to move in the tray is the load, and the force you apply to the handles to do this is the effort. It takes far less effort to move the load with a wheelbarrow than if you tried to lift the load yourself. So in this particular case the wheelbarrow gives you a force advantage.



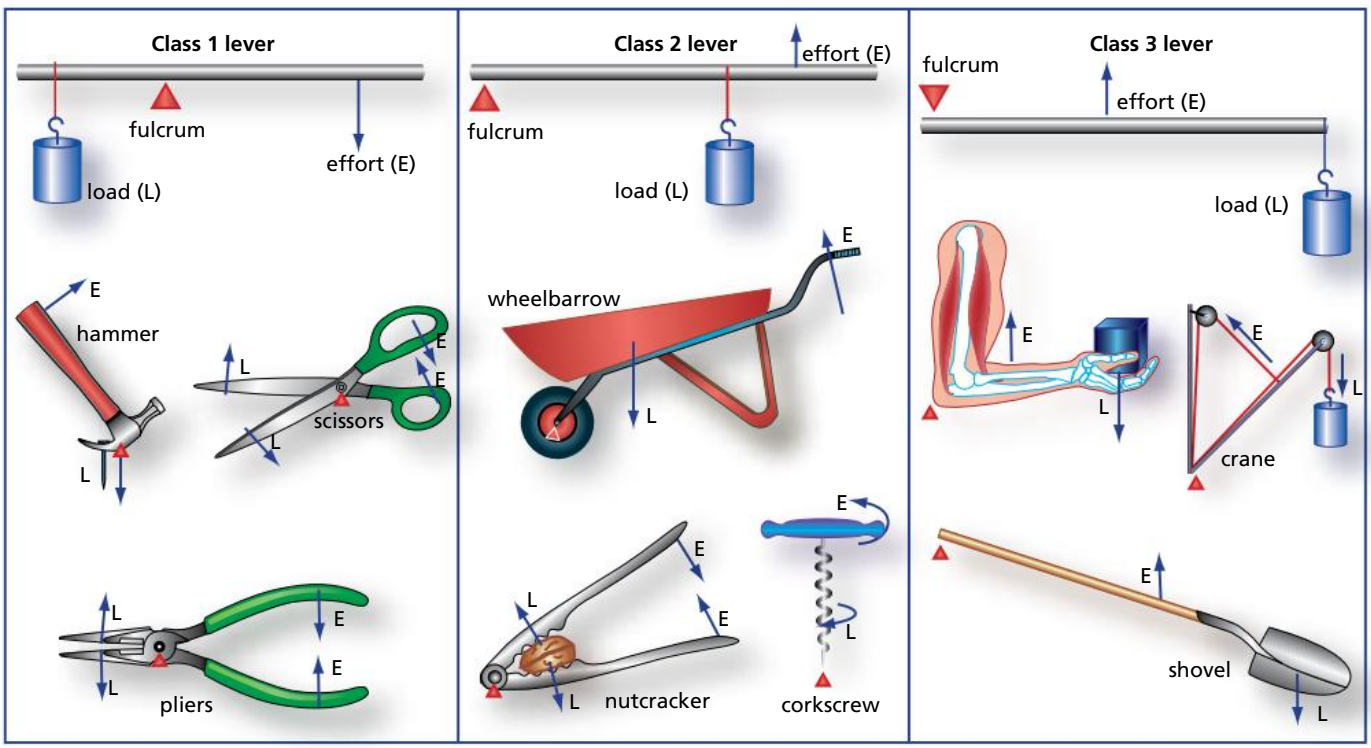
There are times when a lever can provide a distance advantage. For example you can use a slingshot, which is a lever, to catapult a piece of paper across a room. The effort you need to move the paper with the slingshot is much more than if you moved the paper yourself, but the distance the paper moves is much greater than the distance you pull back the elastic.

There are three different classes or types of levers.

Class 1: The fulcrum is between the effort and the load.

Class 2: The load is between the fulcrum and the effort.

Class 3: The effort is between the fulcrum and the load.

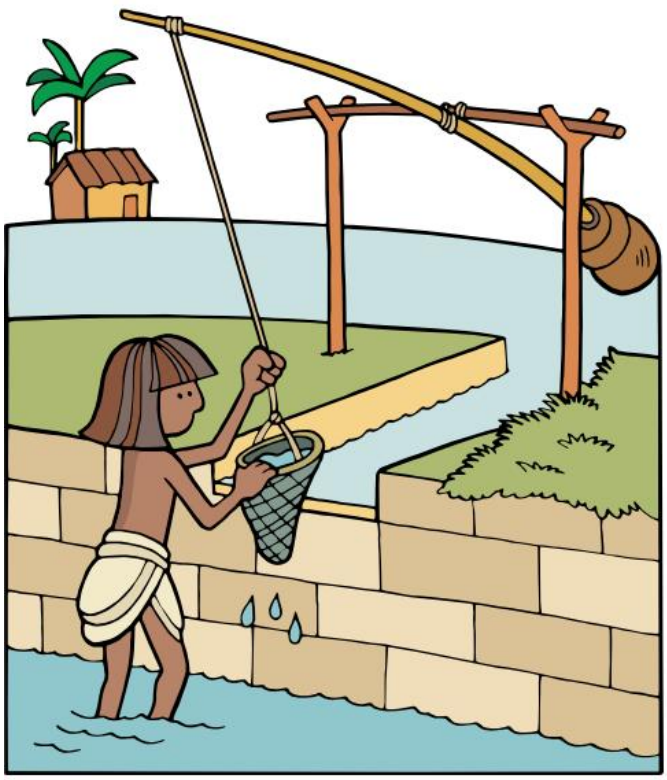


Mechanical advantage

You can see how useful a simple machine is by working out its **mechanical advantage**. To do this, you divide the load moved by the effort you put in. For example, if you were using a car jack to lift a car weighing 1200 N and applied a force of 100 N, the mechanical advantage would be:

$$\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}}$$
$$= \frac{1200\,\text{N}}{100\,\text{N}}$$
$$= 12$$

Levers are not modern inventions. The ancient Egyptians used them to help them with their daily tasks. A machine known as a *shadoof* was used to help irrigate farms. When the Nile River was too low for water to reach the irrigation channels, the shadoof was used to lift water to the crops. It was a simple lever as shown.



A shadoof is a lever.

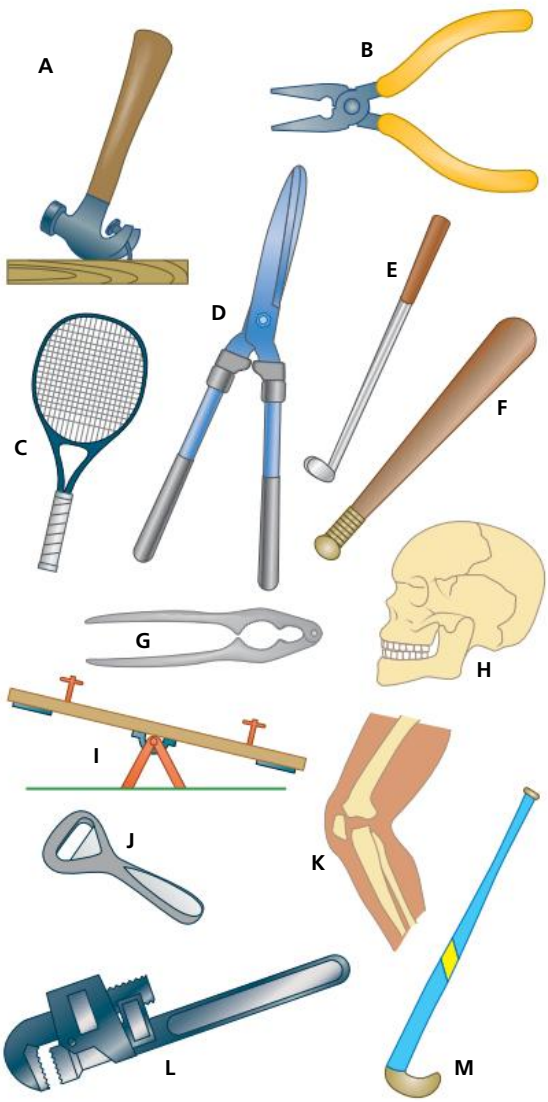
The Romans used a lever to make a wine press. They put grapes under a lever with a hinge at one end. When they pulled the lever down, the grapes were crushed and the wine ran out. Even today farmers, workers and gardeners use levers such as crowbars to make difficult jobs easier.

INQUIRY 3

Classes of levers

You will need: collection of different classes of levers, e.g. pliers, nutcracker, claw hammer, scissors, spanner, bottle-opener, can-opener, stapler, egg-beater

1. Explain in your own words how the three different classes of levers work. Where is the fulcrum, effort and load in each?
2. Classify the levers you have been given into either Class 1, Class 2 or Class 3.
3. Ask your teacher whether you have classified the levers correctly.
4. Look at the diagrams of levers provided here. Classify them.



5. Provide your own example of each class of lever, other than those pictured here.

INVESTIGATION

1 Levers and loads

Aim

To investigate the different classes of levers to see how they lift different loads.

Risk assessment and planning

1 How should you safely use the weights?

2 Where should you set up the apparatus?

3 Read the investigation first and draw up any data tables to help you collect your findings.

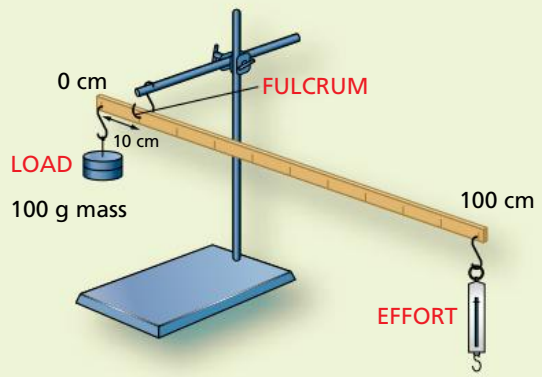
Apparatus

- a metre ruler with holes every centimetre
- masses and hanger
- 5 N spring balance
- 3 paperclips each bent in the shape of an S
- retort stand with boss head and metal rod

Method

PART A: Class 1 levers

1 Set up the apparatus as pictured here with the mass or load at 0 cm, the fulcrum 10 cm from the load and the effort at 100 cm on the ruler.



2 Now complete the table below by calculating the force produced by the load as indicated.

3 Increase the load to find out what effort is needed to keep the load balanced.

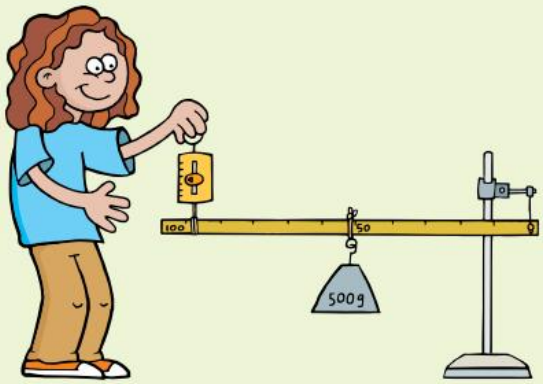
4 Calculate the mechanical advantage for each load for the set-up.

5 Repeat the activity with the fulcrum at 25 cm, 50 cm and 75 cm from the load to find out what effort is needed in each case. (Different groups could do different positions and then report back to the class on their findings. Each group will need another table like the one below for the position they test.)

PART B: Class 2 Levers

1 Set up the equipment shown below. The fulcrum this time will be at the 0 cm mark. The load will vary and so will its position along the ruler.

2 Investigate what efforts are needed to balance the various loads.



PART C: Class 3 levers

1 Set up the equipment to test a Class 3 lever and draw up your own data table.

Results

Complete these questions as your results.

1 In part A, what happens when you move the fulcrum closer to the load? What happens when you move it further from the load?

2 If the lever in part B represented a wheelbarrow, which position of the load makes the wheelbarrow easiest to use?

Conclusion

Write a summary of what you have found out about levers.

Mass (load)	Force (weight) produced by the load. (Divide the mass in grams by 100.)	Effort (newtons)	Mechanical advantage of lever = load/effort
100 g	e.g. 100 /100 = 1 N		
150 g			
200 g			
250 g			

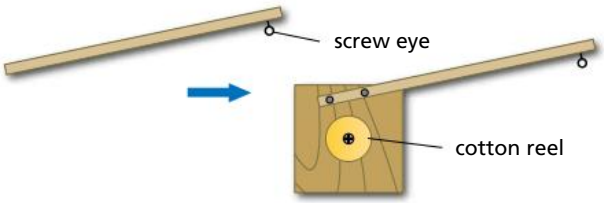
INQUIRY

4 Making your own crane

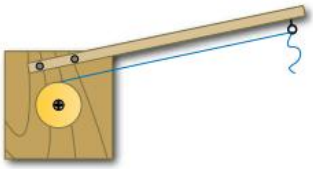
You will need to collect the equipment pictured.

1 Drill a hole in the large block of wood and screw the cotton reel to the wood.

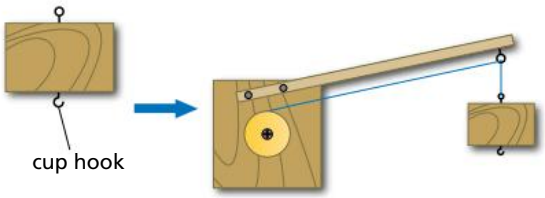
2 Attach a screw-eye to the end of the length of wood and nail it onto the large block as shown.



3 Wind fishing line around the cotton reel and put the end of the line through the screw-eye as shown.



4 Put another screw-eye into the top of the small block of wood and a cup hook into the bottom. Then tie the screw-eye to the fishing line.



5 Try lifting different objects with your crane. Hold the cotton reel to stop it spinning and letting the load fall.

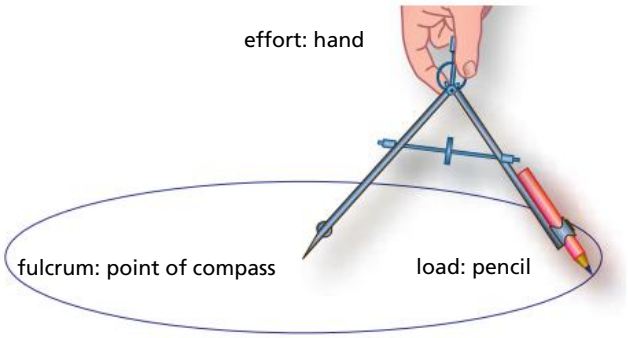
6 Is the crane a simple machine? How does it allow you to do things more easily? (Look at the four ways simple machines help us to do things more easily on pages 135 and 136.)

Over to you

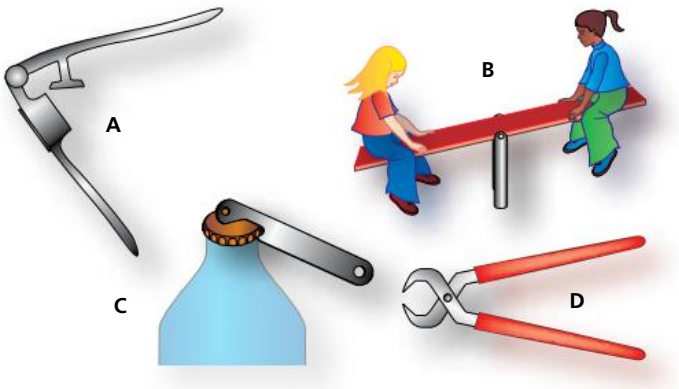
1 Explain in your own words what a lever is and give an example.

2 Explain how a lever can be arranged to have:
- **a** a force advantage
- **b** a distance advantage

3 State whether the following are true or false.
- **a** In a Class 1 lever the fulcrum is between the effort and the load.
- **b** An example of a Class 1 lever is a wheelbarrow.
- **c** In a Class 2 lever the load is between the fulcrum and the effort.
- **d** An example of a Class 2 lever is a pair of pliers.
- **e** In a Class 3 lever the effort is between the fulcrum and the load.
- **f** A drawing compass is an example of a Class 3 lever.



4 State where the fulcrum, effort and load are in the following pictures. Then state what class of lever each one is.



PROBLEM SOLVING

What have you learnt so far that can help you with your task from page 133? Have you decided what sort of gadget you are going to build?

Woomera

The photo above shows a man using a Chuckit® to make it easier to throw a tennis ball for his dog. The Chuckit® is a lever which acts as an extension of his arm, allowing him to throw the ball faster and therefore further.

A woomera is a spear thrower invented by Australian Aboriginal people about 5000 years ago. Woomeras were made of hardwood and were 45–150 cm long. Their shape varied, but a common one is shown below. It has a handle at one end and a hook made of teeth, bone, wood or stone at the other end. The hook was usually glued on with the resin from spinifex grass. The spear had a hollow in its end that fitted over the hook. It was held along the length of the woomera by the thumb and forefinger of the hand on the handle, as shown in the photo top right. When thrust forward the woomera acted as an extension of the thrower's arm, giving greater whip and power to the throw. This increased the speed of the spear, allowing it to go much further than a spear without the woomera. It was used to hunt wallabies, emus, plain turkeys, scrub turkeys and geese.

The woomera was a multi-purpose tool. It could be used for carrying food and drink, and many woomeras had a sharp cutting stone

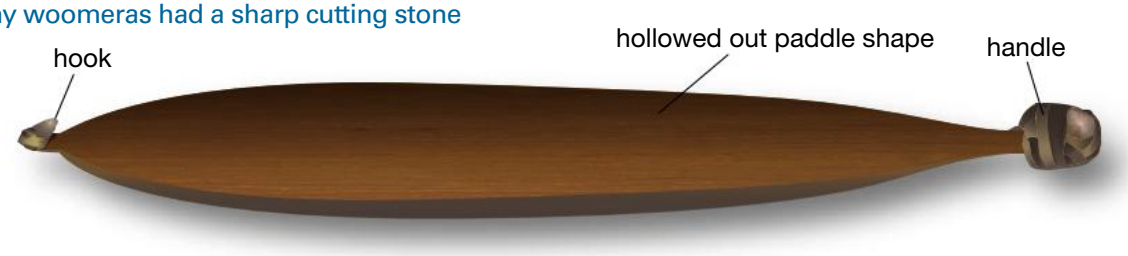
attached to the end of the handle with spinifex resin. This was used for cutting up game or cutting wood. The woomera could also be used as a shield for protection against spears and boomerangs. It could even be used to make fire by rubbing it against a wooden shield or log while adding flammable material and blowing. Woomeras were traditionally decorated with designs which indicated the owner's tribe or clan.

How does it work?

Look at the photo above showing an Aboriginal man hunting for fish with a three-pronged spear and woomera. His wrist is the fulcrum, and the load is the weight of the spear at the hook end of the woomera. The effort is applied by the hunter's hand. This makes it a Class 3 lever, since the effort is between the fulcrum and the load, as explained on page 138.

Questions

1. The woomera is an example of Aboriginal **technology**—the application of knowledge (science) to meet people's needs. How do you think its invention changed Aboriginal life at the time?
2. Why is the central South Australian township of Woomera famous? Why was it called Woomera?
3. The woomera has a distance advantage rather than a force advantage. Explain this using what you learnt on page 138.
4. Make a copy of the Chuckit® in the photo above, and mark the position of the fulcrum, load and effort. What class of lever is it?



7.3 Pulleys, belts and wheels

As you learnt in the first section, machines change the direction of a force. For example, using a pulley to raise a sail on a yacht. When you pull the rope down, the pulley changes the direction of the force and the sail moves up. Pulling down on the rope raises the sail. This is far easier than lifting the sail yourself and trying to hold it in position.

A pulley is a wheel that is grooved so that a rope can fit around it and sit in the groove. A single pulley only alters the direction of the force, making it easier to lift something. It does not magnify your force, so there is no force advantage.

To get a force advantage you need more than one pulley. With two or more pulleys working together it is possible to lift very heavy loads with very little effort. However, because the rope winds around all the pulleys you need a lot more rope to move the load a small distance.

Using three pulleys

INVESTIGATION

2 Pulley power

Aim

To investigate different types of pulleys.

Risk assessment and planning

Read the investigation first.

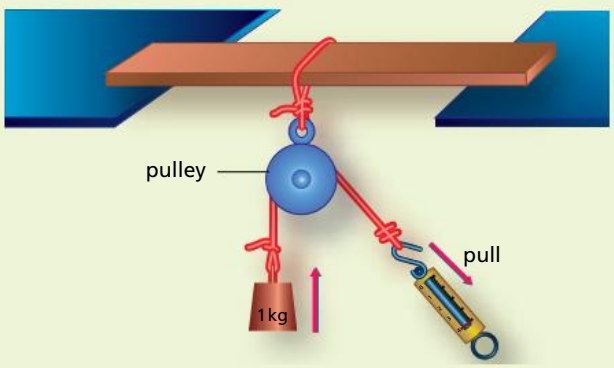
Draw up the table on the next page to record your findings.

Apparatus

- metre ruler
- 2 single pulleys
- 2 double pulleys
- 3 pieces of rope to fit the pulleys (2 short pieces and one 5 m long)
- 1 kg mass
- 10 N spring balance
- piece of timber to span two desks

Method

1. Use the spring balance to find the weight of the kilogram mass in newtons.
2. Set up the apparatus as pictured using the piece of wood to span two desks or benches as a support for the pulley.
3. Slowly pull the spring balance and record how much force is needed to lift the kilogram mass.



4. Pull the load up 20 cm. This is the load distance. Now measure how much rope you have to pull with the spring balance to move the load 20 cm. This is the effort distance.
5. Repeat this for different load distances and record your results in a table like the one on the next page.

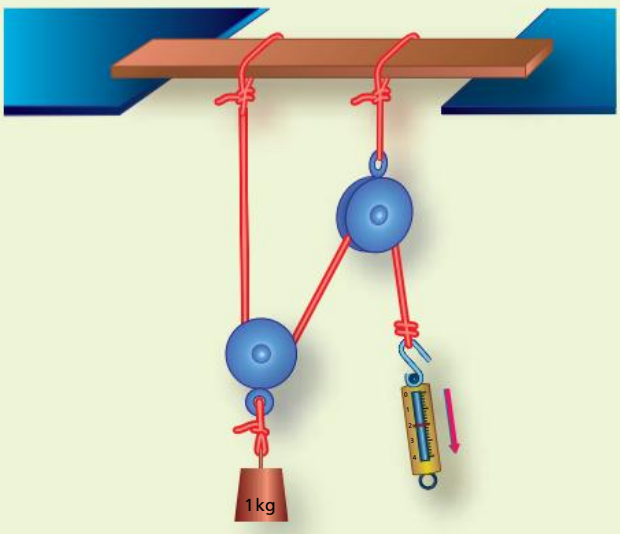
INVESTIGATION

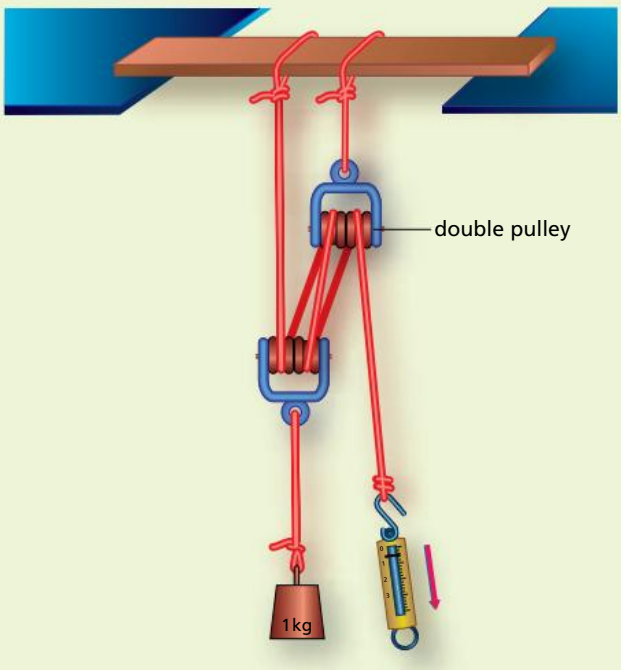
2 continued

Number of pulleys	Load lifted (N)	Load distance (cm)	Effort needed (N)	Effort distance (cm)	Mechanical advantage
1	9.8N	20			
1	9.8N	40			
1	9.8N	60			
2	9.8N	20			
2	9.8N	40			
2	9.8N	60			
4	9.8N	20			
4	9.8N	40			
4	9.8N	60			

6 If time permits, try varying the load lifted and see how this affects the effort distance.

7 Now set up a two-pulley system as pictured and repeat the exercise above. Record your results in the table.





8 Finally, complete the exercise for a four-pulley system (2 double pulleys) as shown on the right and record your observations in the table.

Results

Answer these questions as your results.

1 From your findings state whether the following are correct. Give examples to support your answer.

- **a** Using a single pulley the load distance equals the effort distance.
- **b** Using a double pulley the effort distance is greater than the load distance.
- **c** Using a double pulley the effort needed is less than the load.
- **d** Using more than two pulleys the effort distance is more than twice the load distance, but the effort needed to lift the load is less than half that needed for a single pulley.

2 Calculate the mechanical advantage for each set-up.

Conclusion

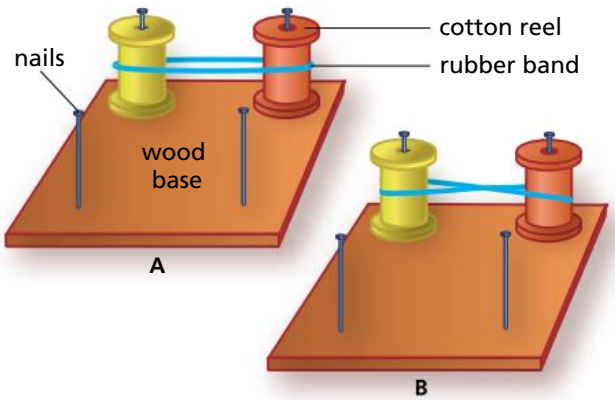
Write a general statement that summarises what you have discovered about pulleys.

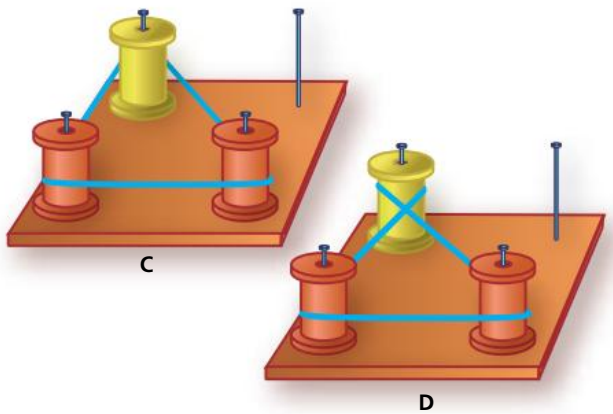
INQUIRY 5 Wheels and belts

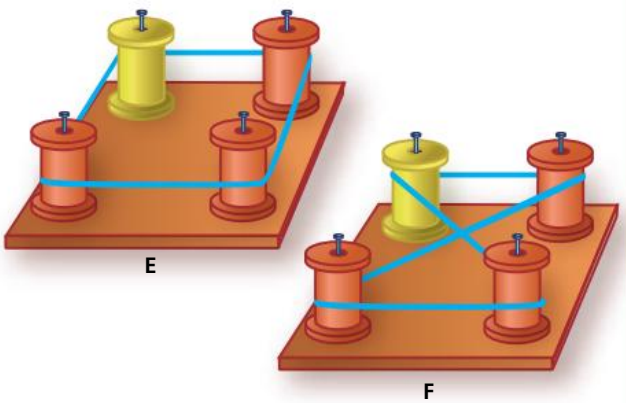
A wheel and belt, or a wheel and chain on a bicycle, is similar to a pulley. The difference is that the rope, belt or cord is continuous and goes around two wheels.

You will need the equipment shown below.

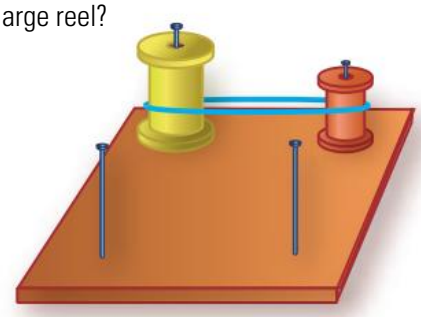
1 For each figure:
   - **a** predict the direction the cotton reel/s attached to the yellow cotton reel (the driving reel) will turn.
   - **b** test your prediction.







2 Now make one cotton reel larger than the other. If the larger cotton reel drives the smaller reel, how many turns does the small reel make for one turn of the large reel?



3 Give real-life examples of wheels and belts.

Over to you

1 Explain in your own words how a pulley changes the direction of a force.

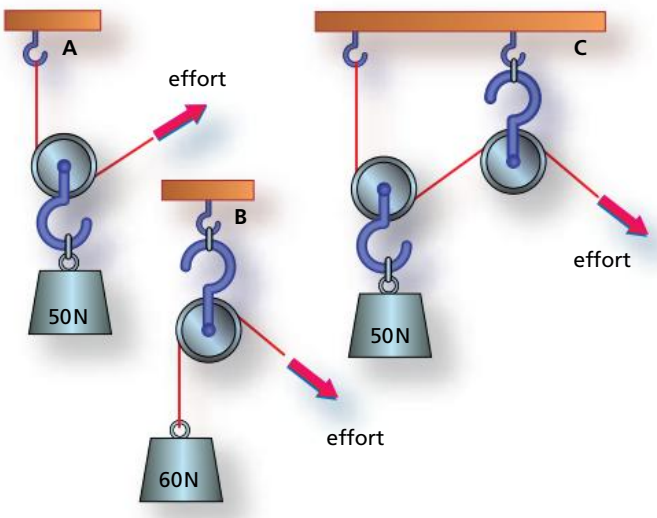
2 Does a single pulley magnify a force? Explain.

3 How many pulleys do you need to get a force advantage?

4 What is the advantage of using many pulleys? Is there any disadvantage?

5 Copy and complete the following sentences.
   - **a** A single fixed pulley only changes the _____ of the force.
   - **b** With a two-pulley system, the effort is _____ than the load.
   - **c** The mechanical advantage of a two-pulley system is _____ than one.

6 Look at the diagrams below. Which pulley would require the:
   - **a** smallest effort?
   - **b** largest effort?
   - **c** largest effort distance?



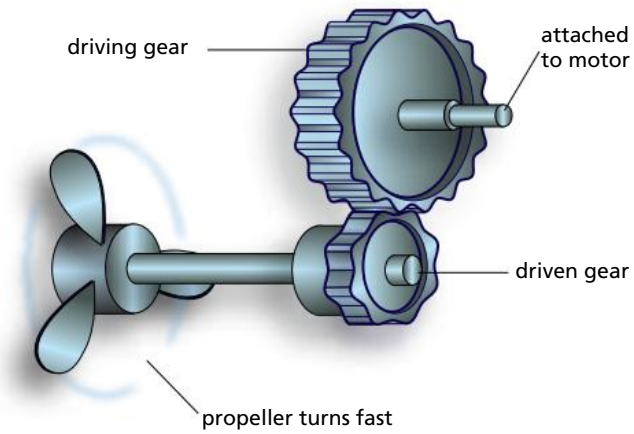
7.4 Gears

In the last activity you saw that changing the size of the cotton reels makes a difference to the numbers of turns they make. A large cotton reel as the driving reel turns a small reel very quickly. A small cotton reel as the driving reel turns a large cotton reel slowly. This is the same principle used in gears.

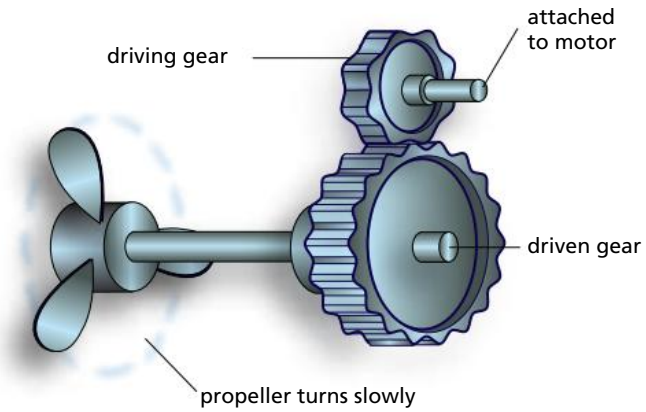
Wheels with teeth or cogs on them are called **gear wheels**. The teeth of one wheel fit into the teeth of the other, so that they can transfer the force from one wheel to the other.

A gear is a device used to change motion. For example, a gear is used on a bicycle or in a car to allow the bicycle or car to speed up or slow down. Suppose a large wheel is attached to a motor as shown below. The large gear wheel is called the **driving gear** because it supplies the force to turn the small gear wheel. The small wheel is called the **driven gear**.

The small wheel will make far more turns for each turn of the large wheel. A propeller attached to the small wheel will therefore turn quickly. This is an example of *gearing up*. Kitchen hand-beaters, hand drills and bicycles have this arrangement of gears, so that the beaters, drill bits and rear wheel can spin quickly.



Now suppose a small gear wheel is the driving gear and is attached to a large wheel. The large wheel will turn slowly compared to the small driving gear. This is called *gearing down*. Anything attached to the large wheel will turn slowly too. Rotating displays in exhibitions use this arrangement of gears so that the goods on display move very slowly.



Bicycles have a large gear wheel attached to the pedals and a small gear wheel attached to the rear wheel. The two gear wheels are connected by a chain.

When you push down on the pedals, the pedals turn and the large gear wheel attached to the pedals turns too. This gear wheel is the driving gear. The smaller gear wheel attached to the rear wheel is the driven gear.

On bicycles with gears you can select different sized gear wheels. If you are going up a hill, you select the largest rear gear wheel. This is low gear and it means you require less effort to get you and the bike up the hill. So a bicycle in low gear gives the rider a force advantage.

On level ground, you select the smallest rear gear wheel. This is high gear and it allows you to cover more distance. So a bicycle in high gear gives the rider a speed–distance advantage. The bike can reach a higher speed and cover more distance.

INQUIRY 6

Egg-beater gears

In this inquiry you will examine an egg-beater and a hand-operated drill.

1 For your egg-beater
   - **a** list how many gear wheels are present. Are these small or large?
   - **b** count the number of teeth or cogs on each wheel. Record these numbers.
   - **c** draw a diagram showing how the gear wheels are connected.
   - **d** Complete the following paragraphs.

     For the egg-beater being studied, there are _____ gear wheels present. The large gear wheel has _____ teeth on it. It is connected to a smaller gear wheel which has _____ teeth on it. The ratio of teeth on the big wheel to the teeth on the small wheel is _____ to _____ or more simply _____ to one.

     The small gear wheels are both the same _____. When the large gear wheel turns, it turns both small gear wheels at once. These smaller gear wheels turn _____ than the large gear wheel.

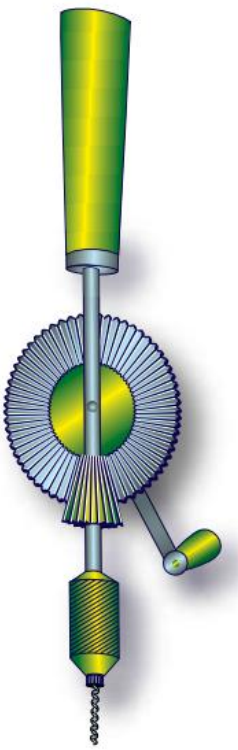
     (You may have to alter your paragraphs if your egg-beater is different from the one pictured.)

2 When you turn the handle of the beater, the large gear wheel turns. This turns the two smaller wheels that spin the blades or whisks. Design an investigation to find answers to the following.
   - **a** How many times does each whisk turn for a single turn of the handle?
   - **b** How could you make the whisks turn faster?

3 Summarise your findings by explaining why the gear wheels have to be different sizes, and how the movement of the whisks is related to the gear wheels and handle turning.

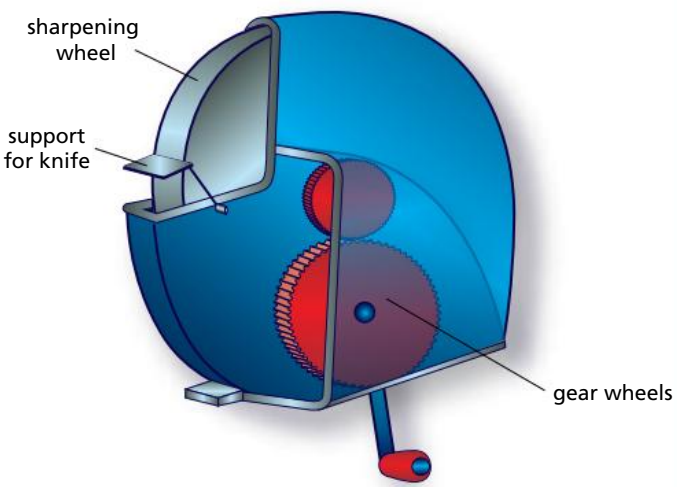
4 Explain how gears are an advantage in simple machines.

5 Repeat this activity for the hand-operated drill or any other equipment your teacher provides.



A hand-operated drill

A knife sharpener



SKILL

Interpreting scientific articles

Many scientific breakthroughs are written in scientific magazines. Being able to read these articles is an important skill.

1 Read the following article.
2 Underline in pencil any words you do not know.
3 Make a list of these difficult words. Use a dictionary to find their meanings and write them down.
4 In groups, discuss each word thoroughly and where necessary, rewrite the meanings.
5 Read the article a second time for meaning.
6 Summarise the main point of the article in one paragraph.

Gearing down

Spinning on a micro-cog

Imagine working with machines the size of a full stop. Try carving a gear cog as thin as a human hair and not much wider. You wouldn't want to slip (or to sneeze).

Machines and electronic devices are getting smaller all the time. These days it's easy to confuse some mobile phones with cigarette lighters, but what we're talking about here is way smaller—whole devices well under a millimetre in length.

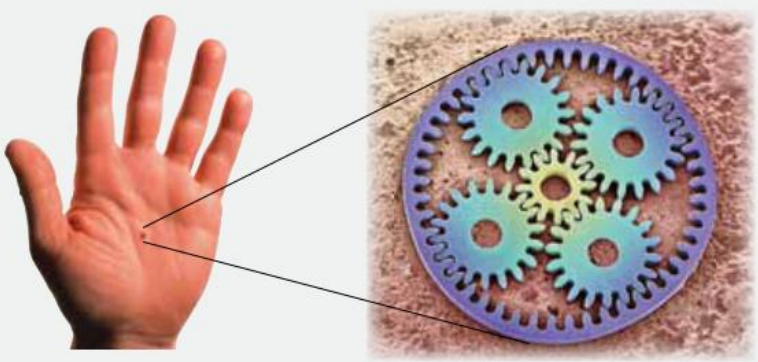
Cogs and gears such as those shown here together with an array of other tiny parts including levers, hinges and micro-mirrors are opening up new worlds of possibilities. Rugged motion sensors smaller than a fingernail, micro-electric motors that can be injected into our bodies, micro-robots and whole chemistry labs built onto the surface of a single silicon chip.

Micro-motion detectors are already being produced for use in car airbag-deployment systems, micro-mirrors could become the standard in high-performance, digital light processors (used in home theatre systems) and micro-machines are revolutionising fibre-optic switching. So reliable are these tiny machines that they've been proposed for use in safety lockout devices to prevent nuclear weapons going off accidentally—24-digit combination locks so tiny no thief could pick them.

And how are they created? The methods employed to create these midget widgets vary from place to place, however in general they are produced in much the same way that microcircuits are carved into silicon chips. The shapes of cogs and other micro components are drawn on to thin layers of silicon and cut out using X-rays or etched out using acid. Sometimes the layer containing the component being created is laid over other layers that can be completely etched by acid, leaving a fully assembled mechanism requiring no assembly, including gears that spin around hubs.

The result is exquisitely intricate tiny machines that can be fabricated by the thousand using relatively cheap materials. No wonder micro-machines are big business. Worldwide there are around 150 companies developing micro-machinery. It's estimated the global market for micro-machines is between US$6 and 8 billion a year, and this could more than double over the next couple of years.

David Salt



Left: Thin as a human hair, these tiny cogs have been carved by a process called X-ray lithography. Mechanisms like these are already being used in printer cartridges and car airbags, as machines grow ever smaller.

INQUIRY 7

Bicycle gears

You will need: bicycle with gears, piece of timber to act as a support beam, coloured electrical tape

1 Place the bicycle between two desks, then put the beam underneath the bar of the bicycle to lift it off the ground.

2 Put the bicycle in its lowest gear. Place a piece of electrical tape on the back tyre.

3 Turn the pedal so that the driving gear makes one complete turn. Count how many times the back wheel turns.

4 Count the number of teeth on the driving gear. What is the ratio of teeth on the driving gear to teeth on the driven gear?

5 Now do the same for each of the other gears your bicycle has.

6 Put your results in a table and summarise them.

7 Which gear arrangement would you use if you wanted to cover the most distance on a flat road quickly?

8 Which gear arrangement would you use if you were going up a hill? Explain.

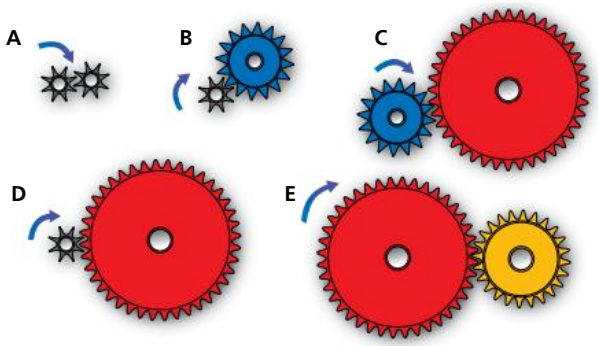
9 Explain how the gear arrangements on a bicycle change for gearing up or gearing down?

Over to you

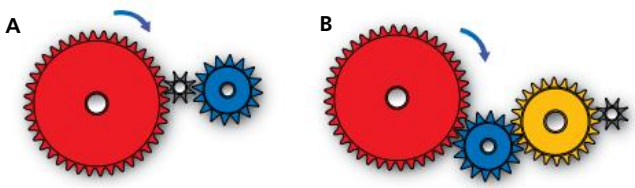
1 For each of the diagrams below answer these questions.

a What is the gear ratio? (Count the number of teeth on each gear wheel. For example, if there are 24 teeth on one and 8 on the other then the ratio is 24:8 or 3:1.)

b For each set-up say whether gearing up or gearing down occurs. (The driving gear has an arrow next to it.)



2 For each of these diagrams state which direction the last gear wheel turns.



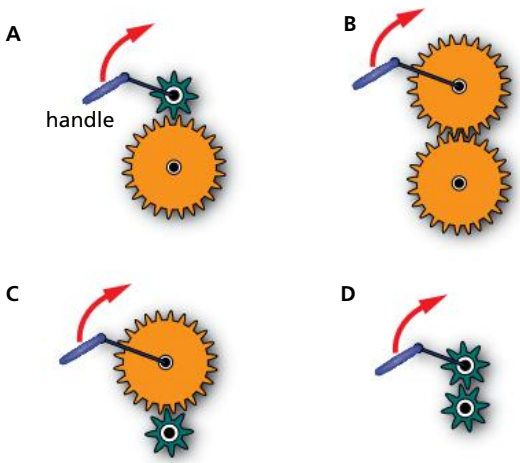
3 State which of the following show

a gearing up.

b gearing down.

c no change in gear.

d the best arrangement for the least effort.

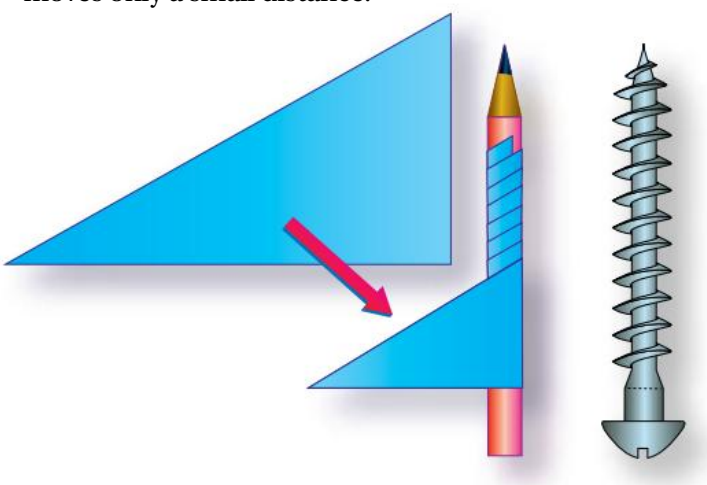


7.5 Other simple machines

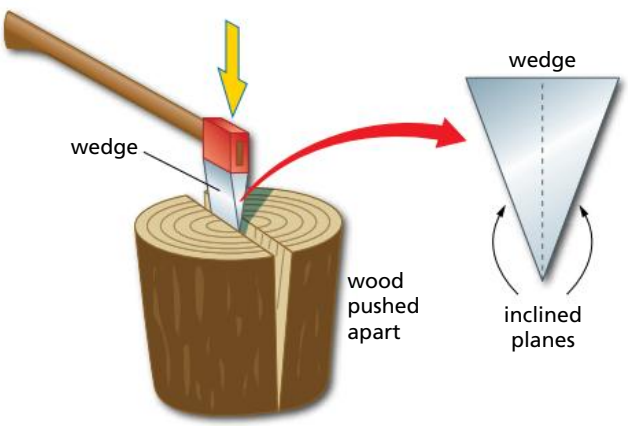
Inclined planes

A ramp, a door wedge and an axe head are all examples of **inclined planes**. You can roll an object more easily up a ramp than you can lift it vertically. This is because you use the same amount of energy to raise the object, but using a ramp requires less force over a greater distance.

A screw is a special kind of inclined plane. If you make the shape of an inclined plane out of paper and roll it around a pencil, you produce something like a screw thread. An advantage of a screw over a nail is that you use very little force to drive the screw into a piece of wood. However, with each turn, the screw moves only a small distance.

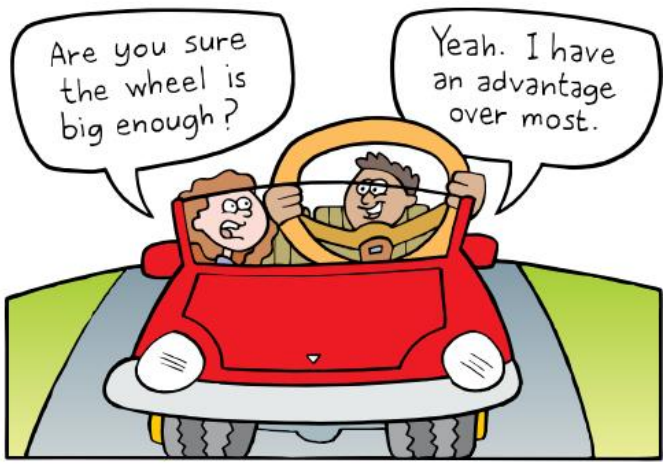


An axe head is a wedge formed from two inclined planes. As you hit down with the axe the wedge shape pushes the wood apart. So the wedge changes the direction of the force.

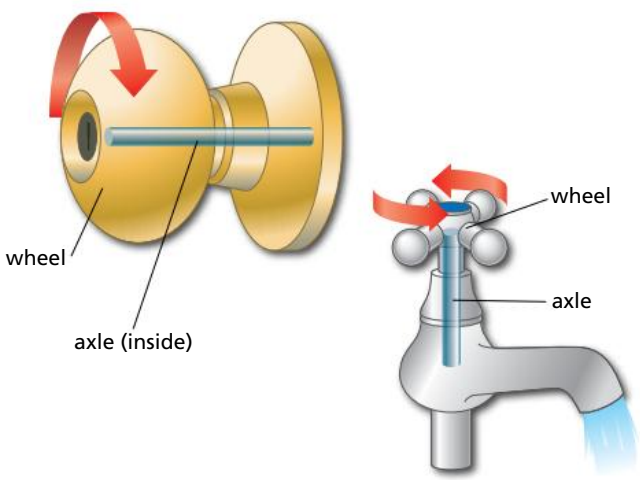


Another type of simple machine is a **wheel-and-axle**. You used a wheel-and-axle when you made a crane in Inquiry 4. A steering wheel on a car is another example of this type of machine.

There is a central shaft or column, called the axle, attached to a large steering wheel that can be turned easily. As you turn the steering wheel the axle turns, and as it is attached to the wheels of the car they move in the direction the steering wheel is turned. It would be impossible to move the wheels of a car if you had to turn the axle itself. Instead a small force on the steering wheel moves the axle that in turn moves the car. Larger vehicles like buses require more force to turn the axle, so they have larger steering wheels.



Another example of a wheel-and-axle is a tap. You turn a wheel around an axle, which opens a valve to allow water to flow. A door knob is also a wheel-and-axle. A small force on the handle produces the large force that is necessary to open the door.



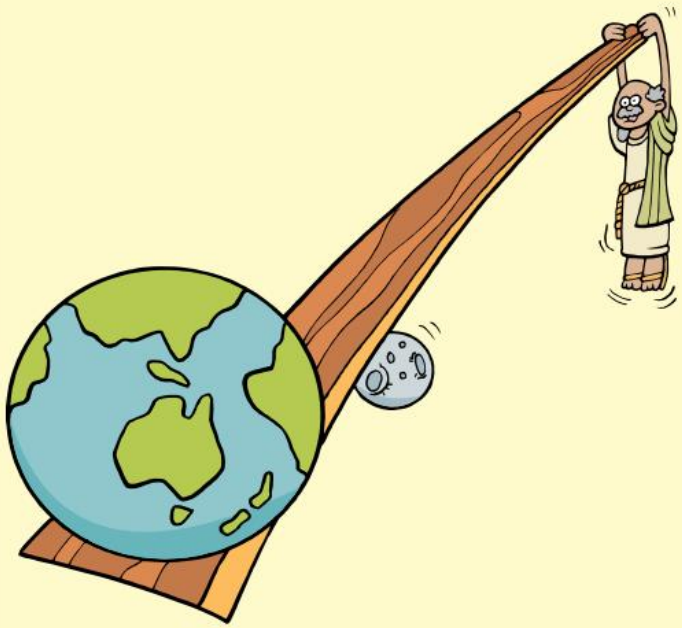
SCIENTISTS AT WORK

Archimedes (287–211 BC)

Archimedes was born and lived in Syracuse, Sicily. At that time Sicily was a province of ancient Greece. Archimedes was the son of an astronomer and so was able to learn and study scientific principles. He was sent to Alexandria in Egypt, considered to be the centre of learning in the ancient world.

Like many people of the time, Archimedes studied mathematics to understand the world. Many theoretic problems were solved using maths, but Archimedes used his mathematical knowledge to solve practical problems in everyday life. He investigated levers and showed people how they could be used to lift a load without a lot of effort.

The story goes that Archimedes realised that a long shaft or rod balanced at a pivot point could be used to move heavy objects. It didn't take much force to move the rod, but the length of the rod magnified the force. Because of this, heavy objects could more easily be moved or lifted. Archimedes knew that the force of a person was limited, but the lever could be made very long. He is quoted as saying 'Give me a lever long enough, and a place to stand, and I can move the world.'



Hearing this King Hiero, who ruled Syracuse at the time, challenged Archimedes to demonstrate his ideas. He demanded Archimedes lift something heavy, so they settled on a ship full of people and goods. If the ship could not be moved empty, how could it be moved full? But Archimedes made a device similar to a pulley and single-handed moved the ship out to sea.

Archimedes also designed a machine now known as the Archimedes' screw for lifting water. Similar machines are still used today.

This Archimedes' screw is being used to lift water to a higher level.

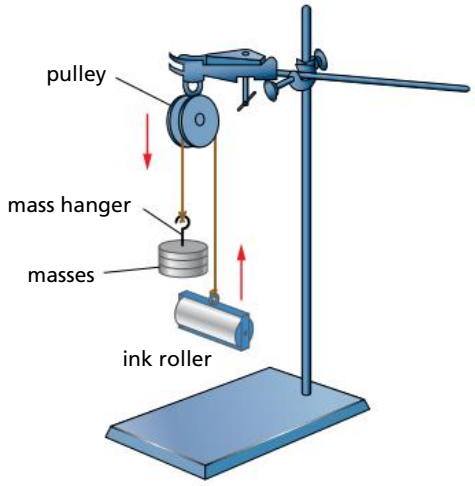
It is said that Archimedes used his scientific ideas to prevent the Roman army from invading Syracuse. King Hiero died in 216 BC and until his death Syracuse remained neutral. However, once the King was dead, the Romans invaded Syracuse. Legend says that Archimedes put curved mirrors on the walls of the city and aimed them at the Roman ships. The ships burst into flames!

In 211 BC the Romans did manage to capture Syracuse. Archimedes was killed as he worked over a scientific problem that he refused to leave. He is now known as the father of mechanics (the science of machines).

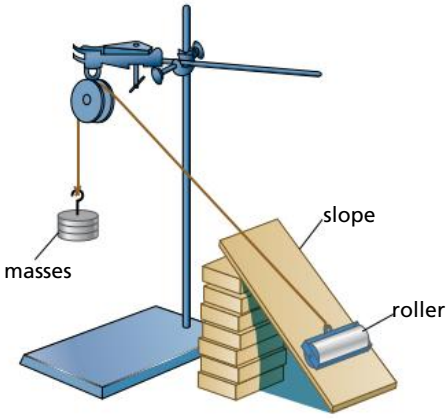
INQUIRY

8 Inclined planes and pulleys

You will need the equipment pictured.



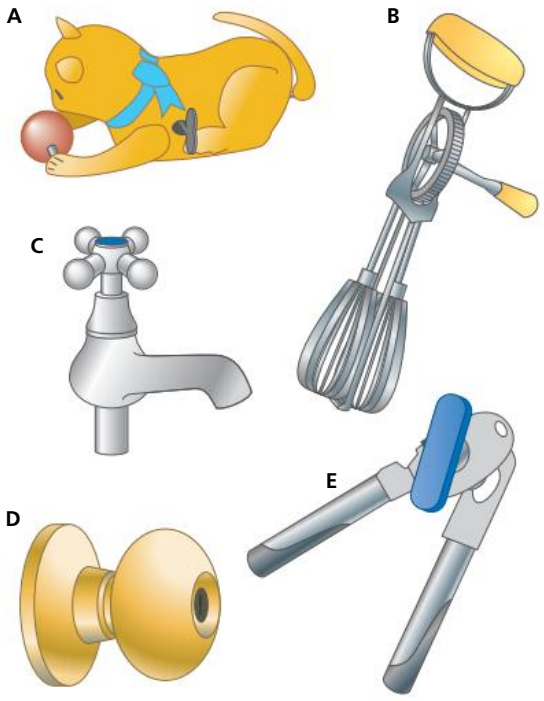
1 Start the activity with an empty mass hanger and the ink roller touching the bench.
2 Add masses to the hanger until the roller starts to move up to the pulley.
3 Now add an inclined plane to your set-up as pictured.



4 Start with an empty mass hanger and add masses to it until the roller starts to move upwards as it did in the first part of the activity.
5 Compare the two masses needed to get the roller moving.
6 Did you need more or less mass with an inclined plane? Explain.
7 Using what you have found, write a paragraph to explain the advantage of using an inclined plane.
8 Give three examples of how we use inclined planes in everyday life.

Over to you

1 State whether the following are true or false. Rewrite the false statements and explain why they are incorrect.
   a An inclined plane is a ramp.
   b A screw is an example of a wheel-and-axle.
   c A large vehicle requires a small steering wheel.
   d An axe blade is made up of two inclined planes.
   e A wedge changes the size of the force.
2 Find the wheel-and-axle in each of these machines.



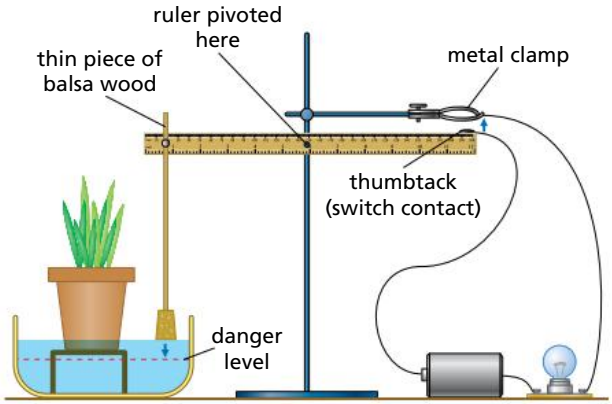
3 Look at the photograph of Archimedes' screw on the previous page. Explain in your own words how you think this screw can lift water.
4 The ancient Egyptians were supposed to have used ramps, logs and ropes to move the huge stones they needed to make the pyramids. How do you think they did this? (A diagram could improve your explanation.)

PROBLEM SOLVING

How are you going with the task you started at the beginning of the chapter? You may want to build and explain a gadget that contains pulleys, gears, inclined planes or wheels-and axles.

THINKING SKILLS

1 Ming wanted to design a machine that let him know when a pot plant needed water. He came up with the following design.



a Which simple machine can you identify?

b Explain how Ming's machine works.

2 Design a machine for one of the following.

- to let a blind person know that they have mail in their letter box
- to let a dog know there is food in its bowl
- to let a person know when their pet's water bowl is empty
- to make a bridge that opens when large ships approach
- a crane or hoist that can sit on a verandah to lift shopping from the ground to the verandah

You should draw a diagram of your design first and have it checked by your teacher to make sure it works.

Once your design has been checked, build your machine using recycled materials where possible.

You may wish to demonstrate your machine to the class and get them to identify the simple machines that you have included in your design.

3 Examine the drawing top right of a wishing well.

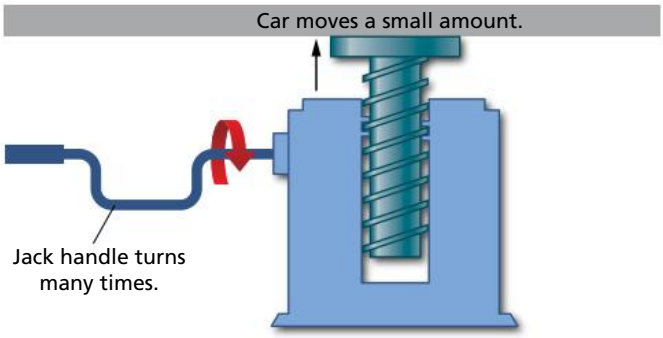
a Which simple machines can you identify in its design?

b If the bucket was still too heavy to lift from the bottom of the well, what could you do to make the machine work?

4 The diagram below shows one type of car jack.

a Name the simple machines in this jack.

b If the car could not be lifted with this jack, what could you do to give the machine a greater force advantage?



5 The diagram below shows a screwdriver.

a What type of simple machine is a screwdriver? Explain.

b Describe how you think a screwdriver works.

c Madison was in the shower and the tap wheel came off the hot tap. She tried turning the axle instead but she couldn't switch the water off. How can you explain this?

6 Spades have handles of different lengths. If the ground is really hard and cannot be dug with a short-handled spade, a long-handled one often works. Explain why a long-handled spade would be better in this situation.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 The amount of force needed to operate a machine is called the _____. The _____ is what the machine has to lift or move.

2 Machines magnify the force used, change the _____ of the force, make things go faster and transform _____.

3 A _____ is a long bar that moves around a fixed point called the _____.

4 A _____ is a grooved wheel with a rope that alters the direction of the force.

5 Wheels with teeth on them are called _____ wheels. Gearing _____ is when a large gear wheel turns a small gear wheel. Gearing _____ is the opposite.

6 A ramp is an _____ that gives a force advantage. A _____ is a special kind of inclined plane. Two inclined planes together form a _____.

7 A steering wheel on a car is an example of a _____ and _____. A small force on the steering wheel provides a large force to turn the car.

axle
direction
down
effort
energy
fulcrum
gear
inclined plane
lever
load
pulley
screw
up
wedge
wheel

Self-management

Is your notebook up to date?

Your notebook should contain all notes, activities, answers to questions and practicals that you have done in the order you did them. If you have done this, revising for a test should be easy.

1 Compare your notebook with a partner's. You should both have similar entries.

2 If you are missing any work, make a list and then use your partner's notes to fill in any gaps. Ask your teacher for any missing worksheets and finish all homework yourself.

3 Briefly explain why you are missing work to your teacher when they check it, e.g. you may have been sick or you may have lost a handout.

4 Now use your notebook to make a list of all the things in this chapter that you know and can do easily. Also list all the things that you have problems with and ask your teacher for help with them. Remember it is no use forgetting about them, because they might just appear on your test!

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Explain what the following statements mean by giving examples.

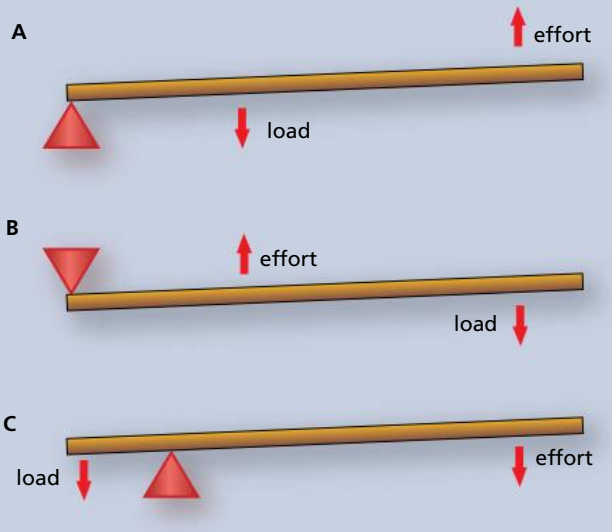
- **a** The amount of force needed to make a machine work is called the effort.
- **b** The load is what the machine has to lift or move.
- **c** A simple machine is anything that helps you do things more easily.
- **d** Machines can magnify the force you use.
- **e** Machines can change the direction of the force.
- **f** Machines can make things go faster.
- **g** Machines can transform energy.

2 To which group of simple machines do each of these belong?

pair of scissors, stapler, can-opener, knife, ramp, door handle, axe, wheelbarrow, sail hoist

3 The diagrams below show the three different classes of levers.

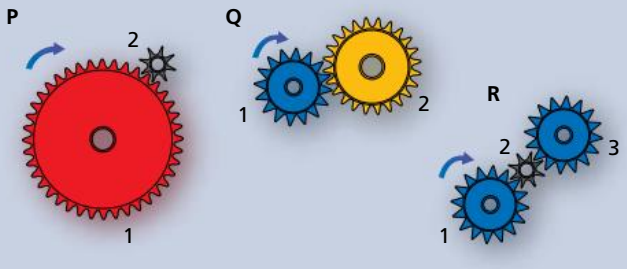
- **a** Which is which?
- **b** Give one example of each class of lever.



4 For each of the set-ups top right, state

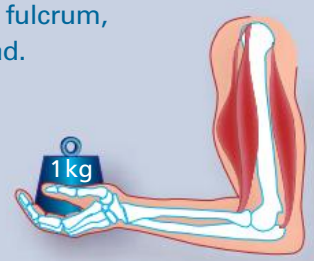
- **a** the gear ratio.
- **b** whether gearing up or gearing down occurs.
- **c** which wheels are the driving gear.
- **d** which wheels are the driven gear.

(You may need to draw diagrams and use arrows to help you explain your answers.)

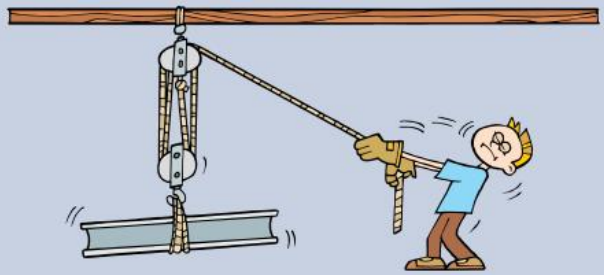


5 Look at the diagrams below showing bicycle parts. Are there any levers? Explain.

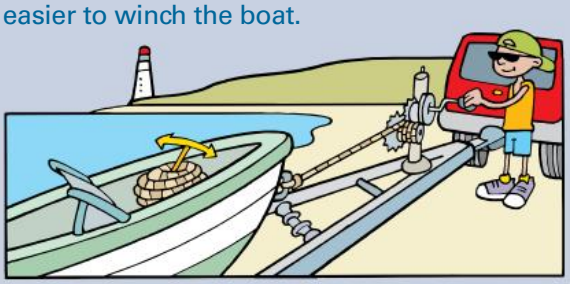
6 Look at the diagram of an arm lifting a mass. What type of lever is the arm? Draw a simple diagram of the arm and label the fulcrum, effort and load.



7 Explain how this pulley system provides the man with a force advantage. What is a disadvantage when using this machine?



8 Explain how this gear arrangement makes it easier to winch the boat.



8

Sound

By the end of this chapter you will be able to …

Science as a Human Endeavour

- describe how the reflection of sound is used in ultrasound imagining and echolocation
- explain in simple terms how a didgeridoo works

Science Inquiry Skills

- do simple demonstrations of how sound travels through different materials
- investigate a range of musical instruments to compare the frequency, quality and intensity of sounds produced
- use a diagram to explain how the human ear works

LITERACY FOCUS

amplitude
auditory nerve
cochlea
compression
decibels
Doppler effect
Eustachian tube
frequency
hertz
inner ear
longitude wave
middle ear
oscilloscope
outer ear
pitch
rarefaction
refraction
sound quality (timbre)
transverse wave
wavelength

Focus for learning

Does anyone in your family or your class have a hearing impairment? This is quite likely, because 22% of the population in Australia has some form of hearing loss, and in 17% of these people this affects their speech. Hearing loss also increases after the age of 50, especially in males.

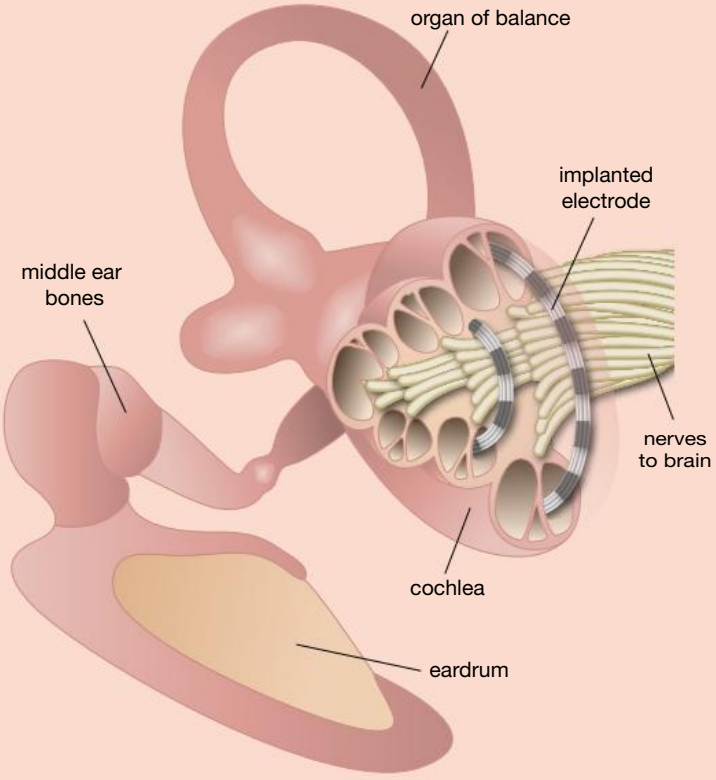
Hearing loss can be mild, moderate or severe. There are four main causes of this.

1. **Conductive hearing loss** occurs when a blockage or disease affects the outer or middle ear. It is not severe and can be corrected by surgery or treatment. A hearing aid can also be effective. The hearing of people with this type of hearing loss is affected in the same way your hearing is affected when you have a cold.
2. **Inner ear hearing loss** occurs when there is damage to the inner ear. It ranges from mild to severe, and is permanent. A hearing aid does not always help. What people with this type of hearing loss hear is similar to what you hear when you listen to a radio that hasn't been tuned properly and the words are fuzzy.
3. **Mixed hearing loss** occurs when there are problems with the outer or middle ear as well as the inner ear, resulting in permanent hearing loss.
4. **Central hearing loss** occurs when there is damage to the nerves that link the ear to the brain or to the part of the brain that makes sense of sound. The ear hears the sounds, but the brain cannot understand them.

Hearing loss can be inherited or caused through illness, ageing or accident. For example, central hearing loss is common in stroke victims.

Being hearing impaired does not affect a person's intellect, and children with a hearing impairment do just as well at school as other students. Hearing loss may affect their speech and language development, but this depends on the age at which the hearing loss occurred.

To understand hearing impairment in more detail you need to know how sound travels and how you hear sound. That is what this chapter is all about.



A cochlear implant or bionic ear can help people with inner ear damage. The implant turns sound waves into electrical signals that pass through an electrode implanted into the cochlear of the person. The cochlear implant was developed by Professor Graeme Clark at the University of Melbourne.

PROBLEM SOLVING

Teaching a hearing impaired person

Your task is to teach a person with hearing loss something about sound from this chapter. For example you may want to show how sound is caused by vibrations by having them see and feel something vibrate, or you could show them how sound travels through the ear, by using a model.

Submit your idea to your teacher for approval. You could even visit a school for the hearing impaired to test your success in communicating.

8.1 What is sound?

Sound is a form of energy. Sounds are made when matter vibrates (moves backwards and forwards). These vibrations can be transferred or passed on to other objects. Because sound causes changes in other things, it is said to have energy. For example, a plucked violin string vibrates, causing the air around it to vibrate too. This makes parts of your ear vibrate, so the sound is heard. In this way the energy from the violin string is transferred through the air to your ear.

Anything that vibrates can produce a sound. A flute creates sound because a column of air is vibrating inside it. The annoying rattle in the car occurs because a loose part is vibrating as the car moves.

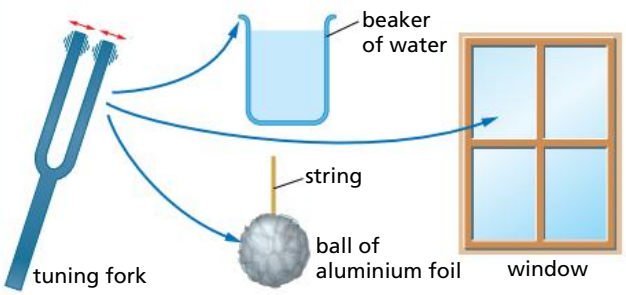
Instruments vibrate in different ways to make sound.

INQUIRY 1 Tuning fork

You will need: beaker, cotton thread, needle, ball of aluminium foil the size of a 20 cent piece, tuning fork

1. Fill the beaker to the top with water.
2. Strike the tuning fork against the heel of your shoe so that the ends of the fork vibrate.
3. Put the vibrating ends into the water in the beaker. What happens?
4. Strike the fork again and this time place it against your temple. What happens?
5. Thread a piece of cotton through a ball of foil with a needle and tie off the cotton. Hold the cotton so that the ball is suspended in mid-air.
6. Strike the tuning fork and lightly touch the ends of the fork to the suspended ball of foil. What happens? Explain your observations.
7. Strike the tuning fork and hold the stem of the fork to the middle of a window pane. What happens?

- Write inferences to explain all your observations.

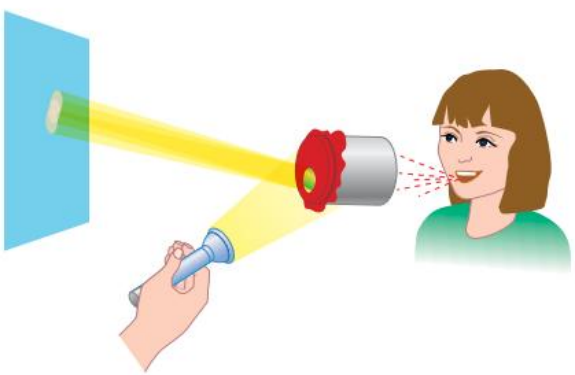


INQUIRY 2 Talk vibrations

You will need: tin can with both ends removed, piece of a balloon, small mirror (2 cm diameter), glue, rubber band, torch or microscope lamp, overhead projector screen

1. Stretch the piece of balloon over one end of the tin can and keep it in place with the rubber band.
2. Glue the mirror to the balloon skin 2 cm below the centre as shown.
3. Shine the torch onto the mirror and angle the tin so that the reflection falls on the screen. Sing, talk and shout into the tin can and observe the reflection on the screen. What happens? How can you change the size of the vibrations observed on the screen?

- Write inferences to explain your observations.

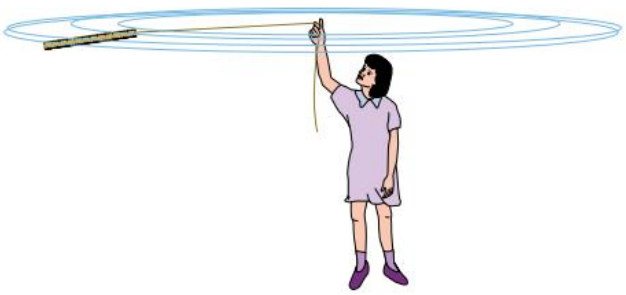


INQUIRY 3 Vibrating ruler

You will need: twine, scissors, wooden rulers cut to different sizes, each with a hole drilled in one end

For safety it is recommended that your teacher demonstrates this activity.

1. Tie 2 m of twine to the end of a wooden ruler.
2. Firmly hold the twine and in a large space outdoors swing the ruler around in a circle as fast as possible. Explain your observations.
3. Swing each of the rulers around and compare the sounds made. Which ruler makes the loudest sound? Which makes the softest sound? Which makes the highest sound? Which makes the lowest sound? Explain your observations.



INQUIRY 4 Wobble board

You will need: large hand saw, protective gloves, sheet of cardboard

For safety it is recommended that your teacher demonstrates the first part of this activity.

1. With the gloves on, hold the handle of the saw firmly and bend the blade of the saw backwards and forwards.
2. Record and explain your observations.
3. Wobble the cardboard backwards and forwards.
4. Compare the sounds made by the saw and the cardboard.
5. Try wobbling or vibrating other objects and compare the sounds made.

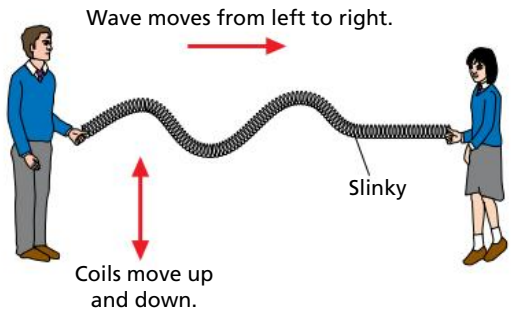
Sound waves

In the activities, the ends of the tuning fork, the balloon rubber, the ruler, the saw and the cardboard all vibrated to produce sounds. But how did the sounds reach your ears? In other words, how does sound travel?

Vibrations are carried to your ears in the form of waves. When the word 'wave' is mentioned you probably think of water—the surf crashing onto the shore. Water waves are different from sound waves. Let's examine both types.

Transverse waves

If you hold a Slinky spring and move your hand up and down, the metal coils go up and down too.



The energy from your hand is transferred to the wire coils of the Slinky. A single coil in the Slinky does not move along the Slinky. It only moves up and down, and each successive coil does the same thing. It is the energy that moves through the coils. The coils do not move along.

If you tie a rope to a doorknob and flick your hand up and down quickly, the same effect can be seen. Each part of the rope moves up and down, but no part of the rope moves forward. The type of wave made here is called a **transverse wave**.

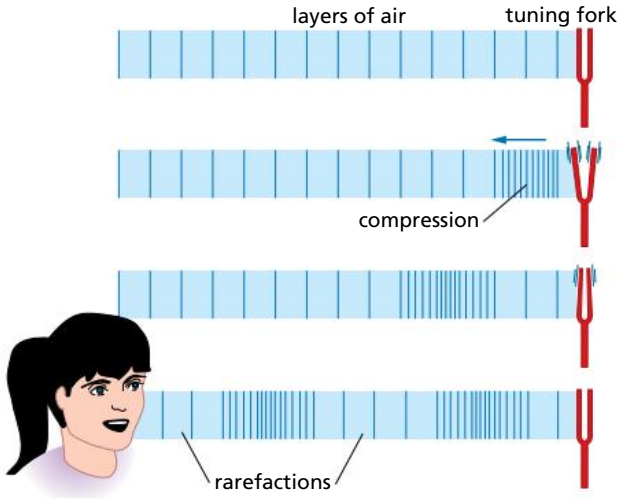
Water waves

Imagine that the water in a pond is made up of billions of invisible molecules. If you throw a stone into the pond, the energy from the stone will cause waves to move outwards in a circle from where the stone hits the water. Each water molecule will move up and down, but not forwards, as the energy passes through the water. This can be seen with a bowl of water and a cork. The cork bobs up and down as the wave passes, but is not carried forward by the energy of the wave. You will notice that boats bob up and down on the ocean for the same reason.

Longitudinal waves

Instead of moving the Slinky up and down, lie it on the bench and push the end coil into the next, squashing the end coils together. When you do this the energy created moves along the Slinky, but rather than going up and down each coil moves back and forth, hitting the coil next to it. The coils move from side to side, compressing each other and creating a wave of energy. This wave of energy is called a **longitudinal** (LON–git–TUDE–in–al) **wave**. Sound energy is carried this way.

When a tuning fork is struck, the prongs of the fork vibrate. As the prongs move outwards, they push the air molecules closer together. The air molecules vibrate too, pushing the molecules near them. When the air molecules are pushed closer together this is called **compression**. In between the areas of compression there are fewer molecules, spaced further apart. These are called areas of **rarefaction** (rare–i–FAC–shun). Sound energy moves along as a compression, then a rarefaction, repeated through the air.



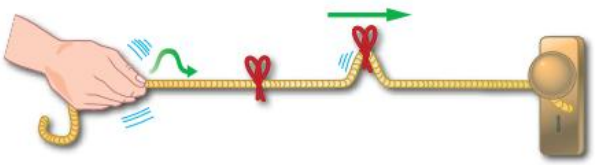
Layers of air stay in one place, but vibrate back and forth. The compressions and rarefactions travel through the air, causing a sound wave.

INQUIRY

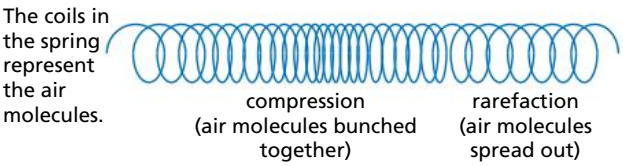
5 Seeing waves

You will need: rope, coloured wool, Slinky spring, pneumatic trough, stone, cork

1. Tie pieces of wool at regular intervals along a rope, then tie the end of the rope to a door knob.
2. Quickly flick your hand up and down to send a wave of energy moving along the rope.



3. Make the wave (energy) move faster or slower along the rope. Observe the wave of energy created each time.
4. Tie wool at regular intervals along a Slinky, then with the help of a partner create a transverse wave. Describe how the energy moves along the wave.
5. Create a transverse wave with water in a pneumatic trough. Observe what happens when a cork is placed on the surface of the water in the path of a wave.
6. Make a longitudinal wave in the Slinky.



Over to you

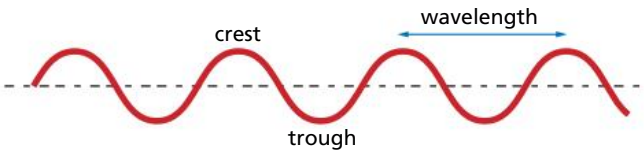
1. Explain why sound is considered to be a form of energy.
2. What makes sound? Give three different examples.
3. What is the difference between a longitudinal wave and a transverse wave? Draw diagrams to help explain each type of wave.
4. Think of a source of sound other than a tuning fork. Describe how sound energy is carried away from it as a longitudinal wave.

PROBLEM SOLVING

Remember your task is to teach a hearing impaired person about sound. How could you use rice grains and a drum to demonstrate that sound is caused by vibrations, using rice grains and a drum? What could they see and feel? How could you teach a hearing impaired person that sound is a form of energy carried in longitudinal waves?

8.2 Wavelength, frequency and speed

The wavelength and frequency of a wave tell you what the wave is like. Let's examine these on the diagram below.

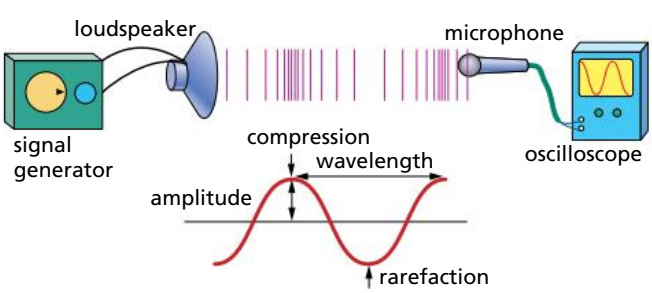


On the transverse wave pictured there are high and low points. Each high point is called a peak or *crest*, while each low point is called a *trough*. The **wavelength** is the distance between two successive points on the wave. This can be between one crest and the next, or one trough and the next. Wavelength is measured in metres.

If you stood at a high point overlooking a beach you could count the number of waves going past you every second. The number of wave crests that pass a given point in 1 second is called the **frequency**. It is measured in hertz (Hz). If 30 wave crests pass a point in 10 seconds, the frequency is the number of waves divided by the time in seconds, that is 30 ÷ 10 = 3 Hz. From your viewpoint above the beach you could also estimate how far a wave travels in 1 second. This would give you the *speed* of the wave in metres per second.

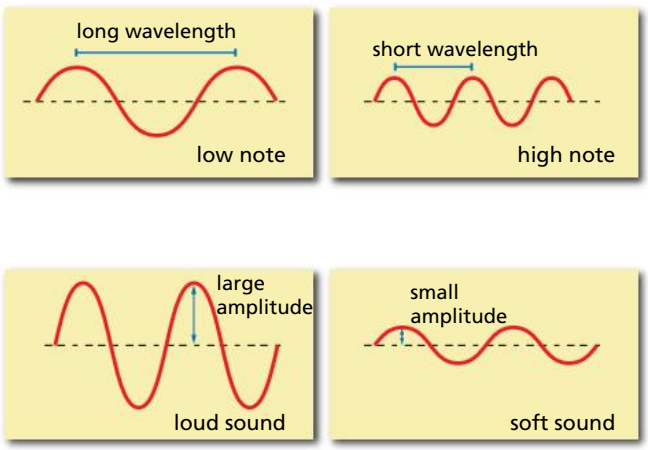
Viewing sound

Wavelength, frequency and speed can also be measured for a sound wave. The best way to do this is to use a machine called an *oscilloscope* (os-CILL-os-scope). This machine displays sound as a transverse wave even though it is a longitudinal wave. Compressions correspond to the peaks of the wave. The rarefactions correspond to troughs.



The note or **pitch** of a sound is determined by the frequency of the sound wave. Low notes have long wavelengths and low frequencies, high notes have short wavelengths and high frequencies.

The **amplitude** or height of the wave shows how far particles within the wave move. The amplitude determines whether the sound will be loud or soft. The larger the amplitude, the louder the sound. A small amplitude produces a soft sound.



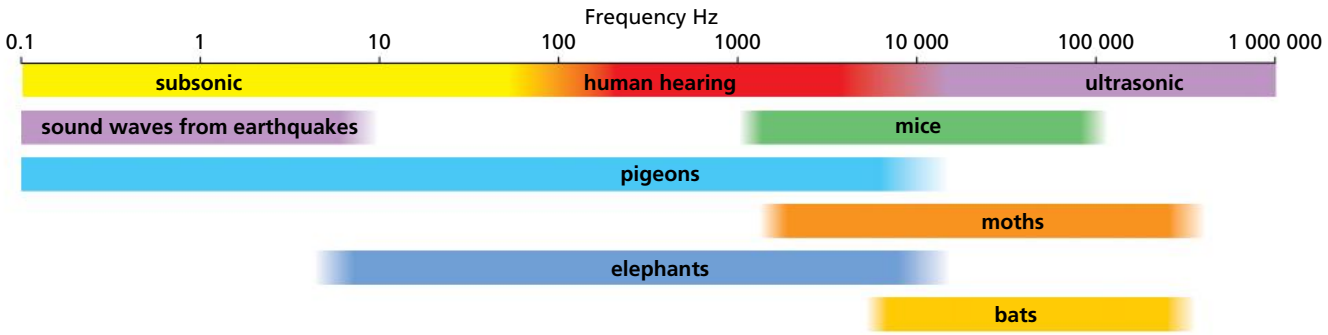
Different frequencies

Different sounds have different frequencies. If a small number of vibrations move past a point in 1 second, it has a low frequency and a low pitch. If the frequency is very low, the sound produced may not be heard. For example, you are not aware of the sound made by the beating of your heart because it has a very low frequency.

If many vibrations move past a point in 1 second, the sound has a high frequency and a high pitch. If the frequency is very high you may not hear the sound.

Human hearing ranges in frequency from as low as 15 Hz to as high as 20 000 Hz (20 kilohertz or 20 kHz) for a young person. An older person is less likely to hear the higher frequencies. A person of about 30 years of age can only hear frequencies up to about 15 kHz. By the time they are 60 they can only hear sounds up to about 10 kHz.

Dogs can detect frequencies up to 50 kHz, which is why they can hear thunder or a person at the door before you do. Bats and porpoises make sounds with frequencies of about 120 kHz, but can hear sound frequencies up to 150 kHz, way beyond our hearing. Sounds like this are called *ultrasonic*.



The different frequencies of some animals' hearing

INQUIRY 6 Ruler rumble

You will need: wooden ruler, plastic ruler

1. Position the wooden ruler as shown below, then push it down and let it go. What happens?
2. Shorten the ruler as shown. How does the sound change? Write a generalisation linking the length of the ruler to the frequency of the sound made.
3. Change the wooden ruler for a plastic one and compare the different sounds made.

INQUIRY 7 Seeing sound

You will need: oscilloscope and microphone

1. Make different sounds into the microphone of an oscilloscope and view the waves made.
2. Make high, low, soft and loud sounds. Draw the waves you see on the screen, labelling them with wavelength and amplitude.

INQUIRY 8 Frequency of insects

The buzz of an insect is made when the insect moves its wings back and forth very quickly, causing vibrations in the air. Different insects make different sounds because they move their wings at different rates. Mosquitoes move their wings about 25 times a second, flies about 120 times per second, and honey bees about 250 times per second. Male crickets rub their abdomen, legs and/or wings together to make a song to attract females. Some male crickets burrow underground and use the shape of the entrance to their burrow to *amplify* their song (make it louder).

You will need: small plastic container with a lid

1. Carefully trap an insect inside the plastic container without harming it. (A piece of meat on a bench can attract flies and you can place the container over the insect to catch it.) Close the lid.
2. Place your ear on the side of the container and describe what you hear. The container should amplify the sound.
3. Record your observations. Which insect makes the highest sound? The lowest sound?

Remember not to harm the insect, and let it go when you have finished.

Over to you

1. What is the difference between the wavelength, frequency and speed of a wave?
2. If 15 waves pass a given point in 1 second, what is the frequency of the waves?
3. If a sound wave is displayed on an oscilloscope, what do the compressions correspond to? What do the rarefactions correspond to?
4. Draw a diagram of a sound that is
   - **a** low and loud.
   - **b** low and soft.
   - **c** high and loud.
   - **d** high and soft.
5. Draw a scale of different frequencies starting at 15 Hz and ending at 150 kHz. On this scale show the different hearing levels for young and older people.

8.3 How sound moves

Speed of sound

Sound can be transmitted through anything that has particles in it to vibrate. How fast the sound is transmitted is affected by factors such as temperature. For example, sound can move through air because the particles vibrate easily. In dry air with a temperature of 0°C (at sea level) the speed of sound is slower than when the air is at 20°C. (See the table below.)

The speed of sound is different in different gases. For example, the particles in carbon dioxide are heavier and do not move as freely as the particles in air, so sound travels more slowly through this gas. The opposite occurs with helium and hydrogen. These gases are made up of particles lighter than the particles in air.

Sound also travels differently through solids and liquids. How fast sound travels through these substances depends on their elasticity, or how quickly they return to their original shape after being affected by the sound energy moving through them. The speed of sound in different materials is shown in the table.

Material	Speed of sound (m/s)
Soil	80–200
Dry air at 0°C	332
Air at 20°C	344
Wood	1000–5000
Water	1525
Copper	3350
Steel	4880

Thunder and lightning

When you see lightning you expect to hear thunder soon after. How far away the lightning is (in kilometres) can be estimated by counting the number of seconds between the lightning and the thunder and then dividing this figure by three.

When lightning flashes, the air is heated very intensely and quickly. This heated air expands and pushes outwards, compressing the air around it. After the flash, the air rushes back to fill the space left by the expanding air. This air movement produces a sound wave that is heard as a huge thunderclap. If you are very close to the lightning you see the flash and hear the thunder almost at the same time. If you are further away, you see the lightning before you hear the thunder. This is because light travels at 300 000 km/s, which is much faster than sound.

INQUIRY 9 Sound through solids

You will need: tuning fork, pencil, string, 3 spoons, fork, watch with a loud tick

For each of the activities below say what the sound travels through to reach your ears.

A Place a pencil between your teeth. Touch the pencil with a vibrating tuning fork. What happens?

B Touch the bony lump behind your ear with a vibrating tuning fork. What happens?

C Listen to a watch with a loud tick at different distances from you in air. Repeat this, but place the watch at different points away from you on the bench. Place your ear on the bench. Which transmits sound better—air or wood?

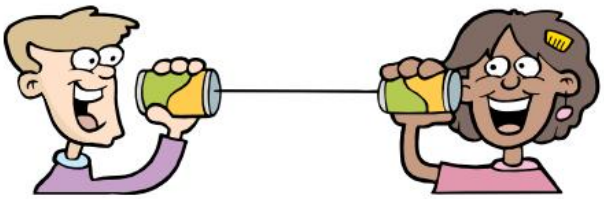
D Tie a fork to the middle of a piece of string and hold the string ends to your ears. Lean forward so that the fork hangs freely. Get a partner to hit the fork gently with a spoon. What do you hear? Set up the apparatus pictured below and this time get your partner to touch the spoons and fork with another spoon. What do you hear now?

E Lie down on a pathway and press your ear to the path. Get a partner to walk towards you. When can you hear them? Select different surfaces and predict which surface will best transmit sound. Explain your predictions. Now carry out the tests. Were your predictions correct?

INQUIRY 10 String telephone

You will need: string, fishing line, wool, wire, candle, pairs of different sized cans with the lid removed and a small hole drilled in the bottom, pair of match boxes, pairs of other boxes, vegetable oil

1. Take two tin cans the same size and thread a 3 m piece of string through the hole in the bottom of each can. Knot the ends of the string so that the cans do not fall off the string.
2. Have your partner hold one can to their ear while you talk into the other can. Keep the string between the cans tight.
3. Take it in turns to talk and listen. Explain how your string telephone works.



4. Investigate the variables that affect your string telephone. You could investigate the:
   - length of string
   - thickness of string
   - type of string, e.g. you could use fishing line, wool or wire
   - size of tins
   - type of tins (You could use boxes instead of tins.)
   - shape of tins
   - string coating (You could wet the string with water or coat it with candle wax or vegetable oil.).
5. Hold a competition to make the best string telephone.

INQUIRY 11 Sound through water

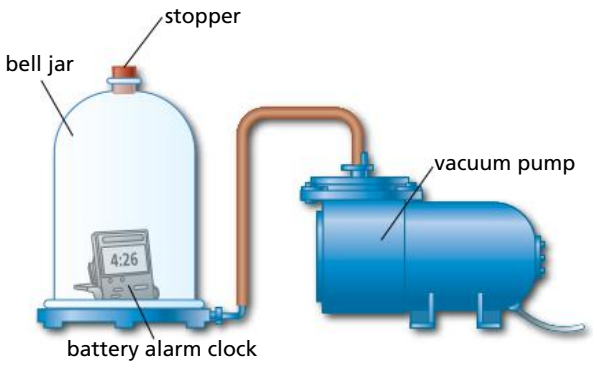
You will need: 2 spoons, 250 mL beaker, watch with a loud tick, pneumatic trough, 2 balloons

1. Blow up a balloon and tie it off. Press your ear to the balloon. Get your partner to rub the opposite side of the balloon with their fingers, carefully so that the balloon doesn't pop! What do you hear?
2. Repeat this activity, but this time fill the balloon with water. What difference does water make to what you hear?

INQUIRY 12 Sound through a vacuum

Can sound be heard in a vacuum where there are no air molecules?

You will need: bell jar with stopper and fitted base, small battery alarm clock, vacuum pump, rubber tubing, Blu-Tack



1. Set up the bell jar and attach the vacuum pump to the jar with the rubber tubing as pictured.
2. Place the alarm clock inside the bell jar.
3. Set the alarm on the clock to make it ring now, and secure the jar to the base. Seal any gaps with Blu-Tack.
4. Predict what will happen when the air is removed from the jar. Now switch on the pump. Was your prediction correct?
5. In space there are no air molecules, yet science-fiction movies often show spaceships zooming past and people hearing huge explosions. From this activity explain to movie makers what they are doing wrong.
6. Fill the pneumatic trough with water and hit the back of two spoons together underwater. Compare the sound of the spoons hitting in water to what you hear in air.
7. Use the pneumatic trough with water again. Get your partner to hold a large ticking watch to one side of the trough while you press your ear to the other side of the trough. Is it easier to hear the ticking through the water than through the air?

INVESTIGATION

1 Light before sound

Aim

To investigate the speed of sound compared to the speed of light.

Risk assessment and planning

1 Identify any possible risks that could occur during this experiment.

2 Copy and complete the table below to record your results.

	0 m	10 m	20 m	30 m	40 m	50 m
Attempt 1						
Attempt 2						
Attempt 3						
Average						

Apparatus

- starting pistol
- stopwatches (enough for the class)
- measuring wheel or tape
- chalk marker
- pair of ear muffs
- plastic cones

Method

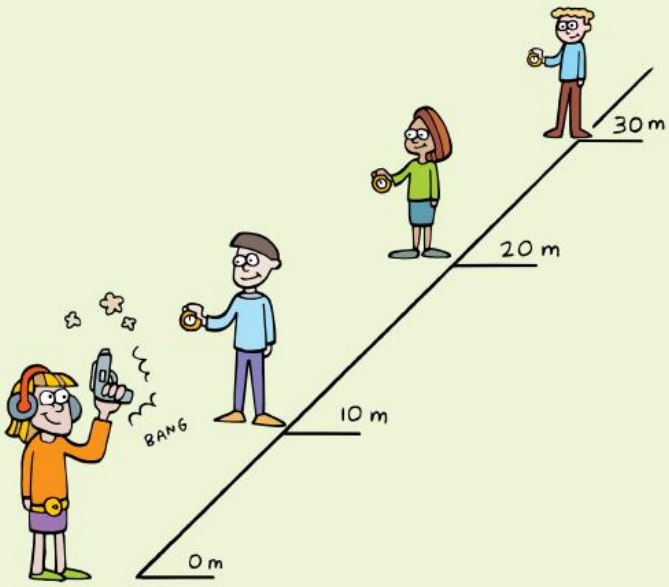
1 At one end of an oval, use a plastic cone to indicate a 0 m mark. Place cones at 10 m intervals away from the 0 m mark up to at least 100 m. Use all the space available to you. (The practical works best when there are marks more than 200 m from the starting point.)

2 Each student must stand on one of the marks with a stopwatch set at 0. For example, if there are 10 students then there will be a student on the 10 m mark, the 20 m mark etc. up to the 100 m mark. The teacher will be positioned at 0 m.

3 The teacher will fire the starting pistol. When you see the smoke from the gun, start timing. When you hear the sound from the gun, stop timing. Record the time interval between seeing the smoke and hearing the sound.

4 Do this twice more, recording the time interval each time.

5 Return to the classroom to collate the results on the board.



Results

1 Work out an average for each column. (Add up the times for each column and divide this number by 3.)

2 Why did you do the test three times and take an average?

3 Draw a line of best fit of the averages, with distance in metres on the *x*-axis and time in seconds on the *y*-axis. Which of these is the independent variable? Which is the dependent variable? Explain.

4 Why did you see the smoke from the starting pistol before you heard it?

5 What did the results show? Was there a noticeable difference between the times recorded for people closer to the gun than those further away? How can you explain this difference?

Discussion

1 What variables could have affected the results?

2 Were you able to control all variables? Explain.

Conclusion

Write a conclusion for this investigation.

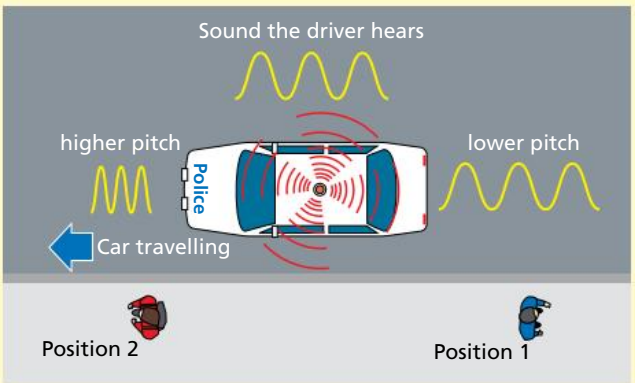
SCIENTISTS AT WORK

The Doppler effect

Christian Johann Doppler (1803–1853) was born in Salzburg, Austria. After completing primary school he went to Vienna to study mathematics. He did very well. He continued studying mathematics, as well as astronomy and mechanics, at the University of Vienna, becoming an assistant to his professor. Later Doppler took up a professorship at a technical school in Prague, teaching mathematics. Many more teaching positions followed. Doppler had to work as a bookkeeper in between his teaching positions to earn a living because teaching did not pay very well. Finally he became the director of the Institute of Physics at Vienna University.

Doppler is known for his principle called the *Doppler effect*. To explain this, think of a police car coming towards you with its siren on. According to Doppler, when the source of the sound (car) is coming towards you, the sound waves have a higher frequency, because they are pushed closer together. So the siren has a higher pitch. Once the police car passes, the sound waves are further apart, producing a lower frequency. So the siren has a lower pitch. Therefore, there has been a shift in pitch. (See diagram on the right.)

The Doppler shift and echoes can be used to explain how radar works. If you send a loud sound towards a car that is moving away you, some of the sound waves hit the car and bounce back as an echo. The sound reflected back to you will have a lower pitch because the wave has been spread out as the car moves away. In this way you can work out how fast the car is going and its distance from you. Radar uses radio waves instead of sound because radio waves can travel much further than sound waves and be detected even when very faint. A police radar gun also works in this way. It is accurate because it uses a single radar beam aimed at one car.



If you were in position 1, the siren would have a lower pitch than if you were standing at position 2.

Doppler radar is also used in weather forecasting. It shows whether a raindrop is moving towards or away from a given point and how far away the rain is. Wind causes the rain to move, so the radar also provides information on the wind.

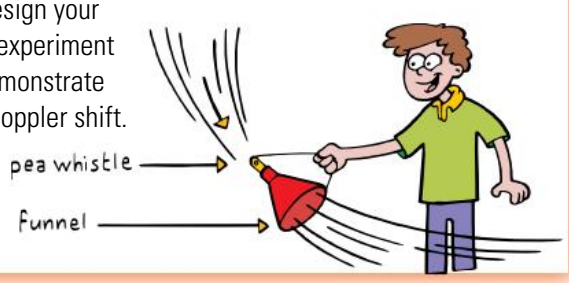
Many advancements in technology have taken place thanks to Doppler.

INQUIRY

13 The Doppler shift

In 1845 Doppler set up an experiment to demonstrate his theory of Doppler shift. He used a train to pull an open carriage full of trumpeters up and down a length of track. The pitch change was judged by people standing next to the track.

Design your own experiment to demonstrate the Doppler shift.



Over to you

1 Copy and complete these sentences.
- **a** Sound can be _____ through anything that has particles in it.
- **b** The speed of sound in dry air at 0°C is 332 m/s. The speed of light is _____ km/s.
- **c** The _____ of solids and liquids affects how fast sound travels through them.
- **d** You see lightning before you hear thunder because the speed of _____ is greater than the speed of _____.

2 How can you demonstrate that sound only travels where there are particles to vibrate?

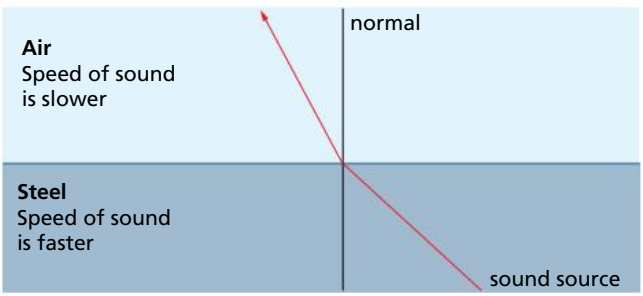
8.4 More about sound

So far you know that

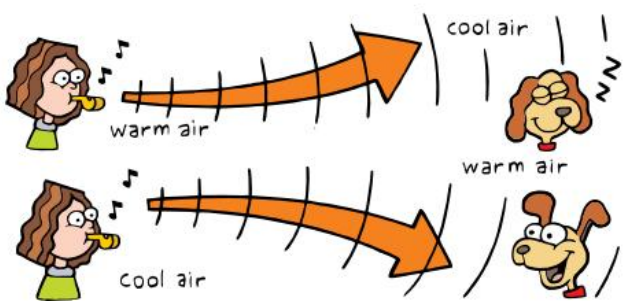
- vibrations make sound.
- sound energy is carried as a longitudinal wave made up of compressions and rarefactions.
- the frequency of a sound wave is the number of vibrations per second.
- wavelength, amplitude and frequency (pitch) are features of a sound wave that affect the sound made.
- sound can travel through solids, liquids and gases, but not through a vacuum.

Refraction

Sound waves travel in a straight line, but can be bent from their original path. **Refraction** or the bending of sound occurs when a sound wave moves into or out of different materials. The diagram below shows a sound wave travelling from steel into air. The sound waves bend towards the vertical line, called the normal, when they travel from steel to air. This is because the speed of sound is slower in air than in steel. The sound waves bend away from the normal if they travel from air to steel, because the speed of sound is faster in steel than in air.

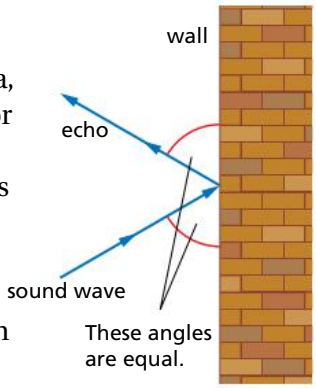


Sound waves are also affected by temperature. For example sound moves faster in warm air than in cold air. As shown in the diagram, when sound waves move from warm air to cool air, they slow down and bend upwards, away from the dog. He doesn't hear the sound. If they move from cool air to warm air they speed up and bend downwards, towards the dog.



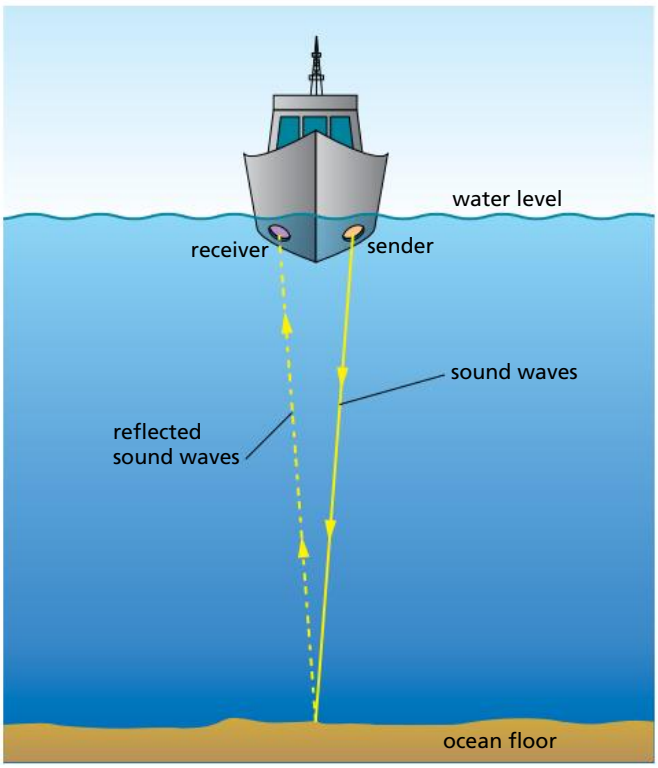
Reflection

Sound can also be reflected. When a sound wave hits a wall it bounces (reflects) back in the opposite direction. The angle the sound wave makes with the wall is the same as the angle the reflected wave makes with the wall. An echo occurs when sound waves hit and bounce off a solid surface such as a building or a mountain, and return to the source of the sound.



Sometimes we try to reduce echoes. In a concert hall, sound studio or cinema, the walls are often padded or have carpet or curtains on them to absorb sound waves and stop echoes occurring. However echoes can be useful. For example, the reflection of sound is used in *ultrasound* technology. When viewing an unborn baby using an ultrasound, an object called a transducer is placed on the mother's abdomen. High frequency sound waves of between 3.5 and 7.0 megahertz (million hertz) are sent from the transducer to the baby. The waves are reflected back to the transducer and the information collected is used to form a picture of the baby on a computer screen. The doctor can then examine the picture and take measurements of the baby to see how well the unborn child is developing.

The reflection of sound is also used in sonar, where sound waves sent through the water bounce off surfaces underwater and provide a picture of what is below. For example, the navy uses sonar to search the ocean for mines. The sonar uses frequencies of 30–500 kHz to find and identify mines up to 1000 m below the surface.



Different types of sounds

You may have noticed that each tuning fork has a letter on it, for example an A, which corresponds to the note heard when the tuning fork vibrates. A tuning fork vibrates at a single frequency to produce a pure tone or note.

Most of the sounds that we hear are not pure tones. They are made up of many different frequencies together. The sounds can be pleasant or unpleasant depending on how the frequencies are combined. For example music, speech and noise are three different types of sounds that are each a mixture of different frequencies.

Music

In an orchestra there are many different types of instruments. When these instruments play the same note, for example middle C, they all vibrate at the same frequency to produce the same pitch. However the *quality* or **timbre** (TAM-brr) of the sounds will be different. This is because instruments do not produce pure tones like a tuning fork. The predominant frequency they produce will correspond to middle C, but they produce other frequencies as well. Middle C on a violin will not sound exactly the same as middle C on a flute.

The notes can also vary in their *intensity*, which is the amount of sound energy passing through a square metre every second. Some sounds will therefore be heard from further away than others.

Speech

Everyone's voice is different because speech is made up of many different sounds and rarely contains pure tones. Two people may sing the same note, at the same pitch, but the note will sound slightly different, because the quality is different. This is why some people are considered good singers and some bad, and why it is possible to distinguish people by their voice alone.

Noise

Noise is a jumble of different sounds, whereas music is much more regular and pleasing to the ear. It is also a personal thing. What one person believes is noise may not be noise to someone else.

Decibels

The intensity of sound is measured in **decibels** (DESS-ee-bels). The decibel scale starts at 0 dB where sounds can only just be heard. Sounds at 40–50 dB are considered to be quiet, for example, normal speech. Once sounds reach a level of 70 dB they start to become very loud and annoying, for example, the sounds of city traffic. At 90–100 dB sounds can be very annoying and can damage your ears after exposure for 8 hours. Sounds 120 dB and above can be painful; sounds of 150 dB or more can break or rupture your eardrum.

The loudness of sound on the decibel scale does not increase one step at a time like going up a ladder. A small increase on the decibel scale produces a large change in the loudness of a sound. A sound of 100 dB, for example, would be twice as loud as a sound of 90 dB. So a sound can soon become annoying with just a small increase in decibels.

It is not always easy to know if you are damaging your ears. Here are some general rules. If any of these apply to you then it is possible that damage to your ears is occurring. You should move away from the sound to protect your ears if you

- can 'feel' the thump, thump, thump of music through a loud speaker.
- are unable to hear what the person standing next to you is saying over the sound.
- have music so loud when listening to your iPod that other people can hear it.
- are working with any power tools or engines without wearing protective ear muffs.
- have pain or ringing in your ears when you are listening to a sound.

Sound	Decibel level (dB)
Sound just heard	0
Whispering	30
Library	40
Normal speech	50
City traffic	70
Train 10 metres away	90
Lawn mower	100
iPod at maximum volume	110
Rock concert	110
Factory machinery	120
Jet plane taking off	130
Gun firing, explosion	140

INQUIRY 14 Singing different notes

You will need: tuning fork, oscilloscope, different musical instruments

1. Strike the tuning fork on the bench and view the sound wave on the oscilloscope. What do you notice about the wave produced?
2. View sound waves produced by different musical instruments playing the same note.
3. Try to sing the same note and observe the wave made. Was the quality of the note pure?

It is possible to sing a note at a frequency and intensity that makes a glass vibrate and break.

INQUIRY 15 Sound echoes

Design your own experiment to show how sound can be reflected.

SKILL

Using your own words

In this book you may be asked to read something and then write it in your own words. This is an important skill when answering questions and doing projects, because you should not copy somebody else's work. It is also a good way to revise. Here are some steps to follow to learn this skill.

1. Carefully read the information and make sure you understand it.
2. If you have a copy of the information you can underline or highlight the important words and sentences. If not, write them down.
3. Read a paragraph and then cover it with your hand or a piece of paper. Write down what you remember from the paragraph. You can leave out a paragraph if you think it is unnecessary.
4. Continue with each paragraph until you have finished reading.
5. Finally, check that the important words you listed in Step 2 are contained in your writing.

Use these steps to write the article below in your own words.

Speaking whale and dolphin

Animals such as whales and dolphins use echolocation to get a picture of their environment. They make a variety of sounds that are reflected back to them from their surroundings. This tells the animal what is around it. For example, toothed whales use low frequency sounds to produce echoes that seem to indicate the water depth, obstacles in the water and the location of the shore. When they get closer to an object in the water these whales make a series of clicks, which are reflected back to the lower jaw and passed on to the middle ear. Whistles, clicks and groans seem to be how toothed whales communicate with one another. They also produce very high, intense bursts of sound that may be used to stun their prey when hunting.

Dolphins produce sounds with frequencies much higher than what humans can hear. Like whales, dolphins use clicking and creaking sounds to communicate and gather information.

It is believed dolphins have a language. They can converse and give instructions to one another. Instead of names, dolphins recognise each other by certain whistles, and a young calf soon knows its mother's whistle.

Dr Vincent Janik from the Woods Hole Oceanographic Institution in the United States studied wild bottled-nosed dolphins near Scotland. He found that these dolphins used whistles to tell others where they were and who made the sound. He identified 1700 different whistle calls. Dolphins use these calls not only to communicate with one another, but to keep in contact with others over large distances or where water visibility is poor. They also tell others where to find food.

Janik's work is important because few studies on wild dolphins have been made. It also shows that we have a lot to learn in order to speak or *squeak* dolphin.

INVESTIGATION

2 Making music

Aim

To design your own musical instrument that demonstrates one of the following.

a Anything that vibrates produces sound.

b Varying the frequency of the vibrations makes low and high-pitched sounds.

c The length of a straw affects the sound produced by blowing through it.

d The length and tension of a string affects the sound produced by plucking it.

Risk assessment and planning

What are you going to do? Try to use materials that you have at home. The following diagrams may help you with ideas for your musical instrument.

Results, Discussion and Conclusion

Demonstrate your instrument to the class and explain how it works. Assess the effectiveness (success) of your instrument and whether the design could be improved.

Over to you

1 What is the difference between refraction and reflection of sound?

2 Give an example of a place where an echo is

a unwanted.

b useful.

3 The speed of sound in air at a temperature of 20°C is 344 m/s. How long would it take for an echo to return to its source across a valley 1032 m wide?

4 If it takes 15 seconds for thunder to reach you, how far away is the lightning? (Assume sound travels at 332 m/s at 0°C.)

5 Copy and complete the following sentences, with the correct words from the list below.

decibels, 90 dB, frequency, change speed

a Sound waves are refracted when they _____.

b Sound levels are measured in _____.

c The pitch of a note is determined by the _____.

d Your ears can be damaged at sound levels of _____ or more.

6 Maria plays the flute and Gino plays the violin. When they both play the same note, they sound different. Explain to Maria and Gino why the same note played on their instruments does not sound exactly the same.

7 List three signs that indicate you could be damaging your ears.

8 How could you change the pitch of a note on a

a guitar?

b drum?

c test tube full of water?

9 Why is there sometimes little difference between what is considered to be noise and what is considered to be music?

PROBLEM SOLVING

Remember your chapter task? Can you use different musical instruments or the instrument you made in Investigation 2 and an oscilloscope to

a demonstrate sound?

b show the difference between a low note and a high note?

c demonstrate that the same note played on two different instruments is not always the same?

Didgeridoo

INQUIRY 16 Straw Oboe

You will need: 2 drinking straws, slightly fatter drinking straw, scissors

1 Flatten the end of a drinking straw between your teeth. Use scissors to cut the end of the straw into a V shape, as shown.

2 Clench the cut end of the straw between your lips and blow hard. It will take a bit of practice, but you should be able to produce a loud sound.

3 Try cutting the straw while you blow. Each cut shortens the straw and the pitch gets higher.
   - Try to explain how your straw oboe works.

4 Slide a second slightly fatter straw over the first straw to make a trombone, where you can vary the pitch.

With the straw oboe you make the cut end of the straw vibrate. Once you get it right, the column of air in the straw vibrates and you can feel the whole straw vibrate. A didgeridoo works in a similar way.

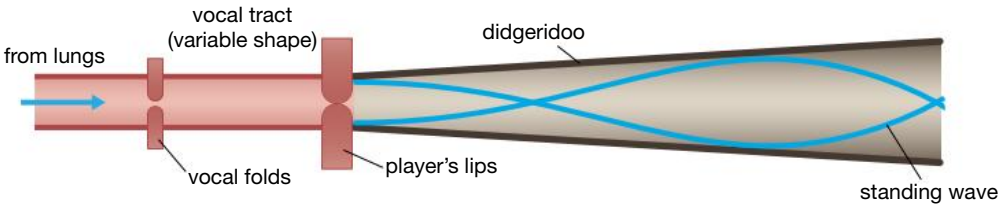
The didgeridoo is thought to be the world's oldest wind instrument. Archaeological studies of rock art suggest that Aboriginal people of the Kakadu region of the Northern Territory have been using the didgeridoo for at least 1500 years. *Didgeridoo* is not an Aboriginal word. Different tribes use different names. In Arnhem Land it is called a *yidaki* (yih-DA-kee). Traditionally, the didgeridoo is played mainly as an accompaniment to ceremonial dancing and singing, usually with clap sticks.

The didgeridoo is made from a hollow branch of a tree, further hollowed out by nesting termites. It varies in length, but is usually about 1.5 m in length. The longer the didgeridoo, the longer the column of vibrating air and the lower the pitch of the sound it makes. It is played by vibrating the lips to produce a drone (essentially blowing a 'raspberry')—a similar technique to that used with brass instruments. The didgeridoo plays only one note but is capable of complex variations of the timbre of this note (see page 168). The player does this by manipulating his lips, tongue, throat and mouth shapes. He breathes in through his nose while at the same time blowing air out of his mouth.

The Australian band, Yothu Yindi, commonly use didgeridoos in their performances.

How does it work?

The musician sends pulses of sound down the didgeridoo which are reflected back from the open end (see the diagram at the bottom of the page). The outgoing pulses interact with the reflected pulses to set up a *standing* sound wave, as shown in the diagram below. This wave doesn't travel like a normal sound wave, but stays in the same place. When the player vibrates his lips to match the natural frequency of the hollow tube, the whole didgeridoo vibrates or *resonates*. The sound travels into the player's vocal tract, which also resonates, depending on its shape. The shape of the vocal tract can be changed by the position and shape of the tongue.



8.5 Human hearing

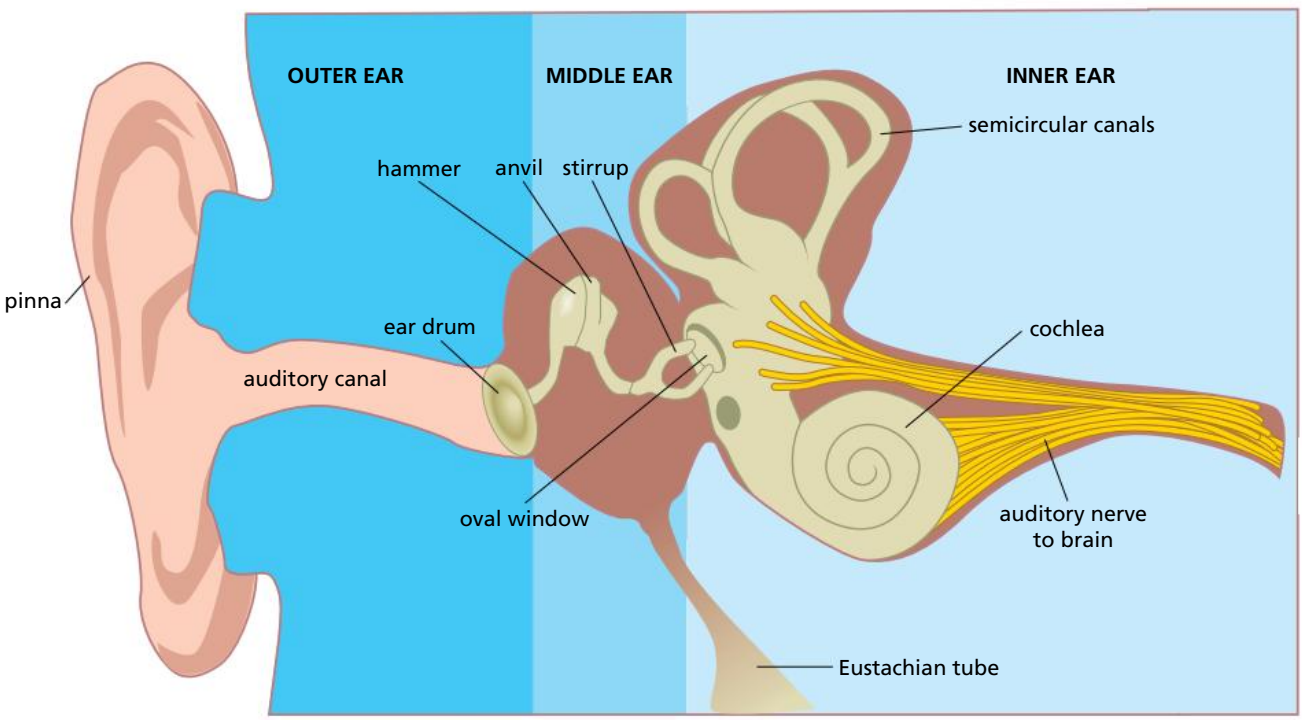
Sound energy is transmitted as vibrations through solids, liquids and gases. We hear the sound when we detect these vibrations. In Inquiry 9 you were asked to strike a tuning fork on the bench then touch it to the bony lump behind your ear. You were probably able to detect the vibrations from the tuning fork because they were transmitted to your inner ear through the bones of your skull, allowing you to hear the sound. This is called bone conduction and some sounds are heard this way. For example, you know the sound of your own voice through bone conduction.

However it is normally the job of your ears to detect sound waves. Let's follow the journey of a sound wave through the ear.

1. Vibrations are collected by the *pinna* and channelled into a tube about 3 cm long called the *auditory canal*. At the end of the auditory canal is a thin, stretched membrane called the *eardrum*, which is able to vibrate. The pinna, the auditory canal and the eardrum make up the **outer ear**.
2. The eardrum is connected to three small bones called the *ossicles* that link together in an air-filled chamber called the **middle ear**. As vibrations pass from the eardrum to the first bone, called the *hammer*, the sound is amplified.
3. The hammer moves the next bone, the *anvil*, which then moves the *stirrup*. This bone is about the size of a grain of rice and is the smallest bone in the body. It is connected to the oval window. The vibrating stirrup moves the oval window in and out. Very loud noises can damage these bones if they move too much. So muscles attached to them limit their movement and protect the middle ear.
4. From the oval window, vibrations move to the *cochlea* which is part of the **inner ear**. The cochlea is like a coiled snail shell, made up of tubes filled with fluid. Within the cochlea are sensory cells with hair-like projections. The vibrating fluid moves the hair cells, which send impulses to the brain via the *auditory nerve*. The brain interprets this information as sound.

The Eustachian tube

The back of the nose and the mouth are connected to the middle ear by a tube called the *Eustachian* (you-STAY-shun) *tube*, named after an Italian biologist Bartolomeo Eustachio. This tube keeps the pressure the same on both sides of the eardrum, so that the eardrum doesn't break. For example, when you take off in a plane, the air pressure in the middle ear is higher than the air pressure in the outer ear. This pressure difference is felt as discomfort or pain in your ear. Yawning, swallowing or coughing opens the Eustachian tube and balances the pressures.



The inner ear

As well as the cochlea, the inner ear contains three tubes—the *semicircular canals*. Two of the tubes are in a vertical position and detect up and down movements of the body such as jumping and falling. Side to side movements such as spinning and turning are detected by the third tube, which is in a horizontal position. The tubes all contain fluid and cells with hair-like projections. Any body movement causes the fluid inside the tubes to move, stimulating the cells to send information to the brain, telling it the position of the body.

The inner ear is also responsible for orientation (knowing what position your head is in). Any head tilt causes information to be sent to the brain about the position of the head. The inner ear also tells your brain when you have stopped moving.

Causes of hearing loss

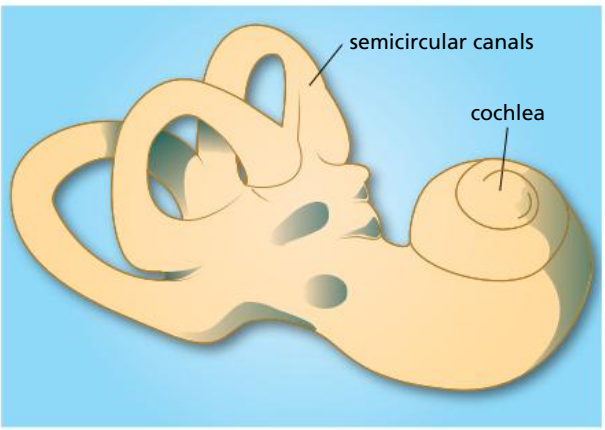
There are many reasons why a person may have a hearing impairment.

INQUIRY 17 Semicircular canals

The diagram below shows a more detailed picture of the semicircular canals. Use this to make a model of this part of the inner ear.

You will need: plastic tubing, coloured water, any other equipment

Demonstrate to the class how your model works. You could even use your model to show hearing impaired children how this part of the inner ear works.



In the outer ear:

- the pinna or auditory canal may be missing
- the pinna may be deformed or scarred
- foreign bodies or wax may be blocking the auditory canal
- the eardrum may be ruptured.

In the middle ear:

- there may be an infection
- the Eustachian tube may be blocked from a head cold, tonsillitis, blocked sinuses or a bacterial infection
- spongy bone may have grown, preventing the ossicles from moving.

In the inner ear there may be:

- tumours of the auditory nerve
- skull injuries
- damage to the cochlea
- abnormal semicircular canals.

Some of these problems can be corrected. Antibiotics can clear infections of the middle ear, and surgery can remove bony deposits that are preventing hearing. However, problems with the inner ear usually result in total loss of hearing or severely impaired hearing.

Hearing aids and cochlear implants

A hearing aid is a tiny electronic device that amplifies sound (see the photo on page 156). Within it are a microphone, an amplifier, a small speaker and a battery. They are connected to a tube that carries the amplified sound into the ear. If a person needs to amplify sounds even more, they can carry a larger unit in their pocket. A hearing aid only makes sound louder for the wearer. Sounds must still pass through the ear, so it is of no use to people who have deafness because of inner ear damage. A hearing aid amplifies all sounds, even those that the person may not want to hear.

A cochlear implant can help people with inner ear damage, but only if their auditory nerve still works. The implant turns sound waves into electrical signals that pass through an electrode implanted into the cochlea of the person. The information from the cochlea is then sent to the brain through the auditory nerve. Although a person with a cochlear implant cannot hear as many sounds as a hearing person, they can learn to interpret what they hear.

INQUIRY 18 Spinning and balance

You will need: large open space, blindfold, stopwatch

1 With a partner to steady you if you need it, spin around very quickly for 20 seconds, then try to stand in one spot. What do you notice?

2 Spin again, but when you stop, try to walk in a straight line.

3 Repeat Steps 1 and 2, this time wearing the blindfold. What do you notice?

Does having your eyes open make any difference to how well you perform after spinning? What can you conclude from this activity?

INQUIRY 19 Recognising sounds

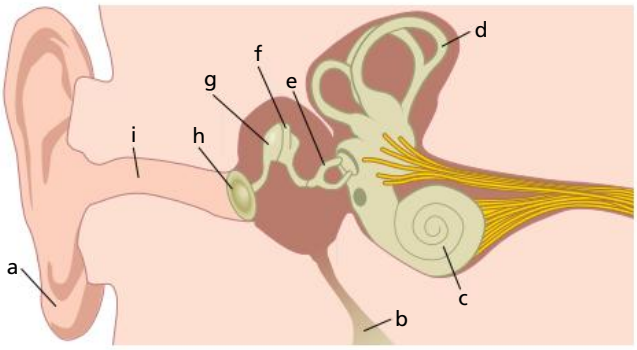
It is the job of the brain to recognise the sounds that are sent to it. Humans are able to recognise about 500 000 sounds. Any sound that reaches the brain is compared to this store of sounds. New sounds are added to memory.

You will need: tape recorder, tape with 10 different sounds on it

Your teacher will play you 10 different sounds. Write down what you think each sound is and see how good you are at recognising the sounds played.

Over to you

1 Label the parts marked on the diagram below.



2 **a** Place these parts in their correct order from the outer ear to the brain:
cochlea, brain, oval window, pinna, eardrum, stirrup, auditory nerve, hammer

b State which of these parts make up the outer ear, the middle ear and the inner ear.

3 Describe in your own words how sound moves through the ear.

4 Explain why the Eustachian tube is connected to the middle ear.

5 Explain why spongy bone growing between the ossicles causes hearing loss.

6 If a person is sick and feeling dizzy, which part of their ear is likely to be affected? Explain.

PROBLEM SOLVING

Do you have any ideas for teaching a hearing impaired person about sound? Here are a few suggestions.

- Place your fingers on your throat and make low and high sounds. What do you notice about the vibrations that you feel?
- Hold a blown up balloon against your throat and get the hearing impaired person to place their hands on the balloon. Talk to them. What do they notice?
- Build a model of the ear to show how sound moves through it.

At this stage you should have enough information to complete your task.

THINKING SKILLS

1 The following table shows the highest sound frequencies that the average person can hear.

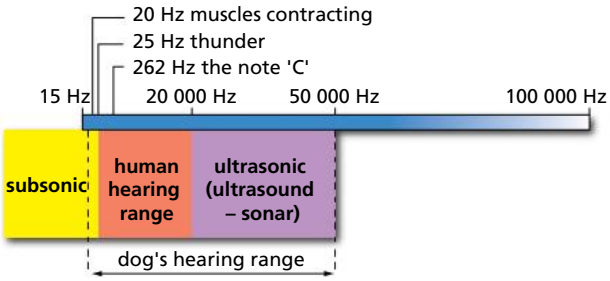
Age (in years)	Highest frequency (kHz)
16 or less	20
30	15
60	10
70	6

a Draw a graph of these figures.

b From the graph, predict the highest frequency that a person who is 20, 40 and 50 might hear.

c Would you expect a person who has been a tractor driver most of his life to have graph results like this? Explain.

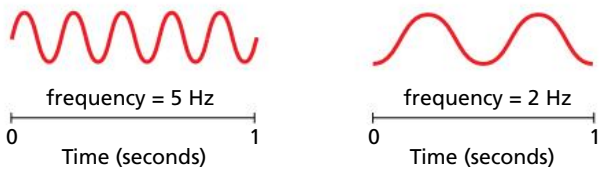
2 Look at the diagram below.



a From this diagram, give a meaning for the words *subsonic* and *ultrasonic*.

b Give examples of sounds that fall in the subsonic and ultrasonic range. (The diagram at the top of page 162 will also help you.)

c Draw a diagram of each frequency mentioned in the diagram above, showing the frequency of each sound wave. (You may have to display the large numbers as kHz instead of Hz.) Two examples are provided for you here.



3 If you block one ear with cotton wool or an earplug and hold the stem of a vibrating tuning fork to the centre of your forehead, you will hear the sound on the side of the blocked ear but not in the unblocked ear. Try this and then try to explain why it happened.

4 A person with damage to the outer and middle ear can 'hear' sounds by bone conduction. What structures of the ear still need to work for this to take place?

5 In Inquiry 9 you used a string, spoons and a fork to make vibrations. Holding the string to your ears and letting the fork and spoons hang freely let you hear sounds when the fork and spoons were hit.

a Does the length of the string or the number of forks and spoons make a difference to the sound produced? Test your predictions.

b Do other objects produce a better sound? Carry out some tests and see.

6 Using a sound meter, carry out a sound survey of different places around your school. Which are the loudest places? Which are the quietest places? Are there any places where the sound is too loud? Put forward a proposal to improve sound levels in your school.

7 Design an experiment to test whether a person can hear equally well in all directions.

8 Design and carry out a test to measure the range of hearing of the people in your class.

9 We use our larynx or voice box to make sounds. Investigate how the larynx works and report back to the class.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 Sound is caused by _____. Sound has energy because it can affect other things.

2 Vibrations are carried by waves. Water waves are called _____, whereas sound waves are _____.

3 _____ is the distance between one crest of a wave and the next. The number of waves that pass a given point in 1 second is called the _____. It is measured in hertz (Hz). The _____ of a wave is measured in metres per second.

4 The _____ determines how loud or soft a sound is.

5 Sound can be _____ through anything that has particles in it to vibrate and carry the sound. This includes solids, liquids and gases.

6 _____ of sound occurs when a sound wave moves in and out of different materials. An echo is a _____ sound wave.

7 The loudness or volume of sound is measured in _____.

8 Our ears detect sound waves and they also help us keep our _____.

9 _____ occurs when sounds cannot travel through the ear to the brain.

amplitude
balance
decibels
frequency
hearing loss
longitudinal waves
reflected
refraction
speed
transmitted
transverse waves
vibrations
wavelength

Self-management

Correcting mistakes

It is an important skill to be able to review your work and correct any mistakes. This is essential when you are completing a test where a silly error could cost you marks.

1 Find the words in this list that are spelt *incorrectly*. Write them out correctly in your notebook.

enargy, vibration, pittch, oscilloscope, longtundinal, frequncie, wave, amplitde, compression, rarfaction, cochleah, wavelenth, pina, refraction, refflection, decibells

2 Correct the following sentences in your notebook.

a One vibration per second is equal to 1 kHz.

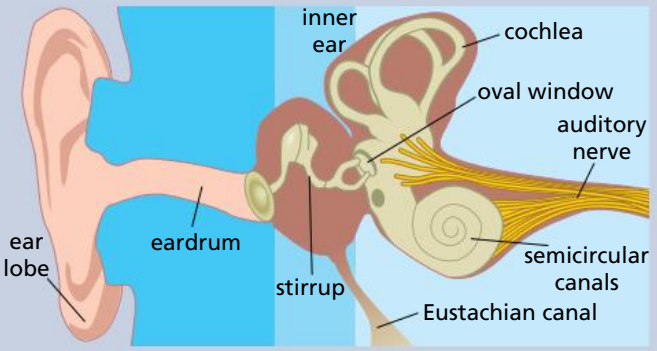
b A sound wave is a series of compressions and rarefactions in a transverse wave.

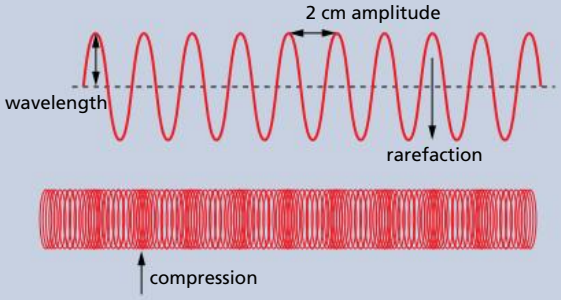
c The speed of sound varies with temperature. In air at 20°C it is 340 m/s.

d The hammer in the middle ear is connected to the oval window so that it can pick up sound waves from the outer ear.

e Refraction of sound occurs when an echo hits a wall and bounces back.

3 Correct the mistakes in these two diagrams.





Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources
OneStopScience

1 Copy and complete the sentences below.

a Anything that _____ can produce a sound.

b The note or _____ of a sound is determined by the frequency of the sound wave.

c The _____ is the distance between one crest and the next on a wave.

d The speed at which sound travels through solids and liquids depends on their _____.

e Vibrations are collected by the _____ of the ear and channelled into the auditory canal.

2 If the speed of sound in cold air is about 330 m/s, complete the following sentences using the words faster or slower, relative to the speed in cold air.

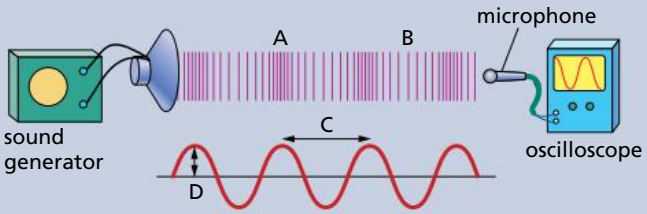
a The speed of sound in carbon dioxide is _____.

b The speed of sound in warm air is _____.

c The speed of sound in a solid is _____.

d The speed of sound in hydrogen _____.

3 Look at the diagram below.



a What are the missing words at A, B, C and D on the diagram.

b What type of wave is the sound wave?

c What type of wave can you see on the oscilloscope?

d The wave pictured has a long wavelength. What type of sound would this make?

e The wave has a small amplitude. Is it a loud or a soft sound?

f What happens to the air particles during compression?

g What happens to the air particles during rarefaction?

4 **a** What does the word *frequency* mean?

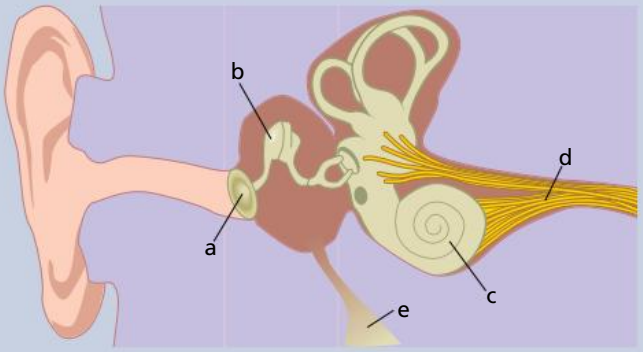
b What does the frequency tell you about a musical note?

c Why do dogs hear thunder before humans do?

d How could you use a ruler to show the difference between a high frequency sound and a low frequency sound?

5 **a** What are the labels missing from this diagram?

b What happens in each part?



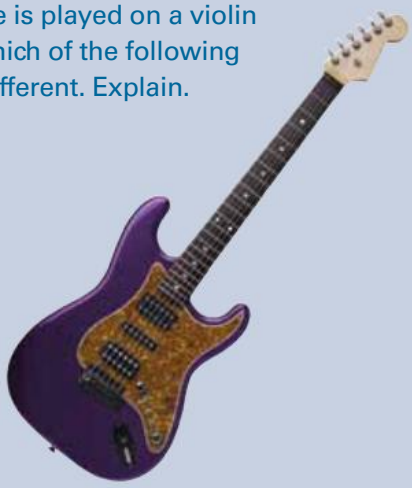
6 Saxon is hearing impaired. One day his teacher organised the class to run a 100 m race. The teacher stood on the finish line and the students lined up at the start line. As Saxon was unable to hear the starting pistol, his teacher told him to start running when he saw the smoke from the gun. At the end of the race the students complained that Saxon had started running before them. Could this be true? Explain.

7 If the same note is played on a violin and a guitar, which of the following is likely to be different. Explain.

a pitch

b quality

c intensity



8 Explain how the ear controls balance as well as hearing.

9

Planet Earth

By the end of this chapter you will be able to …

Science Understanding

- apply a knowledge of the water cycle to explain the formation of clouds and rain
- describe how the presence of water vapour in the atmosphere affects the weather
- apply a knowledge of balanced and unbalanced forces to everyday situations such as drinking through a straw or floating in salt water

Science Inquiry Skills

- write a report on Earth by aliens from the imaginary planet Dork
- use laboratory equipment to make the gases hydrogen, oxygen and carbon dioxide
- distinguish between dependent and independent variables and interpret line graphs

Focus for learning

Imagine there is intelligent life in space. There are creatures called Dorkians on the planet Dork—the third planet around the star HD136118. They have discovered the planet we know as Earth and think it might be similar to their own planet. They have travelled to Earth to investigate.

The Dorkians find that Earth is not as large as Dork—only 12 800 km in diameter. They measure the time it takes Earth to rotate on its axis (24 hours). It is a blue colour since about two-thirds of the surface is covered by oceans. There are patches of white clouds that are constantly moving. Temperatures range from 50 °C at the equator to –90 °C at the poles. This is far warmer than Dork so they plan to land well south of the equator. Their instruments detect a strong magnetic field, and from the way shockwaves travel through the Earth they infer it is partly molten inside.

The Dork spaceship enters the planet's atmosphere. The Dorkians analyse it to see if it is breathable. They find it is four-fifths nitrogen and one-fifth oxygen—not ideal for them but it probably could be modified. They are also a little concerned that the atmosphere doesn't filter enough of the dangerous UV radiation from the sun, especially near the poles. The ocean is H_2O (water), unlike the methane oceans on Dork.

They land near an active volcano in a long mountain range. Red-hot lava is flowing towards a small village where there are signs of intelligent life. They notice the ground is shaking and infer a dorkquake is occurring. They make no attempt to communicate with the Earth creatures. They are fascinated to find that the sky is blue during the day and turns red as the planet turns to face away from the sun.

The gravity is less than on Dork and their ship has no trouble escaping from the planet's gravity and starting the long journey 170 light years back to Dork.

PROBLEM SOLVING

The Dork Report

Imagine the sort of detailed report that the Dorkians would send back to their home planet about planet Earth. As you work through this chapter, your task is to write the Dork Report using the information in this chapter and from other sources if you like.

Your report should have five parts, one for each section in the chapter. Write about half a page for each section and include illustrations where necessary. Finish with a recommendation to the Chief Dork on whether Earth is a suitable place for Dorkians to live.

LITERACY FOCUS

Archimedes' principle
atmosphere
buoyancy (upthrust)
carbon dioxide
core
crust
epicentre
equilibrium
extrapolating
fault
global warming
greenhouse effect
humidity
interpolating
isobars
magma
mantle
ozone layer
pressure
seismograph
tsunami
variables

9.1 Our restless Earth

The photo below shows an eruption of Mt Etna in Italy, with lava flowing down the side of the mountain. Volcanic eruptions like this give us some idea of what it is like inside the Earth.

Structure of the Earth

The Earth is made up of three main layers—the crust, the mantle and the core, as shown on the right.

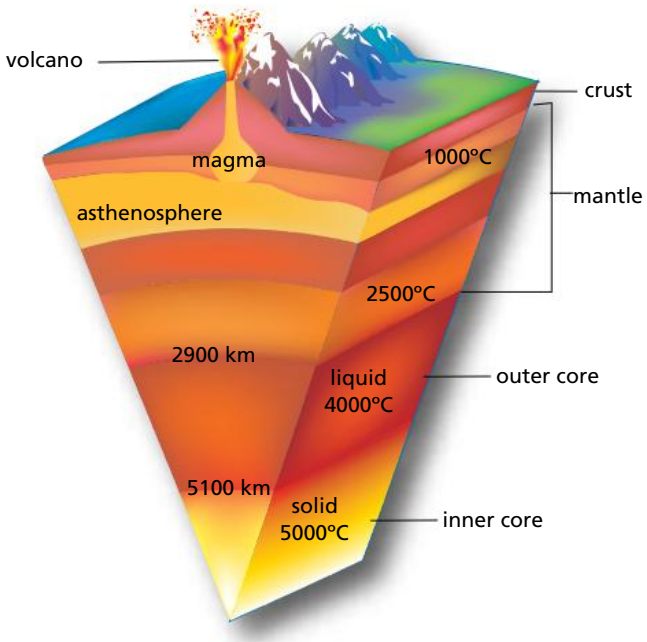
The layered structure of the Earth is a bit like a soft-boiled egg. The outermost layer is called the **crust**, and is very thin compared with the other two layers. It is thicker under the continents than under the oceans. Like the shell of an egg, the Earth's crust can break.

Below the crust is the **mantle**, which can be thought of as the white of the egg. It is a layer of semi-solid rock almost 3000 km thick. It is hotter and denser than the crust because temperature and pressure inside the Earth increase with depth.

Scientists have been able to measure the density of the Earth's **core** and from this they infer it is made of iron and nickel. Unlike the yolk of an egg, however, it is made of two distinct parts—a liquid outer core and a solid inner core.

The crust and the upper part of the mantle form a rigid layer called the *lithosphere* (LITH-os-fear). Immediately below this is the *asthenosphere* (ass-THEN-os-fear). There is so much heat and pressure here that the rock can soften and flow. The intense heat causes circular currents that flow very slowly in the semi-solid viscous material—only 4–5 cm a year. The rigid lithosphere is thought to 'float' on top of the asthenosphere.

When hot molten rock called **magma** is forced upwards from the asthenosphere it may burst through cracks in weaker regions of the crust. When this happens volcanoes form.

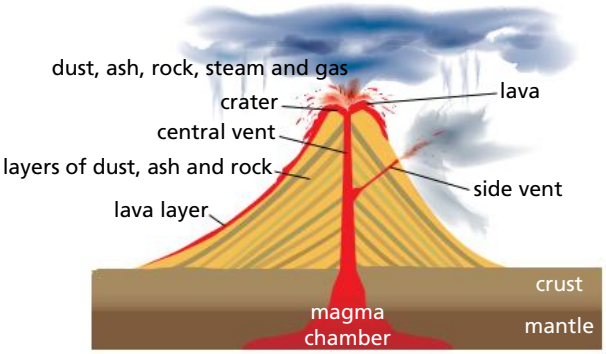


As you saw on page 126, the Earth has a magnetic field. Scientists are not sure but they infer this magnetic field is caused by the churning, twisting flow of molten material in the outer core.

Volcanoes

Volcanoes are formed when magma from inside the Earth is squeezed to the surface. This occurs when there is a build-up of pressure inside the Earth. When the molten rock reaches the surface it is called *lava*.

Volcanoes can erupt on land or under the sea, and there are three types. *Active* volcanoes are ones that are erupting, and there are about 500 of these around the world. The nearest ones to Australia are in New Zealand and Papua New Guinea. For more information look up the website www.volcanoworld.org. A *dormant* volcano is a volcano that is not active at the moment, but could become active again in the future. *Extinct* volcanoes are 'dead' and will not erupt again. There are many in Australia, for example Tower Hill in western Victoria and Mt Warning in northern New South Wales.



Explosive volcanoes form steep, cone-shaped mountains.

INQUIRY 1 A model volcano

You will need: papier-mâché, plaster of Paris or mud, small plastic container, vinegar, baking soda, red food colouring, teaspoon

1. Build a volcano using papier-mâché, plaster of Paris or mud. Build a plastic container into the rim of the volcano. It is probably best to take your volcano outside so that it doesn't make a mess when it erupts. If you don't have time to build a volcano you can still do Steps 2 and 3.
2. Three-quarters fill the container with vinegar and add some red food colouring to give a rich red colour. Stir in a couple of teaspoons of baking soda and watch the mixture erupt.
3. Another lava recipe you could try is cornflour, yellow food colouring and water, stirred to give a thick syrupy mixture. To get it to fizz you can add a couple of Alka-Seltzer tablets.
   - Describe the eruption of your volcano. Do you think it is a good model?

Earthquakes

About 150 000 earthquakes are recorded each year around the world. Some of these are very minor, but others cause tragic loss of life and enormous damage. But what causes earthquakes?

Most earthquakes occur in regions where there are long, deep cracks or **faults** in the Earth's crust. The faults may be hundreds of kilometres long. Over many years pressure builds up in the rocks along the fault, until suddenly the strain becomes too much. The blocks of crust on opposite sides of the crack move, either up, down or sideways. Violent vibrations occur in the rocks and we feel these as an earthquake. Some earthquakes last only a few seconds while others last several minutes.

The point inside the Earth where the movement of rocks occurs is called the *focus*, and the point on the surface above the focus is called the **epicentre**. Earthquake waves travel in all directions from the focus, like the waves produced when you throw a stone into still water.

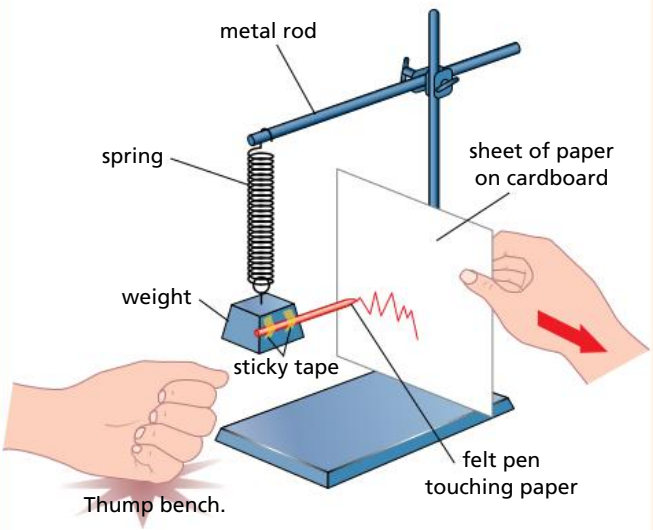
If the earthquake occurs near or under the ocean, the shock waves can cause a **tsunami** (su-NAR-me) or tidal wave of frightening size. The largest ever recorded was 64 m—as high as a 20-storey building.

INQUIRY 2 Making a seismograph

In this activity you can make a model of a **seismograph** (SIZE-mo-graph)—an instrument that records earthquakes and measures their magnitude (strength).

You will need: retort stand, clamp, metal rod, large spring, sheet of cardboard, sticky tape, felt pen, 500 g or 1 kg weight (or can of sand)

1. Use the diagram below as a guide to make your own seismograph.
2. Test the seismograph by bumping the table or jumping on the floor while your partner pulls the paper past the pen. You may need to experiment a bit to get it to work properly.
   - Explain how your seismograph works.
3. Develop your own scale for measuring the magnitude of your 'earthquakes'.



SCIENTISTS AT WORK

Charles Richter (1900–1985)

Charles Richter was born on a farm in Ohio, USA, in 1900. He wanted to study astronomy but ended up working in seismology (the study of earthquakes) and engineering. He was keen on bushwalking, wrote science fiction stories and was a *Star Trek* fan.

Richter is famous for developing the Richter scale for measuring the magnitudes of earthquakes. He said he devised this system because he was tired of journalists asking him to compare earthquakes. He worked with engineers in assessing the risk of earthquakes in particular places, and in designing earthquake-resistant buildings.

Each whole number on Richter's scale represents an increase of ten times in the ground movement as measured by a seismograph. A magnitude 2 earthquake causes ground movement ten times as large as that from a magnitude 1 earthquake. Magnitude 3 is 10 times stronger than magnitude 2 and 100 times stronger than magnitude 1.

A magnitude 1 earthquake can be detected only by seismographs. A magnitude 3 earthquake is felt by most people and feels like a passing truck. Earthquakes with magnitude over 6 can cause major damage in populated areas. The strongest earthquakes recorded are about magnitude 9.

Charles Richter (right) inspects earthquake damage.

The Newcastle earthquake

At 10.27 am on Wednesday 28 December 1989 an earthquake struck the city of Newcastle in New South Wales. Although it lasted only 6 seconds, it left 13 people dead and more than 160 injured.

The city centre was crowded with shoppers and people on holidays when the ground shook violently and the buildings rocked. The streets were showered with bricks, glass, masonry and dust, injuring people and crushing cars. Thousands of homes and dozens of public buildings were damaged and some had to be demolished. The total damage bill came to about a billion dollars.

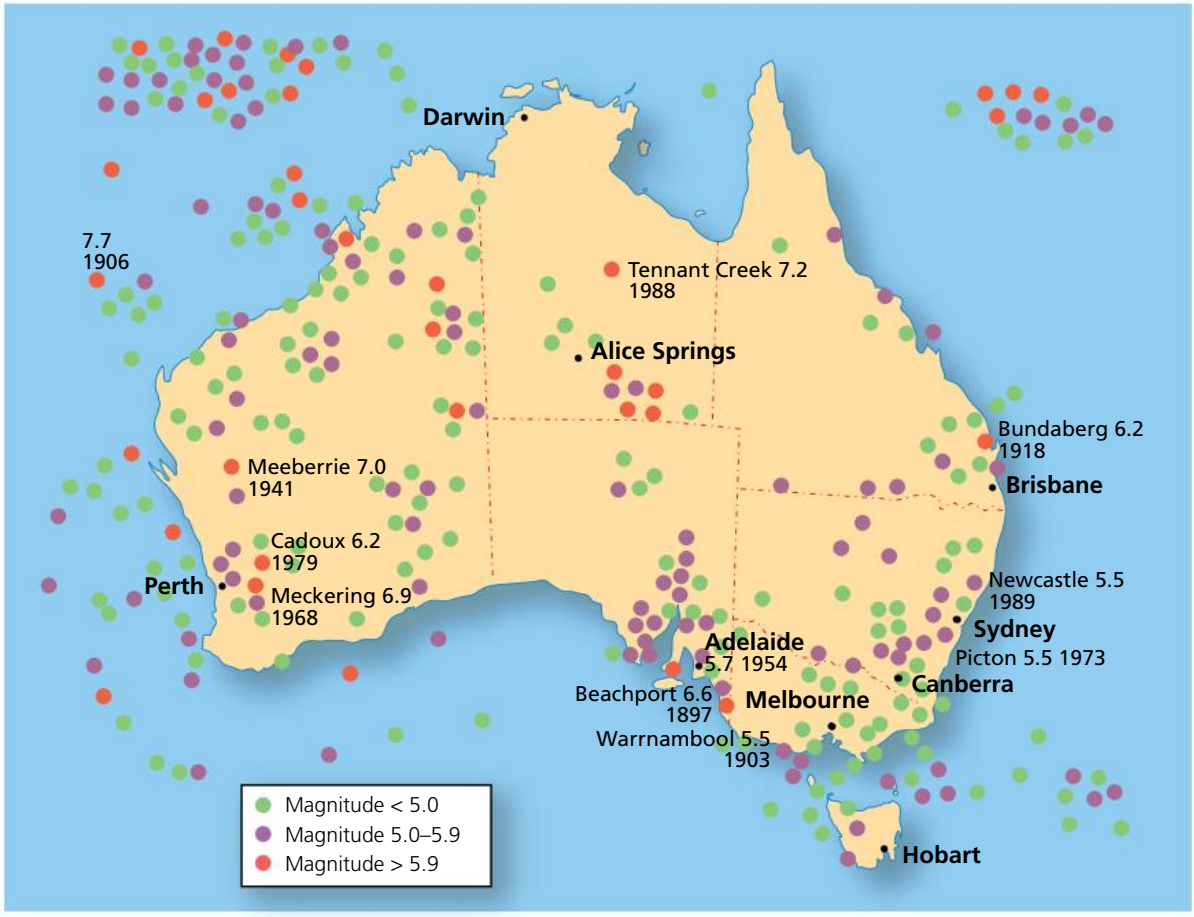
The greatest loss of life was in the Newcastle Workers' Club where a 300 tonne brick retaining wall and a huge concrete floor slab collapsed on top of the ground floor car park. Rescue crews used heat sensing equipment to search for those trapped in the twisted rubble. People in the streets were stunned and disbelieving. 'This sort of thing just doesn't happen in Australia,' one man said.

The epicentre of the earthquake, which measured 5.5 on the Richter scale, was 5 km west of Newcastle. While the quake was felt over a large area of New South Wales, most of the damage occurred in the centre of the city. However, the damage was minor compared with the 9.0-magnitude earthquake and subsequent tsunami in Japan on 11 March 2011.

Nine people were killed when the Newcastle Workers' Club collapsed.

INQUIRY 3 *Is Australia safe?*

- Study the map on the next page showing where earthquakes have occurred in Australia. Where were the three biggest ones?
- Can you see any pattern in the earthquakes' locations? Explain.
- Copy or trace a map of Australia and use colours to show areas where there is a risk of an earthquake. You could show different areas of risk, e.g. low, moderate and high risk. What is the risk where you live?



Over to you

1 Which of the following are true and which are false? Rewrite the ones that are false.
- **a** The crust is the hottest layer of the Earth.
- **b** The outer core of the Earth is molten.
- **c** Hot molten rock inside the Earth is called lava.
- **d** The crust is much thicker than the other layers.
- **e** The upper part of the mantle can flow like a viscous liquid.
- **f** Scientists infer that the core is most likely made of iron and nickel.

2 Copy and complete these sentences.
- **a** Molten rock under the Earth's surface is called _____.
- **b** Molten rock that has reached the surface is called _____.
- **c** The spewing out of gases, dust, ash, rocks and lava from a volcano is called an _____.
- **d** Volcanoes are either active, _____ or _____.
- **e** Magma is under a lot of _____.

3 What is the Richter scale? How much stronger is an earthquake that measures 4 on the Richter scale than a quake that measures 2?

4 Use a diagram to explain the terms *focus* and *epicentre* of an earthquake.

5 In 1968 one of the biggest earthquakes recorded in Australia (magnitude 6.9) occurred at Meckering, east of Perth. From the photo, describe how the Earth has moved to cause this damage.

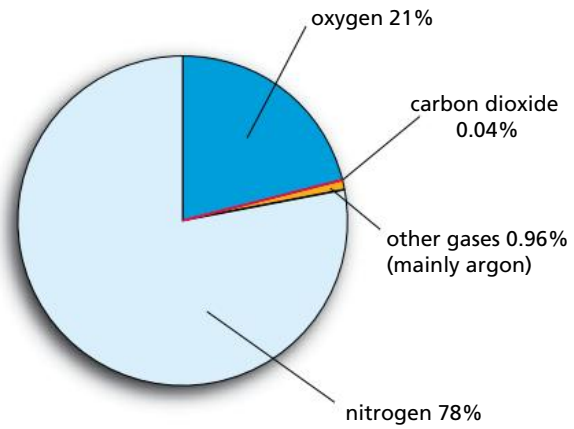
PROBLEM SOLVING

Check back through this section. What information do you think should go into your Dork Report on planet Earth?

9.2 Our air

The Earth is surrounded by a layer of air called the **atmosphere**. Air is a mixture of gases as shown in the pie chart below.

About four-fifths of the air is nitrogen (N_2). The other one-fifth is oxygen (O_2), which we need to live. Argon is an unreactive gas used to fill light bulbs and carbon dioxide (CO_2) is used by plants in photosynthesis. Air contains varying amounts of water vapour (H_2O), and this affects the weather.



Some common gases

In Investigation 1 you will make three different gases—hydrogen, oxygen and carbon dioxide. Surprisingly there is very little hydrogen (H_2) in our atmosphere, even though it makes up about 90% of the total universe. Hydrogen is a colourless gas that is at least 15 times lighter than any other substance. In the presence of a flame, hydrogen reacts so rapidly with the oxygen in the air that it explodes.

We cannot live without oxygen—our bodies need a constant supply of it. Oxygen is needed to get energy from food in the process of respiration. We use about 20 L every hour. Oxygen is used to help people breathe in difficult situations such as after car accidents and in hospitals during operations. It is also used in places where there is not enough oxygen to breathe normally. For example, divers, jet plane pilots, mountain climbers and firefighters carry a supply of oxygen.

Oxygen is a colourless gas that has no smell. It is very reactive, meaning it combines chemically with many substances. For example, burning (or *combustion*) is the process in which oxygen combines rapidly with other substances producing light and heat.

Carbon dioxide is another invisible gas. It is more dense than air and things will not burn in it. It is put into soft drinks to make them fizzy. It is produced by our body in respiration. It is also produced during fermentation and the holes in bread are caused by bubbles of CO_2 produced by yeast.

Air pressure

The invisible air around us can exert a **pressure**. This is the force per square metre exerted by the air on a surface. This air pressure is due to tiny, fast-moving, invisible particles of air that continually bombard any surface open to the air.

INQUIRY 4 **Air exerts pressure**

You will need: large sheet of newspaper, thin wooden ruler

Place a thin wooden ruler on a table with one end as far as possible over the edge and the other covered by a single large sheet of newspaper, as shown. Smooth the newspaper so that there is as little air as possible under it.

If you now hit the end of the ruler sharply it should snap.

- Try to explain what happened.

INVESTIGATION

1 Making gases

Aim

To make and test the properties of hydrogen and oxygen gases.

Risk assessment and planning

You must be well organised for this investigation, so study the method (including the diagram) for each part before you start.

1 Why is it essential that you wear safety glasses when doing this investigation?

2 What special precautions are necessary with hydrochloric acid?

PART A: Hydrogen

Apparatus

- test-tube rack and 3 test tubes
- piece of magnesium ribbon (about 2 cm)
- taper and matches
- dilute hydrochloric acid (1 M)

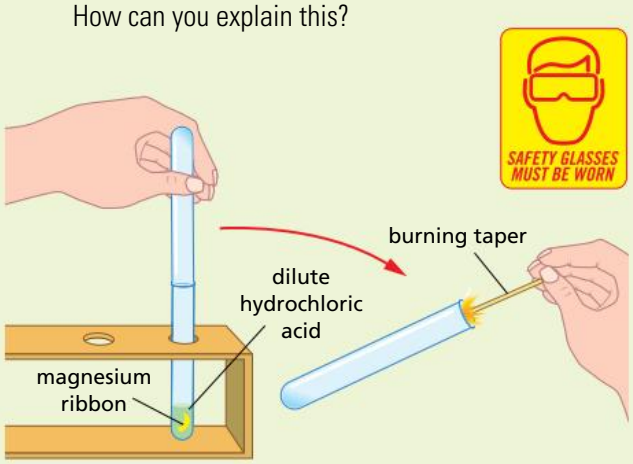
Method

1 Put a test tube in the test-tube rack and fill one-third of it with dilute hydrochloric acid.

2 Pick up another test tube. Put the magnesium ribbon into the acid. Then hold the empty test tube upside down over the mouth of the first test tube, as shown below.

3 Carefully remove the top test tube. Tilt it so that the mouth is just turned upwards, and immediately put a burning taper near its mouth. A 'pop' or 'squeak' indicates that the gas in the tube is hydrogen. You may want to repeat this with another tube of hydrogen.

✻ What do you observe on the inside of the test tube? How can you explain this?



PART B: Oxygen

Apparatus

- conical flask, e.g. 250 mL
- one-holed stopper fitted with glass tube and rubber tubing
- ice-cream container or similar
- wooden splint and matches
- manganese dioxide
- hydrogen peroxide
- 2 test tubes

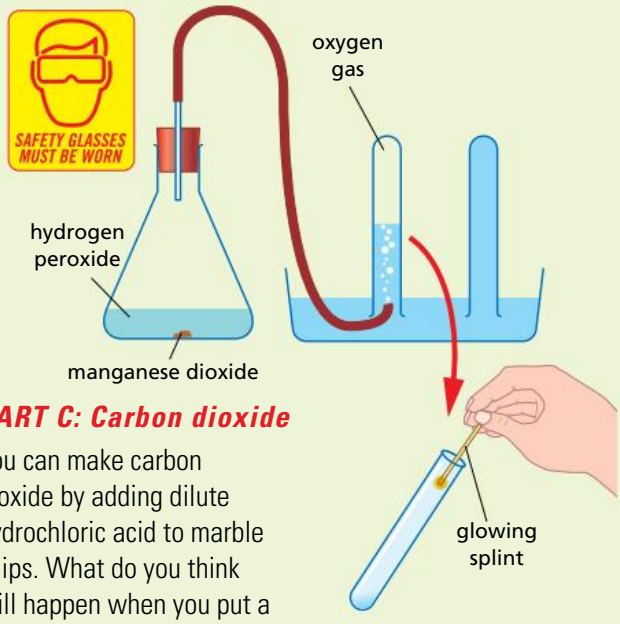
Method

1 Half fill an ice-cream container with water. Also fill two test tubes with water and place them upside down in the container, as shown below.

2 Put a pea-sized amount of manganese dioxide powder in the flask. Then pour in a few millilitres of hydrogen peroxide and quickly put in the stopper and tubing.

3 Place the tubing under the test tube to collect the oxygen gas.

4 When the test tube is full of oxygen, light a wooden splint then blow it out, so that it still has a glowing tip. Take the test tube out of the water and tilt it upwards. Immediately put the glowing splint into the test tube. It should burst into flames. This is the test for oxygen.



PART C: Carbon dioxide

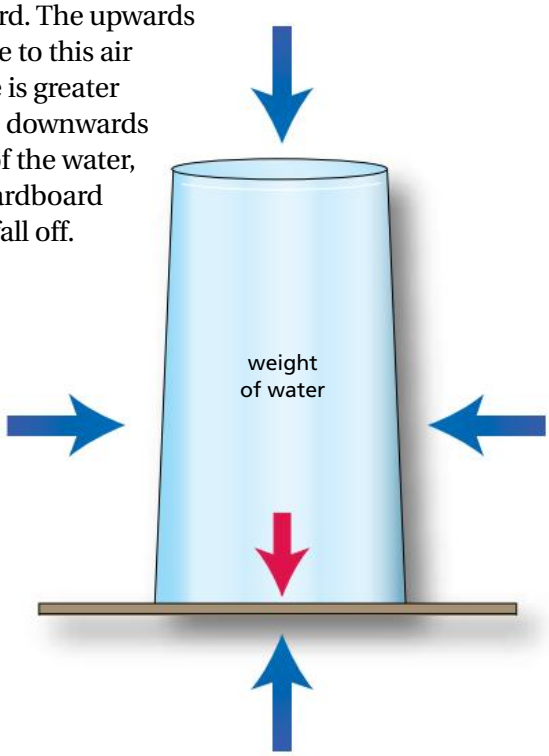
You can make carbon dioxide by adding dilute hydrochloric acid to marble chips. What do you think will happen when you put a burning taper in a test tube of CO_2? Try it.

Write your report

In your method include a simple two-dimensional diagram of the apparatus for all three gases.

Air exerts pressure *in all directions*. In Inquiry 4 on page 185 the air exerted a pressure *downwards* on the newspaper. This held the newspaper in place with enough force to enable you to snap the ruler.

With the upside-down glass of water in Inquiry 4 on page 4, the air exerted a pressure *upwards* on the cardboard. The upwards force due to this air pressure is greater than the downwards weight of the water, so the cardboard did not fall off.



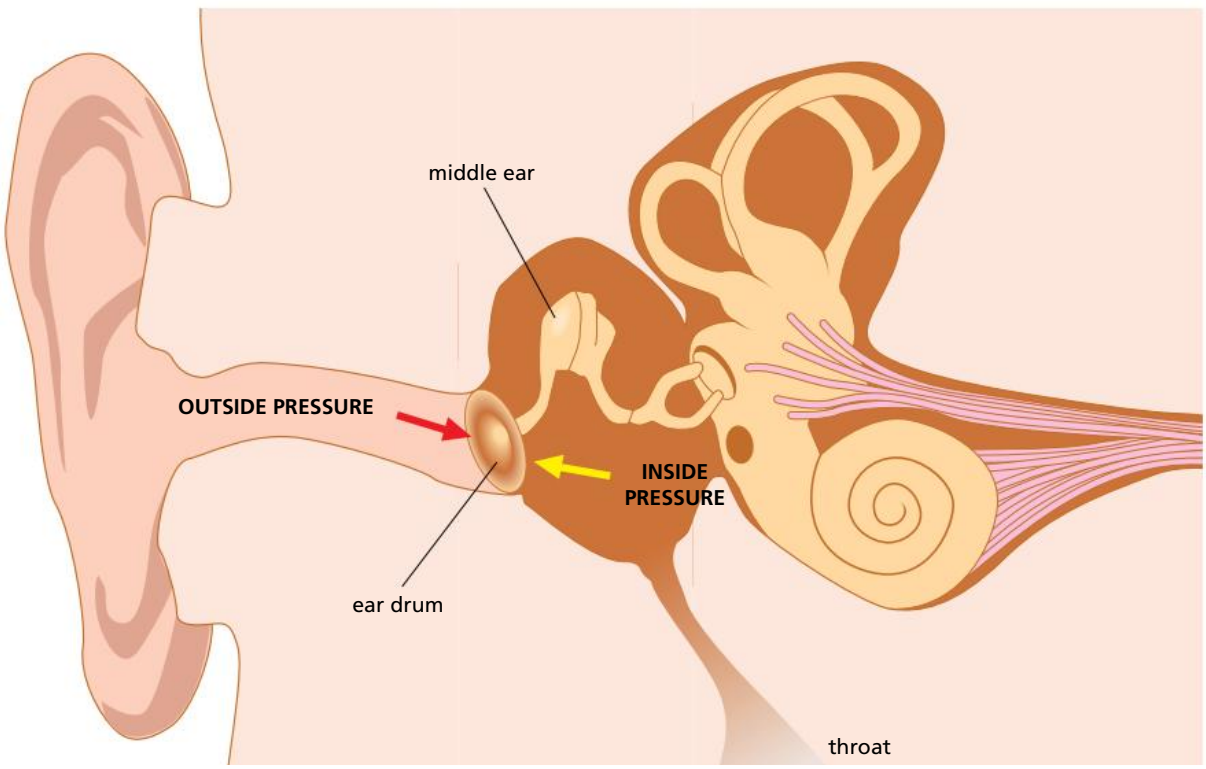
force due to air pressure

Changes in air pressure

At sea level air exerts pressure on all surfaces of about 10 newtons (the weight of a 1 kg mass) for each square centimetre, or 1000 hectopascals. This air pressure on you is equivalent to having a 500 kg mass on your shoulders, but you don't feel it because you are supported by an equal pressure of air on all sides of your body.

As you move upwards away from the Earth's surface the air thins out—its density decreases. As a result air pressure decreases with altitude. At the top of Mt Everest (8900 m) the air pressure is less than half what it is at sea level.

Your eardrums are very sensitive to these changes in air pressure. Normally the pressure inside your middle ear is the same as the pressure outside. This is a state of balance or **equilibrium**. However, if the outside pressure changes, this balance is upset and your eardrum becomes stretched and feels uncomfortable. This is what happens when you go up or down in an aeroplane or when you are driving in the mountains. There is a tube leading from your throat to your middle ear. Air can flow in or out through this tube to balance the pressure in your middle ear with the outside pressure. Swallowing or yawning helps it to do this. Sometimes your ear 'pops' as the air pressures on opposite sides of the eardrum are equalised.



INVESTIGATION

2 Air pressure inferences

Aim

To write inferences to explain observations about air pressure.

Risk assessment and planning

Read both parts of the investigation carefully. Are there any safety hazards? What precautions will you need to take?

PART A: Collapsing can

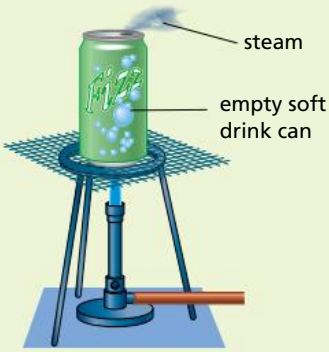
Apparatus

- empty soft drink can
- pair of metal tongs
- large ice-cream container
- Bunsen burner equipment

Method

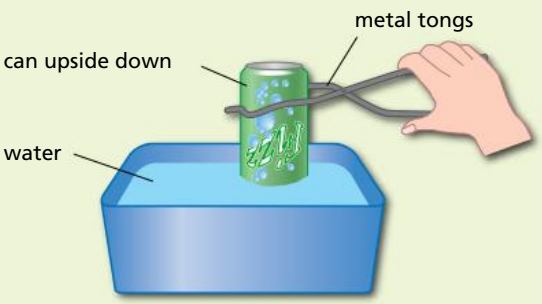
1 Fill the ice-cream container with water and put about 50 mL of water in the can.

2 Heat the can until the water boils and steam escapes from the lid.



3 Using a pair of tongs, quickly place the can upside down in the water in the ice-cream container so that the open top is under water. What happens?

✻ Write an inference to explain your observation in terms of air pressure. A diagram would probably improve your explanation.



PART B: Egg in a bottle

Apparatus

- peeled hard-boiled egg
- large wide-necked flask
- Bunsen burner equipment

Method

1 Add about 20 mL of water to the flask then heat it until the water boils.

2 Turn off the hotplate or burner and place the egg ('sharp end' down) in the mouth of the flask. Watch what happens.

✻ Write an inference to explain your observation.

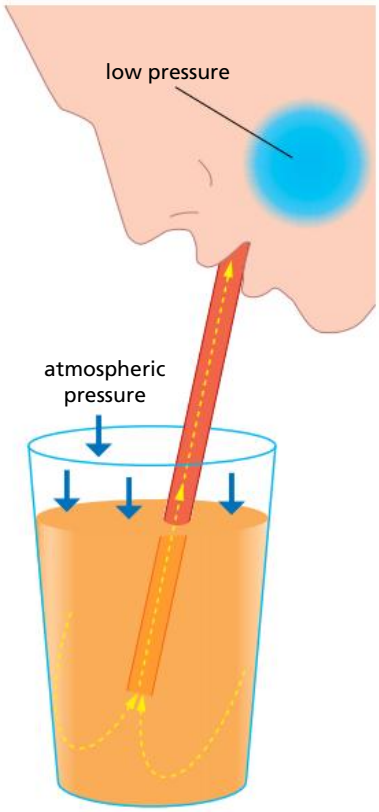
4 As a challenge, use your explanation of why the egg moved into the flask to work out a way of removing it from the flask—*without breaking it*. Try your idea.

Write your report

Include your observations in *Results* and your inferences in *Conclusion*.

Using air pressure

You use air pressure when you drink through a straw. As you suck in your cheeks you lower the air pressure in your mouth. The atmospheric pressure pushing down on the surface of the liquid is then greater than the pressure inside your mouth. There are unbalanced forces and the liquid is forced up the straw by the push of the air on the surface of the liquid.



Over to you

1 Which of the following are true and which are false? Rewrite the false ones.
   - **a** Over three-quarters of the air is oxygen.
   - **b** Carbon dioxide is one of the gases found in the air.
   - **c** The amount of water vapour in the air changes.
   - **d** Air exerts a pressure upwards as well as downwards.
   - **e** Air pressure is caused by invisible particles of air hitting a surface.
   - **f** If a glowing splint is put in a test tube of oxygen it goes out.

2 Explain in your own words what causes air pressure.

3 List three properties of oxygen.

4 Spacecraft must carry a supply of liquid oxygen for the engines, in addition to fuel. Why?

5 Why are compressed air cylinders made out of very thick steel?

6 Use air pressure to explain why it is sometimes very difficult to take the lid off a jar.

7 An aneroid barometer like the one shown below can be used to measure variations in air pressure. How is it possible to use this instrument to measure altitude in an aircraft?

8 In jet planes the cabin pressure is kept about the same as air pressure at sea level. Suppose a window broke in a plane flying at an altitude of 10 000 m. Predict what would happen.

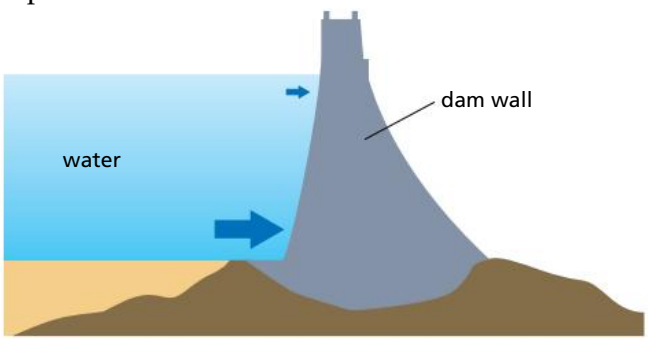
9.3 Our water

Water pressure

Just like air, water also exerts a pressure. The deeper you go under water, the higher the pressure. You can feel the water pushing on your eardrum. In fact, the pressure you feel 10 m under the surface is twice that at the surface.

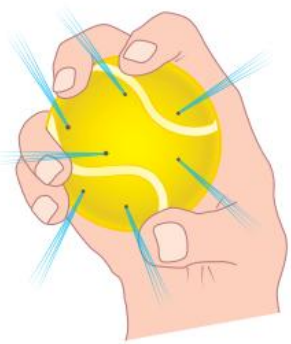
Submarines are designed to travel deep under water and therefore need to have very strong hulls so that they can withstand the crushing pressure of water. For the same reason, divers working in deep water also need to use special equipment such as pressurised diving suits. The walls of dams are built much thicker at the bottom than at the top because the water pressure is much greater there.

Any two places at the same depth have the same pressure. It does not depend on the shape of the body of water or the area of the water's surface—only the depth.



The water pressure is much greater at the bottom of the dam than at the top.

Over 350 years ago the French scientist Blaise Pascal discovered that a liquid in a container exerts pressure equally in all directions. This is called *Pascal's principle*. You can demonstrate this with an old hollow rubber ball. Make a large hole in the ball, and a number of smaller holes all over it. Then fill the ball with water and squeeze it, keeping a finger over the large hole. No matter how you squeeze the ball, the water squirts out of each hole with the same force. Pascal's principle is used in hydraulic equipment such as the hydraulic hoist used in car workshops.



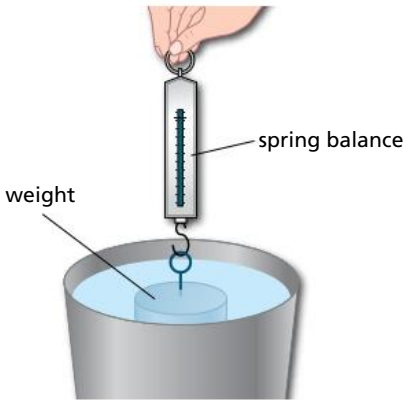
INQUIRY 5

Are things lighter in water?

You will need: rock or other weight, string, bucket, spring balance

Suspend a rock or other weight from a spring balance. Find the weight of the rock in air and then in water.

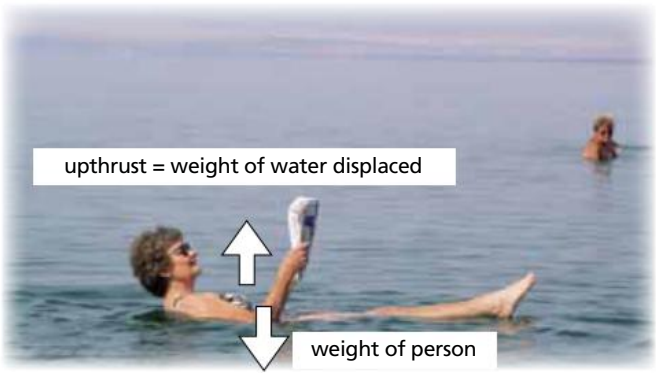
- How much weight does the rock lose?
- How can you explain this apparent loss of weight?



Buoyancy

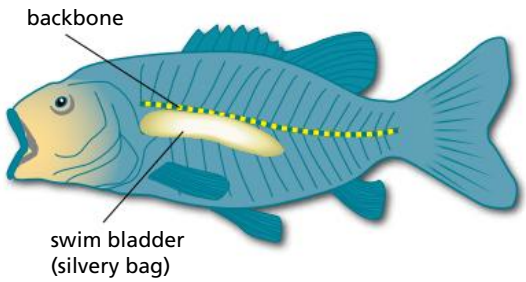
When an object is in water the water exerts an upwards force that is equal to the weight of water displaced (moved aside) by the object. This is called **Archimedes' principle** after the Greek man who discovered it over 2000 years ago. The upwards force is called buoyancy or *upthrust* because it acts upwards against the weight of the object.

Buoyancy is why you can float in salt water. In the photo below the person's weight is exactly balanced by the upthrust of the water. The saltier the water the greater the upthrust and the higher you float. Huge supertankers float because the more water the ship pushes aside, the more the water pushes up on the ship.



Because the forces are balanced, the floating person is in a state of equilibrium.

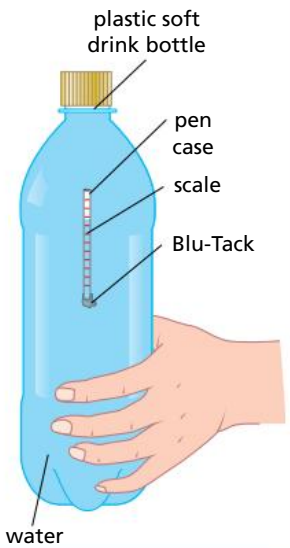
Fish have a swim bladder that contains oxygen, nitrogen and carbon dioxide gases that pass into it from the blood. Adding gas to the bladder adds buoyancy and a fish moves towards the surface. Removing gas reduces the buoyancy and the fish sinks. Submarines work in a similar way by pumping water in and out of diving tanks.



INQUIRY 6 A model submarine

You will need: large soft-drink bottle, old pen, Blu-Tack, large beaker or jug, permanent marker

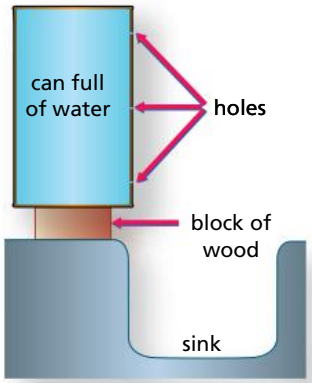
1. Put a small piece of Blu-Tack on one end of an empty pen case, as shown—but don't cover the hole in the end.
2. Use a permanent marker to draw a scale on the pen case.
3. To test the buoyancy of the pen case, drop it into a beaker of water. Carefully adjust the amount of Blu-Tack until the case floats about halfway up the beaker.
4. Fill a plastic soft-drink bottle to overflowing with water.
5. Carefully drop the pen case into the top of the bottle and screw on the lid.
   - Note where the water comes to on your scale.
6. Squeeze the sides of the bottle. What happens to your model submarine?
   - Again note the water level on the scale. Has it changed?
7. What happens when you stop squeezing? Check the water level again.
   - Use what you have learnt about air and water pressure to write an explanation of how your submarine works.



INQUIRY 7 Check your prediction

You will need: tin can, hammer, nail, block of wood

1. Punch three equal-sized holes in a tin can and set it up beside a sink.
   - Predict what will happen when you fill the can quickly with water from a jug. Explain your prediction.
2. Now try it and see if your prediction was correct.



Over to you

1. Copy and complete these sentences.
   - **a** The pressure in a liquid can be measured with a _____.
   - **b** The pressure in a liquid acts in all _____.
   - **c** The pressure of water _____ as the depth increases.
   - **d** When an object is immersed in water its weight _____.
   - **e** When an object floats in water there is an _____ equal to the weight of water displaced. This is _____ principle.
2. Why do you weigh less in water than in air?
3. Why does a piece of steel sink in water, yet a steel boat floats?
4. In the deep-water mini-submarine, *Alvin*, the part where the scientists work is a 1.8 m diameter sphere. Suggest why it is this shape.
5. Whales live successfully in the ocean yet can be crushed by their own weight if stranded on the beach. How can you explain this?

9.4 Our weather

Tornado

The Merrett family lived in Fairydell, 180 km north of Melbourne. On 22 June 2000 at 5.15 pm Mrs Merrett noticed a sheet of corrugated iron fly past the window. Seconds later a tornado (or twister as Americans call them) hit the house 'like a bomb going off'. All the windows imploded (burst inwards), glass and furniture and doors flew everywhere and 30 seconds later the tornado was gone, leaving the house wrecked. Baby Alice had disappeared from the kitchen. They found her 20 m from the house, still strapped in her highchair, face down in the mud. Her head was cut from crashing through the window, but she was unhurt.

Tornadoes are quite common in Australia and over 40 people have been killed by them. In this section you will study changes in the air and how they cause our weather.

Water vapour in the air

In the water cycle water evaporates from oceans, lakes and rivers and later falls as rain, snow, hail, dew and frost. Weather forecasters talk about relative **humidity**. This is a measure of the amount of water vapour in the air compared with the maximum amount possible. If the humidity is 100% the air is saturated (which means it cannot hold any more water) and it is raining or foggy. People feel most comfortable when the humidity is about 50%.

How winds form

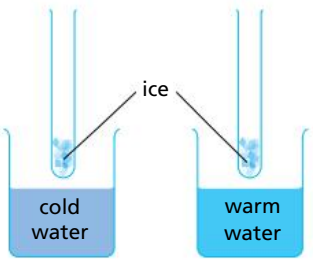
The weather is caused by the sun warming the Earth and its atmosphere. Not all parts of the Earth heat up and cool down at the same time or to the same temperature. You can investigate this for yourself in Investigation 3.

INQUIRY

8 Which holds more vapour?

You will need: 2 beakers, 3 test tubes, crushed ice, warm water, teaspoon, salt

1. Take a test tube and check that it is perfectly dry. If it isn't, get a dry one.
2. Carefully add about 5 cm of ice to the tube, without wetting the outside of the tube.
3. Observe the outside of the tube for a few minutes.
   - Write an inference to explain your observation. What is the name of the process that has occurred here?
4. Take two beakers. Half-fill one with cold water and the other with warm water.
   - Make a prediction about which air you expect to contain most water vapour—that over the warm water or that over the cold water. Explain your prediction.
5. Take two more dry test tubes. Put ice in each, as before.
6. Hold one tube above the water in each beaker, without touching the water. Carefully observe the outside of the tubes.
   - Was your prediction correct?
   - Which was most humid—the air over the warm water or the air over the cold water?



INVESTIGATION

3 Which heats up more?

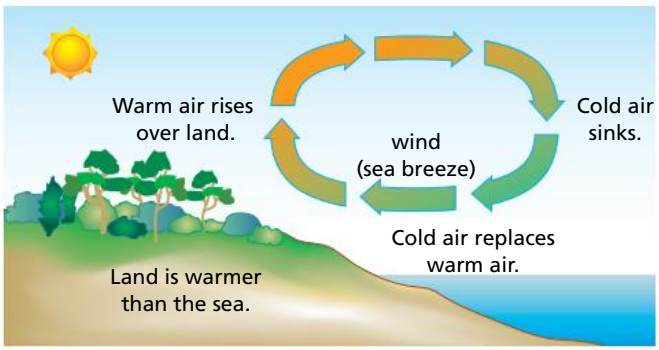
Predict which will heat up more quickly—sand or water. Which will cool down more quickly? Why?

Now design an experiment to test your prediction. You will need to work out what equipment you will need and the details of your method. You could also compare sand and soil or sand of different colours.

Write your report

You will need to write your own aim, apparatus, method, and results. In your conclusion try to explain how uneven heating of the Earth could cause winds. Use your test results and the information on the next page.

Along the coast, on most afternoons, a *sea breeze* blows from the sea towards the land. This is because in the morning the land heats up faster than the sea, as you probably found in Investigation 3. The warm land heats the air just above it and this causes the air particles to move apart. This in turn makes the air less dense, and it begins to rise. Cool air from the sea then comes in to take the place of the rising air, forming a circular current as shown. This is a sea breeze.



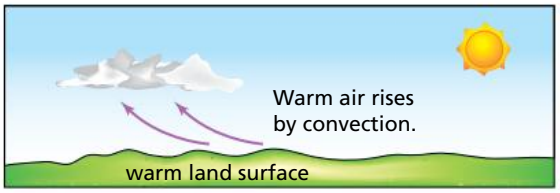
Most winds are more complex than a sea breeze, but they are all caused by the uneven heating of the Earth's surface.

Clouds, rain and storms

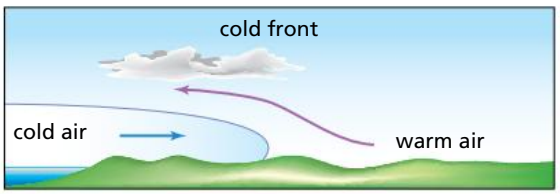
There are three ways in which clouds can form.

1 Imagine a mass of warm air drifting over the ocean towards a range of mountains. As the air passes over the ocean it absorbs a lot of water vapour, and its relative humidity becomes very high. As the air reaches the mountains it is forced to rise. As it rises it cools, and can no longer hold so much water vapour. So some of the water vapour turns to liquid water, or *condenses*. If there are particles of dust in the atmosphere (and there usually are), the liquid water forms tiny droplets around the dust particles. These droplets float in the atmosphere, and we see them as clouds.

2 Clouds can also form when one area of the Earth heats up more than the areas around it. When this happens a patch of warmer air, called a *thermal*, is produced. As this thermal rises it cools, and water droplets condense from it, forming clouds.

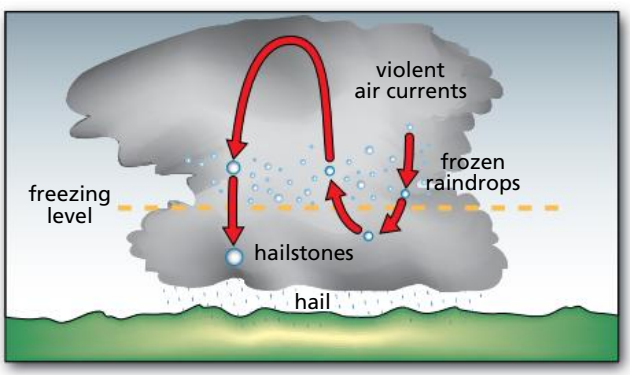


3 Clouds sometimes form when a large mass of cold air moves under a large mass of warm moist air, pushing it up to where it is cooler. This is called a *cold front*. These are common in southern Australia.



As long as the water droplets in a cloud remain small they will not fall to Earth, because the air holds them up. If the air warms up again the liquid water turns back to water vapour, and the cloud disappears. However if the water droplets join together to make larger drops, they fall as rain.

Hailstones are frozen raindrops. They are usually formed when the raindrops are tossed up and down in a thunderstorm cloud by violent air currents. This makes them melt and freeze over and over again. The hailstones become larger as more water freezes around them. Eventually they become heavy enough to fall to the ground, where they can do extensive damage to houses, cars and crops. *Tornadoes* are funnel-shaped clouds that sometimes form under severe thunderstorms.



How hail is formed

INQUIRY 9 Making rain

You will need: Bunsen burner equipment, large beaker, watch glass, ice

1. Boil some water in the beaker.
2. Fill the watch glass with ice and put it on top of the beaker.
   - Observe carefully what happens inside the beaker.
   - Explain *why* this happens.

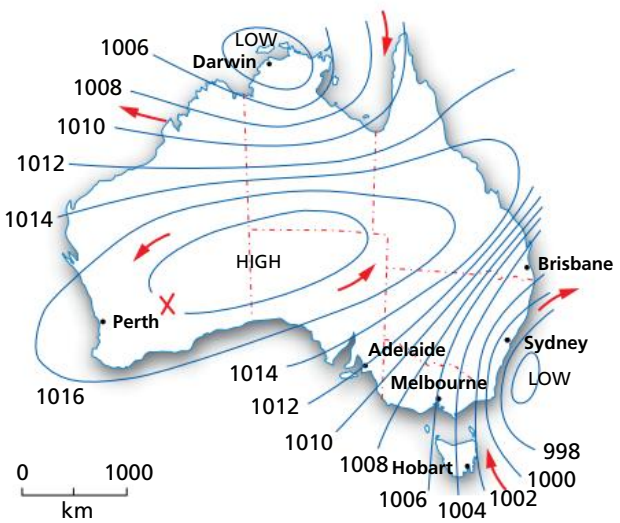
Weather maps

Look at the weather map below. The lines on the map are called **isobars**. They join places that have the same air pressure. The pressure, in hectopascals, is usually marked on the isobar. The Bureau of Meteorology uses computers to draw the isobars from information sent in by observers all over Australia.

Those places on the map where the air pressure is highest are called **highs**. They occur where there is cool, heavy air sinking towards the ground. Those places where the air pressure is lowest are called **lows**. They occur where there is warm, rising air that is likely to form clouds. In general, lows bring wet weather and highs bring fine weather, but there are many complications. In northern Australia lows sometimes develop into cyclones.

Isobars can be used to predict wind directions since winds blow roughly along the isobars, as shown by the arrows between the isobars on the map. In the Southern Hemisphere winds blow anticlockwise around highs and clockwise around lows. Isobars can also give you an idea of wind strengths. When they are close together the winds are strong. And when they are far apart the air is still.

Weather patterns move across Australia from west to east. For example, a high that is over Perth today will be near Sydney in a few days' time. This pattern can be used to make forecasts.



Over to you

1. Copy and complete these sentences.
   - **a** An isobar is a line joining places with the same _____.
   - **b** Winds blow clockwise around a _____.
   - **c** Winds are _____ where the isobars are close together.
   - **d** Lows are regions of _____, rising air.
   - **e** A _____ is a region where a mass of cold air moves under a mass of warm air.
   - **f** Twisters occur in Australia and are called _____.
   - **g** Humidity is the amount of _____ in the air.
   - **h** If there is a high in your area you can expect _____ weather.
2. Explain why your breath forms little clouds on a very cold morning.
3. Explain why there are often clouds near the tops of mountains.
4. Use the weather map to answer these questions.
   - **a** Which city has the highest air pressure?
   - **b** What do you think the pressure would be on the isobar marked X? Explain your answer.
   - **c** Estimate the air pressure in Perth.
   - **d** In which direction is the wind blowing in Sydney? In Perth?
   - **e** Which city would have the strongest wind?
   - **f** Which city would you expect to have the finest weather?
   - **g** The whole weather system is moving across Australia from west to east at an average speed of 700 km each day. How long would it take the weather system over Perth to reach Melbourne? (Use the scale on the map.)

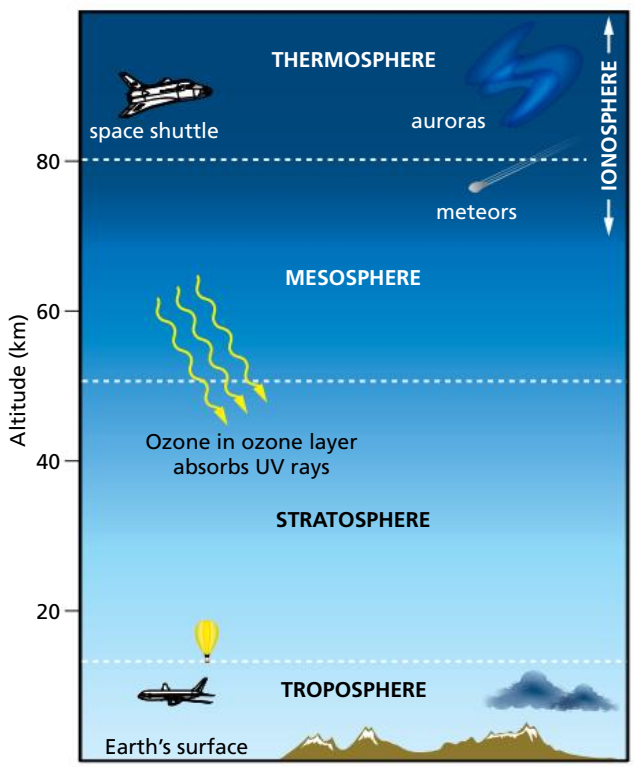
9.5 Our atmosphere

Layers of the atmosphere

The atmosphere is like a blanket of air around the Earth. It is held there by the force of gravity which pulls the molecules of air towards the Earth. Without gravity the atmosphere would float off into space.

Imagine a model of the Earth as a sphere one metre in diameter. In this model 90% of the atmosphere would be in a layer about 1 mm thick around the sphere. So the atmosphere, which is essential to life and which protects us from meteors, UV light and deadly cosmic rays, is only a very thin layer.

As you move away from the Earth the atmosphere becomes less dense, but there is no definite boundary for the end of the atmosphere and the beginning of space. Scientists describe the atmosphere as consisting of four main layers. Each layer fades into the next, so that it is difficult to say where one layer ends and the next begins.



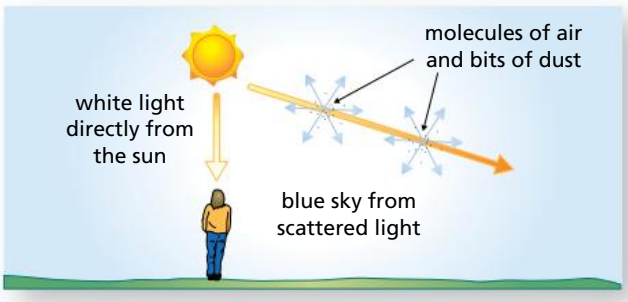
The layer closest to the Earth is called the *troposphere* (TROP-os-fear). It is about 16 km thick and contains about 75% of the air in the atmosphere. It also contains most of the water vapour, dust and clouds, and is where our weather occurs. The temperature steadily decreases as you move up through the troposphere, reaching almost –60 °C. Around 10 km from the Earth's surface there are sometimes huge 'rivers' of air called *jet streams* flowing at speeds up to 700 km/h, usually from west to east. This is why flight times from Perth to the eastern states are shorter than flight times the other way.

The *stratosphere* begins at a height of about 16 km above the Earth and supersonic aircraft can fly in its lower levels. An example is the Concorde. As you move upwards through the stratosphere the temperature increases, due to the absorption of ultraviolet radiation by molecules of ozone gas. This is the **ozone layer**.

In the *mesosphere* the temperature decreases again to about –90 °C. Meteors burn up in its upper zone. The *thermosphere* is the layer furthest from the Earth, and it gets very hot. The sun constantly emits cosmic rays that collide with molecules of air, ripping away electrons and forming charged particles called *ions*. The region where this happens is sometimes called the *ionosphere* (eye-ON-os-fear). When the ions interact with the Earth's magnetic field, beautiful displays of colour called *auroras* can be seen near the poles. Radio waves can reflect off the ionosphere.

Why is the sky blue?

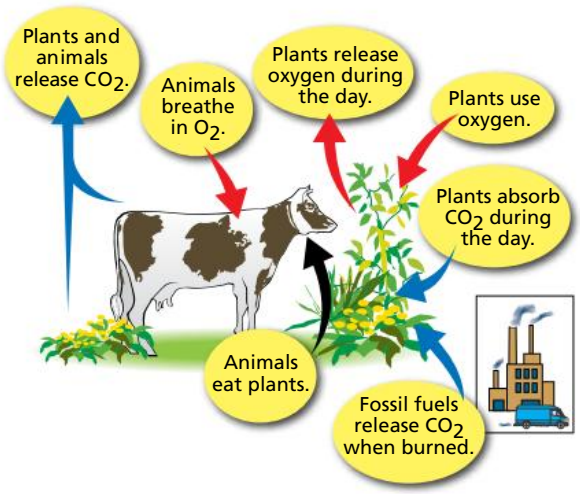
Sunlight is really a mixture of the different colours you can see in a rainbow. As sunlight goes through the atmosphere it bumps into molecules of air and tiny bits of dust. Some colours, like red and orange, pass straight through, but most of the blue light gets scattered all around the sky. This is why the sky looks blue.



As the sun rises or sets its light has to travel further through the atmosphere to get to you. Because the blue light has been scattered you see only the orange and the red.

Keeping the atmosphere in balance

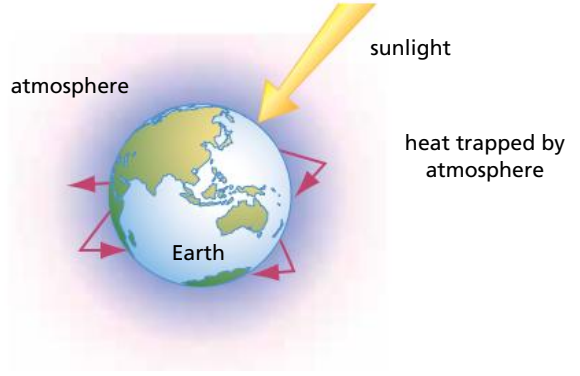
In the troposphere the most important gases are oxygen and carbon dioxide. Plants use carbon dioxide for photosynthesis. In the process they produce oxygen. Both plants and animals use oxygen in respiration and release carbon dioxide. Together, plants and animals keep the amounts of carbon dioxide and oxygen in the atmosphere in balance or equilibrium, as shown. However, human activities are upsetting this balance.



Every year in Australia the burning of **fossil fuels** releases about 70 million tonnes of carbon dioxide into the atmosphere. Trees absorb this carbon dioxide and produce oxygen, but in Australia two-thirds of the forests that existed 200 years ago have been cleared! The trend is towards more carbon dioxide and less oxygen, and it is becoming more and more difficult to keep the balance.

The greenhouse effect

During the day sunlight warms up the Earth's surface. At night much of the heat escapes but the gases in the atmosphere trap some of it, thus keeping the Earth warm. This is called the **greenhouse effect** because it is like what happens in a greenhouse.



INVESTIGATION

4 A model greenhouse

Design a controlled experiment to show how the Earth's atmosphere acts like the glass roof of a greenhouse, trapping heat from the sun.

Work out what equipment you will need to make a model greenhouse and how you are going to collect temperature data. You could use a small juice box with a window in it and cover it with a piece of glass or plastic. You will also need a *control* for comparison—a second set-up without glass. If possible graph your results.

Write a full report of your experiment using the headings *Aim*, *Risk assessment*, *Apparatus*, *Method*, *Results*, *Conclusion* and *Discussion*.

Carbon dioxide traps more heat than most other gases in the atmosphere. This is why people are concerned about the increasing levels of carbon dioxide in the atmosphere. It may cause **global warming**, leading to changes in the climate and rising sea levels.

Hole in the ozone layer

Small amounts of the gas ozone are present in the stratosphere, but in the late 1970s it was discovered that the amount of ozone was decreasing over Antarctica. This thinning of the ozone layer is referred to as the hole in the ozone layer. (See the photo on page 39.)

Ozone is essential for life on Earth because it blocks out more than 95% of the sun's ultraviolet rays. These UV rays cause sunburn and skin cancer. Many of the chemicals we were using were drifting up into the stratosphere and causing chemical reactions that destroyed ozone. The main problems were CFCs (chlorofluorocarbons) used in spray cans and older air conditioners and refrigerators.

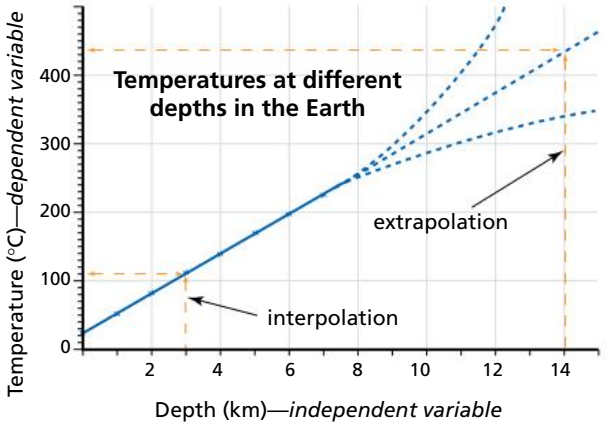
The use of these ozone-destroying chemicals has now been drastically reduced, but the hole is still there and it will be many years before it repairs itself. Meanwhile increased exposure to UV rays will result in many more cases of skin cancer. UV radiation can damage our immune system. It can also lead to eye problems such as cataracts, where the lens of the eye becomes clouded. So hats, sunscreen and sunglasses are essential.

SKILL

Interpreting graphs

Graph 1

The Dorkians sent a temperature probe 7 km into the Earth's crust and displayed their data in a graph. There are two **variables** involved—the depth and the temperature. The depth is the **independent variable** because you can select any value for it. The temperature is the **dependent variable** because it depends on the depth.



Note that the independent variable is usually graphed on the *x*-axis, and the dependent variable on the *y*-axis. The graph then shows the relationship between the dependent variable and the independent variable. In this case the graph is a straight line. This means that as the depth increases the temperature also increases at a constant rate—about 30 °C per kilometre.

You can use the graph to make predictions. For example, the temperature at 3 km was not recorded, but by drawing dotted lines as shown you can predict that it is about 110 °C. A prediction *between* two measurements like this is called **interpolating** (in-TERP-oh-late-ing).

It is also possible to make predictions *beyond* the measured values. This process is called **extrapolating** (ex-STRAP-oh-late-ing). For example, for a depth of 14 km you can extend the straight line to the right and predict a temperature of about 435 °C. However the graph may not be a straight line at that point. It may curve upwards or downwards as shown. If this is the case your prediction will be wrong. This is why you often see widely different predictions for such things as the amounts of carbon dioxide and ozone in the atmosphere in the future. Note that if you want to extrapolate you need to plan your graph so that it is in the bottom left-hand corner of the page so you have room to extend it.

- Use the graph on the left to predict the temperature at 5.5 km and at 10 km.
- At what depth does the temperature reach 300 °C?

Graph 2

Your parents are thinking of buying a house on a new canal development. The house is only 50 cm above high tide mark, and they are worried about rising sea levels caused by global warming.

The data below from Cape Grim in Tasmania shows how carbon dioxide levels have increased in recent years. The concentration of CO_2 is measured in parts per million (ppm). Plot this data and use it to predict future carbon dioxide levels and sea level rises. One estimate is that a 100 ppm increase in CO_2 will cause a sea level rise of 15–20 cm.

Year	CO_2 ppm	Year	CO_2 ppm
1987	345	1999	365
1989	349	2001	368
1991	351	2003	372
1993	354	2005	375
1995	357	2007	379
1997	360	2009	384

- Based on your predictions, what advice would you give your parents about buying the house?
- Check with other students. Are their predictions the same as yours? Suggest reasons for any differences.
- Why do you think scientists disagree on the likely effects of global warming?

PROBLEM SOLVING

This is the second last of the five sections in this chapter, so you should be nearly finished your Dork Report (see page 180).

THINKING SKILLS

1 Why does the amount of oxygen in the air remain relatively constant even though living organisms use it for respiration?

2 A scientist measured the amount of UV radiation on a typical cloud-free summer day using a radiometer.

Daylight saving time	UV radiation
8 am	60
9 am	210
10 am	400
11 am	620
12 noon	850
1 pm	960
2 pm	910
3 pm	690
4 pm	450
5 pm	250
6 pm	130
7 pm	50

a Plot the results on a graph.

b At what time of the day did the UV radiation reach a maximum?

c During what times was the UV radiation count greater than 600?

d An Anti-Cancer Council's slogan is *Between 11 and 3 slip under a tree. The best sunscreen of all is absolutely free.* Does your graph agree with this slogan?

e Predict and draw what the graph would look like on a cloudy day.

3 Kalani and Jordan put a candle in a saucer and added some water. They then lit the candle and put a glass upside down over it. The candle burnt for a while then went out, but they were surprised to see that the water rose inside the glass. How can you explain this? You could try it yourself.

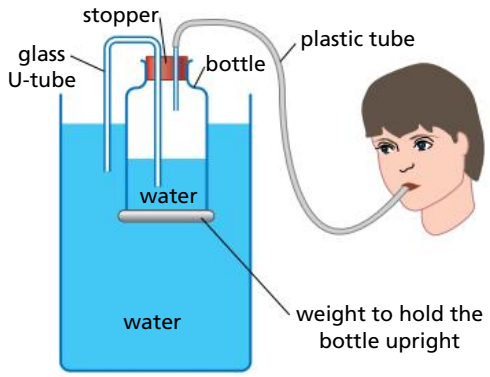
4 Imagine you are the mayor of a large city. What action would you take if you were faced with these two situations? Justify your answers.

a Scientists say that within the next 20 years it is almost certain there will be an earthquake of magnitude 5 or greater whose epicentre is within 500 km of the city.

b Scientists monitoring a major fault line near the city say there is a 50% chance of a major earthquake in the next few days.

5 Why do you have to punch two holes in a can of fruit juice before the juice will pour out easily?

6 Brooke made the model submarine shown below. Sucking on the plastic tube makes the submarine sink and blowing into the tube makes it rise. Explain how this submarine works.

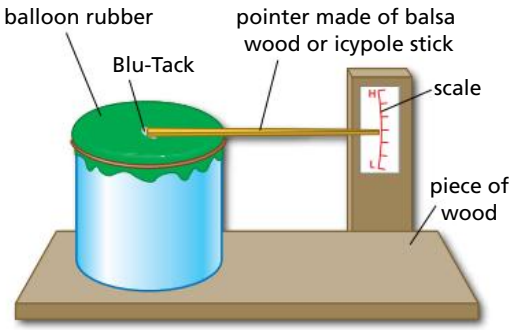


7 The sky on the moon is black. Why is this so?

8 Research and report on the living things that survive in the deepest parts of the ocean.

9 If the icebergs floating around the Earth's poles were to melt, would this raise the level of the oceans? Design an experiment to find out.

10 Make a barometer like the one shown to measure air pressure. Explain how your barometer works.



Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 Scientists infer that the interior of the Earth has three main layers: the _____, the mantle and the core. The mantle consists of very hot, semi-solid material called _____. When this breaks through the Earth's surface, _____ form.

2 _____ occur when rocks in the Earth's crust move suddenly and slide along a fault.

3 Air exerts _____ which acts in all directions, and decreases with altitude.

4 The Earth is surrounded by a blanket of air called the _____ which becomes less dense as you go up. Air is a mixture of gases, consisting of _____ (four-fifths) and _____ (one-fifth) plus small amounts of carbon dioxide, water vapour and other gases.

5 The pressure in a liquid _____ with depth. It acts _____ in all directions.

6 Objects in water seem lighter because of an upwards force called the _____. The effect is called _____.

7 The sun heats up zones of the Earth's surface unevenly and this drives the _____ patterns.

8 Human activity has altered the Earth's atmosphere. Increasing amounts of carbon dioxide are likely to cause _____, and thinning of the _____ layer has decreased our protection from harmful ultraviolet radiation.

atmosphere
buoyancy
crust
earthquakes
equally
global warming
increases
magma
nitrogen
oxygen
ozone
pressure
upthrust
volcanoes
weather

Self-management

1 Copy the following words in your notebook and match them to their correct meanings.

air pressure	The amount of water vapour in the air
Archimedes' principle	The point on the Earth's surface directly above where the movement of rocks occurs in an earthquake
epicentre	The force on surfaces caused by the weight of the air
greenhouse effect	A giant ocean wave caused by an earthquake
humidity	The upthrust on a body in water is equal to the weight of water displaced
tsunami	The trapping of heat energy by gases in the atmosphere, causing its temperature to rise

2 Look through the chapter and find ten other key words. These are usually in **bold** type.

3 Beside each key word write down its meaning. You may find this in the glossary or you may need to write your own.

4 Now jumble up the meanings as in the example above.

5 Give your list to another student to match up. They will give you their list to do.

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

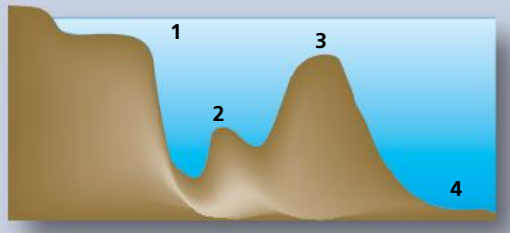
OneStopScience

1 Just below the crust of the Earth is the
- **A** mantle.
- **B** inner core.
- **C** outer core.
- **D** atmosphere.

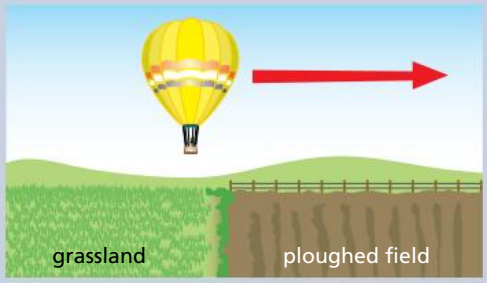
2 The two gases that make up 99% of the air are
- **A** carbon dioxide and ozone.
- **B** nitrogen and oxygen.
- **C** carbon dioxide and water vapour.
- **D** carbon dioxide and oxygen.

3 Which of the following are true and which are false?
- **a** The inside of the Earth is partly molten.
- **b** The molten rock inside the Earth is called lava.
- **c** There are no active volcanoes in Australia.
- **d** Tsunamis are underwater volcanoes.
- **e** A magnitude 2 earthquake is 10 times as strong as a magnitude 1 earthquake.
- **f** Earthquakes rarely occur in Australia.

4 The diagram shows a cross-section of part of the ocean floor. Where would the water pressure be greatest? Explain your answer.

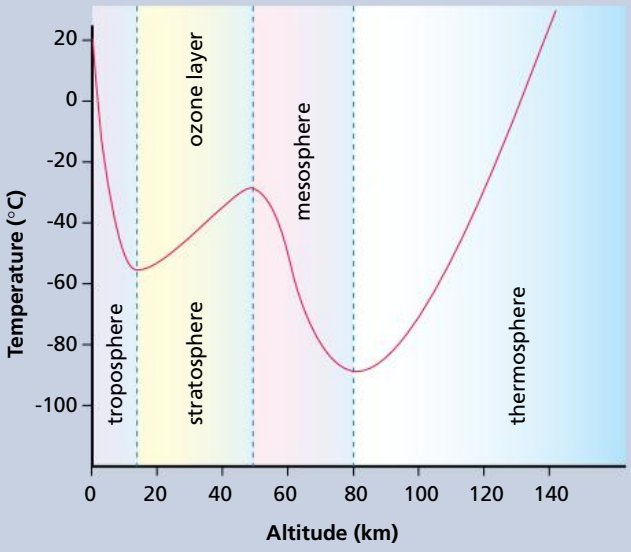


5 As a hot air balloon moved from over an area of grassland to a large ploughed field it was carried higher. Suggest a reason for this.



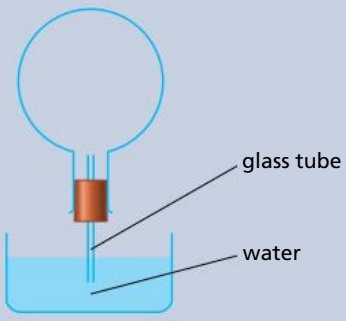
6 Why is it that the Earth stays relatively warm at night but the moon becomes very cold when the sun is not shining on its surface?

7 The Dorkians measured the temperature of the atmosphere as they left the Earth and plotted the graph below.
- **a** What is the independent variable? What is the dependent variable?
- **b** What happens to the temperature as you travel up through the troposphere?
- **c** In which layers does the temperature increase steadily with altitude?
- **d** What is the lowest temperature reached in the atmosphere?
- **e** Suggest why the temperature increases in the stratosphere.



8 You can float more easily in a swimming pool if your lungs are full of air. If you breathe out you sink into the water more. Use what you know about buoyancy to explain these observations.

9 Some water is boiled in a stoppered flask fitted with a short piece of glass tubing. The flask is then turned upside down, with the end of the glass tubing in a trough of water, as shown. What do you predict will happen? Explain your prediction.



10

Using our resources

SCIENTISTS AT WORK

The story of Velcro®

George de Mestral lived in Switzerland and loved going on nature walks with his dog. One day after a walk George noticed that he and his dog were covered in burrs. This was not unusual, but as George picked the burrs from his pants he wondered why the burrs stuck so well. He examined them under a microscope and saw that they had stiff little hooks that caught on the loops in the material of his pants. George decided to make a fastener to replace zips, using hooks and loops like the burrs on his pants. The year was 1948. For the next three years George discussed his idea with fabric makers and weavers in Lyon, France, until he found a weaver who could make a material with hooks on it like burrs.

George found that if nylon was sewn under infrared light it formed firm little hooks (pictured top right) that he could use for his fastener. In 1951 he applied for a patent in Switzerland, which meant that he was the only person who could make this product. He called his new material Velcro® from the French words *velour* (velvet) and *crochet* (hook). He then formed Velcro Industries® to manufacture his material, which today is a multimillion dollar industry.

Burrs have natural hooks to attach to clothing, fur and hair.

Focus for learning

INQUIRY 1

Sustainability

Sustainability is about preserving the Earth's resources for future generations. Our use of a particular resource such as water, timber, oil or plastic is *sustainable* only if we can continue using the resource for a very long time without using it up and without damaging the environment.

- Look at the photo below. How does it illustrate the idea of sustainability?

PROBLEM SOLVING

Materials

Investigate one material you use every day, such as nylon, rubber, silk, laminate, paper, plastic, Tencel, Teflon, latex, polyester, gold, cardboard, fibreglass or plasterboard, and find out the following:

a Where does the material come from? Is it natural or manufactured?

b How is it made? (What resources is it made from?)

c How is the material used?

d Who used the material first or invented it?

Present your research as a one-page information sheet.

By the end of this chapter you will be able to ...

Science Understanding

- give examples of renewable and non-renewable resources
- discuss ways of saving water around the house
- discuss how resources such as forests and plastics can be used sustainably

Science as a Human Endeavour

- research the use of bush medicines by Aboriginal people

Science Inquiry Skills

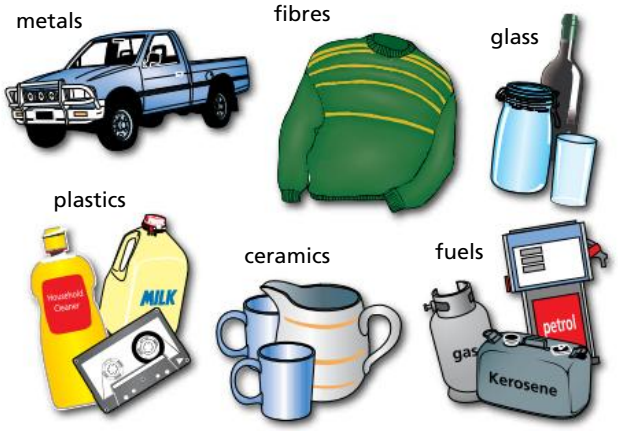
- use flow diagrams to describe manufacturing processes

LITERACY FOCUS

alkalinity
alloy
biodegradable
cracking
fractional distillation
hydrocarbons
monomers
non-renewable
petroleum
phosphates
polymers
polypropylene
polystyrene
process
raw material
recycled
resource
sustainability
synthetic materials
viscous

10.1 What are resources?

Some common groups of materials are metals, plastics, fibres, glass, ceramics, wood and fuels.



These materials have *properties* or characteristics that make them useful in different ways. For example a metal can be bent, twisted and polished. It can hold its shape, be cleaned easily and doesn't splinter. These properties make it the perfect material for a knife, fork or spoon. On the other hand, an envelope is obviously not made of metal because it would be too heavy and awkward to carry. It is made out of paper that is thin, light and easily folded.

Any material that can be of use to humans is called a **resource**. Some resources are *natural* and others are *processed or manufactured*.

Natural resources

Some natural resources come from living things such as plants and animals. For example, trees provide us with wood, sheep give us wool, silk is made by silkworms, and plants provide us with materials such as cotton, hemp and food.

Natural resources can also come from non-living things such as rocks and minerals, valuable substances found in the Earth. For example, sandstone is used for building houses and for paving stones, soil is used to grow plants, and water is needed to drink. Even sunlight is a non-living energy resource. Other resources obtained from non-living things are gas, coal and oil that are used for fuels.

Resources can also be **renewable** (readily replenished or replaced) or **non-renewable** (not readily replaced). For example sunlight is a renewable energy resource. Coal is non-renewable because it takes millions of years to be formed and will eventually run out before more is formed.

Processed resources

Natural resources can be used as they are or they can be modified to produce slightly different or completely new materials. For example gold is used as it is to make bracelets, bangles and rings. The gold is not changed to make these items. On the other hand, wood can be changed into paper, a completely new material.

The wood goes through a **process** or a series of actions to produce the paper. The wood is the **raw material** or the resource used to start the process. The paper is a processed or manufactured material. It can be used to make such things as newspapers, cards and envelopes.

Some processed materials are made using chemical reactions. During a chemical reaction, the atoms of the reactants combine and rearrange themselves, producing one or more new products. Plastics are a resource made using chemical reactions. For example nylon is made from chemicals obtained from oil. It is used to make pantyhose, and many other everyday objects. Materials that are made by a chemical process are called **synthetic materials**.

Processed materials have properties that are completely different from the raw materials from which they are made. For example, sand, gravel, water and cement are the raw materials used to make concrete, which has properties very different from those of the raw materials. Glass is also different from the raw materials used to make it—sand, limestone and soda ash (sodium carbonate).

The properties of concrete are very different from the properties of sand, cement and water used to make it.

Alloys

Processed materials can also be made by mixing raw materials together. For example, iron mixed with carbon makes steel, and copper mixed with zinc makes brass. A substance made of two or more metals mixed together like this is called an **alloy**. The properties of alloys are very different from those of the individual metals from which they are made. For example gold is a very soft, yellow metal that is hardened by adding silver and copper to it. This changes the colour of the metal. The more copper added to the mix, the more pink the alloy, making rose gold. Silver makes the alloy whiter, making white gold.

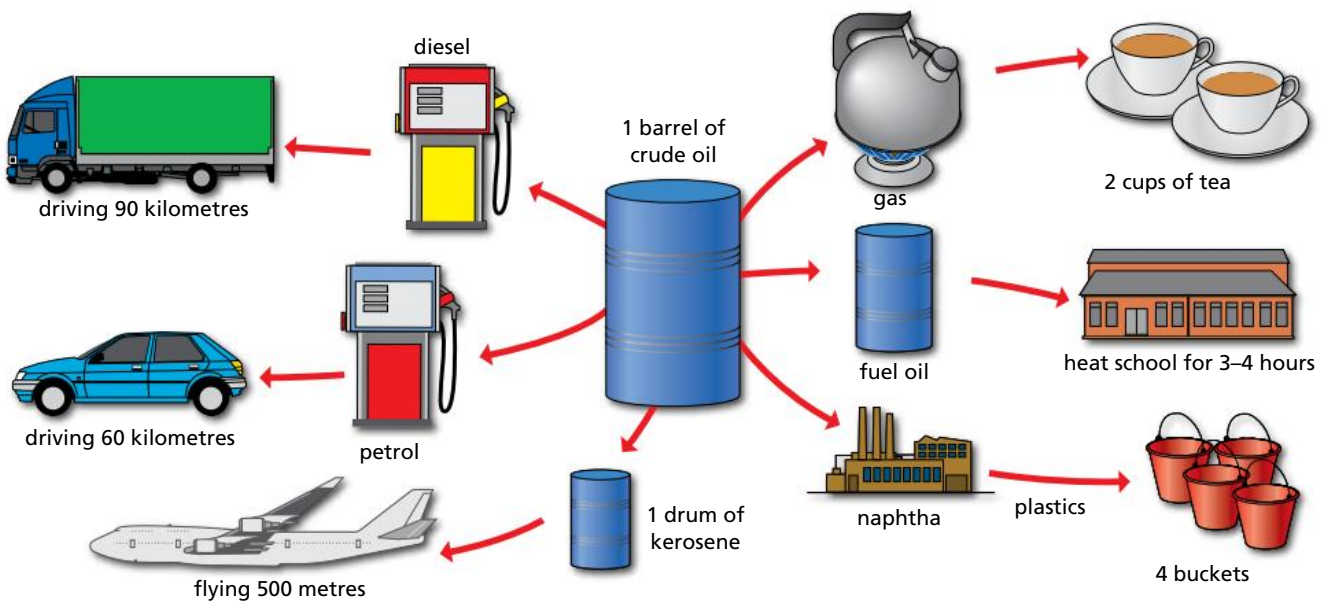
A Russian wedding ring made of yellow gold, white gold and rose gold

The value of our resources

Both natural and processed resources are very important to us. Water and sunlight are natural resources that we cannot live without. Plants provide food, clothing materials and medicines. Crude oil is a natural resource that is taken from the ground. It is a thick black liquid that is a mixture of many hundreds of different carbon compounds, some of which are shown in the diagram below. For example, you have probably heard of kerosene, which is sometimes used in the home for outdoor lanterns. Diesel, gas and petrol are common fuels. Naphtha is a colourless liquid used as a solvent and for making other chemicals such as plastics.

Crude oil is such a valuable resource because so many other resources can be made from it. Life as we know it would be very different without these resources. For example, one barrel of crude oil can provide enough petrol for a car to travel 60 km. Imagine riding a bike or walking 60 km if this resource didn't exist!

Our resources are economically important because they can be used to make money and produce wealth for the country. The wealth of a country often depends on both the natural resources it has and the resources it is able to manufacture and sell overseas.



The resources that can be made from a barrel of crude oil

INVESTIGATION

1 New materials

Aim

To investigate how three different processed materials are made.

Risk assessment and planning

1 Read through the investigation before starting.

2 What safety precautions will be necessary when handling the materials?

Apparatus

Read through each part of this investigation and list the equipment you will need.

PART A: Cement

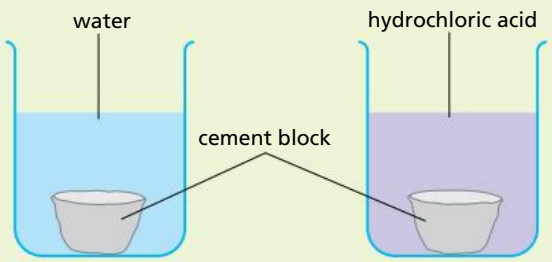
Method

1 Follow the instructions on cement powder to make enough cement to half fill two spaces in an egg carton. Make the cement in a snaplock plastic bag.

2 Mix the cement by moving the plastic bag through your fingers. What do you notice about the temperature of the bag as the cement is made? Pour the cement into the egg carton and leave it to harden. (It is best to do this outside so that cement is not washed into laboratory sinks.)

3 When the cement has hardened, tear the egg carton away from it. Place one block of hardened cement in a beaker with enough water to cover it. Do this for the other block using dilute hydrochloric acid instead of water. Label both beakers and let them stand overnight. Predict what you think will happen.

4 The next day examine both blocks. Were your predictions correct?



Results

1 How did you make the cement?

2 When the cement was mixed with water, did a chemical reaction occur? How do you know?

3 Did the blocks change when left in water or acid? Was there a chemical change?

4 Was a new material made in the reaction? Explain.

5 What properties does cement have that makes it a useful building material? How do these properties change when the cement is left in water or acid?

PART B: Concrete

Concrete is made by combining sand, gravel, cement and water together. Which proportions of these materials make the best concrete? Experiment to find out.

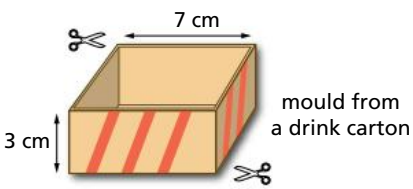
PART C: Bricks

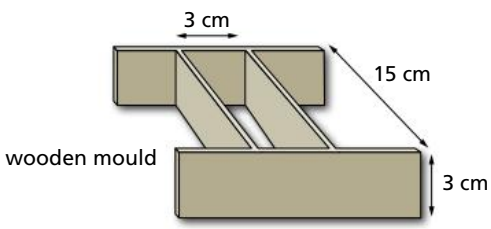
Using the instructions below as a guide, make your own mud bricks. What raw materials will you use? How much of each material will you need? Where do these materials come from? How will you test your new material?

Making bricks

1 Mud, sand and straw are mixed together.

2 The bricks are cut to size or shaped using moulds. Two different types are shown.





3 The bricks are hardened in a kiln or sun dried, then used.

SKILL

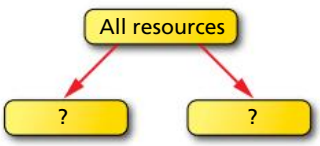
Tables and keys

Tables and keys are useful for describing the properties of resources and classifying them into groups.

1 Copy and complete the following table.

Natural resources			
Living	**Used for**	**Non-living**	**Used for**
Cows		water	
Flowers		crude oil	
Grass		rocks and minerals	
Mushrooms		sunlight	
Birds		ocean	
Trees		soil	

2 Present the information on page 203 as a branching key. You will need to include natural resources, processed resources, synthetic materials, alloys, renewable and non-renewable resources. Start with:

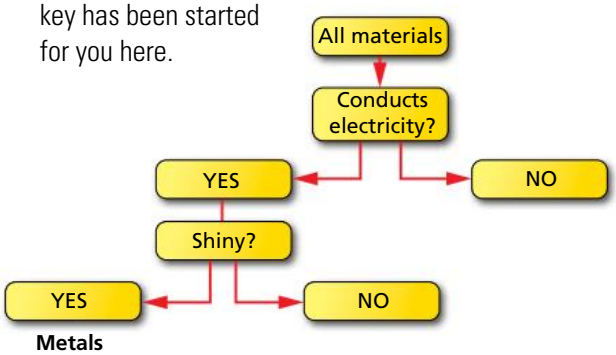


3 **a** Copy and complete the following table.

Resource	Made from	Made into
Brass		
Concrete		
Glass		
Steel		
White gold		
Naphtha		

b Add the materials in the table to the key you made in question 2.

4 Classify the different material groups such as fibres, ceramics (e.g. casserole dishes), plastics, glass and metals by designing your own key. An example of a key has been started for you here.



Over to you

1 In groups of three, list all the materials that you have used today. For each, state
- five properties of the material.
- three things the material is used for.
- whether it is a natural or processed resource and why you think this.

For example: coloured glass
- waterproof, lets light through, easily broken, doesn't decompose, can be cut into shapes
- lampshades, church windows, ornaments
- processed material because it is made from sand, limestone and soda ash.

2 Give an example to show how each of the following statements is true.
a The properties of materials make them useful to us.
b Materials around us can be changed or used as they are.
c New materials can be made by using chemical reactions.
d An alloy is a mixture of metals.
e A resource is anything that can be useful to us.

3 What is the difference between
a yellow gold and white gold?
b a natural resource and a processed resource?
c renewable and non-renewable resources?
d paper and wood?

4 Which of the following materials are made by using chemical reactions? Explain your reasoning.
wood, plastic, silver, nylon, water, crude oil, kerosene, gold, bricks, cement, concrete

5 Name three natural resources and three processed resources.

6 Give an example of an object in the kitchen that is made from a natural resource and one that is made from a processed resource.

7 Explain what the word *synthetic* means, giving an example.

8 Give an example of a *process* that you have used to produce a *product* of some kind.

9 Wool can be used exactly as it is. If it is spun and dyed, is it considered to be natural or processed? Explain your reasoning.

10.2 Water as a resource

The most precious or highly valued natural resource on Earth is water, because all life depends on it. Water is considered to be a renewable resource because it is recycled in the water cycle. Water covers almost three quarters of the Earth, but the supply of fresh water is limited and must be used wisely.

All water on Earth is connected by the water cycle. Water in waterways such as rivers and lakes evaporates to form water vapour in the air. As this water vapour rises into the cooler levels of the atmosphere it condenses and eventually falls to the ground as rain, hail or snow. The water then soaks into or runs off the ground and is returned to waterways to start the cycle again.

Water also cycles through the bodies of living organisms. Plants move water from their roots to their leaves where water evaporates and returns to the air. Animals drink water and pass it out of their bodies as urine and sweat.

The way we use water directly affects the water cycle and all living things on Earth. And of course the Earth would be lifeless without water.

Daily water use

In Australia, on average, each person uses about 825 L of water each day as follows:

toilet	140 L
bathroom	180 L
laundry	110 L
kitchen	55 L
outdoors/garden	340 L

Look at your last water bill and see how your household water usage compares with the 'average'. The table below shows some of the ways water is used in our homes.

Water use	Litres (L)
Dishwasher (one cycle)	12–50
Five minute shower	62.5
Two minute shower	25
Running tap for 1 minute	15
Cleaning teeth with tap running	30
One load in washing machine	120
Garden hose running for 1 hour	1000
Toilet half-flush	3
Toilet full flush	11
Leaking toilet cistern per hour	9.5

Where does the water go?

Water from the hand basin, kitchen sink, bath, shower, dishwasher, washing machine and laundry tub is called *greywater* because it is grey in colour. Water from the toilet is called *blackwater*. Both enter the sewerage system as waste to be treated and purified.

Water from gardens, footpaths, driveways and roads runs into stormwater drains that eventually empty into the ocean. This water is not treated. Any plastic, garbage, fertilisers and detergents that end up in this water are carried to the ocean and can affect life there.

Pollutants in waste water

Greywater contains such things as soap, cooking oil, food wastes, shaving cream, detergents for washing clothes and dishes, toothpaste, cleaning products, paper tissues and hair. Materials such as soap and toothpaste should be used sparingly. Other materials such as cooking oil, paper tissues and hair should not be put in water at all.

Greywater leaving the house is often high in salts. You probably think of table salt or sodium chloride as salt. However, this is only one type of salt. Salts are chemical compounds that produce ions when they dissolve in water. For example, copper sulfate, calcium carbonate and potassium iodide are common salts that you may have used in the laboratory. Ammonium nitrate found in fertiliser is also a salt. Salts build up in the soil, affecting plant growth.

The breakdown of food produces salts called phosphates. These are an indication of how much food material is in water. They cause unwanted plant growth in waterways, and are an indicator of how polluted the water is.

Many products that are used in the home and tipped down the drain are harmful. Most detergents for example are high in phosphates and other salts. Cleaning products such as bleach and ammonia are *caustic*, which means they can burn or damage living tissue.

Finding alternatives

One way to reduce the amount of harmful materials in our water is to look for alternative cleaning products. For example, pure soap flakes have far fewer salts in them than many other soap powders or liquids. There are many environmentally friendly

products at the supermarket that could be used. For example some products have no phosphates and no caustic chemicals such as ammonia in them. There are also products for cleaning floors, bathrooms and other surfaces that use specially designed fibres to clean, rather than relying on chemical sprays.

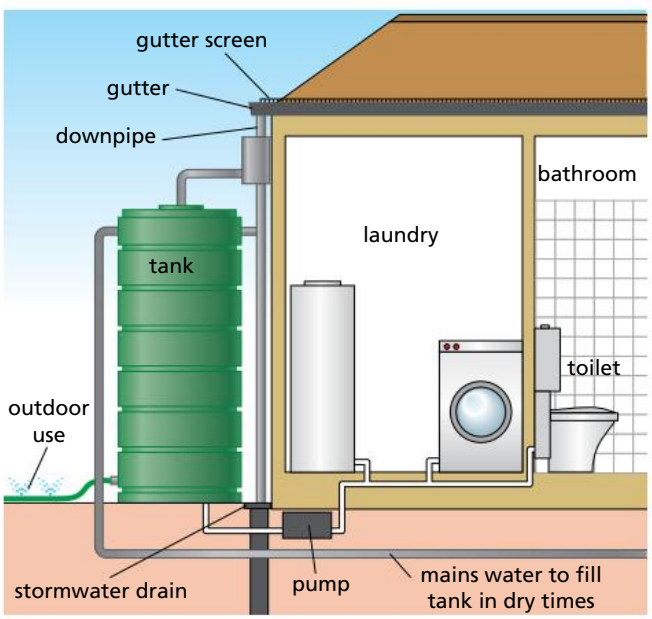
Re-using water

A way to save water is to re-use it a number of times before it enters the sewerage system or drain. Grey water with salts in it cannot be re-used. It will kill garden plants that cannot tolerate high levels of salts. However, if harmful materials were avoided, it would be possible to re-use grey water in the garden.

It is presently illegal to re-use grey water in Australia unless it has been treated in some way. Grey water cannot be stored because it quickly becomes smelly, and there is the possibility that any disease organisms in it could spread. However grey water re-use systems are used in other countries and can successfully be set up as trickle watering systems under mulch and soil.

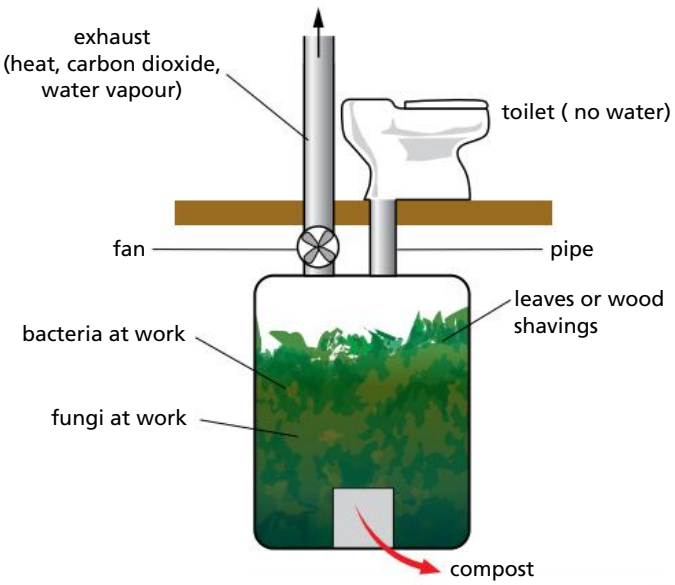
Rainwater tanks

Australian households can save water by installing rainwater tanks. These are common on farms but are rarely used in cities. Recent statistics show that a 3000 L water tank can reduce mains water use by 40%, and a 5000 L tank can reduce water use by 50% or more. In this way excess water bills can be eliminated. The picture below shows where rainwater can be used in an average household.



Bush toilets

Many 'bush' toilets are waterless composting toilets. Human waste and toilet paper are covered with natural materials such as leaves and wood shavings. Just like a compost heap in the garden, bacteria and fungi break down the waste. After 6 months or more the waste can be used as fertiliser. These toilets are well ventilated and destroy disease-causing organisms in the composting process. They could be used in our homes to reduce water use.



INQUIRY 2 Running taps

Design an activity to check some of the water use figures in the table on the previous page. For example:

- **a** How much water is wasted from a leaking toilet over a 24-hour period?
- **b** How much water is used in a 2-minute shower compared to a 5-minute one?
- **c** How much water is used for a bath and how long would it take to use this amount of water in a shower?
- **d** How much water is used by running a tap while cleaning your teeth compared to turning on the tap only when you need to?
- **e** How much water is wasted washing a few clothes using a large load cycle?
- **f** How much water does a front-loading washing machine use compared to a top-loading one?

Decide what you are going to do and what equipment you will need, then carry out your test.

INQUIRY 3 Stop wasting water

1 The following list shows some ways to stop wasting water. Rank these in order from the one you consider to be the most important to the least important. Explain your reasoning.
   - **a** Use the half flush on the toilet as much as possible.
   - **b** Fix dripping and leaking taps.
   - **c** Allow only 2 minutes for a shower.
   - **d** Relax in a bath instead of a long shower.
   - **e** Use the cycle on dishwashers and washing machines that is appropriate for the load you have.
   - **f** Never let a tap run when cleaning your teeth, washing vegetables or rinsing dishes.
   - **g** Use appliances that have a high water efficiency rating; that is, those that use as little water as possible.
   - **h** Collect rainwater for use in the garden in dry times, instead of using a hose or sprinkler system.
   - **i** Use a broom to clean pathways rather than hosing dirt away.
   - **j** Install a timer on garden taps so that the sprinkler or hose is not left running.
   - **k** Use non-salt and non-caustic cleaners wherever possible.
   - **l** Don't put food wastes down the sink, or flush anything other than toilet paper down the toilet.

2 Add any other suggestions to this list that you can think of to reduce water use around your home.

3 Make a list of ways of reducing water use at school.

Use a broom, not water, to clean your driveway.

INQUIRY 4 Water in the garden

Water usage outdoors and in the garden makes up about 40% of our total water usage, and a lot of water is wasted here.

Design an activity to investigate one of the following.

- **a** Does using a sprinkler use more or less water than using a hand-held hose?
- **b** Does a drip watering system on top of the soil use less water than an aerial watering system?
- **c** Can mulch on a garden reduce the amount of watering needed in dry times?
- **d** Can grey water be used to water plants? Which soap or detergent has the least effect on plants?
- **e** Can grey water be filtered somehow to make it suitable for watering plants?
- **f** How much water is used when you wash a car?

Over to you

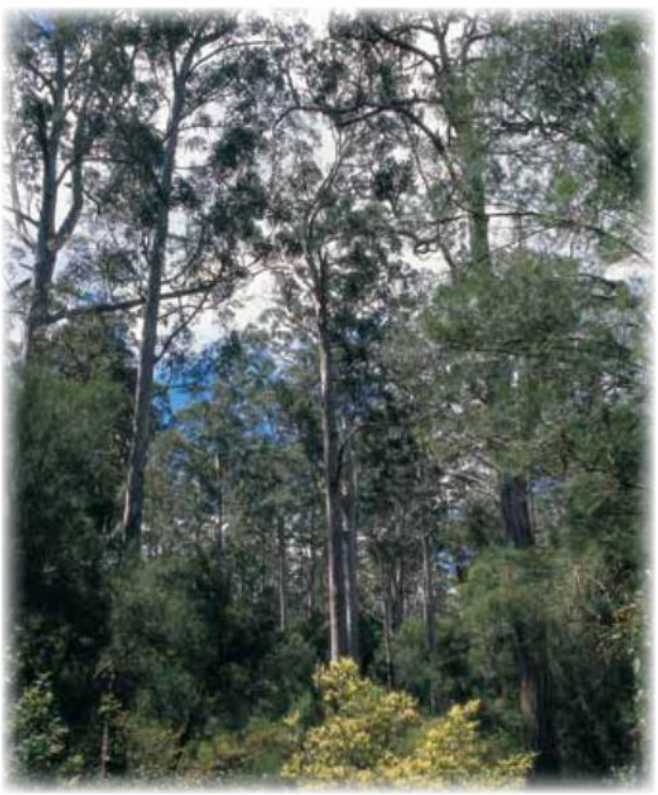
1 Use a diagram to show how all water on Earth is connected in the water cycle.
2 Give five examples of how water is wasted around the home.
3 List three materials that are put into waste water that should not be there. Suggest ways to prevent these materials from going down the drain.
4 Make a 10-point checklist of Dos and Don'ts that you can put on the fridge at home to remind your family about not wasting water.
5 Explain how it is possible to save water by using rainwater tanks, composting toilets and re-using grey water. Predict whether you think these might become common practice in the future.

10.3 Forest resources

Forests and the trees in them are valuable natural resources. Before Europeans arrived in Australia, forests covered 226 million hectares of land. Today they cover about 156 million hectares of land, and of this only 8.4 million hectares are in conservation areas. The areas of forests in each state or territory are shown here.

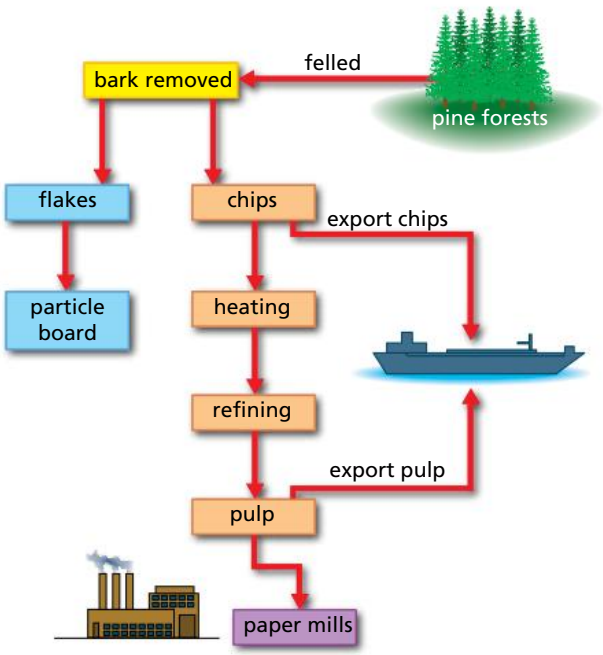
State or territory	Total (thousands of hectares)
Australian Capital Territory	119
New South Wales	20 787
Northern Territory	35 385
Queensland	49 055
South Australia	5499
Tasmania	2904
Victoria	7285
Western Australia	34 800
Total	**155 835**

Eighty per cent of Australian forests are eucalypts. Other types are acacia (wattle), mangrove and rainforests.



You probably use materials from Australia's forestry industry every day—paper, furniture, tissues and newspapers. Forestry products are Australia's second largest manufacturing industry, producing about 11 billion dollars of sales and employing around 83 000 people.

Wood from forests can be cut and used as a raw material or manufactured into other products. Sawmills in Australia produce about 4.5 million cubic metres of timber that is used to build houses. The forestry industry also produces manufactured products such as medium-density fibreboard, plywood and particleboard that are used as building materials. Woodchips are also produced, as well as pulp and paper.



Currently woodchips make up about 40% of forestry *exports*, that is, goods that are sold overseas to earn money for Australia. Other exports are pulp, waste paper and paper products. Australia also *imports* pulp and waste paper (that is, brings them in from other countries). At present more forestry products are imported than exported.

It is better if resources are made and used in Australia rather than imported. This creates jobs and money for Australians rather than for people overseas. It also costs money to import materials into Australia, and this increases the cost of products made with imported goods. On the other hand, exporting goods overseas gives Australian industries money from other countries.

Paper

Australia uses about 3.6 million tonnes of paper products or about 180 kg per person per year. We use this paper for newsprint, tissues and packaging. Two-thirds of this is made in Australia, the rest is imported.

Annual paper use (thousands of tonnes)

Product	Financial year				
	04–05	05–06	06–07	07–08	08–09
Newspaper	737	739	673	679	639
Printing and writing	1620	1656	1735	1822	1733
Tissues	272	259	259	230	240
Packaging	1587	1485	1525	1606	1586
Total	**4216**	**4139**	**4183**	**4338**	**4199**

Source: Australian Bureau of Agricultural and Resource Economics

Paper is made from wood fibres that are shredded from timber. Fifty-seven per cent of wood fibres come from recycling and 43% come from new fibres. Different types of paper are made from different paper pulps. The paper pulp is made using either a mechanical or a chemical process.

Paper processing

In mechanical processing the wood fibres are shredded using a fast-moving grindstone to make a pulp. A lot of energy is used and low quality pulp is made for newspapers and packaging.

In chemical processing, chemicals are used to dissolve the lignin in the wood fibres. Lignin is a substance in the wood that makes the wood fibres stiff and firm, and holds them together. Once the lignin is removed a pulp is made. The chemicals are then collected and disposed of. This process produces a small amount of high quality pulp used for printing and writing paper.

In both these processes the pulp produced is brown. To make white paper, the pulp is bleached with chlorine and washed before going through further processing.

Paper made by both these processes can be recycled. However wood fibres do break down and this limits the number of times they can be re-used. As a result, recycled paper needs to have new fibres added to it.

Why recycle paper?

Forests are the lungs of our planet, taking in carbon dioxide and putting oxygen back into the air. They keep our air clean, so every time a tree is cut down the quality of the air is affected.

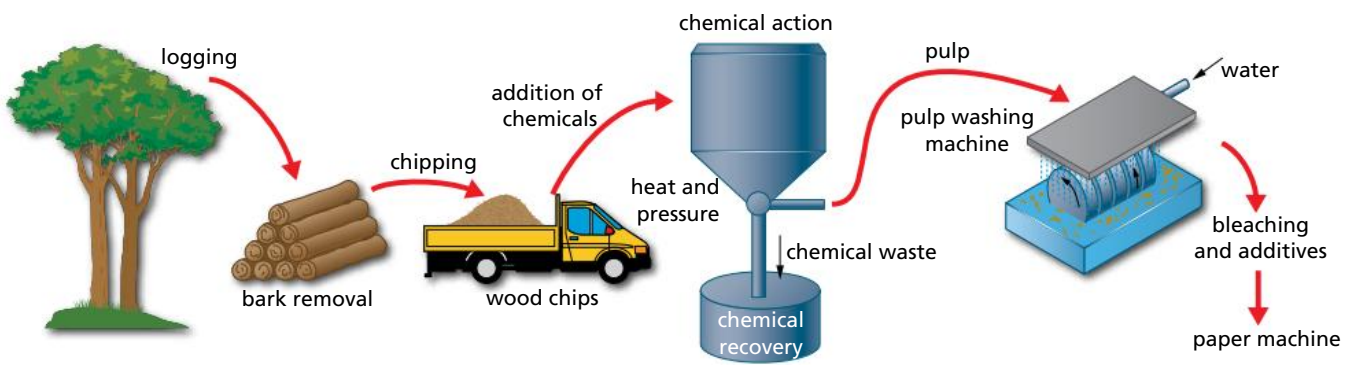
It costs a lot of money to turn a tree into paper. Electricity, which is usually generated using **fossil fuels**, is needed to run paper factories. Energy is also used in cutting the wood, processing it into paper and transporting it. In addition, the whole process adds carbon dioxide to the air.

Recycling paper not only saves trees, but also reduces production costs. It is estimated that for every tonne of paper recycled the following resources are saved:

- 13 trees
- 2.5 barrels of oil
- 4100 kW of electricity
- 4 m^3 of landfill (garbage)
- 31 780 L of water.

Using recycled paper reduces the need for new fibre so that natural resources are not wasted. It also reduces the need to import wood fibres. Also, paper thrown away ends up as landfill that rots to form methane, a greenhouse gas.

Chemicals are used to break down wood fibres to make pulp. The pulp them moves to a paper machine for further processing.



INVESTIGATION

2 Making recycled paper

Aim

To recycle paper from waste paper.

Risk assessment and planning

1 Read through the investigation before starting.

2 What safety precautions are necessary when using a hot plate and the boiling mixture in the stewing pot? Discuss these with your teacher.

Apparatus

- a mould and deckle from a craft shop
- a large tub that the mould and deckle will fit into easily
- shredded waste paper
- 5 L stewing pot
- stirring rod
- tea strainer
- food blender
- Chux cloths
- hot plate
- detergent
- large sieve
- tablespoon
- confetti
- newspaper

Method

1 Add 2 tablespoons of detergent to 2 litres of water in a large stewing pot.

2 Add shredded paper to the pot until the water is like porridge. Boil this mixture for 25 minutes to break down the paper fibres.

3 Use the tea strainer to scoop off any scum or dirt that has formed on the surface, then pour the mixture through a sieve.

4 Use a food blender to blend the pulp you have made into a finer mix. The pulp needs to be like a thick soup when you have finished. Add water if necessary. Fill the tub with the pulp and sprinkle confetti into it to add colour features to it.

5 Set up the mould and deckle, preferably outside. Scoop them through the pulp in the tub so that the deckle fills evenly with pulp. You may have to move the mould and deckle from side to side to do this.

6 Hold the mould and deckle above the tub so that the water drains back into it.

7 Remove the deckle and lay a large Chux cloth across the top of the pulp on the mould. Lay out a wad of newspaper on a flat surface. Then carefully turn the mould upside down so that the cloth with the pulp on top sits on the newspaper.

8 Leave the pulp on the newspaper for at least 24 hours until it is fully dry, then peel the Chux cloth off the paper. Your sheet of paper is now ready to use.

Results

Describe the properties of your paper. How thick is it? Can you write on it? Compare it to the paper in your notebook.

Discussion

1 Where did the wood fibres for your paper come from?

2 Did you use a mechanical or a chemical process to produce the paper pulp? Explain.

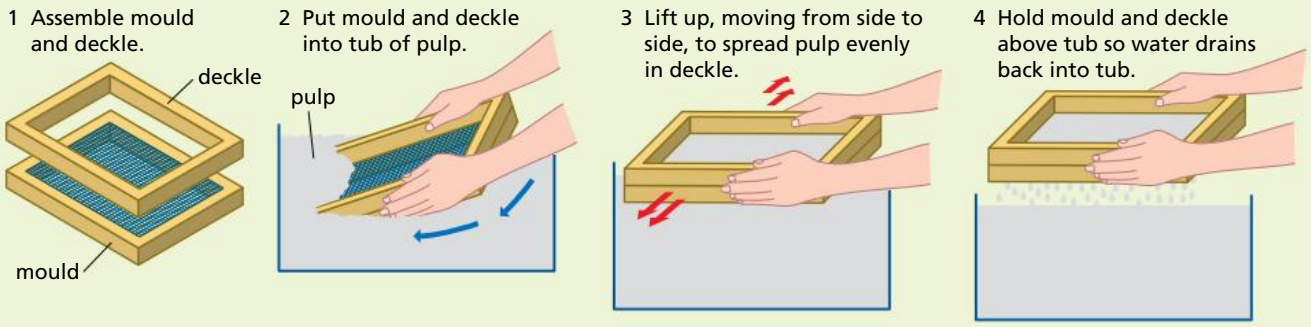
3 Why did the wood fibres need to be boiled?

4 How could you change the paper you made to make it finer, coloured or patterned?

5 Design a test to compare the properties of the paper to those of the paper in your notebook.

Conclusion

Write your own conclusion about paper making.



The importance of rainforests

Rainforests are one of the most important natural resources on Earth. They once spread over 14% of the Earth's surface, but they have been cleared for timber and land use and today cover only 6%. It is predicted that rainforests could be completely cleared within the first half of this century!

Rainforests are the home of millions of plants and animals. The rainforests of the Amazon in South America, for example, contain more than half of the 10 million different insects, plants and animals estimated to be on Earth. Rainforests also produce over one-fifth of the Earth's oxygen.

Rainforests are home to many people and provide food for them. Bananas, figs, avocados, and brazil and cashew nuts are some of the foods that grow there naturally. Rainforests are therefore a huge source of natural resources.

Rainforest plants are also grown for commercial use. For example, coffee plants are grown and their beans used to make coffee. Cacao (ca-KAY-o) plants are grown for their seeds, which are harvested and ground up to make chocolate. Commercial crops such as these from rainforest plants could provide a lot of money for farmers. Money could also be made from obtaining nuts, fruits, medicine and oil from rainforest plants. A balance is needed between clearing the rainforests for timber and commercial land use, and leaving the rainforests for the natural resources they provide.

The cacao plant is a rainforest plant. The seeds from this plant have their husks removed, and they are then roasted and ground to produce cocoa (ko-ko) powder—one ingredient of chocolate.

Rainforests presently provide the materials for one-quarter of the drugs we use. For example, some drugs extracted from rainforest plants have been successful in fighting cancer. Scientists have only tested a small number of the trees and plants in rainforests, so their true value is not fully understood. The rainforests cannot be destroyed because they hold hidden treasures that are only just being discovered. They may hold the key to solving some of the world's presently untreatable diseases.

Quinine and periwinkle

The value of rainforests is illustrated by the use of quinine. Quinine is made from the powdered bark of the cinchona (sing-KO-na) tree that grows in the rainforests of South America. It has been used to treat fevers, malaria, influenza, pharyngitis, cramps and anorexia nervosa. It is also added to drinks as flavouring. For example, it is used in tonic water, which used to be drunk as a 'tonic' to prevent malaria. Quinine makes the blood toxic to the parasite that causes malaria.

Dried cinchona bark

Periwinkle is another rainforest plant used as a dried herb to treat menstrual and urinary tract problems, diarrhoea and nose bleeds. It decreases the amount of fluid or blood lost from the body.

INQUIRY 5 Investigating quinine

You will need: UV light, lemonade, mineral water, different brands of tonic water, including India tonic water

1. Quinine fluoresces or glows under UV light. Predict what you think will happen when you put each bottle of drink that you have been given under the UV light.
2. Test your predictions.

INQUIRY 6

Paper-making flow diagram

Use the flow diagram of chemical pulp processing on page 211 to answer these questions.

1. Describe chemical pulp processing in your own words.
2. Explain how mechanical processing differs from this.
3. Once the pulp is produced by mechanical or chemical processing, it passes to a paper machine. Draw your own flow diagram to show how pulp is made into paper. The description here will help you.

Once at the paper machine, the watery pulp is spread across a horizontal moving belt of wire mesh that slips across rollers. As the pulp moves along the belt, water drains from the pulp into a box beneath. Rubber straps along the edge of the belt keep the fibres in place. The movement of the belt sticks the fibres together and an air pump dries the mix.

The belt passes under a cylinder covered with wire (called a dandy roll). Patterns in the wire press into the paper leaving a watermark that is used to tell the grade of the paper. The paper then moves through felt-covered rolls that stick the fibres together even more. The paper then passes onto a cloth belt and through metal rollers to get a smooth finish. It travels through heated rollers to dry thoroughly and then rollers that give the paper a machine finish. The paper is then cut into sheets ready for use.

Over to you

1 In Australia, how many millions of hectares were covered by forests before Europeans arrived, and what is this figure today?

2 Which state or territory has the largest area of forests in Australia? Would you expect this? Why or why not?

3 What products are made by forestry industries? Classify these products as raw materials or manufactured materials.

4 Look at the flow diagram showing woodchip manufacture and use on page 210. What are woodchips used for?

5 Why are woodchips economically important to Australia? What other forestry products are exported?

6 What is the difference between importing materials and exporting materials?

7 Look at the table on page 211 showing the paper used in Australia. Present this information as a line graph using a separate line for each type of paper used.

8 Give three reasons why it is better to use recycled wood fibres than new fibres.

9 Can paper continue to be recycled? Explain.

10 Which process is better for the environment—chemical pulp processing or mechanical pulp processing? Explain.

11 In a paragraph explain why rainforests in Australia should not be cleared for agriculture and housing development.

12 Are forests a renewable or a non-renewable resource? Give reasons for your answer.

PROBLEM SOLVING

Have you decided on a material to investigate? Which materials could you use from this section? Cardboard, paper and timber are all very useful resources. You could also investigate tencel. It is made from cellulose fibres, which come from trees.

10.4 Using our resources

So far we know that resources:

- can come from living or non-living things
- are often processed to make them more useful
- are economically useful
- can often be recycled
- can be used to make synthetic materials
- can be renewable or non-renewable.

Coal and oil

Coal and oil are fossil fuels that have formed naturally from the remains of dead plants and animals buried in the Earth's crust for millions of years. Over time these remains have changed to materials that can be used as fuels. They are also called **hydrocarbons**, because they are made from the elements hydrogen and carbon.

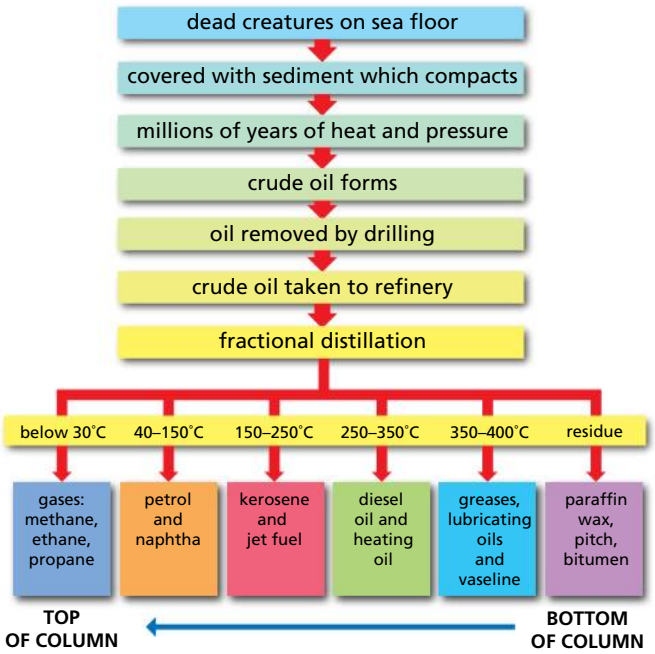
Fossil fuels are non-renewable forms of energy because they cannot easily be replaced. For example, it takes millions of years for coal to form. Under the right conditions, rotting plants break down and form a substance called peat. Rivers and streams wash sediment such as sand and mud on top of the peat. Over time the peat becomes buried under layers of sediment. If it then comes under intense heat and pressure deep in the Earth's crust, it can change to form coal.

Oil is formed in a similar way to coal. The dead plant and animal material changes to form oil which is trapped in layers of sediment. Geologists think Australian oil was made from dead land plants, whereas oil in other parts of the world was made from dead sea life. Petroleum is another name for oil. It comes from the words *petros* meaning 'rock' and *oleum* meaning 'oil'.

Oil taken from the ground is called crude oil and it is a mixture of many different hydrocarbons. These can be separated by using a process called *fractional distillation*.

Crude oil

During fractional distillation, hot crude oil from a furnace enters a large sealed chimney or tower called a fractionating column. The bottom of the column is hot and some compounds boil very quickly, for example kerosene and petrol. As they boil, they evaporate and rise. They cool down and become liquid again (condense) higher up the column, where they are collected. Compounds such as diesel and bitumen are slower to boil. They are collected in the hotter part of the column, close to the bottom.



The various hydrocarbons that make up crude oil have different properties and therefore different uses. Bitumen is thick and very *viscous* (slow flowing), so it is used to cover roads. Petrol is flammable and not very viscous, so it makes an excellent fuel that flows easily into petrol tanks. Some more uses of crude oil are shown on page 204.

Plastics

Plastics are synthetic materials made from oil. The hydrocarbons separated from crude oil can be broken down to simpler substances that boil at lower temperatures. For example, the large molecules in naphtha can be broken down to form small molecules such as those in the gas ethene. This process is called **cracking** and takes place in extremely hot furnaces using a catalyst.

Ethene molecules are called *monomers* and they can be made to react together to form long chains called **polymers**. (*Mono* means 'single', *poly* means 'many' and *mer* means 'units', so *monomer* means 'single units' and *polymer* means 'many units'.) There are many different polymers, and they can be melted and moulded to form various plastic products. Some of these and their uses are shown in the table on the next page.

Uses of plastics

The properties of plastics determine how they are used. For example PET plastic is strong, rigid and does not allow gases to move through it, so it is used for soft-drink bottles. LDPE plastic keeps out moisture and air and is very flexible, so it is useful for preserving food. Products such as cling films are made from LDPE.

Recycling plastics

Recent figures indicate that Australians use more than 1.3 million tonnes of plastic each year, or about 58 kg per person. As 30% less energy is used to make products from recycled plastic than from oil, recycling plastic saves money, energy and resources. It also reduces landfill and helps save the environment.

Identification code	Name and description of plastic	Uses
1 PET PETE	**polyethylene terephthalate PET** clear and tough	bottles for water, soft-drinks, detergent; filling for sleeping bags and pillows
2 HDPE	**high density polyethylene HDPE** usually white	bottles for milk, cream, shampoo and cleaners; shopping bags; compost and rubbish bins
3 V	**unplasticised polyvinyl chloride UPVC** clear and hard **plasticised polyvinyl chloride PPVC** clear and flexible	UPVC: bubble packs, pipes for plumbing, juice and cordial bottles PPVC: flexible hoses and tubing, blood bags, soles for shoes
4 LDPE	**low density polyethylene LDPE** flexible and soft	garbage bags, black plastic sheeting, lids for containers
5 PP	**polypropylene PP** firm and flexible	ice-cream containers, bags for potato crisps, drinking straws, lunchboxes, worm farms
6 PS	**polystyrene PS** brittle plastic and soft-foam-like plastic called expanded polystyrene(expanded means that air is added to produce a foam)	pegs, coat hangers, rulers, CD and video cases, hot food and beverage containers, meat trays
7 OTHER	plastics not listed above, e.g. nylon and acrylic	

Source: Plastics Identification Code Symbols reproduced with the permission of the Plastics and Chemicals Industries Association <www.pacia.org.au>.

INQUIRY 7

Making plastic slime

You will need: PVA glue, beaker, stirring rod, dropper bottle of borax solution (Dissolve 45 g of borax in 1 L of water.)

1. Put 30 mL of PVA glue in a beaker and slowly add the borax solution drop by drop until the mixture forms a soft solid. Has a new substance been formed?
2. Rinse the solid in water before handling it.
3. What happens when you hold the solid in your hand? What happens when you drop the solid, squeeze it, stretch it, throw it, bounce it or hit it?
4. Design your own experiment to see how the rate of the PVA–borax reaction is affected by temperature or the amount of borax added. You could also investigate how the solid changes over time.
5. You can make slime using cornflour and water. Try this and compare the slime you make with your PVA slime.

INQUIRY 8 Plastic bags

The problem with many plastics is they are not *biodegradable*, which means they don't break down or decompose in the natural environment. Some plastics do break down when exposed to UV light, and bags made from PVA dissolve in hot water. They are used for clothing collection and laundry bags in hospitals.

You will need: UV light, different types of plastic bags

Design your own experiment to see if the plastic bags break down in hot water or under UV light.

Most plastic bags end up as landfill because they are not biodegradable. Many supermarkets are encouraging shoppers to bring their own bags or buy bags to re-use rather than carry their shopping home in plastic bags. This will hopefully reduce the demand for plastic bags and help save the environment.

INQUIRY 9 Nasty nappies

Nappies were once made from plastic that did not break down and just contributed to landfill. Today nappies are made of paper, with plastic or cloth fasteners, and they are filled with a polymer that absorbs water.

You will need: different types of nappies

Collect and test different nappies to see which:

a is the most water-absorbent

b contains the smallest amount of plastic

c breaks down the fastest in the environment

d can be refastened often.

Report your findings to the class and explain why each of these properties is important.

Over to you

1. What is a fossil fuel? Why does it take so long for fossil fuels to be replaced?
2. If fossil fuels are made from decomposed living organisms, why are they considered to be forms of non-renewable energy? Explain.
3. What is a hydrocarbon? Give an example.
4. How is crude oil separated into its different fractions?
5. How are petroleum products harmful to the environment, both when they are manufactured and when they are used?
6. Give meanings for these words: *viscous*, *cracking*, *monomer*, and *polymer*.
7. List three advantages and three disadvantages of using plastics.
8. Put forward an argument to explain to your family why they should recycle plastics and other materials.
9. Why is UPVC used for drainage pipes rather than LDPE? (See the table on the previous page.)
10. Lily lives in Brisbane and wants a plastic material to wrap glassware to send to her family in Melbourne. What plastic material would you suggest she use? Explain your reasoning.

PROBLEM SOLVING

Your task is to investigate one material and say where it comes from, how it is made, what it is used for and who invented it. You should be able to complete this now.

Aboriginal bush medicines

For many thousands of years Aboriginal people have used plants, and also animals, as medicines. The leaves, flowers, bark or seeds of certain plants are collected when in season. The plants are usually ground to a pulp and boiled to extract their resins. These resins are then mixed with the fat of kangaroo, emu or goanna to make ointments. These ointments may be used to heal wounds, bites, rashes or as an insect repellent. Leaves may be crushed and soaked in water to make solutions, which can be applied to wounds to prevent infection. Sometimes leaves are laid across a fire and the smoke inhaled. On this page are four examples of Aboriginal bush medicines.

1 *Witchetty grubs* are a rich source of protein and are a favourite Aboriginal food. However they can also be crushed to form a paste to put on burns or to rub on the sore gums of babies getting their first teeth.

2 In eastern Australia Aboriginal people used to throw the leaves of the *corkwood tree* into waterholes to stupefy or stun fish, making them easy to catch. Scientists found the corkwood tree contains a powerful drug which is very useful as a sedative (calming substance) that can prevent seasickness. During World War II the Allies could no longer obtain the sedative from Germany, so they imported it from Australia. It was used to stop the troops getting seasick during the Allied invasion of France on D-Day, 1944.

3 In north Queensland, Aboriginal people know that *green ants* can be used as a cold and flu remedy. They soak a nest of green ants in water and strain out the ants. They then drink the liquid, which acts in a similar way to the cold and flu products we use today. They also squash the ants and use them to rub on their chests—like Vicks VapoRub. Scientists have found that the green ants make their own antibiotic (a drug that kills bacteria) inside their abdomen.

A green ants' nest in north Queensland

4 Aboriginal people in inland Australia used the leaves of the *crimson turkey bush* to make a solution to treat flu, headaches and infections. They also chewed on fresh stems to ease the pain of toothache and gargled the nectar from the flowers to treat sore throats.

Professor Hans Griesser and a team of researchers from the University of South Australia have extracted 11 compounds from the crimson turkey bush. They have found that these compounds have the same bacterial-killing power as the antibiotics we use today. The researchers have worked out a way to stick these antibiotics to the plastic and metal materials used to make surgical implants such as heart valves and hip and knee joints. These antibacterial coatings have been found to be very effective in preventing infections in the implants. However, Professor Griesser wants to make sure that the Aboriginal community gets some benefit from any use of the resource that they have known about for thousands of years.

Questions

1 How do Aboriginal people make ointments from plants?

2 Suggest why the leaves of the corkwood tree stupefy fish.

3 Suggest how the Aboriginal community could benefit from the use of their knowledge of bush medicines.

4 What needs to be done if we are to benefit from Aboriginal bush medicines?

THINKING SKILLS

1 Look at the table below.

- **a** Complete the table. A deficit is the difference between exports and imports.
- **b** Which forest industry product earns the most money in exports?
- **c** What is our largest import? Explain why you think Australia needs to import these materials. How could these imports be reduced?
- **d** Present the data in the table as two graphs, one showing Australia's imports, the other showing Australia's exports.
- **e** Describe any patterns in the graphs.

Value of Australia's exports and imports of forestry products ($ millions)

Forestry products	2002–03	2006–07	2008–09
Exports			
Woodchips	808	950	997
Paper and cardboard	630	650	606
Sawn wood and panels	258	271	226
Total exports			
Imports			
Sawnwood	505	418	405
Wood-based panels	206	276	271
Paper and paperboard	2158	2270	2267
Total imports			
Deficit			

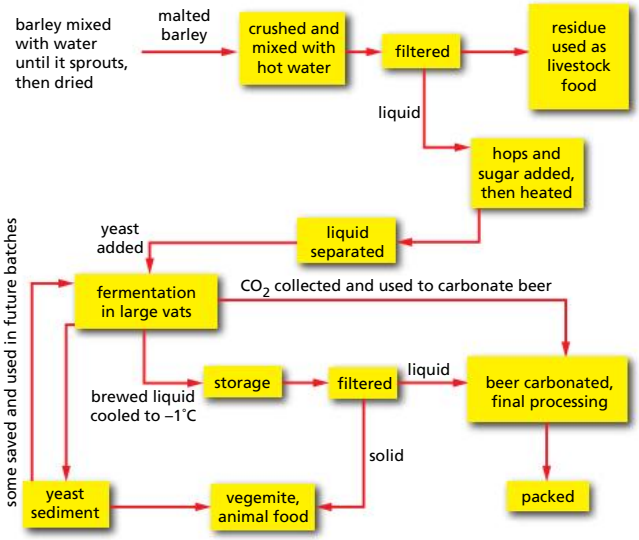
Source: Australian Bureau of Agricultural and Resource Economics

2
- **a** What resources can be obtained from the ocean? List as many as you can.
- **b** At present both amateur and professional fishermen cannot keep fish under a certain size. Undersized fish must be returned to the sea. Explain how this ensures the survival of fish as a resource and maintains the delicate balance of life in the ocean.

3 Imagine you are a park ranger in a rainforest. Put forward 10 guidelines for the public to follow to protect this natural resource.

4 Look at the diagram top right showing how beer is brewed.

- **a** What natural resources are used in the beer brewing process?
- **b** What products are made in the manufacturing process?



5 Look at the following table which shows resources used in the building trade.

Resource	Made of
Glass	sand, limestone, soda ash
Mortar	cement, sand, water
Steel	iron, carbon
Polycotton	cotton, polyester
Plastic (PVC)	polyvinyl chloride
Brass	copper, zinc

- **a** Copy the table and add a third column to it with the heading *Used for*. Complete this column using the following words:

  windows, bricks, beams/framework, hinges, clothes, piping
- **b** Add a fourth column to the table with the heading *Properties*. Complete this column describing the properties of each material that enable it to be used in the way you have listed.

6 Materials called brighteners are fluorescent chemicals that are added to laundry powders. In UV light they glow, making the clothes appear brighter. Design and carry out a test to see which laundry powders contain the most brighteners.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 Common groups of materials are _____, plastics, fuels, fibres, glass, ceramics and wood. These materials have _____ that make them useful in different ways.

2 Resources can be natural or _____ materials, which can be manufactured through chemical reactions.

3 Any material that is useful to us is called a _____. Natural resources are such things as water and _____. An example of a processed resource is _____.

4 _____ is our most valuable resource and we must be careful not to waste it.

5 _____ industries are one of the largest resource industries in Australia. One major resource exported from this industry is _____.

6 Recycling paper saves trees, _____, water and the quality of the air.

7 It is essential to preserve our rainforests. They produce oxygen, are home to many plants and animals and are a source of _____.

8 Coal and oil are important non-renewable resources. They are called _____. Many useful materials, such as petrol and plastics, can be made from them.

energy
forestry
fossil fuels
medicines
metals
paper
processed
properties
resource
trees
water
woodchips

Self-management

Comprehension

Review this chapter by reading this article and answering the questions that follow.

ElekTex is a new flexible material which has microchip technology within it. ElekTex can tell the difference between touch (when it is being pressed) and pressure (when it is being squashed) and react to each. A mobile phone made of ElekTex could be pressed to dial a phone number, but if forgotten and left on a seat, it would not be broken if someone sat on it. ElekTex can also be used to make flexible keyboards.

Another amazing material is Aerogel. It is a silicon product that is extremely light and transparent. It can withstand temperatures of over 1600 °C and as low as –40 °C. It is a better insulating material than fibreglass and has properties that make it useful for clothing. It could also replace glass. However, Aerogel is very expensive to manufacture and products made of Aerogel presently cost too much for the average person to buy. It has so far only been used on NASA space vehicles because, as the lightest material on Earth, it is invaluable in space.

1 What materials are mentioned in this article?

2 What properties do ElekTex and Aerogel have that make them useful?

3 Are ElekTex and Aerogel natural or processed materials? Explain.

4 Are ElekTex and Aerogel able to be used by the average person? Explain.

5 What possible effects could making and using ElekTex and Aerogel have on the environment? Give reasons for your answer.

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Match the following words with their meanings:
resource, manufacture, caustic, exports, viscous, cracking, hydrocarbons

a to make something from raw materials
b a material that is useful to us
c thick and slow flowing
d breaking down molecules in crude oil to simpler ones
e goods sent overseas to earn money
f can burn or damage living things
g substances made up of carbon and hydrogen

2 Which one of the following statements is *incorrect*? It is better to recycle materials than make them from scratch because

A less energy is needed.
B there is less harm to the environment.
C they cost more to recycle.
D raw materials are saved.

3 The following diagram shows how oil and gas are made into other materials.

a What raw material is used?
b Are the materials shown natural or processed resources? Explain.
c Are the materials shown economically important? Explain.
d Which materials will go through further processing?

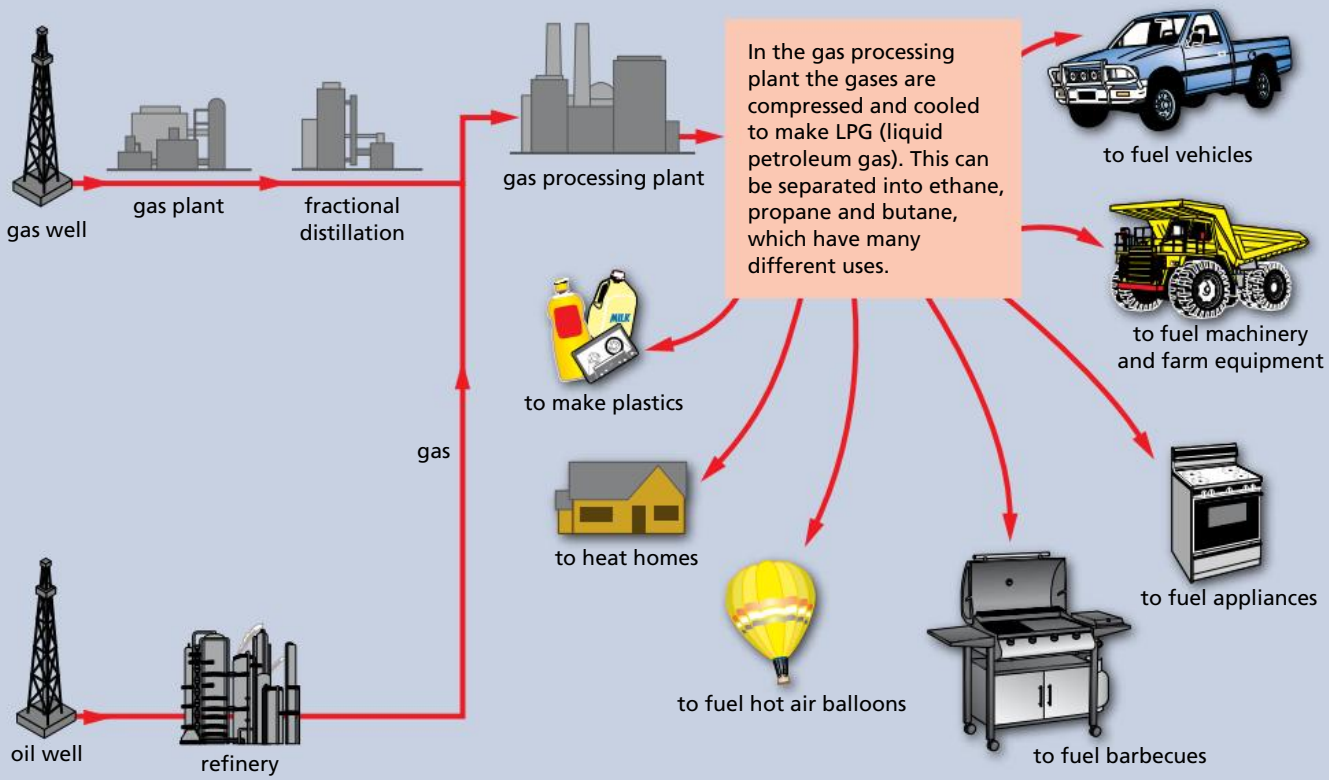
4 What is the difference between:

a a natural resource and a processed resource
b a renewable resource and a non-renewable resource
c black water and grey water
d an import and an export
e a raw material and a manufactured material?

5 Name three products that are found in grey water. How can the use of these be reduced?

6 Give three reasons why it is important to save the rainforests on Earth.

7 Polystyrene is a soft foam-like plastic that is used for hot food and drink containers such as takeaway coffee cups and hamburger trays. What properties of polystyrene make it suitable for use in this way?



11

Jurassic Park

By the end of this chapter you will be able to …

Science as a Human Endeavour

- recognise the significance of fossils in the development of the geological time scale
- discuss in a small group whether scientists should bring dinosaurs back to life

Science Inquiry Skills

- simulate the formation of plant and animal fossils and suggest modifications to your methods to help improve them
- use your knowledge of modern animals to reconstruct an ancient animal from fossil bones
- investigate the dinosaur footprints at Lake Quarry, near Winton in central Queensland
- evaluate from a scientific perspective the idea of bringing dinosaurs back to life

LITERACY FOCUS

amber
Apatosaurus (Brontosaurus)
carnivore
cast
extinction
fossils
geological era
geological period
geological time scale
herbivores
Mesozoic
mould
palaeontologist
petrification
Piltdown Man
Stegosaurus
thylacine
transgenic
Tyrannosaurus rex
velociraptor

Focus for learning

You have probably seen at least one of the *Jurassic Park* movies. In these movies there are many different dinosaurs, from the huge plant-eating *Apatosaurus*, to the meat-eating *Tyrannosaurus rex*, to the aggressive *Velociraptor*. In the first *Jurassic Park* movie scientists find mosquitoes preserved in amber (the hardened sap of trees). They extract dinosaur blood from the mosquitoes that fed on dinosaurs millions of years ago. They then extract the DNA from the ancient dinosaur blood and produce live dinosaurs from it.

PROBLEM SOLVING

Movie review

The first part of the task for this chapter is to watch one or more of the *Jurassic Park* movies. You might also like to read the book by Michael Crichton on which the movie is based. Write down key points as you watch the movie.

The second part of the task is to write a review of the movie, describing briefly what happens and what you think of it. In this review you must answer these two questions:

- Do you think it will ever be possible to bring dinosaurs back to life, as in the movie?
- *Should* we bring dinosaurs back to life?

As you work through the chapter and do the 'Problem solving' sections, you will find information to help you complete the task.

An insect preserved in amber

A scene from the movie, Jurassic Park

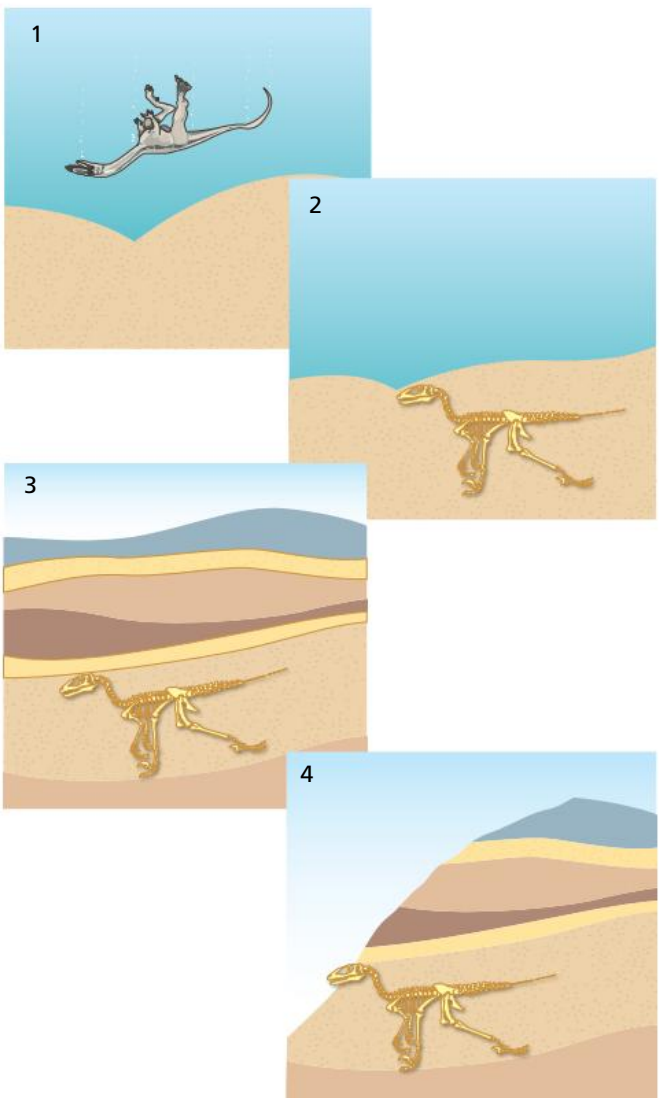
11.1 Fossils

Jurassic Park begins with **palaeontologists** (PAY-lee-un-TOL-a-gists) digging for fossils of velociraptors in the Badlands of Montana, USA. Palaeontologists study fossils to infer what plants, animals and other organisms have lived on the Earth over the last 3 billion years or so.

Fossils are the remains or traces of past life on Earth, preserved in rocks. Only sedimentary rocks such as shale contain fossils. Some fossils are easy to recognise, like shells, fish and leaves. Other fossils are of extinct plants and animals that no longer exist on Earth—like the dinosaurs.

How fossils are formed

Not many organisms are preserved as fossils because the conditions have to be just right. The four steps in the process are shown below.



1. The dead organism (e.g. dinosaur) falls into the soft mud of a swamp or shallow lake. Here it is quickly covered with sediment. More layers of sediment are added over time.
2. Over millions of years the sediment with the remains of the dinosaur in it are slowly changed into rock by heat and pressure.
3. During the process of rock formation, the bones in the skeleton are replaced by minerals from the rock. This process is called **petrification**. Usually only the hard parts of the animal are preserved. In rare cases, other structures such as impressions of skin or fish scales are preserved. Soft-bodied animals generally do not form fossils, but under certain conditions they can. For example, the photograph shows a fossil crinoid (sea lily). When the crinoid died it fell into the mud on the bottom of the ocean. Over millions of years the mud turned to rock and the crinoid was petrified.

A fossil crinoid

4. Rocks containing fossils are affected by movements in the Earth's crust, such as the uplifting, folding and buckling involved in mountain building. These movements can lift fossils to the surface. Rain, wind and sun also cause rocks to weather away, exposing fossils. Sometimes fossils are found by quarrying or by excavating for buildings.

Moulds and casts

A footprint you leave in soft sand is an impression of your foot. It is called a **mould**. If this mould is filled with plaster of Paris and left to set, a **cast** or replica of the bottom of your foot is formed. Most fossil shells are either moulds or casts.

INVESTIGATION

1 Making fossils

Aim

To investigate different ways in which fossils can form.

Risk assessment and planning

Read through the investigation carefully and identify any possible hazards.

Part A: Mould and cast

Apparatus

- large ice-cream containers
- vegetable oil
- plaster of Paris, PVA glue, plasticine, silicone

Method

Your task is to make a mould and a cast of an object. You can try different ways of doing this and use different materials to fill the mould.

✻ Which method works best? Which material works best?

✻ How is the cast different from the mould?

Part B: Insect fossil

Apparatus

- ice cube tray
- dead insect
- freezer

Method

1. Fill the compartments in the ice cube tray with water and put the tray into the freezer.
2. When the water is half frozen, push a dead insect into the middle of a half-frozen cube.
3. Return the tray to the freezer and leave overnight.
4. Take the ice cube out of the tray and examine your 'fossil'.

   ✻ How is your fossil similar to and different from the mosquito-in-amber fossils in *Jurassic Park*?
5. You could also try preserving an insect in resin using a resin kit.

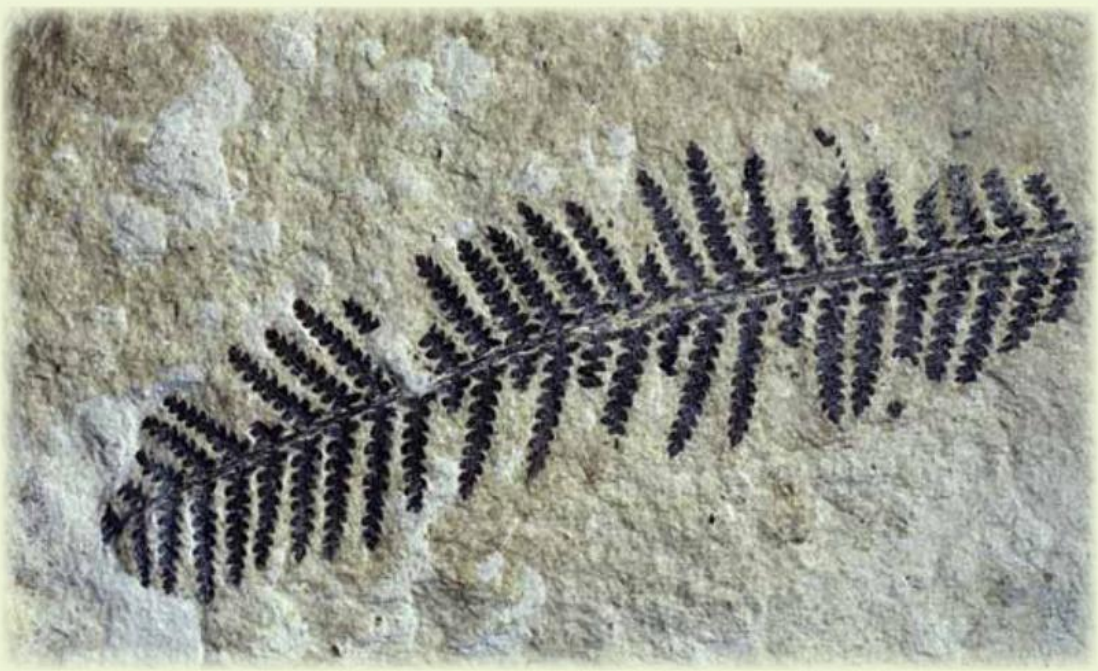
Part C: Leaf fossil

The photograph below shows a leaf fossil. It was formed when a leaf fell into mud. As the mud hardened to form a rock the heat and pressure changed the leaf to carbon. This is similar to what happens when coal formed from plant remains.

Work out a way to make a leaf fossil like the one in the photograph using a leaf and plaster of Paris. If you heat the leaf gently with a Bunsen burner flame it will burn away to leave a carbon print of the leaf.

Conclusion

How successful were the three fossils you made? Can you suggest modifications to your methods to improve them?



A fern fossil

This photograph shows the bones of an Oviraptor dinosaur unearthed in the Gobi Desert, China, in 1993. It died sitting on its eggs, which have been petrified (turned to stone). Notice the claws on the feet, like the raptors in Jurassic Park.

Other examples of fossils

Mosquitoes and other insects can be preserved in amber (see page 223). Sap oozing from a tree can trap the insect. The sap then hardens to form amber.

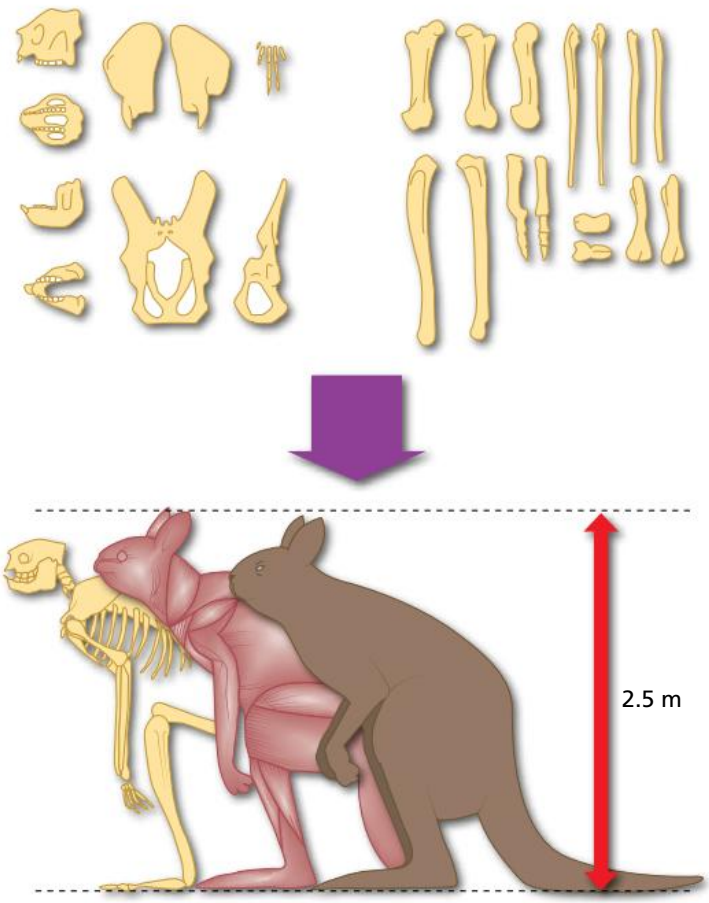
In rare cases, animals have been preserved by freezing. For example, in the frozen soil of Siberia and Alaska, woolly mammoths estimated to be 30 000 years old have been discovered. These creatures were preserved because of the extremely low temperatures. Their flesh was still fresh, as though it had been stored in a deep freezer.

Reconstructing an animal

Usually palaeontologists find only one or two bones from an ancient animal. Only rarely do they find a complete or almost complete skeleton. The bones are often separated from each other and there is usually no flesh on them.

The diagram on the next page shows a collection of bones found in a cave at Naracoorte near the Victoria–South Australia border. Palaeontologists infer these bones came from an extinct giant kangaroo called *Procoptodon*.

The palaeontologists sorted out the bones as shown. They inferred the size and shape of any missing bones by observing similar living species (e.g. the red kangaroo). They then drew muscles on the skeleton to give the animal its shape, and added skin and fur. This process can now be done using a computer. Finally, models of the extinct kangaroo were made to put on display in museums.



How palaeontologists reconstructed the gaint kangaroo Procoptodon

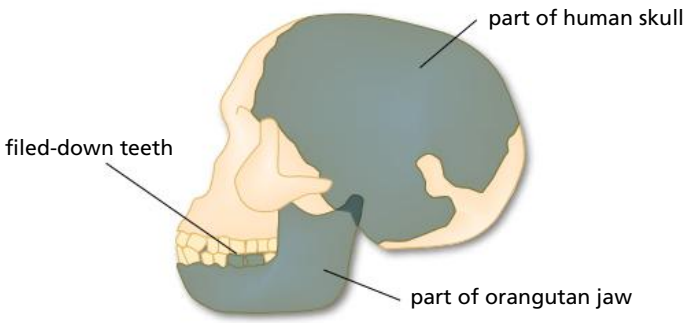
Remember though that models of extinct animals are not the real thing—they are only scientists' best guess (inference) based on the fossil bones found. Similarly, the dinosaur models used in *Jurassic Park* are not the real thing—only inferences of what they might have looked like.

Scientists make mistakes

Because reconstructed animals are only inferences, they are sometimes incorrect.

In 1870 the American dinosaur hunter Edward Cope wrote a report about a plesiosaur—a marine reptile with a small head, very long neck, short tail and four large flippers. However, when he put the bones together he made an embarrassing error—he put the head on the wrong end! When his colleague Othneil Marsh pointed out his mistake, the two palaeontologists became enemies. They followed each other around the United States, muscling in on each other's discoveries and even stealing specimens. Despite this they did discover many dinosaur fossils, for example, *Apatosaurus*, *Stegosaurus* and *Triceratops*.

In 1912 a fragment of a jaw and part of a skull were found in Piltdown quarry in Sussex, England. Many palaeontologists believed this was the ancestor of humans—the missing link between humans and apes. It was called Piltdown Man. In 1953 the bones were dated and it was found that the jaw belonged to a modern-day orangutan. The teeth had been filed down to make the jaw look older. The skull was human but only 600 years old. So the whole thing was a hoax. Nobody knows who was responsible.



The Piltdown Man hoax

INQUIRY 1 Putting bones together

You will need: a cooked chicken, large kitchen pot, newspaper, dinosaur kit (optional)

1. Cut as much flesh off the cooked chicken as possible. Boil the remaining chicken bones until all the flesh comes off them.
2. Remove the chicken bones and dry them overnight on newspaper.
3. Try to put the bones together to make a complete chicken (without the head).
4. Alternatively, you could obtain a dinosaur kit and put the bones together (without reading the instructions).

Over to you

1 If you were to go on a fossil-hunting expedition, which types of rocks would you look for and why?

2 What is the difference between a cast and a mould?

3 Most organisms do not form fossils when they die. Explain why.

4 Why are organisms that live in water more likely to become fossils than land organisms?

5 Which of the following organisms are most likely to leave clear fossils: worm, snail, fish, lizard, coral, gum leaf, rose flower, cockroach? Explain your reasoning.

6 Give the words that correspond to each of the following meanings.
- **a** The remains or impressions of long-dead organisms.
- **b** A person who studies fossils.
- **c** The process by which plant or animal remains absorb minerals and become like stone.
- **d** An impression in rock left by a dead organism's body.

7 Apart from being buried by sediment, describe two other ways fossils can be formed.

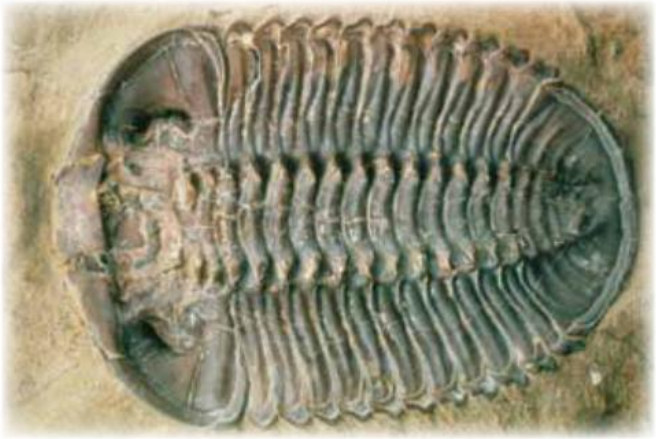
8 The fossilised droppings of an unidentified animal are found. Inside the droppings are small pieces of bone. What can you infer from this observation?

9 Is it possible that someone in a million years time might find the fossilised remains of a present-day koala? Explain how this could happen.

10 In 1991 some German hikers found a body high in the European Alps. The body was found to be 5300 years old.
- **a** Is this body a fossil?
- **b** Suggest why the body was so well preserved.

11 **a** What is amber?
- **b** How can amber be involved in the formation of fossils?
- **c** Which sort of animals are usually found in amber?

12 The photograph below shows a fossil trilobite, an ancient crab-like marine animal, that was found in rocks near Mt Isa, in inland Queensland. What does this suggest about the geological history of the area around Mt Isa?



13 The photograph below is of a large dinosaur footprint preserved in sedimentary rock.
- **a** Why is it called a fossil even though it could be described as a dent in a rock?
- **b** Why haven't all dinosaur footprints been preserved? Why do you think this one has been preserved for almost 100 million years?

PROBLEM SOLVING

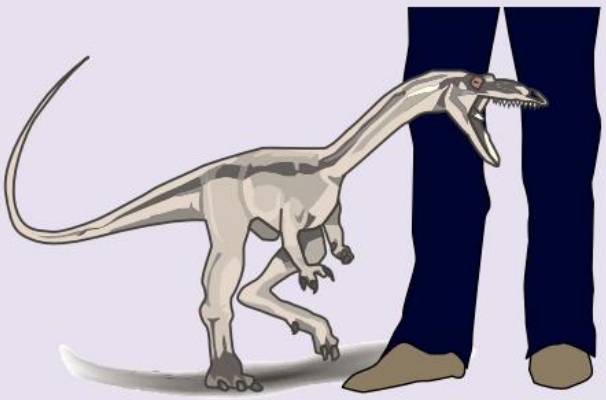
Have you watched the *Jurassic Park* movie yet?

- What fossils were Dr Grant and his team excavating in the Badlands of Montana?
- It takes a long time to excavate a fossil dinosaur. Suggest why.

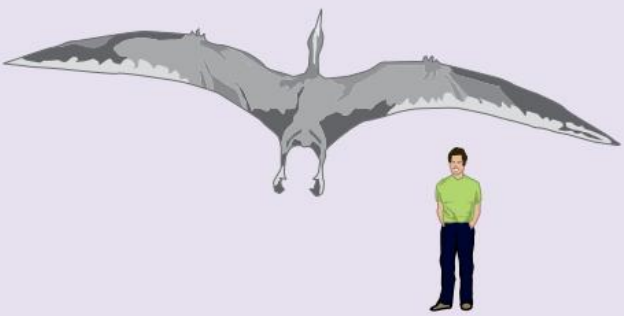
11.2 Dinosaurs

Jurassic Park dinosaurs

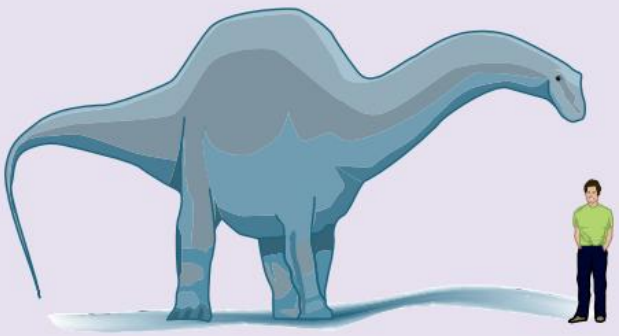
Name: *Procompsognathus* (pro-comp-sog-NATH-us)—first elegant jaw
Diet: Ate tiny animals such as insects, small mammals and other reptiles.
Size: length 1 m, height 30 cm (at hips), weight 2.5 kg
When it lived: 222–219 million years ago (mya)
Interesting facts: One of the smallest dinosaurs, and one of the earliest.



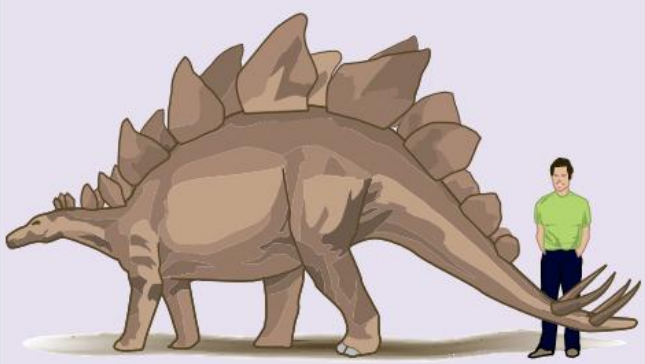
Name: *Pteranodon* (ter-AN-oh-DON)—winged and toothless
Diet: Probably ate mostly fish.
Size: wingspan 9 m, height 1.8 m (at hips), weight 20 kg
When it lived: 85–75 mya
Interesting facts: A flying reptile, closely related to the dinosaurs. Its wingspan was more than any known bird.



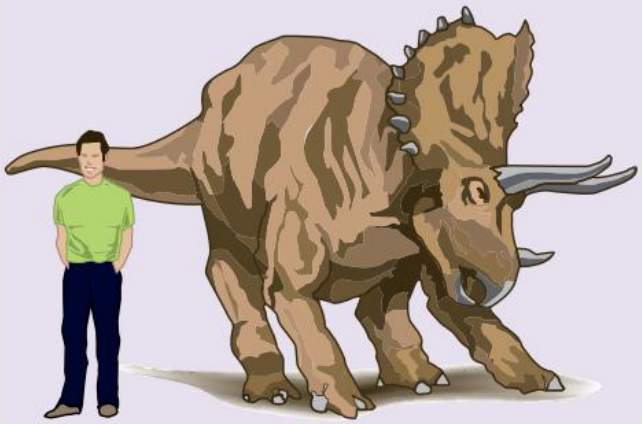
Name: *Apatosaurus* (a-PAT-oh-SAW-us)—deceptive lizard
Diet: Did not chew its food but swallowed stones to help grind up its tough plant food.
Size: length 26 m, height 4 m (at hips), weight 30 tonnes
When it lived: 157–146 mya
Interesting facts: Used to be called *Brontosaurus*. (In 1877 a dinosaur was discovered and named *Apatosaurus*. Two years later a new dinosaur was named *Brontosaurus*. Recently it was discovered that the two dinosaurs are the same, so the earlier name *Apatosaurus* is now used.)



Name: *Stegosaurus* (STEG-oh-SAW-rus)—roofed or covered lizard
Diet: Probably ate ferns and other low-growing plants.
Size: length 9 m, height 2.7 m (at hips), weight 2 tonnes
When it lived: 157–140 mya
Interesting facts: Had bony plates along its back and tail in two rows, and spikes on the end of its tail. Had a very small brain.

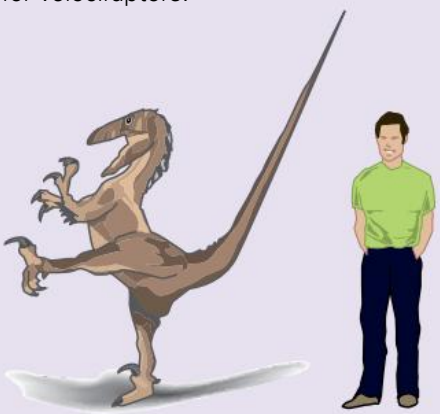


Name: *Triceratops* (try-SER-a-tops)—three-horned face
Diet: Probably ate cycads and other low-lying plants with its tough beak.
Size: length 9 m, height 2 m (at hips), weight 5 tonnes
When it lived: 72–65 mya
Interesting facts: When threatened by predators, it probably charged them like the modern-day rhinoceros does.



Name: *Tyrannosaurus rex* (tie-RAN-oh-SAW-rus)—tyrant lizard king
Diet: Ate large dinosaurs such as *Triceratops*.
Size: length 13 m, height 5 m, weight 6 tonnes
When it lived: 85–65 mya
Interesting facts: Its arms were only about 1 m long and it had two-fingered hands.

Name: *Deinonychus* (dyne-ON-ik-us)—terrible claw
Diet: Probably ate anything it could slash and tear apart with its long, sharp, curved claws.
Size: length 3 m, height 1.2 m, weight 50 kg
When it lived: 110–100 mya
Interesting facts: Bird-like, intelligent and a fast runner. May have hunted in packs. The velociraptors in *Jurassic Park* are more like *Deinonychus*. They are too big for velociraptors.



INQUIRY 2

Dinosaur facts

Use the information on this page and the previous page to answer these questions.

1. Which of the seven dinosaurs were herbivores and which were carnivores?
2. Why is *Pteranodon* different from the other dinosaurs?
3. Which is the biggest dinosaur? Which is the smallest?
4. What does mya stand for?
5. Which is the oldest dinosaur? Which is the youngest? Draw a timeline showing when the various dinosaurs lived.
6. In *Jurassic Park* all these dinosaurs lived together. Did this actually happen?
7. Which of the dinosaurs could have lived together? Could they have been predator and prey? Explain.
8. Did any of the dinosaurs actually live in the Jurassic Period (210–145 mya)?
9. Compare and contrast *Tyrannosaurus rex* and *Deinonychus*. They appear frequently in *Jurassic Park*.
10. Use the drawing on this page to write a description of *Triceratops*.

Dinosaur names

When palaeontologists name a dinosaur they use ancient Greek or Latin words. Take *Tyrannosaurus rex* for example. *Tyranno* means 'tyrant', *saurus* means 'lizard' and *rex* means 'king'. So *Tyrannosaurus rex* means 'tyrant lizard king'. Sometimes palaeontologists use the name of the place where the dinosaur was first discovered. For example, *Muttaburrasaurus* was found near Muttaburra in central Queensland. Once you know how a dinosaur name is made up, it should be easier to pronounce it.

INQUIRY 3 What's in a name?

Here are some Latin and Greek words used in naming dinosaurs.

anklo	crooked	*gnathus*	jaw
apato	deceptive	*hadro*	large
archaeo	ancient	*mega*	large
brachio	arm	*nychus*	claw
bronto	thunder	*ops*	face
cerat	horn	*pro/proto*	first
compso	elegant	*pteryx*	wing
di	two	*raptor*	plunderer
dino	terrible	*tri*	three
don	tooth	*veloci*	speedy

1 What does the word 'dinosaur' mean?

2 Work out what these dinosaur names mean: *Brontosaurus*, *Velociraptor*, *Diceratops*, *Hadrosaurus*.

3 Which three words are used to make up the name *Procompsognathus*?

4 Invent your own dinosaur name using words from the list. You may be able to draw it.

Warm-blooded or cold-blooded?

Until recently, dinosaurs were thought to be cold-blooded, or **ectothermic**, like reptiles and amphibians, whose body temperature varies with the temperature of their surroundings. When it is cold these animals are inactive because they do not have enough energy for movement. This is why lizards and snakes often sit in the sun to absorb its energy.

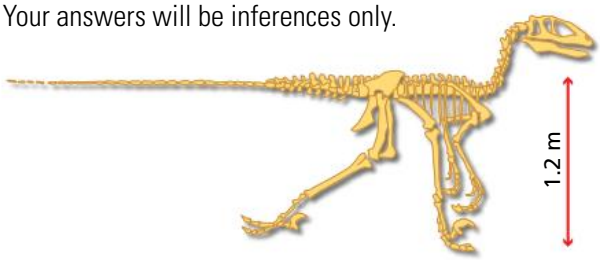
In recent years palaeontologists have found evidence that some dinosaurs may have been warm-blooded, or **endothermic**. This means that they could convert food into energy to keep their body temperature constant, as mammals and birds do. The bone structure of dinosaurs is close to the structure of warm-blooded animals. In 1993 a 66-million-year-old dinosaur was found in South Dakota, in the United States. In its chest cavity was a structure that seemed to be a heart similar to the heart of warm-blooded animals.

Some dinosaur fossils have been found in areas that would have been very cold when they were alive. The dinosaurs found at Dinosaur Cove in Victoria lived when Australia was still connected to Antarctica. These dinosaurs were most likely warm-blooded.

It could be that dinosaurs were neither warm-blooded, or cold-blooded, but something in between. Whatever the case, it is clear that dinosaurs were not just overgrown lizards. The scary velociraptors in *Jurassic Park* may not be far from the truth.

SKILL Making inferences

Palaeontologists use the bones of dinosaurs to infer what the dinosaurs looked like and how they behaved. The diagram shows a skeleton of *Deinonychus*, similar to the velociraptors in *Jurassic Park*. The bones have been put together to show how the dinosaur moved. Use this skeleton to answer the questions below. Your answers will be inferences only.



1 Which present-day animal is most like *Deinonychus*?

2 Copy the skeleton, add muscles and draw what you think the dinosaur would have looked like.

3 Can you infer the colour of the dinosaur? Explain.

4 Infer how the dinosaur caught its prey.

5 Infer the habitat in which the dinosaur lived.

6 Why do you think the dinosaur had such a long tail?

7 Would the dinosaur have walked on all four legs? Explain.

8 Would the dinosaur have had good sight and smell? Explain.

9 Explain whether it is possible to test whether your inferences are correct.

INQUIRY 4 How fast?

1 These footprints were discovered at Lark Quarry, near Winton in central Queensland. Palaeontologists infer they were made about 93 million years ago by a dinosaur slightly smaller than *Tyrannosaurus rex*.

- How many toes did the dinosaur have?
- What is the average length of the footprints (from top of central toe to back of heel)?
- What is the length of the dinosaur's stride (the distance between two consecutive footprints made by the same foot)?

2 By studying bipedal (two-footed) animals, palaeontologists have discovered that the hip height of a bipedal animal is about four times the length of its footprint.

- Estimate the hip height of the Winton dinosaur.

3 Palaeontologists have also found that they can estimate the speed at which a dinosaur is travelling from its stride length s (in metres) and hip height h (in metres) using this formula:

$$\text{speed (km/h)} = \frac{4s}{h}$$

If the speed is less than 8 km/h, then the dinosaur was walking. If the speed is more than 12 km/h, it was running. (Humans walk at about 5 km/h and can run at up to 25 km/h.)

- Estimate the speed of the Winton dinosaur.
- Was the dinosaur walking or running? Do you think you could outrun it?

Extinction of dinosaurs

Throughout the history of life on Earth new species have appeared in the fossil record and other species have become extinct. Over 99% of the species that have ever lived on Earth have, in fact, become extinct! Life today gradually developed from the remaining organisms that did not become extinct. About 65 mya there was a mass extinction and 75% of all species present at the time disappeared, including the dinosaurs. Nobody knows exactly what caused this mass extinction but there are many different theories.

Biological causes

Perhaps the carnivorous dinosaurs ate all the herbivorous dinosaurs and then starved to death. Or the herbivores ate all the suitable plants and starved to death, leaving the carnivores without food. Many new plants appeared about 65 mya and they may not have been suitable food for the dinosaurs.

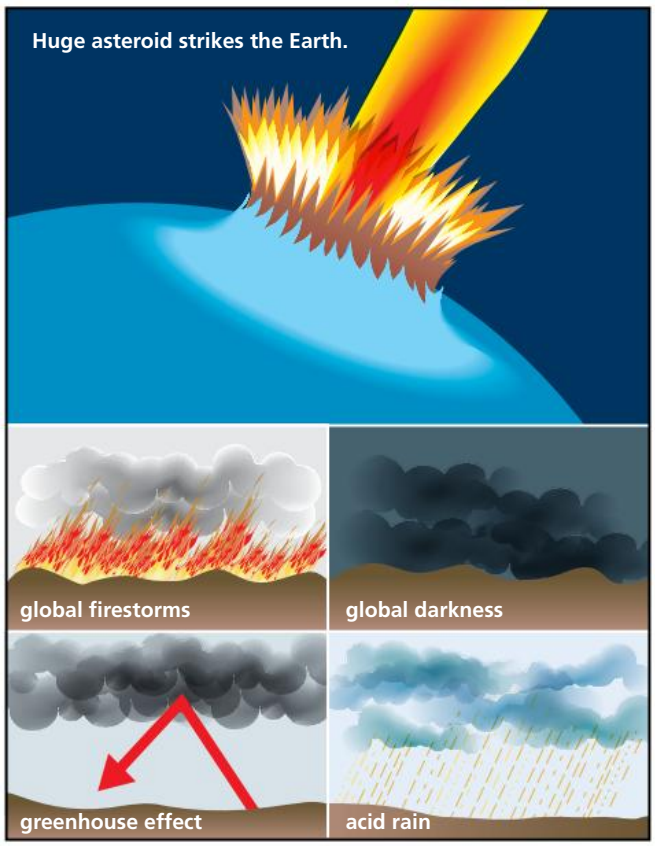
Some scientists believe that the increase in the numbers of mammals about 80 mya caused the extinction of the dinosaurs. As warm-blooded organisms, the mammals would have eaten constantly, and this would have affected the food supply of the dinosaurs. Many mammals also ate dinosaur eggs.

Terrestrial causes

Some scientists infer that the Earth became much cooler about the time of the dinosaur extinction. They infer this cooling was caused by massive volcanic eruptions that spread lava across the land and spewed dust and ash into the atmosphere. This dust and ash blocked the sunlight and caused a lowering of the temperature around the world. A cooler climate may have affected the dinosaurs, particularly if they were cold-blooded. In this climate they would not have been able to move about and protect themselves from the cold in the same way that smaller mammals or birds could. The volcanic activity may have lasted for thousands of years, causing changes in the types of plants. This in turn would have affected the herbivorous dinosaurs, then the carnivorous ones.

Extraterrestrial causes

The most popular theory today is that an asteroid 10–15 km in diameter collided with the Earth about 65 mya, causing a global disaster. The main evidence to support this theory is a thin layer of dust and ash in rocks all around the world. These rocks are 65 million years old, the time the dinosaurs disappeared. The dust and ash layer contains iridium, a metal found mainly in the Earth's core and in asteroids, meteorites and comets. Scientists infer the iridium was spread around the world when an asteroid collided with the Earth.



The dust and ash from the asteroid impact would have caused global darkness. Methane released from the Earth by the impact would have burnt, causing global firestorms. This inference is supported by the fact that soot (possibly from burning forests) is found in the dust–ash layer. Finally, the excess carbon dioxide created by the fires would have led to global warming and acid rain.

Scientists found further support for the asteroid theory when they located a huge crater about 180 km in diameter near Chicxulub in Mexico. It is buried under 65 million year old rocks and lies partly under the sea.

There may of course be more than one cause for the extinction of the dinosaurs. Perhaps an asteroid collision caused volcanic eruptions. We may never know.

Over to you

1 Suggest where each of the following dinosaurs were discovered: *Ozraptor*, *Argentinosaurus*, *Asiatosaurus*.

2 When did the last of the dinosaurs become extinct?

3 Why can scientists be sure about the sizes of dinosaurs but not about what they looked like or how they behaved?

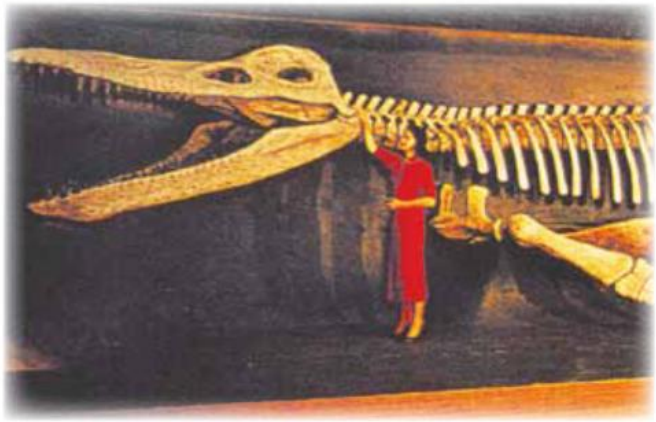
4 What is the difference between an ectothermic and an endothermic animal?

5 How do palaeontologists use dinosaur footprints to estimate the speed at which dinosaurs moved?

6 Give each of the dinosaur extinction theories on the previous page a rating out of 10, with higher scores for the more likely causes. In each case give a reason for your rating. Suggest your own theory for the extinction of the dinosaurs.

7 Which animals and plants do you think would be most likely to survive an asteroid that struck somewhere in Australia today? Explain your answer.

8 Look at the photograph of the skeleton of *Kronosaurus queenslandicus* from 110 mya. What can you infer about where it lived and what it ate? Give reasons for your inferences.



PROBLEM SOLVING

1 Which dinosaurs appear in *Jurassic Park*? Were they portrayed accurately? Find out more about one of the *Jurassic Park* dinosaurs on pages 229 and 230. You might like to research a *Jurassic Park* dinosaur not described on these pages (e.g. *Velociraptor*, *Brachiosaurus*, *Dilophosaurus*, *Hadrosaurus*, *Spinosaurus*). There are many excellent internet sites where you can find information. For example:

enchantedlearning.com/subjects/dinosaurs
dinosaurs.wikia.com/wiki/Main_Page

2 Do you think the dinosaurs in *Jurassic Park* were warm-blooded or cold-blooded? Why?

3 From your viewing of *Jurassic Park*, were the dinosaurs more like lizards or birds?

4 Did the *Jurassic Park* dinosaurs breed? How?

11.3 Australia's *Jurassic Park*

Geological time scale

Scientists throughout the world have used fossils to work out the history of life on Earth. This is called the **geological time scale**. It divides the history of the Earth into a series of eras and periods.

The time scale is divided into four large divisions called **eras**. The names of the first three eras come from Greek words for life. Cainozoic (CANE-a-ZOE-ic) means recent life, Mesozoic (MEES-a-ZOE-ic) means middle life, and Palaeozoic (PALE-ee-a-ZOE-ic) means ancient life. The Pre-Cambrian is the earliest and longest era. These eras are then divided into smaller units called **periods** (see table below). The eras and periods are based on major events, such as widespread volcanic activity, ice ages or the appearance or mass extinction of life. For example, at the end of the Permian Period, about 90% of all species on Earth became extinct.

The geological time scale shows the times (mya) when various organisms lived on Earth. To work this out scientists have dated rocks and matched fossils from many places around the world. The time scale shows the inferred order of life on Earth.

The Earth is estimated to be almost 5000 million years old. The first signs of life appeared about 3500 mya, but fossils are not common until about 600 mya. From this time onwards life forms have continually appeared and become extinct. They have also become more and more complex. For example, it is inferred that fish appeared before reptiles. This is based on the observation that fossil fish are found in older rocks. The fossil record shows that the dinosaurs first appeared about 225 mya and existed for 160 million years. The dinosaurs in *Jurassic Park* did not all live at the same time. Some lived in the Triassic, some in the Jurassic and some in the Cretaceous Period. The dinosaurs became extinct at the end of the Cretaceous Period. Our human ancestors did not appear until about 4 mya.

INQUIRY 5 Toilet roll time scale

You will need: roll of 500-sheet toilet paper, pens

1. Unroll a roll of toilet paper somewhere outside to represent the history of the Earth. If the Earth is 5000 million years old, and there are 500 sheets in the roll, how many years does each sheet represent?
2. Use the geological time scale below to mark the eras and periods on the toilet paper roll. For example, the Cainozoic Era, which goes back 65 million years, will occupy the first 6½ sheets. Also mark important events in the history of the Earth, including when our human ancestors appeared 4 mya.

Geological time scale

Era	Period	Time (mya)	Major events
CAINOZOIC	Quaternary	0–2	Humans
	Tertiary	2–65	Age of mammals
MESOZOIC	Cretaceous	65–145	Flowering plants and extinction of dinosaurs
	Jurassic	145–210	The age of dinosaurs and first birds and mammals
	Triassic	210–245	First dinosaurs
PALAEOZOIC	Permian	245–290	90% of species present at the time become extinct
	Carboniferous	290–360	Large primitive trees and first reptiles
	Devonian	360–410	Age of fishes and first amphibians
	Silurian	410–440	First plants on land
	Ordovician	440–510	First fish
	Cambrian	510–570	First shells, trilobites
PRE-CAMBRIAN		570–2500	First multi-celled animals
		2500–3800	First one-celled organisms
		3800–4600	No life

Geological history of Australia

During the Pre-Cambrian Era 600 mya, Australia was attached to Antarctica and the rest of Pangaea. There was no land where eastern Australia is now (see maps below).

During the Palaeozoic Era weathering and erosion took place and sediments were washed into the surrounding seas, mainly along the east coast. These sediments formed sedimentary rocks around the edges of the older Pre-Cambrian rocks. At the same time Earth movements pushed up the Great Dividing Range along the east coast of Australia.

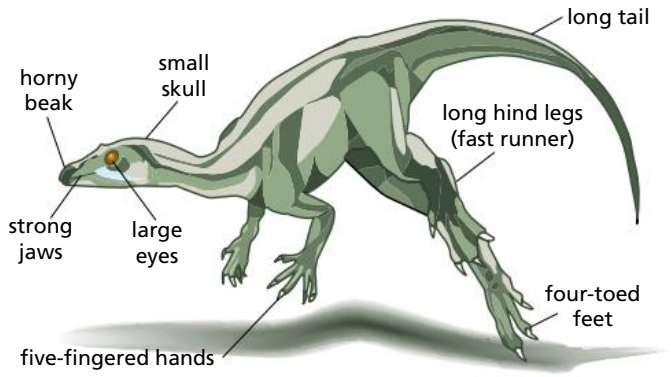
During the Mesozoic Era shallow seas covered much of eastern Australia. Sedimentary rocks containing coal and oil formed in these areas, called basins. This was the age of the dinosaurs.

It was not until about 40 mya that Australia separated from Antarctica. It has been moving north-west ever since at a rate of about 7 cm a year.

Australian dinosaurs

Dinosaurs have been found in quite a few places in Australia. For example, a small dinosaur called *Leallynasaura* (lee-ELL-in-a-SAW-ra) was found at Dinosaur Cove, near Cape Otway in Victoria in 1989. It was a herbivore 2.5 m long with a relatively large brain. *Leallynasaura* lived about 115 mya when Australia was still attached to Antarctica and it was very cold. It had large eyes that scientists infer helped it to find food during the long dark polar winters. It may have been warm-blooded.

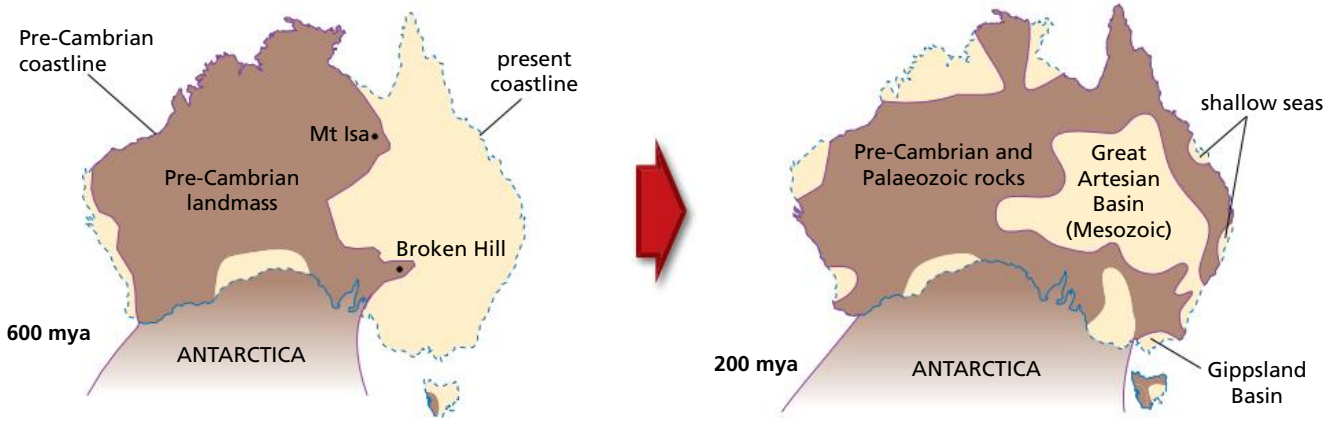
Leallynasaura was named after Leallyn, the daughter of Tom Rich and Pat Vickers-Rich, who asked her parents to find her a dinosaur. *Saura* is the feminine form of lizard in Greek.



Leallynasaura

The largest dinosaur found in Australia is *Austrosaurus* (southern lizard), a long-necked herbivore with enormously thick legs, a relatively small head and a tiny brain. It has been nicknamed Elliot after the local farmer who stumbled across Elliot's hipbone while mustering sheep. Elliot is similar to *Apatosaurus* (*Brontosaurus*) in *Jurassic Park*. It is estimated to have been 15 m long, 5 m high and weighed 25 tonnes (about five African elephants). Smaller dinosaurs slightly larger than the raptors in *Jurassic Park* were found near Elliot.

An artist's impression of Elliot, the largest dinosaur found in Australia

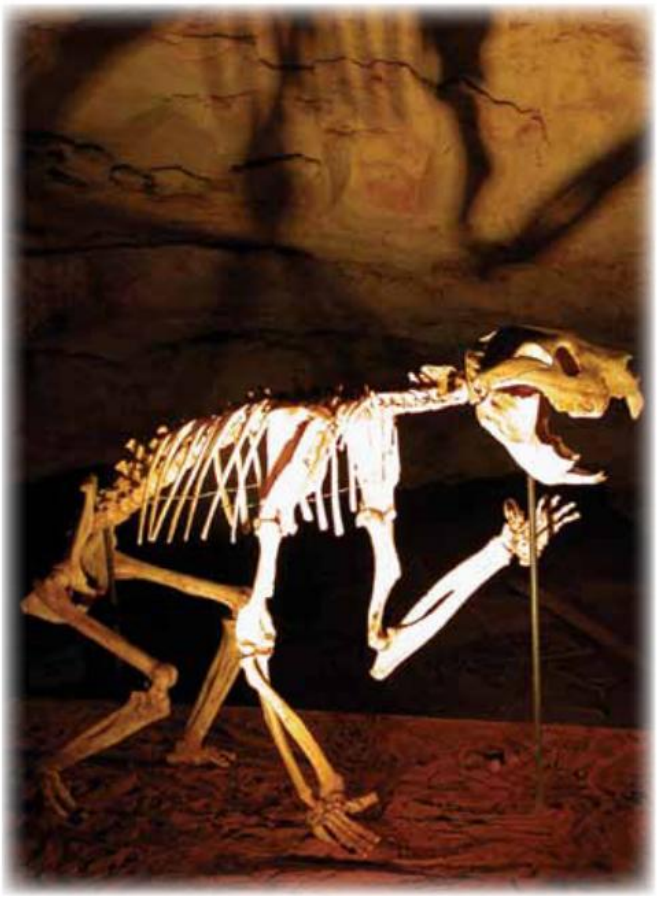


Other extinct Australian animals

After the dinosaurs became extinct and Australia became isolated, many mammals unique to Australia appear in the fossil record. There were giant platypuses, kangaroos 3 m tall, carnivorous, lion-like marsupials that lived in trees and a python 8 m long. The *Diprotodon* was a giant wombat—the largest marsupial that ever lived. It weighed over 2 tonnes but could move almost as fast as a camel. It lived all over Australia during the Quaternary Period and became extinct about 30 000 years ago.

Thylacoleo (THIGH-lac-a LEE-oh), commonly called the marsupial lion, lived in Australia from 25 million to 50 000 years ago. It weighed 120 kg and had a cat-like skull with long slicing teeth. It hunted in forest areas and was a fearsome predator. It ate large animals, including *Diprotodon*.

The skeleton of Megalania prisca *(ancient giant butcher), the largest goanna that ever lived. It grew up to 6 m long and lived in Australia at the same time as* Diprotodon *and* Thylacoleo.



A Thylacoleo *skeleton*

Over to you

1 Use the geological time scale on page 234 to answer these questions.
   - **a** When did the dinosaurs become extinct?
   - **b** During which period did *Tyrannosaurus rex* roam the Earth?
   - **c** In which era was the Devonian Period?
   - **d** How old is planet Earth?
   - **e** When did the first life appear on Earth?
   - **f** When did the trilobites (crab-like marine animals) first appear?
   - **g** There was a mass extinction that wiped out 90% of the species that existed on Earth at the time. When did this occur?
   - **h** How long have humans been on Earth?
   - **i** How long was the Jurassic Period?
   - **j** For how long were the dinosaurs on Earth?
   - **k** Which was the longest era?

2 Was Australia still attached to Antarctica when the dinosaurs became extinct? How do you know?

3 **a** Did *Leallynasaura* (page 235) walk on two feet or four?
   - **b** Why do palaeontologists think that *Leallynasaura* may have been warm-blooded?

4 Use Inquiry 3 on page 231 to work out what *Diprotodon* means.

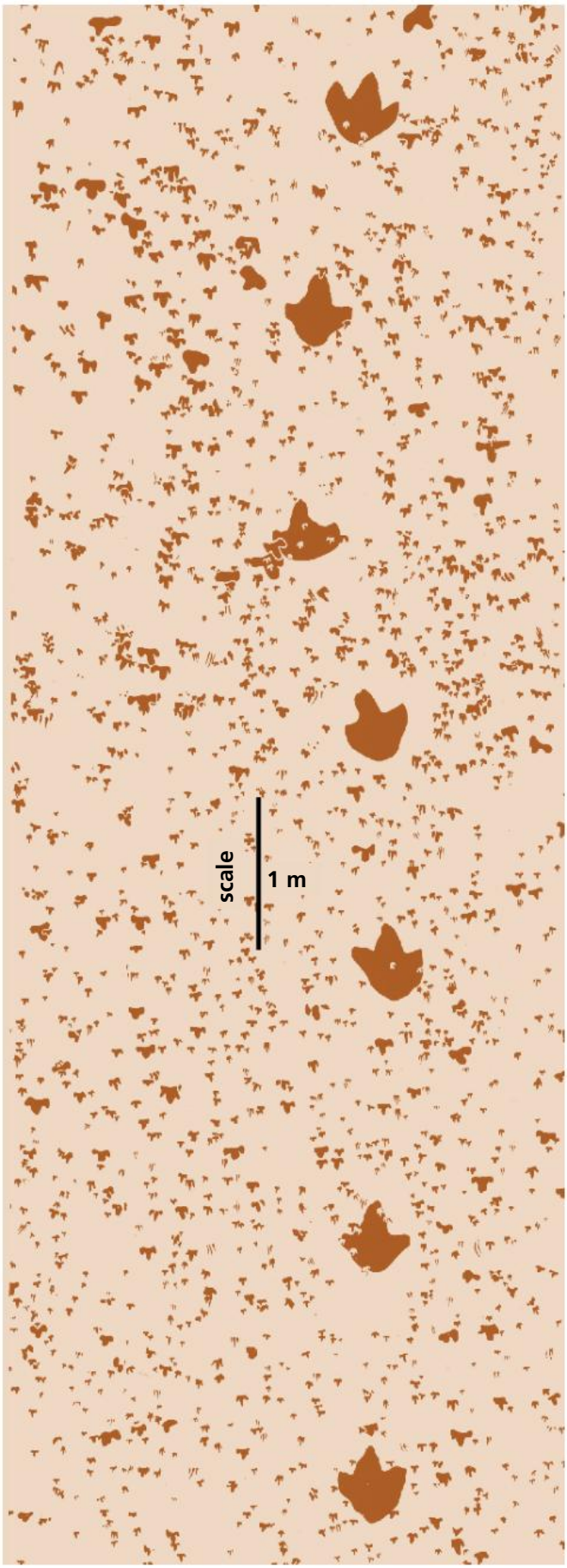
5 What present-day animal is most like *Thylacoleo*?

INQUIRY 6 Dinosaur footprints

The dinosaur footprints you studied in Inquiry 4 were found with thousands of others at Lark Quarry. They were formed in mud beside a shallow lake about 93 mya.

Use your observations of the footprints on the right to answer the questions below. Remember your answers will be inferences. They may or may not be correct, and sometimes it is possible to make several different inferences from the same observations.

1. In which direction was the large dinosaur moving?
2. Did the large dinosaur walk at a constant speed? How do you know?
3. Why does the size of the large footprints vary?
4. How many different types of dinosaurs do you think left their footprints?
5. You can see small prints on top of the large prints. What can you infer from this?
6. In which direction were the smaller dinosaurs going?
7. How many different inferences can you think of to explain what happened at Lark Quarry 93 mya?
8. How were the footprints preserved until now?



PROBLEM SOLVING

1. During which geological periods did the dinosaurs in *Jurassic Park* live? Did humans live then?
2. Which scene in *Jurassic Park* do you think was inspired by the dinosaur stampede recorded in rocks at Lark Quarry?
3. Do you think the dinosaurs of *Jurassic Park* would be able to live on Earth today? Explain.

SCIENTISTS AT WORK

Professor Patricia Vickers-Rich

Prof Pat Vickers-Rich is part Cherokee Indian and part Irish. She grew up on a farm in California in the United States. At the age of four she had a collection of insects in her playhouse that she had found on the farm. Later on she began collecting fossils. Her parents taught her that if you wanted something worthwhile in life you had to work hard for it. They also taught her to follow her own curiosity and dreams—like the pig in *Babe* (one of Pat's favourite movies).

Pat and her family loved the outdoors and she was never bored. She had good teachers at high school who encouraged her natural curiosity about science. She did a science fair project on radiocarbon dating. At university, Pat liked interacting with scientists doing research and particularly enjoyed field trips, where she could apply the things she had learnt in lectures. She met her husband, Tom Rich, at university.

When Pat was at university, scientists were mapping the sea floor and developing the theories of sea floor spreading and plate tectonics. For her PhD thesis Pat studied a group of giant birds (bigger than our present-day emus) that evolved in Australia after it separated from Antarctica. In 1975 Pat moved to Melbourne, where she had a part-time tutorship at Monash University for $2000 a year. In her spare time she hunted for bird fossils and Tom hunted for mammal fossils.

In the late 1970s dinosaur bones were found along the Victorian coast—at Dinosaur Cove near Cape Otway and at Inverloch. Pat and Tom worked with over 500 volunteers to excavate the fossils. These volunteers ranged from mining engineers and blasting experts to jewellers and retired people. They discovered and named several new dinosaurs. For example, *Timimus* (ti-MY-mus) was named after Pat and Tom's son, Tim and Tim Flannery, an Australian scientist and writer. It looked like a big ostrich and probably hibernated during the cold winters. In 1997 *Qantassaurus* was named after Qantas Airlines, which helped fund the dig at Inverloch and carried the fossils around. It was a herbivore about the size of a small kangaroo.

Pat has also hunted for dinosaur fossils in Patagonia near the tip of South America, which was once joined to Australia. Patagonia is a wild place and Pat says, 'I love this place and will continue to search its vast spaces for hidden treasures until I can prospect no more'.

Pat Vickers-Rich with a llama in Patagonia, South America

Pat is now a professor at Monash University, and Tom is a curator at Museum Victoria. She has travelled all around the world and has written several books on dinosaurs. Pat is presently studying the first animals on Earth, more than 550 million years old. She says, 'I love being able to do what I want. I love to discover new things and find out about new things ... If you want to be a palaeontologist, don't let people discourage you—but don't think you are going to make a lot of money doing it. Follow your dreams'.

Questions

1. What good advice did Pat's parents give her?
2. Why are the dinosaur fossils found in Patagonia similar to those found in Victoria?
3. Why would blasting experts and jewellers be used at a fossil dig?
4. Suggest why dinosaur fossils have been found in rocks along the Victorian coast but not further inland?

11.4 Is *Jurassic Park* possible?

Gene technology

Before you can answer the question of whether *Jurassic Park* is scientifically possible, you need to understand what gene technology is.

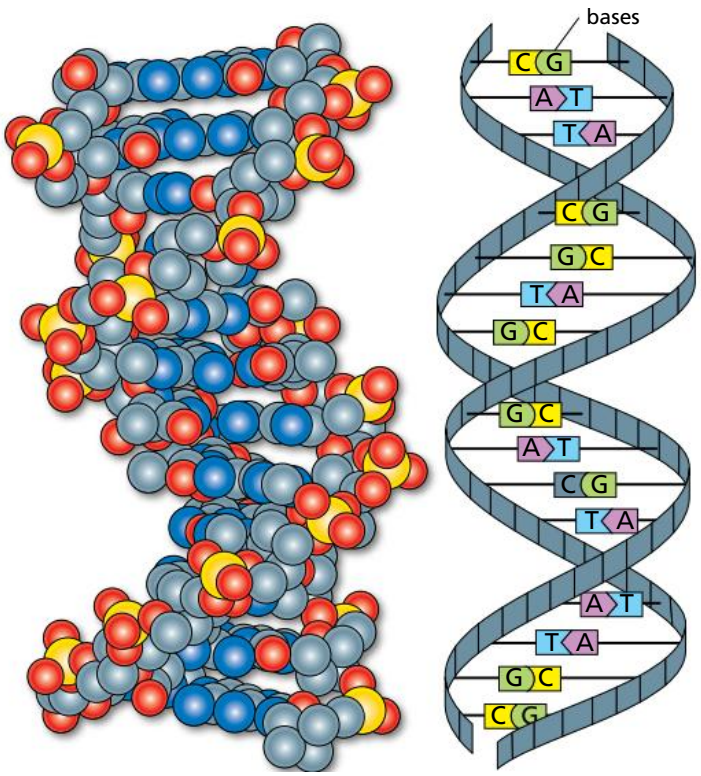
Scientists today understand the mechanism of inheritance and the role of **DNA** and genes better than ever before. **Gene technology**, or genetic engineering, is the modification of the DNA within an organism.

All living things are made of cells. Inside the cells are *chromosomes*, which are made up of DNA. The DNA is like a blueprint (detailed plan) that is passed from one generation to the next. Segments along the DNA molecule are called **genes**. Genes are the code to make the proteins that result in particular characteristics in the body.

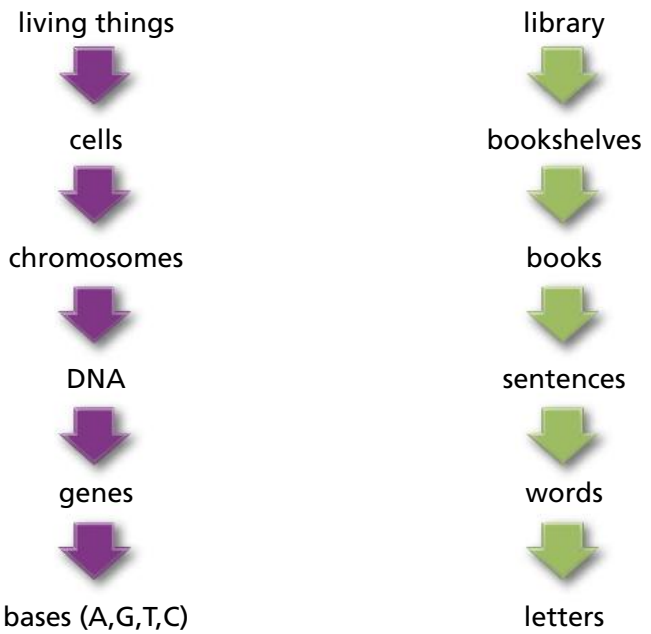
Each strand of DNA is made up of combinations of four different *bases*, called adenine (A), thymine (T), cytosine (C) and guanine (G). These bases occur along each strand of DNA. Three bases together code for a particular amino acid. For example, TTT codes for lysine and GGA codes for proline.

A DNA molecule is a double helix made of two twisted strands of bases side by side (bottom left). The bases of one strand of the DNA molecule pair up with the bases on the other strand. Because of the shape and size of the bases they can pair up with only one other base. Adenine (A) can pair up with thymine (T) and no other base. Cytosine (C) can pair up only with guanine (G).

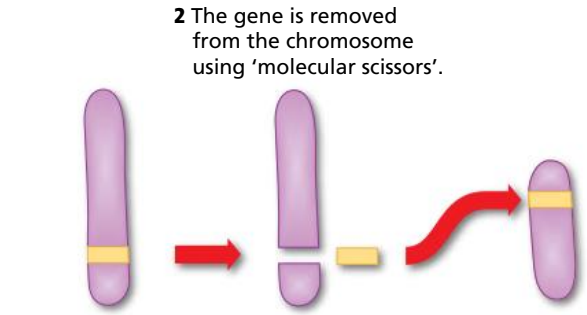
The living things on Earth can be compared to a library, as shown below. Think of the cells as the bookshelves. The chromosomes inside the cells are then the books. The DNA that makes up the chromosomes forms the sentences, which in turn are made up of strings of words (genes). The bases A, T, C and G are the letters in the words. All living things contain DNA in their cells but the combinations of genes and the numbers of chromosomes are different for each species.



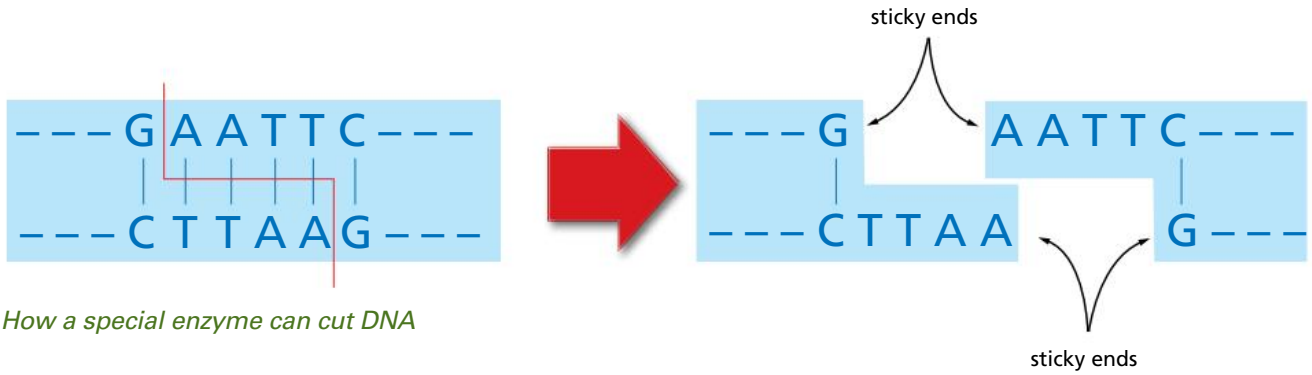
DNA is a complex molecule made up of two twisted strands in the shape of a double helix. The strands are linked by four different bases (A, T, C and G).



The aim of gene technology is to control or modify genes. Scientists have worked out how to move genes between two unrelated species. For example, genes from a plant can be placed into an animal or from an animal into a plant. Genes can also be moved from micro-organisms into plants and animals, or vice versa. When genes are moved from one species to another the new organism created is said to be *transgenic*, or genetically modified. The cells in the new organism created by gene technology produce new proteins that perform new functions.



Gene technology is like a film editor cutting or splicing together lengths of film to make a movie. The 'molecular scissors' used are special enzymes which occur naturally in bacteria. They cut the DNA at particular places along the sequence of bases. For example, suppose the DNA is cut between the G and the A bases, as shown below. This leaves two 'sticky ends', which can be 'glued' back together in a different place. To join the DNA fragments, other enzymes are used. The movie *Splice* is about genetic engineering.



How a special enzyme can cut DNA

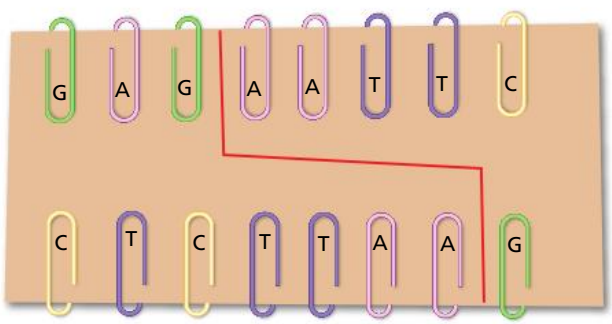
INQUIRY

7 Molecular scissors

In this activity you will make a model of a fragment of DNA to show how gene technology works.

You will need: piece of cardboard 25 cm × 6 cm, 40 paperclips (four different colours), scissors

1. Choose four different colours of paperclips to represent the four different bases (A, T, C and G) that make up a DNA molecule.
2. Push 20 of the different coloured paperclips along one side of the cardboard strip, as shown. Place the bases randomly, but make sure you have the sequence GAATTC in two different places.
   It is a good idea to write the letters behind the paperclips. Remember, each group of three bases codes for a particular amino acid.
3. On the other side of the strip, put the other member of each base pair. A joins with T, and C joins with G. Record the particular sequence of bases in your DNA fragment.
4. Find the first GAATTC sequence and draw a zigzag line between the G and the A, as shown. Do the same for the second GAATTC sequence.
5. Use scissors to cut along the two zigzag lines to make three segments.
6. Swap your middle segment with another group. Fit this new segment between your two 'sticky ends'. Record your new sequence of bases.
   - Is your new DNA fragment different from the one you started with?
   - Would an organism containing this DNA fragment be different from one containing the DNA fragment you started with? Explain your answer.



The future of gene technology

Here are three examples of transgenic organisms.

1. Cotton is grown in Australia but it has to be sprayed with large amounts of pesticide to kill the caterpillars that feed on it. Genetic engineers have developed a genetically modified cotton called Bt cotton. It contains a gene from a naturally occurring bacterium called Bt. This gene produces a protein in the cotton that kills the caterpillars when they eat it, so less pesticide is needed.
2. Some of the foods we eat are made using imported soya beans produced by plants genetically engineered not to be killed by weed killers. Scientists have also successfully bred frost-resistant tomatoes. They did this by inserting into the tomatoes 'anti-freeze' genes from North Atlantic fish that live in subzero waters. These new tomatoes have not been released for sale because many people are reluctant to eat genetically modified (GM) food.
3. *GloFish* is the world's first transgenic pet—a fish that glows in the dark. It contains fluorescent proteins produced by genes extracted from sea anemones and coral.

GloFish

Gene technology has many different uses in medicine. It is used to make insulin for the treatment of diabetes. It is also used to produce new vaccines and drugs. In human *gene therapy*, gene technology is used to treat people with genetic diseases, such as cystic fibrosis. The faulty gene is replaced by a 'normal' gene. In the future it may also be possible to produce transgenic animals to use as organ and tissue donors.

Gene technology, like all technologies, has potential benefits and potential risks. There are many controversial issues with gene technology as people weigh up the benefits against the risks.

How to make a dinosaur

Is it possible to recreate a dinosaur as they did in *Jurassic Park*? Six steps are needed to do this. Read these and discuss whether making a dinsaur is possible.

1. *Find a piece of amber containing a mosquito or other blood-sucking insect that has fed on a dinosaur.*

   Amber is fossilised tree sap. Sometimes insects are trapped in this sap before it hardens. Some amber has been found from the Mesozoic Era when the dinosaurs lived. So it is possible that insects carrying dinosaur blood might be trapped in amber. In most fossilised bones the actual organic material has been replaced by minerals, but amber can preserve the soft tissue of an insect for millions of years.
2. *Take the mosquito out of the amber and extract the dinosaur's blood cells from its gut. Then extract the dinosaur's DNA from its blood cells.*

   DNA is found in every cell in an organism so it is possible that DNA could be extracted from the dinosaur's blood cells. In fact, scientists have already extracted DNA fragments from an extinct weevil trapped in amber 120–135 mya. However, it was only a fragment of the weevil's DNA that was extracted—less than one millionth of the entire sequence. And it was not DNA from the blood of something it had bitten.
3. *Sequence the DNA to create a complete strand of DNA. Fill in any gaps in the DNA with DNA from a similar living animal.*

   DNA strands are easily broken and break down over time. The DNA recovered from the stomach of a mosquito would be broken down into tiny pieces and most of it would be missing. Scientists can use a sort of biological photocopier, where they take a small piece of genetic material and make millions of identical copies. They could also replace missing bits of DNA with DNA from a living animal that is related to the dinosaurs. The closest living relatives are crocodiles and birds. In the movie they use frog DNA. All animals have a lot of DNA that is the same, but if you used too

much frog DNA you might end up with something that was more frog than dinosaur. Putting the DNA together is very difficult. One scientist once compared it to trying to make a complete set of the *Encyclopaedia Britannica* from the letters in a bowl of alphabet soup.

4 *Put the complete DNA into the ovum (egg cell) of a similar living animal to create a dinosaur embryo.*

Once the DNA is sequenced and complete it must be inserted into an ovum from a dinosaur so identical copies (clones) of the dinosaur cells can be made. Putting the DNA into crocodile or bird ova would not work—they are just not dinosaurs.

5 *Put the embryo into a suitable egg and incubate the egg.*

The embryo needs an environment in which to grow. Perhaps a large bird's egg (e.g. an ostrich egg) could be used instead of a dinosaur egg. In the movie, plastic eggs are used. However, this is very difficult because an artificial egg must have a porous shell to let in the right amount of oxygen and let out waste carbon dioxide, allowing the embryo to breathe.

6 *Allow the egg to hatch and grow into a dinosaur. Then keep the dinosaur alive.*

This has been done with other animals. For example, Californian condors (large birds) have been raised in captivity using puppets to play the part of parents. But what would you feed the baby dinosaur? It might not even breathe our air. Our modern-day plants might be poisonous to herbivorous dinosaurs. Also, it would be a big job finding enough food for a large dinosaur.

- Which of the six steps do you think would be the most difficult? Why?

The Jurassic Park *characters watching the baby dinosaurs hatch from the eggs*

Bring extinct animals back to life

While getting DNA from dinosaurs is very difficult, recovering it from more recently extinct animals could be easier. For example, there are many remains of the extinct woolly mammoth from only 10 000 years ago. Also DNA has been extracted from small scraps of skin stuck to some of the preserved remains of moas. These were gigantic flightless birds that lived in New Zealand until about 700 years ago.

In Australia the thylacine (Tasmanian tiger) has been extinct for 70 years. However, the Australian Museum has a 139-year-old thylacine pup preserved in alcohol (see photograph). Scientists have made copies of the thylacine's genes, using the pup, and the bones, teeth and dried muscles of two other specimens. Unfortunately the DNA was too broken up and they were only able to copy four of the genes out of a total of 30 000. However, as the former director of the museum, Professor Mike Archer said, 'Many of us still hope that it might be possible to bring this magnificent animal back to life'.

Over to you

1 Put these in order from the largest to the smallest: DNA, chromosomes, bases, genes, cells.

2 Why is gene technology sometimes called genetic engineering?

3 If the base sequence on one DNA chain is AGCTAC, what is the base sequence on the corresponding DNA chain?

4 What are 'molecular scissors'?

5 What could be done if some herbivorous dinosaurs were brought back to life but they could not eat modern-day plants?

6 Why would some people be concerned about eating food made from transgenic organisms?

7 In *Jurassic Park* the genetic engineers made all the dinosaurs female so they could not breed. They also used frog DNA to fill gaps in the dinosaur DNA. However, some West African frogs have been observed to change sex. What result did this have in the movie?

8 *Velociraptor*, the villain of *Jurassic Park*, is closely related to birds and lived about 80 mya. It has been suggested that it would be easier to bring it back to life than other dinosaurs. Suggest why.

Science as a Human Endeavour

Should we create a *Jurassic Park*?

In small groups, discuss what the following quotes from *Jurassic Park* mean.

1 Dr Malcolm, the mathematician, says, 'Scientists … are focused on whether they can do something. They never stop to ask if they *should* do something'.

2 In *Jurassic Park III* Amanda says, 'Is this how you make dinosaurs?' and Dr Grant replies, 'No, this is how you play God'.

3 When reviewing the *Jurassic Park* movies someone said, 'Just as war is too important to leave to the generals, science is too important to leave to scientists'.

- Is the reviewer's statement also true of gene technology?

PROBLEM SOLVING

Use what you have learnt in this section to complete your review of *Jurassic Park*.

THINKING SKILLS

1 Suppose you find a fossil bone in some limestone (calcium carbonate). Suggest a way to get the fossil bone out without damaging it.

2 A palaeontologist found a skull of a dinosaur but she could not find any other bones in the area. How would you explain this finding?

3 If *Tyrannosaurus rex* could run at 40 km/h, would it be able to outrun a person?

4 How could carnivorous dinosaurs be endangered by the appearance of new plants on Earth?

5 The photograph below shows a fossil of a mammal 130 million years old from China. It would have looked a bit like a very scary possum—about the size of a cat. The stomach of the mammal had broken up, but in the place where it would have been scientists found a couple of tiny leg bones and some teeth. They inferred that these are the bones of a baby dinosaur.

a What inference can you make from this fossil discovery?

b Could the tiny bones belong to an unborn baby mammal rather than a dinosaur? How would you be able to tell?

c Could mammals have caused the extinction of the dinosaurs? Explain your answer.

6 How is it that genes from a plant can be placed into an animal or from an animal into a plant?

7 Look at the dinosaur DNA fragment below. Is there anywhere that this DNA could be cut by the special enzyme described on page 240? Why would you want to do this?

```
   1 GCGTTGCTGG  CGTTTTTCCA  TAGGCTCCGC  CCCCCTGACG  AGCATCACAA  AAATCGACGC
  61 GGTGGCGAAA  CCCGACAGGA  CTATAAAGAT  ACCAGGCGTT  TCCCCCTGGA  AGCTCCCTCG
 121 TGTTCCGACC  CTGCCGCTTA  CCGGATACCT  GTCCGCCTTT  CTCCCTTCGG  GAAGCGTGGC
 181 TGCTCACGCT  GTAGGTATCT  CAGTTCGGTG  TAGGTCGTTC  GCTCCAAGCT  GGGCTGTGTG
 241 CCGTTCAGCC  CGACCGCTGC  GCCTTATCCG  GTAACTATCG  TCTTGAGTCC  AACCCGGTAA
 301 AGTAGGACAG  GTGCCGGCAG  CGCTCTGGGT  CATTTTCGGC  GAGGACCGCT  TTCGCTGGAG
 361 ATCGGCCTGT  CGCTTGCGGT  ATTCGGAATC  TTGCACGCCC  TCGCTCAAGC  CTTCGTCACT
 421 CCAAACGTTT  CGGCGAGAAG  CAGGCCATTA  TCGCCGGCAT  GGCGGCCGAC  GCGCTGGGCT
 481 GGCHTTCGCG  ACGCGAGGCT  GGATGGCCTT  CCCCATTATG  ATTCTTCTCG  CTTCCGGCGG
 541 CCCGCGTTGC  AGGCCATGCT  GTCCAGGCAG  GTAGATGACG  ACCATCAGGG  ACAGCTTCAA
 601 CGGCTCTTAC  CAGCCTAACT  TCGATCACTG  GACCGCTGAT  CGTCACGGCG  ATTTATGCCG
 661 CACATGGACG  CGTTGCTGGC  GTTTTTCCAT  AGGCTCCGCC  CCCCTGACGA  GCATCACAAA
 721 CAAGTCAGAG  GTGGCGAAAC  CCGACAGGAC  TATAAAGATA  CCAGGCGTTT  CCCCCTGGAA
 781 GCGCTCTCCT  GTTCCGACCC  TGCCGCTTAC  CGGATACCTG  TCCGCCTTTC  TCCCTTCGGG
 841 CTTTCTCAAT  GCTCACGCTG  TAGGTATCTC  AGTTCGGTGT  AGGTCGTTCG  CTCCAAGCTG
 901 ACGAATTCCC  CGTTCAGCCC  GACCGCTGCG  CCTTATCCGG  TAACTATCGT  CTTGAGTCCA
 961 ACACGACTTA  ACGGGTTGGC  ATGGATTGTA  GGCGCCGCCC  TATACCTTGT  CTGCCTCCCC
1021 GCGGTGCATG  GAGCCGGGCC  ACCTCGACCT  GAATGGAAGC  CGGCGGCACC  TCGCTAACGG
1081 CCAAGAATTG  GAGCCAATCA  RTTCTTGCGG  AGAACTGTGA  ATGCGCAAAC  CAACCCTTGG
1141 CCATCGCGTC  CGCCATCTCC  AGCAGCCGCA  CGCGGCGCAT  CTCGGGCAGC  GTTGGGTCCT
1201 GCGCATGATC  GTGCT      CCTGTCGTTG  AGGACCCGGC  TAGGCTGGCG  GGGTTGCCTT
1281 AGAATGAATC  ACCGATACGC  GAGCGAACGT  GAAGCGACTG  CTGCTGCAAA  ACGTCTGCGA
1341 AACATGAATG  GTCTTCGGTT  TCCGTGTTTC  GTAAAGTCTG  GAAACGCGGA  AGTCAGCGCC
```

8 The dinosaurs in *Jurassic Park* did not have the base sequence TTT or TTC, which codes for the production of the amino acid lysine, which is essential for life. Instead, lysine was added to the dinosaurs' food. This meant that if the dinosaurs escaped from *Jurassic Park* they could not survive without lysine. This was called the 'lysine contingency'. However, in the movie escaped dinosaurs do survive. Suggest how this might have happened.

9 Why would it be easier to recreate an extinct thylacine (Tasmanian tiger) than an extinct dinosaur?

10 The blood from the mosquito's stomach in *Jurassic Park* could contain DNA from different dinosaur species (e.g. *Tyrannosaurus rex* and *Triceratops*). What would happen if this DNA was used to make a dinosaur?

11 Imagine that you find yourself 10 million years into the future. What might you find in the fossil record for the year 2011 in the area where you live?

a Do you think there would be any human fossils?

b What other objects from 2011 might you find in the rocks?

12 Imagine you have been transported back in time to the Jurassic Period and your time machine is programmed to return you to the present after a week. Write a diary of your adventures.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 _____ are the remains or traces of past life on Earth, preserved in _____.

2 From observations of fossils, palaeontologists _____ what extinct animals looked like and how they behaved.

3 _____ lived on Earth between 225 and 65 _____ years ago. The smallest were the size of a chicken and the largest were over 40 m long.

4 Scientists are not sure what caused the _____ of the dinosaurs. The most popular theory is that an _____ collided with the Earth 65 mya.

5 The geological _____ scale divides the history of the Earth into a series of _____ and periods (e.g. the Jurassic Period).

6 Dinosaurs lived in Australia when it was still connected to _____. Many fossils, including _____, have been used to infer what these dinosaurs were like.

7 Gene technology or genetic _____ is used by scientists to control or modify _____ in DNA, or move them between two unrelated _____.

Antarctica
asteroid
dinosaurs
engineering
eras
extinction
footprints
fossils
genes
infer
million
rock
species
time

Self-management

1 Copy the Findaword.
2 Use the clues below to find the words, which may be written horizontally, vertically, backwards or forwards.
3 When you find a word, cross out the letters in it. (Some letters are used more than once.)
4 When you have crossed out all the words, there will be 12 letters left. Use these letters to make the name of one of the *Jurassic Park* dinosaurs.

Clues

1 An Australian dinosaur named after an airline
2 The movie
3 Warm-blooded
4 Type of rock that contains fossils
5 Flying reptile
6 Herbivorous dinosaur with bony plates along its back
7 Type of organism containing genes from another species
8 Era when dinosaurs lived
9 Period from 145 to 65 mya
10 Period when dinosaurs appeared
11 Insect sometimes preserved in amber
12 Biological molecule made up of amino acids
13 Greek word meaning lizard
14 Some dinosaurs are closely related to these
15 Fossilised sap
16 Type of fossil formed when sediment or mineral fills the imprint left by an organism
17 *Tyrannosaurus* _____
18 The basis of life

J	U	R	A	S	S	I	C	P	A	R	K
C	T	R	A	N	S	G	E	N	I	C	S
I	R	S	U	R	U	A	S	O	E	D	U
O	I	R	A	P	R	O	T	E	I	N	O
Z	M	O	S	Q	U	I	T	O	L	A	E
O	P	T	E	R	A	N	O	D	O	N	C
S	X	S	C	I	S	S	A	I	R	T	A
E	E	A	P	O	O	R	E	B	M	A	T
M	R	C	V	T	G	B	I	R	D	S	E
Y	R	A	T	N	E	M	I	D	E	S	R
C	E	N	D	O	T	H	E	R	M	I	C
Q	A	N	T	A	S	S	A	U	R	U	S

Checkpoint

Remember to look at
www.OneStopScience.com.au
for extra resources

OneStopScience

1 Most fossils are found in

A rock layers that were originally formed under water.

B rocks that were formed by the cooling of lava from volcanoes.

C the waters of seas and lakes.

D the sand and mud on seashores.

2 Which one of the following is correct?

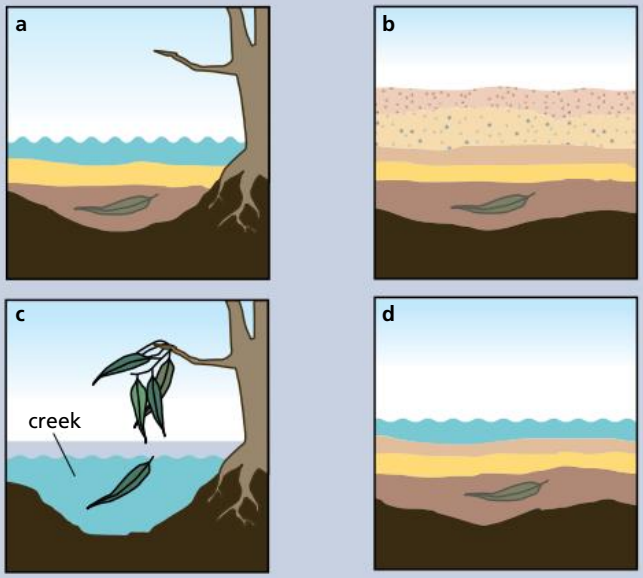
A We know what dinosaurs looked like from descriptions recorded by ancient humans.

B We know what dinosaurs looked like because they have been preserved as fossils.

C We can infer what dinosaurs looked like from their fossils.

D We can only guess what dinosaurs looked like.

3 Look at the mixed up sequence of diagrams showing the formation of a leaf fossil. Put the diagrams in their correct order.



4 Which of the following statements are true and which are false? Rewrite the false ones to make them correct.

a Soft-bodied animals are less likely to form fossils than animals with shells or skeletons.

b The bottom layers of rock in a road cutting or quarry usually contain older fossils than the top layers.

c *Tyrannosaurus rex* was a herbivore.

d Rocks that contain the earliest fish fossils are younger than rocks that contain the earliest mammal fossils.

e All rock layers studied so far by geologists have contained fossils.

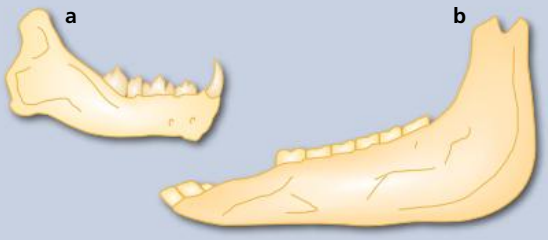
f Minerals may replace the shell or bone of an animal to make a fossil.

5 Match the geological eras to their times.

Era	Time (mya)
Cainozoic	245–65
Pre-Cambrian	570–245
Mesozoic	65–present
Palaeozoic	4600–570

6 Skeletons of a *Proceratops* (a medium-sized herbivorous dinosaur) and a *Velociraptor* were dug up by palaeontologists near some fossilised eggs. The *Velociraptor's* chest was crushed and it was gripping the *Proceratops* by the neck. Infer what might have happened in the past to produce this scene.

7 Palaeontologists discovered the two fossil jawbones below. They inferred that jawbone 'a' belonged to a carnivorous mammal and jawbone 'b' belonged to a herbivorous mammal. Why do you think they made this inference?



8 **a** Dave the *Elasmosaurus* was a large marine reptile, yet its skeleton was found inland from Cairns in Queensland. How can you explain this?

b Palaeontologists have not been able to find Dave's head. Suggest a reason for this.

9 Fossils are more common in Tertiary rocks than in Silurian rocks. Suggest a reason for this. (Refer to the geological time scale on page 234.)

10 Give two examples of how gene technology has been used to benefit humans.

11 Michael Crichton has admitted in interviews that he intended to put across a clear anti-science message when he wrote *Jurassic Park*. Do you think this message comes across in the movie? Write a paragraph to explain your answer.

12

Earth, moon and sun

By the end of this chapter you will be able to …

Science Understanding

- compare times for the rotations and orbits of the Earth, sun and moon
- model the relative movements of the Earth, sun and moon to show how phases of the moon and eclipses occur
- relate the tides to the positions of the Earth, moon and sun

Science as a Human Endeavour

- examine Aboriginal and Chinese stories about eclipses and day/night

Science Inquiry Skills

- accurately map the positions of objects in the sky
- evaluate the claim that the *Apollo 11* moon landing was a hoax

LITERACY FOCUS

axis
azimuth
crescent
Dreamtime
elevation
gibbous
hydrosphere
lunar eclipse
meteors
neap tides
orbit
penumbra
phases of the moon
rotation
solar eclipse
solstice
Southern Hemisphere
spring tides
umbra
zenith

Focus for learning

The Aboriginal people have been in Australia for at least 40 000 years. Different tribes had different stories or legends to explain what they saw in the sky. This one is about an eclipse of the sun.

A long time ago in the Dreamtime, an Aboriginal tribe had plenty to eat and were free and happy. They had rules to live by and for many moons they lived in peace and harmony with the land.

Then there came an unsettled time. People did not help each other. The young ones disobeyed their parents and took no notice of their elders. There were evil spirits about and everyone was unhappy. The Good Spirits decided to teach the people a lesson by blocking out the sun. This made it dark and cold. The plants began to die and the animals became scarce.

The people asked the Kadaicha Man what was happening. He told them that the Good Spirits were angry because the tribe was not obeying the rules. So to make the Good Spirits happy the people started to help one another again. Even though the sun was still dark, they began to live in peace as they had before.

Then one day the sun became bright and the sky turned blue again. The Good Spirits had given them back the sun and sky, but the Kadaicha Man told the people to remember the lesson they had been taught. 'Keep the rules or the Good Spirits will block out the sun forever. And just to make sure you remember, they will block out the sun again every now and then.'

INQUIRY 1 **Dreamtime legend**

- Suggest why the Aboriginal people were so frightened when the sun was blocked out.
- What do you think is the purpose of this Aboriginal legend?
- Is the legend scientifically accurate? For the purposes of the legend, does this matter?

A system within a system

The sun and the planets that orbit around it form the solar system. In this chapter you will learn to explain day and night, the seasons, phases of the moon, eclipses and tides. To do this you will need to consider the Earth, moon and sun as a sub-system within the solar system. Because the Earth, moon and sun are so large you will use models to represent them.

PROBLEM SOLVING

Apollo 13

Like the Aboriginal people, we tell stories to explain what happens in our world. Our stories are told through movies, TV and books. Look at the movie *Apollo 13*. Your task is to make a list of things in the movie that are scientifically correct and another list of things that are incorrect. Use what you learn in this chapter. Researching the *Apollo 13* mission will help too.

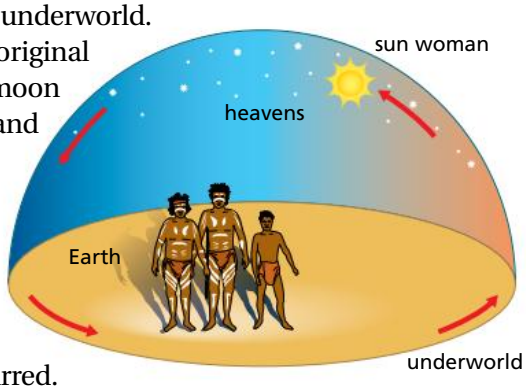
Have a class discussion about the things you notice. Would the movie be as good if Hollywood didn't 'bend' the truth a little?

12.1 How the Earth moves

The Aboriginal people believed the Earth was created during the Dreamtime by god-like beings such as the Rainbow Serpent. The Earth was a flat disc and above this was the dome of the heavens. The stars in the sky were the campfires of the god-like beings. Underneath the Earth was the cold, dark underworld.

In many Aboriginal tribes the sun was a woman who travelled across the sky looking for her lost son. She had a camp in the east and each morning she lit a fire and made a bark torch which she carried with her. She covered her body in ground-up red-coloured rock (ochre). She spilt some of this ochre and that is why the sky is orange-red at sunrise. When she reached the western horizon she spilt more ochre—creating the sunset. She then travelled back under the Earth through the underworld.

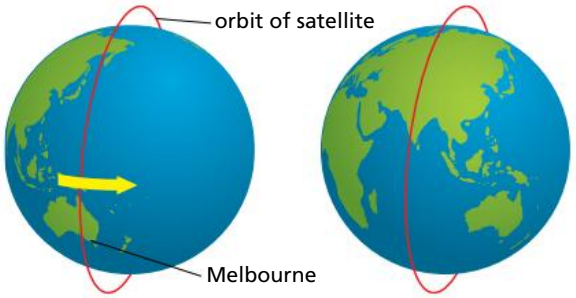
To the Aboriginal people the moon was a man, and when the sun woman and the moon man came together an eclipse occurred.



The Aboriginal people were not the only people who thought the Earth was flat. Five hundred years ago Christopher Columbus, the Italian-Spanish explorer who discovered the United States, decided to sail around the world to show that the Earth was not flat. At this time many sailors were scared to go far from land in case they fell off the edge of the world. If the world was round Columbus would sail back to the place he started, and this is what happened.

The Earth's rotation

Today we can see the Earth from space and have much more information than ancient people to help us understand our world. From a satellite in orbit above the poles, it can be seen that Australia moves from west to east as the Earth spins. As a result the sun appears to move from east to west. The Earth spins at 1700 km/h but you don't notice it because everything around you is moving at the same speed. You would only notice it if the speed suddenly changed.



The Earth rotates from west to east.

INQUIRY 2 **Day and night**

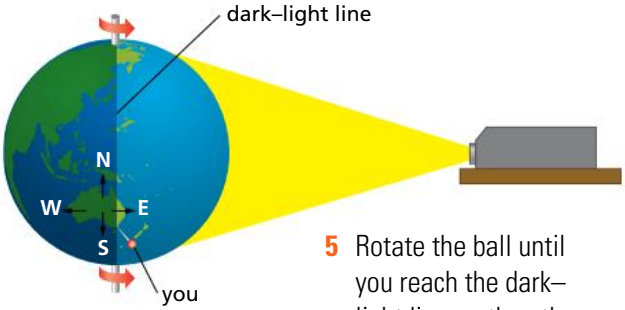
You will need: polystyrene ball (about 7 cm diameter), pin, cooking skewer or knitting needle, projector

1 Push the skewer through the centre of the ball.

2 Draw a rough sketch of Australia in the bottom half of the ball (the Southern Hemisphere). Also mark in the directions north, south, east and west. Represent yourself by a pin stuck in the place where you live.

3 Turn on the projector and hold the ball in the light. Look at the ball from the side.
- What happens as you rotate the ball from west to east?
- What length of time does one rotation of the ball represent?

4 Hold the ball in the light so that your pin is on the dark–light line as shown.
- What time of day is this?
- In which direction does the sun rise?



5 Rotate the ball until you reach the dark–light line on the other side of the ball.
- What time of day is this? In which direction does the sun set?

6 In Perth, does the sun rise before or after it rises in Melbourne? How is the time different?

Keep your model for Inquiry 4.

Rotation and revolution

The Earth moves in two different ways.

1. It spins or rotates on its **axis**—an imaginary line through the centre of the Earth from pole to pole. The rotation time is 24 hours—an Earth day.
2. The Earth *revolves* around the sun. The path it follows is called its **orbit**. This orbit is an ellipse—an oval shape.

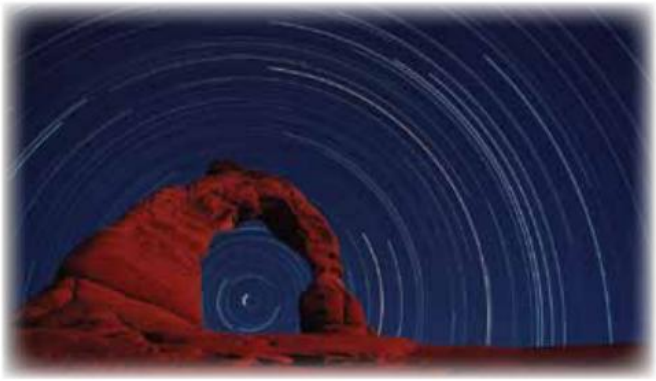
It takes one year for the Earth to revolve around the sun. During this time the Earth rotates on its axis 365¼ times. This means there are 365¼ days in a year. On our calendar it is impossible to have a quarter of a day. We consider each year as having just 365 days, and every fourth year the four quarter days add up to one extra day. We call this a leap year, and the extra day is 29 February.

The Earth's axis is not at right angles to the plane of the Earth's orbit around the sun. (See the diagram below.) The axis is tilted at an angle of 23½° and always points to the same place in space. This point is called the *South Celestial Pole*, and it is near the Southern Cross.

The Earth rotates on its own axis and at the same time revolves around the sun. To give perspective to the diagram below, the Earth's orbit has been drawn as much more of an oval shape than it really is.

On a clear night, go outside and watch the stars by sitting with your head resting on the back of a chair, or by lying on the ground. If you fix your eyes on a star that appears close to some object such as a house, you will soon see that the star either disappears behind the house or appears to move further away from it. It appears that the stars are moving from east to west, like the sun and moon. However, it is the Earth that is rotating—the stars don't move.

The photo top right was taken by pointing a camera towards the South Celestial Pole and leaving

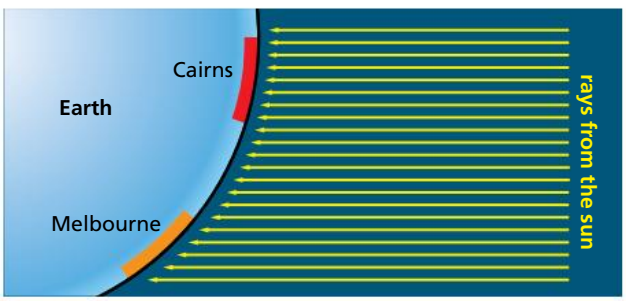


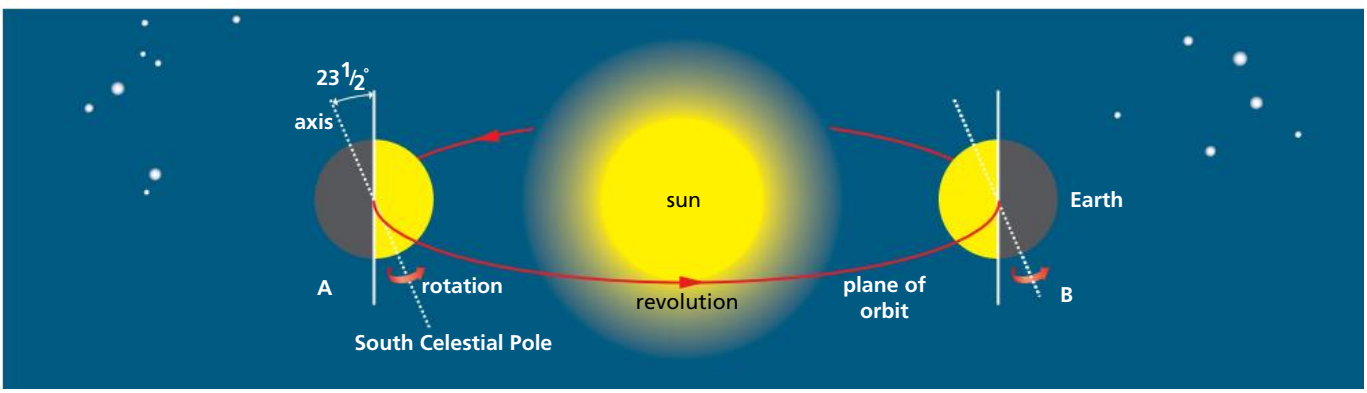
the shutter open for many hours. As the Earth spins on its axis the stars produce circular star trails.

Because the Earth revolves around the sun, our view of the stars changes during the year. Look at the diagram at the bottom of the page. When the Earth is in position A, the stars you see are different from those you see when it is in position B.

Why is Melbourne cooler than Cairns?

The Earth is warmed by heat rays from the sun. Depending on the angle at which the rays hit the Earth, some places are warmer than others. Look at the diagram below. The horizontal lines show heat rays from the sun hitting the curved surface of the Earth. Count the rays that hit each area. From this you can see that the more a surface is tilted away from the sun, the fewer rays hit it and therefore the cooler it is.





INQUIRY 3 Heating by the sun's rays

You will need: torch, sheet of paper, about 5 books, 2 thermometers, black plastic, adhesive tape

Part A

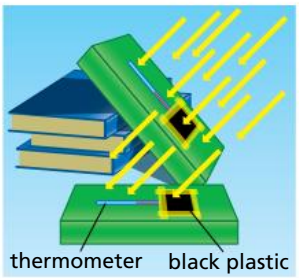
1 Shine a torch straight down onto a sheet of paper. Mark the size of the lighted area.

2 Now hold the torch at an angle. Notice that the light spreads over a larger area.

Part B

1 Set up the equipment as shown. Predict which thermometer will get hotter.

2 Wait about 5 minutes and compare the temperatures on the two thermometers.



- What conclusion can you draw from this inquiry?

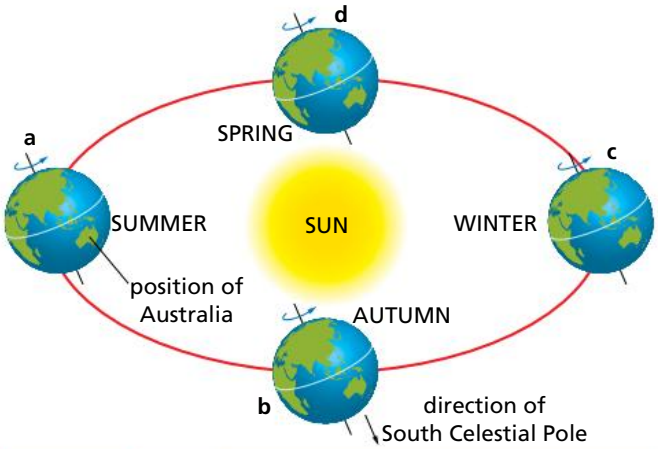
The seasons

Because the cycle of the seasons takes one year, you might guess that the annual revolution of the Earth around the sun is the cause of the seasons. This is true, however, only because the Earth's axis is tilted in relation to the Earth's orbit and always points to the South Celestial Pole. If the axis wasn't tilted, there would be no seasons.

Look at the diagram top right. With the Earth in position A it is summer in Australia. This is because the Southern Hemisphere is tilted towards the sun. This means that the sun's rays hit the Earth almost at right angles to the surface, making it warm. More than half of the Southern Hemisphere is in sunlight at any one time. This means that the days are longer than the nights. The longest day is 22 December, and is called the *summer solstice*.

Six months later the Earth is at position C on the other side of its orbit. The tilt of the axis hasn't changed, but in this position the Southern Hemisphere is tilted away from the sun. It is now winter in Australia and the days are shorter than the nights. The shortest day is 21 June, the *winter solstice*. In autumn (B) and spring (D) the days and nights are about the same length.

In the Northern Hemisphere the seasons are the opposite of those in the Southern Hemisphere.

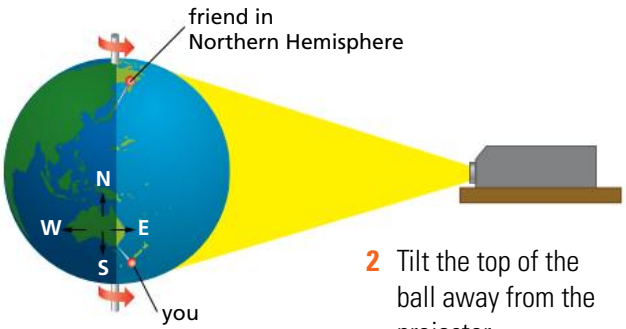


INQUIRY 4 The seasons

You will need: polystyrene ball (from Inquiry 2), cooking skewer or knitting needle, projector, 2 pins

1 Hold the ball in the light from the projector with the axis upright. Use a second pin to represent a friend in the Northern Hemisphere. Place the pin so that both pins are on the dark–light line in the sunrise position, as shown.

- Is the day the same length for both people?



2 Tilt the top of the ball away from the projector.

- Where does the sun rise first—at your place or at your friend's place?

3 Keeping the ball tilted at the same angle, rotate it to the sunset position.

- At whose place does the sun set first? Who has the longest day?
- With the axis tilted like this, is it summer or winter in Australia?
- Is there anywhere on Earth where the sun doesn't set? Is there anywhere the sun doesn't rise?
- How would you need to change the positions of the ball and projector to show winter in Australia? (Remember, you can't change the tilt of the ball.)

INQUIRY

5 Comparing planets

Use the planetary data in the following table to answer the questions below.

Planet	Time to orbit sun (Earth years)	Time to spin on axis (h = hours, d = days)	Tilt of axis (degrees)
Mercury	0.2	59 d	0
Venus	0.6	243 d	177
Earth	1	24 h	23½
Mars	1.9	25 h	25
Jupiter	11.9	10 h	3
Saturn	29.5	11 h	27
Uranus	84	17 h	98
Neptune	165	16 h	30

- Which planet takes the longest time to orbit the sun?
- Which planet has the shortest year? How do you know?
- Write a generalisation linking the length of a planet's year to its distance from the sun.
- Which planet has the shortest day?
- On which planet would a day be about the same length as a day on Earth?
- Draw a diagram showing how all the planets are tilted.
- Which planets have seasons similar to those on Earth? Explain your reasoning
- Would there be seasons on Mercury? Explain.
- The axis of one planet is so tilted that it spins on its side. Which one? What would the seasons be like on this planet?

Over to you

1 In which direction does the sun move across the sky? What makes it appear to move this way?

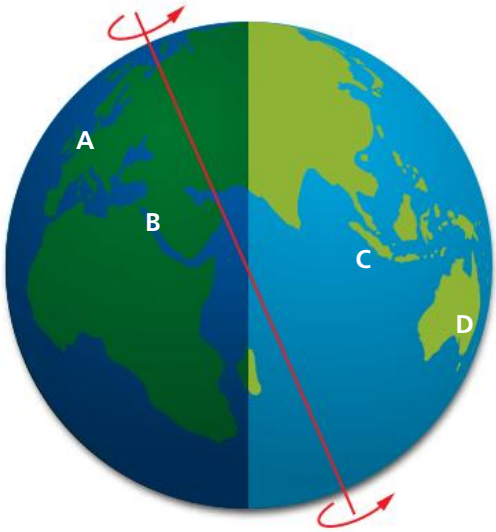
2 Explain in your own words what causes day and night. Use a diagram to help you explain.

3 **a** Use a diagram to explain the difference between the revolution and the rotation of the Earth.

b How long does it take the Earth to complete one *rotation*?

c How long does it take the Earth to complete one *revolution*?

4 Look at the diagram below showing four different places on Earth, marked with the letters A–D.



a Which places are in the Southern Hemisphere? Which are in the Northern Hemisphere?

b In which of these places is it daylight with the Earth in this position?

c In which places is it night?

d Of the places in daylight, which one will have sunset first?

e Of the places where it is night, which will have sunrise first?

f Which places are experiencing summer?

g Which place will have the longest day? The shortest day?

5 People once thought the sun moved around the Earth.

a Why do you think it is possible for people to have this idea?

b How do we know that this idea is wrong?

6 Why is the sunshine stronger in summer than in winter?

7 Places on Earth where the sun doesn't set during summer are called the Land of the Midnight Sun. Where are these places?

8 What would be different in our lives if

a the Earth rotated in 50 hours?

b the Earth took only half as long to complete its orbit around the sun?

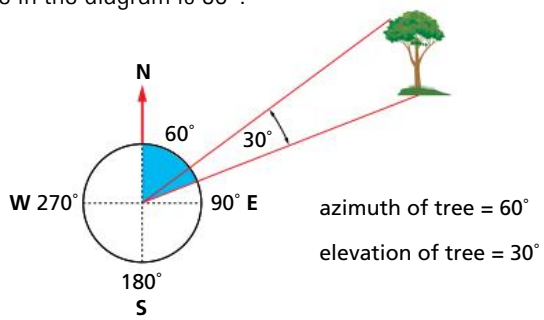
c the Earth's axis was not tilted?

9 What causes the length of daylight to change during the year?

SKILL

Mapping the sky

When you observe the sun, moon and stars you need to be able to describe their position in the sky. To do this you need a compass. Rotate the case of the compass until the pointer is over the letter N (north). You can then find the direction of any object by using the compass markings. The number of degrees clockwise from north is called the *azimuth* (AZ-ee-muth) of the object. So north is 0°, east is 90°, south is 180° and west is 270°. The azimuth of the tree in the diagram is 60°.

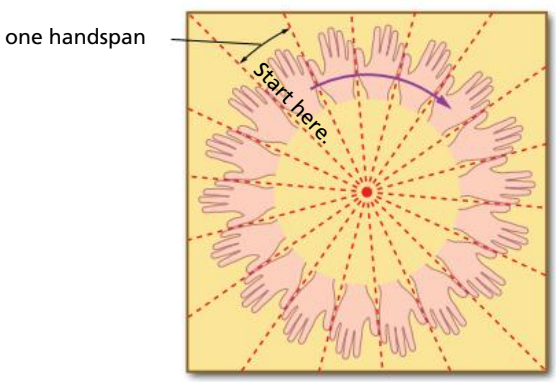


How far an object is above the horizon is called its *elevation*. This is also measured in degrees. For example, the top of the tree above has an elevation of 30°. The elevation can vary from 0° on the horizon to 90° directly above you. The point directly above you is called the *zenith*.

An easy way to measure azimuth and elevation is to use the handspan method. Stretch your arm out straight. Hold your hand flat and stretch out your fingers and thumb. The distance between the tip of the little finger and the thumb is called your handspan. Each person's handspan is slightly different.

Measuring your handspan in degrees

1. Stand in the centre of the room. Line up your thumb with one corner of the room and note where your little finger is pointing.
2. Now move your hand so that the thumb points where the little finger was pointing.



3. Keep going around the room like this until you reach the corner where you started. Count the number of handspans it took to go all the way round the room.
4. Suppose it took 18 handspans to go around the room.

$$\text{Then degrees in handspan} = \frac{360^\circ}{\text{number of handspans}}$$

$$= \frac{360^\circ}{18} = 20^\circ$$

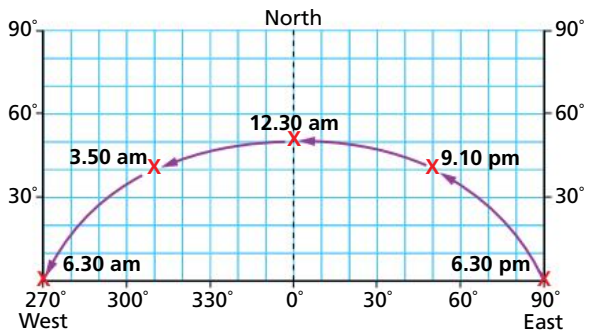
Estimating azimuth and elevation

1. Choose a tall object in the school yard, such as a tree, a pole or the top of a building.
2. Use a compass to find north.
3. Count the number of handspans it takes to go clockwise from north to the tree.
4. Multiply the number of handspans by the number of degrees in your handspan. For example, if the tree is 5 handspans to the right of north and your handspan is 20°, then its azimuth is 100° (just past east). If the tree is to the left of north you need to go all the way round. Or you can subtract from 360°. For example, a 20° handspan left of north would be 340°.
5. Use handspans to find the elevation of the object.

Making a star chart

You can use star charts to map the position of the sun, moon and stars. You can think of the sky as a big dome over your head. On this dome you can map the azimuth and elevation of stars. To record their position, divide the sky into two—the northern and southern halves. Then imagine each half dome flattened out onto a graph. The half dome you see when you look north has 0° in the middle, as shown. The half dome looking south has 180° in the middle.

If the moon rises in the east at 6.30 pm, it has an azimuth of 90° and an elevation of 0°. You can plot its azimuth on the horizontal axis and its elevation on the vertical axis as shown.



12.2 The changing moon

For as long as people have been looking at the sky they have wondered about the moon. What is it? Why does it appear at different times each night? Why does it change its shape? (See the diagram at the bottom of the page.)

Diana the moon goddess

People all around the world made up stories about the moon. For the ancient Romans, Diana the Huntress was the goddess of the moon. She used the crescent moon as a bow and her arrows were moonbeams. The ancient Greeks believed the moon goddess had different faces depending on her moods. The Bushmen of southern Africa told the story of a sun goddess and a moon god. When the sun goddess was angry with the moon god she pierced him with her rays, until his face gradually disappeared. Then a new moon grew. The Arunta Aborigines of central Australia believe the sun is in love with the moon and pursues it across the sky each day.

The cycles of the moon became linked with the cycles of birth, growth and death. The new moon grows to a full moon, then grows thinner and thinner until it disappears. Then after about 30 days it is born again as a new moon.

The word *month* was originally spelt *moonth*, and Monday was *Moon's day*. There is always a full moon at Easter, and the Easter bunny brings eggs, symbolising new life.

This relates back to an old tradition when people in the Northern Hemisphere said they could see the outline of a rabbit on the face of the full moon.

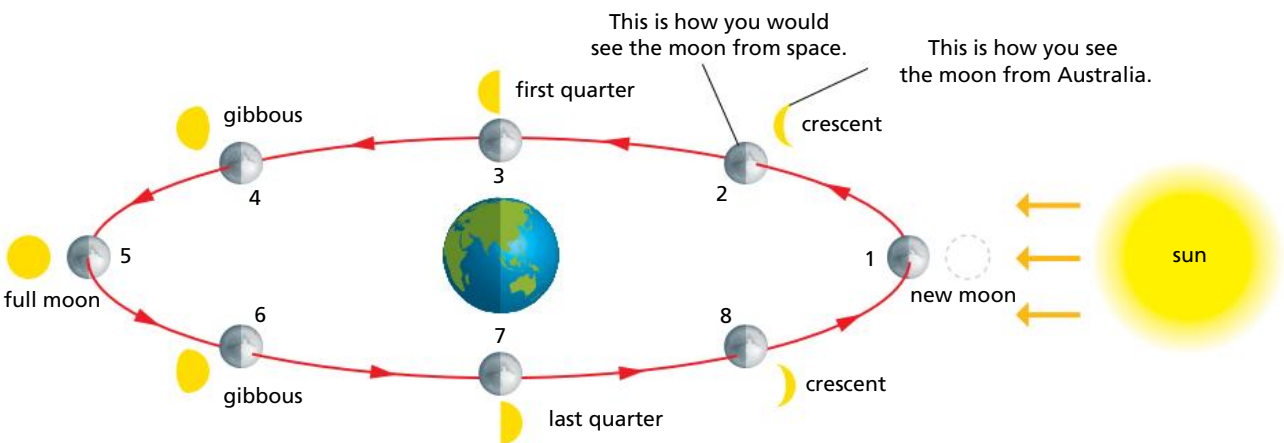
There have always been superstitions about the moon. One was that sleeping in the moonlight would cause you to go insane. The word *lunatic* comes from a Latin word meaning 'moonstruck'.

Phases of the moon

Only one side of the moon is lit by the sun. As the moon orbits the Earth you see varying amounts of this half-lit face. The changing faces you see are called **phases of the moon**.

Look at the diagram below. It shows the phases of the moon as seen in Australia. In position 1 the moon is between the sun and the Earth. Sunlight is shining on the side of the moon facing away from the Earth. In this position almost none of the moon's surface is visible from Earth. This is called the *new moon* and is when the nights are darkest.

As the moon moves to position 2 you see a *crescent moon*. At this stage you can often see the faint outline of the whole moon. As the moon continues in its orbit around the Earth the lit part gets larger. The moon is said to be *waxing*. In position 3, half of the side facing the Earth is lit, so the moon is said to be in its *first quarter*, because we can see only one-quarter of the moon. In position 4 nearly the whole half facing the Earth is lit. The moon in this position is said to be *gibbous*, from a Latin word meaning 'humpbacked'. In position 5, the whole hemisphere is lit and we have a *full moon*. The sun and the moon are now on opposite sides of the Earth. So as the Earth rotates, the sun sets and the full moon rises, and as the sun rises, the full moon sets.



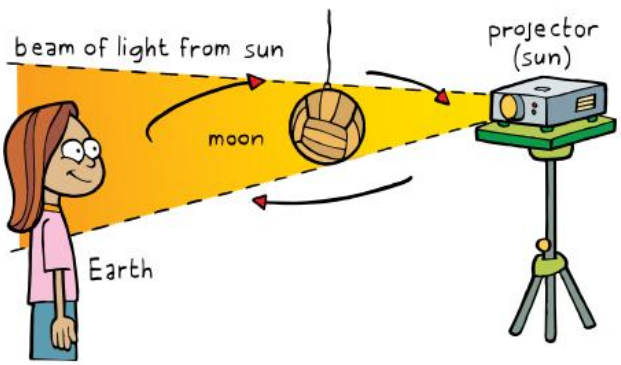
After the full moon, the lit part begins to decrease or *wane*, passing through another gibbous phase (position 6), the *last quarter* (position 7) and finally another crescent phase (position 8). Note that the crescent faces in the opposite direction to the one in position 1.

The whole cycle from one new moon to the next, or from one full moon to the next, takes 29½ days—about a month. Like the sun, the moon rises in the east and sets in the west. It rises about 50 minutes later each night.

INQUIRY 6 Moon phase model

You will need: white ball or blown-up balloon, thread, projector

1 Hang the ball or balloon in a darkened room in front of a projector. The projector represents the sun, the ball is the moon and you are observing from the Earth. Notice that one side of the moon is lit up by the beam of light from the sun.



2 Move around the moon in a circle and note how the part that is lit changes shape in a regular pattern.

3 On an overhead projector transparency, draw a diagram to show the relative positions of the sun, moon and Earth when a full moon occurs. Show this to the rest of the class.

4 Draw a diagram to show the positions for a new moon when none of the lit part is visible.

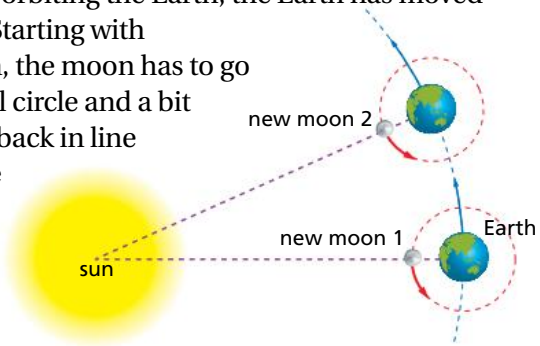
5 Draw a diagram to show the position for a quarter moon when only half the lit part is visible.

Note that in this model the Earth orbits the moon instead of the moon orbiting the Earth, but you still get the same changing moon shapes.

Why we see only one side of the moon

The moon is a *satellite* of the Earth, which means it is held in place by the gravitational force attracting it to the Earth. It rotates on its axis once every 27⅓ days. It also revolves around the Earth every 27⅓ days. As a result it seems that the moon does not rotate because the same side always faces the Earth. The far side of the moon can never be seen from the Earth and is sometimes called the dark side.

This diagram explains why it takes 29½ days rather than 27⅓ days from one new moon to the next. While the moon is orbiting the Earth, the Earth has moved in its orbit. Starting with a new moon, the moon has to go around a full circle and a bit more to get back in line between the sun and the Earth.



INQUIRY 7 Moon model

You will need: 2 oranges, apples or balls

1 Put one orange on the table. It represents the Earth. Mark the other orange with an **x**. This represents some feature on the moon. Place the moon orange on the table about 20 cm away from the Earth orange, with the **x** facing the Earth.

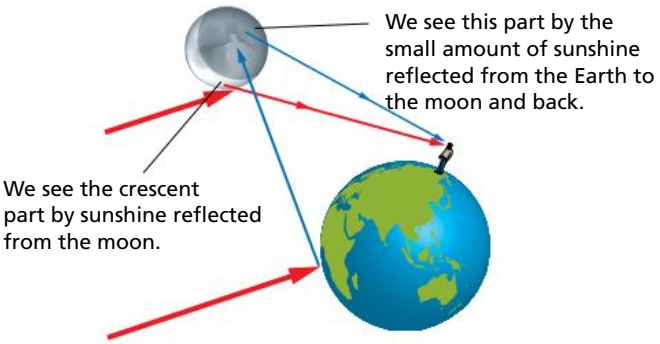
2 Now slowly move the moon around the Earth, keeping the **x** facing the Earth all the time.

- Did the Earth see only one side of the moon?
- Did the moon rotate as it orbited the Earth?
- How many times did the moon rotate in one orbit of the Earth?
- How long is a day on the moon?
- Is it correct to call the far side of the moon the dark side? Imagine you are the sun and use the model to answer this question.

Why the moon shines

The moon produces no light of its own. It reflects light from the sun so it appears to shine. Just after the new moon, you see only a thin crescent shape due to

reflected sunlight, but if you look carefully you can see the faint outline of the rest of the moon, as shown in the photo. This is due to earthshine, where light from the sun is reflected from the Earth to the moon and back to your eyes.



Do the planets show phases?

If you could view the Earth from the moon it would go through phases just like the moon does from Earth. Look at the diagram at the bottom of page 254. Imagine you are on the moon. In position 1 the whole side of the Earth is in sunshine, so you would see a full Earth. In position 5 the lit side is hidden, so you would see a new Earth. Between position 1 and position 5 you would see gibbous, quarter and crescent Earths.

From the Earth, phases of the planets Mercury and Venus can be seen because they are between us and the sun.

The crescent phase of the Earth, taken from the moon by the Apollo *astronauts*

Over to you

1 The shape of the moon changes from day to day. Sometimes it appears as a full round moon, and at other times it is a thin crescent. Why is this?

2 Draw a simple diagram showing how we see the moon by reflected sunlight.

3 Name the following moon phases.

4 Draw diagrams to show the positions of the sun, Earth and moon when the moon is new, in its first quarter, full and in its last quarter.

5 During which phase of the moon is it:
- **a** between the sun and the Earth
- **b** on the opposite side of the Earth from the sun?

6 Are these statements true or false? Rewrite the false ones to make them true.
- **a** The moon revolves around the Earth in 24 hours.
- **b** The moon produces no light of its own.
- **c** There is a full moon every 29½ days.
- **d** During a new moon the sunlit side of the moon faces the Earth.
- **e** A moon day is the same length as a moon year.

7 Why do you always see the same side of the moon from Earth?

8 **a** In an Arnhem Land Aboriginal creation story the moon is described as getting sick and becoming very thin. Relate this description to the phases of the moon.
- **b** Write your own story to describe the moon phases.

9 At what time of day does a full moon rise?

10 Record the position of the moon in the sky using azimuth and elevation (see the Skill box on page 253). You could observe it as it rises and moves across the sky. Or you could observe it at the same time each night (or day).

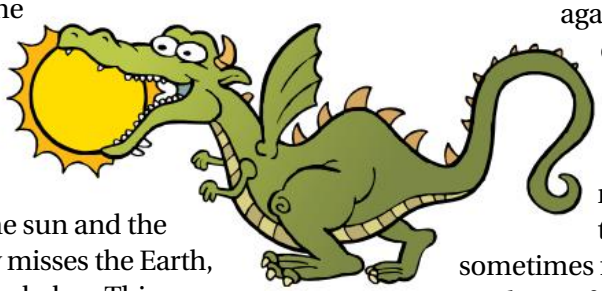
PROBLEM SOLVING

Have you watched the movie *Apollo 13* yet? From what you have learnt in this section, does the movie show the moon correctly? And does it show the Earth correctly from the moon?

12.3 Eclipses

Solar eclipses

The series of photos above show an eclipse of the sun as it gets smaller and smaller and sometimes disappears altogether. This sight terrified ancient people. In China they thought there was a giant invisible dragon that ate the sun. Whenever there was an eclipse the people would run outside shouting, banging on pots and pans and firing arrows into the sky. They thought this would frighten the dragon and cause it to spit out the sun, which the dragon always did.

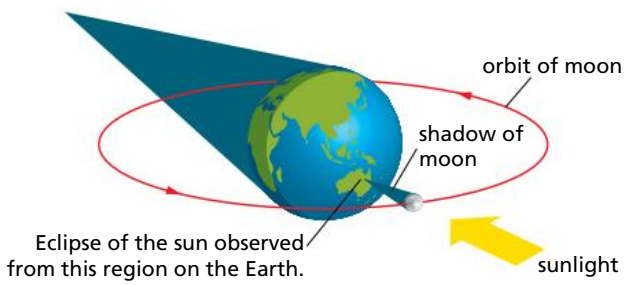


We now know what causes a **solar eclipse**. The moon blocks the light from the sun and casts a shadow in space. At the time of the new moon, the moon is between the sun and the Earth. Normally the moon's shadow misses the Earth, but sometimes it touches it as shown below. This causes an eclipse of the sun in this part of the world. The sun is blocked by the moon, and it appears black. If the moon blocks out the whole of the sun a *total eclipse* occurs. If the moon blocks out only part of the sun a *partial eclipse* occurs. Total eclipses are quite rare and can only be seen in certain places. For example, on 14 November 2012, there will be a total solar eclipse in Australia, which will be seen along a path from Kakadu National Park in the Northern Territory to Cairns in north Queensland. The eclipse will last about 2 minutes. Keen astronomers and photographers travel the world to catch rare glimpses of total solar eclipses.

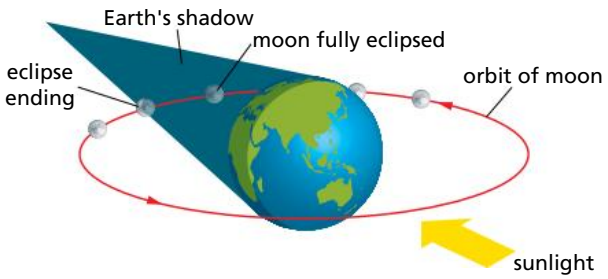
Lunar eclipses

In the year 1504 Christopher Columbus was forced to land in Jamaica in the West Indies. He soon ran out of food and the native people wouldn't give him any. Columbus was interested in astronomy and knew that in a few days there would be an eclipse of the moon. On the day of the eclipse he warned the natives that God would take away the moon if they didn't bring him food. When the eclipse began the natives became frightened. They agreed to give Columbus food if he could make the moon shine again. This he did when the eclipse was over.

At the time of the full moon, the Earth is between the sun and the moon. When this happens the Earth's shadow sometimes falls on the moon, causing an eclipse of the moon (a **lunar eclipse**). This doesn't happen every month because the sun, Earth and moon don't usually line up properly. If the entire moon passes through the Earth's shadow a total eclipse occurs. If only part of the moon passes through the Earth's shadow a partial eclipse occurs. As the moon passes through the Earth's shadow the lit part of the moon gets smaller and smaller and darker and darker. However, it doesn't turn black, but a reddish colour. The Earth's shadow is so wide it sometimes takes the moon several hours to pass through it.



A solar eclipse



A lunar eclipse

INQUIRY 8 Eclipse model

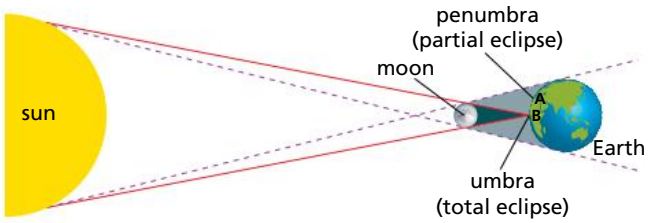
You will need: desk lamp with 100 W frosted bulb to represent the sun, large ball to represent the Earth, small ball to represent the moon

Use the lamp and the two balls to show how solar and lunar eclipses occur.

- Draw diagrams showing the positions of the sun, Earth and moon for a solar eclipse and for a lunar eclipse. What is the phase of the moon in each position?
- Did you notice that the shadow was darker in the centre than on the outside?

Explaining partial and total eclipses

In Inquiry 8 you may have noticed that during an eclipse the shadows on the balls were darker in the centre, and not so dark on the outside. The dark inner part is called the *umbra*, from the Latin word meaning 'shadow'. The lighter part on the outside is called the *penumbra*. *Pen* means 'almost', so the penumbra is the area that is 'almost shadow'.

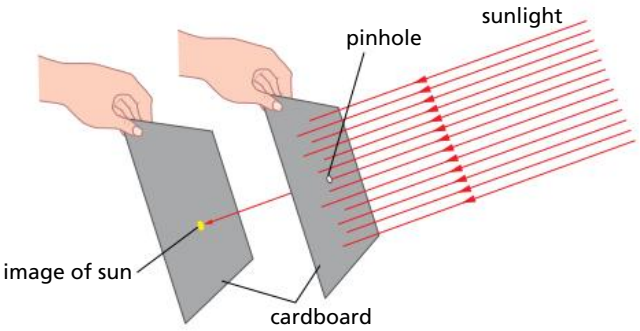


Look at the diagram above. At A, which is in the umbra, the sun is completely blocked, so there is a total eclipse in this part of the world. At B only part of the sun is blocked. Some rays of sunlight get around the edges of the moon into the penumbra, so there is only a partial eclipse in this area.

Astronomers are particularly interested in total solar eclipses because the outer part of the sun, called the *corona*, is visible at this time. The corona is hot gas boiling off the sun and streaming outwards into space. Normally the corona cannot be seen because of the brightness of the sun.

Viewing eclipses

Never look at the sun during a solar eclipse. This could cause permanent eye damage. Sunglasses should not be used either. The safest way to view a solar eclipse is to use two pieces of cardboard, one with a pinhole in it, as shown. It is safe to look at the moon during a lunar eclipse.



Over to you

1 Copy and complete these sentences.
   - **a** During a solar eclipse the shadow made by the _____ falls on the _____. A solar eclipse can occur only during the _____ moon phase.
   - **b** During a lunar eclipse the shadow made by the _____ falls on the _____. A lunar eclipse can occur only during the _____ moon phase.

2 Draw diagrams to show:
   - **a** how a lunar eclipse forms
   - **b** how a solar eclipse forms

3 What is the difference between a total eclipse and a partial eclipse of either the sun or the moon?

4 Look at the series of photos of a solar eclipse at the top of the previous page. How did the ancient Chinese explain this?

5 What is the safe way to observe a solar eclipse?

6 Why don't eclipses occur every month?

7 Jesus Christ was crucified during the Jewish Passover, which takes place at Easter during the full moon. The Bible says 'At noon the whole country was covered with darkness for 3 hours'. Could this darkness have been caused by a solar eclipse? Explain your answer.

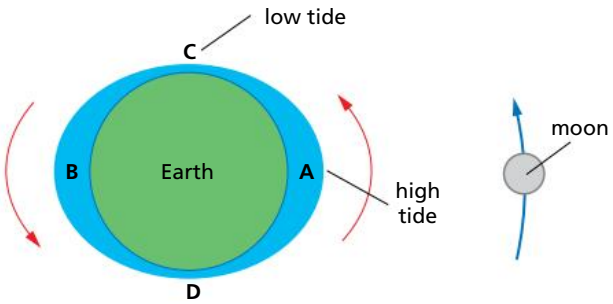
8 Play a game of *Real or not*. Go to the library and find a story or legend told by ancient people about what they saw in the sky. Alternatively you can use what you find out to make up your own story. Read the story to the class and they must decide whether it is a real story or whether you made it up.

12.4 Tides

Both the sun and the moon exert a gravitational pulling force on the Earth. The force of the moon is greater, because it is much closer to the Earth. This force pulls the water of the oceans towards the moon, creating a bulge.

Look at the diagram on the right. The moon attracts the water nearest it, producing a high tide at A. The bulge on the opposite side of the Earth at B is caused by the moon pulling the Earth away from the water on that side. The bulges at A and B draw water away from C and D, causing low tides there.

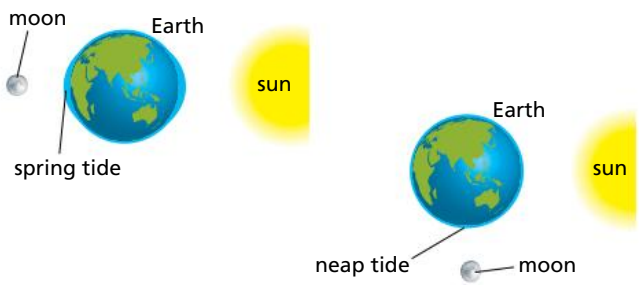
As the Earth rotates, the tidal bulges stay roughly in the same place relative to the moon, because the Earth rotates much faster than the moon revolves. As the Earth rotates, each place on Earth usually passes through two high tides and two low tides each day.



Note: The tidal bulges have been exaggerated.

Larger tides occur when both the sun and moon pull in the same direction. This happens whenever the sun, Earth and moon line up during a full moon or a new moon. These larger tides are called **spring tides**, although it has nothing to do with the seasons. The largest spring tides are called *king tides*.

Between spring tides we have small tides called **neap tides**, where the water doesn't come in as far or go out as far. These tides occur when the sun and moon are at right angles to each other as shown, and pull against each other. This happens at the first quarter and last quarter phases of the moon.



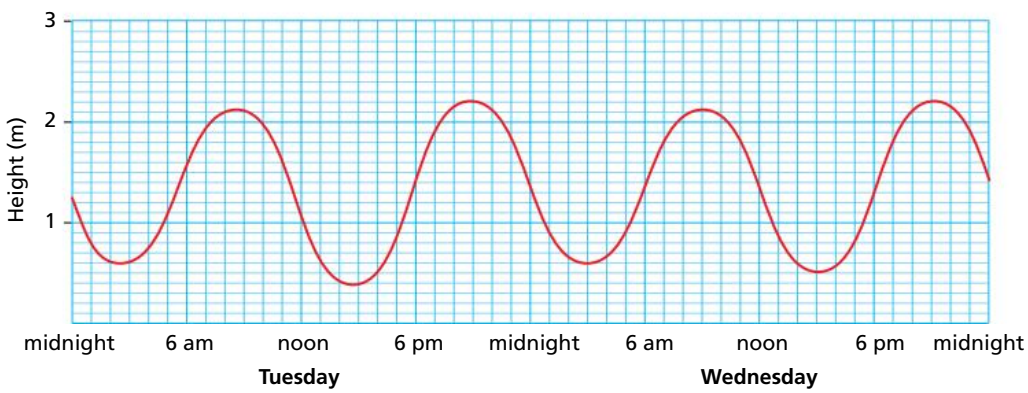
Because the moon is in orbit around the Earth, the Earth does slightly more than one rotation before the second high tide. This takes 24 hours and 50 minutes, so the high tide is about 50 minutes later each day. For the same reason, the moon rises 50 minutes later each day.

INQUIRY 9 Tide tracks

The tides are very important if you are going fishing or surfing. That is why tide times are given on the news each night.

Use the tide track below to answer these questions.

- What do the peaks on the graph represent? What do the troughs represent?
- How many high tides are there each day? How many low tides?
- What time is the high tide Tuesday night? How high is it?
- What is the height difference between the low tide Tuesday afternoon and the high tide Tuesday night?
- What pattern can you see in the times of the high tides over the two days?
- How long does the tide take to come in? How long does it take to go out?



How the tides vary

In most places there are two high tides each day, with a difference of 1–2 m between high tide and low tide. However, the tides are very complicated and depend on the shape of the coastline and unusual currents. For example, tides around Melbourne are larger than those around Sydney and Brisbane. This is because the water tends to pile up as it is funnelled through Bass Strait. The tides along the north-west coast of Australia can be as high as 10 m. In some places there may be only one tide per day.

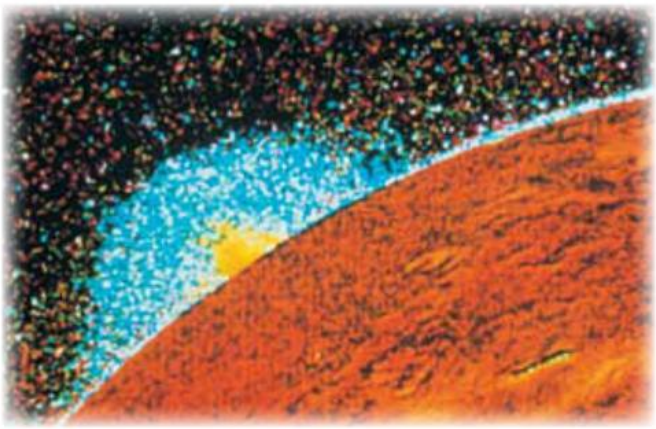
Tidal forces

Gravitational forces exist between all bodies in space. With large bodies close together, like the Earth and the moon, these forces are much larger. They are then called tidal forces. For example, in 1992 a comet almost collided with the planet Jupiter. There were such large tidal forces between Jupiter and the comet that the comet broke into 21 fragments, each of which collided with the planet two years later.

As well as pulling the Earth's oceans up and down, the pull of the moon can also distort the continents, moving the land up and down by as much as 2 cm. These same tidal forces act on the moon, causing it to distort. Scientists infer that these tidal forces cause moonquakes on the moon, but not the earthquakes on Earth.

The tidal bulges on the Earth create friction, which acts like a brake. This has slowed down the Earth's rotation, making our day 16 seconds longer every million years. At the same time the moon is getting further away from Earth. Using a mirror left on the moon by the Apollo missions, scientists have estimated that the Earth–moon distance is increasing by almost 4 cm every year.

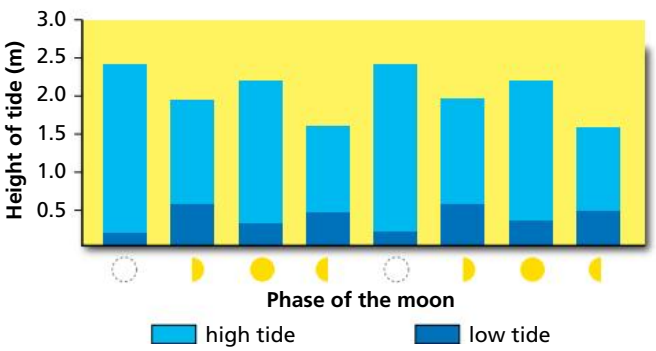
Because Jupiter is so large, there are huge tidal forces between it and its nearest moons. Each time Jupiter's moon, Io, rotates, its surface is pulled up and down and in and out by up to 10 m. Astronomers infer that this motion has heated the interior of this moon, just as a paperclip becomes warm if you bend it back and forth rapidly. This would make Io's interior molten and would explain why the surface is covered in volcanoes. Jupiter's second moon, Europa, is covered with a thick layer of ice with cracks in it. Astronomers have predicted that if tidal forces have caused this ice to melt, there could be extraterrestrial life under the surface of Europa.



Tidal forces between Jupiter and its moon 'Io' may have caused the volcanoes on the surface of Io.

Over to you

1. What do you think the word **hydrosphere** means. Use a dictionary to check if you are correct. How is the hydrosphere affected by the moon?
2. If the sun is bigger than the moon, why doesn't it have a greater influence than the moon on the tides?
3. Why are there usually two high tides and two low tides in a 24-hour period?
4. Draw diagrams to show the relative positions of the sun, moon and Earth to produce:
   - **a** spring tides
   - **b** neap tides
5. Carlos said, 'If the moon's gravitational force causes the tides, then high tides can occur only at night when you see the moon.' Write a paragraph to convince Carlos that he is wrong. You may need to draw diagrams.
6. What does this bar graph tell you about the relationship between the tides and the moon?



7. Why are tides at the end of a long harbour later than at its mouth?
8. If there was no moon would there still be tides? If so, how would they be different?
9. How do tidal forces affect the moon?

12.5 On the moon

INQUIRY 10 Moon gazing

1 It is difficult to see the craters and mountains on a full moon because at that time they don't cast shadows. It is better to observe the moon when about half of it is visible. If possible use a pair of binoculars or a small telescope. You can hold the binoculars steady by resting your elbows on something.
   - Can you see a 'man in the moon', a rabbit or something else?
   - Try to identify the seas (dark areas), mountains and craters marked on the photo above.
2 Make a rough sketch of what you see and label any features you were able to identify.

The surface of the moon

The moon is much smaller than the Earth—its diameter is about the distance across Australia. We only ever see the near side of the moon. The far side was unknown until it was photographed by the Russian spacecraft *Luna 3* in 1959.

The barren surface of the moon has three main features. First, there are millions of craters ranging in size from a few metres to over 200 km across. They are named after famous astronomers. For example, Tycho, the large crater at the top of the moon, is named after Tycho Brahe, a famous Danish astronomer.

Astronomers infer that most of the *craters* were formed when meteors collided with the moon. On Earth most meteors burn up in the atmosphere before they hit the ground. This is due to the heat produced

by friction between the meteor and the air. However, the moon does not have an atmosphere to protect it from meteors. The near side has fewer craters than the far side, because the Earth gives it some protection. Craters such as Copernicus have bright rays radiating from them. Astronomers infer this is material spattered around when the meteor thudded into the moon.

The large dark rounded areas are called *maria* (MA-ree-a) or seas. The early astronomers who studied the moon thought they were the same as the seas on Earth, but they are not. The Sea of Serenity is about the size of Victoria. The Apollo missions brought back rocks from the moon and many of these are basalt, which is formed from lava. Astronomers infer that the areas we call seas were once huge craters which filled with lava. This may have happened when meteors crashed through the moon's crust, opening up cracks that allowed lava to flow out over the moon's surface. After the lava hardened into rock, smaller meteors crashed into it, forming many smaller craters in its surface.

There are also long narrow valleys called rills. One of these is more than 500 km long. Astronomers are not sure how rills were formed. One theory is that they are cracks partly filled by molten material. Another theory is that they are lava tunnels, like those on Earth, whose roofs have collapsed.

The light areas of the moon's surface are mountains or *highlands*, probably formed by volcanic activity. Some of these are as high as the Himalayas on Earth. The highlands are very old and exactly the same as they were when they were formed. This is because there is no air or liquid water on the moon, so no weathering and erosion can occur.

The whole surface of the moon is covered by a thick layer of broken rock and dust. This too has been produced by meteor collisions. The footprints left by the *Apollo 11* astronauts are still there in the moon dust after more than 30 years, because there is no wind or rain to erase them.

How was the moon formed?

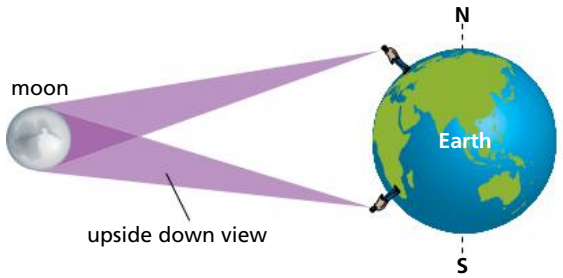
Scientists infer the moon was formed about 4.5 billion years ago, at about the same time as the Earth. This is the age of the oldest rocks so far found on the moon. There have been three theories to explain the formation of the moon. The first theory says the moon was formed at the same time as the Earth when gas and dust clumped together to form the solar system. The second theory says that the moon was somehow split off from the Earth, perhaps pulled out by the tidal force of a passing star. For example, some people have suggested the moon may have come from the area now filled by the Pacific Ocean. The third theory says that the moon was captured by the Earth's gravity.

However, as a result of studying the moon rocks, scientists now favour a fourth theory—the 'Big Whack' theory. A Mars-sized body collided with the Earth, throwing huge amounts of debris into orbit around the Earth. Some of this debris eventually came together to form the moon, as shown below.

A Mars-sized body collided with the Earth, throwing huge amounts of debris into orbit. Some of this debris came together to form the moon.

The land down under

The features we see on the moon are upside down compared to what is seen by people in the Northern Hemisphere. It's like standing on your head to look at the moon. The constellations we see are also upside down compared to what they see.



Landing on the moon

The Earth and the moon are both moving in space, so it is not possible to travel in a straight line from one to the other. A rocket first puts a spacecraft into orbit around the Earth. The spacecraft is then boosted onto a path towards the moon. Once it reaches the moon the spacecraft goes into orbit around the moon, and from here a lunar module can be sent to land on the surface. To understand why this complicated path is necessary, try Inquiry 11.

On the moon

Imagine stepping out of a spacecraft onto the surface of the moon. Probably the first thing you notice is the low gravity. You weigh only one-sixth of what you weigh on Earth. Because you are not used to this low gravity you tend to leap off the surface with every step.

The low gravity means there is no atmosphere, so you need a bulky spacesuit with an air supply to breathe. The spacesuit also protects you from harmful UV rays and tiny meteors, as there is no atmosphere to protect you as there is on Earth. There is no air to carry sound, so your suit also contains a radio for communication.

The sky is black, not blue, because there is no atmosphere and therefore no air molecules to scatter light from the sun. The sun is very bright and the shadows are much darker and sharper than on Earth. The stars are visible during the day. There is no wind or clouds and it never rains.

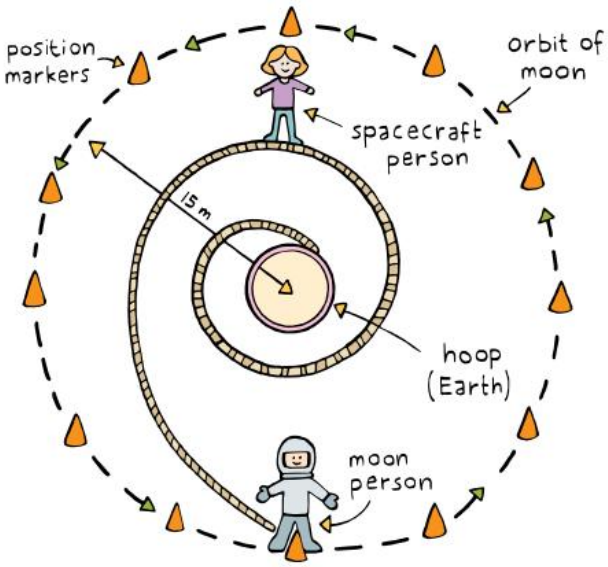
One day on the moon is 27⅓ Earth days, so daylight lasts almost 14 days and so does the night. Due to the long day and the lack of atmosphere, temperatures in the middle of the day reach 100 °C—hot enough to boil water. During the long night temperatures fall to about –150 °C.

Until recently astronomers thought there was no water on the moon, but recent space probes have found large amounts of ice near the poles. This makes it more likely that humans will some day be able to live on the moon.

INQUIRY 11 Moon trip

You will need: hoop, long rope (about 2 m), measuring tape, position markers

1. With a partner, use the measuring tape and position markers to mark out a large circle about 15 m in radius. This represents the orbit of the moon around the Earth.
2. Put the hoop in the centre of the circle. It represents the Earth. Place the rope so that it spirals out from the Earth and eventually reaches the moon's orbit. This represents the path of the spacecraft from the Earth to the moon.



3. One person represents the moon by walking at a steady pace around the large circle. A second person is the spacecraft launched from Earth. They walk along the rope at a steady pace to reach the person representing the moon. You will probably need to try this several times until you work out the correct time to launch.
4. Have a third person walk at a steady pace around the hoop to represent a landing site on the Earth. Work out when to launch from the moon so as to land at this spot on the Earth.

- Why can't you launch a spacecraft in a straight line from the Earth to the moon?

INQUIRY

12 Moon landing hoax

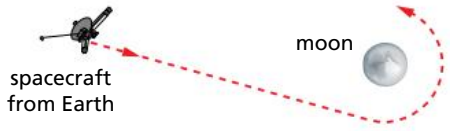
In July 1969, millions of people around the world stopped what they were doing to watch Neil Armstrong take the first steps on the moon, during the *Apollo 11* mission. However, there have been several TV programs that claim that American astronauts did not land on the moon, and that the trip was a hoax. The programs claim that NASA faked the landing in order to win the space race against Russia, and that the video of the landing was made in a movie studio on Earth.

Those supporting the hoax ask 'Why is the flag fluttering when there is no wind on the moon (as in the photograph)?' and 'Why are there no stars in the sky as there should be?' There is an enormous amount of information on the internet—both for and against the hoax. Your job in this activity is to consider this evidence and make up your own mind.

1. Your teacher will place signs in the four corners of the classroom: strongly agree it is a hoax, unsure but think I agree, unsure but think I disagree, strongly disagree. Move to the corner that applies to you.
2. Everyone now has a chance to convince others to swap corners. When everyone has had a chance to speak, the winning corner is the one with the most people in it.

Over to you

1. Why do astronauts need to wear spacesuits on the moon?
2. You can jump much higher on the moon than you can on Earth. Why is this?
3. What are the dark areas you can see on the moon? How were they formed?
4. Name at least six ways in which conditions on the moon are different from those on Earth.
5. What sort of weather would you expect on the moon?
6. Are these statements true or false? Rewrite the false ones to make them true.
   - **a** The moon orbits the Earth in 27⅓ days.
   - **b** On the moon the sky is black.
   - **c** Daylight on the moon lasts almost 14 Earth days.
   - **d** The moon is much younger than the Earth.
   - **e** Gravity on the moon is six times greater than it is on Earth.
   - **f** The far side of the moon is always dark.
7. Daytime on the moon is two Earth weeks long. Why is this?
8. How do scientists now think the moon was formed?
9. Write inferences to explain
   - **a** how the craters on the moon were formed.
   - **b** why there are more craters on the moon than on Earth.
   - **c** why there are more craters in the mountains of the moon than in the maria.
10. If you weigh 60 kg on Earth, what will you weigh on the moon?
11. As a spacecraft nears the moon its path automatically curves as shown. Why do you think this happens?



12. What would be the benefits to us of having a space colony on the moon?
13. Suggest why no life has been found on the moon.
14. The moon is totally silent, even during a moon landing. Why is this? (Think back to Chapter 8.)
15. Draw a diagram that explains why we always see the same side of the moon.

PROBLEM SOLVING

Have you viewed the movie *Apollo 13* and written your list of what is scientifically correct and what is not? Now that you know more about the moon you should find this a little easier to do.

SCIENTISTS AT WORK

The Dish

Have you seen the Australian movie *The Dish*? It tells the story of how the Parkes Radio Telescope in western New South Wales was used to receive the TV images of Neil Armstrong landing on the moon on 21 July 1969 during the *Apollo 11* mission.

The Parkes Radio Telescope is 64 m across—large enough to play cricket on, as they did in the movie. It is used to track radio signals from space and can be rotated and tilted. NASA had three tracking stations to communicate with *Apollo 11*—one in California, one at Honeysuckle Creek outside Canberra, and Parkes. A last minute change of plans meant that NASA was relying on Parkes to receive the TV pictures of the moon landing.

The lunar module from *Apollo 11* landed on the moon at 6.17 am eastern Australian time. The astronauts were scheduled to rest for 10 hours before attempting to walk on the moon, but Armstrong decided to go immediately. This meant that Parkes would not be able to receive the TV signals. The moon hadn't yet risen there and the telescope couldn't 'see' the moon. To make matters worse a storm hit Parkes and 110 km/h winds threatened to damage the telescope. Fortunately it took the astronauts many hours to get ready and at 12.56 pm when Armstrong stepped down the ladder onto the moon's surface, Parkes was ready.

Six hundred million people in 49 countries around the world watched the live coverage of the event on TV. Parkes had the clearest pictures and Australians actually saw them a fraction of a second before anyone else. The live broadcast through Parkes continued for 2½ hours.

Parkes also played an essential role in the recovery of the *Apollo 13* astronauts in 1970 when an explosion in the spacecraft meant they had to survive the return trip to Earth in the lunar module, before re-entering the spacecraft for splashdown. Parkes also helped track the *Voyager II* mission to Uranus and Neptune in 1986–87 and the *Galileo* probe to Jupiter in 1997. The telescope has also been used in the Search for Extraterrestrial Intelligence (SETI).

In 1963 Parkes helped identify the first quasar—a very distant star-like object associated with a very large black hole. The telescope has detected magnetic fields in space and has located more pulsars than any other telescope in the world. Pulsars are extremely dense neutron stars formed by the collapse of large stars. They send out pulses of radio waves that can be detected by the telescope. The Parkes Radio Telescope is still in use today.

Questions

1. What was the plot of the movie *The Dish*?
2. How many people watched the live TV coverage of the moon landing?
3. Besides *Apollo 11*, which other NASA missions has Parkes been involved with?
4. How long ago did Neil Armstrong walk on the moon?
5. What time would it have been in the United States on the east coast when Armstrong walked on the moon?
6. Why couldn't Parkes receive a TV picture until the moon rose?
7. How could the Parkes telescope be used in the search for extraterrestrial life?
8. Why do you think they made a movie about the Parkes Radio Telescope?

THINKING SKILLS

1 Why does someone standing at the Earth's equator spin with the Earth faster than someone in Antarctica, even though they don't notice it?

2 Eloise was looking at the stars in the sky during summer and noticed that they were different from those she saw during winter. How can you explain this?

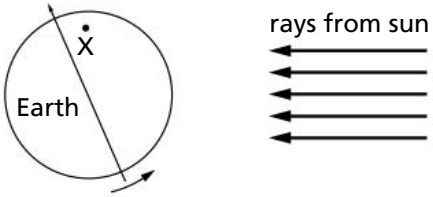
3 In winter the sun is lower in the sky as it crosses the sky than it is in summer. Why is this?

4 **a** Why can't you see much of the moon during a new moon?

b Why do new moons usually occur during the day? (Hint: Use the diagram at the bottom of page 254.)

5 Why don't the stars twinkle when seen from the moon?

6 Look carefully at this diagram.



a What time of day is it at the place marked X? Explain your answer.

b Would X be experiencing summer or winter?

c Copy the diagram and shade in the area of the Earth that would be dark for 24 hours. Explain.

d Shade in the area where there would be a 'midnight sun'.

7 What phase of the Earth would you see from the moon when the Earth experienced:

a a lunar eclipse **b** a solar eclipse?

8 Why is it that lunar eclipses are more common and last longer than solar eclipses?

9 How would the tides be different if:

a there was no moon

b the Earth had two moons

c the Earth did not rotate? (Assume the moon continues to orbit the Earth.)

10 **a** Research what the saying 'once in a blue moon' means.

b What is a 'blue moon'?

11 The illustration below recreates a photograph that was taken with a camera pointed into the sky with the shutter open.

a What are the curved lines? Explain.

b In which direction was the camera pointed?

c What do you think caused the straight line?

d Estimate how long the shutter was left open.

12 Imagine you see the moon as shown in the diagram.

a In which direction would the sun be?

b Draw a diagram to show where the sun, Earth and moon would have to be for you to see a moon like this.

13 Galileo was the first to observe the moon through a telescope. He said 'All the Earth sees one half of the moon. Only half the moon sees all the Earth.' What do you think he meant when he said this?

14 Does the same side of the moon always face the *sun*? Use a diagram to explain your answer.

15 In a group of four people, design a role-play to explain one or more of the following to a group of primary school children.

a day and night

b the revolution of the Earth around the sun and the moon around the Earth

c the phases of the moon

d solar and lunar eclipses

e the seasons

f the tides

You will need three people to represent the sun, Earth and moon, and a fourth person to be the narrator.

Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 The Earth rotates upon a tilted _____. Because of this rotation the sun appears to rise and set every day.

2 The Earth revolves around the sun every 365¼ days. This is called a _____. This revolution and the fact that the Earth's axis is tilted causes the _____.

3 Because of the rotation of the Earth the _____ appear to move across the night sky. The _____ of the Earth around the sun explains why we see different stars at different times of the year.

4 The moon does not produce any light of its own, it only reflects the light from the _____. Over a month the moon passes through _____, from a new moon to a full moon and back to a new moon.

5 One complete revolution of the moon takes 27⅓ days. One _____ of the moon occurs in the same time. This is why the moon always keeps the same _____ towards the Earth.

6 An eclipse of the sun (_____ eclipse) occurs when the moon casts a _____ on the Earth. An eclipse of the moon (lunar eclipse) occurs when the Earth casts a shadow on the _____.

7 The gravitational pull of the moon (and the sun) causes the oceans on the Earth to bulge, producing _____.

axis
face
moon
phases
revolution
rotation
seasons
shadow
solar
stars
sun
tides
year

Self-management

Cause and effect

In everyday life and in science there are reasons for things happening. Suppose you are so tired you can't stay awake in class. This is the effect—what you see happening. Perhaps the cause of this is that you were up late doing your homework. In this way you relate the cause (the reason) to the effect.

1 Throughout this chapter there are many examples of cause and effect. Copy the table, leaving plenty of space for the diagrams. Complete the table by adding the missing causes or effects and drawing a diagram to explain the link between the cause and the effect, as shown in the first example in the table.

2 Check through the chapter and write your own cause or effect, different from the ones here. Then ask someone else to complete your example.

	Cause	Effect	Diagram
1	sun shines on only half of Earth at any one time	day and night	
2	moon passes through Earth's shadow		
3		two high tides and two low tides each day	
4		stars appear to move from east to west	
5	moon revolves around Earth in 27⅓ days and rotates on its axis in 27⅓ days		
6		moon seems to disappear at new moon phase	
7		solar eclipse	

Checkpoint

Remember to look at
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1 The dark-coloured parts of the moon's surface are
- **A** craters formed by meteor impacts.
- **B** mountain ranges.
- **C** oceans.
- **D** plains of basalt.

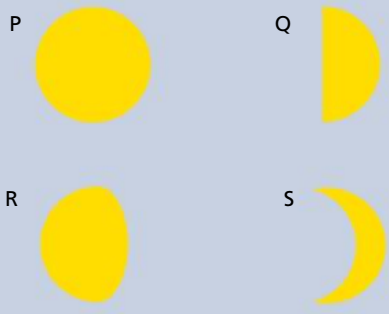
2 The sun and stars appear to move across the sky because
- **A** the Earth's axis is tilted.
- **B** the Earth is rotating on its axis.
- **C** the Earth is orbiting the sun.
- **D** the sun and stars are orbiting the Earth once each day.

3 The planet Mars rotates on its axis in 25 hours. This means that
- **A** seasons on Mars and Earth are about the same.
- **B** a Martian year is about the same length as a year on Earth.
- **C** a Martian day is about the same length as a day on Earth.
- **D** temperatures on Mars are about the same as those on Earth.

4 Which one of the following is *incorrect*? On the moon an astronaut
- **A** would be weightless.
- **B** would need to carry a supply of air to breathe.
- **C** would need protection from heat and cold and UV radiation.
- **D** could not be caught in a thunderstorm.

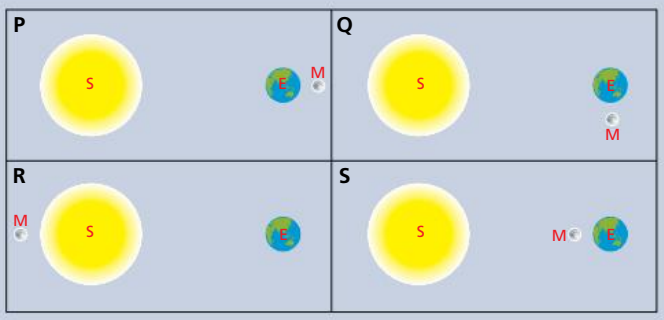
5 How long does it take for
- **a** the Earth to turn on its axis?
- **b** the Earth to orbit the sun?
- **c** the moon to orbit the Earth?

6 **a** Name the four moon phases below.
- **b** Put the four phases in the order we see them, starting with the full moon.



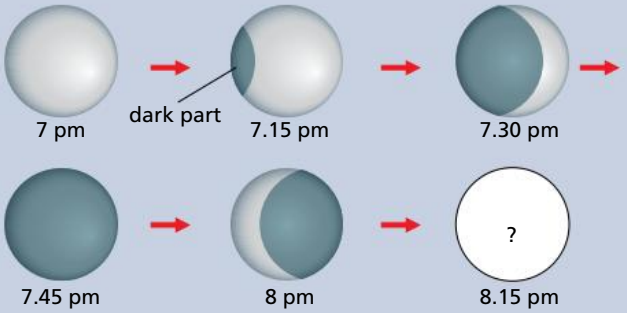
7 Which of the diagrams below show the positions of the sun, Earth and moon for
- **a** a full moon?
- **b** a quarter moon?
- **c** a solar eclipse?
- **d** a lunar eclipse?

You may need to use an alternative more than once.



8 Draw two possible arrangements of the sun, Earth and moon that could cause a spring tide.

9 The drawings show an eclipse of the moon, from 7 pm to 8 pm. Draw what you predict the moon will look like at 8.15 pm.



10 We never see the far side of the moon. Would a person on the far side of the moon ever see the Earth? Explain your answer.

11 Write down how life on Earth would be different in each of the following situations.
- **a** If the Earth did not rotate
- **b** If the Earth did not revolve around the sun
- **c** If the time taken for the Earth to complete one rotation was the same as for one revolution

Explain your answers in each case. There may be more than one effect for each cause.

Checkpoint answers

If your answer does not agree with the answer given here, go back to the chapter, and read that section again. Your answers may be slightly different from the answers given here. If you aren't sure about your answers, check with your teacher.

Chapter 1 Nature of science

1 **a** True **d** False **g** False
b True **e** False **h** True
c True **f** False

2 observe → question → experiment → collect information → record

3 what the chemical looks like
properties of the chemical, e.g. melting point and boiling point
how the chemical reacts
how the chemical should be stored
hazardous symbol and storage rating
first aid

4 **a** Results **c** Method **e** Conclusion
b Apparatus **d** Aim

5 Cuts from broken glass
Burns from hot equipment
Splashes from chemicals
Poisoning
Explosions
Electrocution

6 **A** hose **D** air hole
B barrel **E** base
C collar

7 Do not enter a science laboratory without a teacher.
Do not eat or drink in a laboratory.

8 Trisha was using a sooty yellow flame. She should open the air hole to give a blue flame.

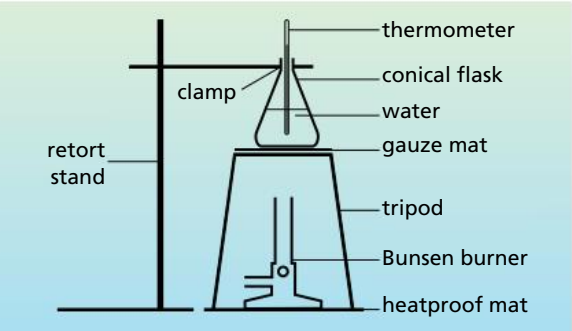
9 **b** Place the Bunsen burner on the bench with a heatproof mat underneath.
a Make sure the air hole is closed.
d Light the match and hold it close to the top of the Bunsen burner.
c Switch on the gas.

10 **a** Take to your local waste disposal centre.
b Put on the garden.
c Take to your local waste disposal centre.
d Wrap in newspaper and put in bin, or put in worm farm or compost heap.

11 Hold the test tube on its side in the flame, and move it from side to side, as shown on page 19 (top right).

12 **a** test-tube rack **d** mortar and pestle
b crucible **e** pipette
c spatula

13



Chapter 2 Kitchen chemistry

1 **a** chemical **d** chemical
b physical **e** chemical
c physical

2 **a** True
b False—Precipitation is where *water falls to Earth as rain*.
c False—Physical changes can be reversed.
d False—A *quantitative* observation requires measurement.
e True
f True
g True
h False—Photosynthesis is a *wanted* chemical reaction.
i True
j False—Predicting a future observation is called making a *prediction*.

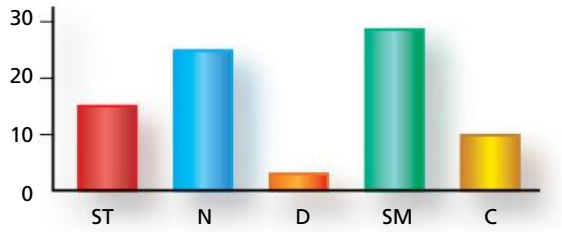
3 **a** 86°C **c** 25 mL
b 29°C **d** 68 mL

4 **a** Parallax error—not reading the meniscus at eye level.
b Using an old crinkly tape measure.

5 **A** liquid **C** condensation
B heat **D** solidification or freezing

6 In the water cycle, water evaporates from rivers, lakes or seas forming water vapour. As this water vapour moves high into the atmosphere it cools and condenses back to a liquid in clouds. It then falls back to Earth as rain (precipitation). See page 25.

7 **a** balance—grams
b tape measure—centimetres
c thermometer—degrees Celsius
d watch—seconds
e measuring cylinder—millilitres

8 

Chapter 3 Separating mixtures

1 **B**—Add water to dissolve the salt, filter to remove the sand, then evaporate the filtrate leaving the salt.

2 **a** filtration
b distillation
c centrifuge
d evaporation
e condensation
f decanting
g sedimentation
h chromatography
i flotation

3 **a** distillation
b Heating causes the water in the flask to boil. Water vapour travels along the glass tube and condenses to form pure water in the test tube. The salt that was dissolved in the water is left behind in the flask, so the water in the test tube is drinkable.
c The wet towel lowers the temperature inside the glass tube. This causes the water vapour in the tube to condense back to liquid water.

4 **a** **B**—since it is a solution
b **A**
c **A**
d **A**—since it is a suspension

5 A solution stays mixed but a suspension settles out on standing. Also, solutions are clear while suspensions are cloudy.

6 **a** Water—since it dissolves more of solid B than the other liquids do.
b Water—If you add water to the mixture of A and C, only A will dissolve. You can then separate them by filtration and evaporation.
c A mixture of A and B could be separated using acetone. Some of A would dissolve, and this could be recovered by evaporation. However, this is not a good method because A doesn't dissolve very well in acetone.

7 **a** B and D because the spots in the unknown mixture are the same distance up the paper as pure substances B and D.
b You can infer that C is the most soluble in alcohol, since it moves furthest up the paper.

Chapter 4 Biological classification

1 **a** True
b False—Roundworms are Nematoda.
c False—They are invertebrates.
d True
e True
f True

2 C

3 Colour is not used to classify organisms because organisms of the same colour can be very different in other ways. For example, a red spider is totally different from a red plant.

4 **a** classification
b spores
c vacuole
d amphibians

5 **a** Porifea have a body wall of two cell layers. Platyhelminthes have flat bodies. See page 75.
b Angiosperms reproduce by flowers and seeds. Gymnosperms reproduce by seeds in cones. See page 77.
c Ferns are vascular and mosses are non-vascular. See pages 77–78.
d Fungi are multicellular and have no chlorophyll. Monerans are unicellular and some have chlorophyll. See pages 81–83.

6 **a** **1** invertebrates
2 mammals
3 birds
4 fish
5 arthropods
b The key is not correct because single-celled microscopic organisms are now grouped in a separate kingdom called Protists.

7 The characteristics indicate that the plant is vascular. Being evergreen, with seeds and cones, indicates that it is a conifer.

8 **A** Echinoderms
B Flatworms (Platyhelminthes)
C Molluscs
D Cnidaria (Coelenterates)
E Segmented worms (Annelids)
F Arthropods

Chapter 5 Survival

1 adaptation: a feature or characteristic of an organism that helps it survive

producer: an organism at the beginning of a food chain or web that can make its own food

nocturnal: active at night

extinct: organisms already wiped out, with no individuals left anywhere on Earth

stomata: pores or holes in the surface of a leaf that control the movement of gases such as carbon dioxide into and out of the leaf

turgid: swelled up, filled out or swollen

2 **a** habitat

b adaptations

c natural selection, characteristics

d littoral zone

e biodiversity

3 **a** living on land: dehydration, lack of body support

b living in water: buoyancy, lack of oxygen, water movement

4 freeze: helps to avoid being seen, a behavioural adaptation (what the insect does)

spray a chemical on its predator: helps to fight off the predator, a functional adaptation (the chemical is produced by the body)

hiss and kick its legs: helps to scare of a predator, a behavioural adaptation

open its bright wings: helps to make the phasmid look bigger and scare off predators, a behavioural adaptation

5 cabbages → caterpillars → birds

6 **a** tortoises, fish and snails

b water beetles, frogs and water birds

c green algae

d The birds would eat frogs, fish and snails, and the numbers of these animals would decrease.

e The animals that eat green algae would not have enough food, and their numbers would decrease.

7 **a** Eucalypts need fire to clear the forest floor so that their seeds can grow. Without fires, the forest floor would become so dense with leaf litter that only beech trees would grow. The eucalypts would die out.

b If there were regular fires, the beech trees would die out, leaving the eucalypts.

Chapter 6 Forces

1 **a** A force is a *push* or a *pull*.

b Forces can act in different *directions*.

c There is movement when the forces are *unbalanced*.

d *Action* forces in one direction cause *reaction* forces in the opposite direction.

2 With contact forces the objects need to touch, e.g. pushing a trolley or pulling a trailer. With non-contact forces the object don't need to touch, e.g. two magnets attracting, the sun attracting the planets.

3 **a** True

b False—Thrust is the force that pushes a plane forwards. Friction with the air is called drag.

c False—Rolling friction is less than sliding friction.

d False—Oil, grease and streamlining decrease friction.

e True

f False—You need friction to stop the knot from slipping.

4 When you comb your hair there is a movement of electrons. The hair and the comb end up with opposite charges and therefore attract each other.

5 Put a sheet of plastic or paper over the magnet and sprinkle iron filings over it. The iron filings will form a pattern that shows the magnetic field around the magnet.

6 **a** gravity

b The Earth we live on is a large body and there will always be a gravitational force between it and objects on or near its surface.

c Sir Isaac Newton

d There is a gravitational force between any two bodies on Earth or in space. The greater the masses of the objects, the larger the attractive force between them.

7 **a** Friction is a contact force that opposes motion. For example, there is friction between your shoes and the ground.

b Static electricity is a build-up of electricity when objects are rubbed together. For example, a balloon rubbed on a woollen jumper will attract your hair.

c Magnetism is a force that magnets exert on magnetic materials and other magnets. For example, a magnet will pick up iron filings.

d Gravity is a force of attraction between two objects because of their mass. For example, an apple falls because it is attracted to the Earth.

8 **a** The forces are lift due to the rockets, and drag due to air resistance and gravity. The space shuttle lifts off the ground, so the upwards lift must be greater than the downwards gravity and drag.

b The two solid fuel rockets provide lift and the streamlined shape of the shuttle reduces the drag.

c Gravity and drag. Because the shuttle is falling towards Earth, the gravitational force on it is greater than the drag.

d As the shuttle lands it flies like a plane, so gravity, lift and drag all exist. Because the shuttle is landing, gravity is greater than the lift. And because there is no thrust, air resistance, the drag of the parachute and friction between the tyres and the ground bring the shuttle to a stop.

Chapter 7 Simple machines

1 **a** To make something work you need to apply a force called the effort. For example, a bicycle only works when you push down on the pedals.

b The load is anything a machine has to lift or move. For example, a wheelbarrow carries a load of dirt in its tray.

c A can opener is a machine because it reduces the amount of effort needed to open a tin.

d Machines can magnify the force you put in. For example, a small force at one end of a crowbar is magnified by the lever to give a large force at the other end.

e A pulley is an example of a machine changing the direction of a force. You pull down on the pulley and what needs to be lifted goes up.

f A large gear wheel connected with a smaller one is an example of how a machine can make things go faster. For example, the whisk of a egg-beater turns more quickly than the handle.

g Machines can transform energy. For example, a TV set transforms electrical energy into light, sound and heat.

2 pair of scissors—levers
stapler—lever
can-opener—wheel-and-axle and gear wheels
knife—lever and inclined plane (wedge)
ramp—inclined plane
door handle—wheel-and-axle
axe—lever and inclined plane (wedge)
wheelbarrow—lever
sail hoist—pulley

3 **A** Class 2, e.g. wheelbarrow, nutcracker

B Class 3, e.g. crane, forearm

C Class 1, e.g. crowbar, scissors

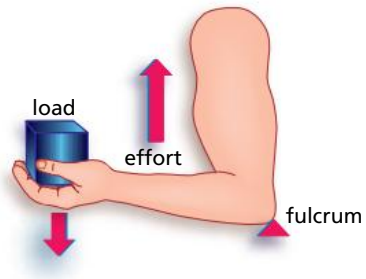
4 **P** 40:8 or 5:1, gearing up, 1 is the driving gear and 2 is the driven gear

Q 16:24 or 2:3, gearing down, 1 is the driving gear and 2 is the driven gear

R 16:8:16 or 2:1:2, no gearing, 1 is the driving gear and 3 is the driven gear

5 There are three levers—the handle bars, the brake handles and the pedals.

6 Class 3



7 Two or more pulleys gives a force advantage. The disadvantage, however, is that a lot of rope is needed to move the load a short distance.

8 A small gear wheel attached to the handle turns a large gear wheel that turns more slowly. The large gear wheel is part of a wheel-and-axle, which gives you a mechanical advantage and makes it easier to winch the boat.

Chapter 8 Sound

1 **a** vibrates

b pitch

c wavelength

d elasticity

e pinna

2 **a** slower

b faster

c faster

d faster

3 **a** A—compression, B—rarefaction, C—wavelength, D—amplitude

b longitudinal wave

c transverse wave

d low sound

e soft sound

f The air particles are squashed or pushed closer together.

g The air particles move apart or spread out.

4 **a** Frequency is the number of wave crests that pass a given point in one second, measured in hertz (Hz).

b The frequency tells you the pitch of the musical note.

c Dogs have greater hearing range than humans. They hear sounds of lower and higher frequencies. So they hear thunder before we do.

d Hold the full length of the ruler so that it overhangs the edge of the bench. Strike the ruler downwards. The vibrating ruler will produce a low sound. Shorten the ruler and hold it on the edge of a bench as before. Strike the ruler downwards. The vibrating ruler will produce a high sound.

5 **a** eardrum—vibrates when sound waves hit it

b hammer—transmits vibrations and amplifies sound

c cochlea—contains sensory cells

d auditory nerve—transmits impulses to brain

e Eustachian tube—tube to throat for equalising pressure

6 Saxon is likely to start running before the other students. Because light travels faster than sound, Saxon would see the smoke from the gun and start running before the other students heard the sound of the gun.

7 The pitch will be the same because they are both playing the same note. The quality will be different because instruments produce a mixture of frequencies rather than pure notes. The intensity is likely to vary with each instrument.

8 The inner ear contains the semicircular canals which detect up and down, and side to side movements of the body. Any head tilt causes information to be sent to the brain about the position of the head. The inner ear also tells your brain when you have stopped moving.

Chapter 9 Planet Earth

1 **A**—see page 181

2 **B**—see page 185

3 **a** True

b False—It is called magma.

c True

d False—Tsunamis may be caused by underwater volcanoes.

e True—see page 183

f False—see page 184

4 The water pressure would be greatest at 4 since pressure increases with depth.

5 During the day the soil in the ploughed field heated up more quickly than the grassland. As a result the air above the field was warmer than that above the grassland. This warmer air rose, and carried the balloon with it.

6 During the day heat from the sun warms up the Earth's surface. At night much of the heat escapes but the gases in the atmosphere trap some of it, thus keeping the Earth warm. This is the greenhouse effect and it doesn't happen on the moon because it has no atmosphere.

7 **a** The independent variable is the altitude, on the x-axis. The dependent variable is the temperature, on the y-axis.

b As you travel up through the troposphere the temperature decreases, as you can tell from the falling graph.

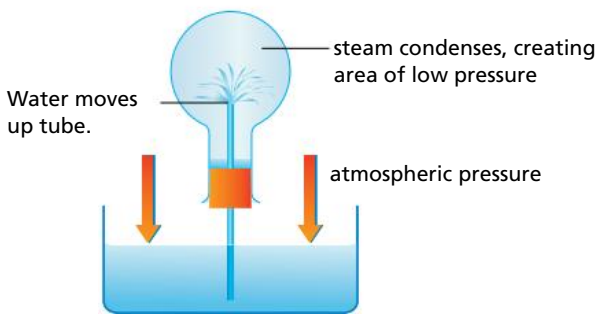
c The temperature increases in the stratosphere and the thermosphere, as you can tell by the rising graph.

d The lowest temperature reached is almost –90°C.

e The ozone at the top of the stratosphere absorbs ultraviolet radiation. This causes the temperature to increase.

8 When your lungs are full of air your volume is larger and you displace more water. As a result the upthrust of the water on you increases and you float more easily. When you breathe out your volume decreases. The upthrust also decreases and you tend to sink.

9 When you boil water in the flask the air in the flask is driven out and replaced by steam. When you turn the flask upside down in the trough of water the steam condenses to water, which takes up much less space than the steam. This creates a partial vacuum or low pressure area inside the flask. The normal pressure of the air pushes down on the surface of the water in the trough as shown. There are unbalanced forces and water is forced up the glass tube.



Chapter 10 Using our resources

1 **a** to make something from raw materials—manufacture

b a material that is useful to us—resource

c thick and slow flowing—viscous

d breaking down molecules in crude oil to simpler ones—cracking

e goods sent overseas to earn money—exports

f can burn or damage living things—caustic

g substances made up of carbon and hydrogen—hydrocarbons

2 **C** Usually materials cost less to recycle than to make from scratch.

3 **a** The raw materials used are oil and gas.

b Both natural and processed materials are shown in the diagram. Crude oil is a natural material. It is then processed into substances such as ethane, propane and butane.

c Yes, the materials shown are economically important to us. They are used in farms, homes, industries and as exports. They are also used to make other materials.

d LPG, ethane, propane, butane and crude oil will go through further processing.

4 **a** A natural resource comes from substances that exist in nature, e.g. timber from trees. A processed resource is made using a process or series of steps. For example, plastics are made from substances extracted from crude oil by using chemical reactions.

b A renewable resource can be readily replenished and replaced. A non-renewable resource is limited and will eventually run out.

c Black water is water from the toilet. Grey water is water from the shower, hand-basin, sink etc. that is grey in colour.

d An import is a commodity brought into a country from overseas to be used, processed or sold there. An export is a commodity that is sent overseas to be used, processed or sold.

e A raw material is the material used to start a process. A manufactured material is produced from raw materials by a process or series of actions.

5 salts: use cleaning products that do not contain salts or have lower levels of salts than those you are presently using

hair: use inserts for sinks that catch hair instead of allowing it to go down the drain

caustic substances: avoid cleaning products such as ammonia

6 The rainforests are home to millions of plants and animals. They provide food for the many people who live there. They are an untapped source of medicines and drugs that could cure diseases for which we have no cures at present.

7 As a soft foam-like plastic, polystyrene is an excellent insulator. So hot food or drink is usually served in polystyrene containers because the insulating properties of this plastic help keep the food or drink warm. It is also light to carry and it does not contaminate the food or drink in it.

Chapter 11 *Jurassic Park*

1 **A** is the best answer (see diagram on page 224). **C** and **D** are only partly correct.

2 **C**

3 **c** → **a** → **d** → **b**

4 **a** True

b True

c False—*Tyrannosaurus Rex* was a carnivore.

d False—rocks that contain the earliest fish fossils are older than rocks that contain the earliest mammal fossils (see geological time scale on page 234)

e False—only some rock layers studied so far by geologists have contained fossils

f True

5

Era	Time (mya)
Cainozoic	65–present
Mesozoic	245–65
Palaeozoic	570–245
Pre-Cambrian	4600–570

6 The most likely inference is that the carnivorous *Velociraptor* attacked the *Proceratops* and gripped it around the neck. The much larger *Proceratops* then struck the *Velociraptor* or fell on top of it, crushing its chest.

7 The sharp teeth of the carnivore (a) are adapted to tearing the flesh of its prey. The flat teeth of the herbivore (b) adapted to grinding plant material.

8 **a** The area where Dave's fossil was found must have been part of the ocean or an inland sea millions of years ago (see maps of Australia on page 235). When Dave died his skeleton was buried in sediment under water.

b Perhaps marine scavengers chewed off the head and carried it away before the skeleton was covered in sediment.

9 The main reason is that the Tertiary rocks are much younger than the Silurian rocks (see the geological time scale on page 234). During the Silurian Period there were a limited number of animal species and the first plants had just appeared on land. However, by the Tertiary Period most of the plant and animal groups we have today had evolved (amphibians, reptiles, birds, mammals and flowering plants).

10 Benefits from gene technology:

- genetically modified plants, such as Bt cotton and soya beans
- production of drugs such as insulin
- gene therapy to treat people with genetic diseases

11 In each of the *Jurassic Park* movies, the experiment to bring dinosaurs back to life goes badly wrong. In the first movie, Dr Malcolm makes the point that scientists tend to rush in and do things without thinking carefully about the ethical and social implications of what they are doing.

Chapter 12 Earth, moon and sun

1 **D**

2 **B**

3 **C**

4 **A** Gravity on the moon is only one-sixth of what is on Earth, but it is not zero.

5 **a** 24 hours

b 365¼ days

c 27⅓ days

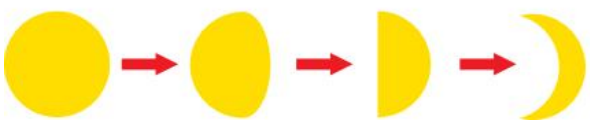
6 **a** **P**—full moon

Q—quarter moon (last quarter)

R—gibbous

S—crescent

b



See page 254.

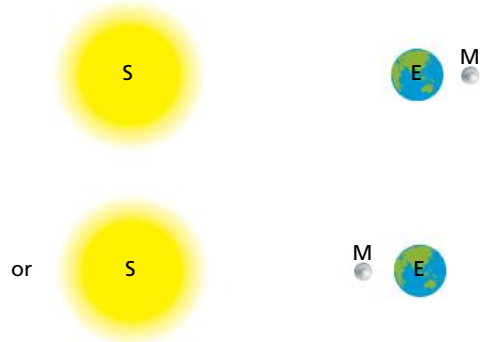
7 **a** **P**

b **Q**

c **S**

d **P** A lunar eclipse occurs at the same time as a full moon.

8 Spring tides occur when the sun, Earth and moon are lined up. This occurs in the full moon and new moon positions.



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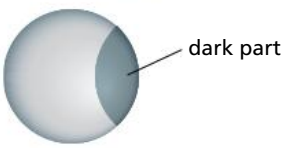

8.15 pm

10 We never see the far side of the moon from Earth. So a person on the far side of the moon would never see the Earth.

11 **a** If the Earth did not rotate there would be no day and night. The sun would not rise and set and the stars wouldn't move across the sky. There would still be tides but they would go in and out much more slowly.

b If the Earth did not revolve around the sun there would be no seasons. The stars would not change their positions in the sky over time.

c If the time taken for the Earth to complete one rotation was the same as for one revolution, one side of the Earth would always face the sun, just as one side of the moon always faces the Earth (page 255). The side of the Earth facing the sun would be extremely hot and the other side would be extremely cold.

Glossary

The words in this list occur in bold type throughout the book. The number after each entry gives the page where you will find more information. For some words the pronunciation is given. The syllable in capitals should be stressed; for example, tsunami (su-NAR-me).

abiotic factors (AY-by-OT-ik) physical or non-living factors which affect organisms, e.g. climate and weather 90
adaptations the characteristics that an organism has that help it survive in the place where it lives 89
adsorption a process used to remove unwanted chemicals by concentrating them on the surface of a solid; it is different from absorption 57
aim what you are trying to find out or why you are doing an experiment 12
alloy a substance made of two or more metals mixed together 204
amplitude the loudness of a sound, measured by the height of the wave 161
angiosperms a group of plants that have phloem and xylem tubes and reproduce by flowers and seeds 77
apparatus science equipment put together for an experiment 7
Archimedes' principle when an object is in water, the water exerts an upwards force that is equal to the weight of water displaced by the object 190
asexual reproduction producing offspring without the meeting of male and female sex cells, e.g. by budding, grafting or spores 70
atmosphere the layer of gas surrounding a planet 185
axis imaginary line through the centre of an object in space; the object rotates around this axis 250

biodegradable able to be broken down by organisms in soil or water 17
biodiversity the great variety of living things, both within a species and between different species 103
biological control using the natural enemy of a pest to control it 104
biotic factors the living factors that can affect an organism where it lives 90
buoyancy (upthrust) the upwards force on objects when they are in water 91

capillary action the process by which a liquid rises up a narrow tube 62
carnivore an animal that eats other animals 94
cast a type of fossil formed when sediment fills the imprint (mould) left by an organism 224
cell membrane the material that surrounds a living cell and allows substances into and out of the cell 73
cells smallest units or building blocks that make up all living things 70
cell wall the cellulose material that surrounds a plant cell 77
centrifuge a device for whirling suspensions so the particles settle to the bottom 50
change of state when matter changes form, e.g. when a liquid changes to a gas 25
chemical equation a statement that tells you the reactants and products in a chemical reaction 33
chemical reaction (chemical change) a change in which one or more new substances are formed; the change usually cannot be reversed 30
chromatography (CROW-ma-TOG-ra-fee) a method of separating substances that depends on the way each substance adsorbs to a particular surface 62
classification placing objects or living things into groups based on common characteristics or features 67
colloid (COL-oid) a mixture which has properties in between a solution and a suspension; the particles in the colloid may be tiny bits of solid, liquid droplets or gas bubbles 48
combustion when substances, especially fuels, burn in oxygen to produce heat and light 33
compression part of a longitudinal wave in which the air particles are pushed closer together 160
conclusion a statement describing the outcome of any investigation, test or experiment 12
conductor material that allows heat or electricity to move through it easily by conduction 37
conifers a group of plants that have phloem and xylem tubes and reproduce by seeds enclosed in cones; they are also called gymnosperms 77
contact force a force where there is touching or contact, e.g. friction is a contact force that occurs when two surfaces touch or rub against one another 114
control part of an experiment not allowed to change; results obtained in the experiment are compared with this control 32
core the innermost part of the Earth, made of a liquid outer part and a solid inner part 181
cracking breaking down hydrocarbons into smaller molecules with lower boiling points, using a catalyst 215
crust the relatively thin, solid outer layer of the Earth 181
crystallisation the formation of crystals as the solvent evaporates from a solution 55
cytoplasm (SIGH-toe-PLAZ-um) the jelly-like fluid found in a cell 73

data table table with rows and columns for recording information, e.g. in experiments 28

decanting gently pouring off a liquid, leaving the solid in the container 50
decibels (DESS-ee-bels) units used to measure the loudness of sound 169
dependent variable a variable that changes in response to changes in the independent variable; values for this variable are graphed on the y-axis 197
dialysis (die-AL-a-sis) the separation of smaller molecules from larger molecules; used to remove the wastes from blood 57
dicots (dicotyledons) plants which have two first leaves that form from the seed 78
dissolves when two or more substances mix completely, so that they appear as one; e.g. coffee dissolves in water 47
distillation a separation technique which involves evaporating a liquid, then condensing the vapour in a separate container 55
DNA deoxyribonucleic acid, a complex molecule which carries the genetic code for your body 239
driven gear a gear wheel that moves because another wheel forces it to 146
driving gear a gear wheel that turns and forces another wheel to turn 146

ectothermic cold-blooded, or having a body temperature the same as the environment; lizards and snakes are ectothermic 231
effort the force that is needed to move a load 134
emulsion (ee-MULL-shun) a colloid with tiny droplets of one liquid spread through a second liquid; milk is an emulsion 48
endangered organisms in danger of being wiped out, with very few individuals remaining in the wild 89
endothermic warm-blooded, or having a contant body temperature; humans are endothermic 231
energy the ability to make things happen or cause changes; light and sound are two of the many forms of energy 34
environment the term used to decribe all the factors, both living and non living, that affect an organism where it lives 90
enzymes (EN-zimes) substances that speed up the rate of a chemical reaction without taking part in the reaction themselves 34
epicentre the point on the Earth's surface directly above where the movement of rocks occurs in an earthquake 182
equilibrium (equal-LIB-ree-um) the condition of a system in which competing influences are balanced, resulting in no net change; for example equal and opposite forces, or gases in the atmosphere 187
era a major division or geological time—Cainozoic, Mesozoic, Palaeozoic and Pre-Cambrian 234
Eustachian tube (you-STAY-shun) a tube connecting the middle ear to the throat 173
extinct organisms already wiped out, with no individuals left anywhere on Earth 89
extrapolating (ex-STRAP-oh-late-ing) using a graph to predict a value beyond the range of a set of measurements 197

fault a crack in the Earth's crust along which rocks can move 182
fermentation the process by which substances break down and decay due to the action of various living organisms, e.g. yeast, bacteria and moulds 34
filtrate the liquid that passes through a filter 51
filtration a way of separating a solid from a liquid (or gas) using a filter 51
flocculation (FLOK-you-LAY-shun) the process in which the particles in a colloid clump together 53
food chain a diagram that shows a chain of organisms in which each organism is eaten by the next in the chain 93
food web interconnected food chains showing many feeding relationships among the organisms present 94
force a push or a pull; measured in newtons (N) 111
fossil fuels fuels obtained from material that was once living; e.g. oil, coal and natural gas 211
fossils the preserved remains or traces of past life on Earth, buried in rocks 224
frequency the number of wave crests that pass a given point in one second, measured in hertz (Hz) 161
friction a contact force that occurs when two surfaces touch or rub against one another 117
fulcrum the pivot point of a lever 138
fungi organisms, e.g. mushrooms and moulds which do not contain chlorophyll; they obtain their food from dead organisms 81

gear wheel a wheel with teeth or cogs on it 146
gene a unit of inheritance; a sequence of bases on a DNA molecule that codes for a particular characteristic 239
generalisation a statement based on many observations that is true in most cases 11
gene technology (genetic engineering) rearranging DNA to alter the genetic make-up of organisms 239
genus a level of classifying living things in which groups contain closely related organisms of more than one species 80
geological time scale a timeline of events in the history of the Earth, presented as a chart with the oldest events at the bottom and the present events at the top 234
global warming an increase in the global temperature of the Earth, thought to be due to the build-up of greenhouse gases in the atmosphere 196
glucose a simple sugar made by green plants; it is broken down in living things to release energy 34

gravity a force of attraction between any two bodies, e.g. the pull of two objects towards the centre of the Earth 120
greenhouse effect the trapping of heat energy by gases in the atmosphere, causing its temperature to rise; carbon dioxide is the main greenhouse gas 196
gymnosperms see *conifers* 77

habitat the place where an organism lives 89
herbivore an animal that eats plants 94
high an area of high air pressure on the Earth's surface, caused by dry, sinking air 194
humidity the amount of water vapour in the air 192
hydrocarbons compounds made of the elements hydrogen and carbon 215
hydrosphere the water on the surface of the Earth 260

inclined plane a simple machine consisting of a ramp; two inclined planes together form a wedge 150
independent variable a variable that is purposely changed in an experiment; values for this variable are graphed on the x-axis 197
inference a statement made to explain an observation; it may or may not be correct 38
inner ear the section of the ear made up of the cochlea and semicircular canals 173
insulator a material that does not allow the movement of heat or electricity through it 37
interpolating (in-TERP-oh-late-ing) using a graph to predict a value between two or more measurements 197
invertebrates animals that do not have a backbone 70
isobar a line on a weather map joining places of equal air pressure 194

key a diagram showing the grouping of objects or living things and the characteristics used to group them 70
kingdoms the main groups used in the classification of organisms 67

laboratory a place, room or building that contains the apparatus needed for scientific investigations, tests and experiments 3
lever a simple machine consisting of an arm or bar that moves around a pivot point of fulcrum 138
littoral zone the area where water meets the land; it can be a rocky shore, a mud-flat, a tidal area, a beach or the shore of a lake 91
load what is lifted or moved using a simple machine 134
longitudinal wave a wave in which the movement of particles within it is in the same direction as that in which the wave is moving, e.g. a sound wave 160
low an area of low air pressure on the Earth's surface, caused by moist, rising air 194
lunar eclipse the darkening of the moon by the shadow of the Earth when the Earth is between the sun and the moon 257

magma molten rock within the Earth 181
magnetic field the space in which the force of a magnet acts 126
mammary glands breasts or milk-producing parts of mammals 73
mantle thick layer of rock below the Earth's surface; it is partly solid and partly molten 181
Material Safety Data Sheet (MSDS) information on the properties of a particular chemical and risks in using it 9
mechanical advantage a measure of how useful a machine is, calculated by dividing the load by the effort 139
meniscus (men-IS-cus) the curved or crescent shape the surface of water makes in a glass container such as a measuring cylinder 26
method procedure or recipe to be followed to carry out an investigation 12
middle ear the section of the ear that lies between the outer and inner ear; it contains three tiny bones called the ossicles 173
mixture two or more pure substances mixed together but not chemically combined 47
model a way of representing something that cannot be observed directly because it is too small, too large or too complicated, e.g. a model of a molecule 129
Monera a kingdom of unicellular organisms, such as bacteria 81
monocots (monocotyledons) plants which have a single first leaf that forms from the seed 78
mould (fossil) an impression in rock left by a dead organism's body or its footprint 224

neap tides lower than normal tides when the moon and sun pull in different directions 259
nocturnal active at night 96
non-contact force a force where there is not contact, e.g. magnetism 114
non-renewable resources resources that cannot be replaced as they are used; for example, metal ores and oil 203
non-vascular plants plants (mosses and liverworts) that do not have phloem and xylem in their bodies, and have no true roots, stems or veins in their leaves 78
nucleus that part of a cell where activities are coordinated; it is the brain-centre of the cell 73

orbit the path followed by an object in space as it revolves around another object 250
outer ear the section of the ear made up of the pinna, auditory canal and eardrum 173
ozone layer a layer containing ozone gas found at the top of the stratosphere; it absorbs some of the dangerous UV radiation from the sun 195

palaeontologist (PAY-lee-un-TOL-a-gist) a person who investigates the history of life on Earth through the study of fossils 224
parallax error an incorrect measurement caused by not looking directly over the pointer or square on to a measuring instrument 28
period a minor division of geological time; several periods make up an era 234
petrification the process in which materials in the body of a dead organism are replaced by minerals from the surrounding rock 224
phases of the moon the different shapes of the sunlit face of the moon as seen from Earth 254
photosynthesis the process by which plants produce food using sunlight 34
physical change a change in which now new substance is formed, e.g. water → ice; the change can easily be reversed 25
pitch a property of sound related to frequency; it tells how high or low a sound is 161
poles the ends of a magnet where the magnetism is strongest; there is a north pole and a south pole 126
polymers compounds made from small units called monomers; poly means 'many' and mer means 'units', so polymer means 'many units' 215
predators organisms that hunt and kill other organisms for food 93
prediction a future prediction based on past observations and knowledge 38
pressure the force acting on a certain area of surface, e.g. air pressure and water pressure 185
prey an organism that is killed and eaten by other organisms 93
process a series of actions to produce some end or some product 203
producer an organism at the beginning of a food chain or web that can make its own food 94
products the new substances that are made when chemicals combine in a chemical reaction 33
properties the characteristics or features something has 24
protists large group of organisms (kingdom) that have a very simple structure; the group includes algae and unicellular organisms that live in water 81
pure substance matter in which all particles are identical 47

qualitative (KWAL-i-tat-ive) type of observation using words, without measurement 12
quantitative (KWONT-i-tat-ive) type of observation that involves measurement 12

rarefaction (rare-I-FAC-shun) the part of a longitudinal wave in which there are fewer particles, spaced further apart, in between areas of compression 160
raw material a resource used to make a product or the resource used to start a process 203
reactants the chemicals that combine in a chemical reaction 33
refraction the bending of sound waves from their original path that occurs when the waves move into or out of different materials; also occurs with light 167
renewable resources resources that can be replaced as they are used; for example, timber and solar energy 203
residue the material left behind in a filter 51
resource any material that can be of use to humans 203
respiration the process by which all living things produce energy 34
risk assessment assessing the possible dangers associated with performing any activity or experiment 12

science the study of the world around us and every living and non-living thing in it 2
sedimentation a separation process involving the settling of the heavier pieces in a suspension 47
seismograph (SIZE-mo-graph) an instrument which records earthquakes and measures their magnitude 182
sexual reproduction the meeting of male and female sex cells, e.g. egg and sperm, to produce offspring 70
simple machine a simple device that magnifies a force or charges its direction; a complex machine is two or more simple machines working together 135
solar eclipse occurs when the moon is between the Earth and the sun and the moon's shadow passes over part of the Earth 257
solution a mixture of two or more substances that looks as though it is all one substance, due to the solubility of one or more solutes in a solvent 47
solvent a substance that can dissolve other substances 47
species a single type of organism; members of the same species can breed amongst themselves to produce fertile offspring 80
spore an asexual form of reproduction, without the joining of sex cells 77
spring tides higher than normal tides when the moon and sun pull in a line; they occur around the full moon and the new moon 259

states of matter the different forms that matter or substances around us can take—solids, liquids or gases 25
static electricity the build-up of charges on an object 123
stomata (STOW-ma-ta) (singular stoma) pores or holes in the surface of a leaf that control the movement of gases such as carbon dioxide into and out of the leaf 100
suspension a mixture in which tiny bits of solid (or liquid) are evenly spread through a liquid (or gas), but are not dissolved; if allowed to stand, the suspended matter slowly settles out 47
sustainability the property of being sustainable; our use of a particular resource is sustainable only if we can continue using the resource for a very long time without using it up and without damaging the environment 202
synthetic materials materials that are not natural but made using chemical reactions 203
system something that has parts that work together as a whole; for example the digestive system, the solar system, an ecosystem, a bicycle system 134

technology the application of knowledge (science) to meet people's needs 142
timbre (TAM-brr) the way a note sounds that distinguishes it from others, also called quality 168
transverse wave a wave in which the movement of particles is at right angles to the direction of the wave; for example a water wave 159
tsunami (su-NAR-me) a huge wave caused by an earthquake near or under the ocean 182

unicellular made up of only one cell 81

variables factors that can alter or affect the outcome of an investigation 197
vascular plants plants (ferns, conifers and flowering plants) which have phloem and xylem in their bodies, and true roots, stems and veins in their leaves 77
vertebrates animals that have a backbone 70

water cycle the movement of water from lakes, rivers and streams through the atmosphere and back to Earth 25
wavelength the distance between two successive points on a wave, between one crest and the next, or one trough and the next; wavelength is measured in metres 161
weight the heaviness an object has because of the force of gravity acting on it 120
wheel-and-axle a simple machine consisting of a central axle with a wheel attached to it 150

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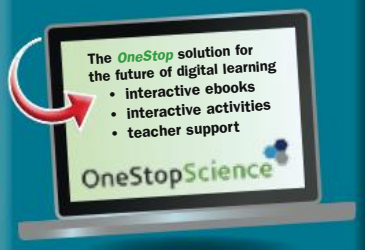

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