PEARSON science

NEW SOUTH WALES

S.B.

7

AUSTRALIAN CURRICULUM

It’s an exciting time to be in education.

We are embarking on a journey that unites two significant educational initiatives: the implementation of the NSW Syllabus for the Australian Curriculum and the ever-increasing use of technology in our students’ educational experience.

Pearson Australia is pleased to introduce their solution for the NSW Science Syllabus: **PEARSON science NEW SOUTH WALES**. It has been written from the ground up for the Australian Curriculum and developed specifically for the NSW Syllabus, and has been tested in focus groups and trialled in classrooms throughout Australia.

Whether you choose to use a printed book or a digital delivery medium, the **PEARSON science NEW SOUTH WALES** series can provide the content that you and your students need.

We hope you enjoy the journey you are about to take as much as we have enjoyed preparing for it. We look forward to working with you to implement the NSW Syllabus for the Australian Curriculum and to helping you manage your digital aspirations.

We would like to thank our authors for their extraordinary dedication and their contribution to the development of this project.

The reason for colour change in chameleons is not fully understood. Latest studies indicate that chameleons use colour change for communication. Other suggestions include camouflage and reacting to temperature changes.

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500

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Contents

Contents

4 Mixtures

5 Habitats and interactions

6 Classification

7 Forces

8 Earth in space

PEARSON science NEW SOUTH WALES

Student Book

Written from the ground up for the Australian Curriculum and developed specifically for the NSW Science Syllabus for the Australian Curriculum, the student book acts as a guide for both student and teacher.

- Developed specifically for the NSW Science Syllabus
- Utilises an inquiry approach throughout
- The content is presented in a range of contexts within the interrelated strands of Knowledge and Understanding and Working Scientifically.

Activity Book

The activity book is a write-in resource designed to enrich students' skills by providing a variety of activities and questions to reinforce learning outcomes.

- Supports and extends the student book
- Caters for a range of learning styles.

Teacher Companion

The teacher companion makes lesson preparation easy by combining full-colour textbook pages with teaching strategies, ideas for class activities and fully worked solutions.

- Ties the entire **Pearson Science New South Wales** package together
- Includes all answers to the student and activity book.

EAL/D Activity Book

The EAL/D activity book incorporates tailored language and vocabulary support for English as an Additional Language or Dialect (EAL/D) learners. With activities matching page-for-page, the EAL/D activity book can be used alongside the standard activity book.

AUSTRALIAN CURRICULUM

ALWAYS LEARNING

ALWAYS LEARNING

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How to use this book

PEARSON science NEW SOUTH WALES 7 Student Book

PEARSON science NEW SOUTH WALES 7 has been designed for Stage 4 of the NSW Science Syllabus for the Australian Curriculum. It includes content and activities that cover all learning outcomes within the interrelated strands of Knowledge and Understanding, and Working Scientifically. The content is presented through a range of contexts to engage students and assist them to make connections between science and their lives.

Additional syllabus content is clearly identified and carefully placed in the flow of core content. Learning Across the Curriculum content is addressed throughout the series and indicated using icons.

PEARSON science NEW SOUTH WALES 7 is designed for an inquiry approach to science learning. Its engaging design, unambiguous features and clear easy-to-understand language make this a valuable resource for students of all interests and abilities.

Chapter opening page

The chapter opener engages students through questions that get them thinking about the content and concepts to come.

The key ideas reflect the syllabus content relevant to the chapter.

science4fun

Inquiry-based activities using everyday materials assist students to understand key concepts under development.

These can be used as a focus or context for the unit.

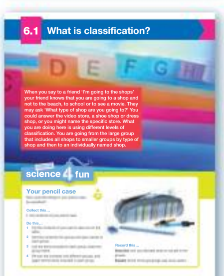
Icons indicate whether an activity is suitable to be done at home or requires teacher supervision.

Look who is using science

Careers pages spread throughout the book look at careers that involve and use science.

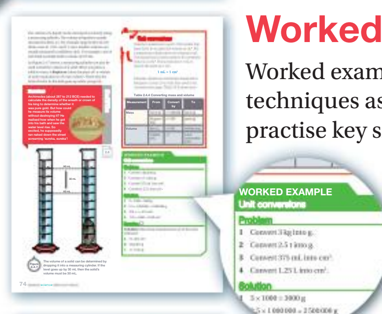
Skill builder

Key skills are outlined in clear steps to support science learning.



Unit opening

Each chapter is divided into self-contained units. The unit opener includes an introduction that places the material to come in a meaningful context.

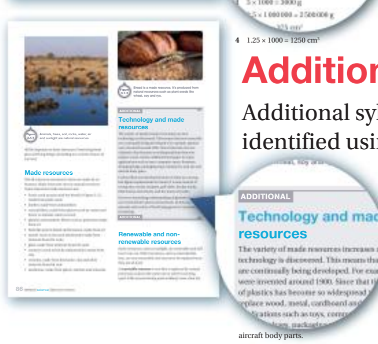


Worked example

Worked examples of problems and techniques assist students to master and practise key skills.

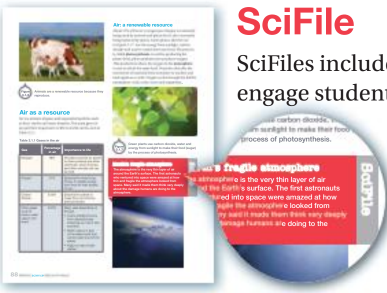
Photos and illustrations

Stunning and relevant photos and illustrations are clearly referenced from within the text to assist stu dents to understand the idea being developed.



Additional content

Additional syllabus content is clearly identified using shading and icons.

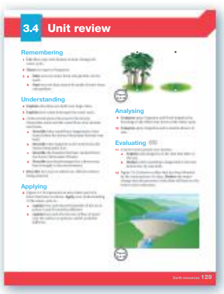


SciFile

SciFiles include quirky information to engage students.

Chapter review

Each chapter finishes with a set of questions and activities organised under the headings of Bloom's Taxonomy of Cognitive Processes.



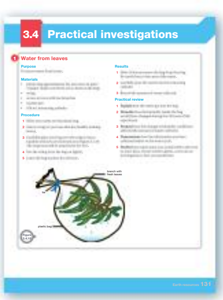
Unit review

Each unit finishes with a set of questions and activities organised under the headings of Bloom's Taxonomy of Cognitive Processes. To further students' understanding of the intent of a question and level of explanation expected, bolded verbs are used throughout. A list of all verbs and their meanings can be found on page xii.

The final heading is 'Inquiring'. These questions challenge students to use their inquiry skills to research additional syllabus content and to go beyond the unit content.

Thinking scientifically

Following the Chapter review are Thinking scientifically style questions relevant to that chapter. These test students' science and interpretive skills.



Practical investigations

Practical investigations are placed at the end of each unit. Practical investigation icons appear throughout the units to indicate suggested times for practical work.

A Student-design icon indicates that an activity includes student input and design.

Safety boxes highlight significant hazards.

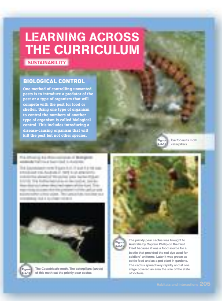
A safety glasses icon reminds students when appropriate to wear safety glasses.

Glossary

Every chapter concludes with an illustrated glossary that engages students and provides a ready reference for the key terms of the chapter.

Activity Book icon

This icon indicates a related Activity Book worksheet that enhances or extends this area.



Learning Across the Curriculum

Learning Across the Curriculum content is addressed throughout the Student Book using icons and in Learning Across the Curriculum spreads. A full list of Learning Across the Curriculum icons can be found on page xiii.

Go to icon

Go to icons are used to make important links to relevant content within the student book and to the next student book in a stage.

The PEARSON science NSW 7 package

Don't forget the other PEARSON science NEW SOUTH WALES 7 package components that will help engage and excite students in science:

- Activity Book
- EAL/D Activity Book
- eBook 3.0
- Teacher Companion
- Pearson Assess New South Wales

Verbs

The verbs below, based on Bloom's Taxonomy, appear in **bold** text throughout this book. The verbs help students know the level of response required for a question. The verbs in black are consistent with the key verbs used in NSW syllabuses and examinations. The verbs shown in blue in this list may also feature throughout the book and are provided for additional support to teachers and students.

Remembering	
enter	Place data into a computer program by key strokes or copying from a digital source, e.g. CD, DVD, USB storage device
label	Add annotations to a diagram or drawing
list	Write down phrases or items only without further explanation
name	Present remembered ideas, facts or experiences
present	Provide information for consideration
recall	Present remembered ideas, facts or experiences
record	Store information and observations for later
specify	State in detail
state	Provide information without further explanation
Understanding	
account	Account for—state reasons for, report on. Give an account of—narrate a series of events or transactions
calculate	Ascertain/determine from given facts, figures or information (simply repeating calculations that are set out in the text)
clarify	Make clear or plain
construct	Prepare or devise something, such as a key or diagram
define	State meaning and identify essential qualities
describe	Provide characteristics and features
determine	Find out the size or extent, either by using an equation, counting, estimating, or similar method
discuss	Identify issues and provide points for and/or against
draw	Use a pencil to produce a likeness onto a page, or sketch to provide a representation or view
explain	Provide a sequence to make the relationships between things evident; provide why and/or how
extract	Choose relevant and/or appropriate details
gather	Collect items from different sources
modify	Change in form or amount in some way
outline	Sketch in general terms; indicate the main features
predict	Suggest what may happen based on available information
produce	Provide
propose	Put forward for consideration or action
rank	Place in order of size, age, or as instructed
recount	Retell a series of events
summarise	Express, concisely, the relevant details
write	Compose or construct a sentence that explains a feature
Applying	
apply	Use, utilise, employ in a particular situation
calculate	Ascertain/determine from given facts, figures or information
demonstrate	Show by example
examine	Inquire into
identify	Recognise and name
use	Employ for some purpose
Analysing	
analyse	Identify components and the relationship between them; draw out and relate implications
calculate	Ascertain/determine from given facts, figures or information (requiring more manipulation than simply applying the maths)
classify	Arrange or include in classes/categories
compare	Show how things are similar or different
contrast	Show how things are different or opposite
critically (analyse/evaluate)	Add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to (analyse/evaluate)
discuss	Identify issues and provide points for and/or against

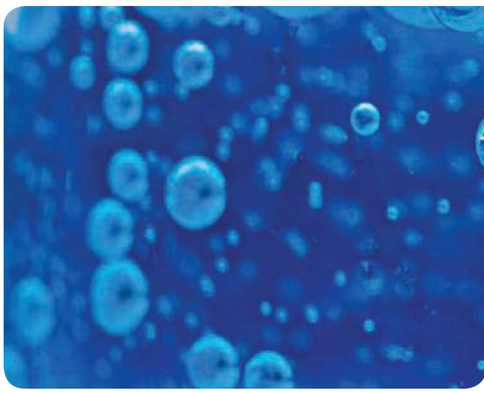
distinguish	Recognise or note/indicate as being distinct or different from; to note differences between
infer	Recognise and explain patterns and meaning and relationships
interpret	Draw meaning from
research	Investigate through literature or practical investigation
Evaluating	
appreciate	Make a judgement about the value of
assess	Make a judgement of value, quality, outcomes, results or size
conclude	Come to a judgement or result based on the reasoning or arguments that you present
critically (analyse/ evaluate)	Add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to (analyse/ evaluate)
deduce	Draw conclusions
evaluate	Make a judgement based on criteria; determine the value of
extrapolate	Infer from what is known
justify	Support using an argument or conclusion
propose	Put forward (for example a point of view, idea, argument, suggestion) for consideration or action
recommend	Provide reasons in favour
select	Choose one or more items, features, objects
Creating	
construct	Make; build; put together items or arguments
design	Provide steps for an experiment or procedure
investigate	Plan, inquire into and draw conclusions about
synthesise	Put together various elements to make a whole

Learning Across the Curriculum

NSW Syllabus Learning Across the Curriculum content is addressed throughout the series and is identified using the following icons.

Learning Across the Curriculum icons	
AHC	Aboriginal and Torres Strait Islander histories and cultures
A	Asia and Australia's engagement with Asia
CC	Civics and citizenship
CCT	Critical and creative thinking
DD	Difference and diversity
EU	Ethical understanding
ICT	Information and communication technology capability
IU	Intercultural understanding
L	Literacy
N	Numeracy
PSC	Personal and social capability
S	Sustainability
WE	Work and enterprise

Look who is using science



SCIENCE TEACHER

My name is Sarah Peng and I am a science teacher at a state secondary school.

Like many scientists, I have always been curious about how the things around me work. It was natural, then, that I moved into the sciences. At university I specialised in biology and chemistry, and I soon discovered that the best way to share my passion and enthusiasm was to become a science teacher. So, here I am today!

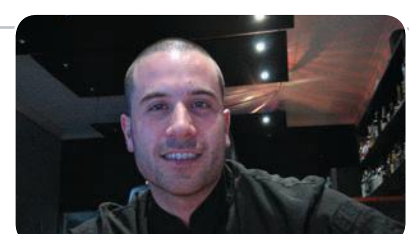
In my role as a teacher I help my students develop a better understanding of the world around them, and show them the skills that enable them to investigate it safely and explore it scientifically. Teaching always brings its challenges and rewards, but overall I really enjoy seeing my students get excited about science and become confident in their skills and their understanding of the subject.

PERSONAL TRAINER

My name is Rebecca O'Sullivan and I'm a gym instructor at one of the gyms run by the YMCA.

In health consultations and re-assessments, I take measurements to determine a person's fitness. I take their blood pressure and heart rate to see the health of their cardiovascular system and measure their height and weight to determine if a member is at an ideal weight for their height. I also measure the thickness of their arms, chest, waist, hips and thighs so that I can compare their size at the next re-assessment. The member is also taken through an aerobic fitness test to determine the volume of oxygen pumped to the muscles during exercise. All these measurements then allow me to write up a suitable exercise program for the member. In my own way, I am a scientist who tests the fitness of people. My laboratory is the health consultation room.

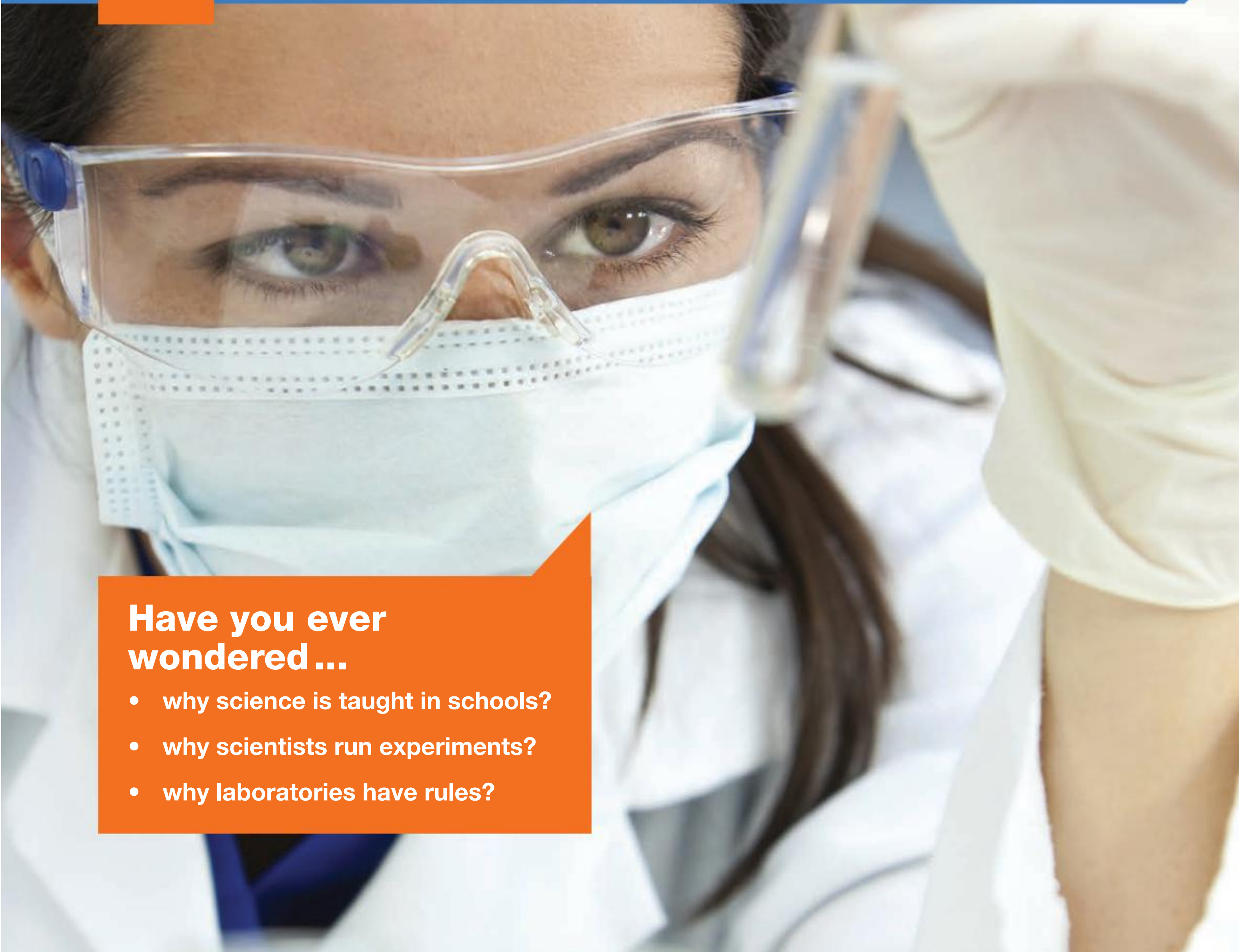
CHEF



My name is Joe Spataro and I'm the head chef and owner of a restaurant.

As a chef I invent new dishes, but as head chef I'm also responsible for the efficient running of the kitchen. This includes looking after the safety of everyone who works in the kitchen. Like laboratories, kitchens can be extremely dangerous. We work with knives, hot stoves and ovens, and pots of boiling water and oils that can scald or burn. I also need to ensure that the kitchen is kept clean and tidy and that foodstuffs are stored at the right temperatures and away from cleaning chemicals. In this way, a kitchen is like a laboratory. It is where I experiment but it also has risks.

1 Working scientifically



Have you ever wondered…

- why science is taught in schools?
- why scientists run experiments?
- why laboratories have rules?

After completing this chapter students should be able to:

- identify suitable equipment, including safety equipment and digital technologies for an investigation ICT
- record information and findings accurately and honestly EU
- record observations and measurements using appropriate units L
- describe safety guidelines for an investigation EU PSC
- construct and use graphs, keys, models, diagrams, tables and spreadsheets N L
- design investigations including experiments and research
- identify variables to be controlled, measured and changed
- evaluate different strategies for solving problems EU CCT
- identify improvements to a method CCT WE
- summarise information from different sources CCT N L
- draw conclusions and produce inferences CCT

ADDITIONAL

- investigate how science has developed through teamwork across different branches, such as in space exploration and resource management. CCT L

1.1 A subject called science

Scientists study the world around them to find out how it works. They investigate the living world of animals, plants, bugs and micro-organisms, and they investigate the planet and environments they live on and in. They investigate the physical world of substances like plastics and metals, and chemicals like water and acids. They investigate forms of energy such as heat, light and sound. They even study things that are out of this world, like other planets, stars and galaxies.

INQUIRY science 4 fun

Cool sounds

YES

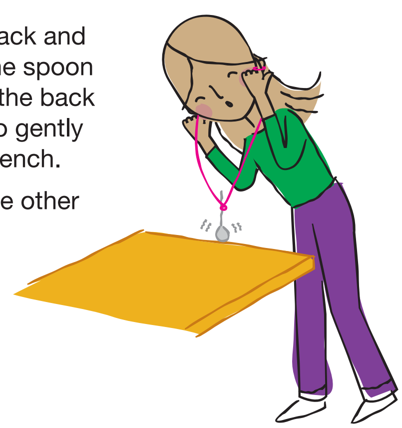
Can you hear down a string?

Collect this …

- length of string (about 75 cm)
- metal spoons (teaspoon, dessertspoon, soupspoon, tablespoon)

Do this …

1 Loop the string around the handle of one of the spoons so that the spoon is about halfway down the string.
2 Hang the spoon by the string and place each end of the string against your ears like a doctor's stethoscope.
3 Gently sway back and forth so that the spoon swings. Allow the back of the spoon to gently hit a table or bench.
4 Repeat with the other spoons.



Record this …

Describe what happened.

Explain how this activity can be considered to be science.

Science is important

The world is very complex and is becoming more complex every day. New technology is constantly developing and new issues are constantly hitting the headlines. For example, HD televisions, Blu-ray, smart phones and tablet computers were not common ten years ago. Laptop computers, mobile phones, email and the internet are only a little older. Likewise the issues of climate change were not heard of until relatively recently.

Developments in science have also caused argument and debate. Cloning, the use of stem cells to repair damage in the body, and genetically modified food have all developed from scientific discovery. Society has split into those who support the use of these new discoveries and those who don't. Climate change, and what we as humans should do to control it, has also split society into those who believe that it is happening and those who don't. There is even debate among those who do believe it is happening: some believe that it is caused by human activity, while others believe it could be part of a natural cycle. Whatever its cause, glaciers like the one in Figure 1.1.1 are melting at a higher-than-normal rate. Older issues, such as whether nuclear power should be used in Australia, are being debated again because of our increasing energy needs. As a future adult and voter you will need an understanding of science to help you decide what we should do about these issues and any new issues that arise. To make good decisions about our future, you will need an understanding of science.

Figure 1.1.1 Climate change: do we believe the evidence that temperatures are rising because of human activity or do we reject it based on other evidence?

The branches of science

The subject of science covers many different areas, ranging from acids to aardvarks, electricity to emus, rats to rocks, Venus to viruses, and much, much more. Science covers so many different areas that it must be split into different **branches** or **disciplines**, some of which are shown in Figure 1.1.2. Scientists tend to work in one particular branch of science. This allows them to explore it in detail and develop a deep understanding of it without being distracted by what is going on in the other branches.

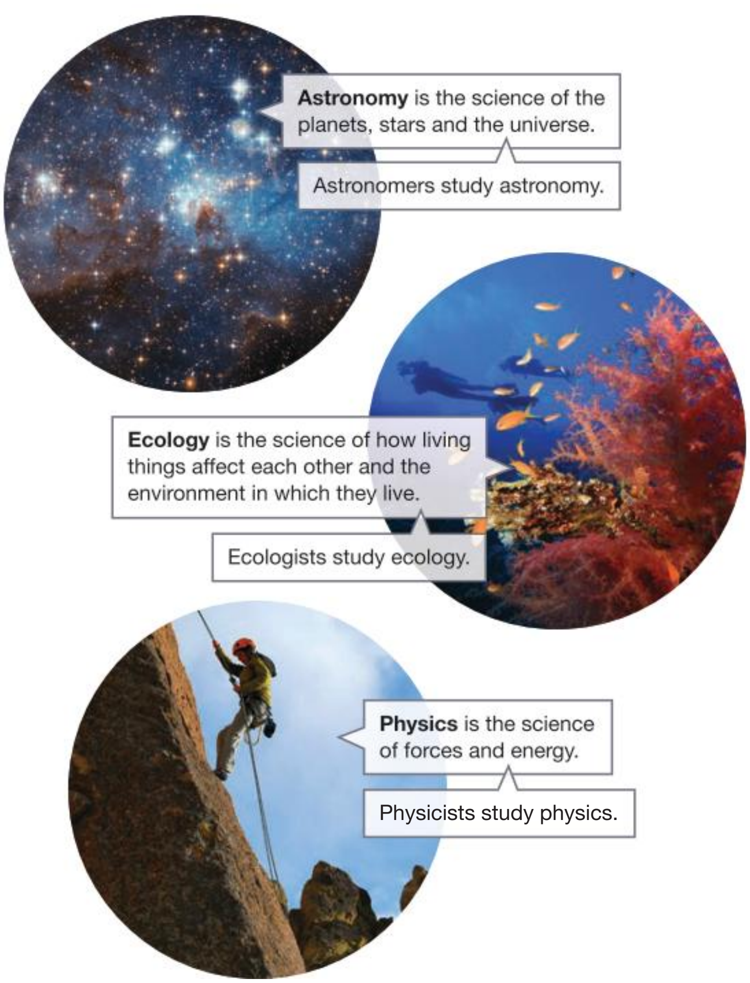


Figure 1.1.2 The main branches of science

Sub-branches of science

The branches of science are so broad that they are split into smaller sub-branches. For example, geology covers so much material that a geologist would find it impossible to study it all. Instead geologists tend to specialise by working in a sub-branch like petrology (the study of rocks), palaeontology (fossils), vulcanology (volcanoes) or seismology (earthquakes).

Likewise, there are so many types of living things that biologists specialise in the study of only one type of living thing, such as animals (zoologists study zoology), plants (botanists study botany) or germs (microbiologists study microbiology). Even sub-branches are sometimes too big. For example, zoology covers so many different types of animals that it is split into smaller sub-branches such as insects (entomologists study entomology), spiders (arachnologists study arachnology) and fish (ichthyologists study ichthyology), as shown in Figure 1.1.3.

SciFile

The many branches of science

There are lots of other very specific sub-branches of science. Some are teuthology (the study of octopuses), mycology (the study of fungi), chiropterology (the study of bats), carpology (the study of fruits and seeds) and oology (the study of eggs).

Teamwork

Science requires teamwork. In the laboratory, you will frequently work as part of a team, particularly when doing experiments or research. Everyone is good at something and not as good at something else. Working in a team allows you to pool everyone's talents. Scientists usually work in teams too. As Figure 1.1.4 shows, some teams have only a few members.

Figure 1.1.4 Everyone is good at something and not as good at something else. By working as part of a team, scientists can share their skills.

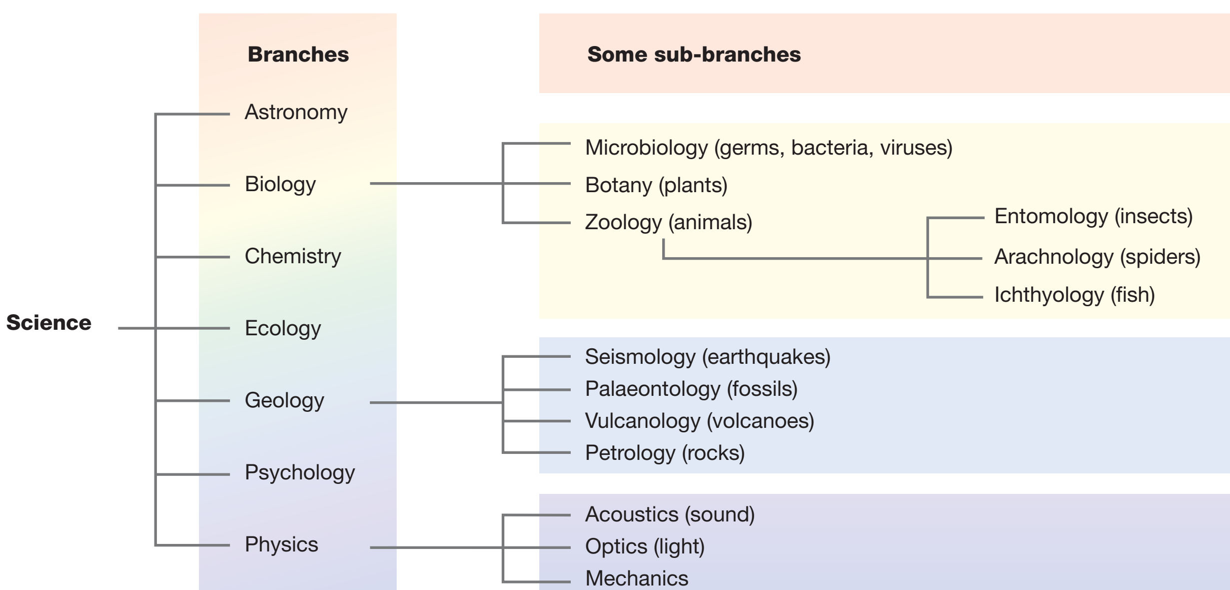


Figure 1.1.3 The branches of science are split into smaller sub-branches. Some of these are then split into even smaller sub-branches.

Prac 1 p. 8
Prac 2 p. 9

Some common tasks

All scientists carry out the same basic tasks regardless of what team they are part of or which branch or sub-branch of science they investigate. All scientists:

- make observations and measurements
- make inferences and predictions about what is happening and what might happen in the future
- analyse their measurements, construct tables and keys, plot graphs, make calculations and look for patterns
- make models to help them understand what is happening
- classify objects into groups of similar things.

GO TO Unit 6.1

ADDITIONAL

Teamwork across different branches

To solve bigger problems, bigger teams with a range of skills from different branches and sub-branches of science are required. For example, there are fewer than 500 mountain pygmy-possums (*Burramys parvus*) left in NSW. The species is classified as endangered and scientists are working to prevent it from becoming extinct. The possum lives in the mountains of the Kosciuszko National Park. In summer and autumn it eats Bogong moths, beetles, millipedes and spiders, and sometimes the seeds of plants. In winter, it hibernates, sleeping under a cover of snow that insulates it from the freezing cold. You can see it in Figure 1.1.5.

To protect the possum, scientists need to find out why their numbers are falling. This research needs a variety of different skills that only come from being part of a team made up of scientists working in different branches of science (Figure 1.1.6).

Figure 1.1.5 The mountain pygmy-possum is endangered in NSW. Scientists are working to make sure it doesn't become extinct.

Figure 1.1.6 Big problems require teamwork across different branches of science

ADDITIONAL

LEARNING ACROSS THE CURRICULUM

CIVICS AND CITIZENSHIP

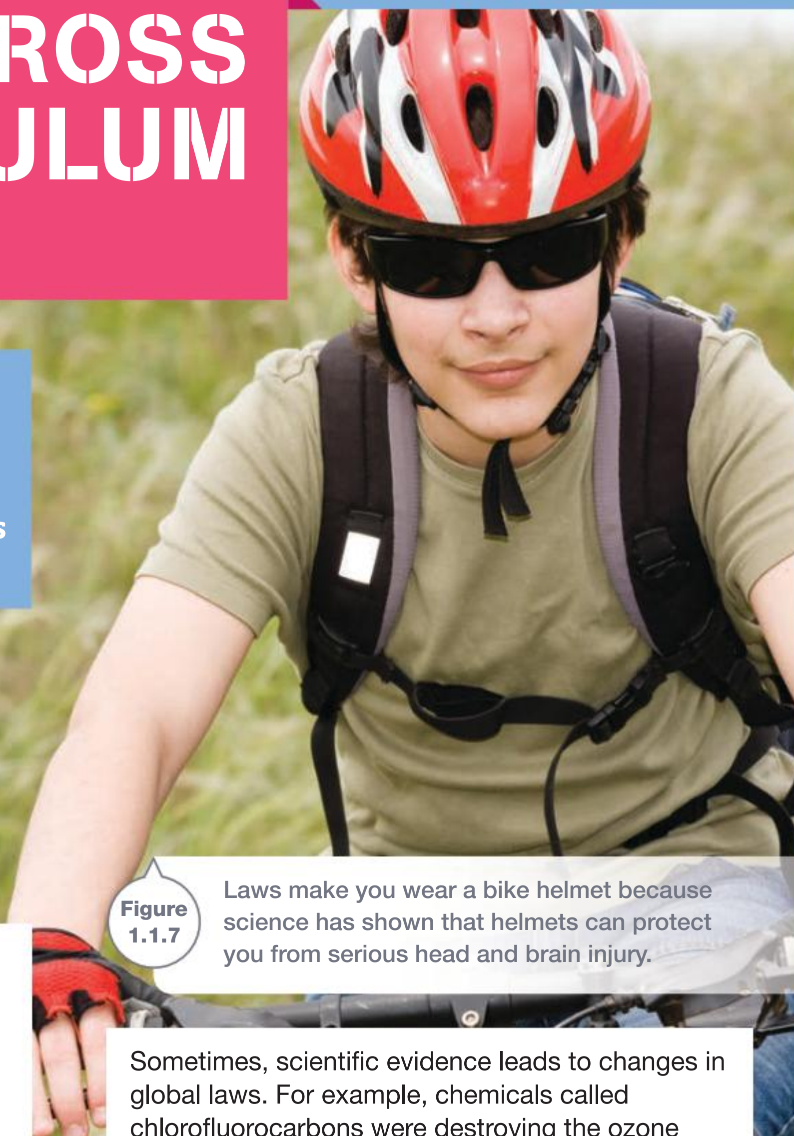


Figure 1.1.7 Laws make you wear a bike helmet because science has shown that helmets can protect you from serious head and brain injury.

SCIENCE AND THE LAW

The observations that scientists gather and the conclusions they make form the basis of many of the laws and regulations that we all must follow every day.

For example, scientific evidence on car and bike crashes has led to speed limits, and laws that make us wear seat belts in cars and helmets when riding a bike or motorbike (Figure 1.1.7). In a similar way, scientific evidence on bushfires has led to laws determining days of total fire ban and the types of houses that are built in areas of high bushfire risk.

Scientific evidence has also been used to form laws and regulations that:

- make car manufacturers include airbags, crumple zones and crash-resistant fuel tanks
- control the type of houses built in areas at risk of floods or cyclones
- determine which drugs should be illegal, which should be available on prescription and which can be bought at the supermarket
- control the additives that can be put in food
- control how long food can be sold for ('use by' and 'best before' dates)
- determine unsafe levels of sound, chemicals and dust for workers
- control the type and amount of pollutants that can be released into rivers, soil and the atmosphere
- preserve animals, plants and landscapes at risk of being lost forever.

Sometimes, scientific evidence leads to changes in global laws. For example, chemicals called chlorofluorocarbons were destroying the ozone layer, putting us all at greater risk of skin cancer. Governments across the world have since banned the use of chlorofluorocarbons in everyday products like deodorants and hair sprays and in fridges. Similar laws will be required to limit the release of carbon dioxide to minimise global climate change.

REVIEW

1 **Name** the chemicals banned across the world that were destroying the ozone layer.

2 Since 1971, wearing seatbelts in cars has been compulsory by law in NSW. **List** the sort of scientific evidence that led to this law.

3 Different drugs are treated differently by the law. **Propose** a reason why.

4 **Propose** a reason why laws now determine the type of houses that are allowed to be built in areas at risk of cyclones or bushfires.

1.1

1.1 Unit review

Remembering

1 **Name**:
   a devices that have only been around in the last ten years
   b a scientific issue that has arisen in the last ten years.

2 **List** seven important branches of science.

3 **List** four sub-branches for each of:
   a biology
   b geology
   c physics.

Understanding

4 **Explain** why everyone needs to have an understanding of science.

5 A biologist usually specialises in one sub-branch of biology. **Explain** why.

Applying

6 **Identify** the branch (or branches) of science being investigated in the science4fun on page 2.

7 **Identify** the branches of science that are being studied below.
   a Amanda is measuring the amount of pollution in a lake.
   b Sarah is making a video of a volcano erupting.
   c Brian is studying the movement of the planets.
   d Yang is measuring the speed of sound.
   e Joe is testing what an acid does to metal.

8 For each of the following investigations, **identify** the branch and sub-branch that is being studied.
   a Abdul is counting how many eggs a cockroach has laid.
   b Hon is studying the crystals embedded in a rock.
   c Travis is investigating how light bends as it passes through glass.
   d Lisa is photographing the bones of a dinosaur.
   e Francesca is measuring the growth of a seedling.

Analysing

9 **Compare** the similarities and differences between the types of work done by a detective and a scientist.

10 Refer to the contents pages (pages v–vi) and **classify** each of the chapters as biology, chemistry, physics, geology or astronomy (space).

Evaluating CCT

11 Some branches of science cover two or more other branches. **Propose** what two branches of science are studied in biochemistry.

Inquiring

1 Find more information about the mountain pygmy-possum. Find details such as how and where it lives, its food, breeding cycle, average life expectancy and predators.

Present your findings as a poster that shows how its survival is being affected by changes to its environment.

ADDITIONAL

2 Space exploration and resource management are two areas in which new discoveries have been made only through teams of scientists working together from different branches of science.
   a Investigate the website of the Department of Natural Resources of NSW to:
      - state what resource management is
      - list different types of resource management
      - list the branches of science that might be involved.
   b Investigate the NASA website to find the branches of science that might be involved in space exploration.

Present your findings as a series of dot points. CCT L

ADDITIONAL

1.1 Practical investigations

1 Potato sprouts

Purpose

To determine if plants respond to light.

Materials

- old potato (with sprouts)
- handful of potting mix

- 1 cardboard box (such as a shoe box or cereal box) or cardboard to make one
- 2 pieces of cardboard
- sticky-tape
- scissors

Method

1. Adapt your cardboard box so that it has a lid like a shoebox. This may require taping up its original lid and cutting out a new one.
2. Puncture a small hole in one end of the box and expand it until it is 1 to 2 cm in diameter.
3. Cut three or four small cardboard 'walls'. Tape them into your box so that light cannot get to the potato directly, as shown in Figure 1.1.8.
4. Make a 'bed' of potting mix at the other end of the box and nestle your potato in it. Point one of the potato sprouts towards the hole.
5. In your workbook, construct a diagram showing the arrangement of the potato, 'walls' and light-hole.
6. Put the lid back on the box and make sure no light can get in around it. If you think light can enter, tape another piece of cardboard on top. Do not tape over the light-hole.
7. Put the box in a sunny place where it won't be touched. Point the light-hole towards the Sun.
8. In every science class over the next month, carefully open the lid. Adapt your original diagram by using a different coloured pen, pencil or highlighter to show what has happened.

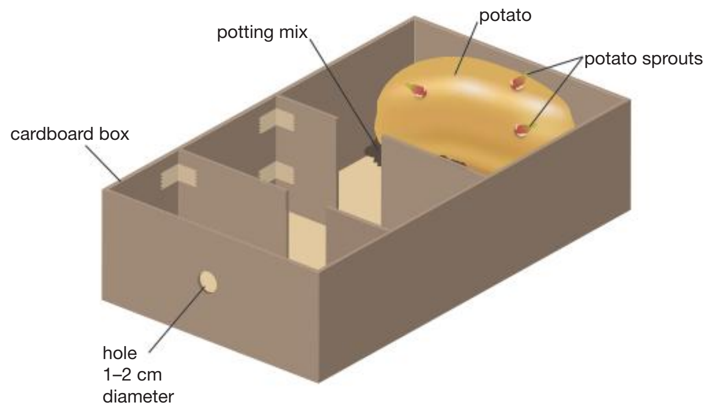


Figure 1.1.8

Results

Construct a diagram of the box, potato and objects and use different coloured pens, pencils or highlighters to show how the potato changes over the month.

Practical review

1. a **Identify** which branch of science this experiment belongs to.
   b **Justify** your choice.
2. **Identify** which statement below best summarises what you learned from this experiment.
   a Potatoes need potting mix to survive.
   b Potatoes are what chips are made from.
   c Potatoes are plants.
   d Potatoes have shoots that grow towards the light.

2 Blowing up balloons

In the laboratory, you will need to follow safety instructions and instructions on how to run experiments.

Purpose

To follow instructions to blow up a balloon.

Materials

- up to 500 mL water

- 1.25 L soft drink bottle and cap
- balloon
- drawing pin

Procedure

1. Dangle the balloon inside the soft drink bottle. Secure it by stretching its mouth over the mouth of the bottle as shown in Figure 1.1.9.
2. Try to blow the balloon up. Record what happens.
3. Use the drawing pin to make a hole in the wall of the bottle near its base.
4. Try to blow up the balloon again. While keeping your mouth on the bottle, cover the pinhole with your finger. Record what you see.
5. Remove your finger. Record what you see.
6. Blow up the balloon again and cover the pinhole with a finger.
7. Pour water into the blown-up balloon. Remove your finger and record what you see.

Results

Record all your observations in your workbook.

Practical review

1. **Assess** how well you followed the instructions for this prac.
2. **Propose** a reason why:
   a. it was almost impossible to blow up the balloon without the pinhole.
   b. the pinhole allowed the balloon to inflate.
   c. a blocked pinhole kept the balloon inflated.
   d. water rushed out of the balloon when your finger was removed from the pinhole.

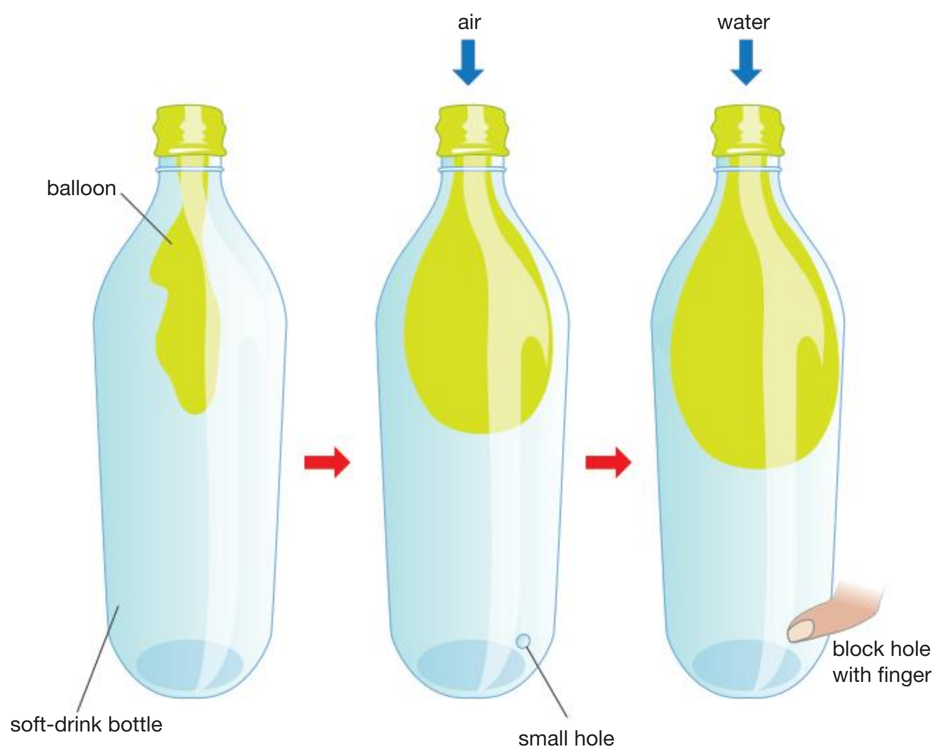


Figure 1.1.9

1.2 The laboratory

The laboratory is where scientists carry out experiments and make observations and measurements. The type of laboratory used by different scientists depends on what they are studying. For many, the laboratory is outdoors. For others, it is a room specially fitted for their experiments. Whatever laboratory and whatever branch of science they work in, scientists use equipment and follow strict rules regarding safety. As a beginner scientist, so will you.

Different laboratories for different scientists

A scientist works in a **laboratory**. Laboratories are where scientists run most of their experiments and make most of their observations, measurements and discoveries. Your idea of a laboratory is probably a large room equipped with Bunsen burners, sinks, glassware, balances and chemicals and occupied by people in white coats and safety glasses. This is the type of laboratory that chemists tend to work in and the type of laboratory that you will eventually work in at school. It might look something like Figure 1.2.1.

Figure 1.2.1 To most of us, the laboratory is a place full of Bunsen burners, glassware and people in white coats.

Different scientists have very different ideas about what a laboratory is. For marine biologists, the laboratory could be a coral reef. The laboratory of a zoologist might be a rainforest, and a laptop computer and video camera could be their most important equipment. The laboratory of an astronomer will be wherever their telescope is mounted. Figure 1.2.2 shows a palaeontologist at work in his laboratory. Scientists like him will usually have another laboratory in which they can test the samples they collected outdoors. For example, an ecologist might collect samples of polluted water from a creek but then analyse them back in their other laboratory.

Figure 1.2.2 For palaeontologists, the laboratory could be the site at which a dinosaur skeleton has been found. Their equipment is likely to be a spade and brushes to clear the soil away from around the bones. Sturdy boots, overalls and perhaps a hat will be far more important to them than white coats.

Equipment

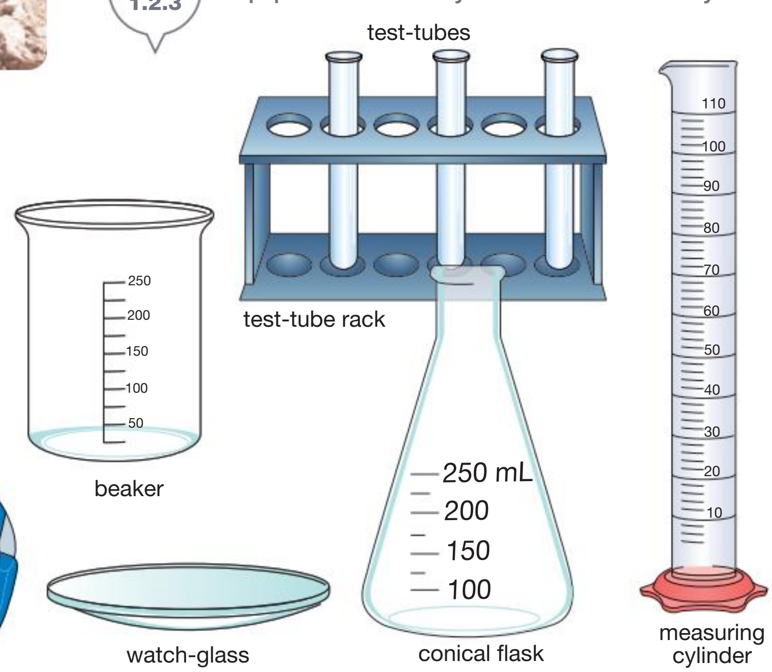
Tools and equipment are a necessary part of most jobs. A builder uses power drills and saws, nail guns and measuring tapes, while a chef uses ovens, pots and pans, sieves and measuring spoons. Scientists use equipment too, to help them carry out experiments and to help them describe what they observe more accurately. Each branch of science uses its own specific tools and equipment. An astronomer will not see much without a telescope, and a microbiologist needs a microscope to see bacteria that are invisible to the naked eye. Physicists need ammeters and voltmeters to measure electrical current, and ecologists need pH meters to determine how acidic creek water is. However, there is a set of equipment common to most laboratories, including the ones at school.

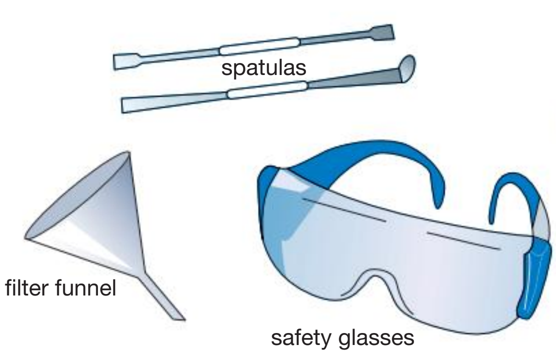
Glassware

Glassware such as beakers, conical flasks, test-tubes and watch-glasses allows you to mix and heat chemicals. Most glassware in the laboratory is made of Pyrex, a special type of glass that is less likely than normal glass to crack when it is heated or cooled. Some common pieces of equipment are shown in Figure 1.2.3.

Beakers and conical flasks usually have markings up their sides, but the markings only indicate rough volumes. You would use a measuring cylinder to measure more accurate volumes. Volume is normally measured in the laboratory in millilitres (unit symbol mL). Larger volumes are measured in litres (unit symbol L).

Figure 1.2.3 Equipment commonly used in the laboratory





SKILL BUILDER

Reading a meniscus

A **meniscus** is the curved shape formed by the surface of a liquid where it contacts another surface. The meniscus is easy to see when the liquid is in a tube such as a measuring cylinder. Sometimes the meniscus curves upwards and sometimes it curves downwards. This could make measuring volumes a little difficult. Figure 1.2.4 shows how scientists measure the volume when a meniscus is present.

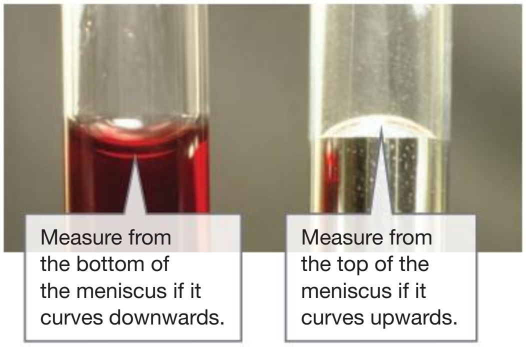


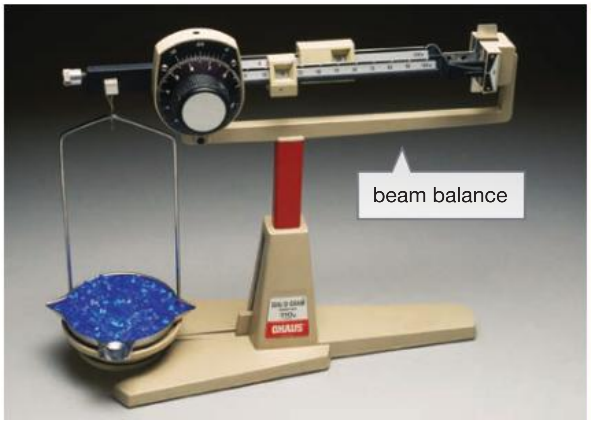
Figure 1.2.4 The surface of a liquid in a measuring cylinder forms a curve called a meniscus.

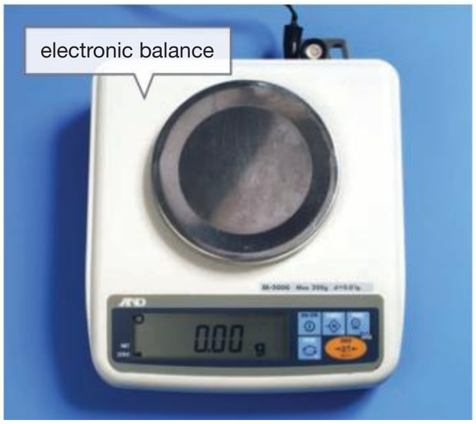
Balances

The beam balances, electronic balances and spring balances shown in Figure 1.2.5 can all be used to measure the **mass** of an object. Mass is a measure of how much matter there is in an object.

In the laboratory, mass is usually measured in grams (unit symbol g) or kilograms (kg).

Figure 1.2.5 Different balances can be used to measure the mass of an object. Mass is sometimes incorrectly called weight.





Heating equipment

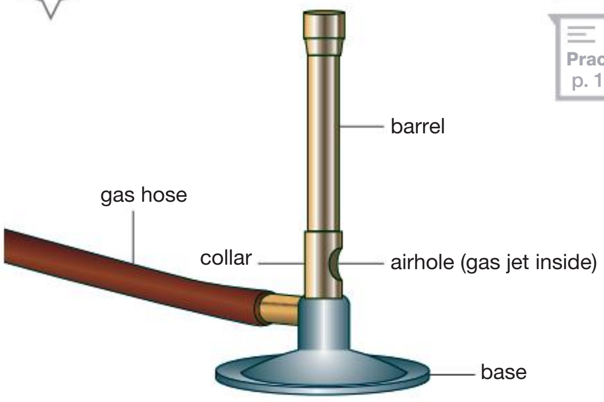
Hotplates and **Bunsen burners** are some of the most important and dangerous pieces of equipment that you will use in the school laboratory. Both get extremely hot and so can burn you seriously if you use them incorrectly.

Parts of the Bunsen burner

Figure 1.2.6 shows the parts of the Bunsen burner. The collar controls the amount of air that enters the burner and controls the heat and colour of the flame. If you *shut* the airhole, very little air is able to mix with the gas. The gas does not burn well and it produces a pale yellow flame that is easily visible and relatively cool. This is shown in Figure 1.2.7. For these reasons, the yellow flame is called the **safety flame**. It is also a dirty flame, because it leaves a layer of black carbon soot on anything that is heated in it.

Figure 1.2.6 The Bunsen burner

Prac 1 p. 17
Prac 2 p. 18



If you *open* the airhole, then a lot of air will enter. The gas will burn efficiently with no smoke, and will be extremely hot (about 1500°C). This flame is noisy. It has a blue colour and is sometimes difficult to see. At the very base of the flame, there is a small cone of unburnt gas. As Figure 1.2.7 shows, the hottest part of the flame is just above this cone.

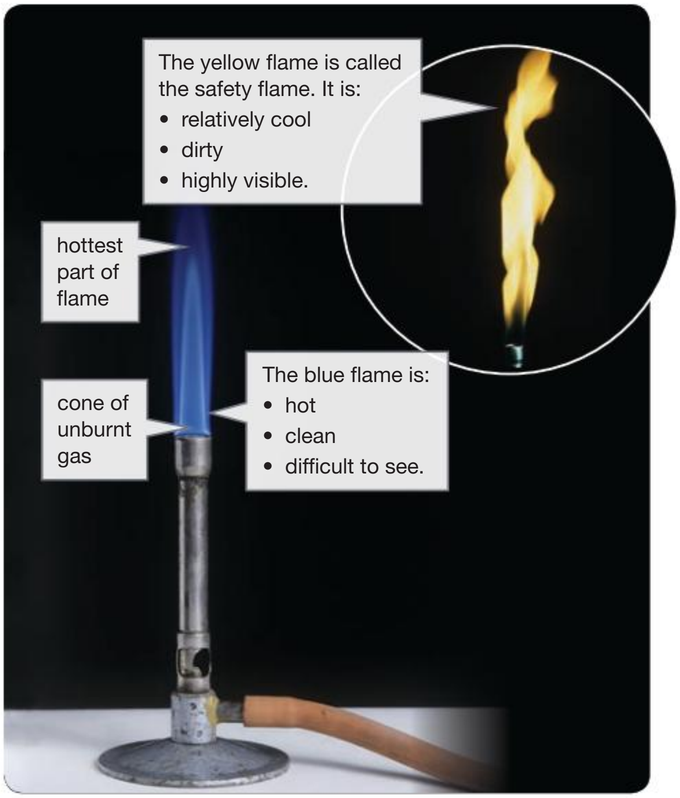


Figure 1.2.7 The yellow flame is easy to see and relatively cool. The blue flame is much hotter and almost invisible. This makes it much more dangerous.

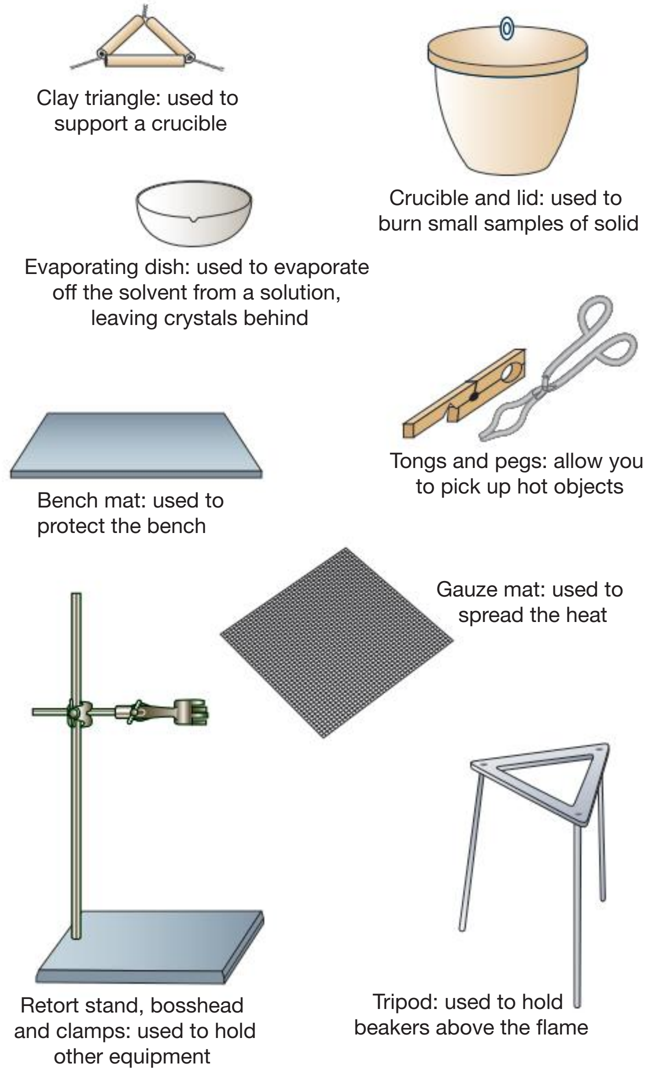


Figure 1.2.8 The hotplate and Bunsen burner need additional equipment to make them useful.

1.2

Other equipment used for heating

A kitchen stove isn't very useful unless you have frying pans, saucepans, tongs and stirring spoons to help you cook the food safely. A Bunsen burner also needs additional equipment to help you heat objects and to keep you safe. Some of this equipment is shown in Figure 1.2.8.

SKILL BUILDER

Heating a test-tube

Test-tubes can spit out their contents if you heat them incorrectly. They can also break.

1. Use a peg or test-tube holder to hold the test-tube near its open end.
2. Point the opening of the test-tube away from everyone, including yourself.
3. Heat the bottom gently, moving it back and forth through the flame as shown in Figure 1.2.9.

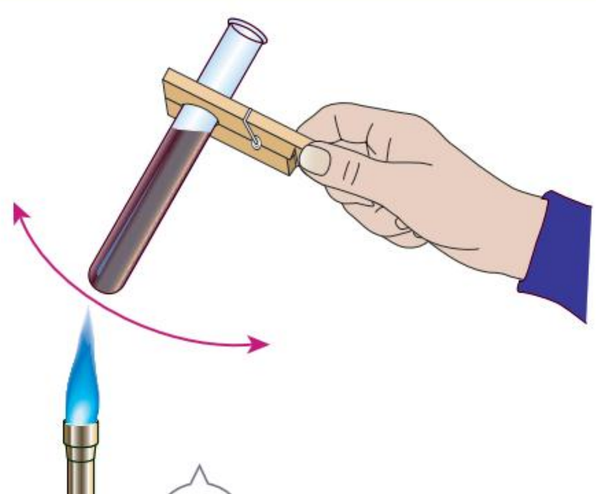


Figure 1.2.9 Never leave a test-tube in the one spot in a flame for too long.

Drawing equipment

Scientists do not draw equipment realistically but as simple two-dimensional (2D) line-drawings, 'splitting' the equipment down the middle to show its **cross-section**.

Figure 1.2.10 shows how scientists draw some of the most common equipment used in the laboratory.

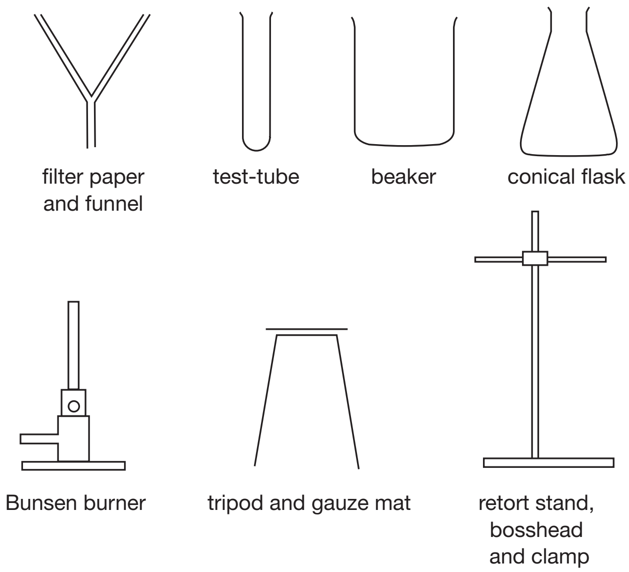


Figure 1.2.10 Scientists draw scientific equipment as simple, two-dimensional cross-sections.

Safety

Science can be fun. Experiments are part of that fun, but they can also be very dangerous. Hotplates and Bunsen burners can burn, and Bunsen flames can set clothes or hair on fire. Acids are corrosive and can burn badly, especially if splashed into your eyes. Many other chemicals are **toxic** and are poisonous if you sniff or taste them. Broken glassware can cut, and small fragments can easily enter your eyes.

Safety rules

The laboratory can be dangerous, but it can be safe if we all follow some simple rules. Although each school, each laboratory and each teacher will have their own set of rules that you must follow, some rules are common to all laboratories:

- Always follow instructions from your teacher or laboratory technician.
- Move about the lab in a safe way. Do not run, push or shove.
- Always wear safety glasses when using chemicals.
- Do not eat, taste, drink or sniff anything in the lab.
- Treat all glassware with care.
- Make sure that test-tubes cannot roll off a bench when not in use.
- Always tell your teacher if you break something or if you are unsure about what to do.
- Turn on the tap before placing any glassware under it. Otherwise the water might crack the glass of whatever you are holding.

Your teacher and school will give you a list of any other rules that you need to follow in your laboratory.

Other rules apply when you are heating something:

- Always tie back long hair; otherwise it's a fire risk.
- When you need to leave a Bunsen burner on, turn it to a visible yellow safety flame.
- Only use matches to light Bunsen burners.
- Always use tongs to pick up objects that have been heated.
- When you are heating a test-tube, ensure that it is pointed away from everyone (including you).
- Hotplates and Bunsen burners, tripods and gauze mats remain hot for a long time. Allow them to cool before you pack them away.

Safety in the laboratory is really just common sense. If something has the potential to hurt someone then *don't do it!*

Your local experts

If you are confused about equipment, safety, or what you are supposed to do in a laboratory, then there are usually two experts you can turn to:

- Your science teacher is trained in science and has probably specialised in one particular branch of science, such as biology, chemistry or physics.
- Your laboratory technician (lab tech) will usually be found working behind the scenes in a science department. He or she may come into your laboratory to help your science teacher out, especially if an experiment is particularly dangerous. Your lab tech is trained in safety, the laboratory, its equipment and chemicals.

1.2 Unit review

Remembering

1 **Name** an essential piece of equipment for:
- a a microbiologist
- b an astronomer.

2 **Name** the special type of glass from which most laboratory glassware is made.

3 **Specify** the temperature that a Bunsen burner flame can reach.

4 **List** four dangers that you will meet in the laboratory.

5 **Name** the two experts you can turn to in the laboratory.

Understanding

6 **Define** the term *cross-section*.

7 a The markings on beakers and conical flasks cannot be used to measure out volumes accurately. **Explain** why.
- b **Name** the piece of equipment used to measure volumes accurately.

8 All laboratories are different. **Explain** how.

9 A yellow flame will burn you if you are careless, but it is called the safety flame. **Explain** why.

10 a **Explain** how heating a test-tube can be dangerous.
- b **Outline** how to safely heat a test-tube.

Applying

11 **Identify** the volumes indicated in Figure 1.2.11.

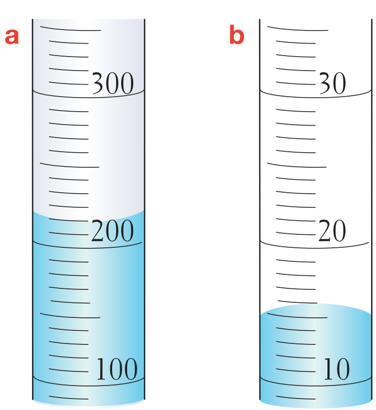


Figure 1.2.11

12 **Identify** whether the following observations would be made of a yellow Bunsen burner flame or a blue Bunsen burner flame:
- a dirty
- b noisy
- c almost invisible
- d extremely hot
- e closed airhole.

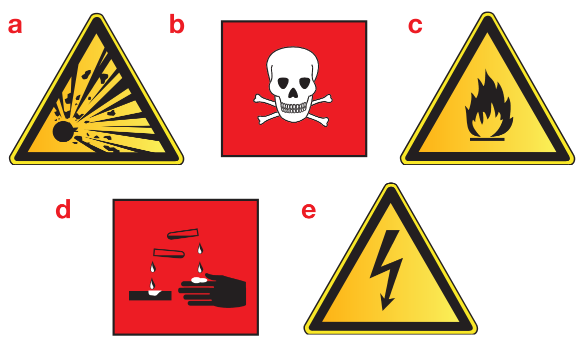
13 **Identify** what the students in Figure 1.2.12 are doing right or are doing wrong.

Figure 1.2.12

1.2 Unit review

Analysing

14 **Assess** what the following safety signs are saying.



15 **Compare** a beaker with a conical flask.

Evaluating CCT

16 In the laboratory, **propose** a way you could:

- **a** protect your eyes
- **b** avoid slipping while moving around.

17 **Propose** reasons why:

- **a** you should light a match before you turn on the gas to the Bunsen burner
- **b** long hair should be tied back when you are using the Bunsen burner
- **c** eating and drinking is banned in the laboratory
- **d** you should turn a Bunsen burner to a yellow flame if you need to leave it.

Creating CCT

18 You are using a Bunsen burner to heat water in a beaker. **Construct** a scientific diagram to show how your equipment looks.

19 **Construct** a sign that warns people that Bunsen burners are hot. Your sign must be in two colours only and use no words.

Inquiring

1 Fire blankets, eyewashes and fume hoods are common safety equipment in the laboratory. For each, find:

- an image
- what it is used for
- how it is used
- its location in your science laboratory.

Present your research as a plan of the laboratory with attached images and descriptions.

2 Research the person named Bunsen, after whom the burner was named.

- Find his full name, dates and locations of birth and death.
- Determine what he had to do with the burner.

Present your findings on an A4 sheet. Only include relevant information.

INQUIRY science 4 fun

Fake wounds

YES

Can you fake an injury?

Collect this …

- small ball of coloured dough from your teacher
- small amount of bright red food dye
- knife or bamboo skewer
- small twigs, cotton wool and bandages

Do this …

1. Pat your lump of dough until it is flat.
2. Pat it onto your skin and blend it in to your skin by squashing its edges down with your fingers.
3. Use the skewer or the blunt edge of a knife to make a fake 'cut' in the surface of the dough. Be careful when handling the knife—get supervision from an adult.
4. Make the wound look more realistic by inserting a small twig into the 'cut' and by dribbling some red food dye into it.
5. Use paper towelling, cotton wool or bandages to disguise the edges of the dough.

Record this …

Describe what the cut looked like. Did it look realistic?

Explain what you should do if someone really cuts themselves in the laboratory.

1.2 Practical investigations

1 The Bunsen burner

Purpose

To light a Bunsen burner and produce a yellow flame and a blue flame.

Materials

- Bunsen burner, bench mat and matches
- pin

SAFETY

Tie long hair back so it won't get in the flame.

Whenever you are not using the Bunsen burner, set its flame to yellow so that you can see it.

Equipment will be hot, so let it cool before packing it away.

Procedure

Copy the table in the results section into your workbook.

Part A: Lighting the Bunsen burner

1. Follow the instructions in the skill builder to light a Bunsen burner.
2. Turn the collar to open and shut the airhole. Observe what colour flames are produced.
3. Turn off the Bunsen burner and allow it to cool.

Part B: Unburnt gas

4. Push a pin through the wood near the top of an unlit match. Balance the match on the top of the Bunsen burner so that the match head is in the centre of its barrel.
5. Light the Bunsen burner as usual and quickly turn it to a blue flame. Figure 1.2.13 shows the correct set-up.

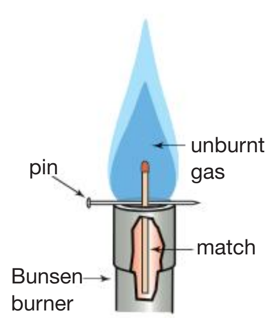


Figure 1.2.13

Results

Record all your observations in your results table.

Airhole	Was the flame noisy or quiet?	Flame colour	Other observations
Closed			
Half-closed			
Open			

Practical review

1. **Propose** a reason why the airhole should be closed when you light a Bunsen burner.
2. **Describe** what happened to the match in the barrel of the Bunsen burner.
3. **Explain** your observations.

SKILL BUILDER

Lighting the Bunsen burner

1. Place the Bunsen burner on a heatproof bench mat and connect it to the gas jet.
2. Turn the collar of the Bunsen burner so that the airhole is completely closed.
3. Light a match.
4. Turn on the gas at the gas tap.
5. Hold the lit match about 1 cm over the top of the barrel.
6. If the match blows out then immediately turn the gas off and start again.
7. When lit, the Bunsen burner should produce a bright yellow flame.
8. To obtain a blue flame, turn the collar so that the airhole is opened.
9. This sometimes causes the flame to blow out. If it does, turn off the Bunsen burner and follow the steps above to light it again. Then, to obtain a blue flame, adjust the airhole so that it is not completely open.

2 Investigating the flame

Purpose

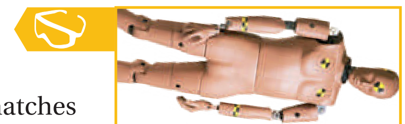
To determine which flame is hot, which is cool, which is dirty and which is clean.

Hypothesis

Which flame do you think will be hotter and which do you think will be cleaner – a blue flame or a yellow flame? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- Bunsen burner, bench mat and matches
- old, 'bald' gauze mat
- small piece of broken white porcelain
- tongs



SAFETY

Tie long hair back so it won't get in the flame.

Whenever you are not using the Bunsen burner, set its flame to yellow so that you can see it.

Equipment will be hot, so let it cool before packing it away.

Procedure

Part A: Hot or cool?

1. Set up and light the Bunsen burner.
2. Set it to a yellow flame.
3. With tongs, hold the gauze mat vertically in the flame so that it touches the top of the burner as shown in Figure 1.2.14.
4. Set the flame to blue and repeat step 3.
5. Carefully draw diagrams of any heat markings that you see.

Part B: Clean or dirty?

6. With tongs, hold the small piece of porcelain in a blue flame and record your observations.
7. Set the flame to yellow and repeat step 6.

Practical review

1. The wire of the gauze mat will glow red if it is really hot. **Identify** which flame (yellow or blue) made the wire glow red.
2. **Describe** the markings caused by the blue flame.
3. **State** where the flame was the hottest and where it was the 'coolest'.
4. **Compare** what happened to the porcelain in the yellow flame and the blue flame.
5. **Identify** which flame could be called 'dirty'.
6. **State** whether this was the hot flame or the cool flame.
7. a **Construct** a conclusion for your investigation.
   b **Assess** whether your hypothesis was supported or not.

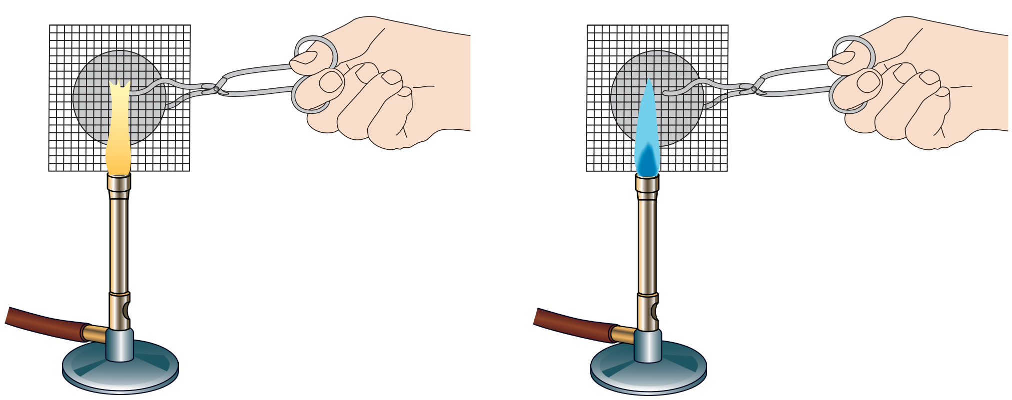


Figure 1.2.14

1.3 Experiments

Scientists carry out experiments to find out something about the world around them or to test a little bit of it. They record their observations and measurements and analyse them so that patterns and trends become clear. They can then make a logical inference about what happened and why. Inferences lead to predictions of what might happen in the future or in experiments under different conditions.

INQUIRY

science 4 fun

Magic candles

Can you relight a candle from a distance?

NO

Collect this …

- candle
- saucer or Petri dish
- matches

Do this …

1. Stand the candle upright on the saucer or Petri dish. Melt a little of its base to help it stick.
2. Light the candle and use all your senses except taste to make as many different observations as possible. (Michael Faraday, a nineteenth century scientist, made 53!)
3. Gently blow the candle out and attempt to relight it by moving a lit match down the smoke trail as shown.

SAFETY

Candles, matches and hot wax can burn, so avoid touching the hot parts.

Record this …

Describe what happened.

Explain why you think this happened.

Practical investigations

An **experiment** or **practical investigation** is a test on a small part of the world around us. It might test the temperatures at which different metals melt, or it might test how Bogong moths know when to migrate to the alpine regions of New South Wales and Victoria. It might test the intelligence of dolphins, how to make building materials fireproof, why some people are allergic to peanuts, why solar eclipses occur, or how chocolate can be made even tastier.

Scientists either design their own experiments or follow the instructions of other scientists who have performed them already. You will be doing this too. You will be given instructions for most practical activities, but some will require you and your group to plan and carry out your own investigations.

Observations and measurements

Although scientists use all of their five senses to make **observations**, sight is probably the sense that gives them the most information. This is the sense being used in Figure 1.3.1. Scientists make either qualitative or quantitative observations.

Figure 1.3.1 The main sense a scientist uses is sight. They will also use hearing, smell, taste and touch, although often it will be far too dangerous to use some of these.

Qualitative observations

Qualitative observations are descriptive. They are recorded as diagrams or written down in words. Qualitative observations would be made about the noise a bird makes, the colour of its feathers, what it eats, and how it acts throughout the day. The appearance of shaving foam and the shape of a crab are qualitative observations too, as is the taste of the food in Figure 1.3.2.

Figure 1.3.2 The look, smell and taste of pizza are qualitative observations.

Quantitative observations

Describing a day as hot (a qualitative observation) doesn't really give an idea of how hot it is. There is no uncertainty about how hot the day is if you specify the temperature it reached: 43°C is hot in anyone's language! Measurements like this are **quantitative observations**. They are written as numbers and allow scientists to be more detailed and accurate in their observations. Distance, mass, time, temperature and volume are quantitative observations, since all can be written as numbers. For example, chips come in 200 gram bags, cans of soft drink hold 375 mL, water boils at 100°C, and it takes 60 minutes to fly from Melbourne to Sydney, a distance of 881 km.

Sometimes an optical illusion like the one shown in Figure 1.3.3 will trick your senses into making qualitative observations that are incorrect. Measurement will usually indicate whether your senses were correct or not.

1.5 1.6 Prac 1 p. 25

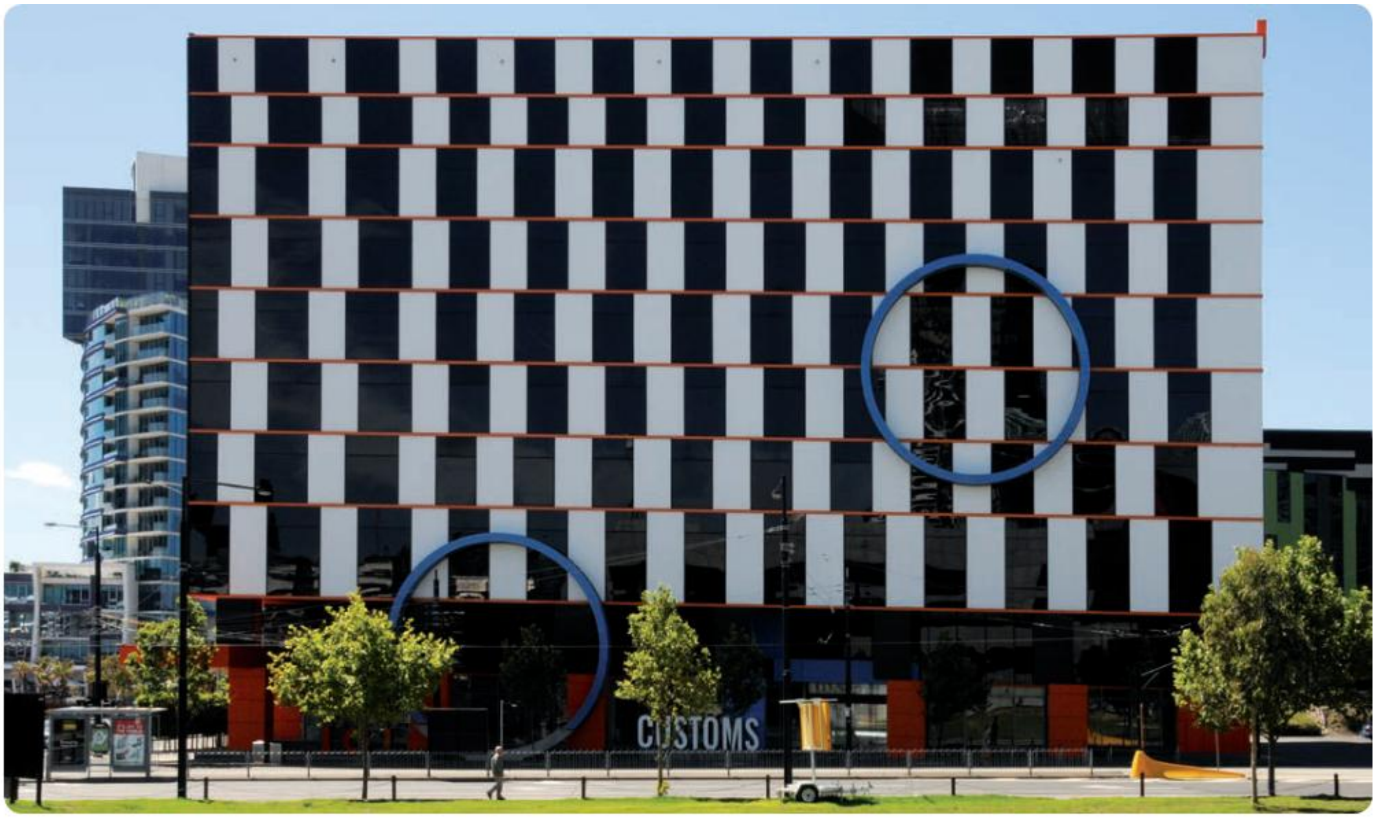


Figure 1.3.3 An optical illusion makes the floors (orange) of this building in Melbourne's Docklands look as if they are at sloping at different angles. Measurement of the distance between the floors proves that they are all horizontal.

SciFile

Moonface!

The Moon often looks huge as it rises in the east but it is really just the same size as when it is somewhere else in the sky. Check this out by holding your hand out and using your fingers to measure its width as it moves across the sky.

Figure 1.3.4 An optical illusion causes the Moon to look huge when it rises.

Units

Measurements are useless unless the units of measurement are included. Scientists use units from the metric system for their measurements.

- Distances, lengths and heights are measured in millimetres (unit symbol mm), centimetres (cm), metres (m) or kilometres (km).
- Small masses are measured in grams (g). Heavier masses are measured in kilograms (kg) or tonnes (t).
- Volume is measured in millilitres (mL) or litres (L).

Other non-metric units are used as well. For example:

- time is measured in seconds (s), minutes (min) or hours (h)
- temperature is measured in degrees Celsius (°C).

The above units together form a system of units called *Système international d'unités* (otherwise known as SI units). Each unit has its own symbol and there is a correct way of writing each symbol. For example, the symbol for millilitres is mL and not ML (which means a million litres). Likewise, the symbol for kilograms is kg, not Kg, KG or kgs.

Taking accurate measurements

Measurements are only worthwhile if they are accurate and they are recorded accurately and honestly. So that your measurements are as accurate as possible, make sure that:

- everyone in your laboratory team takes their own measurement. You can then calculate the average of everyone's values.
- you keep your eye level with the measurement (as in Figure 1.3.5)
- the measuring device starts at zero.

Mistakes are often made when measurements are recorded but you can avoid this if you take enough care. Reduce the chance of recording measurements wrongly by:

- writing down measurements (with their units) as soon as you take them. Do not try to remember measurements.
- avoiding fractions like $\frac{1}{2}$ or $\frac{1}{4}$ in measurements. Use decimals instead. 9.5 kg is fine, $9\frac{1}{2}$ kg is not.
- making sure that everyone in the group has a copy of the results before you leave the laboratory.

Prac 2 p. 26

Prac 3 p. 26

1.7

Figure 1.3.5 Keep your eyes level with your measurement.

Inferring and predicting

From your observations and measurements, you can sometimes make an **inference**, or logical explanation, about what happened and why it happened. You may then be able to predict how it could work in the future or if the experiment was run in a different way.

A **prediction** must be logical and must be based on the observations you made in your experiments. Every day you make observations, inferences and predictions, probably without even knowing it!

Observation: Everyone is packing up.

Inference: It must be nearing the end of the lesson.

Prediction: The bell will ring soon.

In science, you might start with an observation from an experiment:

Observation: Cubes of sugar dissolve in tea faster when they are broken into smaller pieces.

Inference: Smaller pieces mix better with the water than larger lumps, making them dissolve faster.

Prediction: If the sugar is crushed even finer, then it will dissolve even faster.

INQUIRY science 4 fun

Milk swirls

YES

Is there a better way to record some observations?

Collect this ...

- full cream milk
- food dyes (assorted colours)
- liquid dishwashing detergent
- shallow plate with flat bottom (such as a bread plate or dinner plate)

Do this ...

1. Pour enough milk into the plate until it is 5 mm to 10 mm deep.
2. Place a single drop of food dye anywhere into the milk. Place single drops of other colours elsewhere.
3. Place 1 or 2 drops of detergent into the centre of the plate.

Record this ...

Describe in words what happened.

Explain why it is sometimes difficult to produce a written record of what happened in an experiment.

1.3 Unit review

Remembering

1 **List** your five senses.

2 **List** three observations about each of the following:
- a a candle
- b molten (melted) candle wax
- c a candle flame
- d the smoke from a candle that has been blown out.

3 **State** the measurements shown in each of the measuring devices in Figure 1.3.6. N

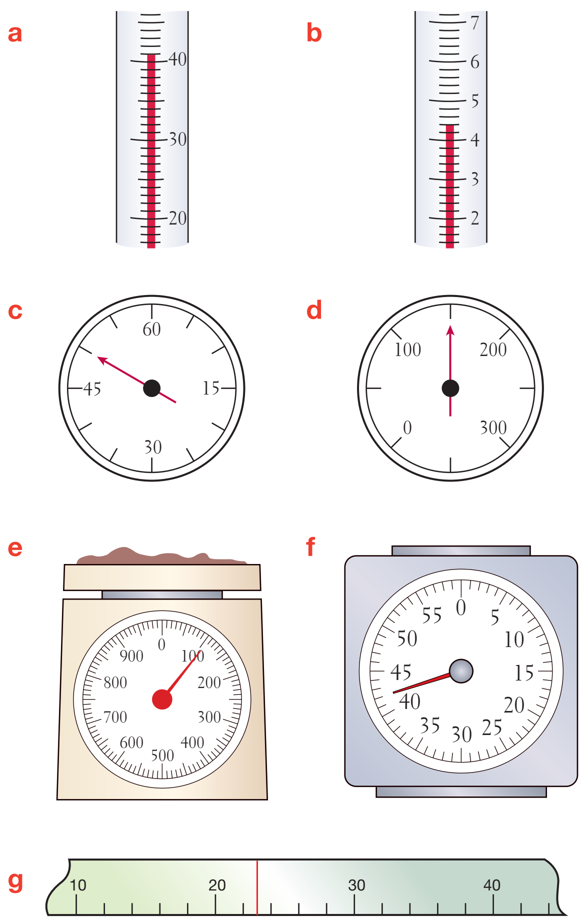


Figure 1.3.6

4 **State** what is wrong with the way these measurements have been recorded. N
- a The mass of a mouse = $150\frac{1}{4}$ g.
- b The car was travelling at 100.
- c A full bottle of soft drink contained 1.25 mL.

5 **State** which of the abbreviations below are correct for these units: N
- a gram
  - A gm B gms
  - C G D g
- b kilogram
  - A kilo B kg
  - C Kg D KG
- c millimetre
  - A mms B mm
  - C Mm D mL
- d litre
  - A lt B mL
  - C lit D L
- e minutes
  - A min B m
  - C mins D ms

Understanding

6 **Explain** what advantages quantitative observations have over qualitative observations.

7 Give an example to **explain** how optical illusions can lead you to make faulty observations.

Applying

8 **Identify** the best metric unit to use to measure the length of: N
- a a bull-ant
- b the length of a cricket field
- c the distance between Brisbane and Sydney.

9 **Identify** the best SI unit to measure the: N
- a mass of a mouse
- b time it takes to sneeze
- c temperature of a sick dog
- d mass of a person
- e volume of a swimming pool.

10 Below is an observation, an inference and a prediction. **Identify** which is which.
- The colours of a felt-tip pen ran when they got wet.
- Washing should get the stain of a felt-tip pen out of my shirt.
- The inks used in a felt-tip pen can dissolve in water.

1.3 Unit review

11 Sometimes it is too dangerous to use some of our senses. **Identify** which senses you would and would not use in the following investigations and complete the table.

Activity	Senses that would be safe to use	The sense that would give you the most information	Senses that would be unsafe to use
Testing a new rat poison			
Testing whether minced steak is OK to eat or is 'off'			
Testing the lava flowing from a volcano			
Testing how dangerous an acid is			
Testing whether tomatoes are ripe			

Analysing

12 **Classify** the following observations as qualitative or quantitative.

- a The night was dark.
- b It took 15 minutes to walk to school.

13 The following are statements about the gas you breathe out. **Classify** each statement as an observation, an inference or a prediction.

- a It's hot, moist, colourless and clear.
- b It's carbon dioxide.
- c It's one of the chemicals produced by chemical reactions in your body.
- d If gas stops coming out, then you will soon be dead.

Evaluating CCT

14 When a candle is snuffed out, a trail of smoke rises from it. This smoke is unburnt gas. **Propose** how this trail of unburnt gas can be used to relight the candle.

15 In the science4fun on page 22, detergent gathered together the fat in the milk, causing the liquid to swirl around. This pattern is nearly impossible to describe in words. **Propose** a better way of recording what happened.

16 Look at the images in Figure 1.3.7.

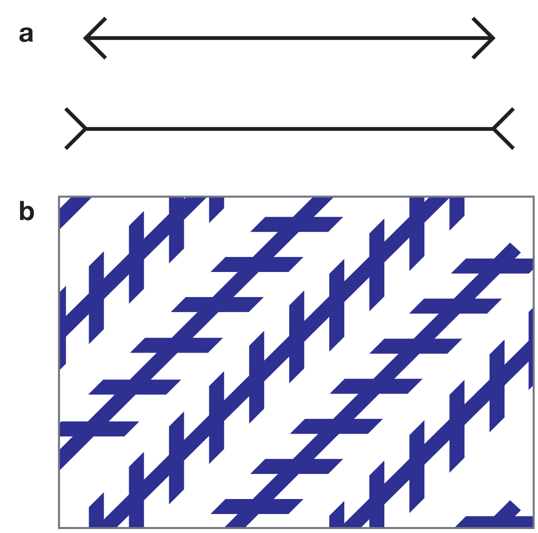


Figure 1.3.7

- a **Assess** whether the main lines in diagram **a** are the same length or not.
- b **Assess** whether the main lines in diagram **b** are parallel to each other.
- c **Use** a ruler to check whether you were correct or not.

Inquiring

1 Use the internet to find and save images and video of optical illusions such as the Zolner illusion. ICT

2 Research the history of the metric system. Summarise your main findings as ten dot points.

1.3 Practical investigations

1 Hot, hotter, hottest

Purpose

To compare qualitative with quantitative measurements.

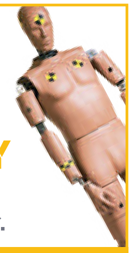
Hypothesis

Which do you think will be more accurate in measuring temperature – your hands or a thermometer? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- ice
- warm water

- 4 × 250 mL beakers or identical tubs
- thermometer



SAFETY
Do not use boiling water.

Procedure

1. Copy the table from the Results section into your workbook.
2. Fill four beakers and arrange them as shown in Figure 1.3.8.
3. Immerse (place) your left hand in the beaker containing cold water and your right hand in the beaker containing warm water. Leave your hands in the water for 30 seconds or so.
4. Remove your hands and put each hand into a beaker containing tap water.
5. Leave them there for 30 seconds or so. Does the water feel the same to both hands, or does one feel hotter?
6. In your table, rate what the temperature of the water in each beaker felt like – very hot, hot, cool or cold.
7. Use the thermometer to measure the actual water temperature of each beaker. Record the temperatures in your table.

Results

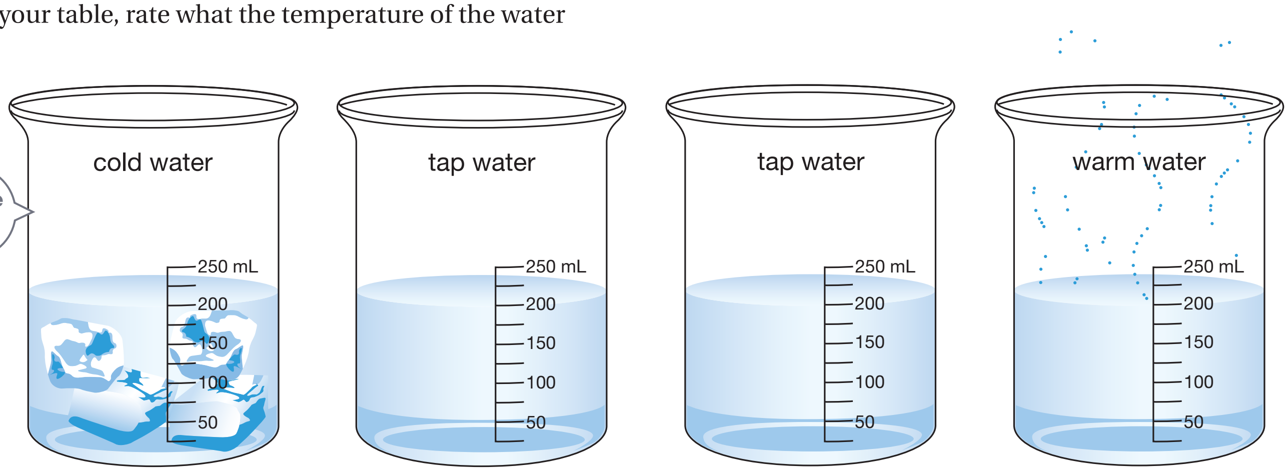
Copy out the table below into your workbook.

Beaker	What it felt like (very hot, hot, cool, cold)	Actual temperature (°C)
Water–ice mixture		
Tap water 1		
Tap water 2		
Warm water		

Practical review

1. **Identify** the quantitative observations you made in this activity.
2. **Identify** your qualitative observations.
3. **State** whether your qualitative observations agreed with your quantitative ones.
4. a **Construct** a conclusion for your investigation.
   b **Assess** whether your hypothesis was supported or not.

Figure 1.3.8



1.3 Practical investigations

2 Taking measurements

Purpose

To observe that not everyone takes the same measurement.

Materials

- access to a range of equipment that shows different quantities (such as a 250 mL beaker, 100 mL conical flask or a 100 mL measuring cylinder containing different quantities of water, a beam or electronic balance with a mass on it, a sheet of paper with a ruler to measure its length)
- A4 sheet of paper next to each piece of equipment

Procedure

Move around the laboratory and read the measurement for each piece of equipment.

Results

1 Construct a table similar to the one below in your workbook.

Name of equipment	Measurement	Units

2 Record your measurement in the table and on the paper next to each piece of equipment.

3 After you finish, check all the measurements written on the pieces of paper and determine if they are all exactly the same.

Practical review

1 Everyone in a team will take slightly different measurements, even when measuring exactly the same thing. **Propose** reasons why.

2 **Describe** a way of using all the results on the paper to obtain an even better result.

STUDENT DESIGN

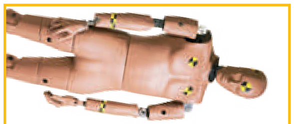
3 When measuring is difficult

Purpose

To develop ways of taking measurements.

Materials

- small box of Smarties or M&Ms
- stack of A4 paper (recycled is OK)
- ruler
- watch or timer



SAFETY
A Risk Assessment is required for this investigation.

Procedure

1 Design three small experiments that will measure the:
   - mass of a Smartie or M&M without using any weighing device
   - thickness of a single sheet of A4 paper with a normal ruler
   - time it takes for your heart to do one heartbeat.

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

Record every measurement you take and every calculation you make.

Practical review

1 **List** any problems that you had in this investigation.

2 **Assess** how well your procedure worked for measuring each of the items.

3 **Propose** other ways of measuring these quantities.

1.4 Communicating

It's not worthwhile running an experiment unless you have some way of communicating what you find out to other scientists. Scientists write a scientific report to explain how they ran an experiment, what they measured and how they interpreted the results. Tables and graphs help to display patterns in their measurements.

INQUIRY science 4 fun

Broken whispers

YES

Can a group communicate a piece of information accurately without writing it down?

Do this ...

1 As a class or in a group, sit around in a circle.
2 One of you is to construct a short story that takes no more than two sentences to tell.
3 The story is to be passed on around your group by one person whispering it very quietly to another.
4 Compare the original story with the story that it ended up being.

Record this ...

Describe what happened.
Explain why you think this happened.

Tables

Measurements and observations are easier to read and analyse if they are displayed in tables. Tables also make trends (patterns) in the measurements more obvious. Each column in a table needs to have a clear heading that includes the units in which each measurement has been taken.

Computer programs such as Excel allow you to produce an electronic table on a computer. This type of table is known as a spreadsheet.

Graphs

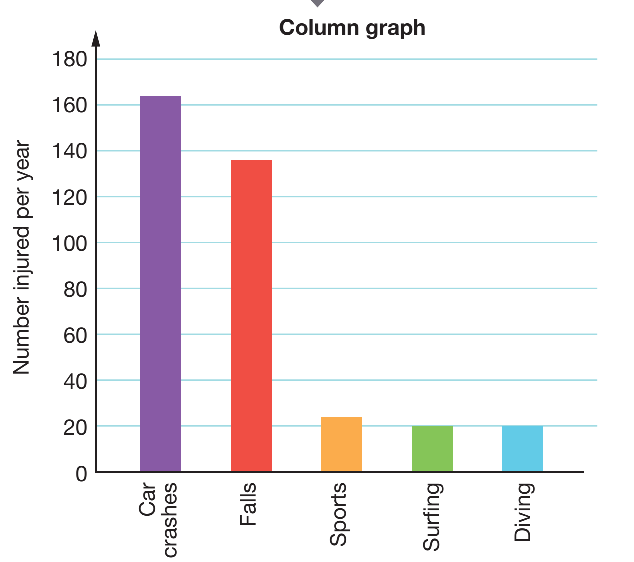
A graph shows trends in measurements even more clearly than tables do. The type of graph you draw depends on the types of observations you make.

Bar and column graphs

Some observations fall into discrete groupings. This means that all the observations can be sorted into categories and counted. Animals, for example, fall into discrete groupings like kangaroos, ants, cockatoos and sharks. Other observations that have discrete values are makes of cars (such as Holden, Toyota, Ford, Mazda), sports (netball, football, golf, tennis), building materials (timber, brick, concrete, glass) and the sex of people (male or female).

Bar and **column graphs** are used when you have a set of observations that are discrete, such as the data in the table below. These discrete values are displayed on one of the axes of the graph while numbers are displayed on the other axis, as shown in Figure 1.4.1. Axes are the horizontal and vertical lines 'framing' the graph.

Cause of spinal injury	Average number injured per year
Car crashes	164
Falls	136
Sports	24
Surfing	20
Diving	20



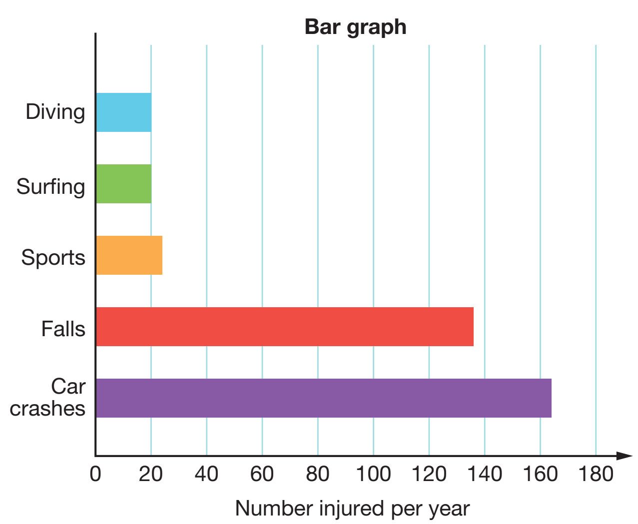


Figure 1.4.1 There are five main causes of injuries to the spine. These two graphs indicate how many Australians are injured on average per year.

Pie graphs

Discrete groupings are also used to construct **pie graphs** or **sector graphs**. A pie graph shows the proportions of each grouping within a total. In a pie graph, the whole pie represents 100%, half the pie represents 50% and a quarter-pie represents 25%. As an example, Figure 1.4.2 shows the percentages of different animals living in a nature reserve.

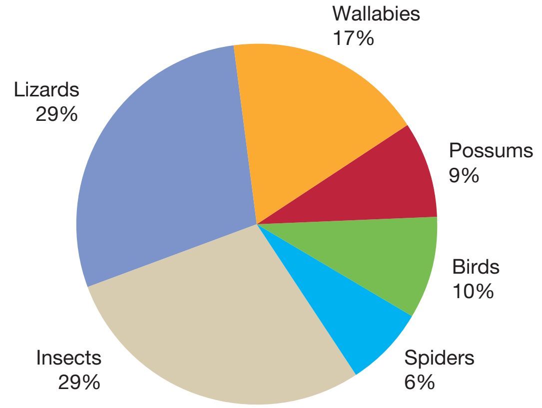


Figure 1.4.2 This pie graph shows the proportions of each animal in a nature reserve and not their real numbers.

Line graphs

Measurements involve numbers that are not discrete but *continuous*. This means that if you choose two numbers, then you can always find other numbers in between them. For example, between 10 and 20 you will find the numbers 11, 12, 13, 14 and so on. Between them are even more numbers such as 11.4, 12.7 and 13.576362. Therefore measurements vary continuously. Continuous variation is shown in the height of humans. Imagine measuring the height of every student and teacher in your school. There would be a spread of heights from short to tall with most heights represented in between. Length, mass, time, volume and temperature measurements are continuous.

Line graphs require two sets of measurements that show continuous variation. This is shown in Figure 1.4.3.

Once you have plotted all the points on a line graph, do not connect up the points dot-to-dot. Instead, draw a straight line or a smooth curve roughly through the centre of the points you have plotted. A straight line like this is called a line of best fit while the curve is called a curve of best fit. These 'best fits' clearly show patterns that might exist in the measurements you took in the experiment. An example is shown in Figure 1.4.4.

Prac 1 p. 32
Prac 2 p. 33
1.8

Age of mouse (days)	Mass (g)
0	5
2	15
4	22
6	25
8	27
10	28

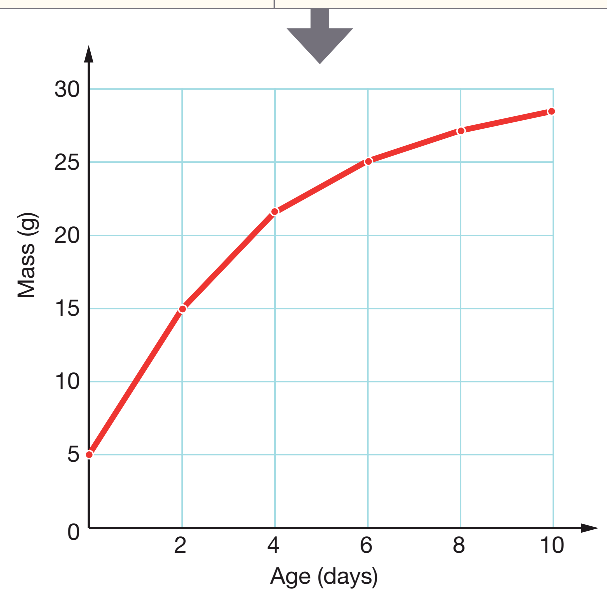


Figure 1.4.3 Line graphs need two sets of numbers to plot.

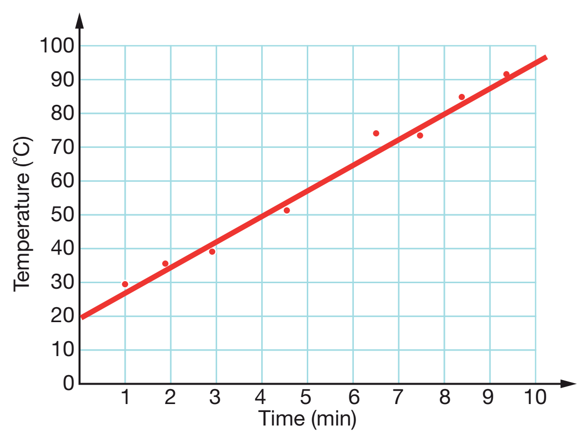


Figure 1.4.4 A line of best fit is drawn roughly through the middle of all the points. In this way, the line of best fit shows the trend or pattern in the graph.

Scientific reports

Scientific reports are used by scientists to communicate to other scientists how they performed an experiment and what they found out in it. If you set out your report clearly and logically, then other scientists will be able to repeat your experiment.

Purpose

The **purpose** or **aim** is what you wanted to do in an experiment or practical activity, what you wanted to show or wanted to prove.

Hypothesis

You probably have some idea of what might happen in an experiment even before you start it. This 'educated guess' is called your **hypothesis**. A hypothesis is an inference based on what you already know. A hypothesis is not always included in a scientific report.

Materials

This is a list of all the *important* equipment, chemicals and materials that you used. If equipment comes in different sizes, then make sure you include the size you used (for example, 250 mL beaker).

Procedure

The **procedure** or **method** is a detailed list of what you did in the experiment. You must include what quantities were used (for example, 5 g, 2 spatula loads or 10 mL), and the exact order in which the steps of the experiment were performed. A diagram of the experiment is a useful way of showing what you did.

Results

Results include all your observations and all your measurements, preferably displayed in a table. This is also where you include graphs and calculations.

Discussion or analysis

Include in your **discussion** or **analysis**:

- an explanation about what you think your results showed about the experiment
- what you have found about the experiment from other sources such as textbooks, the internet or encyclopaedias
- a description of any problems you had with the experiment and what you did to overcome them.

Most investigations will have a set of questions that will guide you through your discussion.

Conclusion

Your **conclusion** needs to summarise what you have found out in the experiment. The conclusion should be short and must relate to the purpose.

1.4 Unit review

Remembering

1 **Recall** the main sections of a scientific report by matching the following terms with their definitions:

Purpose	instructions
Hypothesis	the end
Materials	aim
Procedure	analysis
Discussion	equipment
Conclusion	educated guess

2 **List** the things that should be included in the following sections of a scientific report:
- **a** materials
- **b** procedure
- **c** discussion.

Understanding

3 **Explain** why scientists would want to read what others have found out in experiments.

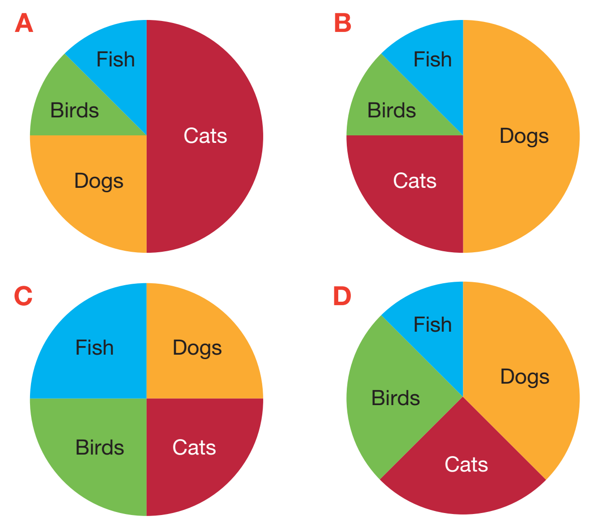
Applying

4 Adrian ran an experiment in which he tested how much sugar would dissolve in a hot cup of tea. **Identify** the best conclusion for his experiment.
- **A** The experiment was fun.
- **B** I learnt a lot from the experiment about sugar dissolving in hot tea.
- **C** 3 teaspoons of sugar were able to be dissolved in a hot cup of tea.
- **D** Tea tastes better when there is sugar dissolved in it.

5 **Identify** whether a column/bar, sector or line graph would best show the following results.
- **a** The top speeds of different makes of cars
- **b** The temperature of a room throughout a winter's day
- **c** The types of animal with different numbers of legs
- **d** The percentages of your classmates who were born in Australia and overseas
- **e** Your height as you get older

6 **Identify** which of the graphs A–D best represents the results in the table.

Type of pets	Percentage (%)
Dogs	50
Cats	25
Fish	13
Birds	12



7 **Use** the key below to **identify** the term that best describes the trend shown in each of the line graphs in Figure 1.4.5.
- **A** constant
- **B** increasing
- **C** decreasing
- **D** no trend shown

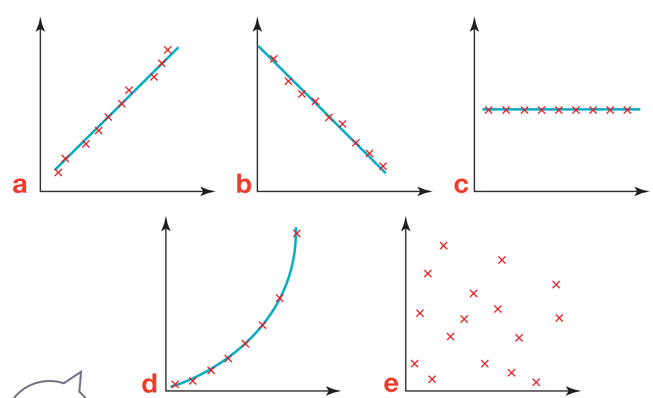


Figure 1.4.5

Analysing

8 **Draw** simple sketches to **contrast** a column graph with a:

- **a** bar graph
- **b** sector graph
- **c** line graph.

Evaluating CCT

9 **Propose** reasons why a message sent around a room via whispers often ends up very wrong.

Creating CCT

10 **Construct** an appropriate conclusion for the following aims.

- **a** To test if fishing line is stronger than string
- **b** To prove that water boils at 100°C
- **c** To determine how much water a sponge can hold

11 **Construct** a table for the poorly recorded results shown in Figure 1.4.6.

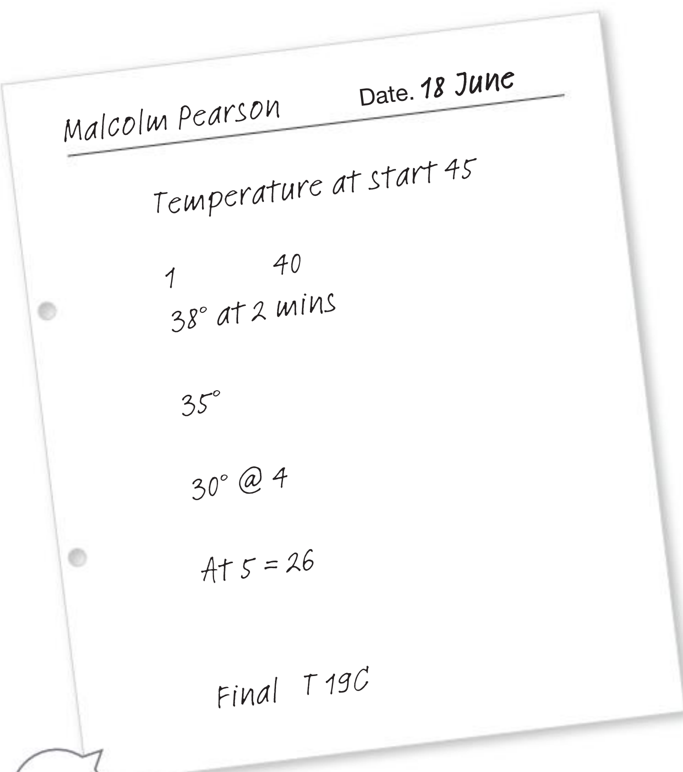


Figure 1.4.6

12 Bridie noted the speedometer reading every 5 seconds as her mum's car accelerated. At the start, the speed was 0 km/h. The speed was 20 km/h after 5 seconds, then 30, 50, 60 and 80 every 5 seconds after.

- **a** **Construct** a table to display her results.
- **b** **Construct** a line graph to show her results. N

Inquiring

Scientists around the world eagerly awaited the landing of the Mars Polar Lander (shown in Figure 1.4.7) in 1999. One important mission of the lander was to search for water. However, after descending into the Martian atmosphere, the lander was never heard from again. Find:

- when it was launched from Earth
- what its mission on Mars was to be
- when it crashed
- what caused it to crash.

Present your research as four short paragraphs, one paragraph answering each dot point.

Figure 1.4.7 An artist's impression of what the landing of the Mars Polar Lander *should* have looked like.

1.4 Practical investigations

1 Spaghetti predictions

Purpose

To use a graph to predict unknown measurements.

Materials

- 4 lengths of dry spaghetti
- beam balance or electronic balance
- 30 cm ruler (with 1 mm markings)

Procedure

1. Break three lengths of spaghetti into three pieces each so that you end up with nine different lengths.
2. Measure the length and mass of each piece of spaghetti.

Results

1. Record the lengths and masses you measure in a table like that shown below.

Length (mm)	Mass (g)

2. Use this information to plot a line graph. Draw a straight line so that it passes roughly through the centre of your points. An example of a line of best fit is shown in Figure 1.4.8.

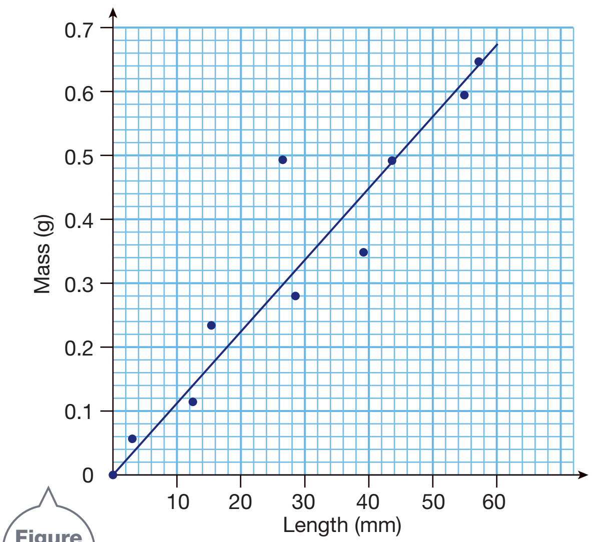


Figure 1.4.8

3. You only had nine lengths of spaghetti and there were lots of other lengths that you could not measure. Mark on your graph a length that you did not measure.
4. Use the graph to estimate the mass of this length.
5. Snap your final length of spaghetti at the length you chose in step 3 and measure its mass.
6. Compare its mass with your prediction in step 4.

Practical review

1. **Explain** why a line of best fit is better than joining points dot-to-dot.
2. **Construct** a conclusion about the link between mass and length of spaghetti.

STUDENT DESIGN

2 Hot drinks cooling

Purpose

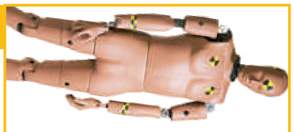
To compare the rates at which different cups of hot drink cool.

Hypothesis

Which do you think will cool faster – a cup of tea or coffee, one with milk or one without, a cup or a mug, a large cup or a small cup? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

To be selected by students.



SAFETY
A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that will compare the cooling rates of:
- cups, mugs and beakers
- tea, coffee and drinking chocolate
- tea or coffee with and without milk and sugar
- different volumes of drink.

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

Only test one thing at a time. For example, test the cooling in a cup, mug and beaker but keep everything else the same (such as drink volume and type of drink).

Results

1 Record all your temperatures in a results table similar to the following.

Time (min)	Cup of tea	Beaker of coffee	Mug of drinking chocolate
0 (at the start)			
1			
2			
3			
4			

2 Plot the results of each drink as a line graph on a similar grid to that shown in Figure 1.4.9.

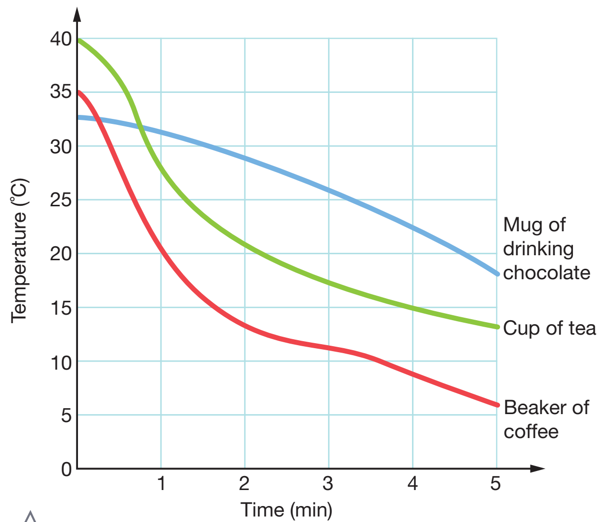


Figure 1.4.9

Practical review

1 **Describe** the trend or pattern that each graph showed. Was it increasing, decreasing, constant, unpredictable?

2 **Identify** which drink cooled the:
- a fastest
- b slowest.

3 **List** as many factors as you can to **explain** why the drinks cooled at different rates.

4 **Propose** improvements that could be made to your experiment.

5 a **Construct** a conclusion for your investigation.
b **Assess** whether your hypothesis was supported or not.

1.5 Planning your own investigation

In most practical activities you will be given a detailed set of instructions. Sometimes you will need to plan your own investigation and decide what equipment and substances you use and how you intend to run the activity. Whatever you do in an experiment, you will need to run a fair test.

INQUIRY science 4 fun

No-leak bags

YES

What happens when you stab a plastic bag full of water?

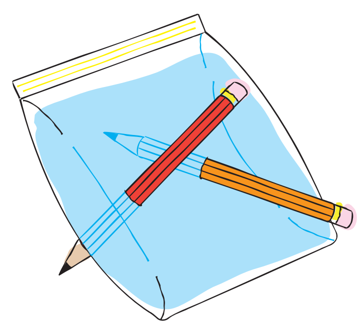
Collect this ...

- water
- 1 zip-lock plastic bag
- pencils
- pencil sharpener
- access to a sink or bucket

Do this ...

1 Sharpen the pencils so that their tips form a very sharp point.

2 Three-quarters fill the plastic bag with water, and zip it shut.



3 Hold the plastic bag above a sink or bucket (or work outside).

4 Stab the bag fast with a pencil so that the tip comes out the other side.

5 Repeat with the other pencils.

Record this ...

Describe what happened.
Explain why you think this happened.

Identifying variables

Many different factors influence what happens in an experiment. In science, these factors are known as **variables**. Think of the time it takes someone to run 100 metres. The time taken will depend on many variables, such as the age, weight and fitness of the runner, the shoes being worn, the direction of the wind and whether the surface was grass, concrete or sand.

Any experiment that you carry out must be a **fair test**. To be fair, you should change only one variable at a time. Otherwise you won't be able to work out what variable caused any change. All the other variables must be controlled, being kept exactly the same.

In any experiment you should be able to identify the:

- **dependent variable**: this is what you are trying to measure. It depends on all the other variables. For the 100-metre run, the dependent variable is the time taken.
- **independent variable**: this is the variable that you want to test and is what the dependent variable depends on. Change this and what you are trying to measure will probably change too. For the 100-metre run, you might choose to test the surface run on, and so this would be the independent variable.
- **controlled variables**: these are all the other variables that you don't want to test right now. These are kept constant. In the 100-metre run, you are testing the surface, so every other variable needs to be kept the same. The age, fitness and weight of the runner, the type of shoes they are wearing and the wind direction would all need to be kept constant.

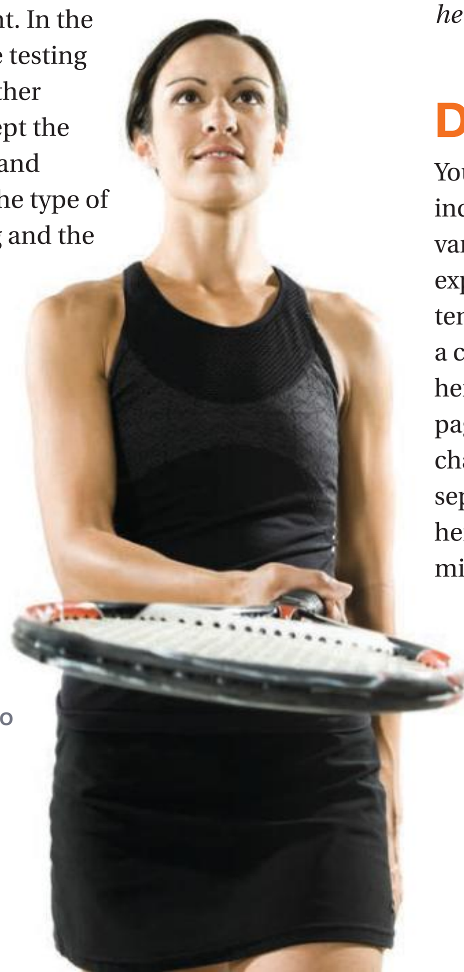


Figure 1.5.1

The type of ball and the surface it is dropped onto are two variables that will affect the height to which the ball bounces.

Figure 1.5.1 shows a ball bouncing on a racquet. When a ball is dropped onto a surface such as a racquet, many variables influence the height the ball bounces back to. The height of a bounce (bounce height) is the dependent variable because it depends on other (independent) variables. Just a few of these are the:

- type of ball that is being bounced
- type of surface it is being bounced on
- height the ball drops from (drop height).

Let's say you decide to test how the drop height of a ball affects the bounce height. Your variables are therefore:

- dependent variable: bounce height. This is what you are measuring and will be the basis of your aim.
- independent variable: drop height. This is what you are changing.
- controlled variables: the type of ball and surface. These must be kept the same throughout the experiment.

Your purpose therefore would be: *To test how drop height affects bounce height.*

Developing a hypothesis

Think about what is likely to happen in the experiment. Write down what you think might logically happen. This is your hypothesis. For the ball-drop experiment, your hypothesis might be: *I think that increasing the drop height will increase the height the ball bounces to.*

Developing your procedure

Your procedure must test the effect of only the independent variable you chose earlier. All other variables must be kept the same. In this ball-bounce experiment, you need to test one type of ball (such as a tennis ball) and one type of surface (for example, onto a concrete path). The only thing you can change is the height from which you drop the ball. Figure 1.5.2 on page 36 shows how this might be done. If you want to change another variable, then you need to run a new and separate experiment. Before you start, think about the heights you might drop the ball from and the results you might obtain.

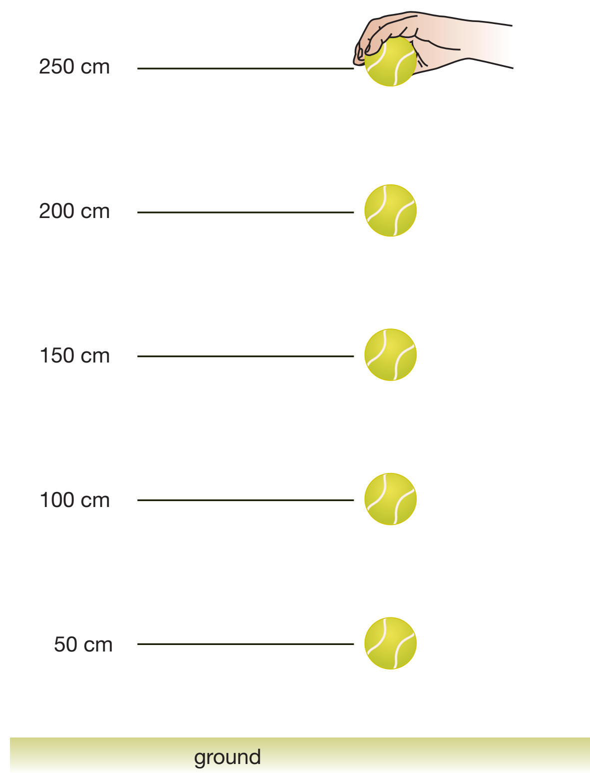


Figure 1.5.2 Try to test five or more different heights and make sure they are not too close to each other. Anything less than five measurements and measurements that are too close make patterns difficult to see.

Putting your results in a table

Here you are measuring drop height and bounce height. An appropriate results table would look like the one shown in Table 1.5.1.

Table 1.5.1 Results table

Drop height cm	Bounce height (cm)
0	0
50	30
100	62
150	95
200	120
250	148

Plotting a graph

When plotting a graph, you first need to decide which type of graph you are to plot. Line graphs are used when you have two sets of continuous measurements.

The results from the ball-drop experiment have two sets of numbers and so a line graph is the most appropriate graph to plot. It might look like the one in Figure 1.5.3. In this example, a column, bar or pie graph would make no sense.

Bar graphs are used when one set of results is discrete. For example, bar graphs would be a good way of showing the way bounce height changed when the type of ball or type of surface was changed.

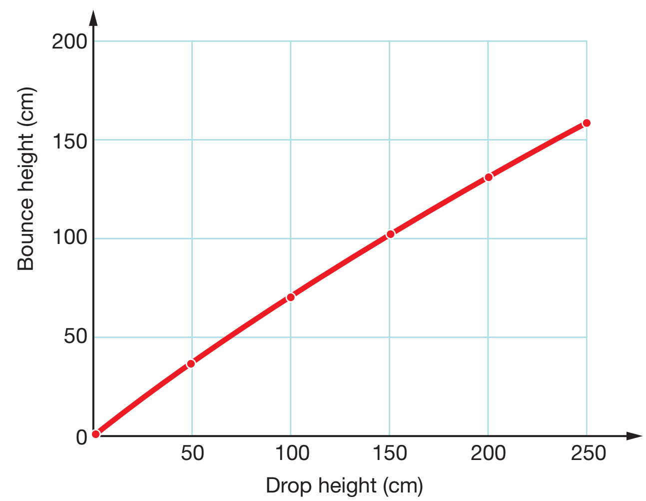


Figure 1.5.3 Two sets of measurements require a line graph.

Your conclusion

Your conclusion must answer the purpose or aim of your experiment. Depending on what you tested, an appropriate purpose and conclusion would be:

Purpose: To test what increasing drop height does to bounce height.

Conclusion: Increasing drop height causes bounce height to increase.

1.9
Prac 1 p. 38

1.5 Unit review

Remembering

1 **Recall** variables by matching the different terms with their definitions.

Dependent variable	Kept the same
Independent variable	Changed during the experiment
Controlled variable	What you are measuring

2 In the science4fun activity on page 34, sharp pencils were stabbed into a plastic bag full of water. For this activity, **state**:

a an aim
b a hypothesis.

3 **List** variables that are likely to affect the:

a amount of sugar that will dissolve in a cup of tea
b number of visitors to a swimming pool
c growth of a plant
d time taken to cook a potato
e number of times you go to the toilet in a day.

Understanding

4 **Explain** why only one variable should be changed in any single experiment.

5 **Explain** why you should try to collect five or more results in an experiment.

6 Georgie heard an old tale that if you want an avocado to ripen quickly, then it should be placed in a brown paper bag with a banana. She thought this sounded weird and wanted to see if it was true. **Describe** in detail how she could test if the tale was true or not.

Applying

7 **Identify** which of the following sets of drop heights would give the best idea of what happens when drop height is increased. N

A 10 mm, 20 mm, 30 mm, 40 mm, 50 mm
B 5 cm, 10 cm, 15 cm, 20 cm, 25 cm
C 50 cm, 100 cm, 150 cm, 200 cm, 250 cm
D 10 m, 20 m, 30 m, 40 m, 50 m

8 **Identify** likely aims that would have led to these conclusions.

a Tennis balls bounced best on concrete. They did not bounce as well on short grass and bounced poorly on long grass.
b Superballs bounced best, followed in order by tennis balls and volleyballs. Squash balls were the worst bouncers.

9 **Identify** the variables that are likely to affect the amount of detergent froth produced when washing the dishes.

Evaluating CCT

10 Bob ran an experiment on bouncing balls and recorded the following results.

Ball	Surface	Drop height (cm)	Bounce height (cm)
Tennis	Sand	30	1
Squash	Concrete	300	30
Golf	Gravel	100	5
Volleyball	Grass	50	10

On the basis of his results, he claimed that squash balls bounced better than tennis balls.

a **State** the dependent variable that Bob tested.
b **Identify** how many variables Bob changed during the experiment.
c **Assess** whether the experiment was a fair test.
d Do you agree with Bob's conclusion? **Justify** your answer.

Creating CCT

11 For the experiment in question 9 or 10, **design** an experiment that would test a single variable.

Inquiring

Scientific investigations are regularly reported in the newspaper, on websites and in scientific magazines such as *Cosmos* and *Scientific American*. Find an article that discusses a scientific investigation and:

- give the names of the scientists involved
- summarise what they found out.

Present your information in whichever way you choose.

1.5 Practical investigations

STUDENT DESIGN

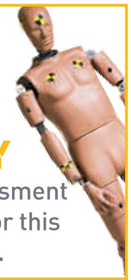
1 Planning your own investigation

Purpose

To design and run an experiment that tests a single variable.

Materials

Choose your own, depending on your choice of topic.



SAFETY
A Risk Assessment is required for this investigation.

Procedure

1 List the variables that are likely to affect the:
- bounce height of a ball
- amount of sugar that can be dissolved in a cup of tea
- adhesive strength of sticky-tape
- stretch of an elastic band or another elastic material such as stockings
- strength of paper.

2 Choose ONE of the above topics and design an experiment that will test ONE of its variables. In your workbook, write a hypothesis that describes what you expect when you change that variable. For example, 'We expect that a tennis ball will bounce higher than a soccer ball when dropped from the same height.'

3 Write your procedure in your workbook.

4 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

Construct a table and a graph (column, bar or line graph) to display your results.

Practical review

1 a **Construct** a conclusion for your investigation.
b **Assess** whether your hypothesis was supported or not.

2 **Construct** a scientific report describing what you did in your prac. In it, you should include a:
a table of results
b graph.

3 **Identify** other variables that would affect your experiment.

1 Chapter review

Remembering

1 **Name** the branch of science that studies:
- **a** living things
- **b** chemicals
- **c** forces and energy
- **d** the mind
- **e** the Earth
- **f** space
- **g** the environment.

2 **State** two metric units commonly used for:
- **a** distance
- **b** volume
- **c** mass.

3 **State** which abbreviation is correct for these units.
- **a** degrees Celsius
  - **A** deg C **B** deg
  - **C** °C **D** C
- **b** seconds
  - **A** sec **B** secs
  - **C** S **D** s

4 **State** one qualitative and one quantitative observation for each of:
- **a** a can of soft drink
- **b** yourself.

Understanding

5 **Define** the following terms: L
- **a** meniscus
- **b** cross-section
- **c** hypothesis
- **d** variable.

6 **Describe** the features of a safety flame.

7 **Explain** why the senses of taste and smell are rarely used in science.

Applying

8 **Identify** the equipment in these jumbled words. L
- **a** kaeber
- **b** aluspat
- **c** burccile

9 **Identify** the best SI unit to measure the: N
- **a** time to run the 100 m sprint
- **b** mass of a car
- **c** volume of water in a sink.

10 **Identify** which of the following statements are observations, which are inferences and which are predictions.
- One Olympian is bigger than the other.
- The bigger Olympian will win the event.
- One will lift a heavier weight than the other will.

11 **Identify** the best type of graph (bar, column, pie or line) from the clues below.
- **a** It shows percentages.
- **b** It has two sets of measurements.
- **c** It has discrete groups along its bottom, horizontal axis.
- **d** It has discrete groups along its vertical axis.

Analysing

12 **Classify** the following observations as qualitative or quantitative.
- **a** The cow went 'moo'.
- **b** The car was travelling at 60 km/h.
- **c** The Swans won by 25 points.
- **d** The Sea Eagles won by a lot.

Evaluating CCT

13 **Propose** reasons why the Bunsen burner gas must be turned on after the match is lit.

14 **a** **Determine** whether you can or cannot answer the questions on page 1 at the start of this chapter.
- **b** **Assess** how well you understand the material presented in this chapter.

Creating CCT

15 **Use** following ten key words to **construct** a visual summary of the information presented in this chapter.

laboratory	equipment
experiment	safety
observations	measurements
units	quantitative
variables	qualitative

1.10

Thinking scientifically

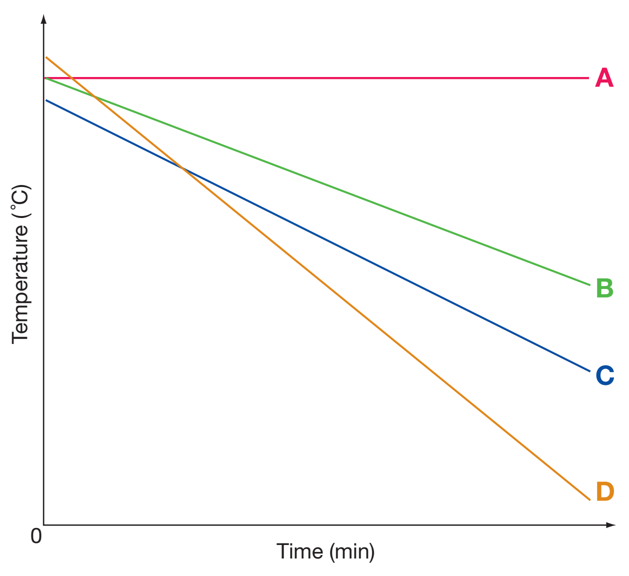
The Three Bears returned home and found someone had been eating their porridge. Being scientific bears, they were interested in how fast different-sized bowls cooled. They filled them with hot porridge and measured the temperature every minute. Their results are shown in the table.

Time (min)	Temperature of Papa Bear's porridge (°C)	Temperature of Mama Bear's porridge (°C)	Temperature of Baby Bear's porridge (°C)
0	60	58	61
1	55	48	50
2		39	48
3	45	31	30
4	40		20
5	35	18	10

Q1 Identify which bowl cooled the fastest. CCT

A Papa Bear's
B Mama Bear's
C Baby Bear's
D Not enough information to decide

Mama Bear then sketched line graphs to show what was happening. These are shown below.



Q2 Identify which of the above graphs most likely represents: CCT

a Papa Bear's bowl
b Mama Bear's bowl
c Baby Bear's bowl.

Q3 Identify which of the following variables are *unlikely* to have much effect on the cooling of the porridge. CCT

A size of bowl
B amount of porridge
C amount of sugar in porridge
D starting temperature of porridge

Q4 Baby Bear misread his thermometer once. Identify which of his readings is probably wrong. CCT

A 50°C
B 48°C
C 30°C
D 20°C

Q5 Papa Bear forgot to read his thermometer once. Identify the most likely missing temperature. CCT

A 31°C
B 53°C
C 50°C
D 18°C

Q6 Mama Bear also forgot to read her thermometer. Identify the most likely missing temperature. CCT

A 30°C
B 24°C
C 20°C
D 18°C

Glossary

Unit 1.1 L

Astronomy: the study of space

Biology: the study of living things

Branches: sub-groups of science. Also known as disciplines

Chemistry: the study of chemicals and their reactions

Disciplines: sub-groups of science. Also known as branches

Ecology: the study of the environment

Geology: the study of Earth

Physics: the study of forces and energy

Psychology: the study of behaviour

Psychology

Unit 1.2 L

Bunsen burner: used in the laboratory to provide heat

Cross-section: split down the middle

Hotplate: heating device

Laboratory: where a scientist works

Mass: amount of matter

Meniscus: curved surface of liquids in narrow tubes

Safety flame: yellow flame

Toxic: poisonous

Bunsen burner

Unit 1.3 L

Experiment: a scientific test

Inference: logical explanation

Observation: what is seen, heard, smelt, felt, tasted

Practical investigation: experiment

Prediction: what might happen

Qualitative observations: observations in words only

Quantitative observations: measurements including numbers

Unit 1.4 L

Aim: what you are trying to do

Analysis: looking for trends in the results

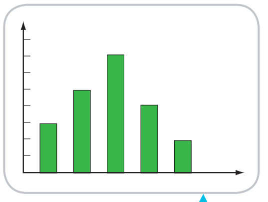
Bar graph: used when one set of observations is discrete. Bars are horizontal

Column graph: used when one set of observations is discrete. Columns are vertical

Conclusion: what you have found out

Discussion: analysis

Hypothesis: educated guess

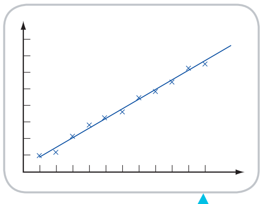


Column graph

Line graph: used when there are two sets of continuous measurements

Method: tells how you did the experiment

Pie graph: used to show proportions. Also known as a sector graph



Line graph

Procedure: tells how you did the experiment

Purpose: aim

Results: the measurements and observations made in an experiment

Sector graph: used to show proportions. Also known as a pie graph

Unit 1.5 L

Controlled variables: held constant throughout an experiment

Dependent variable: will change naturally as you change the other variables

Fair test: changing only one variable at a time

Independent variable: what you change in an experiment

Variables: factors that influence an experiment

2 Properties of substances

Have you ever wondered...

- why solids, liquids and gases appear so different?
- why clothes dry even when it's not hot?
- why you breathe out fog on a cold morning?
- why icebergs float?

After completing this chapter students should be able to:

- describe matter in terms of particles
- outline how particle movement is related to energy
- use the particle model to predict what happens when different states of matter are heated or cooled
- explain how the physical properties of matter change during changes of state
- explain density in terms of the particle model
- identify the benefits and limitations of using models to explain solids, liquids and gases CCT

ADDITIONAL

- research how Aboriginal and Torres Strait Islander peoples use the physical properties of natural materials in everyday life AHC
- investigate how the chemical properties of a substance affect its use
- explain how gas pressure is related to the frequency of particle collisions
- outline historical developments that have advanced our understanding of the particle model.

2.1 Physical and chemical properties

There are millions of different substances in the world. Each can be identified by its properties. Properties describe a substance and how it acts. They include its appearance, what it does when heated or cooled, and how it reacts with other substances.

INQUIRY science 4 fun

What is foam?

YES

Is shaving foam a solid, a liquid or a gas?

Collect this …

- can of shaving foam
- plate (not paper)
- small mass (such as a 50c coin or a pebble)

Do this …

1. Squirt a blob of shaving foam onto the plate. What does it look like? Does the foam flow or change shape without being pushed around?
2. Place the small mass on the top of the foam. Does it stay there or does it sink?
3. Squirt another blob of foam onto the plate. Put the plate into a cupboard so that it won't be touched. Leave it there overnight. What does the foam look like the next day?

Record this …

Describe what happened.

Explain why you think it happened.

Physical properties

You can probably tell which objects and substances around you are solid, liquid or gas by the way they look and act. What you see are **physical properties**. Testing a substance for its physical properties doesn't destroy the substance, or change it into anything new.

Some of the most useful physical properties of a substance are:

- whether it's a solid, liquid or gas at room temperature (normally taken as 25°C)
- the temperatures at which the substance freezes or boils (known as its freezing point and boiling point)
- its appearance (such as its colour and texture, the shape of any crystals within it and whether it is shiny or dull)
- its density (how heavy it is compared to other substances of the same size)
- how hard or brittle the substance is (whether it is easily scratched or whether it crumbles)
- whether the substance dissolves in different liquids (known as solubility)
- its ability to let heat or electricity pass through it (known as its thermal and electrical conductivity).

Solids, liquids and gases

Substances exist in either solid, liquid or gaseous form. These forms are known as the **states** (or phases) of matter.

Solids, liquids and gases have very different physical properties. Think of the van in Figure 2.1.1. The bodies of cars and vans only change shape when they are in an accident or when they are broken up to be recycled. Also solids cannot be **compressed** (squashed to make them smaller). Try to compress a sugar cube and it might crumble, but the volume of sugar is exactly the same as it was before. The fact that solids do not change shape or size allows them to be used to build structures.

Liquids are similar to solids in that they don't change their size and are **incompressible** (unable to be compressed or squashed). They differ from solids in that they can flow and change shape. Think of orange juice: it splashes about and can be poured from one container into another, taking on a new shape as shown in Figure 2.1.2. The ability of liquids to squeeze along pipes and hoses without changing volume allows them to be used in hydraulic (powered by liquid) systems such as car brakes.

No teardrops!

SciFile

The shapes of raindrops change as they change size. None of them looks like the teardrops shown in the weather report!

Diameter (mm)	Less than 1	1 to 2	2 to 4.5	Bigger than 4.5
Shape				

Solids:

- have a fixed shape
- have fixed size and volume
- cannot be compressed (pushed in to make it smaller)
- will usually sink when placed in liquids of the same material.

Figure 2.1.1 The bodies of cars and vans are solid. They don't change shape or size unless they are in an accident or they are crushed to be recycled.

Liquids:

- have fixed size and volume
- are able to flow
- take the shape of the bottom of the container they are in
- are incompressible (not able to be compressed).

Figure 2.1.2 Liquids always flow to take up the shape of their container.

Gases are often invisible and many have no **odour** (smell). Water vapour is a gas that is invisible because it is colourless and its particles are spread too far apart for the gas to be seen. However, you can feel water vapour since it gives air its humidity. There is a lot of water vapour in the air on a humid day, making you feel sweaty and sticky. Figure 2.1.3 shows a mixture of gases that does have a smell.

Gases differ from solids and liquids in that they can be compressed. This property allows gases to be squeezed into small volumes such as barbecue gas cylinders. It also makes them useful in the gas struts or shock absorbers found in the suspension of bikes and cars. A bump compresses the gas in the struts, softening the impact of the bump. The gas then expands once more, pushing the strut back to its original shape.

Prac 1 p. 50
Prac 2 p. 51

Gases:
- are often colourless and invisible (you may be able to detect their smell)
- will spread out to take the shape of the container
- have no fixed shape or volume
- can be compressed (pushed in to make them take up a smaller amount of space).

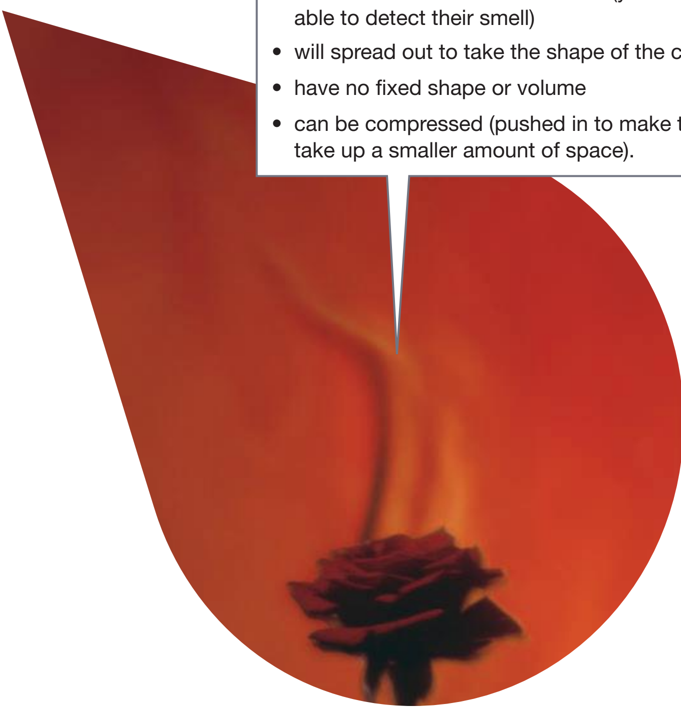


Figure 2.1.3 Perfume, smells, vapours and fumes are all gases. This image shows the gaseous perfume rising from a rose.

SciFile

The fourth state

There is a fourth state of matter but it is very rare on Earth. **Plasma** is a gas-like state that only exists at temperatures above 6000°C, making it common on stars but not here.

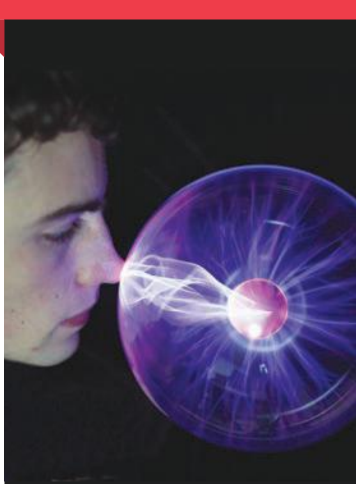


Figure 2.1.4 On Earth, plasma is found wherever high-voltage sparks are generated such as lightning bolts or in this plasma sphere.

2.1

Chemical properties

Chemical properties describe how a substance reacts with other substances. A new substance is formed in the process, often with very different properties. For example, iron rusts because it combines with oxygen and water. Iron is grey, hard and often shiny, while the rust it forms is red-orange, flaky and brittle. Likewise, paper burns and dynamite explodes, leaving behind ash and smoke.

Chemical properties that are worthwhile knowing about are whether a substance:

- burns or explodes in oxygen (this is known as combustion)
- rusts or corrodes (known as corrosion) or is corrosion-resistant
- is an acid like vinegar or a base like bicarbonate of soda or neither (this is measured by its pH)
- reacts quickly or slowly with other chemicals (this is known as the rate of reaction). Explosions like the one in Figure 2.1.5 have a very fast rate of reaction.

Figure 2.1.5 The chemical properties of LPG and petrol cause them to explode when there is plenty of oxygen and a flame or spark to start it off.

Choosing the right substance

The different properties of substances affect how they are used. For example, the frame of a skyscraper needs to be solid and strong and so is commonly made out of steel. Shopping bags are made of plastic, paper or fabric because they need to be cheap, light, strong and flexible. Likewise, takeaway food containers are often made of polystyrene because it's light and keeps the heat in.

Sometimes liquids or gases will be a better choice than solids. For example, car brakes only work because liquid is pumped through tubes to activate them, while a gas (air) is used to keep a jumping castle in shape. Imagine if the jumping castle shown in Figure 2.1.6 was filled with lead!

Figure 2.1.6 The walls and floor of a jumping castle need to be solid and strong but also smooth and flexible. Inside is a gas (air) that can compress when you jump on it but which will expand as soon as you jump to another spot.

INQUIRY science 4 fun

The mass of a gas

Does gas have mass?

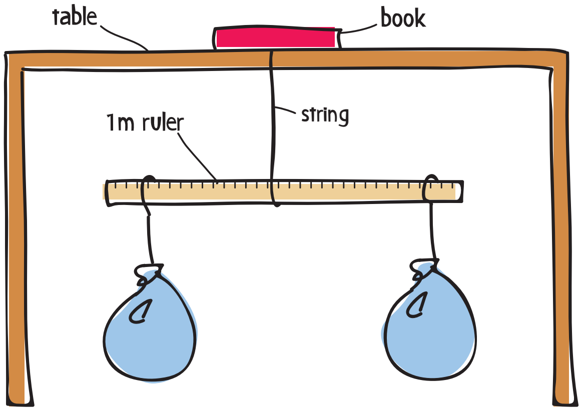
YES

Collect this ...

- 2 balloons
- 3 lengths of string (each about 30 cm long)
- 1 m ruler
- needle (sharp enough to burst a balloon)

Do this ...

1. Inflate both balloons until they are roughly the same size.
2. Tie their ends and tie a piece of string to the top of each balloon.
3. Tie one balloon to one end of the ruler and the other balloon to the other end as shown in the diagram. Use the ruler markings to make sure that the strings are the same distance from the ends of the ruler.
4. Tie the third string to the middle of the ruler and hang the ruler from the edge of a table.
5. Balance the ruler so that it hangs parallel to the floor. Do this by sliding the middle string along the ruler until you find the balance point.
6. Puncture *one* of the balloons with the needle and observe what happens.



Record this ...

Describe what happened.

Explain why you think this happened.

LEARNING ACROSS THE CURRICULUM

SUSTAINABILITY

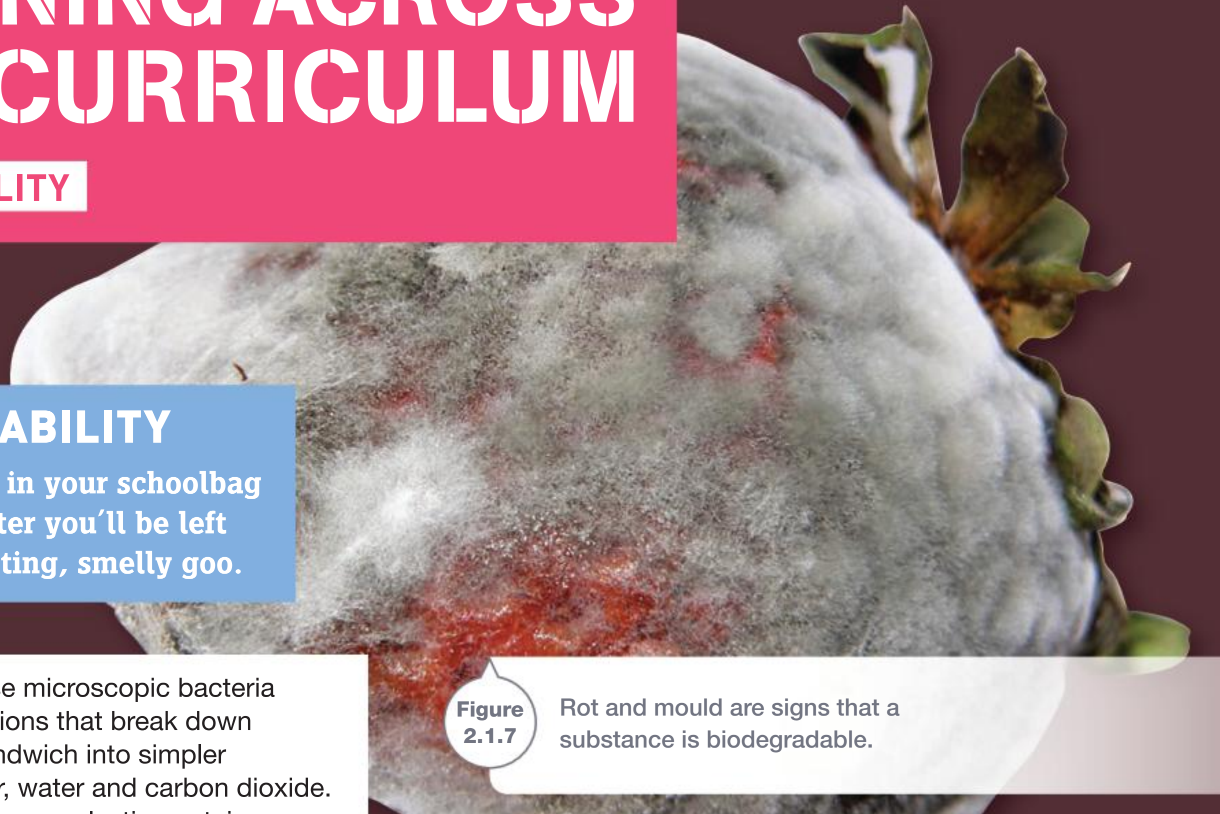


Figure 2.1.7 Rot and mould are signs that a substance is biodegradable.

BIODEGRADABILITY

Leave a sandwich in your schoolbag and a few days later you'll be left with a mess of rotting, smelly goo.

This happens because microscopic bacteria cause chemical reactions that break down substances in the sandwich into simpler substances like sugar, water and carbon dioxide. However, the cling wrap or plastic container holding the sandwich is unlikely to have changed. The chemical properties of the bread, lettuce and tomato caused them to rot, while the chemical properties of the cling wrap or plastic gave them rot-resistance.

BIODEGRADABLE

Substances are classified as being **biodegradable** if bacteria or fungi break them down. Fruit, vegetables, flowers, wood, twigs and leaves are biodegradable since they all break down quickly. This is why they are put into composts: they break down, forming simple substances that can then be used to fertilise other plants. The mould on the strawberry in Figure 2.1.7 shows that it is biodegradable. Animals are biodegradable because bacteria quickly break them down into simpler substances once they die.

Anything made of natural, living substances (or from substances that once lived) is usually biodegradable too:

- paper and cardboard (made from wood)
- cotton, hessian, linen fabrics (made from plants)
- woollen fabrics (the 'hair' of animals like sheep and goats)
- soaps (made from natural fats and oils).

NON-BIODEGRADABLE

Non-biodegradable substances eventually break down but often take hundreds of years to do so. Non-biodegradable substances have structures that bacteria and fungi cannot pull apart. Even though most plastics are made from a long-dead natural substance (crude oil), their structures are too different from the structures of living substances for them to be biodegradable. Other non-biodegradable substances are:

- polyethylene cling wrap (used to wrap sandwiches)
- most plastic shopping bags
- wrappers (used for lollies, chocolate bars and ice-creams)
- polystyrene (used for takeaway food)
- house paints
- glass (used for soft-drink and sauce bottles)
- metal cans (used for soft-drinks and canned spaghetti).

Anything made from these substances remains in the environment as rubbish and pollution for many, many years. They might crush, break or rip into smaller pieces, but their chemicals are still there polluting the environment for a long time.

Figure 2.1.8 Most plastics are non-biodegradable but many can now be recycled. This reduces waste and stops their chemicals from polluting the environment.

WHAT CAN WE DO?

Most non-biodegradable substances can be burnt but they release toxic (poisonous) fumes and smoke unless the fire happens in special incinerators at extremely high temperatures. Some (like glass bottles and plastics like PET) are able to be recycled (Figure 2.1.8). However, most non-biodegradable substances are simply thrown out. To minimise the impact of non-biodegradable substances on the environment, we all need to:

- use biodegradable packaging whenever possible, and buy food with no packaging or wrapped in paper or cardboard
- recycle or dispose of non-biodegradable packaging in bins, so that it will not end up on the street, rivers and oceans where it may catch and tangle fish, dolphins and birds like the one in Figure 2.1.9
- recycle glass, PET bottles and other plastics wherever possible
- re-use plastic shopping bags or use paper or re-useable cloth bags instead.

Scientists have developed biodegradable plastics from plant-based substances but these plastics are more expensive than similar oil-based plastics. They can't be recycled and cannot be used for long-term packaging. For these reasons, their use is not yet widespread.

Figure 2.1.9 Most plastic bags are non-biodegradable and so they don't rot away. If they get washed into rivers and the ocean, wildlife like this bird can get caught up in them and can die.

REVIEW

1 **List** four biodegradable and four non-biodegradable substances.

2 **Describe** the evidence that shows that fruit and cardboard are biodegradable.

3 A log in the forest grows mushroom-like fungi on it.

  a **Use** this information to **classify** the log as biodegradable or non-biodegradable.

  b **Predict** what will be left of the log after 10 years.

4 **Classify** faeces (poo) as biodegradable or non-biodegradable.

2.2

2.1 Unit review

Remembering

1 **State** an alternative term for *states of matter*. L

2 **List** the three states of matter commonly found on Earth.

3 **State** whether the following are solids, liquids or gases.
   a a sugar cube
   b ink
   c air

4 **List** the different states in which different substances exist in the following mixtures.
   a soft drink
   b chicken curry
   c mud

5 **List** two physical properties and one chemical property of a sheet of paper.

6 Shaving foam cannot be classified as a solid or a liquid because it has some of the physical properties of both. **List** the physical properties of shaving foam that could be used to classify it as:
   a a solid
   b a liquid.

Understanding

7 a **Explain** why plasma is usually found in stars but rarely on Earth.
   b **Describe** the conditions on Earth that are required for plasma to form.

8 **Define** the terms: L
   a compressed
   b incompressible
   c odour.

9 **Explain** how the compressibility of gases makes them ideal for using in shock absorbers in the suspension of cars and bikes.

10 a **State** what causes humidity.
   b **Describe** what a humid day feels like.

Applying

11 It is easier to list the physical properties of a substance than its chemical properties. **Use** an example to **explain** why.

Analysing

12 Each of the following substances displays some properties of both liquids and solids. **Analyse** the properties of each substance and **use** them to **classify** it as solid or liquid.
   a sand
   b toothpaste
   c hair gel

Evaluating CCT

13 Inspect the apparatus shown in the science4fun activity on page 46. Two balloons full of air are balancing on a metre ruler.
   a **Predict** what will happen when one of the balloons is punctured.
   b **Justify** your prediction.

14 Liquids flow to take up the shape of their container but on a surface they sometimes form small droplets instead. **Propose** a reason why the liquid doesn't spread across the surface.

Inquiring

ADDITIONAL

Aboriginal and Torres Strait Islander peoples have long used the physical properties of the natural materials around them to create items used in their everyday life. Research some of these materials. Some you might look at are: AHC

- waxes and resins used as glues
- saps, barks, oils, leaves and fruit used for bush medicine
- bark, timber, leaves and fronds used for utensils, shelter and housing
- plant fibres and animal sinews used for string and rope
- stones, bones, shells, teeth, branches and roots used for tools, weapons and utensils
- stalks and leaves used for weaving baskets.

Whatever materials you research, find:

- an image or video of the material being used
- how their physical properties makes them ideal for their particular uses
- whether the use of the material was restricted to a particular region or is/was used Australia-wide.

Present your research as a PowerPoint presentation. ICT

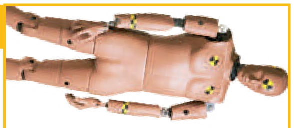
ADDITIONAL

2.1 Practical investigations

1 Slime

Purpose
To make slime and observe its properties.

Materials
Note: PVA tends to change consistency depending on the brand chosen and its age. The quantities of PVA and borax shown below may need to be altered slightly depending on the brand of PVA used.



SAFETY
Borax may irritate if it is inhaled or it gets into the eyes or on the skin. Wear safety glasses and rubber gloves at all times.

- 10 mL 4–6% borax solution
- 25 mL PVA glue
- a few drops of food dye

- eye dropper/Pasteur pipette
- disposable medicine measuring cup
- 10 mL measuring cylinder
- 2 disposable plastic cups
- icy-pole stick
- disposable rubber gloves

Procedure
1. Use the measuring cylinder to measure out 10 mL of borax solution.
2. Use the disposable medicine measuring cup to measure out 25 mL of PVA glue.
3. Pour the PVA into a disposable plastic cup, using the icy-pole stick to scrape out the last bits.
4. Add a few drops of food dye to the PVA.
5. Pour the borax solution, all at once, into the cup containing the PVA and food dye. Stir thoroughly with the icy-pole stick.
6. Empty out the slime and rinse it gently under a slow-running tap.
7. Test your slime to find:
   - if it can be rolled into a ball
   - what happens when it is stretched
   - whether it flows to take the shape of a container
   - what happens when it is dropped.

Results
Record your results in a table like that shown below.

Practical review
1. **List** the physical properties of your slime.
2. **Use** the physical properties of solids and liquids to **classify** your slime as solid or liquid.
3. **Justify** your classification.

Investigation	Observation	Is this property more like that of a solid or a liquid?
Can slime be rolled into a ball?		
What happens when slime is stretched?		
Does slime flow to take the shape of its container?		
What happens when a ball of slime is dropped?		

STUDENT DESIGN

2 Oobleck

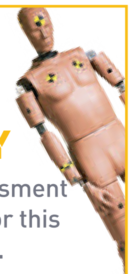
Oobleck is an easy-to-make slimy goo.

Purpose

To find a recipe for oobleck and then to make some.

Materials

To be selected by students.



SAFETY
A Risk Assessment is required for this investigation.

Procedure

1. Search the internet to find recipes or videos that show how to make oobleck. Print or save the recipe and save any video you find.
2. Summarise the main points of the recipe or video and write them in your workbook as your procedure.
3. Before you start making your oobleck, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.
4. Once you have made your oobleck, test it by:
   - hitting it with your fist (or prodding it with your finger if you have only a small amount)
   - slowly lower your hand (or a finger) into it
   - quickly remove your hand (or finger) from it.
   - running the tests that were performed on slime in Prac 1.

Results

Record your results in a table like that used in Prac 1.

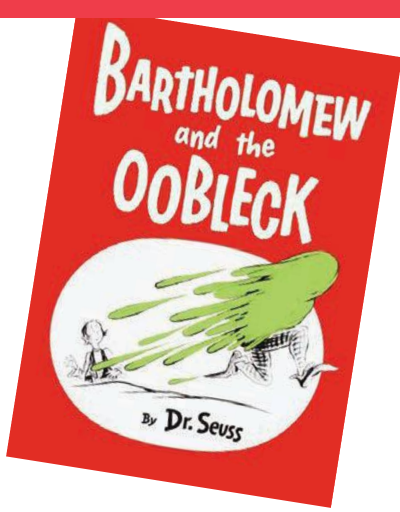
Practical review

1. **List** the properties of your oobleck that belong to:
   a. liquids
   b. solids.
2. Oobleck is classified as a 'non-Newtonian' fluid. **Use** the properties found in this investigation to **describe** a non-Newtonian fluid.

The Oobleck of Dr Seuss

SciFile

In the book *Bartholomew and the Oobleck* by Dr Seuss, a king is so bored with ordinary weather that he instructs his wizard to create something new. A green goo called oobleck soon falls from the sky, gumming up the whole kingdom!



Running on wet sand

SciFile

The wet sand at the edge of the sea has many of the physical properties of a solid and a liquid. Run across the sand and it firms up and becomes more solid under your feet. However, walk across and it liquefies and you sink into it. For this reason, wet sand is given a special classification as a non-Newtonian fluid.

2.2 Solids, liquids and gases

Each of the states of matter has its own characteristic properties that can be explained using a simple model called the particle model.

INQUIRY science 4 fun

Get packing

YES

Collect this …

- 1 cup uncooked rice
- plastic or glass container (with lid)
- small ball that will fit in jar (such as a squash ball or ping-pong ball)

Do this …

1. Pour uncooked rice into your container until it is half to three-quarters full.
2. Push the ball under the rice.
3. Put the lid on and shake the container jar sideways (not up and down).

Record this …

Describe what happened.

Explain why you think this happens.

Models in science

Scientists often use models to test or explain something that is difficult to understand. Sometimes, the model will be a physical model like the one shown in Figure 2.2.1. These models are commonly used by scientists and engineers to test how something acts under certain conditions. For example, a model could be used to test how a building withstands an earthquake, how a car crumples in an accident or how a landscape will be changed by a flood.

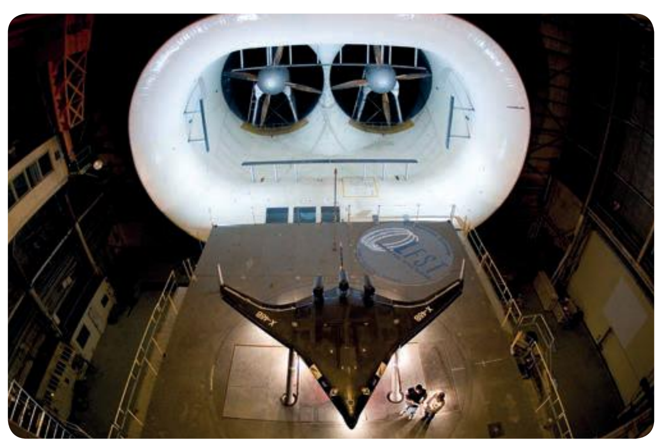


Figure 2.2.1 Engineers use models and wind tunnels to test how new aircraft perform at high speeds. Problems can then be fixed before an expensive full-size aircraft is built.

Analogies

The heart is often compared with a water pump. This simple type of model is known as an 'analogy'. An analogy uses a common, everyday thing to help us understand how something that is complicated works. Likewise, a computer is sometimes used as an analogy for the brain.

Thought models

Models can also be 'thought' models. 'Thought' models help scientists imagine objects and events that are difficult to understand. This might be because the object or event is incredibly large. For example, the universe is so huge that it is difficult to imagine how it is arranged and how it began. For this reason, 'thought' models have been developed for our solar system and the Big Bang, the event which started the whole universe off around 13 billion years ago (Figure 2.2.2).

Thought models are also helpful when you are trying to understand incredibly tiny things and what they do. For example, scientists and doctors use a model to explain how microscopic bacteria or viruses (germs) spread from one person to another during a disease outbreak.

Good scientific thought models are always supported by lots of scientific observations and evidence. Bad thought models are often quickly dismissed because they don't have much real science behind them!

Figure 2.2.2 A computer artwork showing a 'thought' model that describes the evolution of the universe from the Big Bang to now.

The particle model

The **particle model** is a 'thought' model that attempts to explain the properties of substances.

In the particle model, all substances are thought to be made of incredibly small, hard, spherical balls called particles. Each ball has energy and moves according to how much energy it has. If a particle has lots of energy, then it will move about a lot. If the particle has very little energy, then it will be sluggish and move about slowly. You add energy to a substance whenever you heat it. This causes the particles to move about more, and faster. If you cool a substance, then the reverse happens: the particles move about less and move more slowly.

The particle model assumes the following:

- All substances are made up of tiny, hard particles that are too small to see even with a normal microscope.
- The particles always have energy and are moving.
- The particles move about more and move faster as temperature is increased.
- vcloser the particles are to one another, the stronger the attraction between them.

SciFile

Colder than cold

As a substance is cooled, energy is removed from its particles, making them vibrate less and less. Eventually they have no energy at all and all vibrations stop. This happens at a temperature of **absolute zero** (–273°C). The particles can't move any slower and so absolute zero is the lowest temperature that is possible.

Explaining solids

In solids the particles are closely packed in fixed positions. Forces between neighbouring particles form **bonds** that hold all the particles in the solid closely together. The particles in a solid have energy and jiggle about as shown in Figure 2.2.3. The particles don't break out of position but just **vibrate** about on the spot. If you increase the temperature, the particles have more and more energy and so they vibrate about more and more.

Table 2.2.1 shows how the physical properties of solids are explained by the particle model.

Figure 2.2.3 The particles in a solid are closely packed together and just jiggle about on the spot.

Table 2.2.1 How the particle model explains the physical properties of solids

Property of solids	How the particle model explains it
Solids have a defined shape (they do not flow).	The particles in solids are strongly bonded to their neighbours, fixing their positions.
Solids are incompressible.	The particles in a solid cannot be pushed closer to each other because they are so closely packed that there is almost no space between them.
Solids expand when heated and contract when cooled.	Heating causes the particles in a solid to vibrate faster, making them spread further apart and causing the solid to expand. Cooling slows down vibrations and the opposite happens.

SciFile

An exception to the rule

Water is an odd substance in that it expands when it cools to form ice, and contracts when ice melts to form liquid water.

Explaining liquids

In a liquid, the particles are still packed closely together but they are far more loosely bonded (joined) to their neighbours than the particles are in a solid. This is shown in Figure 2.2.4. The loose bonding allows the particles to move about and over each other, allowing the liquid to flow, drip and fill the bottom of whatever container it is in. As the liquid is heated, this movement gets faster.

Table 2.2.2 shows how the particle model explains the properties of liquids.

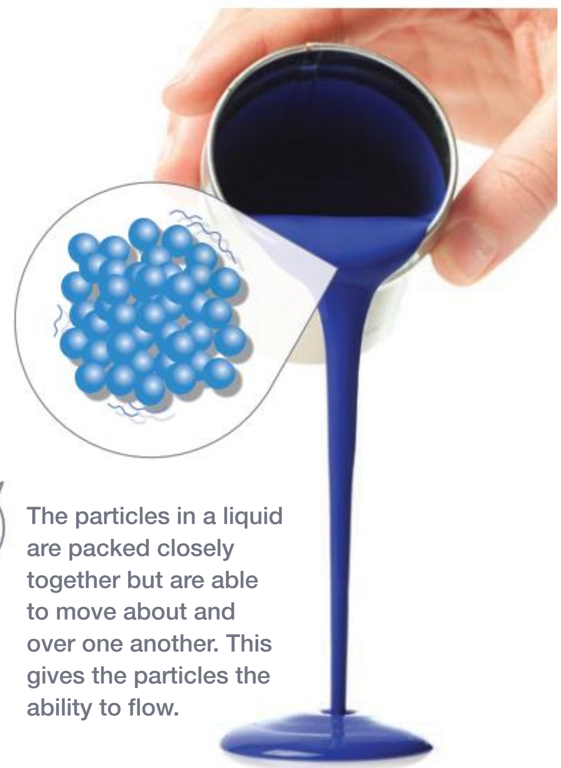


Figure 2.2.4 The particles in a liquid are packed closely together but are able to move about and over one another. This gives the particles the ability to flow.

Table 2.2.2 How the particle model explains the physical properties of liquids

Prac 1 p. 60

Property of liquids	How the particle model explains it
Liquids flow to take the shape of the bottom of their container.	Bonds are strong but loose enough to allow the particles in liquids to slip over one another.
Liquids are incompressible.	The particles in a liquid cannot be pushed closer to each other because they are so closely packed that there is almost no space between them.
Liquids expand when heated and contract when cooled.	Heating causes the particles in a liquid to move over each other faster, making them spread further apart and causing the liquid to expand. Cooling slows down this movement and the opposite happens.

Explaining gases

Gases have nothing holding their particles together. This lack of bonds allows the gas particles to travel randomly in straight lines until they hit something. The particles could hit other gas particles or the walls of the container they are in (as shown in Figure 2.2.5).

Table 2.2.3 shows how the particle model explains the properties of gases.

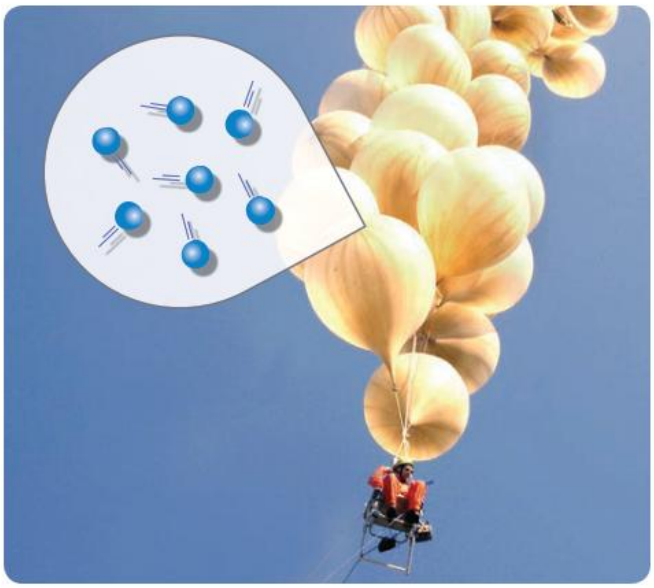


Figure 2.2.5 The particles in a gas are a long way apart and move fast and in straight lines. The particles only change direction when they hit the walls of their container or each other. In this case the gas is contained in balloons.

Prac 2 p. 61
2.3

Table 2.2.3 How the particle model explains the physical properties of gases

Property of gases	How the particle model explains it
Gases are often invisible.	Particles in a gas are spread so far apart that you cannot see the gas.
Gases can be compressed.	Particles in a gas are spread so far that there is plenty of vacant space between them. This space allows them to be pushed closer together.
Gases spread to fill their container.	There are no bonds between gas particles and so they are able to move unrestricted by other particles. They travel until they hit the walls of the container.
Gases expand when heated and contract when cooled.	Heating causes the particles in a gas to move faster, making them spread further apart and causing the gas to expand. Cooling slows down this movement and the opposite happens.

INQUIRY
science 4 fun

Pop the lid

Can pressure pop the lid of a soft-drink bottle?

YES

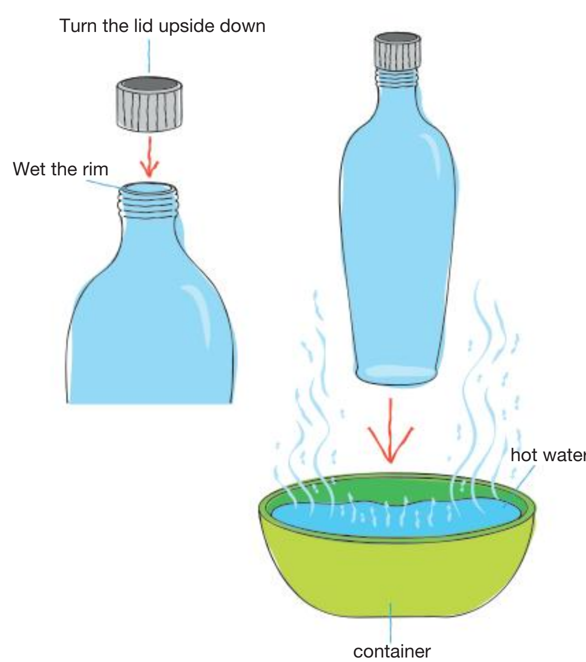
Collect this …

- hot tap water
- any size plastic soft-drink bottle with its lid
- any container a little bigger than the base of the soft-drink bottle

SAFETY
Be careful handling hot water.

Do this …

1. Remove the lid from the soft-drink bottle.
2. Run hot water from a tap into the container until it is about 5 cm deep.
3. Lightly wet the top of the lid and then place it UPSIDE DOWN on the bottle. It should stick slightly to it.
4. Carefully lower the soft-drink bottle into the container until the hot water reaches a few centimetres up the side of the bottle.



Record this …

Describe what happened.

Explain why you think it happened.

Pressure

Any gas particle that hits a wall will bounce off, giving the wall a little push as it does so. The combined push of all the gas particles bouncing off the walls of their container is known as the **pressure** of the gas.

Increasing pressure

The pressure of a gas can be increased by:

- forcing more gas into a particular space
- squashing the gas into a smaller space
- heating the gas up.

Forcing air into a balloon increases the pressure inside it by increasing the number of gas particles and the number of collisions with the walls of the balloon. This forces the balloon to expand (get bigger). The balloon keeps expanding until the pressure inside and outside the balloon becomes the same. This occurs when the gas inside the balloon is pushing the walls out with the same force as that of the outside air pushing the walls in. Forcing more air into the balloon causes the pressure to increase again and so the balloon expands once more. With each breath, the balloon will keep expanding until the rubber it is made of becomes so thin that it breaks.

A balloon has very flexible walls but the walls of the gas bottles shown in Figure 2.2.6 are not flexible. Forcing more gas into a gas bottle increases the pressure inside it. Sometimes, there is so much gas inside the bottle that the gas particles are pushed close enough to attract each other and form a liquid such as LPG (liquefied petroleum gas).

Figure 2.2.6 Gas bottles have rigid walls. Forcing more gas into them increases the pressure inside.

Heating a gas causes its particles to move faster. The particles collide harder with the walls and so pressure increases. A car engine uses the pressure of a hot gas to force its pistons downwards. As Figure 2.2.7 shows, petrol vapour is let into the cylinder and then an electrical spark causes it to explode. The gas formed by the explosion is now extremely hot and its pressure rams the piston downwards. This power is then transmitted to the car's driving wheels. The hot gas is then allowed to escape and the procedure repeats once more.

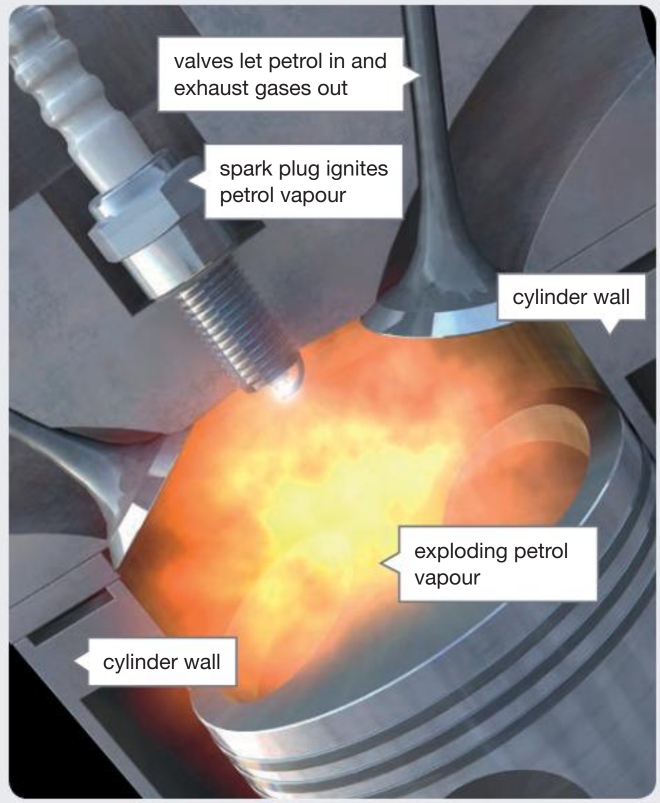


Figure 2.2.7 Heat from explosions increases the pressure of gases inside the cylinders of a car engine. This pressure forces the piston downwards and the power generated is used to get the car moving.

Decreasing pressure

Gas pressure can be reduced by reducing the amount of gas in a container, increasing the size of the container or by cooling the gas. For example, balloons, and car and bike tyres go 'flat' because the pressure inside has dropped so much that they cannot keep their shape. The reason is usually that a hole or leaky valve has allowed air to escape.

Prac 3 p. 61

LEARNING ACROSS THE CURRICULUM

CRITICAL AND CREATIVE THINKING

INDIRECT EVIDENCE AND PARTICLES

Scientists have long wondered what makes up substances. The ancient Greeks thought that all substances were built up from incredibly tiny particles that they called *atomos* (meaning indivisible). We now call these particles *atoms*.

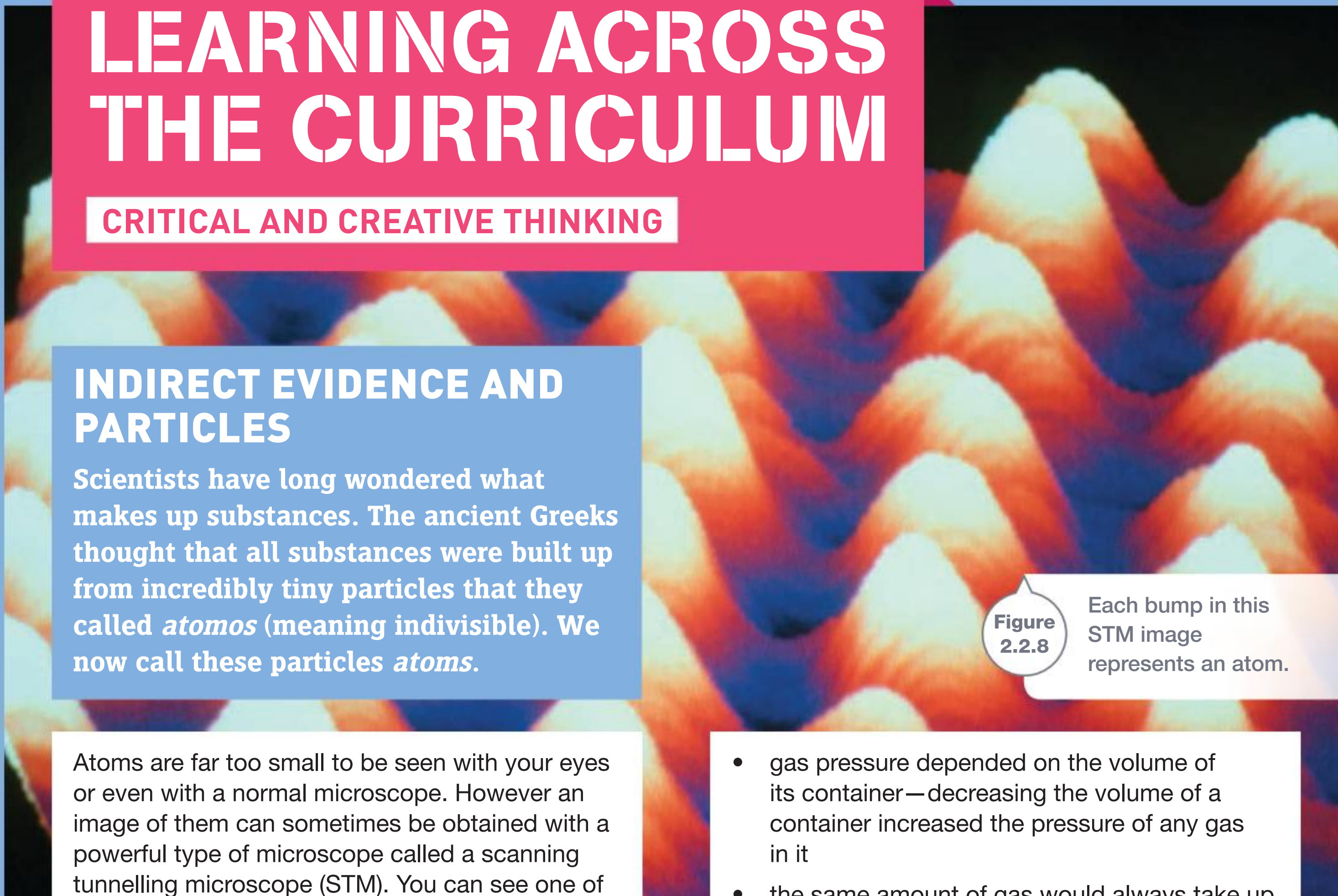


Figure 2.2.8 Each bump in this STM image represents an atom.

Atoms are far too small to be seen with your eyes or even with a normal microscope. However an image of them can sometimes be obtained with a powerful type of microscope called a scanning tunnelling microscope (STM). You can see one of these images in Figure 2.2.8.

Even before the invention of the STM, scientists had an extremely good idea that substances were made from tiny atom-like particles.

This is because you don't always need to see something to know that it exists. Observations indicated that, although they are 'invisible', atoms do exist. These types of observations are known as **indirect evidence**. You use indirect evidence every day: you know what you are having for dinner from smells coming from the kitchen, and you can often guess what's in a package by its weight and shape and the sounds it makes when shaken.

BEHAVIOUR OF GASES

During the 17th and 18th centuries, scientists including Robert Boyle, Amedeo Avogadro and Joseph Louis Gay-Lussac investigated how the pressure and volume of a gas were linked to the amount of gas and the temperature. They found that:

- gas pressure depended on temperature: an increase in temperature led to an increase in pressure
- gas pressure depended on the volume of its container—decreasing the volume of a container increased the pressure of any gas in it
- the same amount of gas would always take up the same volume under the same conditions regardless of what type of gas it was.

From these observations, the **gas laws** were developed. These laws use mathematics to predict what gases will do under different conditions. Most importantly, the laws were easily explained if it was assumed that gases were made of fast-moving, widely spaced particles with little or no attraction between them.

DIFFUSION

Perfume quickly spreads throughout the air of a room. Its smell gets weaker until eventually you can't smell it. This spreading process is called **diffusion**. In 1833, the Scottish chemist Thomas Graham used the idea of particles to explain how diffusion might work. Perfume particles are constantly moving and over time they will move through the gaps between the air particles. Likewise, the air particles will move through the gaps between the perfume particles. In this way, the two gases diffuse (mix and spread). The process also happens when two liquids are mixed. This is shown in Figure 2.2.9 on page 58.

Figure 2.2.9 This coloured liquid is easily seen as a twisting ribbon of orange when first added to water but soon diffuses throughout it. Cordial diffuses through water in a similar way, spreading its colour and flavour throughout.

BROWNIAN MOTION

Some of the most convincing indirect evidence for particles came from the work of the Scottish botanist Robert Brown. In 1827, Brown was using his microscope to study tiny pollen grains that were floating on some water. He expected the pollen grains to be still but they were moving about, as if being jostled about by something in the water. His sketches of their motion are shown in Figure 2.2.10. Brown could not explain what was happening and it was 1905 before Albert Einstein explained it: 'invisible' particles in the water were constantly moving about, colliding with the pollen grains and pushing them around as they did so.

Brown was not the first to notice this type of motion. In 1785, Jan Ingenhousz had observed similar movement in coal dust suspended in alcohol, and the ancient Roman Lucretius wrote in around 60 BCE of dust particles jiggling about in a beam of sunlight. You may have already noticed something similar. This jiggling eventually became known as **Brownian motion**.

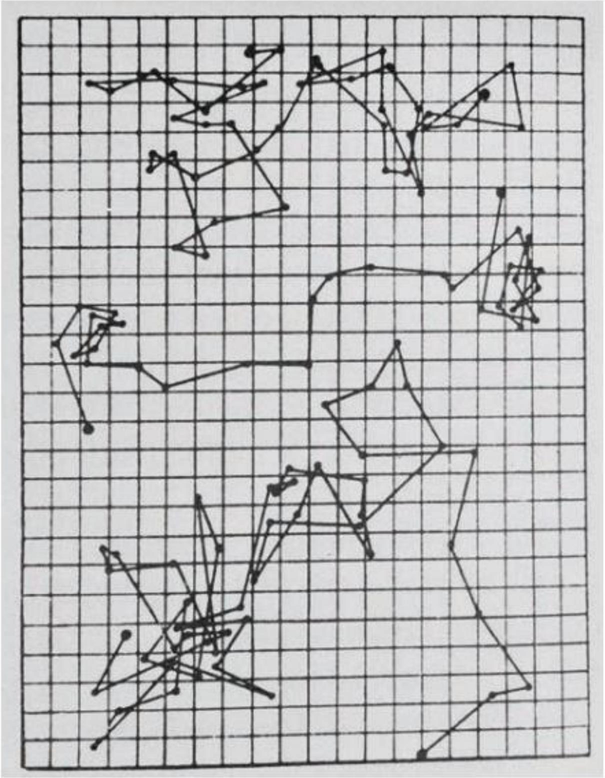


Figure 2.2.10 Robert Brown's original notes marking the positions of pollen grains every 30 seconds.

REVIEW

1 **Outline** three scientific discoveries that advanced our understanding of the particle model.

2 The gas laws predict that the pressure of a gas doubles if the volume of the container it is in is halved. **Use** the particle model to **explain** why.

3 A drop of dye added to a swimming pool spreads and diffuses until eventually you can't see any of its colour. **Use** the particle model to **propose** a way this might happen.

4 a **Outline** what Brownian motion is.

   b **Use** the particle model to **explain** Brownian motion.

   c **Describe** an example of it in action.

2.2 Unit review

Remembering

1 **State** what causes atoms to move constantly.

2 **State** what temperature is absolute zero.

Understanding

3 Match the state of matter with the movement of its particles that **describes** it best.

Solid	Particles move very fast in straight lines.
Liquid	Particles vibrate on the spot.
Gas	Particles vibrate but can also move over one another.

4 **Explain** what happens to the particles in a substance when it is:
- a heated
- b cooled.

5 **Describe** the arrangement of the particles in a:
- a solid
- b liquid
- c gas.

6 **Define** the following terms: L
- a vibrate
- b bonds.

7 **Predict** what would happen in the science4fun activity on page 55 when the bottom of the soft-drink bottle is placed in:
- a hot water
- b ice water.

Applying

8 **Use** the particle model to **explain** why:
- a solids keep their shape
- b a gas can be compressed
- c liquids take the shape of the container into which they are poured
- d a solid cannot be compressed.

Evaluating CCT

9 Barbecue gas cylinders are usually weighed as they are being filled. **Propose** a reason why.

10 The ball in the science4fun activity on page 52 rises when the container of rice is shaken. **Use** packing to **propose** a reason why.

Creating CCT

11 **Construct** a Venn diagram showing which properties are shared between solids, liquids and gases and which properties belong to only one state. Follow these instructions.
- a **Draw** a diagram like that in Figure 2.2.11 in your workbook.

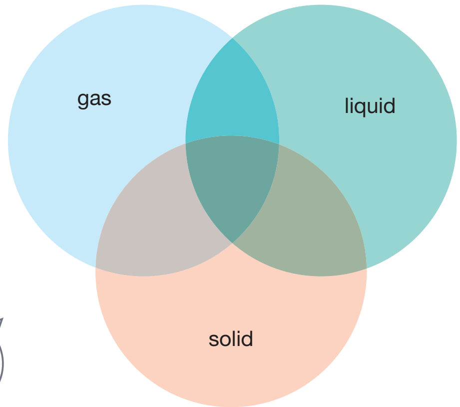


Figure 2.2.11

- b **Identify** which of the following properties is shared by all three states and write it in the overlap of all three circles.

has energy	fixed shape
changing shape	fixed volume
changing volume	can be compressed
incompressible	closely packed
loosely packed	

- c **Identify** the properties shared by two states (for example, solid and gas) and **list** them in the relevant overlaps.
- d **Identify** the properties displayed by only one state and **list** these in the appropriate spaces.

Inquiring

1 Research how LPG is made commercially.

Present your findings as a flow chart showing the main steps in its production.

2 Find the main differences between a petrol car engine and a diesel one.

Present your research as a table or a series of diagrams that compares the two engine types.

2.2 Practical investigations

1 Liquid thermometer

Purpose

To build a model thermometer.

Materials

- water
- 2 drops of food dye
- Plasticine

- 250 mL conical flask
- clear drinking straw
- permanent marker pen

Procedure

1. Set up the apparatus as shown in Figure 2.2.12a.
2. Carefully blow down the drinking straw. Water should rise up it. Stop blowing when the water rises about 1 cm above the Plasticine plug.
3. Use the permanent marker to mark this water level as shown in Figure 2.2.12b. This level represents the 'temperature' of the room today.

Results

1. Hold the conical flask in your hands. Don't squeeze but just let your hands warm it up.
2. Release your hold on the flask and record what happens to the water level.
3. After it reaches the line again, put the flask into a sink of cold water. Record what happens.

Practical review

1. **Explain** what happened in this experiment by copying the following sentences and choosing the correct term.
   a. Adding heat causes liquids to *expand/contract*. This caused the liquid to *rise/drop* in the drinking straw.
   b. Removing heat causes liquids to *expand/contract*. This caused the liquid to *rise/drop* in the drinking straw.
2. Thermometers usually do not use water but instead use alcohol (coloured red) or mercury. **Propose** a reason why.

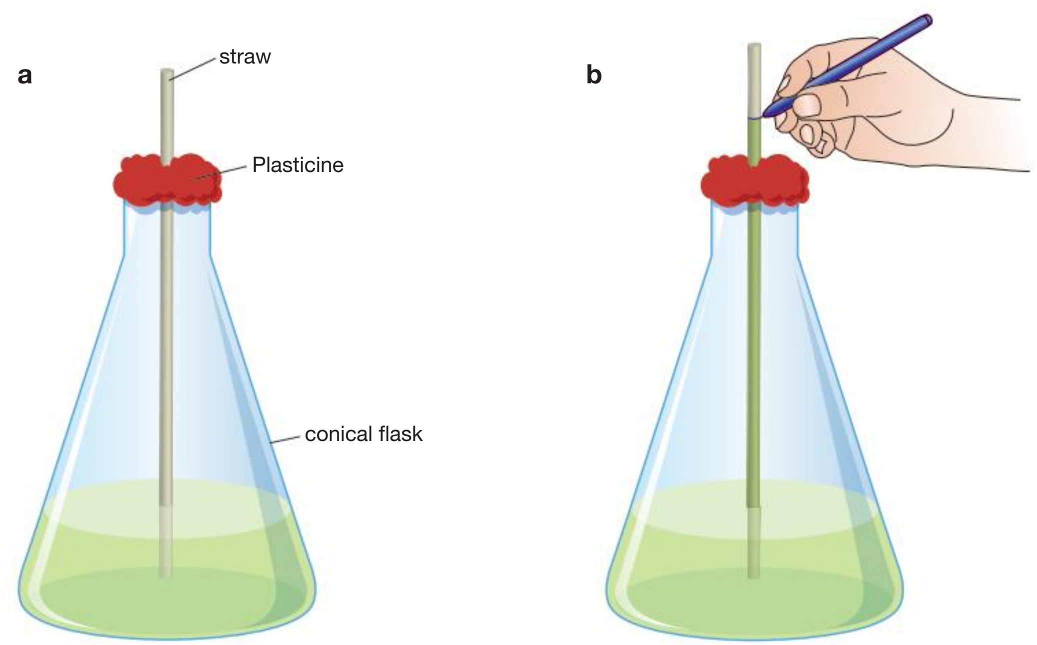


Figure 2.2.12

2 Compressing liquids and gases

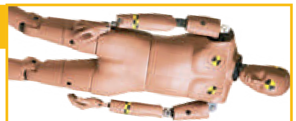
Purpose

To determine whether liquids and gases can be compressed.

Materials

- water

- plastic syringe (without needle)
- 250 mL beaker



SAFETY

Do not use the syringe to squirt water at other people.

Procedure

1. Fill the beaker with water and use the syringe to suck up water until it is full.
2. Push the nozzle of the syringe against your finger as shown in Figure 2.2.13.
3. Push the plunger down and observe what happens. Can you compress the water?
4. Take the syringe apart, empty it of its water and re-assemble it.

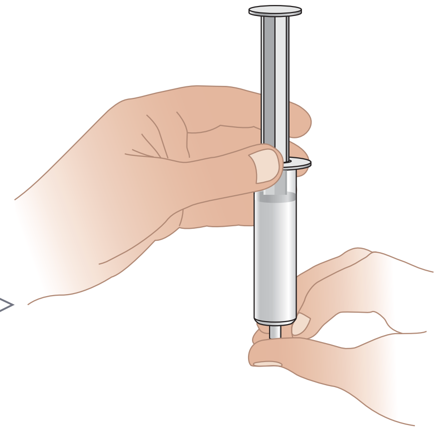


Figure 2.2.13

5. The syringe is now full of air (with a little water that will help seal it). Once again, push the nozzle against your finger and attempt to push the plunger down. Observe what happens. Can you compress the air?

Practical review

1. **Explain** your observations in terms of the spacing of particles in liquids and gases.
2. **Construct** a conclusion for your investigation.

STUDENT DESIGN

3 Pressure can protect

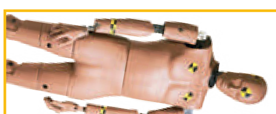
Purpose

To design and test a container that uses pressure to protect an egg.

Materials

- 1 fresh egg (uncooked)

- 2 zip-lock bags
- 1 drinking straw
- sticky-tape



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1. Design:
   a. a container that uses air pressure and the materials listed above to protect a fresh egg when it is dropped onto a hard surface.
   b. an experiment that will test how far your container needs to drop for the egg to break.
2. Before you start constructing your container or start testing, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

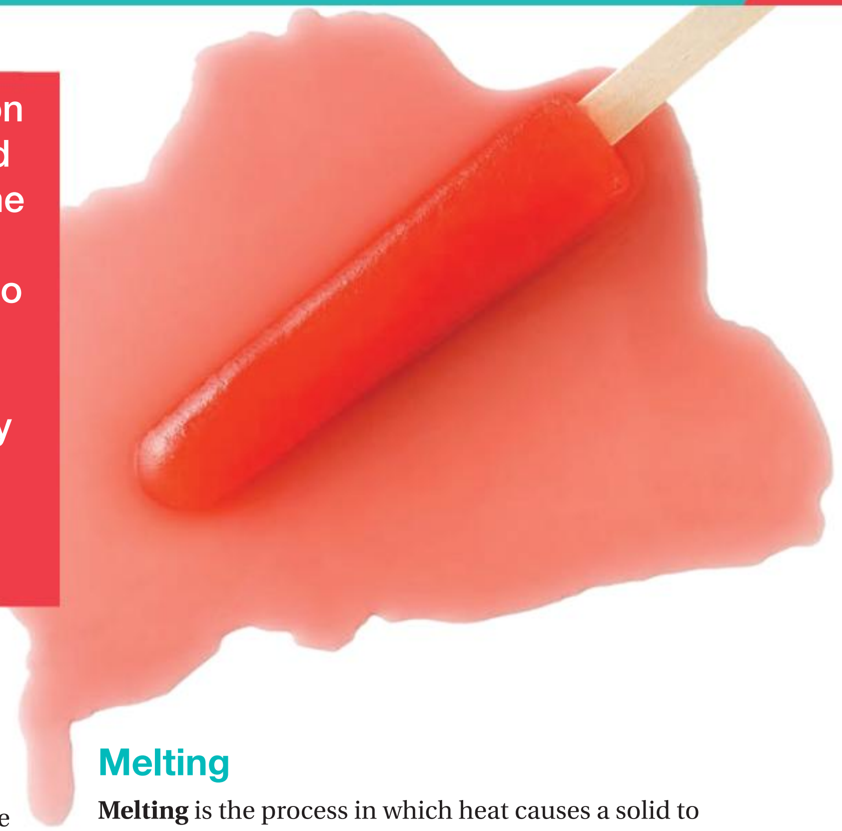
Construct a table to show the results of your egg drops and the heights they were dropped from.

Practical review

1. **State** the height from which the egg eventually broke (if it ever broke).
2. **Explain** how you used air pressure to protect your egg.

2.3 Changing state

Liquid water freezes to form frost on cold mornings. When it's really cold water can form ice and snow. As the temperature increases during the day, the frost, ice and snow begin to melt to form pools of liquid water. Water can be changed from one state into another by adding energy to it or by removing energy from it. This is done by heating it up or cooling it down.



Adding heat

A solid, liquid or gas might just increase its temperature when heated. However, if you add enough heat, the substance will change its state. Given enough heat, solids will change into liquids and liquids will change into gases. You can see this in Figure 2.3.1.

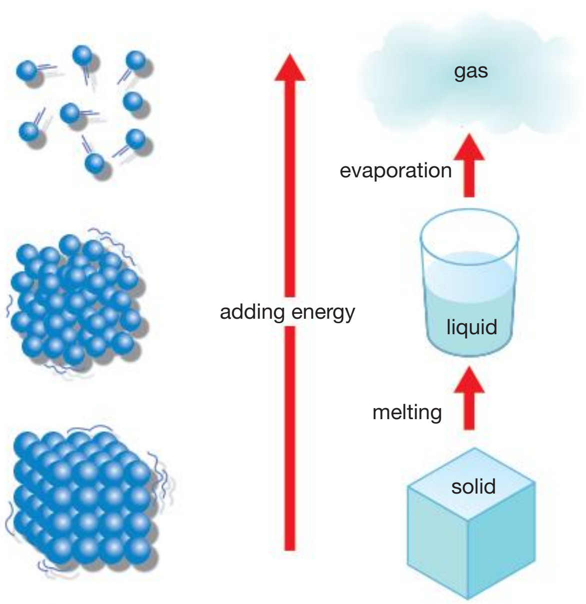


Figure 2.3.1 Adding heat to a solid or liquid causes its particles to move about more, and faster. If enough heat is added, particles break free from each other and the substance changes state: it may melt, evaporate or sublime.

Melting

Melting is the process in which heat causes a solid to change into a liquid. Although the physical properties of the substance change, the substance itself is exactly the same as it was before. Ice (solid water) is exactly the same substance as the liquid water it melts into when it is heated. Likewise, the solid wax that makes up a candle is exactly the same substance as the clear, molten drips of wax that slide down its side.

Heat adds energy to the particles in a solid, making them vibrate faster. If you add enough heat, then the particles at the edges of the solid will be vibrating so violently that they will break free, allowing them to melt away from the others in the solid. You can see this in the melting butter in Figure 2.3.2.

Figure 2.3.2 Melting starts at the edges of the solid because these particles are the first to receive heat from outside. This is why butter and ice cubes melt from the outside towards the centre.

Melting point

The temperature at which a solid melts is known as its **melting point**. A substance is solid below its melting point and is molten (a melted liquid) above it. For example, water, has a melting point of 0°C.

Different substances have different melting points, as Table 2.3.1 shows.

Table 2.3.1 The boiling, melting and freezing points of various substances

Substance	Boiling point (°C)	Melting point (°C)	Freezing point (°C)
Ethanol (alcohol)	78	–114	–114
Water	100	0	0
Mercury	357	–39	–39
Silver	2193	961	961

Evaporation

Evaporation is the process in which heat causes a liquid to change into a gas. Evaporation is sometimes also known as **vaporisation**. For example, heat causes liquid water to evaporate (or vaporise), turning it into the gas known as water vapour. Wet clothes eventually dry out because the liquid water in them has evaporated to become water vapour. This water vapour then escapes from the clothes and joins the other gases of the air. Figure 2.3.3 shows this process being used.

The bonds between the particles in a liquid are just strong enough to hold them all together to form a fixed volume of liquid. These bonds are too weak to stop the particles from moving about within the liquid, slipping and sliding over one another. Adding energy to a liquid causes its particles to move faster and loosens their bonds even more. If sufficient energy is added, then the particles at the liquid surface move so fast that they can break away completely from the rest of the particles in the liquid. They are now particles of gas, and escape into the atmosphere.

Prac 1 p. 67

Boiling

Boiling is a special case of evaporation. Evaporation occurs at any temperature, but boiling only happens at a temperature known as the **boiling point**. Boiling is obvious because bubbles appear throughout the liquid. These bubbles are formed by the evaporation of pockets of liquid deep inside the liquid. These pockets change into gas, which expands to form a bubble. The bubble then rises and escapes into the atmosphere when it reaches the surface of the liquid.

Boiling point

The boiling point of a substance is the temperature at which it changes from a liquid into a gas. Water has a boiling point of 100°C. This represents the highest temperature that liquid water can be, and the lowest temperature at which water vapour can be.

Prac 2 p. 68

Figure 2.3.3 Evaporation occurs at all temperatures because there will always be some particles moving fast enough to break free from the liquid. This explains why clothes on the line will eventually dry, even on cold days.

SciFile

Sublimation

Most substances change from solid to gas in two stages: first they melt, and then they evaporate. A few substances change from solid into a gas directly, without going through a liquid stage. This process is called sublimation.

Two substances that sublime are iodine (Figure 2.3.4) and solid carbon dioxide (dry ice).

Figure 2.3.4 Iodine doesn't melt. Instead, the black crystals sublime to produce a purple vapour (gas).

SKILL BUILDER

Identifying boiling

Although boiling is accompanied by the release of bubbles from deep within a liquid, it is not the only time bubbles are released when a liquid is heated. Most liquids contain some dissolved gases, such as the oxygen that fish use to breathe. These gases form small bubbles soon after heating begins and can trick you into believing that boiling is happening. However, the bubbles appear at temperatures well below the boiling point and are generally much smaller than big bubbles seen at boiling, shown in Figure 2.3.5. After a short time, these small bubbles stop being released and no more bubbles appear until the liquid itself is boiling.

Figure 2.3.5 Continuous bubbling is a sign of boiling.

Removing heat

The temperature of a substance drops when heat is removed from it. A substance might change state if sufficient heat is removed from it, as seen in Figure 2.3.6.

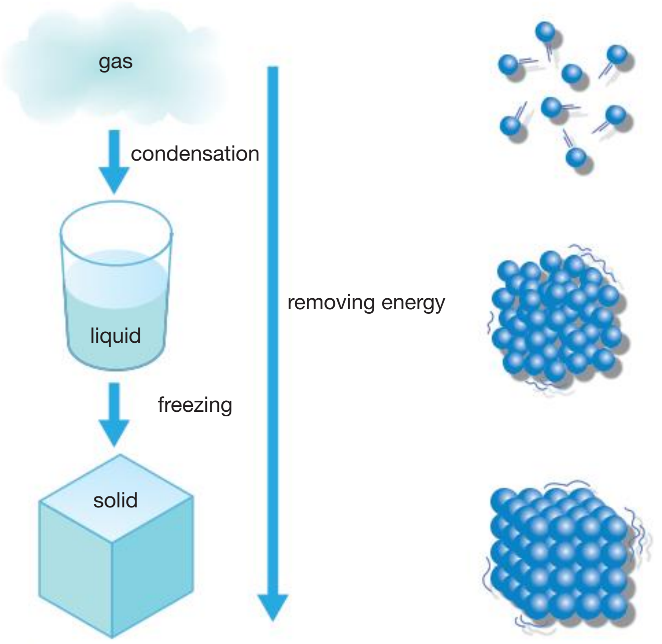


Figure 2.3.6 Substances will condense or freeze if enough heat is removed from them.

Freezing

Freezing (also known as **solidification**) occurs when heat is lost and a liquid changes into a solid. An example of freezing is shown in Figure 2.3.7. These snowflakes show some of the amazing shapes that can form.

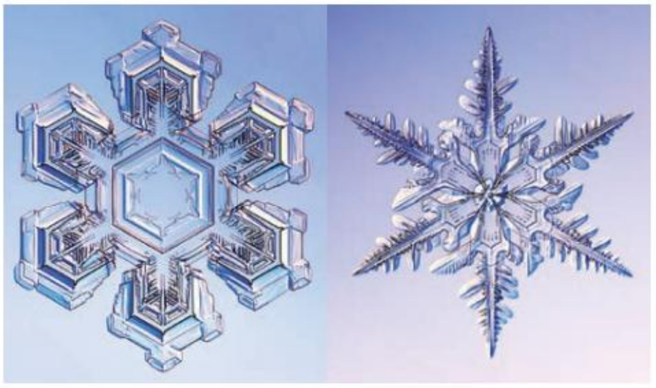


Figure 2.3.7 Snow is a form of ice. It is caused by liquid water freezing around a speck of dust high in the atmosphere to form fantastically shaped snowflakes. Likewise, frost is dew (liquid water) that has frozen overnight.

As a liquid cools, energy is lost from its particles and the particles move more slowly than before. If you remove enough energy, then the particles will end up just vibrating on the spot. Bonds form between the particles, locking them into their position to form a solid of definite shape and size.

Freezing point

The **freezing point** is the temperature at which a liquid changes into a solid. Freezing is the opposite process to melting, and so freezing and melting occur at exactly the same temperature. For water, the freezing point is 0°C.

Prac 3 p. 70

INQUIRY science 4 fun

Role play

NO

Collect this ...

- masking tape
- a clear space of floor (a carpeted area is ideal)

Do this ...

1. Use the masking tape to mark out a closed rectangle on the floor or on a grassed area.
2. Stand within the marked-out area with all the other students in the class.
3. Imagine you are all particles within a solid and that the masking tape represents solid walls. Move about to model what the particles would be doing when:
   - very cold
   - the solid is being heated
   - the solid is starting to melt
   - the liquid formed is being heated
   - the liquid is starting to evaporate
   - the gas formed is being heated.

Record this ...

Describe what happened.

Explain why you think this happened.

Condensation

Condensation occurs when a substance loses heat and changes from a gas into a liquid. Your lungs are full of water vapour (gaseous water) that will condense into tiny droplets of liquid water when you breathe out onto something cold, like a window or mirror. Likewise, water vapour in the air will condense on a cold night to form droplets of liquid dew that will make the lawn and spider webs wet. This is shown in Figure 2.3.8.

Figure 2.3.8 The dew on this spider web is caused by water vapour condensing overnight.

As a gas is cooled, its particles slow down. When they have slowed enough, the individual particles begin to attract each other and form bonds that will tie their movement to the other particles in the substance. They now act as a group, forming droplets of liquid.

Steam is water vapour that has condensed to form a cloud of tiny but visible liquid water droplets in the air. Water vapour emerges as a gas from a kettle or from a boiling pot on the stove but quickly cools in the air to form a visible fog of tiny liquid water droplets.

Prac 4 p. 70 2.4 2.5

2.3 Unit review

Remembering

1 **State** the temperature at which liquid water:
   a boils   b freezes.

2 **Name** two substances that sublime.

3 **State** alternative words for: L
   a evaporation   b freezing.

4 **Recall** the various changes of state by copying and completing Figure 2.3.9.

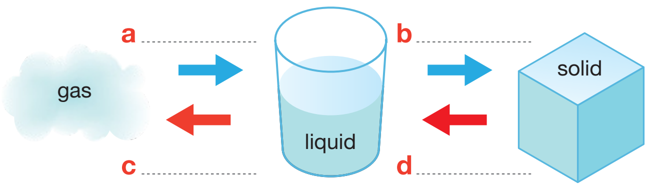


Figure 2.3.9

Understanding

5 **Explain** why the melting point and freezing points of a substance are at exactly the same temperature.

6 **Describe** the signs that show that water is boiling.

7 You peg some wet clothes on a clothes line. **Explain** why the water in the clothes evaporates despite the temperature never getting near the boiling point of water.

8 **Explain** how:
   a snow forms
   b dew forms
   c frost forms.

Applying

9 **Identify** two substances that:
   a melt at relatively low temperatures
   b evaporate at relatively low temperatures.

10 **Identify** the change of state that happens when:
   a ice-cream starts to drip
   b jelly sets
   c the bathroom mirror gets foggy.

11 **Use** the information from Table 2.3.1 to **predict** what state ethanol, water, mercury and silver would be in at the following temperatures. N
   a −20°C   b 50°C
   c 200°C   d 500°C

12 Sunglasses often fog up when you walk outside from an air conditioned building on a humid summer day. **Use** the idea of condensation to **explain** why.

Analysing

13 **Contrast**:
   a melting and sublimation
   b steam and water vapour.

Evaluating CCT

14 The science4fun on page 65 models a substance being heated and changing states. Your class is to role play a substance being cooled and changing states. **Propose** how each performer should model particles that are in:
   a a gas
   b a gas that is starting to condense
   c a liquid
   d a liquid that is starting to freeze
   e a solid.

15 The addition of impurities such as salt to water lowers its freezing point and increases its boiling point. **Use** this information to **propose** reasons why:
   a salt is spread on the roads in northern United States and Canada to help keep the roads clear of ice.
   b additives can stop a car radiator from boiling over.
   c ice-cream makers are cooled with a mixture of salt and ice.

Inquiring

1 Search the internet to download 20 images of different-shaped snowflakes.

   Present your images as a slide show. ICT

2 Find out what supercooled water is and what it does when ice is added to it.

   Present your findings as a weblink or downloaded video. ICT

2.3 Practical investigations

1 Rates of evaporation

Purpose

To determine whether water or alcohol evaporates faster.

Hypothesis

Which do you think will evaporate faster—water or the alcohol that you find in substances like Deep Heat or Dencorub? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 10 mL water (about $\frac{1}{2}$ tablespoon)
- 10 mL alcohol (about $\frac{1}{2}$ tablespoon)

- 1 cotton bud
- 2 × 250 mL beakers or similar to act as supports
- 2 × 100 mL beakers
- 1 sheet thick paper towel
- pencil
- sticky-tape
- plastic ruler
- rubber gloves

SAFETY

A Risk Assessment is required for this investigation. This kind of alcohol is extremely poisonous so do not sniff or taste it. It irritates eyes and open cuts so wear rubber gloves and safety glasses at all times. Alcohol is flammable so keep it away from all open flames.

Procedure

Part A

1 Cut two identical strips of paper towel from the sheet. Each strip needs to be about 3 cm wide and as long as the width of the sheet of paper towel. Label one strip *Water*. Keep these for Part B.

2 Use the cotton bud to paint a streak of water on the leftover paper towel. Use the other end of the cotton bud to paint an identical streak of alcohol on the same sheet of leftover paper towel as shown in Figure 2.3.10.

3 Lay the sheet of paper towel on your workbench. Note which streak 'disappears' first.

Part B

4 Set up the apparatus as shown in Figure 2.3.11, taping the pencil so that it cannot move.

5 Pour 10 mL of water into one of the 100 mL beakers.

Figure 2.3.10

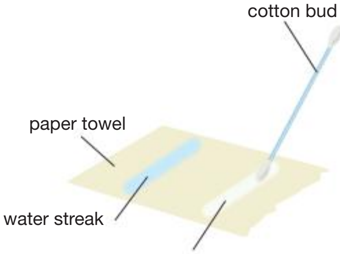
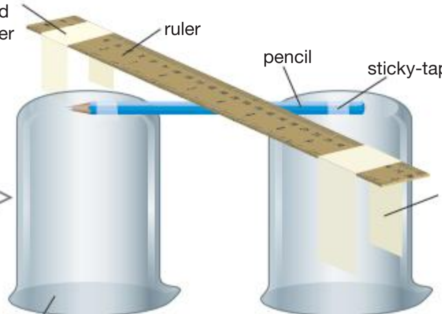


Figure 2.3.11



6 Dip one strip marked *Water* into the beaker of water so that it soaks it up. Remove the strip from the water, making sure it does not rip. Drape the wet strip over one end of the ruler.

7 Pour 10 mL of alcohol into the other 100 mL beaker.

8 Roll the other strip of paper into a coil and place it in the beaker of alcohol. Once it has soaked up most of the alcohol, quickly remove it and drape it over the other end of the ruler.

9 Quickly balance the ruler and its strips on the pencil, noting which is the water end and which is the alcohol end.

10 Watch what happens to the ruler as the substances start to evaporate.

Results

Part A: Record which streak 'disappeared' first.

Part B: Record which end of the ruler drops.

Practical review

1 **Compare** your results from Parts A and B.

2 The water and alcohol don't really 'disappear' in Part A. **Describe** what really happens to them.

Rates of evaporation continued on next page

Rates of evaporation continued

3 The soaked paper strips in Part B become lighter as the experiment proceeds. **Explain** why.

4 The ruler becomes unbalanced if one of the substances evaporates faster than the other. **Identify** which end would drop if:
  a water evaporated faster than alcohol
  b alcohol evaporated faster than water.

5 a **Use** your answers to questions 1–4 to **construct** a conclusion for your investigation.
  b **Assess** whether your hypothesis was supported or not.

6 You used two different methods here to test the same thing.
  a **Assess** why this is considered good science.
  b **Evaluate** both methods used in this prac and **determine** which is better at answering the question 'Which evaporated faster?'
  c **Justify** your choice.

2 Temperature graphs

Purpose

To determine what effect salt has on the melting and boiling points of water.

Hypothesis

What do you think will happen when salt is added to water – will it increase or decrease its melting and boiling points? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- handful of crushed ice or ice cubes
- water
- about two large spatulas full of salt

- 250 mL beaker
- thermometer
- stirring rod
- spatula
- stopwatch, watch or clock
- Bunsen burner, bench mat, tripod and gauze mat
- retort stand and clamp
- graph paper
- ruler
- grey-lead pencil

SAFETY

Tie long hair back so it won't get in the flame.

Whenever you are not using the Bunsen burner, sets its flame to yellow so that you can see it.

Water can spit when heated so wear safety glasses at all times.

Equipment will be hot so let it cool before packing it away.

Procedure

1 Copy the table from the Results section into your workbook.

2 Your teacher will tell you which of the following two groups you and your lab partners will be part of:
  - The control water group: this group will heat a mixture of tap water and ice.
  - The experimental group: this group will heat a mixture of salt, pure water and ice.

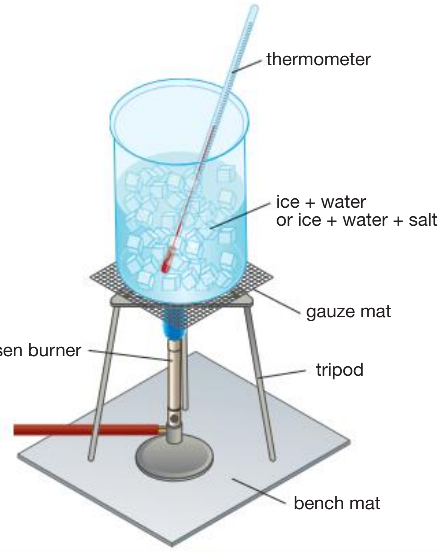
3 Both groups need to add crushed ice or ice cubes to their beaker so that the ice comes up to about the 100 mL mark.

4 Add water to the ice cubes so that it surrounds the ice and also comes up to about the 100 mL mark.

5 The experimental group also needs to add salt (a couple of large spatula loads) to their ice–water mixture.

6 Set up the apparatus as shown in Figure 2.3.12.

Figure 2.3.12



Temperature graphs continued on next page

7 Measure and record the starting temperature of the ice–water or ice–water–salt mixture.

8 Light the Bunsen burner and turn the collar so that the airhole is open and the flame is blue. Start timing immediately.

9 Measure and record the temperature every minute. Use the stirring rod to stir the mixture gently before measuring the temperature.

10 Continue measuring and recording the temperature until the water has been boiling for 2 or 3 minutes. Once it is boiling, you may need to turn the collar on the Bunsen burner to partly close the airhole.

Results

1 Record all your measurements in a table like the one below.

My group was *the tap water group/salty group*	
Time (min)	Temperature (°C)
0 (before heating starts)	
1	
2	
3	

2 Copy the graph template shown in Figure 2.3.13 onto graph paper. Ensure that your scale uses equal intervals. Plot your data on the graph and join the points with straight lines.

GO TO Unit 1.4

3 Your graph probably has two parts that are reasonably flat with little or no increase in temperature. Highlight those sections of your graph.

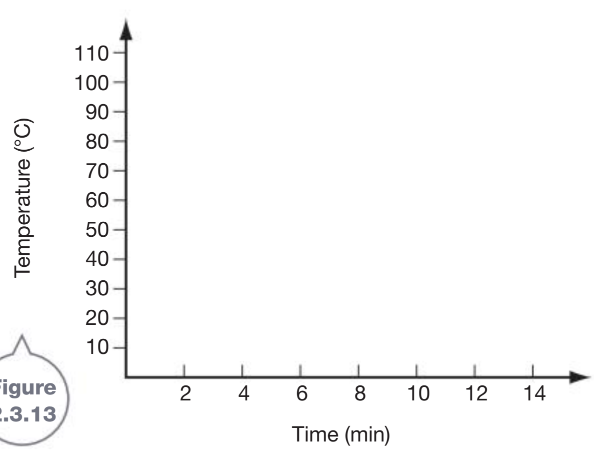


Figure 2.3.13

Practical review

1 **Use** your graph to:
- a **identify** the melting point and boiling point
- b **state** the water temperature 5 minutes after you started heating
- c **state** the length of time it took your sample to reach 80°C
- d **predict** the temperature of your sample 10 minutes after it started to boil.

2 a **Compare** your graph with those of other groups.
- b **Use** the graphs to **compare** the melting and boiling points of salt water with those of tap water.

3 Figure 2.3.12 showed the equipment used in this prac in three dimensions (3D). **Construct** a scientific diagram that shows it in two dimensions (2D).

4 a **Construct** a conclusion for your investigation.
- b **Assess** whether your hypothesis was supported or not.

SKILL BUILDER

Graphing changes of state

A substance changes state because heat causes bonds between its particles to break. The temperature will not change while this is happening, as shown by the flat sections on the graph of temperature versus time in Figure 2.3.14.

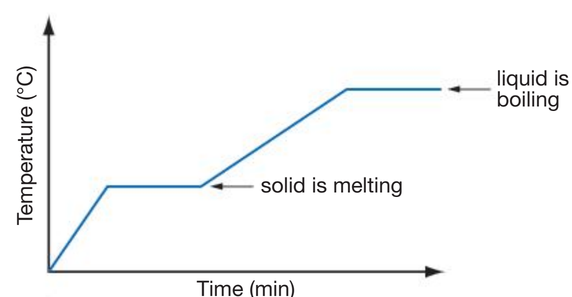


Figure 2.3.14

2.3 Practical investigations

STUDENT DESIGN

3 Freezing

Purpose

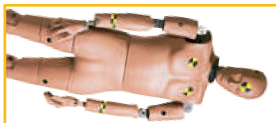
To determine whether hot or cold water freezes faster.

Hypothesis

Which do you think will freeze faster—hot water or cold water? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

To be selected by students.



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that will test whether hot or cold water freezes faster.

GO TO Unit 1.5

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

Make sure that you use identical containers and the same volume of cold and hot water.

Practical review

1 **State** which water sample froze first.

2 **Propose** a reason why.

3 a **Construct** a conclusion for your investigation.
  b **Assess** whether your hypothesis was supported or not.

STUDENT DESIGN

4 Condensation

Purpose

To observe condensation.

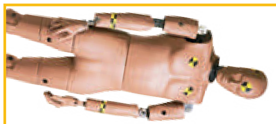
Hypothesis

Drops of liquid water (condensation) quickly appear on the outside of a glass beaker that contains ice and water. Where do these drops come from—from the beaker and its contents or from the air? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- ice cubes
- water

- 2 zip-lock plastic bags (each large enough to hold a 250 mL beaker)
- 250 mL beakers
- drinking straw(s)



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that uses the above materials and which tests where the droplets of liquid water on the outside of a beaker come from.

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

Air has gaseous water vapour (humidity) in it.
Suck the air out of a zip-lock bag and you will suck out the water vapour too.

Results

Construct labelled diagrams to show what happened.

Practical review

1 **Compare** the beakers that you tested.

2 **Explain** any differences you saw.

3 a **Construct** a conclusion for your investigation.
  b **Assess** whether your hypothesis was supported or not.

2.4 Density

Some materials like lead, gold, granite and steel are very heavy for their size. Other materials like foam rubber, cork, balsa wood and feathers are so light that huge piles don't weigh much at all. Density measures how much matter is packed into a space. Density determines how heavy a handful of a substance will be and whether it floats or sinks in water.

INQUIRY

science 4 fun

Salty lava lamp

Can you make your own lava lamp?

YES

Collect this ...

- cooking oil
- salt shaker
- food dye
- water
- tall glass or 250 mL beaker

Do this ...

1. Pour water into the glass or beaker until it is one-third full.
2. Add a few drops of food dye.
3. Pour in an equal quantity of cooking oil and observe which layer is on top.
4. Sprinkle salt into the glass and carefully observe what happens to the grains of salt.

Record this ...

Describe what happened.

Explain why you think this happened.

Density: a physical property

The physical properties of a substance describe things such as:

- its appearance
- the temperatures at which it melts, freezes and boils
- its hardness (how easy it is to scratch the material).

Density is one of the physical properties of a substance. Density depends on how heavy a substance is, but it is not the same as its weight or mass. For example, 1 kilogram of lead always weighs exactly the same as 1 kilogram of polystyrene, which weighs as much as 1 kilogram of feathers. Density instead measures how much matter is packed into a specific space (Figure 2.4.1).

Figure 2.4.1

Stones are much more dense than feathers. This makes a small pile of stones weigh a lot more than a big pile of feathers.

Density and packing

The particles in a solid are usually packed more closely than they are in a liquid, making most solids a little denser than liquids of the same material.

When heated, the particles in solids and liquids move a little further apart, causing the substance to expand slightly. The substance takes up more space and so its density decreases. You can see this in Figure 2.4.2.

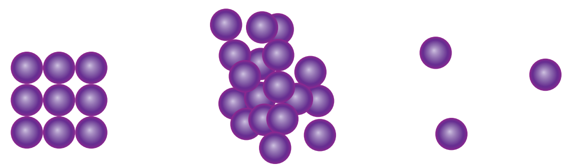


Figure 2.4.2 Density depends on the packing of the particles making up a substance. The more closely packed, the denser the substance will be.

When a gas is heated, its particles spread out even further, lowering its density even more. For this reason, hot air is less dense than cold air and will rise above it (Figure 2.4.3). This is why smoke rises—the air is hot and it carries soot and burnt material up with it. Likewise, bubbles of gas rise through the liquid, as seen in Figure 2.4.4.

Figure 2.4.3 The overall density of a hot-air balloon is less than the density of the air around it, allowing it to rise into the sky.

Figure 2.4.4 Gases are much less dense than liquids and will bubble upwards through them.

SciFile

Danny Deckchair

Helium is a gas that is less dense than air. In 1982, US man Larry Walters tied 45 large helium-filled balloons to his aluminium garden chair and floated to a height of 4900 metres. After 45 minutes he punctured some of his balloons and crashed down among power lines. A similar flight was used in the plot of the 2003 Australian film *Danny Deckchair*.

Mass, volume and density

Density depends on the amount of substance (its mass) and the space it takes up (its volume) and so its unit includes the units for mass and volume.

Density is normally measured in gram per centimetre cubed (g/cm^3). The densities of different gases, liquids and solids can be seen in Tables 2.4.1, 2.4.2 and 2.4.3.

Table 2.4.1 Densities of gases

Gas	Density (g/cm³)
Hydrogen (at 0°C)	0.000 09
Helium (at 0°C)	0.000 18
Air (at 40°C)	0.001 1
Air (at 0°C)	0.001 3
Oxygen (at 0°C)	0.001 4

Table 2.4.2 Densities of liquids at 25°C

Liquid	Density (g/cm³)
Petrol	0.80
Vegetable oil	0.91
Water	1.00
Honey	1.36
Mercury	13.6

Table 2.4.3 Densities of solids

Solid	Density (g/cm³)
Polystyrene foam	0.03
Wood (oak)	0.65
Concrete	2.40
Copper	8.90
Gold	18.9

Density depends on mass

Mass measures how much matter is in a substance. It is sometimes incorrectly referred to as weight. Scientists use grams (g) to measure small masses such as a twig, a mouse or a spatula load of chemicals, kilograms (kg) for heavier masses such as a dog or a human, and tonnes (t) for even bigger masses such as a car or an aircraft. Mass is measured using a beam balance or electronic balance.

A substance will be denser if more mass is packed into the same volume. The four cubes shown in Figure 2.4.5 are all exactly the same volume but their masses are all different. This means that their densities are different too.

GO TO Unit 7.3

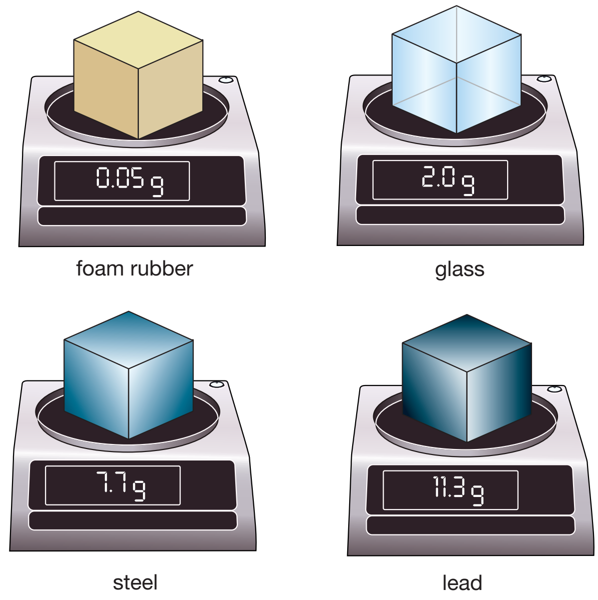


Figure 2.4.5 All of the cubes have exactly a volume of 1 cm³. This makes the heaviest cube (lead) the densest and the lightest cube (foam rubber) the least dense.

Density depends on volume

Volume is the amount of space a substance takes up. Figure 2.4.6 shows that denser substances pack the same mass into smaller volumes.

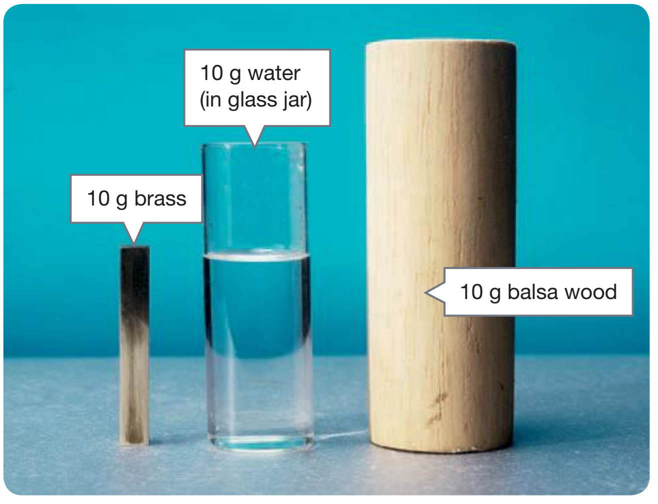


Figure 2.4.6 These substances all have the same mass of 10 grams. Denser substances require less volume to pack in the same mass. Here, the smallest volume represents the densest substance (brass).

The volume of a liquid can be measured accurately using a measuring cylinder. The volume of liquids is usually measured in litres (L). For example, large bottles of soft drink come in 1.25 L and 2 L sizes. Smaller volumes are usually measured in millilitres (mL). For example, cans of soft drink normally hold a volume of 375 mL.

As Figure 2.4.7 shows, a measuring cylinder can also be used to find the volume of a solid. When you place a solid in water, it **displaces** (takes the place of) a volume of water equivalent to its own volume. That's why the level of water in the bath goes up when you get in.

SciFile

Eureka!

Archimedes (about 287 to 212 BCE) needed to calculate the density of the wreath or crown of his king to determine whether it was pure gold. But how could he measure its volume without destroying it? He realised how when he got into his bath and saw the water level rise. So excited, he supposedly ran naked down the street screaming 'eureka, eureka'!

2.6

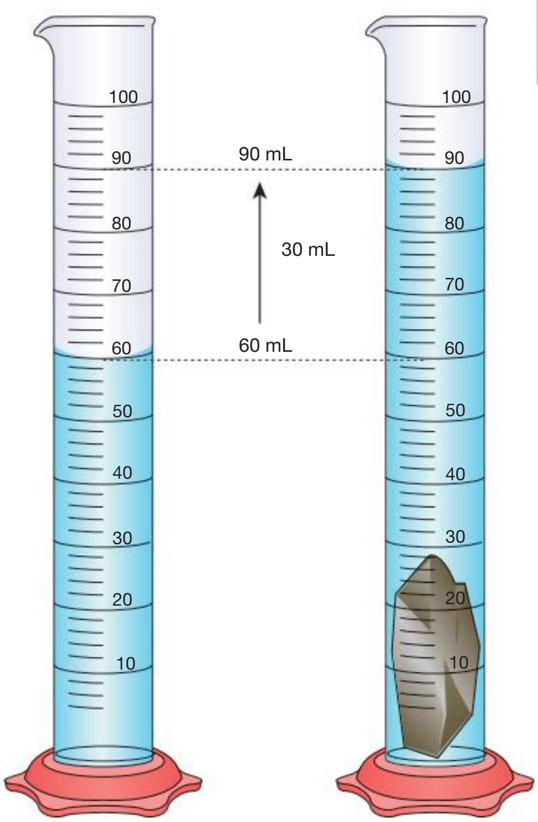


Figure 2.4.7 The volume of a solid can be determined by dropping it into a measuring cylinder. If the level goes up by 30 mL then the solid's volume must be 30 mL.

SKILL BUILDER

Unit conversions

Density is measured in g/cm^3. This means that mass must be in gram and volume in cm^3. But a measuring cylinder gives its volumes in mL. This means that volume needs to be converted from mL to cm^3. This is easy since 1 mL is exactly the same as 1 cm^3.

$$1 \text{ mL} = 1 \text{ cm}^3$$

Likewise, masses are sometimes measured in kilogram or tonne. If so, then they need to be converted into gram. Table 2.4.4 shows how.

Table 2.4.4 Converting mass and volume

Measurement	From	Convert by	To
Mass	tonne (t)	x 1 000 000	gram (g)
	kilogram (kg)	x 1000	gram (g)
Volume	litre (L)	x 1000	millilitre (mL)
	millilitre (mL)	x 1	cubic centimetres (cm^3)

WORKED EXAMPLE
Unit conversions

Problem

1 Convert 3 kg into g.

2 Convert 2.5 t into g.

3 Convert 375 mL into cm^3.

4 Convert 1.25 L into cm^3.

Solution

1 $3 \times 1000 = 3000$ g

2 $2.5 \times 1\,000\,000 = 2\,500\,000$ g

3 $375 \times 1 = 375$ cm^3

4 $1.25 \times 1000 = 1250$ cm^3

Practice N

Calculate what these measurements are in the units indicated.

a 2 L in cm^3

b 4 kg in g

c 1.1 t in g

Calculating density

Density measures the mass packed into a certain volume. This can be represented by the mathematical formula:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Using symbols, this formula can be written as:

$$d = \frac{m}{V}$$

Mass is normally measured in grams (g) and volume in cubic centimetres (cm^3).

2.7

WORKED EXAMPLE
Calculating density

Problem

Calculate the density of a pebble with a mass of 20 g and a volume of 10 cm^3.

Solution

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{20}{10} = 2\ \text{g/cm}^3$$

Practice N

Calculate the density of:

a a piece of pine with a mass of 50 g and a volume of 100 cm^3

b a sausage with a mass of 30 g and a volume of 30 mL.

Floating and sinking

Density determines how different substances will arrange themselves when mixed together. The densest substance will drop to the very bottom while the least dense will rise to the top.

For example, cooking oil floats on top of water because its density is less than that of water. A steel bolt will sink in water because its density is far greater than that of water.

The density of water is 1.0 g/cm^3. Anything more dense than this will sink when placed in water. Anything less dense will float on top of the water. Figure 2.4.8 shows two types of rock of very different densities.

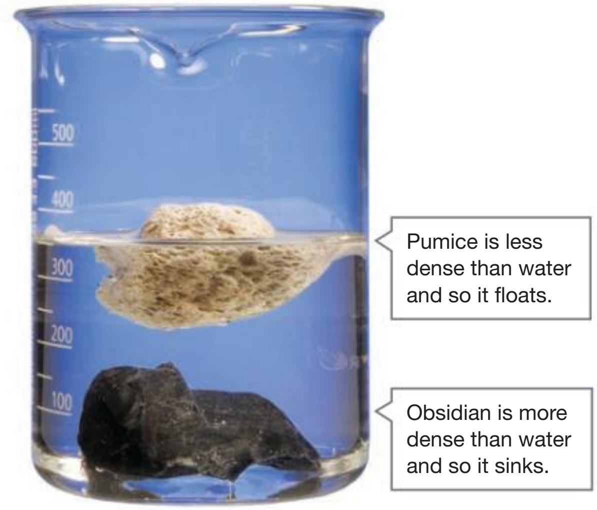


Figure 2.4.8 Density determines whether things float or sink.

Prac 1 p. 78

Water and ice

Water acts just like other liquids above 4°C and ice acts just like other solids below 0°C—it expands when heated and contracts when cooled. However, between 0°C and 4°C, water does the exact opposite. Water at 4°C is denser than at any other temperature, and drops to the bottom of any pond, lake or swimming pool. Colder water floats on top of it, and any ice will float on the surface of that colder water. This is shown in Figure 2.4.9.

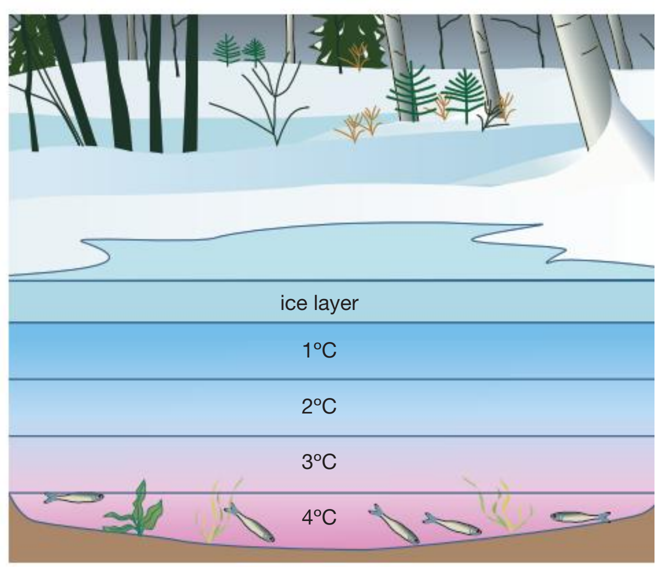


Figure 2.4.9 The water at the bottom of a pond, lake or swimming pool is always the densest. Even in freezing conditions, this layer is unlikely to drop below 4°C, giving fish some chance of survival.

Icebergs

Thicker, heavier chunks of ice will be partly submerged with only their top exposed, forming an iceberg. Despite their huge size and mass, icebergs float because their density is less than that of pure water and seawater, as shown in Table 2.4.5.

Table 2.4.5 Densities of water

Substance	Density (g/cm³)
Ice	0.92
Pure water	1.00
Seawater	1.03

Icebergs are incredibly dangerous to shipping because:

- they shift with ocean currents and winds, often into shipping lanes.
- 80–90% of the iceberg lies hidden below the water as shown in Figure 2.4.10. This hidden part doesn't melt as fast as the ice above the water, and so it usually extends wider than the ice visible above the water line. Any ship that comes near can collide with this bulge, making a hole and sinking the ship.

Although radar gives modern shipping some warning of a nearby iceberg, disaster can still happen. In 2007, the Canadian cruise ship MS *Explorer* (shown in Figure 2.4.11) hit submerged ice off Antarctica and sank.

There was no radar in 1912 when RMS *Titanic* hit an iceberg and sank on its maiden (first) voyage from England to the USA. Although the crew knew that icebergs lay in the path of the ship and were watching out for them, it was a moonless night and the iceberg was only seen at the last moment.

Figure 2.4.11 When MS *Explorer* sank, all 154 passengers and crew were saved by a nearby cruise ship.

Figure 2.4.10 Most of an iceberg lies below the surface of the water.

SciFile

Iceberg seen in Sydney Harbour!

In 1978, businessman Dick Smith towed an iceberg into Sydney Harbour so that it could be broken up and sold off as ice cubes. However, rain soon exposed the 'iceberg' as a fake! It quickly washed off the shaving cream and firefighting foam and revealed white plastic beneath! It was April Fool's Day!

2.8 2.9 Prac 2 p. 79 Prac 3 p. 80

2.4 Unit review

Remembering

1 **State** whether each of the following is true or false.
  a 1 kg of lead has a greater mass than 1 kg of polystyrene.
  b 1 kg of lead takes up less space than 1 kg of polystyrene.
  c 1 kg of lead has the same density as 1 kg of polystyrene.

2 **Recall** the densities of different states and forms of water by arranging the following in order from least dense to most dense:

ice	seawater
pure water at 1°C	pure water at 4°C
water vapour	

Understanding

3 **Explain** why it is easier to float in the sea than in a freshwater lake.

4 For the science4fun activity on page 71, **predict**:
  a which layer (the water or oil) will start on top
  b what might happen once the salt is sprinkled on top.

Applying

5 **Use** the particle model to **explain** why:
  a gases are less dense than liquids and solids.
  b gases become less dense as they are heated.

6 **Use** the densities in Tables 2.4.1, 2.4.2 and 2.4.3 on page 73 to **explain** why:
  a lifesaving rings are usually made of polystyrene
  b helium balloons rise
  c spilt petrol forms a layer floating on top of water.

7 Figure 2.4.12 shows four diagrams of exactly the same substance. **Identify** which diagram best represents it:
  a as a solid
  b as a liquid
  c as a hot gas
  d as a cool gas
  e at its most dense
  f at its least dense.

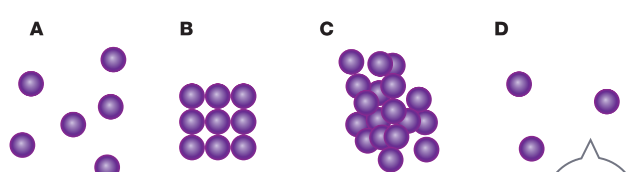


Figure 2.4.12

Analysing

8 **Calculate** the density of a solid that has a volume of 2 cm^3 and a mass of 3 g. N

9 The pebble in Figure 2.4.7 had a mass of 60 g. **Calculate** its density. N

10 **Calculate** the missing numbers in the following unit conversions: N
  a 7 kg = __ g
  b 600 mL = __ cm^3
  c 4 t = __ g
  d 2 L = __ cm^3

Evaluating CCT

11 a **Predict** whether you are more or less dense than water.
  b **Justify** your answer.

12 Newspaper usually floats on water but then sinks after a while. **Propose** reasons why.

Creating CCT

13 a **Construct** a diagram showing a measuring cylinder containing all the liquids shown in Table 2.4.2 on page 73.
  b Small lumps of wood, copper and gold were then dropped into the measuring cylinder. **Modify** your diagram to show where each would settle.

Inquiring

1 Find evacuation procedures recommended by your state fire service.

Present your findings as a simple poster that displays an evacuation procedure.

2 The older ice in a glacier or an iceberg often has an incredible blue colour. Find images of a glacier or iceberg that has this blue colouring. ICT

Explain:
- what causes the blue colour
- how it is connected to density
- why there are different shades of blue in the ice.

Present your research in digital form.

2.4 Practical investigations

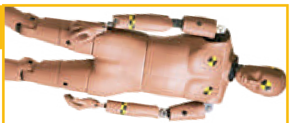
1 Density tower

Purpose

To construct a tower of different liquids, layered according to their densities.

Materials

- 50 mL (maximum) each of corn syrup or honey, vegetable oil, ethanol or methylated spirits, coloured dishwashing liquid, water
- a variety of small solids (such as a cornflake, single penne pasta, cork, sultana, bolt)
- a few drops of food dye
- rubber stopper, grape, Lego™ block



SAFETY

Ethanol and methylated spirits are flammable so keep away from naked flames.

Wear safety glasses at all times.

- large measuring cylinder
- small beaker
- digital camera or mobile phone (optional)

Procedure

1. Carefully squeeze the honey into the measuring cylinder so that it forms a layer at least 1 cm thick on the bottom.
2. Carefully squeeze or pour a similar quantity of dishwashing liquid into the measuring cylinder. Do this by tilting the cylinder and slowly pouring the dishwashing liquid down its side.
3. Choose a food dye that is a different colour from the dishwashing liquid. Add a few drops of it to a small beaker of water. Tilt the cylinder again, and carefully pour the coloured water in to form a 1 cm layer of about the same thickness as the others.
4. Use the same method to carefully pour a 1 cm layer of vegetable oil on top of the coloured water.
5. Add a few drops of food dye to a small beaker of ethanol or methylated spirits. As before, make another 1 cm layer by gently pouring the ethanol or methylated spirits down the side of the measuring cylinder.
6. Stand the measuring cylinder upright and allow the contents to settle.
7. Gently lower the small solids, one by one, into the measuring cylinder.

Results

1. Construct a labelled sketch showing the layering of liquids in the tower. Alternatively, photograph the tower with a digital camera or the camera function of your mobile phone.
2. Record on your diagram the level at which each small solid settles.

Practical review

1. **Explain** why:
   a. the liquids formed layers
   b. some objects floated and others sank.
2. **Identify** the least dense:
   a. liquid
   b. object.
3. **Explain** your answers to question 2.
4. **List** in order from most to least dense all the:
   a. liquids you tested
   b. solids you tested
   c. liquids and solids you tested.

2 Icebergs and eggbergs

Purpose

To demonstrate how the different densities of fresh and salt water change how something floats.

Hypothesis

Which do you think is more dense—an ice cube or an egg? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

For Part A: Icebergs

- 2 ice cubes
- salt
- water

- 250 mL beaker
- plastic 30 cm ruler
- spoon

For Part B: Eggbergs

- fresh uncooked egg
- salt
- water

- 2 tall glasses, tall beakers or large measuring cylinders, wide enough to take an egg
- spoon

Method

Part A: Icebergs

1. Three-quarters fill the glass or beaker with water.
2. Slide in a cube of ice.
3. Use the ruler to measure how much of the ice cube is above water and how much is below water.
4. Use a calculator to calculate the percentage of the ice cube that lies below the water. N

$$\% = \frac{\text{how much ice cube is below water}}{\text{total height of ice cube}} \times 100$$

5. Use the spoon to remove the ice cube. Add salt to the water and stir. Keep stirring and adding salt until no more will dissolve.
6. Slide in another cube of ice and repeat your measurements.

Part B: Eggbergs

7. Fill two tall glasses, tall beakers or large measuring cylinders with approximately the same amount of water.
8. Add spoonfuls of salt to one glass until no more will dissolve.
9. Use the spoon to lower the fresh egg gently into the glass of fresh (non-salty) water. Observe what happens.
10. Lower the egg into the glass of salt water. Observe what happens.
11. Remove the egg and pour half of the salt water out.
12. Very slowly add half of the fresh water, making sure that it does not mix with the salt water. The best way of doing this is by slowly pouring the fresh water down the inside of the glass.
13. Use the spoon to lower the egg gently into the water. Watch where the egg settles.

Results

Record your observations at each stage in Part A and Part B.

Practical review

1. **List** the evidence that suggests that salt water is more dense than fresh water.
2. **List** the following substances in order from most dense to least dense:
   egg, fresh water, ice cube, salt water
3. **Use** the evidence found in this experiment to **explain** why icebergs are so dangerous to shipping.
4. Although many attempts were made to find the wreck of RMS *Titanic*, it was only discovered in 1985, 21 km away from its last recorded position. Some scientists think that the wreck may not have hit the bottom immediately but settled somewhere in the water above it. **Use** observations made in this activity to **explain** how this might have happened.
5. a **Construct** a conclusion that compares the densities of ice cubes and eggs.
   b **Assess** whether your hypothesis was supported or not.

STUDENT DESIGN

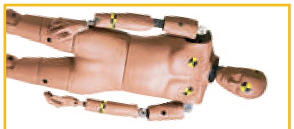
3 Calculating density

Purpose

To calculate the density of different objects.

Materials

- selection of small masses (such as pebbles, bolts, rubber stopper, Lego blocks)
- large measuring cylinder
- access to electronic scales or beam balance



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that:
- identifies which of the selected objects sink and which float in water
- gives the measurements you need to calculate the density of each object.

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

You will need to measure the mass and volume of each object you have.

Some objects might float so you will need a way of keeping them underwater without affecting your volume measurements.

When using a measuring cylinder, make sure you read volumes from the bottom of the meniscus.

GO TO Unit 1.2

Results

Construct a table like the one below to record all your measurements and results from any calculations.

Object	Sink/ float?	Mass (g)	Volume (mL or cm^3)	Density (g/cm^3)

Practical review

1 **State** the density of water.

2 **List** the objects that:
  a floated (if any)
  b sank.

3 **Compare** the density of each object with the density of water.

4 Read the following statement and **determine** if your results agree or disagree with it.

Objects more dense than water sink while objects less dense than water float.

2 Chapter review

Remembering

1 **State** two physical properties each for:
a solids **b** liquids **c** gases.

2 **State** what happens to particles in the following states when they are heated.
a solid **b** liquid **c** gas

3 **Name** the opposite process to:
a melting **b** evaporation.

Understanding

4 Gases are less dense than liquids or solids of the same material. **Explain** why.

5 **Describe** the property that makes gases ideal for filling jumping castles.

6 **Predict** which of the following is most likely to be the melting point of butter: N

A –20°C **B** 0°C

C 30°C **D** 100°C

7 **Predict** what might happen when you place an empty balloon around the rim of a conical flask with some water in it (shown in Figure 2.5.2) and heat the flask.

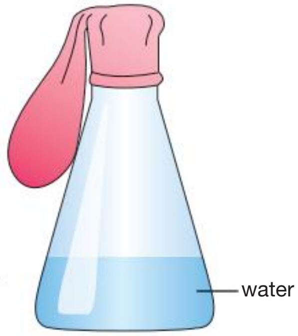


Figure 2.5.2

Applying

8 When you dive into a swimming pool, the water parts around you as you enter it. **Use** the particle model to **explain**:
a what happens to the water particles as you dive in
b why the swimming pool water gives you a ‘punch’ in the stomach when you do a ‘belly flop’ and not a clean dive.

9 Figure 2.5.1 shows a balloon full of gas. **Identify** which of the following diagrams best shows the gas and balloon after the gas is warmed up.

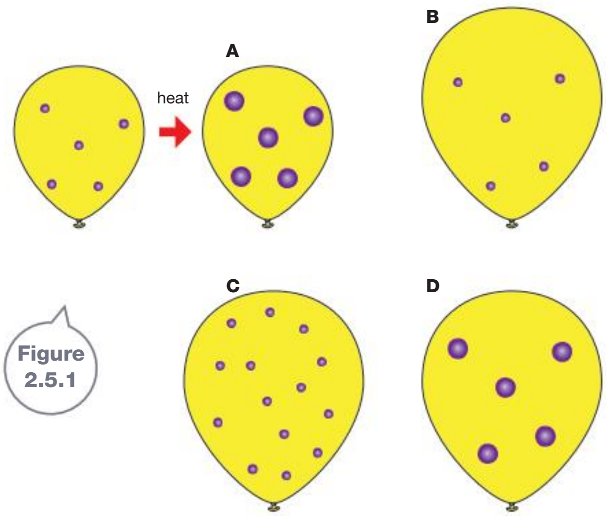


Figure 2.5.1

Analysing

10 **Use** the particle model to **contrast**:
a melting and freezing
b evaporation and condensation.

Evaluating CCT

11 **a** **Propose** what would happen to you if you jumped around in a jumping castle filled with water instead of gas.
b Refer to the particle model to **justify** your prediction.

12 Aerosol cans should never be thrown in a fire. **Propose** reasons why.

13 **a** **Determine** whether you can or cannot answer the questions on page 42 at the start of this chapter.
b **Assess** how well you understand the material presented in this chapter.

Creating CCT

14 **Use** the following ten key words to **construct** a visual summary of the information presented in this chapter.

matter	solid	liquid
gas	melt	freeze
evaporate	condense	
sublime	heat	

2.10

Thinking scientifically

Q1 The properties of a substance never change. Properties describe what a substance looks like, how heavy, dense, hard and brittle it is and how it acts when heated, cooled or mixed with other chemicals. Below are several statements that describe solid gold. Assess which is *not* a property of solid gold. CCT

A Gold is yellow and shiny.
B Gold melts at a temperature of 1064°C.
C One gram cost $49.05 in August 2012.
D Gold reacts with strong acids to form hydrogen gas.

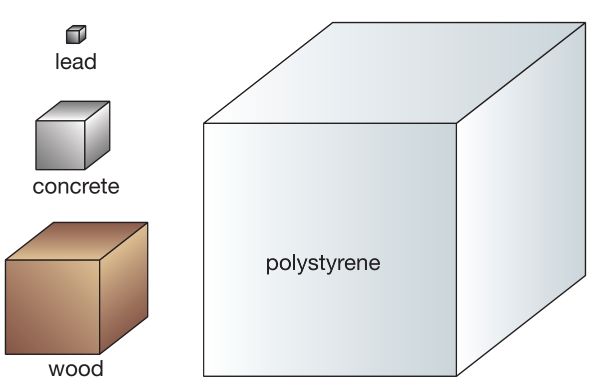
Q2 All the blocks in the diagram below have exactly the same mass. Density measures how much of a substance fits into a volume. Which of the following shows the correct order of densities from highest to lowest density? CCT

A Highest density = concrete
lead
wood
Lowest density = polystyrene

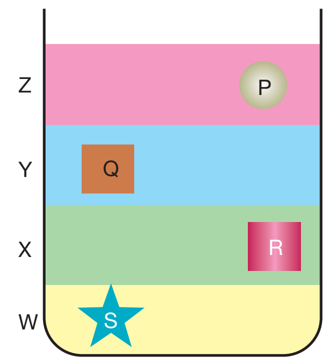
B Highest density = lead
concrete
wood
Lowest density = polystyrene

C Highest density = concrete
wood
lead
Lowest density = polystyrene

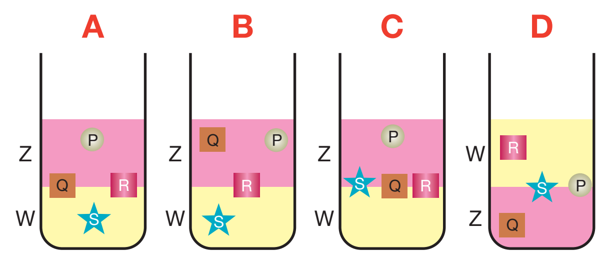
D Highest density = lead
polystyrene
concrete
Lowest density = wood



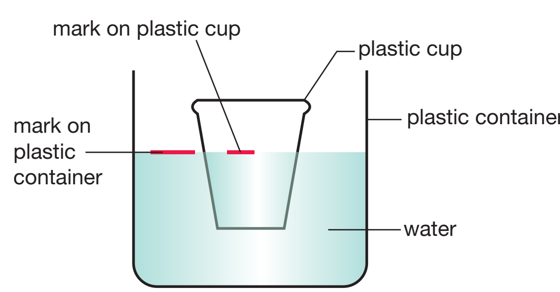
Q3 Liquids do not always mix together. Sometimes one liquid floats on top of another. Alice filled a container with some liquids as shown. P, Q, R and S are different objects floating in the liquids. CCT



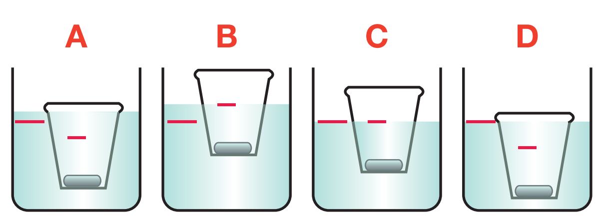
What would happen if liquids X and Y were removed?



Q4 Angus placed a plastic cup in a plastic container filled with water. He marked the level of the water on the cup and the container. CCT



Angus then placed a heavy rock inside the plastic cup. What did he observe?



Glossary

Unit 2.1

Biodegradable: bacteria or fungi breaks down the substance into simpler substances

Chemical properties: how substances react with other substances

Chemical properties

Compressed: squashed

Incompressible: not able to be compressed or squashed

Non-biodegradable: doesn't rot or break down

Odour: smell

Physical properties: describe things about the substance like its appearance, melting, freezing and boiling points and its hardness

Plasma: the fourth state of matter; found in sparks, lightning bolts and in stars

States (phases): solid, liquid, gas (also plasma at temperatures above 6000˚C)

Unit 2.2

Bonds: forces of attraction that hold particles together (verb: bonds)

Brownian motion: random motion of particles caused by being bumped and jostled by other particles

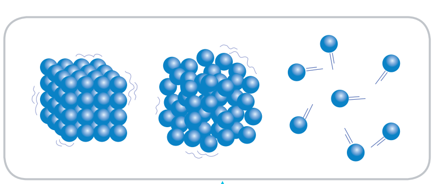
Diffusion: a process in which two liquids or gases mix

Gas laws: laws that describe how gas particles behave

Indirect evidence: facts and evidence from which something else can be inferred or reasoned

Particle model: the model used to help describe and explain the behaviour of particles in solids, liquids and gases

Pressure: combined push of gas particles bouncing off the walls of their container



Particle model

Vibration: jiggling about on the spot (verb: vibrates)

Unit 2.3

Boiling: when vigorous bubbling appears (verb: boils)

Boiling point: the temperature at which a liquid boils; 100°C for water

Boiling

Condensation: removal of heat, changing a gas into a liquid (verb: condenses)

Evaporation: heat changing a liquid into a gas (verb: evaporates). Also known as vaporisation

Freezing: removal of heat, changing a liquid into a solid (verb: freezes)

Freezing point: the temperature at which a liquid freezes; 0°C for water

Melting: heat changing a solid into a liquid (verb: melts)

Melting point: the temperature at which a solid melts; 0°C for ice

Melting

Solidification: removal of heat, changing a liquid into a solid (verb: solidifies). Also known as freezing

Steam: condensation of water vapour, forming a visible fog of water droplets

Vaporisation: heat changing a liquid into a gas (verb: vaporises). Also known as evaporation

Unit 2.4

Density: a measure of the mass per unit volume of a substance, $d = \frac{m}{V}$ (unit: g/cm^3)

Displaces: when one object takes the place of another, for example a solid pushes water upwards

Mass: measures how much matter is in a substance (unit: g)

Volume: measures how much space is occupied by a substance (units: mL or cm^3)

3 Earth resources

Have you ever wondered…

- if humans could run out of resources like coal or oil?
- why you should save energy?
- how clouds form?
- why people should care about what they put in the air or soil?

After completing this chapter students should be able to:

- describe uses of a variety of natural and made resources
- classify Earth's resources as renewable or non-renewable S
- outline features of non-renewable resources
- investigate strategies used to conserve and manage non-renewable resources S
- discuss different viewpoints that people may use in making decisions about the use of a major non-renewable resource PSC DD
- outline the choices that need to be made when considering whether to obtain a resource EU S PSC
- identify that water is an important resource that cycles through the environment
- explain the physical processes involved in the water cycle
- demonstrate how understanding the water cycle has influenced water management practices CCT S
- research how Aboriginal and Torres Strait Islander peoples' knowledge is used in management of resources AHC S IU

ADDITIONAL

- describe ways technology has increased the variety of made resources L
- debate the economic and environmental impacts of mining and resource exploration CCT PSC S
- debate intergenerational aspects of using non-renewable resources. CCT PSC S

3.1 Natural and made resources

Humans need many things to stay alive, like food, air, water and shelter. Other living things have similar needs. These needs are met by the natural resources on Earth. It is the responsibility of everyone to protect these vital resources.

INQUIRY science 4 fun

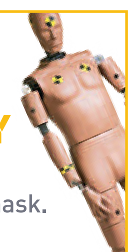
In the soil

What is in soil?

NO

Collect this ...

- samples of different soils
- stereomicroscope or hand lens
- rubber gloves



SAFETY

Wear rubber gloves and mask.

Do this ...

1. Study one of the soil samples with a stereomicroscope at about ×40 magnification or with a hand lens. Is the material in the soil all the same or is it made of different materials? Try to work out what things are in this soil.
2. Study the other soils to see if they have the same materials in them.

Record this ...

Describe what you saw.

Explain why some samples were similar while others were different.

Natural resources

A **resource** is anything obtained from the Earth to satisfy a particular need of humans or other living things. Most natural resources are substances, such as rocks, air or water. However, sunlight is a vital resource too. Sunlight is not a substance but is a form of energy. It is needed by almost all living things on Earth and so it can be considered to be an Earth resource (even though it comes from space).

The major natural resources of Earth are:

- rocks
- minerals (including metals) and fossil fuels (like coal and oil) found in rocks
- soil
- air
- water
- living things
- sunlight.

Some of these resources are shown in Figure 3.1.1 on page 86.

Figure 3.1.1 Animals, trees, soil, rocks, water, air and sunlight are natural resources.

All life depends on these resources. Protecting them gives all living things (including us) a better chance of survival.

Made resources

Not all resources are natural. Some are made by us humans. Made resources start as natural resources. Some important made resources are:

- foods, such as pasta and the bread in Figure 3.1.2, made from plant seeds
- leather, made from animal skins
- natural fibres, made from plants (such as cotton and linen) or animals (such as wool)
- plastics and synthetic fibres (such as polyester) made from oil
- fuels like petrol, diesel and kerosene, made from oil
- metals (such as iron and aluminium) made from minerals found in rocks
- glass, made from minerals found in sand
- ceramics (such as bricks and porcelain) made from clay
- cements, made from limestone, clay and other minerals found in rock
- medicines, made from plants, animals and minerals.

Figure 3.1.2 Bread is a made resource. It's produced from natural resources such as plant seeds like wheat, soy and rye.

ADDITIONAL

Technology and made resources

The variety of made resources increases as new technology is discovered. This means that new materials are continually being developed. For example, plastics were invented around 1900. Since that time, the use of plastics has become so widespread that they now replace wood, metal, cardboard and paper in many applications such as toys, computer cases, furniture, shopping bags, packaging trays, banknotes, and car and aircraft body parts.

Carbon fibre was developed more recently as a strong but lighter replacement for metal. It is now used in F1 racing cars, tennis racquets, golf clubs, hockey sticks, bike frames and wheels, and the masts of yachts.

Our ever-increasing understanding of genetics has led us to breed better plants and animals. In this way the amount and variety of food being grown is constantly increasing.

ADDITIONAL

Renewable and non-renewable resources

Some resources, such as sunlight, are renewable and will never run out. Other resources, such as minerals like iron, are non-renewable and can never be replaced once they are all used.

A **renewable resource** is one that is replaced by natural processes at about the same rate at which it is being used. If the amount being used suddenly rises, then the resource may eventually run out. Careful management is required to ensure that this does not happen.

An example is the timber in a forest. If the trees are cut down only as fast as new ones can grow then the forest will be renewable. In contrast, if all the trees are cut down at once, then the forest may never regrow. In this way, poor management of the resource can make it non-renewable. Figure 3.1.3 shows logging in the Amazon rainforest, the largest forest on Earth.

Figure 3.1.3 The Amazon rainforest in Brazil is a renewable resource only if the trees can regrow as fast as they are used.

Air, water, sunlight and living things are considered to be renewable resources.

Non-renewable resources are those that take a very long time to be replaced, usually much longer than a human lifetime. Coal, oil and natural gas take many millions of years to form. Therefore, they are non-renewable and will eventually run out (Figure 3.1.4). Rocks, the minerals they contain, and soils are also non-renewable because they usually take thousands to millions of years to form.

Figure 3.1.4 This gas platform is used to drill for oil and gas on the ocean bottom. Oil and gas are not renewable resources because they take millions of years to form.

Living things as a resource

Living things are a resource for humans and other organisms. For instance, animals eat plants and other animals. Sometimes living things even use other organisms as places to live. For example, tapeworms live in the gut of other animals. Plants use waste materials from animals and other plants as nutrients. Some plants rely on animals as a way of pollinating flowers, such as in Figure 3.1.5. Humans use plants and animals for food, shelter, building materials, clothing, medicines, fertilisers, fuel and many other purposes.

Figure 3.1.5 This plant relies on the honeyeater to pollinate its flowers. To attract the honeyeater the plant produces a sugary substance called nectar.

Living things also depend on their surroundings to supply other resources that they need. Water, rocks, air and soil supply the materials needed for all life. Sunlight is essential for plants to make their own food and to keep the Earth warm enough for life to exist.

Living things: a renewable resource

Living things are a renewable resource because they reproduce. A forest that has been cut down can regrow. Replacing some forests may take just a few decades, while other forests would take much longer to replace. Plantations (where trees are planted for timber) can be replaced faster than a natural forest. Animals, like the cows in Figure 3.1.6 on page 88, are replaced through reproduction. Replacing animals on farms may only take a year or so.

Figure 3.1.6 Animals are a renewable resource because they reproduce.

Air as a resource

Air is a mixture of gases and suspended particles such as dust, smoke and water droplets. The main gases in air and their importance to life on Earth can be seen in Table 3.1.1.

Table 3.1.1 Gases in the air

Gas	Percentage in air	Importance to life
Nitrogen	78%	Provides nutrients for plants to make proteins and other chemicals, which humans and other animals can use as food.
Oxygen	21%	Essential for most living things, to release energy from food for their bodies to use.
Carbon dioxide	0.03%	Essential for plants to make their own food by photosynthesis.
Other gases such as ozone, water vapour and argon	0.97%	Many uses depending on the gas. • Ozone shields humans from ultraviolet rays (reducing our risk of skin cancers). • Water vapour is part of the water cycle that carries water around the planet. • Argon is used in light globes.

Air: a renewable resource

About 21% of the air is oxygen gas. Oxygen is constantly being used by animals and plants but is also constantly being replaced by plants. Green plants, like the one in Figure 3.1.7, use the energy from sunlight, carbon dioxide and water to make their own food. The process is called **photosynthesis**. As well as producing the plant's food, photosynthesis also produces oxygen. This production allows the oxygen in the **atmosphere** to stay at about the same level. Scientists describe the movement of materials from one place to another and back again as a 'cycle'. Oxygen cycles through the Earth's atmosphere, soils, rocks, water and organisms.

Figure 3.1.7 Green plants use carbon dioxide, water and energy from sunlight to make their food (sugar) by the process of photosynthesis.

SciFile

Earth's fragile atmosphere

The atmosphere is the very thin layer of air around the Earth's surface. The first astronauts who ventured into space were amazed at how thin and fragile the atmosphere looked from space. Many said it made them think very deeply about the damage humans are doing to the atmosphere.

Only about 0.03% of air is carbon dioxide. This is enough to supply the carbon dioxide needed by plants to carry out photosynthesis. Animals breathe out carbon dioxide because it is a waste product of the processes that release energy in their bodies. So carbon dioxide is also being replaced in the air. It is part of a cycle, in which it goes from the atmosphere to plants, and then back again from animals to the air. This cycle of oxygen and carbon dioxide is shown in Figure 3.1.8.

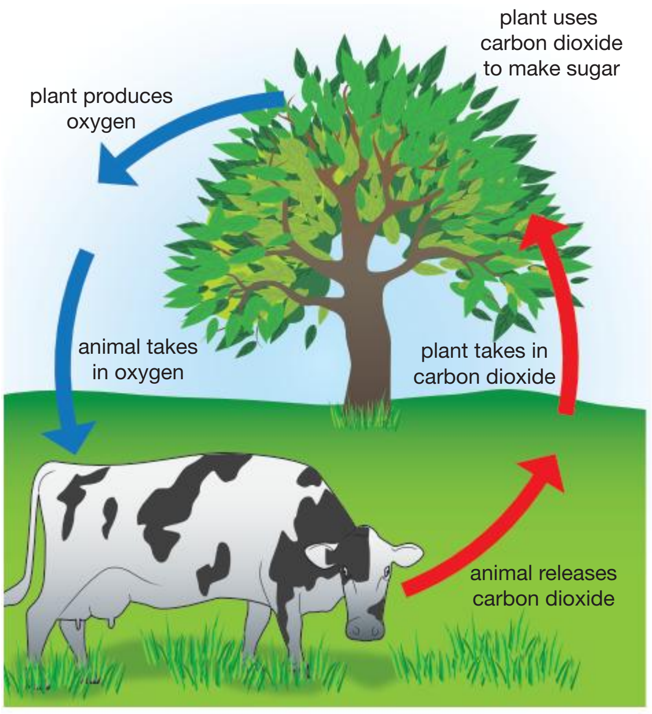


Figure 3.1.8 The exchange of oxygen and carbon dioxide between plants and animals renews these gases in the atmosphere.

The most abundant gas in air is nitrogen (78%). Nitrogen gas also has its own cycle as it is absorbed by some organisms and released by others.

Prac 1 p. 96

Sunlight as a resource

Sunlight is essential for life on Earth. This is because:

- plants use sunlight to produce food
- sunlight warms the Earth's atmosphere, land and water, keeping it warm enough for most water to stay liquid. If the Earth cooled too much, then all water would freeze and turn to ice. Living organisms contain a lot of water and so they would freeze too!

Sunlight: a renewable resource

Sunlight is a renewable resource and will be for as long as the Sun keeps shining. The Sun is a star, and it will continue to shine for billions of years.

Water as a resource

Water covers most of Earth's surface and all living things (like the bird in Figure 3.1.9) need it. No organism can live without water for long. For this reason, water is Earth's most important resource.

Figure 3.1.9 Water is the most important resource on Earth because no living thing can survive without it.

SciFile

Living on other planets

Life cannot exist without water. For this reason, scientists searching for signs of life in space are only looking at planets and moons where water can be detected.

Water: a renewable resource

Water is a renewable resource because it can move from place to place and replenish an area. It has a cycle. Only a tiny fraction of the water on Earth is made new each day. Some water is made whenever:

- living things like trees burn
- fossil fuels like petrol and coal burn
- living things release energy in their bodies.

The total amount of water on Earth is thought not to have changed much since the planet formed.

GO TO Unit 3.3
GO TO Unit 3.4

Rocks as a resource

Rocks provide two different resources:

- the rocks themselves
- minerals found in rocks.

There are many different types of rock. Some types are hard and can be used without altering them or removing any materials from them. These rocks are used mainly for roads and buildings, like the one shown in Figure 3.1.10. Other types of rocks are soft, like limestone and sandstone. These rocks are easy to cut, so they are used in paving and walls. Many of the early buildings of Sydney are built from local sandstone.

Figure 3.1.10 Stone buildings are built from rocks.

Rocks are made from substances called **minerals**. Minerals differ in their physical properties such as colour and hardness. You can see how minerals appear in a magnified view of a rock in Figure 3.1.11. Many minerals are important resources for humans. A variety of minerals and their uses are shown in Table 3.1.2.

Figure 3.1.11 This is a magnified view of a rock showing that it is composed of different minerals. Each different colour is a different mineral.

Table 3.1.2 Minerals and their uses

Mineral	Main use
Bauxite	Contains aluminium. Aluminium is used for making aircraft, drink cans and high voltage powerlines.
Haematite	Contains iron. Iron is used to make steel, which is used in car bodies, nails, ships and bridges.
Malachite	Contains copper. Copper is used in electrical wiring.
Halite	Contains sodium chloride (table salt). Sodium chloride is used in food preparation and medical applications.

Rocks contain some of the minerals that are needed by living things. As the rocks gradually break down, they release minerals which end up in the water of oceans and lakes, and in the soil. From the water and soil, the minerals are taken up by plants and animals, providing them with necessary trace elements.

Rocks also contain resources that are not minerals. Water is often found in rocks. The fossil fuels oil, natural gas and coal are energy sources that are found in or between layers of rock deep below the ground.

Rocks: a non-renewable resource

Most of the rocks of the Earth were formed millions of years ago. However, in a few places, rocks are still forming today. Some form when hot liquid rock (magma) from inside the Earth cools and solidifies. This type of rock is called **igneous rock**. Volcanoes are places where igneous rocks form. The igneous rocks that form when magma cools below ground can take thousands to millions of years to form. In contrast, igneous rocks form on the surface in a day or so (Figure 3.1.12). This is because the liquid rock (lava) cools quickly in the air or under the sea.

Figure 3.1.12 Although new rocks form every day, they cannot be considered renewable because the overall process takes so long.

Other types of rocks form when **sediments** (sand, silt and clay) stick together and harden to become rock. This type of rock is called **sedimentary rock**. Most sedimentary rocks form over many thousands or millions of years.

Only a tiny fraction of Earth's rocks is being replaced each year. The replacement takes so long that rocks cannot be considered to be renewable resources. Therefore the minerals in the rocks are considered to be non-renewable resources too.

Fossil fuels, like oil and coal, were formed from dead plants and animals that lived many millions of years ago and are not being formed today. For this reason, fossil fuels are also non-renewable resources.

GO TO Pearson science NSW 8 Chapter 8

Soil as a resource

Rocks are broken down (**weathered**) into smaller particles such as sand, silt and clay. The small particles are carried away by wind, water and ice in a process called **erosion**. The particles are then dropped somewhere when the wind, water or ice stops carrying them. When the particles drop, this is called **deposition**. You can see sand being deposited in Figure 3.1.13.

The deposited sediments are added to any soil they fall on, making new soil in the process. Soils are composed of:

- fine rock particles (sediments)
- living organisms (such as worms and moss)
- **humus** (decaying wastes and dead organisms)
- water
- dissolved minerals and gases.

Soil: a non-renewable resource

In some places the rock particles carried by water, wind and ice can build up quickly. An example is where many rivers carrying sediments meet in a river flood plain. In this way the soil is continually added to. Soil can also be enriched in home gardens or on farms by adding fertilisers or mulch (rotting leaves, bark and twigs) to add nutrients to it.

However, in most places on Earth, soils are not being renewed. If a farmer's soil blows away in the wind (or a tornado like the one in Figure 3.1.14) or is washed away in floods, then it is not likely to be replaced in the farmer's lifetime. Some soils form in places where the rocks on the Earth's surface are weathered. However, this process takes hundreds or thousands of years to form soil only a few centimetres thick. Therefore most soils are considered to be a non-renewable resource.

Prac 2 p. 97
Prac 3 p. 98
3.1

Figure 3.1.13 This sandstorm approaching the Saudi Arabian capital Riyadh shows how much erosion and deposition the wind can cause.

Figure 3.1.14 Tornadoes can strip topsoil from the ground and make it very difficult for any crops to grow.

Conserving resources

There are several ways we all can save our valuable resources.

- **Limiting consumption:** Everyone should avoid wasting resources by only using as much of the resources as is needed. For example, you can save energy by turning off lights that are not needed in rooms.
- **Increasing the price:** One strategy used by governments to encourage people to limit resource use is to charge a lot for resources such as water, gas and electricity. This works because people will not waste a resource if it costs them a lot of money.
- **Using alternative resources:** Another strategy to limit the use of a resource is to develop alternatives to it. For example, cars with electric engines save petrol, which keeps oil for other vital uses such as making plastics (Figure 3.1.15).

GO TO Unit 3.2

3.2

- **Public awareness campaigns:** Public awareness campaigns use the media to educate people about the need to conserve resources. These campaigns encourage people to limit their consumption because it saves them money and is better for the community.
- **Recycling:** Recycling is the process of re-using materials rather than throwing them away then having to make more of the material. For example, re-using aluminium means that less bauxite (aluminium ore) needs to be mined. Recycling materials such as iron, glass, copper, paper, wood and clay bricks also saves resources. Using the recycling bins that your council provides is an important way of recycling materials.

SciFile

Recycle and save (the planet!)

Each aluminium can you recycle saves about as much energy as it takes to run your TV for three hours!

Figure 3.1.15 Hybrid cars have both electric and petrol engines that save fuel. Although currently more expensive to buy, hybrid cars are much cheaper to run.

LEARNING ACROSS THE CURRICULUM

DIFFERENCE AND DIVERSITY

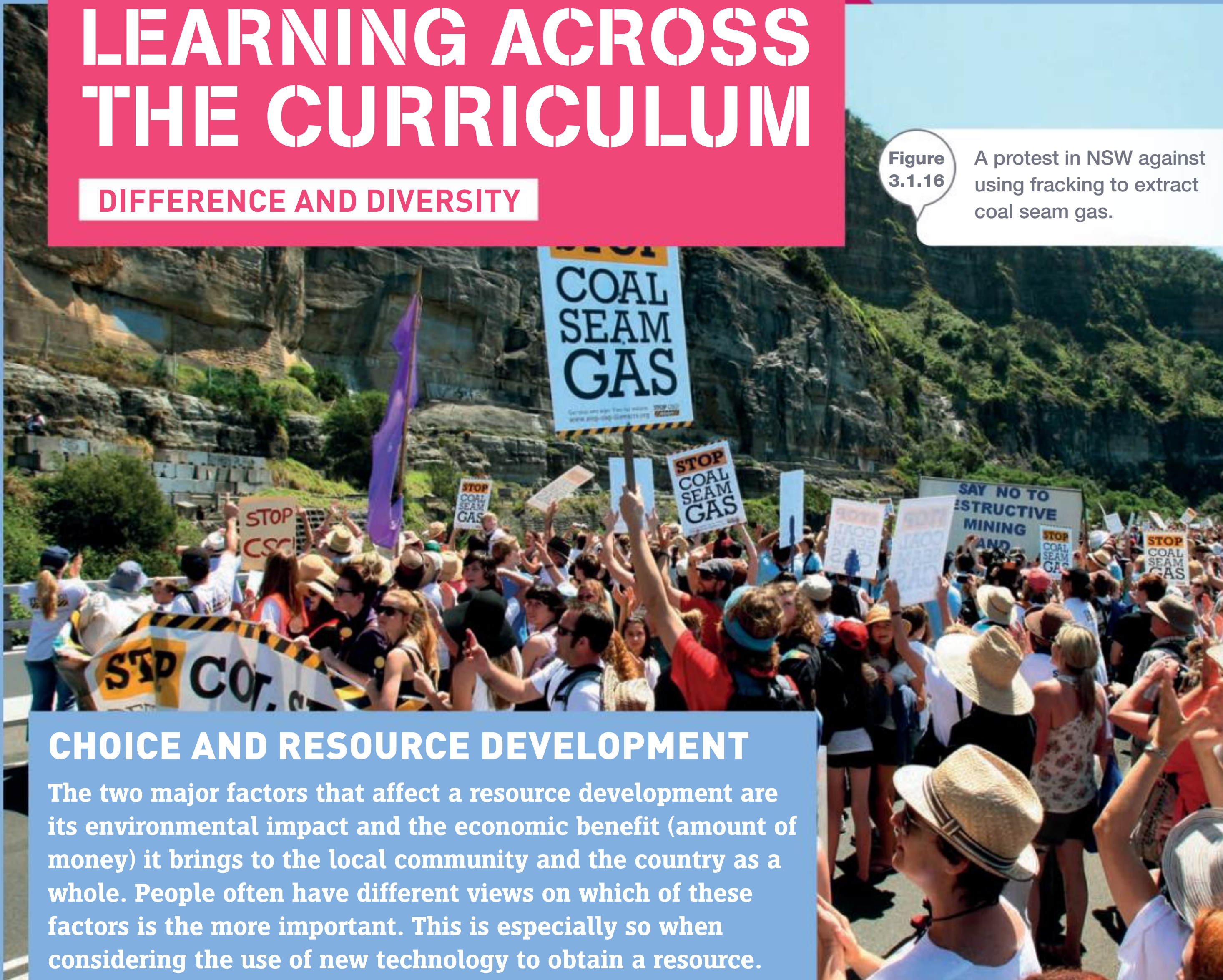


Figure 3.1.16 A protest in NSW against using fracking to extract coal seam gas.

CHOICE AND RESOURCE DEVELOPMENT

The two major factors that affect a resource development are its environmental impact and the economic benefit (amount of money) it brings to the local community and the country as a whole. People often have different views on which of these factors is the more important. This is especially so when considering the use of new technology to obtain a resource.

The economic benefit gained from mining a particular resource is affected by the changing prices obtained for the resource and the ‘life’ of the mine. Mines only continue while they are profitable or until the resource runs out. New technology can make some old mines profitable to use again.

Sometimes new technology allows an entirely new type of mining. An example of this is **fracking**, in which water and other chemicals are pumped into rocks, causing them to fracture (break). The cracks allow resources to escape from the rock so that they can be extracted.

In Australia, fracking is used to release natural gas from coal. This gas is known as **coal seam gas**. However, there have been cases in the USA where fracking has contaminated water supplies. In rural NSW, groups have protested against the use of fracking. One such protest is shown in Figure 3.1.16.

Cost and efficiency are major considerations with any new technology. The new method will be favoured if it is more efficient in supplying the resource or if it is cheaper than the old method. The new technology will also be favoured if it causes less damage to the environment. The most difficult decision is whether to allow some environmental damage because the technology is cheaper.

One major issue at present in Australia is the burning of coal to generate power. Coal burning produces carbon dioxide gas, which most scientists believe has caused warming of the Earth’s atmosphere and is changing some climates. There is debate about whether Australia should try to switch from coal to other less polluting forms of generating electricity such as solar energy and wind power.

GO TO Unit 3.2

INDIGENOUS AUSTRALIANS AND RESOURCES

The knowledge of Indigenous Australians has been useful in protecting the environment in resource developments. Their knowledge of plants and animals, rock art and fossil sites (Figure 3.1.17) has been used by state and federal governments when making decisions about whether projects should proceed and how the environment should be protected.

In NSW:

- All local governments have been encouraged to involve Indigenous people when developing resources such as parks and reserves.
- 'Green Teams' made up of Indigenous people visit sites and advise on resource developments.
- State laws define what is an Aboriginal Place, protecting places of significance to indigenous people.
- Native Title laws enable Indigenous people to make a claim to traditional land where they and their ancestors have lived.

REVIEW

1 **State** the two major factors that affect resource development.

2 **Describe** the process of fracking.

3 **Propose** why farmers and miners in rural NSW may have different, opposing views on using fracking to mine coal seam gas.

4 **Propose** why it is a difficult decision to use new technology that may be much cheaper but could cause damage to the environment.

5 **Assess** whether economics (money) should be as important as environmental damage when considering the long-term survival of life on Earth.

6 **Clarify** why the knowledge of Indigenous Australians is useful in determining the environmental impact of a mine.

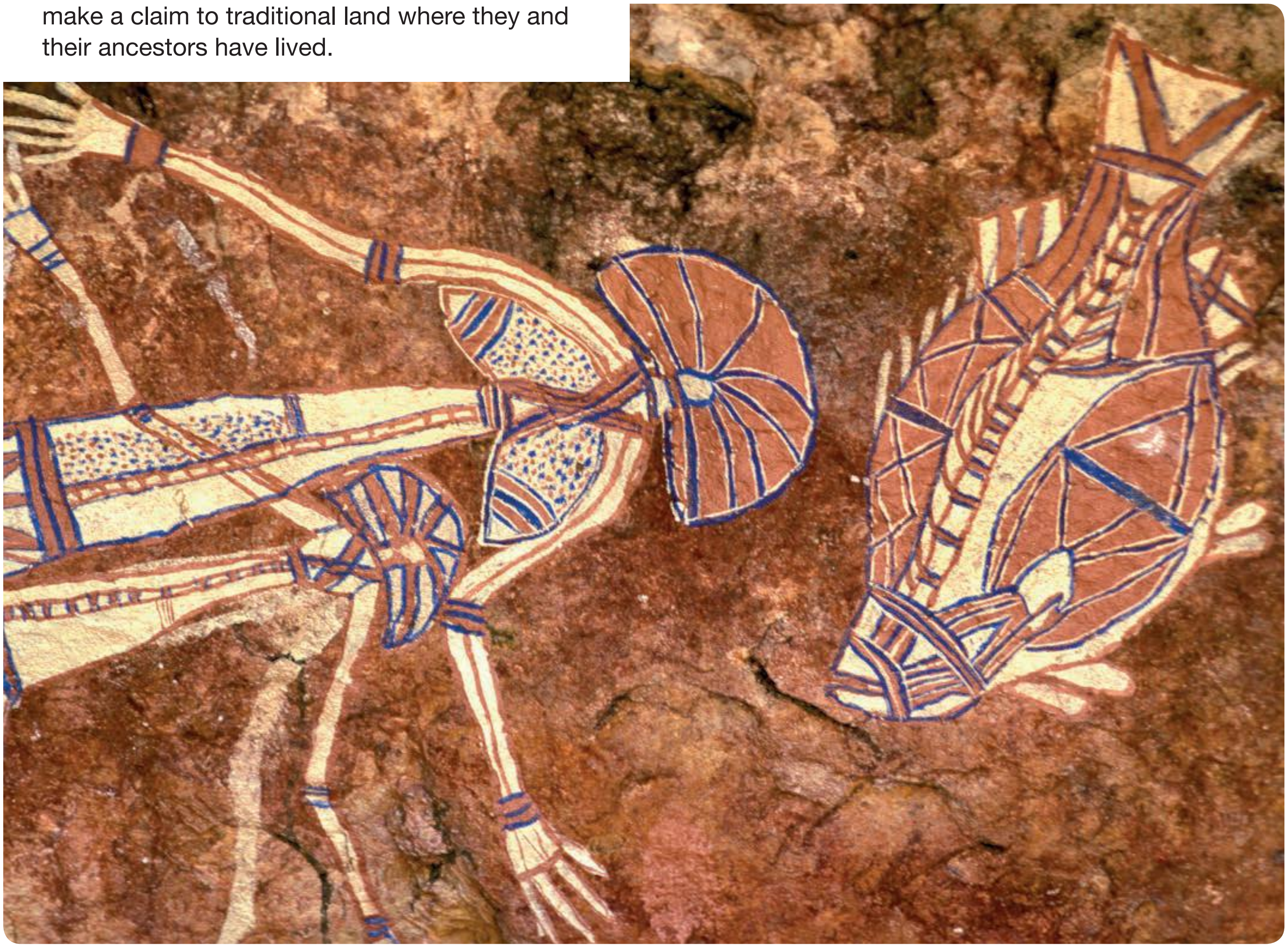


Figure 3.1.17 Aboriginal rock art at Nourlangie Rock in Kakadu National Park, Northern Territory. The area is so important that it is protected as a World Heritage Site.

3.1 Unit review

Remembering

1 **List** the major natural resources of the Earth.

2 **List** ten made resources that help humans survive.

3 **List** five strategies that assist in conserving resources.

4 **Recall** two factors that must be considered when deciding whether to develop resources.

Understanding

5 **Define** the term *resource*. L

6 **Explain** why it is important to conserve non-renewable resources.

7 **Explain** why living things can be considered a renewable resource.

8 **Explain** why minerals in rocks are not considered a renewable resource.

9 **Explain** how each of the following assists in conserving non-renewable resources:
  a recycling
  b public awareness campaigns
  c increasing their price.

Applying

10 **Identify** the major resource on Earth that sustains all life.

11 **Identify** the major Earth resources that are:
  a renewable
  b non-renewable.

12 **Identify** what you would expect to see when looking through a hand lens or stereomicroscope at the soil in the science4fun on page 85.

Analysing

13 **Classify** the following as renewable or non-renewable:
  a gum trees
  b water
  c sand
  d cows.

14 **Compare**:
  a renewable resources with non-renewable resources
  b made and natural resources.

Evaluating CCT

15 **Justify** the following statements:
  a Forests are renewable resources.
  b Soils are non-renewable resources.

Creating CCT

16 **Construct** a plan involving five strategies you could use in your home to conserve natural resources. Include in your plan discussion of the resources that are being conserved and how your strategy conserves the resource.

Inquiring

1 Research how the knowledge of Indigenous people in Australia has been used in protecting the environment during resource developments. In your research discuss a specific example for each of the following: AHC ICT
- major resource developments
- creating parks and reserves
- Green Teams
- local government initiatives.

Present your findings as a PowerPoint presentation or poster.

ADDITIONAL

2 Research any existing (or planned) mine in Australia. Find the economic benefits it has had (or will have) and the likely environmental impacts.

Present your findings as an argument for or against the mine, to be used as a class debate.

ADDITIONAL

3.1 Practical investigations

1 Renewing air

Purpose

To investigate whether a green plant produces oxygen.

Materials

- pieces of a leafy green plant such as geranium

- 3 × 250 mL conical flasks labelled A, B and C
- 3 small test-tubes
- 3 one-hole stoppers each with a filter funnel
- aluminium foil to cover one conical flask
- drinking straw
- 3 test-tube stoppers
- test-tube rack
- wooden splint
- matches

Procedure

1 Place enough plant shoots in each flask to fill it, then fill the flasks to the brim with tap water.

2 Using the drinking straw, blow bubbles through the water in flasks A and C for one minute. This adds carbon dioxide to the flasks.

3 Place a stopper with the filter funnel into each flask. Make sure some water enters the stem of the funnel.

4 Wrap flask C with foil so no light can enter.

5 Carefully add water to three-quarter fill each filter funnel. Then fill each test-tube with water and carefully turn the test-tubes upside down and place them in the filter funnels as shown in Figure 3.1.18.

6 Place the conical flasks outside in direct sunlight for the day if possible. Otherwise use a strong light in the laboratory and leave it on until the next day.

7 The next day, carefully lift the test-tube out of flask A, place a stopper in the top of the test-tube and place it in a test-tube rack.

8 Light the wooden splint and hold it near the test-tube in the rack. Quickly blow out the wooden splint, remove the test-tube stopper and hold the glowing splint in the test-tube.

9 Repeat steps 7 and 8 with the other test-tubes and record what happens.

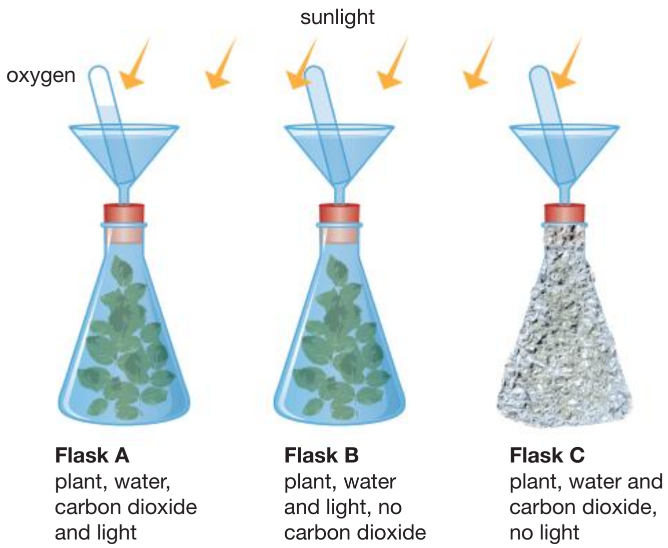


Figure 3.1.18

Results

Record your results in a table like the one below.

What happened to splint		
Test-tube A	Test-tube B	Test-tube C

Practical review

1 **Describe** the results for each test-tube.

2 Oxygen gas has the ability to make a glowing splint of wood catch fire again. **Deduce** whether any of the test-tubes contained oxygen.

3 **Propose** what happened in the three conical flasks.

4 **Explain** how this experiment is relevant to the importance of air as a resource.

5 **Explain** how this prac shows that sunlight is a resource.

2 Water-holding capacity of soil

Purpose

To compare the water-holding capacity of different soils.

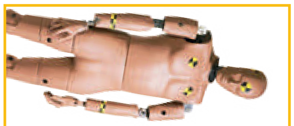
Hypothesis

Which soil type do you think will be able to hold more water—sand, loam or clay? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 100 mL each of dry clay, loam and sand

- 3 plastic filter funnels
- retort stand and 3 clamps, or filter stands
- 3 × 100 mL beakers
- 50 mL measuring cylinder
- cotton wool
- rubber gloves



SAFETY

Do not inhale or touch the soil with bare hands—it can contain dangerous organisms (pathogens) and can also trigger asthma. Wear rubber gloves at all times and wash your hands afterwards.

Procedure

1 Set up the equipment as shown in Figure 3.1.19, with a cotton wool plug in the neck of each funnel.

2 Half fill each funnel with a different type of soil.

3 Pour 20 mL of water into each funnel and collect any water that comes through. If no water comes through a particular soil, add another 20 mL of water to that soil until some water runs through it.

Results

Record in a table how much water you added to each soil and how much water collected in the beaker.

Practical review

1 a **Identify** the soil which has the largest water-holding capacity and the soil that has the smallest capacity.

b **Justify** your decision.

2 a **Construct** a conclusion for your investigation.

b **Assess** whether your hypothesis was supported or not.

3 **Outline** some possible reasons why the soils had different water-holding capacities.

4 Soils described as 'well drained' allow much of the water that enters them to pass through them. Labels on plants at a plant nursery sometimes say that the plant likes well-drained soils. **Propose** the characteristics of soils that make them well drained.

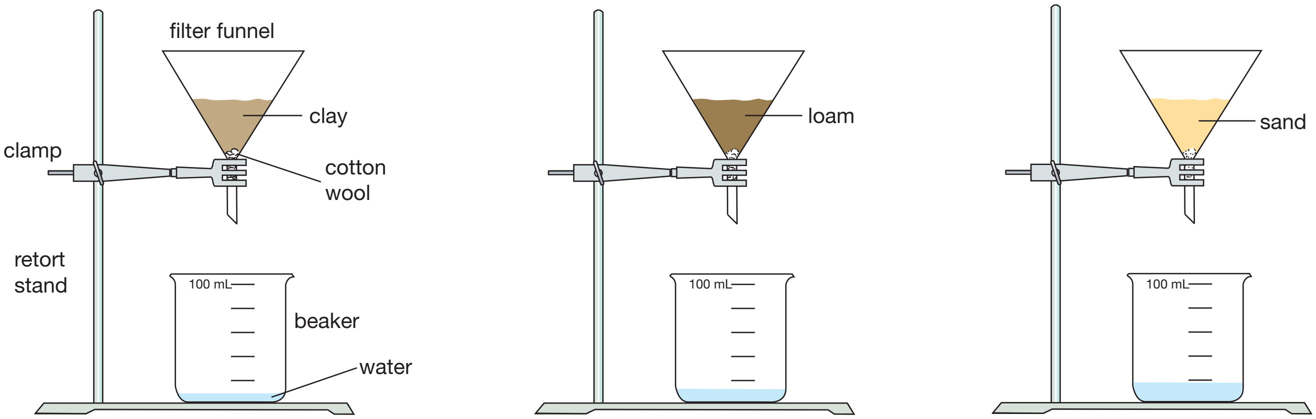


Figure 3.1.19

3.1 Practical investigations

STUDENT DESIGN

3 Erosion on a slope

Purpose

To test if the amount of soil erosion depends on the slope of the land over which the water runs.

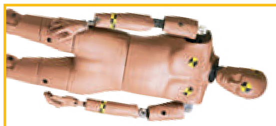
Hypothesis

Which slope do you think will have the greatest erosion—a shallow or a steep slope? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 20 L dry sand
- 20 L dry loam

- plastic gutter
- bucket
- tap
- hand lens or microscope
- protractor
- wooden blocks or bricks
- rubber gloves



SAFETY

Do not inhale or touch the soil with bare hands—it can contain dangerous organisms (pathogens) and can also trigger asthma. Wear rubber gloves at all times and wash your hands afterwards.

Procedure

1. Design an investigation that will test how the angle of a slope affects the amount of soil erosion when water runs down it. Figure 3.1.20 shows water cascading down a hill.
2. In your design you can use any equipment your teacher has provided or agreed to supply to you.
3. Decide in your group how you will proceed. Draw a diagram of the equipment you need and the procedure you will use to conduct your investigation.
4. Write your procedure in your workbook.
5. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

Record your results and observations.

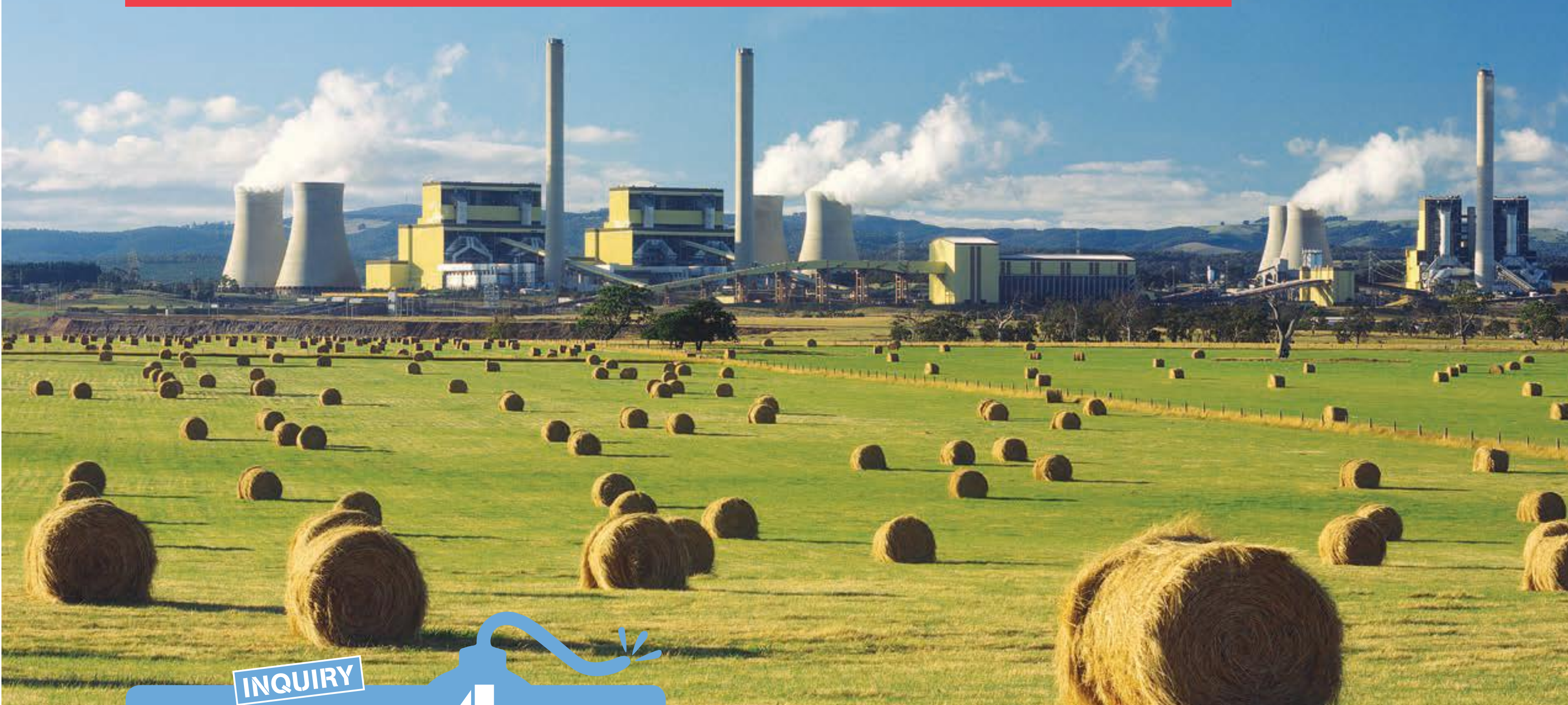
Practical review

1. **Evaluate** your procedure.
2. **Outline** how your procedure could have been improved.
3. a **Construct** a conclusion for your investigation.
   b **Assess** whether your hypothesis was supported or not.

Figure 3.1.20 Does the slope of the land affect the amount of soil erosion caused by water?

3.2 Energy sources

In Australia, the burning of coal generates most of our electricity. Fossil fuels produce vast amounts of the greenhouse gas carbon dioxide. This gives Australia one of the highest rates of greenhouse gas emissions per person in the world. Renewable resources such as wind, solar, tidal, hydroelectricity and biomass provide sustainable and clean alternatives.



INQUIRY

science 4 fun

Using the Sun

What energy changes occur in a solar cell?

Collect this ...

- solar cell
- connecting wires
- electric motor with a fan

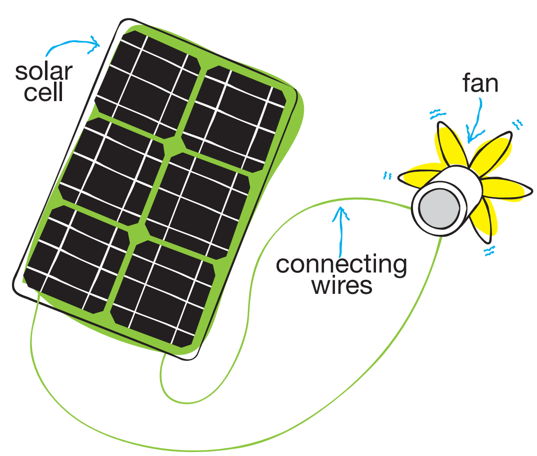
NO

Do this ...

1 Use the connecting wires to connect the solar cell to the electric motor.

2 Stand outside (preferably on a sunny day) with the solar cell facing the Sun.

3 Now partially or fully cover the cell and observe.



Record this ...

Describe what happened.

Explain why you think this happened.

Energy demand

Early humans had basic energy needs. Without electricity and fossil fuels, their energy needs were met from sunlight and from burning fuels like wood and dried animal manure. Since then, energy demands have risen dramatically. Figure 3.2.1 shows how the demand for electrical energy has grown in NSW since 1989. Appliances and gadgets, such as televisions, mobile phones, home entertainment units, gaming consoles and computers, require a lot of energy to manufacture. They also require ongoing energy to use. Air conditioning and the convenience of car and air travel come at an energy cost too. Table 3.2.1 shows that, relative to many parts of the world, Australia and other Western societies, such as the United States and Europe, consume large amounts of energy.

3.3

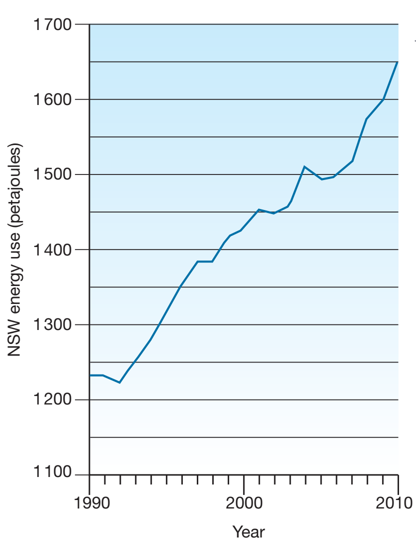


Figure 3.2.1 Increasing population and lifestyle changes have resulted in increased demand for electricity in NSW. 1 petajoule = 1000 million million joules.

Table 3.2.1 Energy use per person (in gigajoules, GJ) in various countries as stated by the World Bank, 2008–12

Country	Yearly energy use per person (GJ) [1 GJ = 1000 million J]
Australia	235
Canada	310
China	76
Egypt	38
El Salvador	28
Ethiopia	17
Greece	103
Italy	119
Pakistan	20
United Kingdom	137
United States	301

Non-renewable energy sources

Oil, coal, gas and nuclear are energy sources that cannot be replaced. Energy sources such as these are called **non-renewable energy sources**.

Oil, coal, gas and their products (such as petrol and diesel) are known as **fossil fuels**. Some 300 million years ago, the dead remains of prehistoric animals and plants were covered by layers of mud, sand and dirt. Pressure and heat below the Earth's surface gradually transformed these remains into the different fossil fuels found today. The original source of energy for these fuels was the sunlight absorbed by the prehistoric plants. It was stored in their remains or in the remains of the animals that ate the plants. When burnt, fossil fuels release large amounts of energy but also large amounts of the **greenhouse gas** carbon dioxide. This increased concentration of carbon dioxide in the atmosphere is thought to contribute to climate change.

Nuclear fuels, such as uranium and plutonium, are non-renewable sources of energy that are used as the main power source in many countries overseas. There are no nuclear power plants in Australia. The nuclear reactor at Lucas Heights in Sydney only produces radioisotopes for use in medicine and engineering. Small amounts of these fuels can produce large amounts of energy in a chain reaction in a process called nuclear fission. This chain reaction is carefully controlled in a nuclear power plant. The heat created is used to generate electricity. Nuclear power plants do not produce greenhouse gas emissions. However, the process of nuclear fission used produces wastes that remain radioactive for thousands of years. Long-term safe storage of these wastes remains a problem.

Figure 3.2.2 shows that more than 80% of the world's energy supply is obtained from oil, coal and gas. These are all non-renewable fossil fuels. Australia has plentiful supplies of coal and it is relatively cheap. Major energy sources used in Australia include:

- black and brown coal, to produce steam used to generate most of our electricity
- petrol to power most of our cars, with some using LPG (liquefied petroleum gas, another fossil fuel)
- diesel to power most trucks, cars and tractors and some trains
- natural gas for much of our cooking, central heating and hot water services.

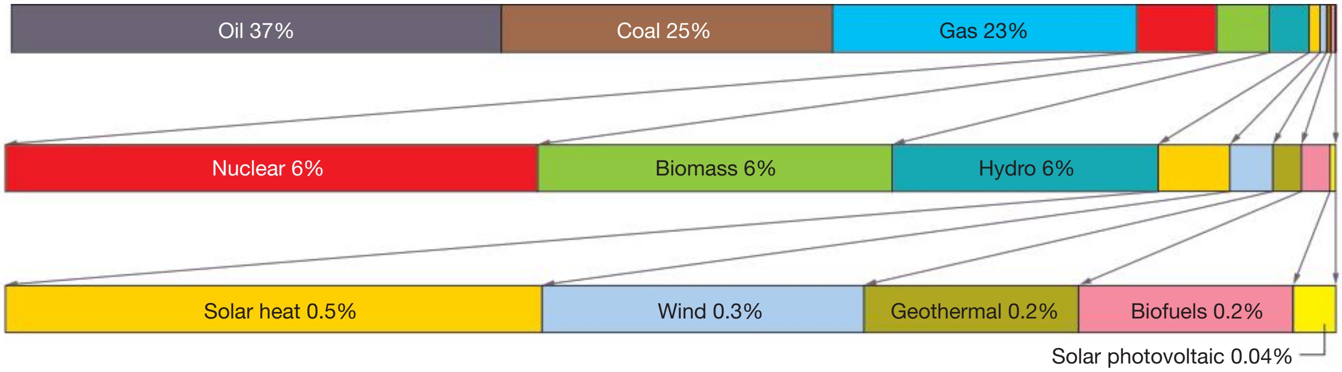


Figure 3.2.2 This chart shows where the world's energy comes from. The second and third rows show detail that cannot be seen in the smallest bands of the row above.

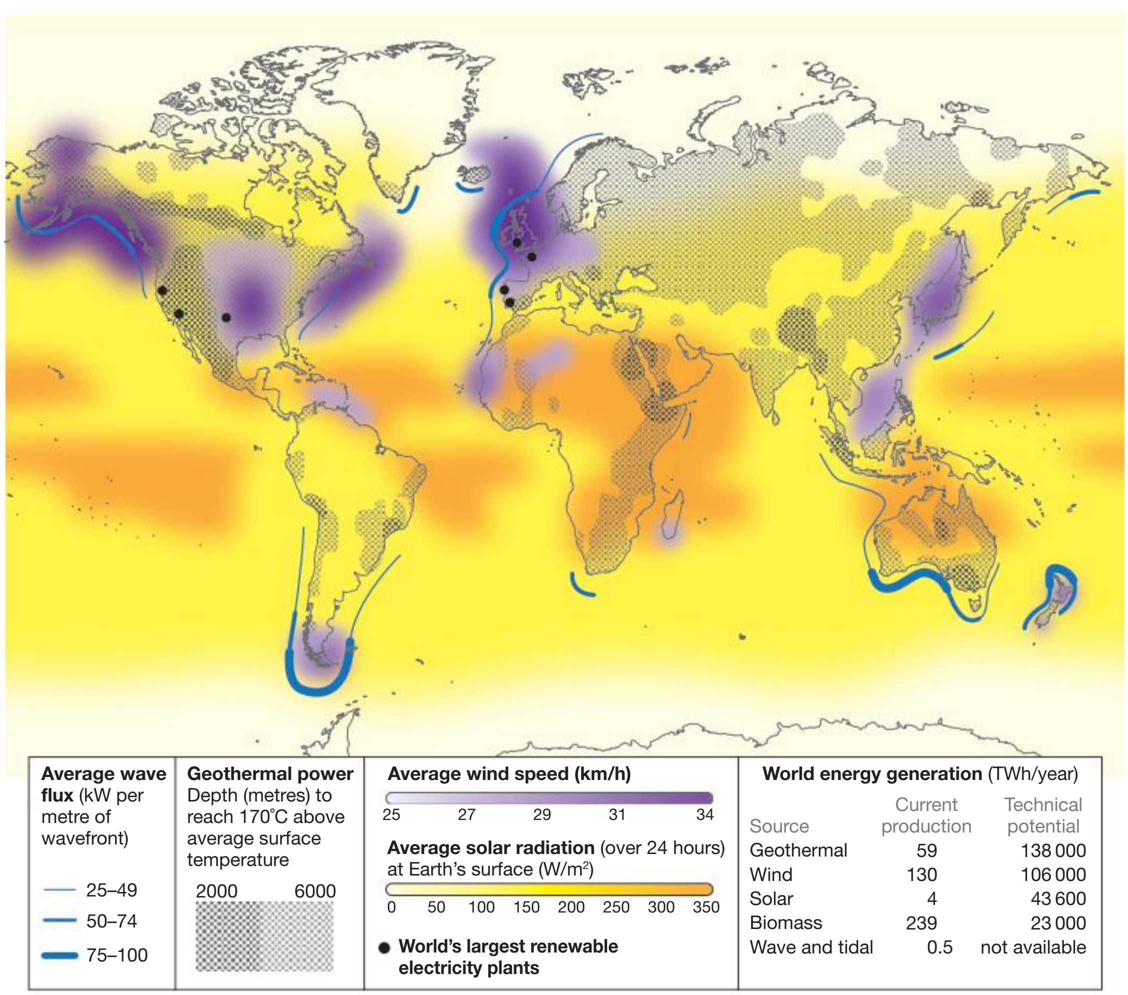
Renewable energy sources

Renewable energy sources can be used over and over again. If we want to build an energy supply for the future and to limit greenhouse gas emissions then we need to switch from fossil fuels to renewable sources. Power companies offer households the option to buy all or some of their electricity from a green power provider. You pay slightly more but you buy electricity that has been sourced from renewable energy. Key sources of renewable energy are:

- moving water
- Sun
- wind
- heat within the Earth
- oceans and rivers
- biomass.

Figure 3.2.3 highlights the regions of the world best suited to each type of renewable energy.

Figure 3.2.3 The depth of yellow shading indicates the average solar radiation reaching the surface of the Earth. The purple zones indicate regions of high wind speed. The blue lines indicate high tidal activity. The dotted zones indicate where heat is relatively close under the Earth's crust.



A major problem with renewable energy sources is that their energy output is not continuous. Wind turbines, solar systems and wave generators rely upon the wind blowing, sun shining and waves breaking. Better methods need to be developed to store renewable energy when demand is low so that it can be used later when demand rises.

Hydroelectricity

Gravity causes things to fall, including water. Water falling from a higher to a lower level (such as from the dam shown in Figure 3.2.4) can be used to turn turbines and generate electricity. This form of electricity is called **hydroelectricity**. The Snowy Mountains hydroelectric scheme in NSW is the largest hydroelectric power scheme in Australia. It consists of 16 dams, 7 power stations and over 145 km of tunnels. Hydroelectric schemes are a renewable energy resource. However, large-scale projects change the way rivers flow and alter the environment.

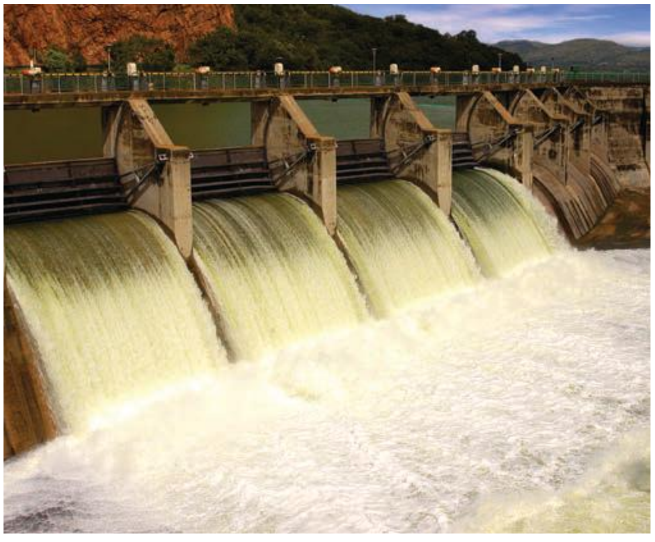


Figure 3.2.4 The energy of falling water is used to turn turbines that generate electricity in a hydroelectric power station.

A sugar rush

SciFile

Brazil produces vast crops of sugarcane and uses some to produce ethanol. Most new cars are designed to run on ethanol. This change has lessened Brazil's dependence on oil – its cars are essentially solar powered!

Biomass

Biomass is material, such as dead plants, other types of plant matter, or animals and their wastes, from which energy can be obtained. These materials contain stored energy captured from the Sun. This energy can be released for use in many different ways:

- Heat energy is released when products such as wood, peat or dried manure, such as cow pats, are burnt.
- When organic wastes such as fruit peelings and grass clippings are put into landfill, they decompose, producing methane and carbon dioxide gases. This gas mixture, called **biogas**, can be collected from landfill sites and the methane gas then used as a fuel. Biogas can also be produced from human sewage and animal wastes.
- **Biofuel** is liquid fuel made from living things like plants or algae. For example, ethanol can be fermented from agricultural crops, such as sugarcane or corn (shown in Figure 3.2.5), or from agricultural wastes, such as rice husks. Biodiesel fuel can be made from vegetable oils extracted from plant seeds, such as palm oil, sunflower, canola, soybean, sesame and linseed, or by harvesting algae.

3.4 Prac 1 p. 110

Figure 3.2.5 Corn ethanol is produced in this processing plant in Iowa, USA. The corn grain shown here is a waste product of the process and is sold as animal feed.

Solar energy

Light from the Sun is a valuable renewable resource. It can be used in many ways to provide energy.

- The direction a house faces (its orientation) can help to reduce the need for additional heating and cooling. Using interior materials that absorb sunlight through the day and then release heat at night also helps.
- Sunlight can be used to heat water flowing through rooftop solar collectors to provide households with hot water.

GO TO Pearson science NSW 8 Unit 5.2

- **Solar cells** (such as those shown in Figure 3.2.6) use materials called semiconductors to convert sunlight directly into electricity. Rooftop solar cells can provide household electricity, and any extra electricity generated can be fed back into the electricity grid or into storage batteries. Solar cells are expensive to produce, but the amount of electricity they make is increasing each year. This increased efficiency of solar cells is making them more affordable to householders.

Figure 3.2.6 Solar cells are useful for providing energy to small-scale devices, such as calculators or garden lighting, and for providing electricity in remote areas.

- A solar pond consists of a large volume of water to which salt is added. The pond is lined with black plastic. Sunlight heats water at the base of the pond, and the heat can be used to generate electricity.
- Large-scale solar energy systems, such as that shown in Figure 3.2.7, rely upon vast arrays of mirrors to concentrate sunlight. These devices can be used to generate electricity with no greenhouse gas emissions.

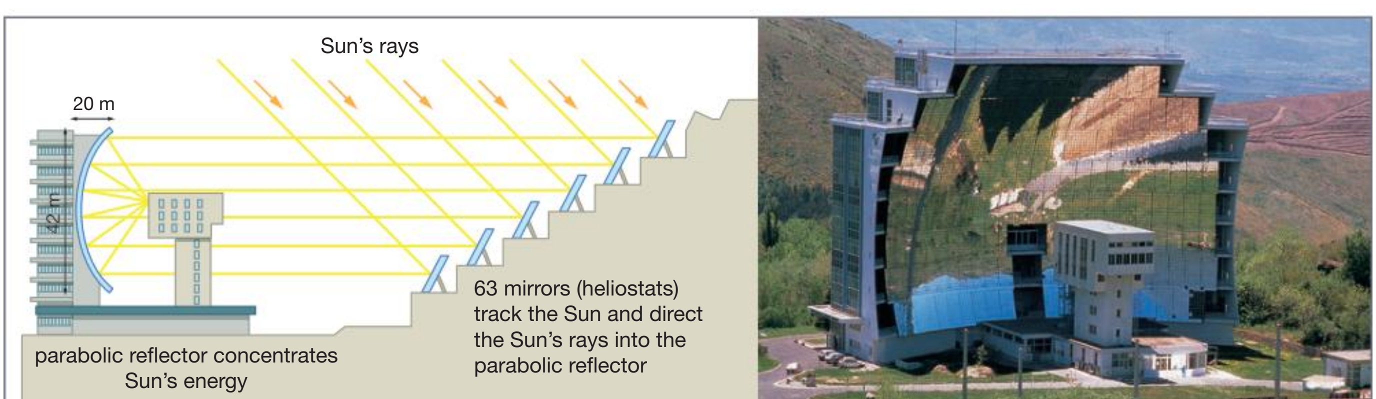
Wind energy

Wind energy has been used for centuries and windmills have long been used in Australia to pump water. Wind turbines are like large windmills but are used to generate electricity. Wind farms are located in windy places. You can see a wind farm in Figure 3.2.8.

Prac 2 p. 111

Figure 3.2.8 Wind energy generates no greenhouse gas emissions. Nearby residents may object to wind farms because they produce some noise and birds may be injured by the turbines as they spin.

Figure 3.2.7 A solar furnace can produce temperatures up to 3800°C. Solar furnaces, such as this one in Odeillo, France, can be used to generate electricity.



Energy from the ocean

There are a number of different techniques that harness energy from the ocean. Although these techniques are generally expensive to establish, they offer a clean energy source once they are operating. An **oscillating wave column** (shown in Figure 3.2.9) and a **tidal barrage** (shown in Figure 3.2.10) are two examples.

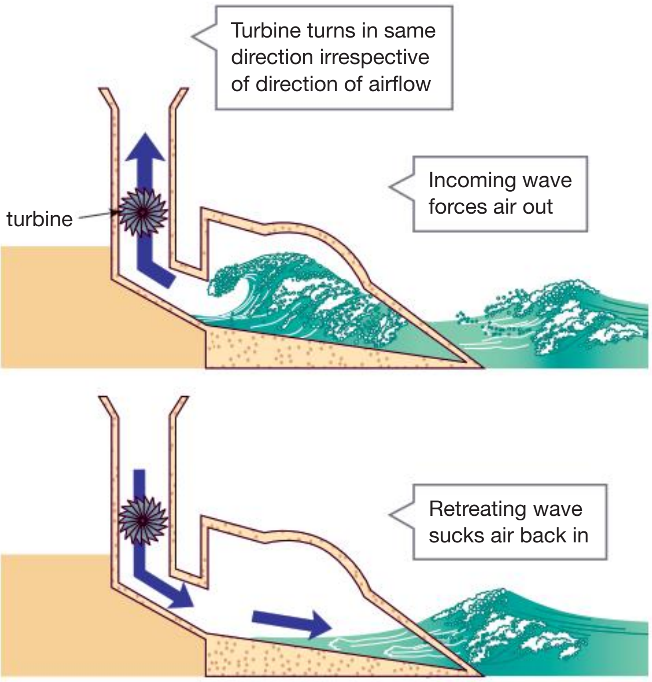


Figure 3.2.9 The oscillating wave column relies on the pressure of the waves to suck air in and out around a turbine to generate electricity.

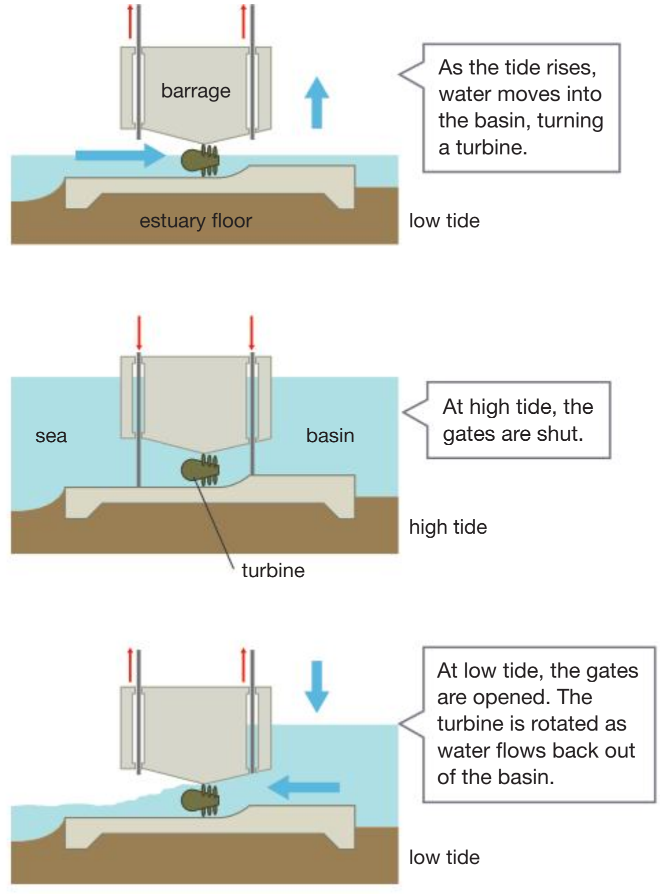


Figure 3.2.10 At low tide, the gates of the tidal barrage open to allow water to fill a basin. These gates are shut at high tide. When the tide is low, the gates are reopened and the pressure of water rushing out is used to generate electricity.

Geothermal energy

Beneath the Earth's crust lies molten magma (melted rock). In Iceland, Japan and New Zealand, this heat lies fairly close to the surface and heated water may burst from the surface as a natural hot spring or geyser like the one shown in Figure 3.2.11. This heated water can be used directly to generate electricity. Another way to use **geothermal energy** is to pump water underground through drilled channels and circulate it through the hot rock. The water is heated by the rock and is used to generate electricity when it returns to the surface. This is shown in Figure 3.2.12. A geothermal power plant has been built at Birdsville, in Queensland, and plants are being developed in South Australia. Geothermal power plants tap into a plentiful natural energy source. However, they are limited to specific areas and can result in pollutant gases escaping from below Earth's surface.

Figure 3.2.11 This steam is produced by geothermally heated water in Iceland.

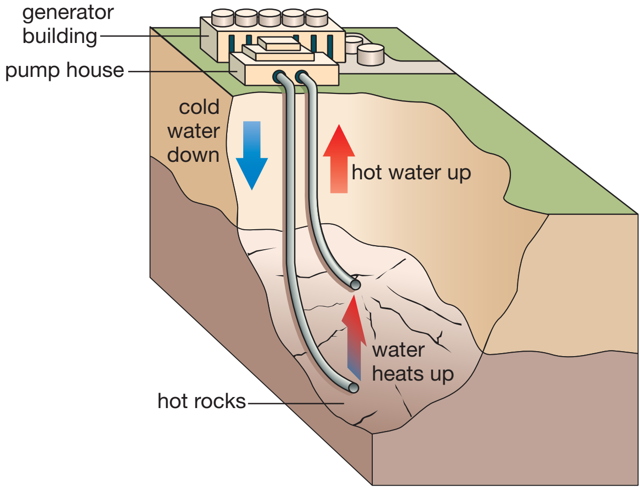


Figure 3.2.12 A geothermal power plant pumps cold water below the surface where it is naturally heated over hot rocks. It then returns to the surface.

Powering NSW

Fossil fuels supply 94% of the energy needed in NSW. Coal and petroleum (petrol) make up most of the fossil fuels used. As Figure 3.2.13 shows, electricity supplied by renewable sources is a small part of the total energy used in the state.

Electricity generated from renewable sources is on the rise. From 2001–08, electricity from renewable sources contributed 6% of the total electricity produced but by 2010 this type of energy supply had doubled. In NSW, the main renewables used are hydroelectricity, biomass (wood, wood waste, biogas, biofuels) and, increasingly, wind and solar energy.

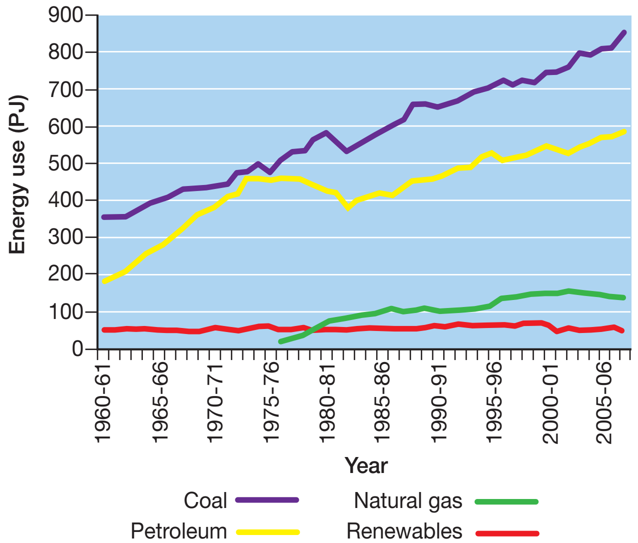


Figure 3.2.13 This graph shows the increasing use of coal to meet energy demands in NSW and the ACT.

The abundant and accessible reserves of black coal in NSW have been a source of massive economic benefit. In 2008, exports of black coal contributed more than 8 billion dollars to the Australian economy and the industry employed more than 13 000 people. Figure 3.2.14 shows the location of the coalfields of the Gunnedah basin.

Figure 3.2.14 The Gunnedah basin contains almost all of the coal resources found in NSW. This area of land is approximately 500 km long by 150 km wide.

Powerful Gunnedah

SciFile

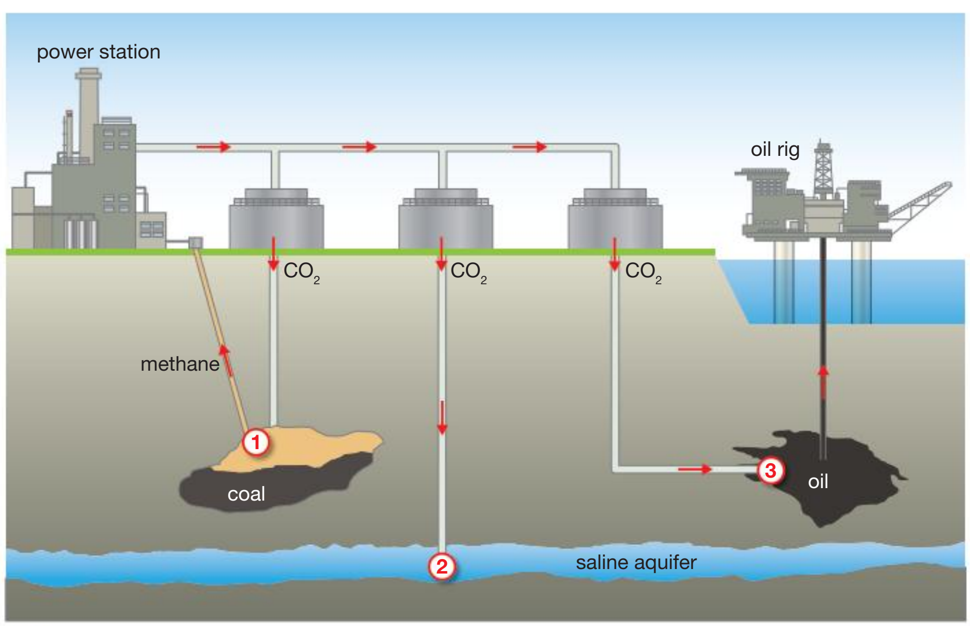
In the 1800s, trains, steamships and most machinery were driven by steam engines, which burned coal. Back then, coal was as important as oil is to us today. The rich coal seam beneath the Gunnedah region was discovered in 1877 by a local farmer boring for water. Prior to that, the area derived its wealth from sheep and wheat farming.

The coal mining industry provides a reliable source of energy, income and employment, but there are serious concerns about its impact on the environment. These include:

- the emission (release) of large quantities of greenhouse gases (particularly carbon dioxide) produced when coal is burnt
- pollution of surface and groundwater
- erosion and changes to the landform (Figure 3.2.15)
- changes to the environment that might make it more difficult for different types of animals and plants to survive.

Carbon capture and storage is the process whereby carbon dioxide gas is isolated and captured either before or after coal is burnt. Once captured, the carbon dioxide is liquefied (changed into a liquid). It is then pumped into geological formations where it is to be stored underground. This is shown in Figure 3.2.16. Such 'clean coal technologies' aim to reduce greenhouse gas emissions generated when burning coal. Smallscale trials have been conducted, but the process has not yet been used on a large scale. Some scientists fear the process could trigger instability within the Earth, potentially leading to earthquakes.

Figure 3.2.15 The impact of coal mining on the environment can be seen in this open cut mine near Lake Macquarie, NSW.



1. Carbon dioxide can be pumped into abandoned coal mines. As carbon dioxide is pumped in, methane gas can be pumped out for use as an energy source.
2. Carbon dioxide can be pumped into geological formations, such as deep saline aquifers, in which it is believed it can be safely stored.
3. Carbon dioxide can be pumped into oil fields in which output is dropping. This process can increase oil recovery output from the oil field.

Figure 3.2.16 Carbon capture and storage aims to isolate and safely store carbon dioxide produced when coal is burnt.

LEARNING ACROSS THE CURRICULUM

ETHICAL UNDERSTANDING

UMEME KWA WOTE—ENERGY FOR ALL

About one-quarter of the world's population does not have access to an electricity supply.

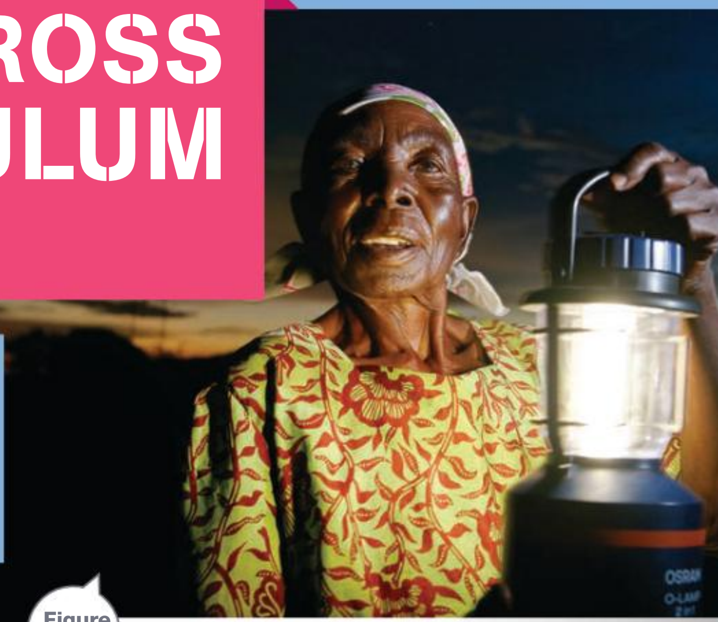


Figure 3.2.17 This Kenyan woman carries a chargeable solar-powered lamp.

For many generations, fishermen living by the shores of Lake Victoria, in Eastern Africa, have relied upon kerosene lamps to light their homes and catch fish at night. Kerosene is a non-renewable resource. It is readily available in remote areas and easy to buy in small quantities. However, it is expensive and highly flammable, and at times kerosene leaks into the lake, adding to its pollution. It is estimated that the burning of kerosene in lamps around the lake produces about 50 000 tonnes of carbon dioxide gas every year.

In April 2008, a lighting company built the first 'energy hub' on the banks of Lake Victoria. Its name is *Umeme Kwa Wote*, Swahili for *energy for all*. It is an energy station consisting of 42 solar panels installed on its roof. These panels convert the renewable resource of sunlight into a clean supply of electricity. Three hubs have been built in Kenya and one in Uganda, with hopes to build another 100 energy hubs in Africa and 20 in Asia.

For a small fee, locals can use this electricity to recharge energy-efficient fluorescent lamps for use on their boats and in their homes. They can also take a rechargeable battery from the energy hub to power fishing lamps. Typical lamps are shown in Figures 3.2.17 and 3.2.18. They rely on an 11 W globe and are watertight and dust resistant. Costs are much lower than the equivalent costs for kerosene, the light from the lamps is brighter, it carries no health risks, and no greenhouse gases are produced in the process. The battery can also be used to operate or charge small appliances such as mobile phones and radios. When the batteries are flat, they are brought back to the hub for recharging and are swapped for a charged battery.

The woman shown in Figure 3.2.17 is carrying a lantern with an internal rechargeable battery. This lantern operates for 8 hours, or even longer when switched to a lower power LED light designed to provide enough light to read a book at night.

Figure 3.2.18 These fishermen on Lake Victoria plan to catch sardines attracted by the light source.

REVIEW

1. **State** the fraction of the world's population that has no access to electricity.
2. **List** the disadvantages of using kerosene as a light source in remote communities.
3. **Outline** how the program *Umeme Kwa Wote* provides solar lights in Kenya.
4. **Propose** areas in Australia that might benefit from a similar scheme.

3.2 Unit review

Remembering

1 Refer to Figure 3.2.1 on page 100 and **state** the approximate energy use (in petajoules) in NSW in the years:
   a 1990
   b 1999–2000
   c 2010.

2 a **State** one key advantage of fossil fuels.
   b **State** two key disadvantages fossil fuel.

3 **State** one advantage and one disadvantage associated with the use of nuclear fuel.

4 **List** the three sources of energy that supply the majority of the world's needs.

5 **List** five types of plant seeds that can be used to produce biodiesel fuel.

6 **Recall** another name for a solar cell. L

7 **Name** the region of NSW that contains the richest reserves of coal.

Understanding

8 Refer to Figure 3.2.1 on page 100 and **describe** how the demand for electricity has varied in NSW between 1990 and 2010. N

9 **Explain** the difference between renewable and non-renewable sources of energy, giving an example of each type.

10 **Outline** how fossil fuels are formed.

11 **Define** the term *biomass*. L

12 **Describe** five different ways sunlight can be used as an energy source.

13 **Discuss** at least three positive and three negative effects of coal mining in NSW.

14 **Explain** the process of carbon capture and storage.

Applying

15 a **State** the average energy use in gigajoules (GJ) of an Australian over a year.
   b **Calculate** this value in joules (J). N

16 Each situation **a–h** below describes different energy changes. **Use** the options below to **identify** which type of energy is being used in each case.

hydroelectricity
oscillating wave column
biomass
fossil fuel
tidal barrage
solar energy
geothermal energy
wind energy

   a Wood is burnt in a camp oven to boil a kettle.
   b Natural gas is used to heat a saucepan of pasta on a stove.
   c Falling water turns turbines that generate electricity.
   d Sunlight falling on a photovoltaic cell is directly converted into electricity.
   e Turbines rotate as air flows through them and this is used to generate electricity.
   f A turbine rotates in one direction and then the other as moving water sucks air past its blades.
   g Water flows rapidly over a turbine, which is used to generate electricity.
   h Water pumped below the surface of the Earth is heated and used to generate electricity.

17 **Use** Figure 3.2.2 on page 101 to **state** the percentage of world energy consumption supplied by: N
   a oil
   b solar photovoltaic energy
   c nuclear energy.

18 **Use** Figure 3.2.13 on page 105 to **list** the energy sources used to provide electricity for NSW in order from the largest to the smallest contributor. N

Analysing

19 a **Identify** the source of energy being used in the science4fun activity on page 99.
   b **Classify** this as a non-renewable or a renewable energy source.

20 **Compare** the key advantages and disadvantages of two renewable energy sources, such as solar, wind, tidal, geothermal or hydroelectric energy production.

Evaluating CCT

21 a **Assess** whether nuclear energy is a renewable or non-renewable energy source.
b **Justify** your answer.

22 Refer to Figure 3.2.3 on page 101 to answer the following questions.
a **State** the current production of electricity from solar sources (in terawatt hours per year, TWh/yr).
b **State** how much electricity could potentially be produced from solar sources (in TWh/yr).
c **Propose** three regions of the world that would be best suited to utilising:
i solar energy
ii wind energy
iii ocean energy
iv geothermal energy.
d Looking at Australia on this illustration, **propose** which renewable resource you think would be best suited to development in NSW.

23 **Propose** what is meant by the term *green energy*. L

24 **Propose** reasons why electricity demand in NSW drops occasionally during a day or over a year.

Creating CCT

25 Australia has plenty of brown and black coal. It is relatively easily mined and relatively cheap.
a **Construct** an argument for or against the use of coal as an energy resource.
b **Use** the arguments of the class to run a debate on whether coal should continue to be used as a major source of electrical energy in Australia.

Inquiring

1 Many remote communities in Australia are located large distances from the electricity grid. These communities generally rely on isolated diesel power stations. Such diesel power stations are affected by price variations in diesel fuel and also contribute greenhouse gases to the atmosphere.
- Research other sources of electricity that are being used or could be used in remote communities.
- Collect photos of some examples of other sources that provide energy.
- Link each photo of a source with its position on a map of Australia.
- Investigate factors that affect the cost of supplying electricity to remote communities.
- Summarise any improvements that are being made to the delivery of electric power in such regions.

Present your findings as a poster or as a digital presentation. ICT

ADDITIONAL

2 The phrase *intergenerational justice* can be used when discussing the use of non-renewable resources. To investigate this concept:
- Research what *intergenerational* means.
- Explain what is meant by the term *non-renewable resource.*
- Outline what you think is meant by the term *intergenerational justice* when linked with non-renewable resources.
- Construct arguments that agree or disagree with the statement that:

People today must have a sense of intergenerational justice when using non-renewable resources.

Present your findings as a Word document. ICT

ADDITIONAL

3.2 Practical investigations

1 Energy from food (biomass)

The stored chemical energy in food can be used to produce biofuels. Food is also used to produce chemical energy inside your body.

Purpose

To burn a sample of food and calculate its energy content.

SAFETY

Do not use peanuts or any nut product because of possible food allergies.

Watch the burning food sample at all times.

Ensure that the room is well ventilated or complete this experiment inside a fume cupboard.

Materials

- food samples (such as Cheezels, crusty bread, Marie biscuit)

- cork
- aluminium foil
- paper clip
- retort stand and clamp
- thermometer
- test-tube
- electronic balance
- small measuring cylinder

Procedure

1 Copy the results table below into your workbook.

2 Using the measuring cylinder, carefully measure 20 mL of water. Pour it into the test-tube.

3 Cover the cork with aluminium foil. Shape the paper clip like a hook and poke it into the cork.

4 Cut a small piece of your first food sample. Measure and record its mass in your table.

5 Set up the equipment as shown in Figure 3.2.19 so that the food sample will sit about 2 cm below the test-tube.

6 Measure and record the initial temperature of the water.

7 Use the Bunsen burner to set the food sample alight, and then carefully place the burning sample under the test-tube.

8 When the sample stops burning, measure the final temperature of the water and record this result.

9 Repeat the activity using two other food samples.

Results

1 Record all your measurements in the results table.

2 Calculate the change in water temperature by subtracting the initial temperature from the final temperature. N

3 For each sample, divide the change in water temperature by the mass of the sample. N

Practical review

Compare the different samples and **list** them in order from the one that contains the most energy per gram to the one that has the least energy per gram.

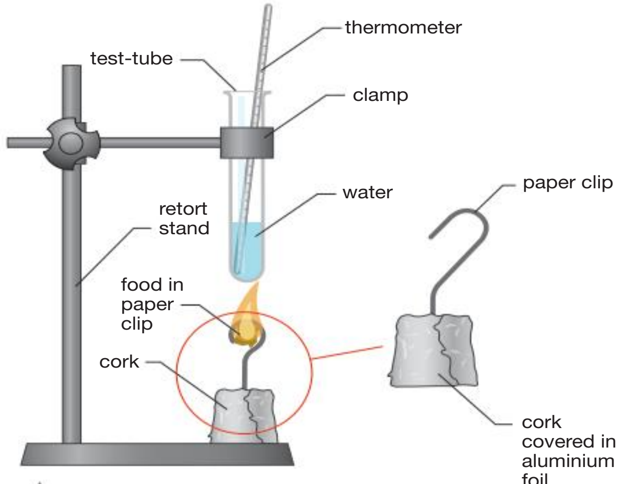


Figure 3.2.19

Food sample	Mass of sample (g)	Initial temperature of water (°C)	Final temperature of water (°C)	Change in water temperature (°C)	Change in water temperature ÷ mass of sample (°C/g)
1					
2					
3					

STUDENT DESIGN

2 Harnessing the wind

Purpose

To investigate the effect that wind direction has on wind power.

Hypothesis

Which direction of wind will make a turbine spin the fastest—will it be when the wind hits the turbine from straight in front or at an angle? Before you go any further in your investigation, write your hypothesis in your workbook.

Materials

- pedestal fan or a hairdryer
- pinwheel made from a sheet of light cardboard
- nail or drawing pin
- bamboo skewer
- protractor
- masking tape
- cardboard cylinder
- length of string
- paper clip

SAFETY

A Risk Assessment is required for this investigation. Do not operate the hairdryer near water or insert any materials inside the fan.

Procedure

1 Produce a cardboard pinwheel by following these instructions:
   i Enlarge the template of the pinwheel shown in Figure 3.2.20 and print it onto a sheet of paper or cardboard.
   ii Cut along the unbroken lines.
   iii Carefully bend each of the four corners towards the centre of the pinwheel.
   iv Secure the corners at the centre using a nail or drawing pin.
   v Press the nail into the bamboo skewer.

2 Design an experiment to test the speed at which the turbine will spin when wind hits the turbine from directly in front or when it hits from an angle. Figure 3.2.21 may give you some ideas.

3 Write your procedure in your workbook.

4 Before you start any practical work, assess your procedure. Assess any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

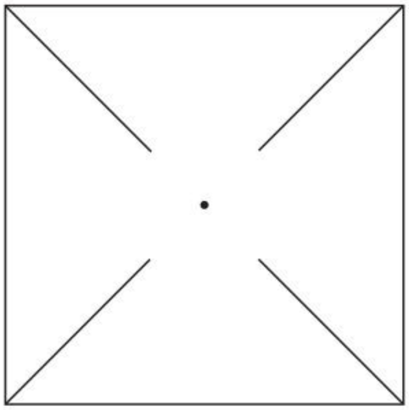


Figure 3.2.20 Use this template to make your pinwheel 'turbine'.

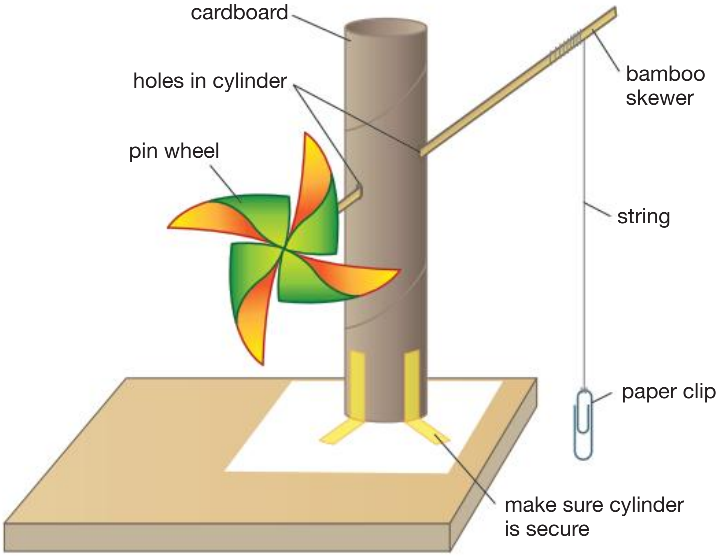


Figure 3.2.21 If the cylinder is unstable, tape it to a thick cardboard base so it is sturdy when standing upright.

Results

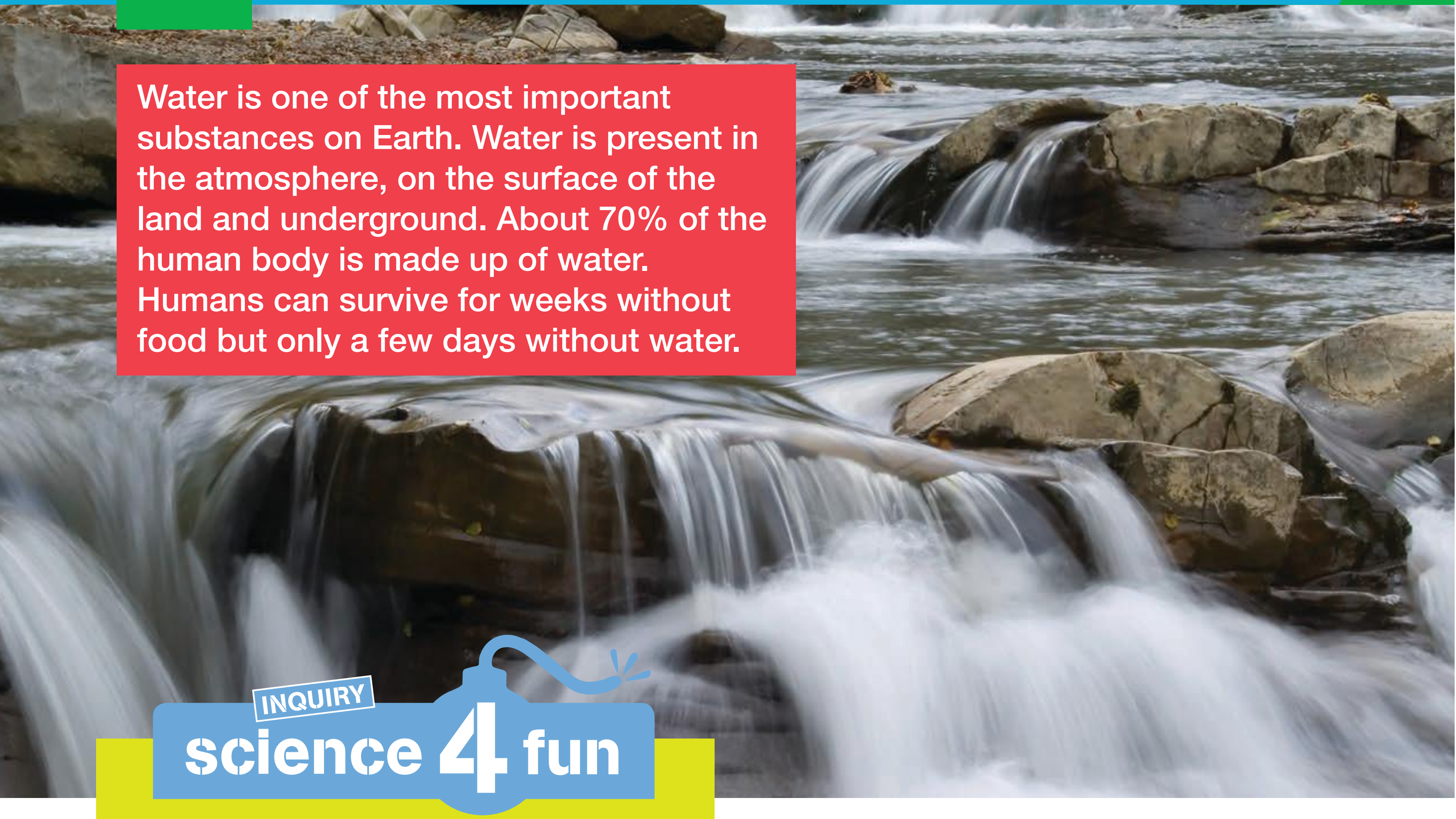
Present your results in a table.

Practical review

1 **Construct** a conclusion for your investigation.

2 **Assess** whether your hypothesis was supported or not.

3.3 The water cycle



Water is one of the most important substances on Earth. Water is present in the atmosphere, on the surface of the land and underground. About 70% of the human body is made up of water. Humans can survive for weeks without food but only a few days without water.

INQUIRY science 4 fun

Dripping glass

YES

Where did the water on the outside of the glass come from?

Collect this ...

- cold water from the fridge
- glass
- sticky-tape or marker pen (optional)
- paper towel

Do this ...

1. Half fill the glass with cold water.
2. Dry the outside of the glass with the paper towel.
3. Mark the level of the water with the sticky-tape or marker pen.
4. Place the glass on a piece of paper towel on a bench and leave for 5 to 10 minutes.

Record this ...

Describe what happened.

Explain why you think this happened.

Water on Earth

Look at the map of the Earth in Figure 3.3.1. It shows that there is far more water than land. About 70% of the Earth's surface is covered by water.

However, almost all (97.5%) of the water that covers Earth is in oceans and salt water lakes. This makes it unsuitable for drinking and most other uses. The other

Figure 3.3.1 Seventy per cent of the Earth's surface is covered by water.

2.5% is fresh water, but almost all of that cannot be used because it is either trapped underground or frozen in glaciers and in the ice caps of the North and South poles. Only about 0.01% of all water on Earth is renewable fresh water and is available for use. The tiny dark blue square in Figure 3.3.2 shows the very small proportion of water on Earth that is available for use by humans and other living things.

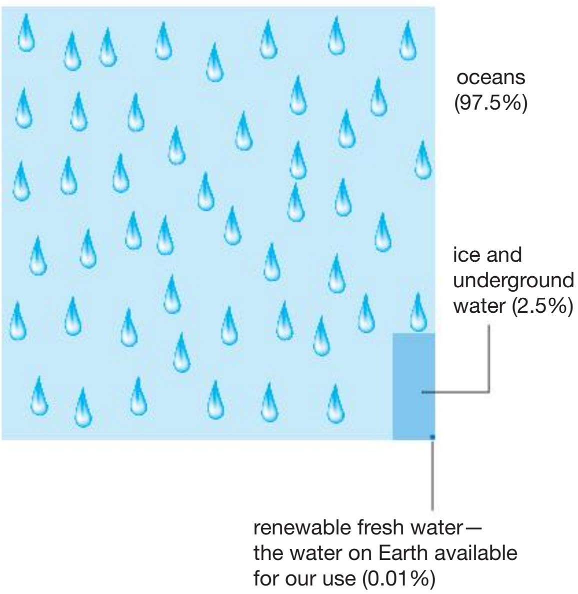


Figure 3.3.2 The amount of water on Earth available for our use is very small compared to the total amount of water on Earth.

The water cycle

The water on Earth has been recycled over and over again since the planet was formed.

The natural process of recycling water is known as the **water cycle**. As water moves through the cycle it changes state. Figure 3.3.3 shows that energy from the Sun causes water to evaporate from bodies of water such as the ocean, rivers and lakes. Liquid water in the ocean has changed into water vapour in the atmosphere.

As the water vapour rises, it cools. At a certain height the air cannot hold any more water vapour and the air is said to be **saturated**. Any further cooling causes water vapour in the air to condense, changing into tiny drops of liquid water. These tiny droplets form clouds, like the one in Figure 3.3.4.

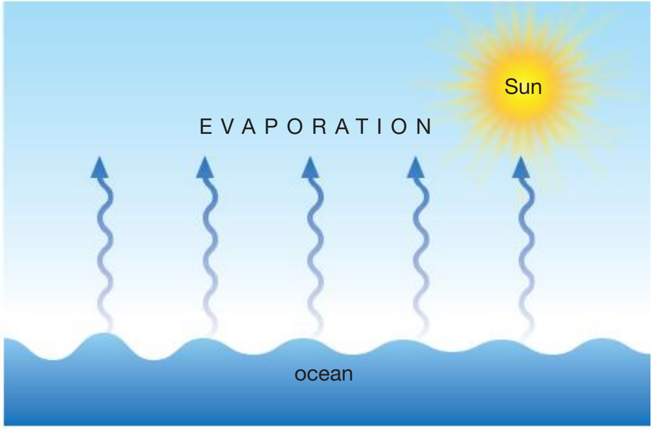


Figure 3.3.3 Evaporation moves water from oceans, rivers and lakes into the atmosphere. About 86% of the evaporation in the water cycle is from the oceans because they are the largest bodies of water.

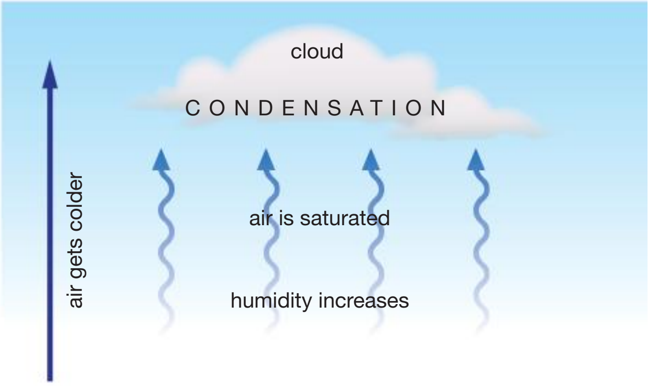


Figure 3.3.4 Cool air holds less water vapour than warm air. In cool air, water vapour condenses to form clouds.

When the air cools further, the droplets of water combine to become larger and heavier droplets, which then fall back to Earth as **precipitation**. The precipitation may be in the form of liquid rain or it may be frozen, falling to Earth as snow or hail (Figure 3.3.5).

Figure 3.3.5 Water droplets in the clouds freeze when the atmosphere falls below 0°C. Precipitation then happens as snow or hail.

As Figure 3.3.6 shows, two things may happen to the precipitation that falls on land.

- It may flow over the surface as **run-off**, moving back into rivers, lakes and streams, and eventually flow back to the oceans.
- It may soak down into the soil in a process called **percolation**.

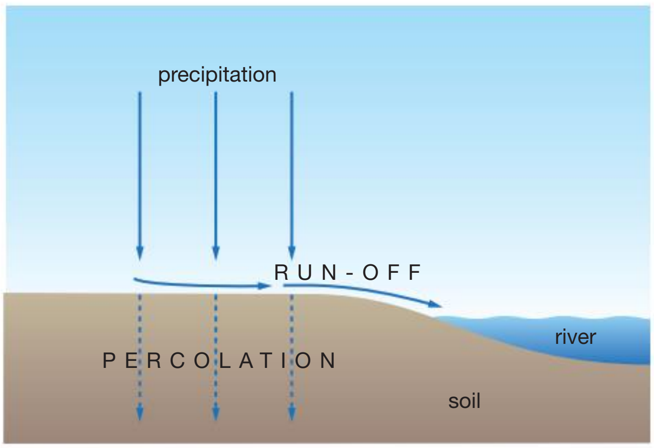


Figure 3.3.6 Once precipitation has landed on Earth it may flow over the surface or percolate into the soil and rocks beneath.

Some of the water that percolates through the soil is taken up by the roots of plants. This water then moves up through the plant. The heat of the Sun causes some of this water to evaporate from the stems, flowers and leaves of plants. The process of the evaporation of water from plants is called **transpiration**. It is shown in Figure 3.3.7. About 10% of the water vapour entering Earth's atmosphere comes from transpiration.

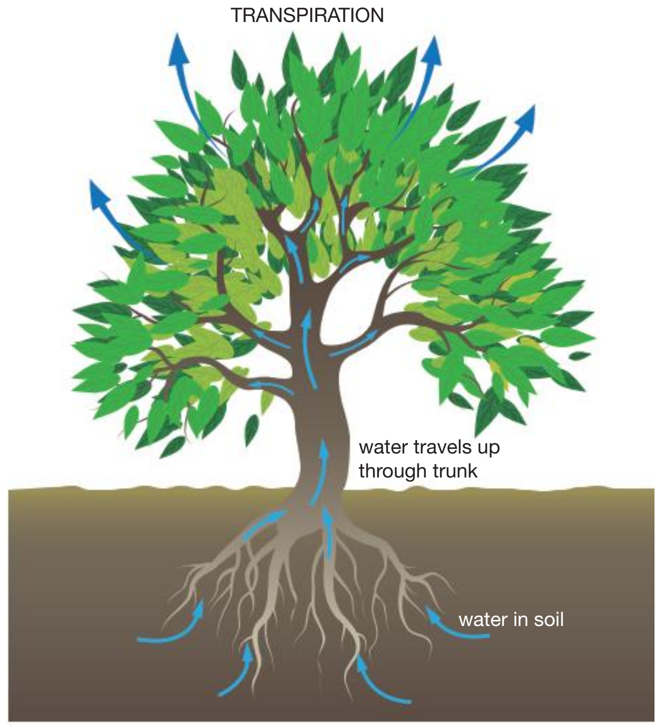


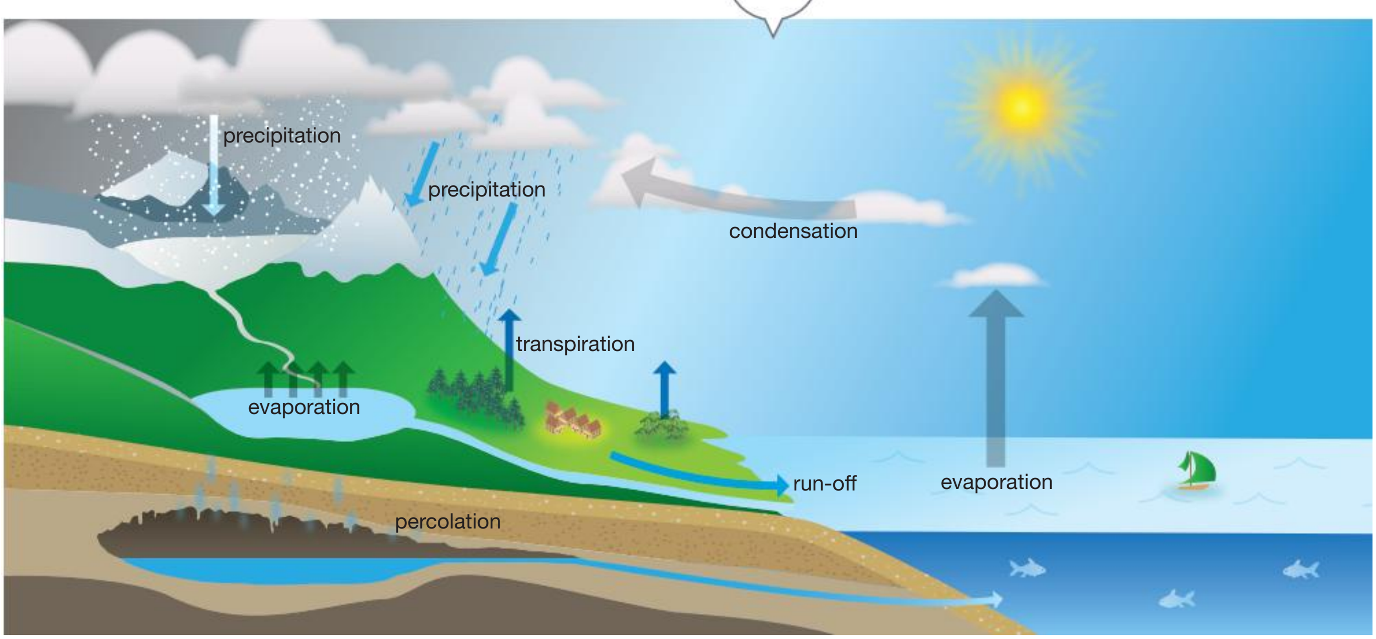
Figure 3.3.7 Transpiration is the evaporation of water from leaves and other parts of a plant. Through transpiration, water is carried from the soil and returned to the atmosphere.

Animals drink fresh water from rivers and lakes. This water is returned to the atmosphere as it evaporates from their bodies, or returned to the ground when it is excreted (removed from their bodies) as urine.

Putting all these processes together creates the water cycle, as shown in Figure 3.3.8.

Figure 3.3.8 The water cycle

Prac 1 p. 120
3.5
3.6



Groundwater

Rainwater, rivers and dams are major sources of water for Australia. However, more than 20% of the water used in Australia each year comes from groundwater. **Groundwater** is water that exists underground. Most groundwater is not in underground lakes or rivers but is trapped in the tiny spaces between grains of sand or within pervious rocks. **Pervious rocks** are rocks that allow water to soak into them. Pervious rocks contain tiny spaces into which water can soak. Figure 3.3.9 shows how this works.

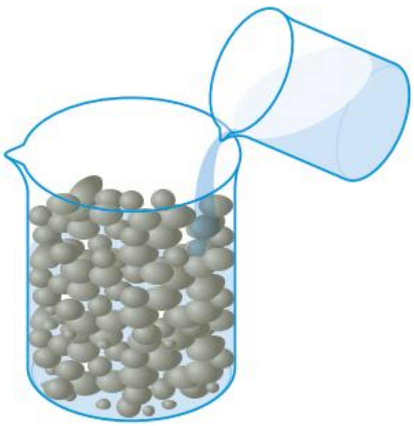


Figure 3.3.9 The effect of pervious rocks is like pouring water into a jar of pebbles or sand. The water does not sit on top. Instead, the water moves down, filling up the spaces between the sand or pebbles.

When the water within the pervious rocks can be extracted using a bore or well, then the layer of rock is known as an **aquifer**. Perth in Western Australia gets about 60% of its water from an aquifer.

The Great Artesian Basin

The Great Artesian Basin is one of the largest groundwater basins in the world. About one-fifth of Australia is sitting on top of it. Many millions of years ago there was an inland sea in Australia. Under this sea, rocks formed in alternating layers of pervious rock and impervious rock. **Impervious rock** does not allow water to soak into it. Movement of the land has exposed areas of the pervious rock. Water can soak into the pervious rock and flow underground. The impervious rock prevents the water from escaping. The result is a very large store of groundwater—the Great Artesian Basin. You can see its structure in Figure 3.3.10.

It takes a very long time for the water to soak through the rock and into the aquifers. Some of the water in the Great Artesian Basin has been there for millions of years.

Prac 2 p. 120

Factors affecting the water cycle

Many natural factors influence the rate at which water moves through the water cycle. It can take a few days to thousands of years for an individual particle of water to move through the water cycle. In that time the water goes from ocean to atmosphere to land and back to ocean again. Some of it slowly seeps through the rocks and is then trapped underground. This water is still part of the cycle but will not move on to a different stage until the water is carried up to the surface through a bore or well.

States of water

The water that is trapped as ice at the North and South poles, in glaciers and on the top of high mountains is also part of the water cycle. The water in the ice and snow of Figure 3.3.11 on page 116 cannot move on to the next stage until it melts.

GO TO Unit 2.3

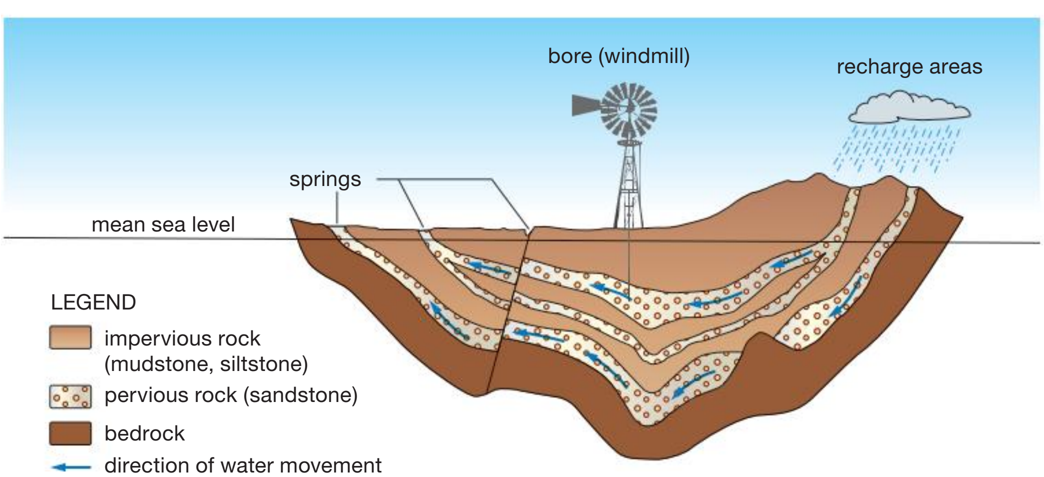


Figure 3.3.10 The Great Artesian Basin is made up of alternating layers of pervious and impervious rocks. Water is extracted from the pervious rocks using aquifers. These aquifers supply water to large areas of inland Australia.

Figure 3.3.11 The water in ice and snow is still part of the water cycle. However, it may be hundreds or thousands of years before the water is able to move on to the next stage of the cycle.

Ice cannot be taken up by plants. Many trees living in areas where water in the soil is frozen for part of the year are deciduous. Deciduous trees lose all their leaves in winter. Without leaves there is very little transpiration. Without leaves the trees are able to survive until the weather becomes warmer and water becomes liquid again.

SciFile

Martian water

Ice is found at the polar ice caps of the planet Mars. Some scientists think there may be liquid water on Mars. NASA photographs have revealed soil deposits, suggesting that water had carried sediment through two small valleys in the time between the Mars mission in 2005 and the next Mars mission in 2012. Analysis of rock samples collected by the Mars *Curiosity* Rover in 2013 provided evidence that in the past, water on Mars may have been good enough to drink.

Air temperature

Air temperature affects the rate of evaporation from bodies of water and soil. It also affects the rate of transpiration. As the air temperature increases, the rate of evaporation and transpiration both increase. Plants can slow transpiration down if they are losing water more quickly than they can take it in through their roots. Plants have special openings through which the water evaporates. Plants are able to close these openings if they are losing too much water. In this way plants are able to reduce the rate of transpiration and slow down the movement of water through the water cycle.

Humidity

Humidity is the amount of water vapour in the air. Water vapour can be added to the air until the air becomes saturated. When this happens, the air cannot hold any more water vapour. As the air above a surface reaches saturation point the rate of evaporation (and transpiration) slows down and stops.

You may have experienced the effect of saturated air. When you sweat on a hot day with low humidity, the sweat dries (evaporates) off your skin quickly and cools you. However, if the air is very humid then the sweat remains on your skin and you feel hot and sticky.

Air movement

Air moving across a wet surface increases the rate of evaporation. Moving air carries away the saturated air, allowing evaporation and transpiration to continue. This is why turning on a fan makes you feel cooler and more comfortable on a hot, humid day: the breeze blows away the saturated air allowing your sweat to start evaporating again. Figure 3.3.12 shows how this happens.

Prac 3 p. 121

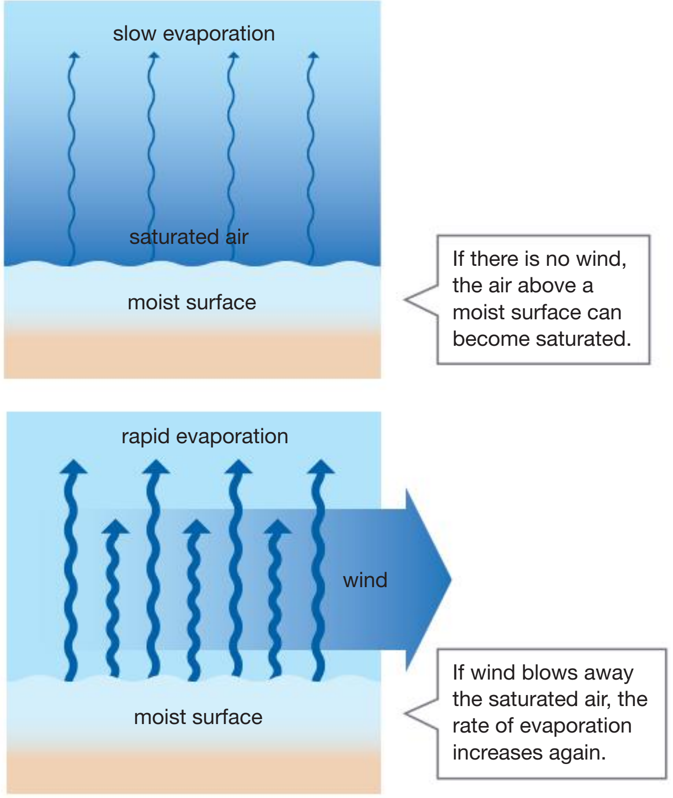


Figure 3.3.12 Air becomes saturated and evaporation is slow if there is no wind. Wind blows away moist air and so evaporation increases.

Landscape

Topography is the hills, valleys, rivers and other physical features of the landscape. The topography of an area affects run-off and percolation. Rain falling on smooth rock and steep slopes (such as the one in Figure 3.3.13) will quickly run over the surface and into streams and rivers. These streams and rivers will move the water quickly back into the ocean.

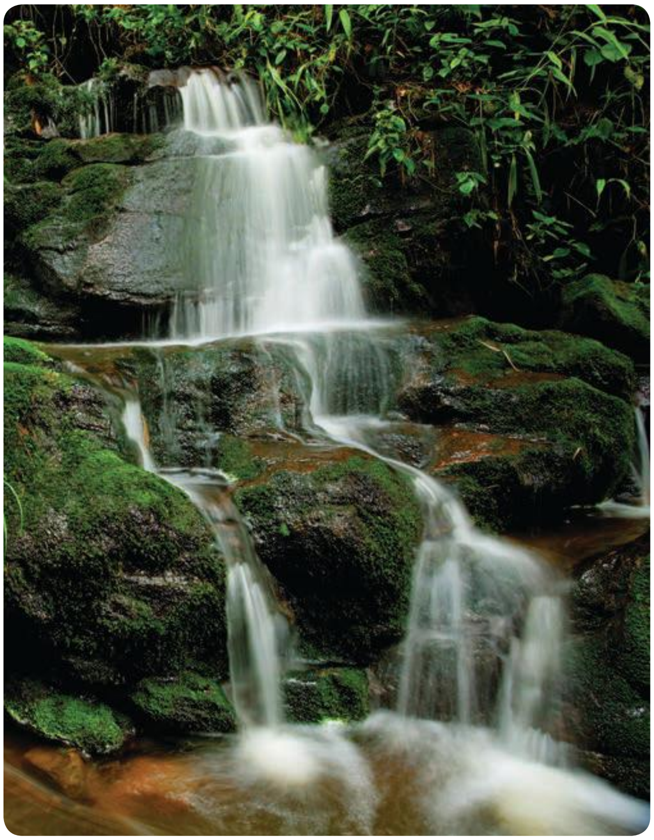


Figure 3.3.13 Water moves very quickly downhill when there is no vegetation to slow it down.

Where there are broken rock surfaces and areas of dense vegetation, run-off will be slower. Slower run-off allows more time for percolation to take place. Some soils like sand have many large spaces between the particles. Water can easily percolate into these soils and there is very little run-off. Other soils have small particles that are closely packed together. It takes a long time for water to percolate through these soils and more of the water will flow over the surface as run-off.

Hills and mountains experience more precipitation than low-lying areas. As air moves towards hills and mountains it rises to get over them. The rising air cools and the water vapour it holds condenses, resulting in clouds or precipitation. As Figure 3.3.14 shows, clouds are often seen over mountains when there are otherwise few clouds around.

Figure 3.3.14 The clouds on high mountains spoil the view of the top. However, they are evidence of the water cycle at work.

SciFile

Boiling water

At sea level water boils at 100°C.
At the top of Mt Everest there is less air pressure and water boils at just 68°C. Deep in the ocean, water pressure increases. Water near deep geothermal vents remains liquid at temperatures much higher than 100°C.

Vegetation

The type of environment a plant is growing in will affect the rate of transpiration. For example, cacti and many Australian plants have spikes or small narrow leaves. These are characteristics that help them conserve water so that they can survive in dry climates. They transpire less than plants without these characteristics.

Amount of sunshine

In nature the energy needed to evaporate water comes from the Sun. In parts of the world where there is a lot of sunshine there is more evaporation than in areas with little sunshine and heavy cloud.

3.3 Unit review

Remembering

1 **State** how much of the Earth's surface is covered in water.

2 **State** how much of Earth's water is:
  a salt water
  b fresh.

3 **State** the word that describes rain, hail and snow. L

4 **List** three natural factors that influence the water cycle.

Understanding

5 **Explain** why it is important that water is recycled in nature.

6 **Explain** why water is considered to be a resource that is in short supply when there is so much of it on Earth.

7 **Outline** what could happen to the rain that falls onto a field of grass.

8 **Describe** the role that animals such as cows or kangaroos play in the water cycle.

9 **Explain** what is meant by the phrase *The air is saturated.*

10 **Discuss** the statement *All the water you use is recycled.*

11 For the science4fun on page 112, **predict** what would happen to:
  a the outside of the glass
  b the level of water in the glass.

Applying

12 **Identify** the process that moves water from:
  a rivers to the atmosphere
  b oceans to the ice cap at the South Pole
  c the atmosphere to freshwater lakes
  d surface water to aquifers
  e surface water to rivers.

13 **Use** diagrams to **demonstrate** how water droplets in a cloud develop into rain.

14 Sketch a simple version of Figure 3.3.15 and **use** it to **demonstrate** what would happen to water that fell on the piece of ground represented by the diagram.

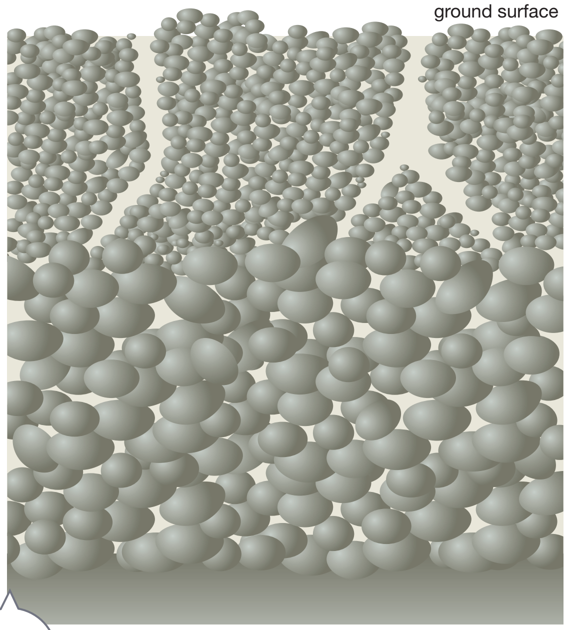


Figure 3.3.15

Analysing

15 **Compare**:
  a evaporation and transpiration
  b pervious and impervious rocks
  c percolation and run-off.

16 **Use** the table below to answer the questions that follow.

Water source	Percentage of total water
Oceans	97.24
Rivers and freshwater lakes	0.01
Inland seas	0.008
Ice caps and glaciers	2.14
Soil moisture	0.005
Groundwater	0.61
Atmosphere	0.001

  a Oceans are the largest source of water on Earth. **Identify** the next largest source of water.
  b **Identify** which holds more water, the soil or the atmosphere.
  c **Compare** the amount of water in inland seas, and in freshwater lakes and rivers.

17 **Compare** the formation of clouds in the atmosphere with the formation of water on the outside of a glass or can of cold soft drink.

Evaluating CCT

18 a **Propose** how you would respond to someone who says that all the water you use is recycled water.

b **Explain** your response.

19 a **Deduce** which set of conditions shown in Figure 3.3.16 would cause the greater rate of transpiration.

b **Justify** your answer.

Figure 3.3.16

20 a **Deduce** which set of conditions shown in Figure 3.3.17 the would dry the washing quicker.

b **Justify** your answer using your understanding of the water cycle.

Figure 3.3.17

Creating CCT

21 **Construct** a diagram that demonstrates how the cloud on top of the mountain in Figure 3.3.14 on page 120 could have formed.

22 **Construct** a bar or column graph to accurately show the information in the table in question 16. N

23 **Use** information from this unit to **construct** a pie graph (sector graph) showing the different percentages of water on Earth's surface. N

Inquiring

1 More than 97% of all water on Earth is sea water. It would be very useful if we could drink it but we can't. Research to find out:

- how sea water compares with the water we drink
- what would happen to your body if you drank it.

Present your research as a series of tables, labelled diagrams and/or graphs.

2 Some parts of the world have very cold winters. In these places lakes and ponds may freeze. Research what happens to fish and other living things in these bodies of water. Find out:

- which part of the water freezes first and why this happens
- whether all living things use the same strategy for survival. Describe the strategies.
- how the survival of some living things could be different in a very severe winter compared to an average winter, or in a relatively shallow pond compared to a deep lake.

Present your findings as a poster.

3 Hailstones are lumps of ice that may be the size of a grain of rice or as big as a tennis ball. Research the formation of hailstones to find:

- where they are formed
- what conditions cause hail to be created rather than rain
- why tropical summer thunderstorms often produce very large hailstones.

Present your research as a series of labelled photos and/or diagrams.

3.3 Practical investigations

1 Water cycle

Purpose
To construct a model of the water cycle.

Materials
- crushed ice (1 small handful)
- water at room temperature (about 50 mL)

- 500 mL beaker
- clear plastic film
- small plastic bag
- tape (optional)

Procedure
1 Set up the equipment as shown in Figure 3.3.18.

2 Observe your model of the water cycle for about 20 minutes. Take note of what happens in the first minute and after about 5 minutes and 10 minutes.

Results
1 Look at the underside of the plastic film (where the air in the beaker is in contact with the plastic). Describe the changes you observed:
   a in the first minute of your investigation
   b after about 5 minutes
   c after about 10 minutes.

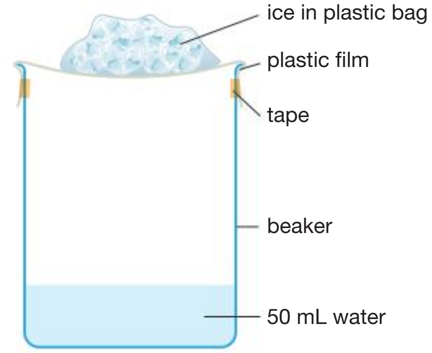


Figure 3.3.18 Model of the water cycle

2 Use labelled diagrams to record any changes you observed.

Practical review
1 **Identify** the part of the water cycle represented by the water in the beaker.

2 a **Explain** what was happening to the water in the beaker.
   b **Identify** the process in the water cycle that this represents.

3 a **Explain** what was happening to the air in the beaker when it was in contact with the plastic film.
   b **Identify** the process in the water cycle that this represents.

4 **Describe** how precipitation was represented in the model.

2 Run off or soak in?

Purpose
To observe the percolation of water through different surfaces.

Hypothesis
Which soil do you think will allow the water to percolate into it the quickest—gravel, sand or clay? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials
- very fine gravel to half fill the beaker
- sand to half fill the beaker
- clay soil to half fill the beaker
- water
- 3 × 250 mL beakers
- 100 mL measuring cylinder
- marker pen

Procedure
1 Label the three beakers: *gravel*, *sand* and *clay* (Figure 3.3.19).

Figure 3.3.19

Run off or soak in? continued on next page

Run off or soak in continued

2 Fill the gravel beaker with gravel until it is half full. Gently tap the side of the beaker to settle the contents. Add more gravel if necessary.

3 Fill the sand beaker with sand in the same way.

4 Add some clay soil to the clay beaker and push it down firmly. Add more clay soil and push it down again. Repeat this process until the beaker is half full.

5 Measure 100 mL of water and pour it into the top of the gravel beaker. Pour it over the whole surface, not just in one place. Observe what happens for 5 minutes.

6 Repeat step 5 for the other two beakers.

Results

1 Record your observations of the way the water percolates through the three different materials.

2 Record whether any of the materials had water lying on the top after 5 minutes.

Practical review

1 **Propose** why it was necessary to push the clay soil down firmly instead of just tapping the side of the beaker.

2 **Identify** the material through which percolation occurred most quickly.

3 **Identify** the material through which percolation occurred most slowly.

4 **Explain** why the different rates of percolation occurred.

5 a **Identify** the material from which run-off is most likely to occur.
  b **Justify** your response.

6 a **Construct** a conclusion for your investigation.
  b **Assess** whether your hypothesis was supported or not.

STUDENT DESIGN

3 Measuring evaporation

Purpose

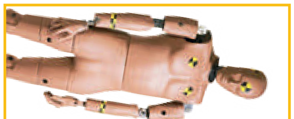
To test the effect of sunshine on the rate of evaporation.

Hypothesis

Which do you think will evaporate faster—water in in the sun or water in the shade? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- water
- 2 shallow containers of the same size, material and depth, such as rectangular takeaway food containers
- ruler
- electronic balance (or kitchen scales that measure in 1 g intervals)
- marker pen



SAFETY
A Risk Assessment is required for this investigation.

Procedure

1 As a group, identify variables that might affect your investigation and design a way to control them.

2 Decide how your group is going to:
- measure the amount of evaporation
- measure or calculate how fast it is happening (its rate)
- record your results.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you will do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect the required materials and start work.

Practical review

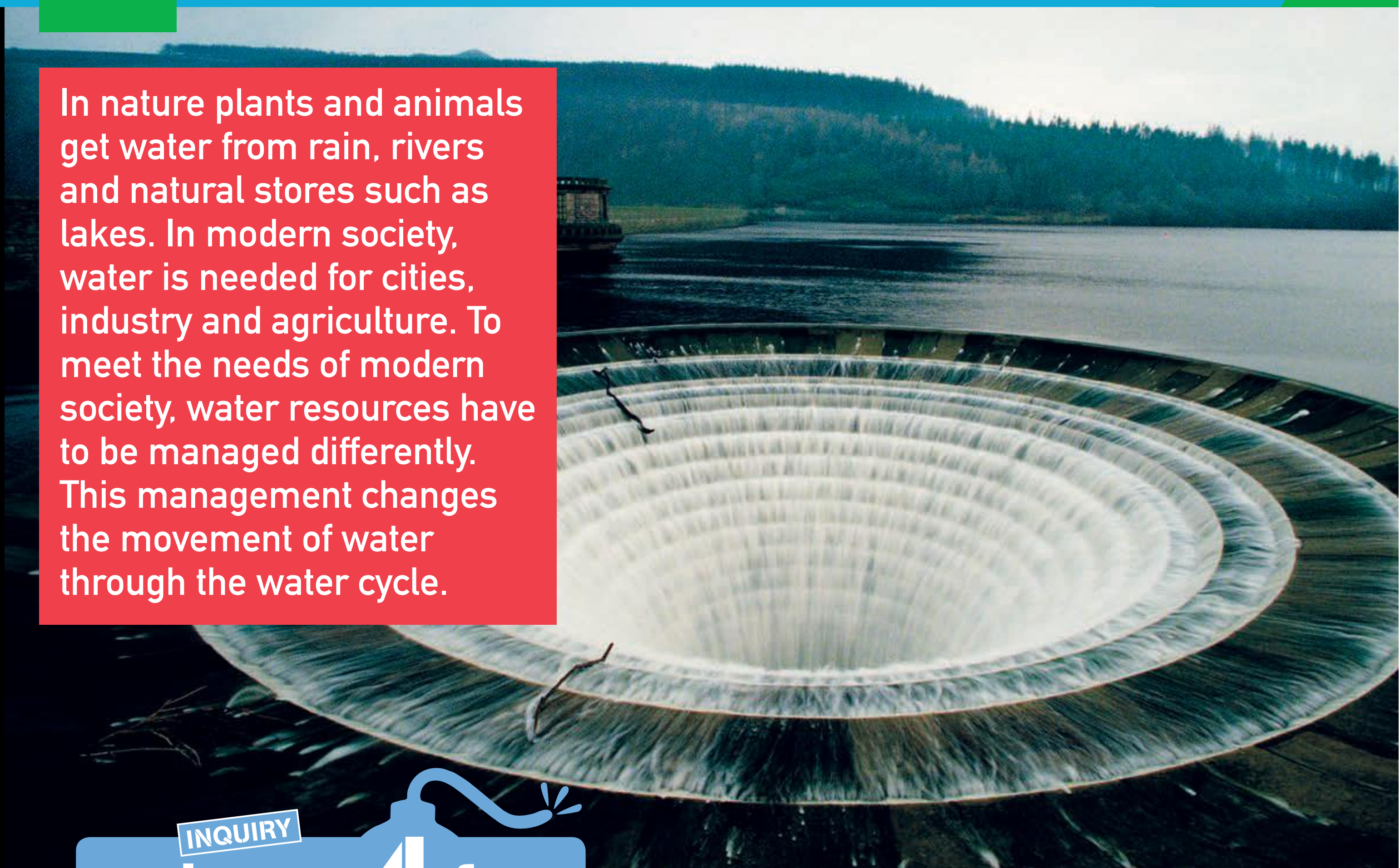
1 a **Calculate** the amount of water lost from each container.
  b **Compare** the amount of water lost.

2 **Compare** your results with the results from other groups.

3 **Identify** any factors that you were not able to control that might have affected your results.

4 a **Construct** a conclusion on the effect of sun and shade on the rate of evaporation.
  b **Assess** whether your hypothesis was supported or not.

3.4 Water management



In nature plants and animals get water from rain, rivers and natural stores such as lakes. In modern society, water is needed for cities, industry and agriculture. To meet the needs of modern society, water resources have to be managed differently. This management changes the movement of water through the water cycle.

INQUIRY science 4 fun

Ants and water

Can ants help locate a water source?

YES

Collect this …

- shallow container for water

Do this …

1. Fill the container with water.
2. Place it on a path or on the grass in a partially shaded part of the garden.
3. Leave the container undisturbed for about an hour.

Record this …

Describe any change in the behaviour of ants in the area.

Explain why this happened.

Storing water in dams

Australia is the driest permanently inhabited continent. The rain that does fall is not distributed evenly over the country. Dams are built to capture and store the rain.

Most farms in Australia have dams. The water collected is used for cattle to drink and may be used to irrigate crops. There are also many much larger dams such as Warragamba Dam near Sydney. You can see this in Figure 3.4.1. These large dams collect and store water to be used by industry and households in the cities.

SciFile

All ice, no water!

Australia might be dry but the continent of Antarctica is even drier! This is because all of its water exists as ice. The constant freezing temperatures never allow the ice to melt.

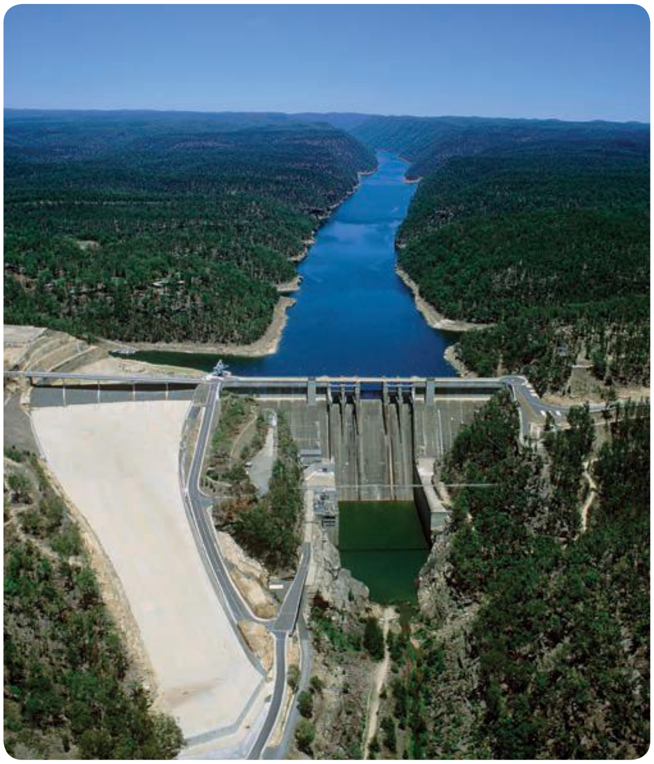


Figure 3.4.1 Large dams like Warragamba Dam near Sydney are needed to collect enough water for the needs of cities.

All dams interrupt the water cycle because water stored in them does not flow down the river and into the ocean. Water from the surface of the dam evaporates and is returned to the water cycle. However, in a very deep dam some water may not be available for evaporation for a very long time.

SciFile

That's big!

The tallest dam in the world is the Nurek in Tajikistan in the Himalayan Mountains. The dam wall is 300 metres high. In 2014 when the Jinping-I Dam in China is completed it will be taller at 305 metres. Compare this with Warragamba Dam. It is just 142 metres high!

Irrigation

Most of the farm crops grown in Australia have been introduced here from other parts of the world. This means that they do not have characteristics that allow them to grow with only small amounts of water. These crops need continuous supplies of water and farmers provide this water through irrigation. **Irrigation** is a practice used in agriculture that provides water to crops using pumps, pipes and ditches.

There are two ways farmers irrigate their land:

- spray irrigation
- flood irrigation.

Spray irrigation

You can see spray irrigation in Figure 3.4.2. In **spray irrigation** a pump forces small droplets of water into the air. The water falls on the soil and percolates down to the roots of plants. The water then moves up through the plant and is eventually lost back to the atmosphere through transpiration.

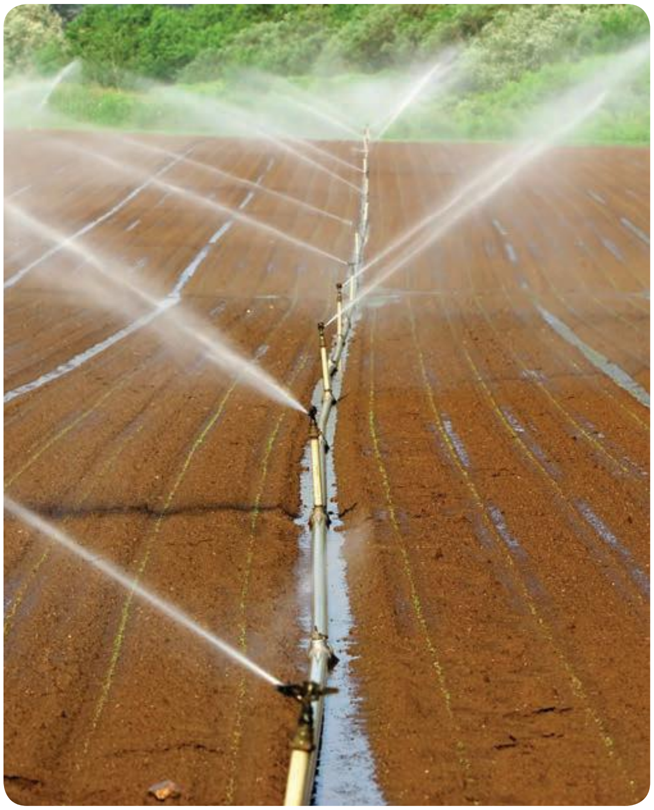


Figure 3.4.2 Spray irrigation is like having rain fall on the crop whenever it is needed.

There are some differences between spray irrigation and rain. When it rains there are usually clouds in the sky and the air is very humid. These factors reduce the rate of evaporation. Spray irrigators may be used on hot days when there is bright sunshine. The tiny droplets of water produced by the spraying equipment evaporate quickly in hot, dry air. Water landing on the leaves also evaporates more quickly than in a natural rain storm. Therefore a lot of the water that would normally percolate into the soil evaporates into the atmosphere instead.

Flood irrigation

In **flood irrigation**, water is released into channels between the crop plants. This is shown in Figure 3.4.3. The water percolates into the soil to the plant roots. However, the water will evaporate quickly if the soil and irrigation channels are not shaded.

Figure 3.4.3 With flood irrigation the water reaches the roots. However, if there is not a good cover of vegetation much of the water will evaporate.

Moving water around

Dams and pipes can be used to move water from an area where there is plenty of water to areas where there is not enough. The Snowy Mountains Scheme was a very ambitious project that began in 1949 and was completed in 1974. Figure 3.4.4 shows part of the scheme's dam and pipelines. Most of the scheme is underground. The Snowy River in New South Wales is fed from melting snow and rain in the Snowy Mountains. Its location can be seen in Figure 3.4.5. The tunnels, dams and pipes divert most of the water from the Snowy River.

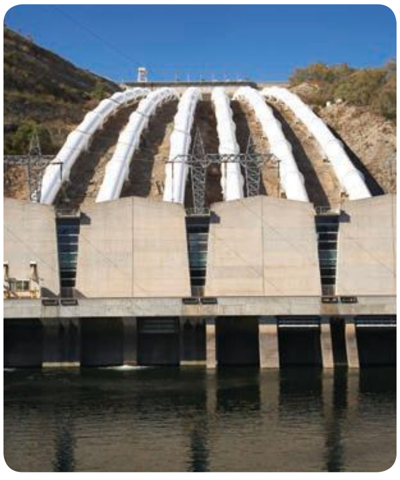


Figure 3.4.4 The Snowy Mountains Scheme is one of the largest irrigation projects in the world, with about 225 km of tunnels and pipelines.

Figure 3.4.5 Map showing the locations of the Snowy Mountains Scheme and the Murrumbidgee Irrigation Area.

The water is used to irrigate large farming areas in the Murrumbidgee Irrigation Area. Irrigation has enabled this area to become one of the main wine and food producing parts of Australia. Water that once flowed very quickly into the ocean is spread across land that is naturally dry.

The water used for irrigation is returned to the atmosphere through transpiration and evaporation from soil. Irrigation water also percolates through the soil into the groundwater. Eventually the excess water flows via the Murrumbidgee and Murray rivers into the ocean on Australia's southern coast. Meanwhile the Snowy River carries only 1 per cent of its original flows. This has affected ecosystems along the banks of the river.

Using stormwater

Building cities replaces pervious soil with impervious concrete and bitumen surfaces. Water that lands on soil percolates about 15 mm into the ground before there is any run-off. Water that falls on roofs, roads and footpaths runs off immediately. The water flows into stormwater drains (like the one in Figure 3.4.6) and out to the ocean.

Figure 3.4.6 Water flowing off roofs, streets and other impervious city surfaces goes straight into stormwater drains. From there it goes directly to rivers and the ocean.

In many parts of Australia, attempts are being made to use stormwater. In some Sydney suburbs, stormwater is being collected in tanks and pits. Harmful substances are removed from the water and then it is used to irrigate parkland and sports fields and to water trees in the city.

In the city of Orange in New South Wales, some of the water that flows into Blackman's Swamp Creek during storms is captured and then transferred to a nearby dam. Figure 3.4.7 shows how much water flows out during such a storm. All this stormwater is now collected, increasing the water supply for the city.

Baldwin Swamp is a natural wetland in the Queensland city of Bundaberg (Figure 3.4.8). As well as being a habitat for a wide variety of birds and animals it has another important function. Three main drainage channels from the city carry run-off from the city streets into the swamp. When it rains, the stormwater flows to Baldwin Swamp, carrying with it rubbish and pollutants. The rubbish has to be collected by City Council workers. Natural processes in the wetland absorb pollutants from water and improve the quality of the water before it flows out into the river and ocean.

The ability of wetlands to clean water has been used by city councils and land developers in projects such as rain gardens.

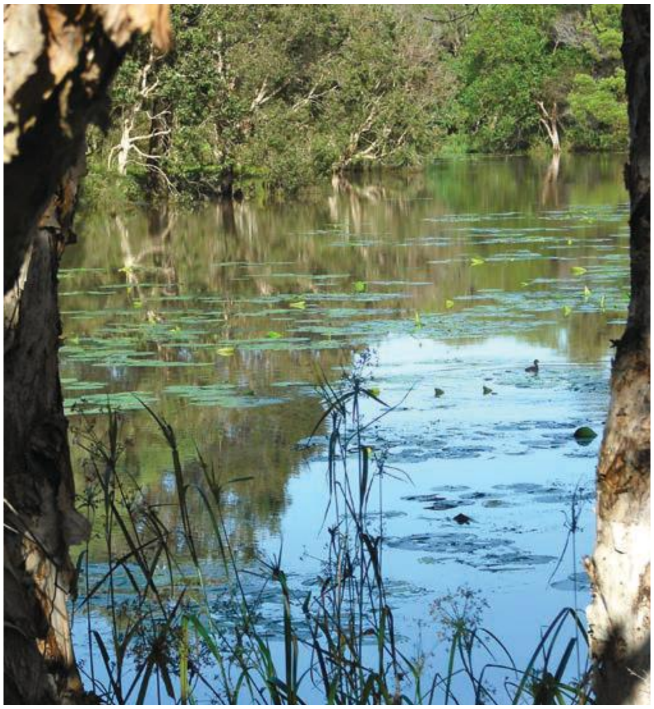


Figure 3.4.8 Baldwin Swamp in Bundaberg is a natural wetland that is home to over 150 species of birds and many other animals.

Figure 3.4.7 A large amount of water flows along Blackman's Swamp Creek during a storm.

Rain gardens

Rain gardens are a much smaller scale way of dealing with stormwater. Figure 3.4.9 shows how rain gardens slow down the rate of flow and clean pollution from the stormwater before it enters creeks and rivers.

Stormwater is channelled into the rain garden bed. In the garden bed is a layer of sand that filters the water. The filtered water is similar in quality to the water in undisturbed streams. It is not drinking quality but it is suitable for irrigation.

Rain gardens can be landscaped into suburban gardens as well as city parks, school yards and large nature strips that divide freeways. Figure 3.4.10 shows a working rain garden.

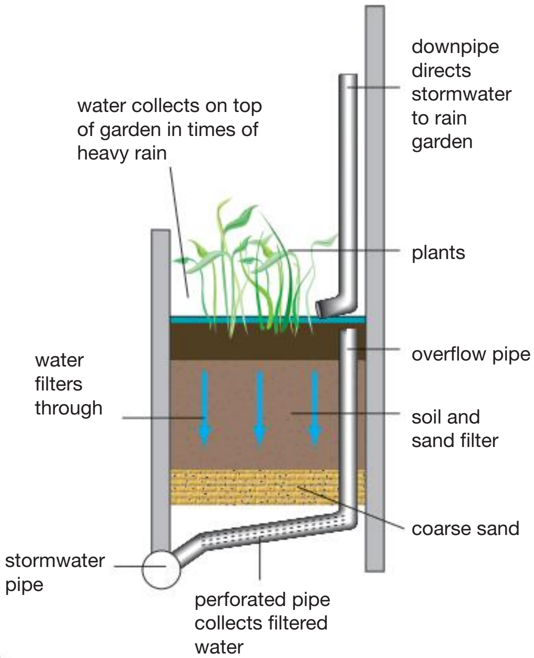


Figure 3.4.9 A rain garden cleans stormwater before it enters creeks and rivers.

Figure 3.4.10 Rain gardens are attractive to look at and they also serve a very useful function.

Changing vegetation

Changes in vegetation affect the water cycle of the area. Planting trees will increase the amount of water that moves from the soil through the plant and is transpired into the air. Low-growing shrubs and grasses reduce the amount of evaporation from the soil surface.

When trees are cut down and replaced with grass or bare soil, the movement of water over the land surface is changed. Trees, shrubs and long grass slow the rate at which water can flow over the ground. This means that there is more time for the water to soak into the soil.

In the absence of vegetation, water moves quickly over bare ground and often carries large amounts of soil. This eroded soil is carried with the water as it flows into streams and rivers. Figure 3.4.11 shows the effect of this fast-moving water.

GO TO Unit 3.1

Prac 1 p. 131

Prac 2 p. 132

Figure 3.4.11 These channels in the soil (known as **rills**) have been created by erosion of soil by fast-flowing water.

3.7 3.8

LEARNING ACROSS THE CURRICULUM

ABORIGINAL AND TORRES STRAIT ISLANDER HISTORIES AND CULTURE

INDIGENOUS WATER USE

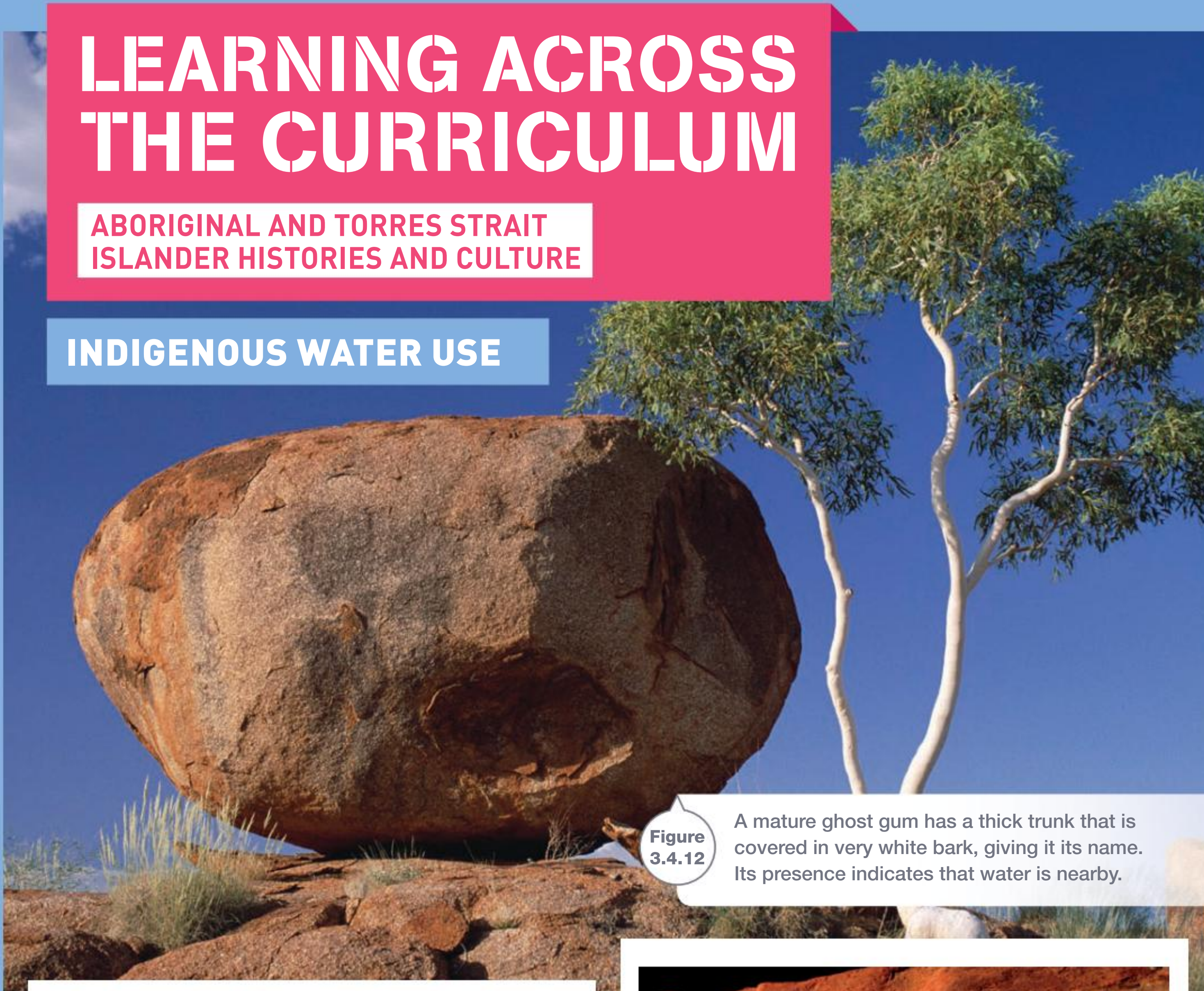


Figure 3.4.12 A mature ghost gum has a thick trunk that is covered in very white bark, giving it its name. Its presence indicates that water is nearby.

Indigenous Australians are able to live in some of the driest parts of Australia. They can do this because they are able to use their observations to find sources of water. In the middle of a dry area, ghost gum trees (such as the one in Figure 3.4.12) indicate where there is underground water. Ant trails also lead to underground water and dingo tracks lead to rock pools and waterholes.

Traditional methods used by Indigenous Australians to obtain water include creating shallow wells and digging tunnels to reach water deeper underground. The mouth of the well or tunnel is covered to reduce evaporation and to prevent animals from drinking the water and polluting it.

In the past, the location of water sources determined the routes Indigenous Australians used to travel around the country. Markings such as these in Figure 3.4.13 were made on the rocks to indicate where water could be found. In this way they were sure to have reliable sources of water.

Figure 3.4.13 These circular rock markings show that a number of waterholes are nearby.

There are many **springs** where water from the Great Artesian Basin comes to the surface. One is shown in Figure 3.4.14. These springs were a major source of water for Indigenous Australians and for native plants and animals. Some European explorers and early settlers learned how to find water from the Indigenous people and so they too could get their water from springs.

In general, non-Indigenous Australians see water as a resource to be used. Indigenous Australians also view water as essential for survival but it is also an important part of their culture. There are many ceremonies, songs and customs which have been followed for thousands of years to make sure that rains come to keep the land, plants and animals healthy.

Early explorers were glad of the help Indigenous Australians could give them. However, Indigenous knowledge of land was not valued when decisions were being made about development of land and use of water. This is beginning to change as decision makers develop a respect for Indigenous knowledge. For example, in the Kimberley region of Western Australia the knowledge of the wetlands held by the Karajarri people was almost the same as the information required by the scientists studying the area for possible development. However, the Karajarri described the information in a different way. Indigenous Australians are now involved in decision making relating to the use of water and any developments that may cause changes to water sources.

REVIEW

1 **Recall** two observations Indigenous Australians used to help them find water sources.

2 **Explain** how Indigenous Australians protected underground water sources from pollution by animals.

3 **Describe** a difference in the ways that Indigenous Australians and non-Indigenous Australians think about water.

4 **Propose** one reason for Indigenous knowledge now being part of decision making about future developments.

3.9

Figure 3.4.14 Springs from the aquifers of the Great Artesian Basin were used by native animals and later as watering points for cattle.

3.4 Unit review

Remembering

1 **List** three ways that human actions change the water cycle.

2 **Name** two types of irrigation.

3 a **State** one way water from rain gardens can be used.
  b **State** one use that cannot be made of water from rain gardens.

Understanding

4 **Explain** why dams are built near large cities.

5 **Explain** how a dam interrupts the water cycle.

6 At the end of winter the snow in the Snowy Mountains melts and the water flows into streams and rivers.
  a **Describe** what would have happened to that water before the Snowy Mountains Scheme was built.
  b **Describe** what happens to the water from the Snowy Mountains now.
  c **Describe** the benefits that have resulted from the Snowy Mountains Scheme.
  d **Describe** any disadvantages the scheme may have brought to the environment.

7 **Describe** two ways in which run-off from cities is being reduced.

Applying

8 Figure 3.4.15 represents an area where part of a forest has been cut down. **Apply** your understanding of the water cycle to:
  a **explain** how and why the humidity of the air at points A and B would be different
  b **explain** how and why the rate of flow of water over the surface at points C and D would be different.

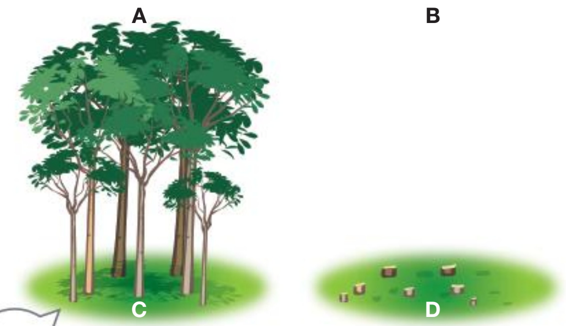


Figure 3.4.15

Analysing

9 **Compare** spray irrigation and flood irrigation by focusing on the effect they have on the water cycle.

10 **Compare** spray irrigation and a natural shower of rain.

Evaluating CCT

11 A severe storm passes over Sydney.
  a **Explain** what happens to the rain that falls on the city.
  b **Deduce** what would have happened to the rain before the city was built.

12 Figure 3.4.16 shows a valley that has been flooded by the construction of a dam. **Deduce** the major change that the presence of the dam will have on the water cycle in that area.

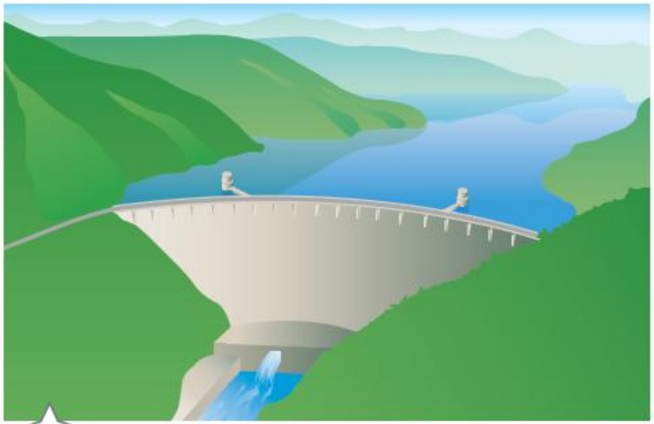


Figure 3.4.16

3.4 Unit review

13 Explorers in the desert observed the animal tracks shown in Figure 3.4.17. Copy the diagram into your workbook.

a **Propose** the most likely position for a source of water. Add this to your diagram.

b **Justify** your answer.

Figure 3.4.17

Creating CCT

14 Imagine a city block in the middle of a large city such as Sydney. **Construct** a diagram of the water cycle for that city block.

Inquiring

1 Design a project that would reduce the run-off from your school grounds and would make better use of stormwater.

Present your project as a series of labelled sketches or photos.

2 Research any projects in your area that are designed to reduce the amount of stormwater flowing directly to rivers and oceans.

- Find a map showing the locations of rivers and creeks in your area.
- Identify locations where stormwater flows into these waterways.
- Find out different ways that stormwater is treated before release. Wetlands and rain gardens are only two methods. There are others.
- Record one advantage and one disadvantage of each method you identify.
- Locate on the map places where the different methods are used.

Present your findings as a poster or in digital form. In your presentation include a statement about the effectiveness of stormwater treatment in your area. ICT

3 The construction of the Snowy Mountains Scheme reduced the flow of water in the Snowy River by 99%. Research the effects the loss of water had on the environment of the river.

Topics to consider include:

- The effect a reduced flow of water may have on the animals living in the water
- Ways the plants on the river banks may be affected when the water level drops
- The reaction of local land owners to changes that have occurred
- Comments made by environmentalists about changes to water flow
- If there are any plans to address any effects.

Present your findings as an illustrated report on the health of the Snowy River.

4 The Aswan High Dam (shown in Figure 3.4.18) was built on the river Nile in Egypt between 1960 and 1970. Research the Aswan High Dam or the Three Gorges Dam in China to:

- identify the reasons for the dam being built
- compare the flow of the river before and after the dam was built
- describe the effect that any changes have had on the environment downstream of the dam.

Present your findings as a poster or in digital form. ICT

Figure 3.4.18 Aswan High Dam, Egypt

3.4 Practical investigations

1 Water from leaves

Purpose

To extract water from leaves.

Materials

- plastic bag approximately the size of an A4 piece of paper (make sure there are no holes in the bag)
- string
- access to trees with low branches
- marker pen
- 100 mL measuring cylinder

Procedure

1. Write your name on the plastic bag.
2. Select a twig on your tree that has healthy-looking leaves.
3. Carefully place your bag over the twig so that a number of leaves are enclosed as in Figure 3.4.19. The twig must still be attached to the tree.
4. Use the string to tie the bag on tightly.
5. Leave the bag in place for 24 hours.

Results

1. After 24 hours remove the bag from the twig. Be careful not to lose any of the water.
2. Carefully pour the water into the measuring cylinder.
3. Record the amount of water collected.

Practical review

1. **Explain** how the water got into the bag.
2. **Describe** how the humidity inside the bag would have changed during the 24 hours of the experiment.
3. **Propose** how this change in humidity could have affected the amount of water collected.
4. **Demonstrate** how the information you have collected relates to the water cycle.
5. **Predict** how much water you would collect after two or more days. If your teacher agrees, carry out an investigation to test your prediction.

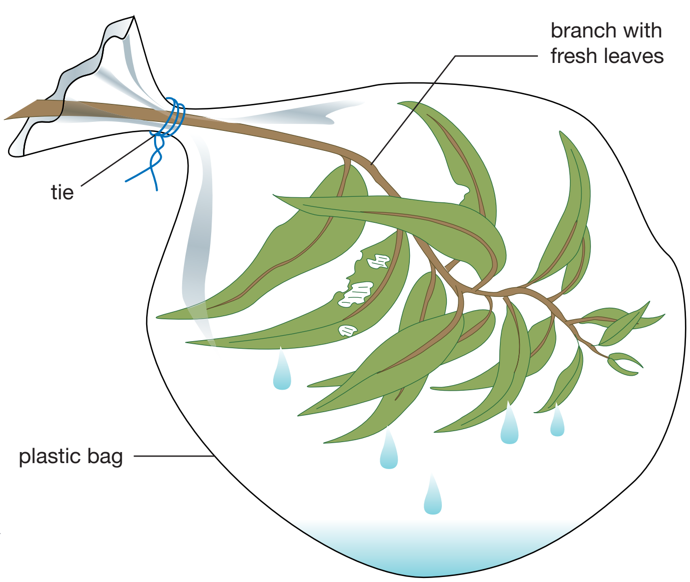


Figure 3.4.19

STUDENT DESIGN

2 More water from leaves

Purpose

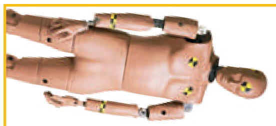
To investigate factors affecting water loss from leaves.

Hypothesis

What factors do you think will affect the amount of water lost from leaves—amount of sunlight, leaf type and number or some other factor? Before you go any further with your investigation, write a list of factors and how you think each one will affect the amount of water lost. Write your hypothesis in your workbook.

Materials

Materials as per prac 1.



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that compares the amount of water lost from leaves in different circumstances. Before you start work, first decide on which factor or variable you are going to test. You might try:
- leaves in the shade and in bright sunlight
- old and young leaves
- Australian native trees (such as eucalypts or melaleucas) and non-natives (such as camellias or roses)
- green and variegated leaves
- length of time for water collection.

2 Revisit the hypothesis you wrote down earlier and make sure it covers the variable you are going to test. If not, then write a new hypothesis.

3 Write your procedure in your workbook.

4 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

Make sure you only change one variable (such as sunlight). Keep all the other variables (such as type of plant and number of leaves) the same.

Results

Record your observations in your workbook.

Practical review

1 a **Construct** a conclusion for your investigation.
  b **Assess** whether your hypothesis was supported or not.

2 a **Evaluate** the procedure used in your experiment.
  b **Describe** what could have been done to improve the outcome.

Figure 3.4.20 Will leaves in sunlight or shade lose water faster?

3 Chapter review

Remembering

1 **Name** the following:
  a The process of small particles of rock being carried away from the parent rocks by wind, water and ice.
  b The process of re-using materials rather than disposing of them and then having to make more of them.
  c A natural resource that is replaced by natural processes at about the same rate at which it is being used.

2 **List** ten devices that may be found in your home that use energy but did not exist 50 years ago.

3 **List** the three changes of state that water passes through in the water cycle.

Understanding

4 **Modify** the following definitions to make them correct.
  a A natural resource is a substance supplied by the Earth for humans to make products they need.
  b A renewable natural resource is one that is replaced by natural processes that occur on Earth on a timescale much longer than a human life.
  c Deposition is the process by which sediments are carried away by a moving stream of water, air or ice.

5 **Explain** the advantages of recycling metals instead of making them from natural resources.

6 Renewable energy researchers are working to develop better ways to store energy. **Explain** why this technology is important.

7 **Describe** the effect that the ice sheets at the North and South poles have on the movement of water through the water cycle.

8 a **Describe** how the rate of evaporation changes on a windy day compared with a calm day.
  b **Explain** why this change happens.

9 Figure 3.5.1 is a simplified diagram of the water cycle.
  a Copy the diagram into your workbook.
  b **Modify** the diagram by adding the names of the changes of state that are taking place.
  c **Predict** places where water could stay for a long time before moving on.
  d **Predict** places where the movement to the next part of the cycle could be fast.

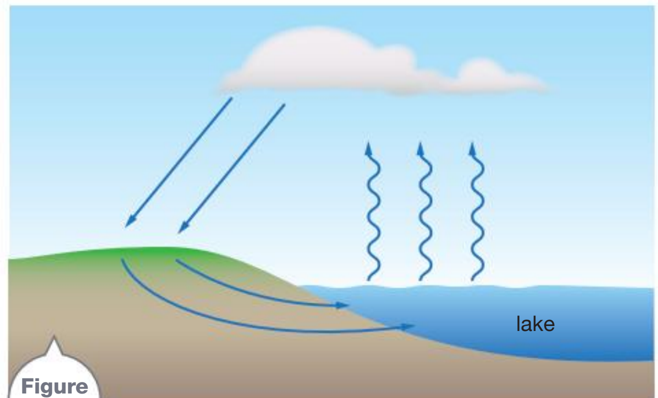


Figure 3.5.1

Applying

10 **Demonstrate** your understanding of how resources can be conserved by discussing at least five different strategies.

11 **Identify** the original source of the energy in fossil fuels.

12 **Identify** the source of heat in water springing from a geyser.

13 **Identify** the part of the water cycle that is represented in Figure 3.5.2.

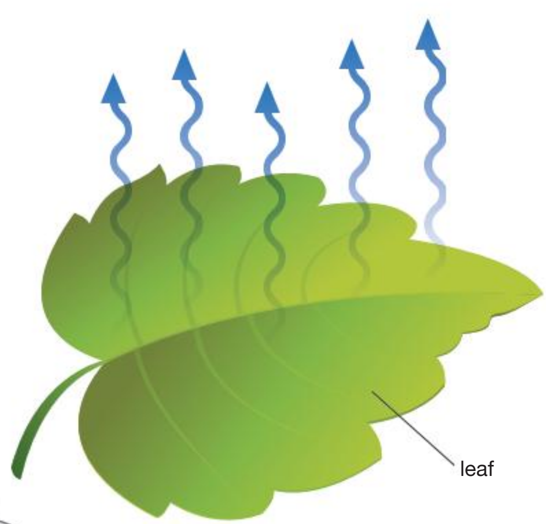


Figure 3.5.2

3 Chapter review

Analysing

14 **Compare** how long it takes to renew soils with how long it takes to replace water in the soil.

15 **Compare** how long it takes to replace rocks with how long it takes to renew gases such as oxygen in the air.

16 **Classify** these energy sources as either renewable or non-renewable:

- solar energy
- oil
- coal
- wind energy
- wave energy
- tidal energy
- LPG gas
- geothermal energy
- wood
- paper
- uranium.

17 **Compare** the amount of water lost from a field of bean plants when it is irrigated using spray irrigation and when it is not irrigated at all.

Evaluating CCT

18 Tides are local temporary currents caused by the gravity of the Moon. **Propose** how a tide may affect soil erosion.

19 Considering the impact of greenhouse gases on global warming, it could be argued that the world should immediately stop using non-renewable forms of energy such as oil, coal and gas. **Evaluate** this argument.

20 Algae can grow in salty or waste waters and do not require the fresh water needed for many other biodiesel crops. **Propose** why algae could potentially offer a good source of biofuel.

21 **Deduce** why some clouds pass overhead without producing any rain.

22 Flexible solar cells are currently being developed for use instead of the rigid panels currently being used. **Propose** three ways in which flexible solar cells may be used in the future.

23 a **List** the major sources of energy used in Australia to power appliances and for transportation.

b **Propose** what Australia's major energy sources might be in 50 years time.

24 Stormwater that has passed through a wetland before entering a creek is less polluted than stormwater that has gone directly from a street to a creek. **Propose** a reason why.

25 a **Determine** whether you can or cannot answer the questions on page 84 at the start of this chapter.

b **Assess** how well you understand the material presented in this chapter.

Creating CCT

26 When storing water is it better to have one large dam or a number of smaller dams? **Design** an experiment that could be used to answer this question.

27 **Use** the following key terms to **construct** a visual summary of the information presented in this chapter:

renewable resource
non-renewable resource
renewable energy source
solar energy
fossil fuels
water cycle
change of state
transpiration
precipitation
human impacts

3.10

Thinking scientifically

Q1 A renewable natural resource is one that is replaced by natural processes that occur in a timescale less than an average human lifetime. Some students were asked to classify some of Earth's resources into renewable resources and non-renewable resources. Their answer is shown in the following table. CCT

Renewable resources	Non-renewable resources
1 rocks	7 wind
2 water	8 air
3 sunlight	9 coal
4 soil	10 petroleum
5 waves	11 natural gas
6 hydroelectric	12 nuclear

Which resources (using the number) did the students classify incorrectly? CCT

A 1, 4, 7, 8
B 2, 3, 9, 10
C 5, 6, 11, 12
D 9, 10, 11, 12

Q2 A non-renewable energy source cannot be replaced. Identify which list below contains only non-renewable energy resources. CCT

A coal, oil, sunlight, wind
B natural gas, sunlight, wind, tidal energy
C oil, uranium, sunlight, tidal energy
D natural gas, coal, oil, uranium

Q3 The change of state from gas to liquid represents: CCT

A the changes taking place as the water level in a lake decreases in dry weather
B the change that takes place in saturated air as it cools
C the change that takes place in leaves of trees with the Sun shining on them
D the change of state necessary for water to be able to percolate through soil

Q4 If the air temperature increased throughout the world, the rate at which water moves through the water cycle would: CCT

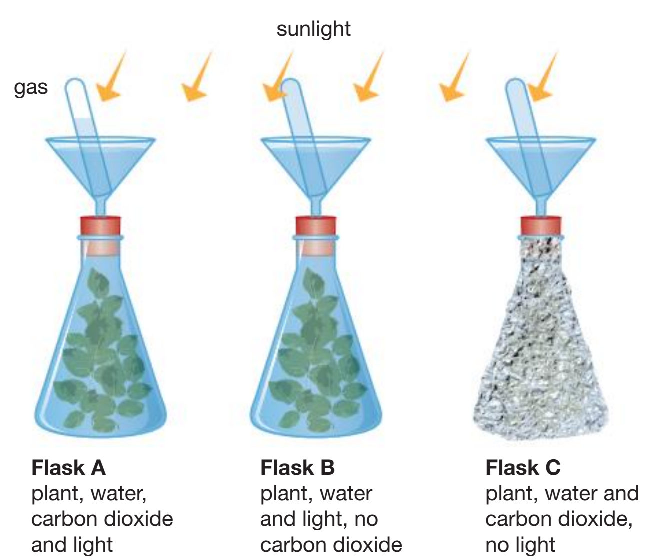
A stay the same
B decrease
C increase
D increase in some areas and decrease in others

Q5 As water goes through the water cycle again and again, the amount of water on Earth: CCT

A increases
B decreases
C stays the same
D varies from time to time

Q6 An experiment testing whether oxygen in air can be renewed was set up as in the diagram below. The flasks were placed in strong sunlight for a day. The gas collected in test-tube A made a glowing splint ignite. From the results, you could conclude that: CCT

A sunlight turns water into oxygen and carbon dioxide
B plants take in oxygen from the air and give out carbon dioxide
C plants produce oxygen if they have sunlight and carbon dioxide
D all the oxygen in the atmosphere comes from green plants



Glossary

Unit 3.1 L

Atmosphere: layer of gases above the Earth's surface

Coal seam gas: natural gas released from coal by fracking

Deposition: the process in which sediments drop out of a moving stream of water, air or ice

Erosion: the removal of sediments away from the place of their formation or deposition

Fracking: a form of mining in which water and other chemicals are pumped into rocks, causing them to fracture (break) and release the non-renewable resource

Erosion

Humus: decaying plants and animals and their wastes

Igneous rock: rock formed by the cooling of molten rock, for example basalt

Minerals: substances found in rocks

Non-renewable resource: a resource that takes longer than the average human lifespan to be replaced

Igneous rock

Photosynthesis: the process by which plants use carbon dioxide, water and sunlight to make food

Renewable resource: a resource that is always being replaced naturally

Resource: something that satisfies a particular purpose or need

Sediment: material such as silt and sand that is transported and deposited by water, ice and wind and forms layers on the Earth's surface. In time it can become compacted to form sedimentary rock

Renewable resource

Sedimentary rock: rock formed by compacting and sticking together of sediments, for example sandstone

Weathering: the process of breaking rocks down into smaller pieces

Unit 3.2 L

Biofuel: fuel obtained from plants, agricultural waste or algae

Biogas: a gas produced from the fermentation of organic waste, such as waste from sugarcane, and used as fuel

Biomass: all plant and animal matter found on Earth

Carbon capture and storage: the process whereby carbon dioxide gas is isolated and captured for underground storage after coal is burnt

Fossil fuels: fuels such as coal, oil and natural gas, formed from the remains of living things buried millions of years ago

Geothermal energy: energy sources from heat below the Earth's crust

Greenhouse gas: gas that traps heat close to Earth's surface

Hydroelectricity: the process of using water falling from a height to turn turbines and generate electricity

Non-renewable energy source: a source of energy that cannot be replaced after it is used, such as oil or coal

Nuclear fuel: a material that can be used to generate energy by splitting apart in a nuclear reaction

Non-renewable energy source

Oscillating wave column: a chamber containing a turbine that is fixed in the ocean. As water flows into and out of the chamber, air pushes the turbine back and forth. This rotation is used to generate electricity

Renewable energy source: a source of energy that can be replaced after it is used, such as solar or wind energy

Renewable energy source

Solar cell: a device that absorbs solar energy and converts it directly into electrical energy

Solar cell

Tidal barrage: a construction in which water fills a basin as a tide comes in, rotating a turbine as it flows. The water is stored until low tide, when it is released and again turns the turbine. This rotation is used to generate electricity

Wind energy: harnessing energy from the movement of air using wind turbines

Unit 3.3 L

Aquifer: a layer of pervious rock from which water can be extracted using a bore or well

Groundwater: water that exists underground

Humidity: the amount of water vapour in the air

Impervious rock: rock that does not allow water to soak into it

Percolation: the process of water soaking into the soil

Pervious rock: rock that allows water to soak into it

Precipitation: any water falling from the sky

Run-off: rainwater not absorbed by the soil

Saturated: not able to hold any more water vapour

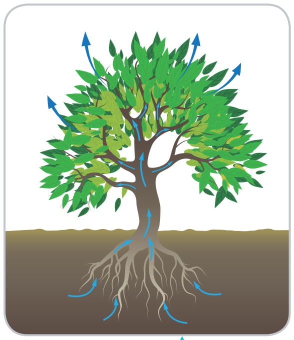
States: solid, liquid and gas (another state called plasma exists at temperatures above 6 000°C)

Topography: the hills, valleys, rivers and other physical features of the landscape

Transpiration: the evaporation of water from plants

Water cycle: the natural process of recycling water

Precipitation



Transpiration

Unit 3.4 L

Flood irrigation: a type of irrigation where water is released in between crops in channels

Irrigation: a practice used in agriculture that provides water to crops using pipes and ditches

Rills: channels in bare soil created by fast-flowing water

Spray irrigation: a type of irrigation where a pump sprays water droplets into the air, which fall onto crops like rain

Springs: places where underground water comes to the surface

Flood irrigation

Rills

Spray irrigation

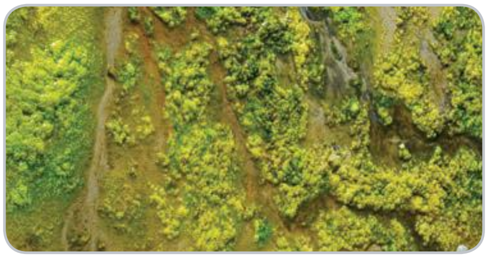
SCIENCE TAKES YOU PLACES

Look who is using science

ENVIRONMENTAL SCIENTIST

My name is Adeline Morrissey and I am an environmental scientist working in the mining industry.

In my job I help mining companies to look after the environment. One of my jobs is to do water sampling to check whether the mine site is contaminating the groundwater. I also study how well a company has restored the areas where they have mined. This involves studying the soil and plants. I assist with surveys of animals before companies mine areas to see what animals are present, such as rare species. I am regularly back in the city for report writing and data analysis after I do the field work. The sciences I studied at school and university that I use in my everyday job include chemistry, biology, soil science, plant science and animal sciences.



TAXONOMIST

My name is Dr Will White and I am a fish taxonomist with the CSIRO Marine and Atmospheric Research laboratories.

I work on applied taxonomy and biogeography of Indo-Pacific fishes, mostly sharks and rays. A large proportion of my work has involved field trips to Indonesia to look at the fisheries over there and I have discovered a large number of new species of sharks and rays during this work. I have been involved in the description of almost 50 new species of sharks and rays. I always had an interest in sharks and rays and have always enjoyed diving and underwater photography. Science has been a great way not only to learn new things but also to lead a varied work life with a large amount of travel.

SEWAGE QUALITY ENGINEER

My name is Brett Maurer and I am a sewage quality engineer working for City West Water.

Trade waste (waste released into the sewers from industry) can potentially contaminate and damage pipes and sewage treatment plants. It can also put our sewer workers at risk, particularly if it is releasing dangerous gases. I take samples of sewage and test them to determine what contaminants they contain and whether they meet the regulations for discharging into the sewer. I also collect samples from the space in the pipe above the flowing sewage to determine what gases are there. The information obtained also helps our business identify ways of treating and recycling industrial water and using biosolids—the nutrient-rich sludge that is generated from the treatment plant process. Water is essential for living and my work helps to ensure that supply meets the increasing demand of our increasing population.

4 Mixtures

Have you ever wondered...

- where bubbles in a soft drink come from?
- where sugar goes when you stir it into tea?
- how recycled garbage is separated?
- where clean tap water comes from?

After completing this chapter students should be able to:

- describe aqueous mixtures in terms of solute, solvent and solution
- describe a range of physical separation techniques, including filtration, decantation, evaporation, crystallisation, chromatography and distillation CCT
- investigate how physical separation techniques are used in everyday situations or in industrial processes, such as water filtering, sorting waste materials, extracting pigments or oils from plants, separating blood products or cleaning up oil spills S
- research how different occupations and industries carry out separation techniques CCT WE
- describe the importance of water as a solvent in daily life, industry and the environment.

4.1 Types of mixtures

Most of the substances that you deal with every day are not pure substances; they are mixtures. The air you breathe is a mixture, as are an artist's paints and the water you get from a tap.

INQUIRY
science 4 fun

Mixing oil and water

YES

Do oil and water mix?

Collect this …

- cooking oil
- detergent
- 2 small thin clear containers with lids (such as pill bottles)

Do this …

1. Pour about 5 cm of water into each container.
2. Add about 5 drops of detergent to one container. Mark the container so that you remember that it contains detergent.
3. Pour about half a centimetre of oil into each container.
4. Put a lid on each container and shake each for about 20 seconds.

Record this …

Describe what happened.

Explain why you think this happened.

What is a mixture?

Paints, drinks, foods, seawater and air are not pure substances; they are mixtures. In science a **mixture** is a substance made from two or more pure substances or pure chemicals that have been stirred together. For it to be called a mixture, you must be able to separate them again.

Solutions

Watch carefully as sugar is stirred into water and the solid sugar will seem to disappear! The sugar has dissolved. The sugar breaks up into tiny particles that are too small to see. These particles then spread throughout the water. Although these sugar particles cannot be seen, the sweetness of the liquid tells you they are still there. This is what is meant when something is said to **dissolve**. A substance that dissolves like this is described as **soluble**. A substance that does not dissolve is described as **insoluble**.

When things mix really well, like when sugar dissolves in water, the mixture is known as a **solution**. When you stir sugar into water, you make a sugar solution.

Prac 1
p. 145

Solutes and solvents

When you make a solution, the substance that dissolves is known as the **solute**. In a sugar solution, the sugar is the solute. The substance that dissolves the other one is the **solvent**. So in this case the water is the solvent.

The soft drink in Figure 4.1.1 has sugars, preservatives and flavourings dissolved in water. There is also carbon dioxide gas dissolved in it to give the drink its bubbles. This shows that solutes don't always need to be solid. Table 4.1.1 shows other types of solutions made by combining different solvents with different solutes.

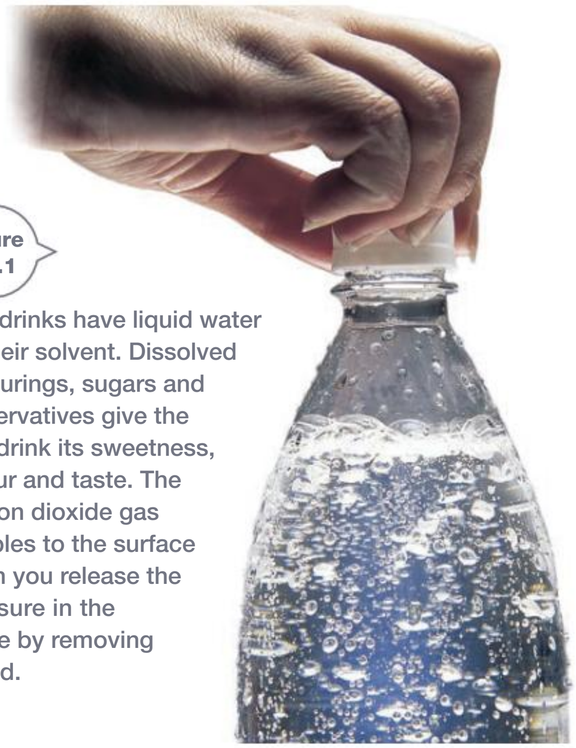


Figure 4.1.1 Soft drinks have liquid water as their solvent. Dissolved flavourings, sugars and preservatives give the soft drink its sweetness, colour and taste. The carbon dioxide gas bubbles to the surface when you release the pressure in the bottle by removing the lid.

Table 4.1.1 Common types of solution

Type of solution	Examples
Solid dissolved in a liquid	Grease dissolved in petrol, sugar dissolved in water
Liquid dissolved in another liquid	Liquid detergent dissolved in water, oil dissolved in petrol
Gas dissolved in a liquid	Oxygen gas dissolved in water, oxygen gas dissolved in blood
Gas dissolved in another gas	Oxygen gas, carbon dioxide gas and water vapour dissolved in the other gases of the air

Most of the solutions you will meet in science and at home are aqueous solutions. An **aqueous solution** always has water as its solvent. Sugar dissolves in water, so a sugar solution is classified as an aqueous solution. Likewise, soft drink is an aqueous solution of sugars, preservatives, flavouring and carbon dioxide.

A particular solute will dissolve in some solvents and not in others. For example, grease will not dissolve in water but will dissolve in the fluids used by drycleaners. Particular solvents will dissolve some substances and not others. For example, water will dissolve detergent, but not oil. You can see this in Figure 4.1.2.

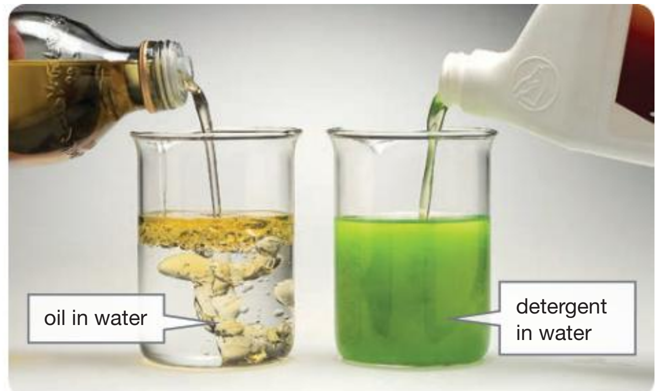


Figure 4.1.2 Oil will not dissolve in water but detergent will.

Solution or not?

Light passes easily through a solution, allowing you to see through it. This is one way of telling whether a mixture is a solution or not. Solutions are transparent (see-through). You can describe solutions such as this as 'clear', meaning you can see through them.

Solutions can be colourless, looking much like water. Other solutions are coloured. For example, blue copper sulfate solid dissolves in water to form a blue-coloured solution. You know that a solution has been formed because you can see straight through it. You can see its preparation in Figure 4.1.3.

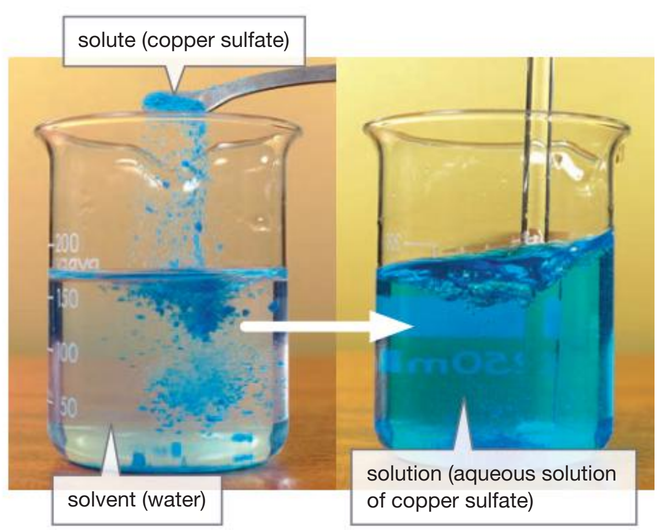


Figure 4.1.3 Preparation of an aqueous solution of copper sulfate

Colourless and clear are not the same. Clear means that you can see though it. Colourless means it is not coloured. Figure 4.1.4 helps explain these different meanings.

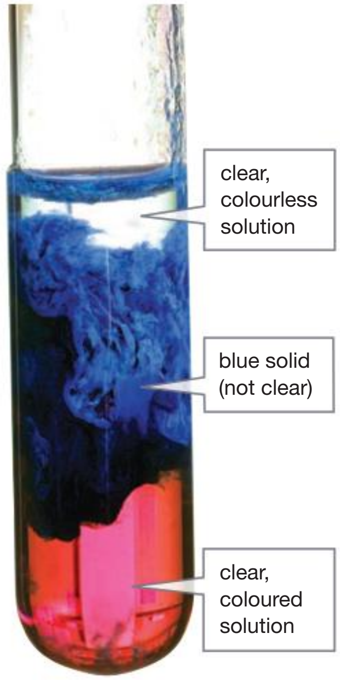


Figure 4.1.4 Solutions can be coloured or colourless and are always transparent. You can see through them.

> **Shake your bottle**
> Many medicines need to be shaken up before you take them. If you don't, then one of the important ingredients in the medicine might remain as a sediment on the bottom of the bottle and so you would receive an incorrect dose. That is why you are told to 'shake the bottle before using'.
>
> SciFile

Dilute, concentrated and saturated solutions

A solution is said to be **concentrated** if there is a lot of solute dissolved in the solvent. If there is only a little solute in the solution, then it is a **dilute** solution. Four spoonsful of sugar dissolved in a swimming pool will produce a dilute solution. In contrast, four spoonsful of sugar in a cup of tea will make it concentrated. A concentrated solution and a dilute solution are shown in Figure 4.1.5.

Imagine you took a glass of water and kept adding spoonsful of salt to it, stirring each time. You would find that eventually the salt would stop dissolving. When a substance will no longer dissolve in a solvent, the solution is said to be saturated. Any undissolved solute then falls to the bottom as sediment. This is shown in Figure 4.1.6.

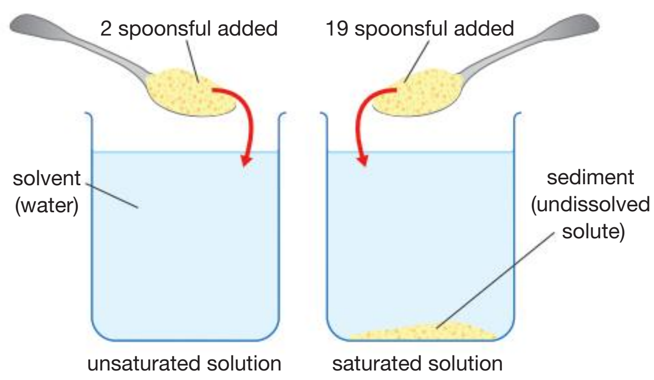


Figure 4.1.6 The solution that is saturated with salt has the higher concentration—so high that no more salt will dissolve.

Figure 4.1.5 Concentrated solutions have a lot of solute dissolved in them while dilute solutions have very little.

In the natural world, solutions sometimes become saturated. This can cause solid salt to be deposited (left behind) around the edges of salt lakes when the salt reaches a high concentration. The solution becomes saturated because of the water evaporating and also because of high levels of salt entering the lake. Figure 4.1.7 shows Lake Gairdner, a salt lake in South Australia.

Figure 4.1.7 Salt crystals often form around the edges of salt lakes.

Prac 2 p. 146 | Prac 3 p. 147 | 4.1

SciFile

Sweet tea!

If you tried to saturate a hot cup of tea with cane sugar (sucrose) then you would need to add about 700 g or 100 teaspoons of sugar! Your cup would overflow long before the tea became saturated.

Suspensions

Sand does not dissolve when it is mixed into water. Instead it stays solid and spreads throughout the water. This type of mixture is called a **suspension**. In suspensions, substances like sand do not dissolve but **disperse** (spread) through a liquid or gas. Figure 4.1.8 shows dust floating in the air. This is another example of a suspension. Usually, the suspended particles are too large and heavy to stay in suspension and will fall and settle if left undisturbed. Sand mixed into a beaker of water will, after a while, settle on the bottom of the beaker. In the same way, dust in the air eventually drops to cover floors and other surfaces.Table 4.1.2 lists some different types of suspension.

Table 4.1.2 Types of suspension

Type of suspension	Examples
Solid suspended in a liquid	Most suspensions are made of large solid particles that stay mixed with a liquid for a short time, before settling out. Sand in water is an example.
Solids suspended in a gas	Sand carried by the wind drops out of the air it is suspended in as soon as the wind stops.
Liquids suspended in another liquid	Many medicines are suspensions of liquids within another liquid. Oil paints are generally suspensions of one liquid in another.

Figure 4.1.8 Dust floating in the air forms a suspension of a solid (dust) in a gas (air). Eventually, the dust will settle onto the furniture.

4.2

4.1 Unit review

Remembering

1 **List** two examples each of a solute, a solvent and a solution.

2 **List** four types of solution and give an example of each.

3 **List** three types of suspension and give an example of each.

4 **Recall** the correct names for these mixtures.
 a A type of mixture in which one substance does not dissolve in another but quickly separates out to form a sediment
 b A clear mixture in which a substance dissolves in another

Understanding

5 **Explain** why cooking oil forms clumps of drops when added to water but seems to 'disappear' when added to detergent.

6 **Define** the term *concentrated solution.* L

7 Mylanta® is an antacid liquid used to relieve heartburn. The label tells you to shake the bottle well before use. **Explain** why.

8 **Outline** how you could show that a sugar solution is just saturated.

Applying

9 A chef dissolved salt in boiling water that he was going to use to cook pasta. **Identify** whether the salt, water or salty water was the:
 a solute
 b solvent
 c aqueous solution.

10 **Identify** a solvent that will dissolve:
 a sugar
 b grease.

11 In a 250 mL cup of water, it would take about 90 g of salt to saturate the water. This is about 13 teaspoonsful. **Calculate** how many teaspoonsful you think it would take to saturate a 1 L (1000 mL) bottle of water. N

Analysing

12 **Compare** a concentrated sugar solution with a dilute sugar solution.

13 **Compare** a sugar solution with a suspension of sand in water.

14 Melting occurs when a solid changes state to form a liquid. **Use** this information to **compare** dissolving and melting.

15 **Classify** each of the following as a solution or a suspension.
 a cordial in water
 b carbon dioxide gas in lemonade
 c clouds
 d food colouring in water
 e dust in air
 f smoke from a car exhaust

Evaluating CCT

16 Fiona found that 10 mL of water tasted just as sweet whether she mixed 5 teaspoons or 10 teaspoons of sugar into the liquid. **Propose** an explanation for this.

17 Figure 4.1.9 shows milk being poured into salt water.
 a **Identify** which substance is the solution.
 b **Justify** your answer.

Figure 4.1.9

18 Vitamin C in food is soluble in water. Vitamins A, D and K are soluble in oils. Chefs recommend that:

- vegetables are not soaked in water before or during cooking
- steaming or microwaving is better than boiling.

One reason for these recommendations is to stop heat destroying the vitamins. **Propose** another reason.

19 Figure 4.1.10 shows beams of sunlight passing through foggy air.

a **Identify** whether the air is a solution or a suspension.

b **Justify** your answer.

Figure 4.1.10

20 Solutions are transparent. This means that there are no particles in the solution big enough to reflect or scatter the light as it passes through. Figure 4.1.11 shows two test-tubes A and B that contain different mixtures. Green and red lights are shone through both.

a **Identify** the test-tube that contains a solution.

b **Justify** your choice.

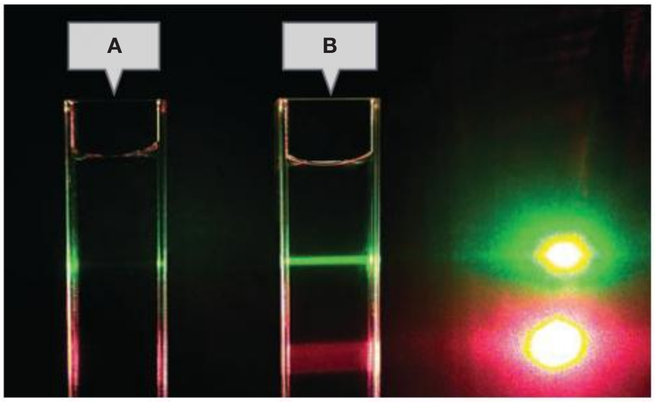


Figure 4.1.11

Creating CCT

21 Think of a common mixture and write down what is in it, but don't tell your partner what it is. Your partner does the same. Now **construct** a series of questions you could ask your partner to work out the secret identity of their mixture. Write down your questions, again keeping them secret. Your task is to identify your partner's mixture. Toss a coin to decide who goes first. The winner is the person who needs the smallest number of questions to identify the mixture.

Inquiring

It is impossible to sink in the Dead Sea, which is bordered by Jordan, Israel and Palestine. No fish live in it and people with cuts are advised not to swim in it. Research the Dead Sea and find:

- a map showing its location
- the reason that fish cannot live in it
- an explanation of why it is impossible to sink in it
- the reason that people with cuts are advised not to swim in it
- photographs or video of people trying to swim in it
- information on the major industries around the Dead Sea
- the reason behind the current drop in sea level of about 1 metre per year.

Present your findings as a PowerPoint presentation. ICT

4.1 Practical investigations

1 Soluble and insoluble substances

Purpose

To investigate what substances will dissolve in water and kerosene.

Materials

- ½ spatula copper carbonate ($CuCO_3$)
- ½ spatula copper sulfate ($CuSO_4$)
- 1 spatula table salt (NaCl)
- cooking oil in dropping bottles
- 6 mL kerosene

- 6 medium-sized test-tubes with stoppers to fit
- test-tube rack
- marking pen or sticky labels
- spatula

SAFETY

Copper sulfate and copper carbonate are toxic so do not touch, sniff or taste them.

Kerosene is flammable and should be kept away from naked flames. Wear safety glasses and rubber gloves at all times to avoid contact with your skin and eyes. Avoid inhaling its fumes by using a fume cupboard.

Procedure

1. Copy the table in the Results section into your workbook.
2. Place the test-tubes in the rack. Use the marking pen or sticky labels to number them 1 to 6.
3. Add about 5 cm of tap water to test-tubes 1 to 4. Pour 3 cm of kerosene into test-tubes 5 and 6.
4. Add different solutes to the different test-tubes as shown in Figure 4.1.12.
5. Place a stopper in each test-tube. Shake each of the test-tubes for about 1 minute. Place all the test-tubes in the test-tube rack and record what you see.
6. Do not tip anything down the sink. Return all test-tubes and liquid to your teacher.

Results

1. Record your observations in the following table.

Test-tube number	Solvent	Solute	Observation
1	water	copper carbonate	
2	water	copper sulfate	
3	water	salt	
4	water	oil	
5	kerosene	oil	
6	kerosene	salt	

Practical review

1. **Describe** an easy way of telling whether a solution has been formed or not.
2. **Specify** the test-tubes in which a solution formed.
3. **Name** the substances that were insoluble in water.
4. **Name** the substances that were insoluble in kerosene.
5. **Name** the substance that is a solvent of salt but not of oil.
6. **Name** the substance that is a solvent of copper sulfate but not of copper carbonate.

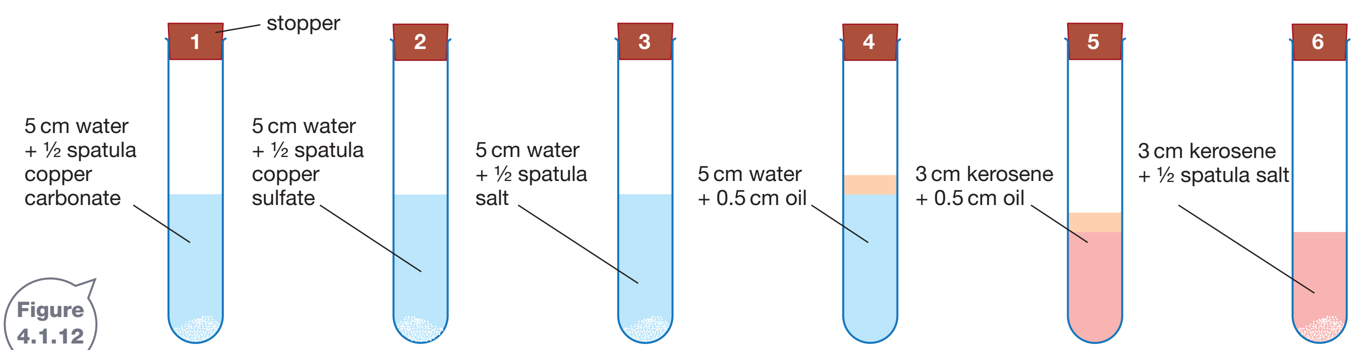


Figure 4.1.12

STUDENT DESIGN

2 Dissolving and surface area

Purpose

To test whether breaking up a solute into smaller particles can change how fast it dissolves.

Hypothesis

Which do you think will dissolve faster—a whole Sugarine® tablet or a crushed Sugarine tablet? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 2 Sugarine tablets
- 2 test-tubes and stoppers
- an object to crush one of the tablets (such as a teaspoon or mortar and pestle)
- stopwatch (optional)

SAFETY

A Risk Assessment is required for this investigation.

Procedure

1. Design an experiment that will test whether a crushed Sugarine tablet dissolves faster or slower than a whole Sugarine tablet. Figure 4.1.13 might give you some ideas on how to do this.
2. Write your procedure in your workbook.
3. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

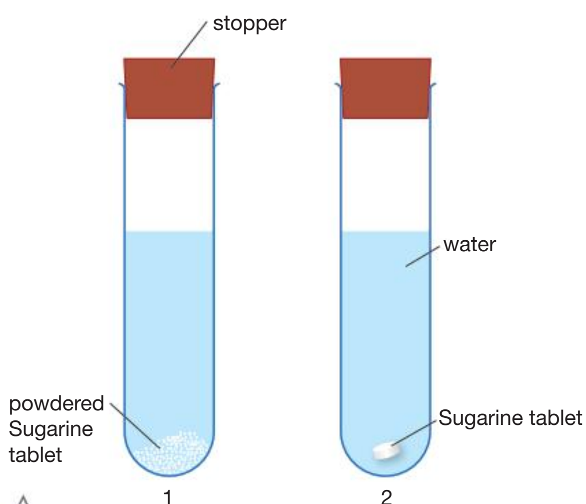


Figure 4.1.13

Hints

- You should use the same size test-tubes with the same amount of water in each.
- You only need to find out which tablet dissolves faster—you do not need to find the exact time each tablet takes to dissolve.

Results

Record which tablet (whole or crushed) dissolved first. If you measured the time taken for each to dissolve, then record the times as well.

Practical review

1. **List** the variables that you controlled (kept constant) during this experiment.
2. **State** the variable that you changed.
3. a **Construct** a conclusion for your investigation.
   b **Assess** whether your hypothesis was supported or not.
4. In this investigation, it was not necessary to measure the length of time it takes for the two tablets to dissolve. **Explain** why.
5. A crushed Sugarine tablet has more surface area and more contact with the water than a whole tablet. **Use** this information to **explain** your results.
6. You sometimes take an aspirin tablet or capsule when you have a bad headache. Capsules contain roughly the same amount of aspirin as a tablet. However, a capsule has its aspirin as small particles held in a shell that dissolves when you swallow it.
   a **Assess** whether a tablet or a capsule would go to work on your headache faster.
   b **Justify** your answer.

STUDENT DESIGN

3 Investigating dissolving

Purpose

To investigate how things dissolve.

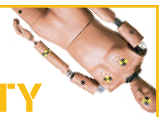
Hypothesis

Once you have decided which investigation to perform, write a hypothesis in your workbook.

Materials

Students to choose from:

- sugar
- copper sulfate ($CuSO_4$)
- salt
- 3 varieties of liquid dishwashing detergent
- source of grease (such as oil)



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Design an experiment that will answer one of the following questions.
   - Can sugar and copper sulfate both dissolve in the same container of water?
   - Is the amount of salt that can dissolve in water more or less than the amount of sugar that can dissolve in the same volume of water?
   - Can copper sulfate dissolve in a saturated solution of salt?
   - Are all dishwashing liquid detergents equally good at dissolving grease?

2 Write your procedure in your workbook. Include a diagram of your design for your experiment

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

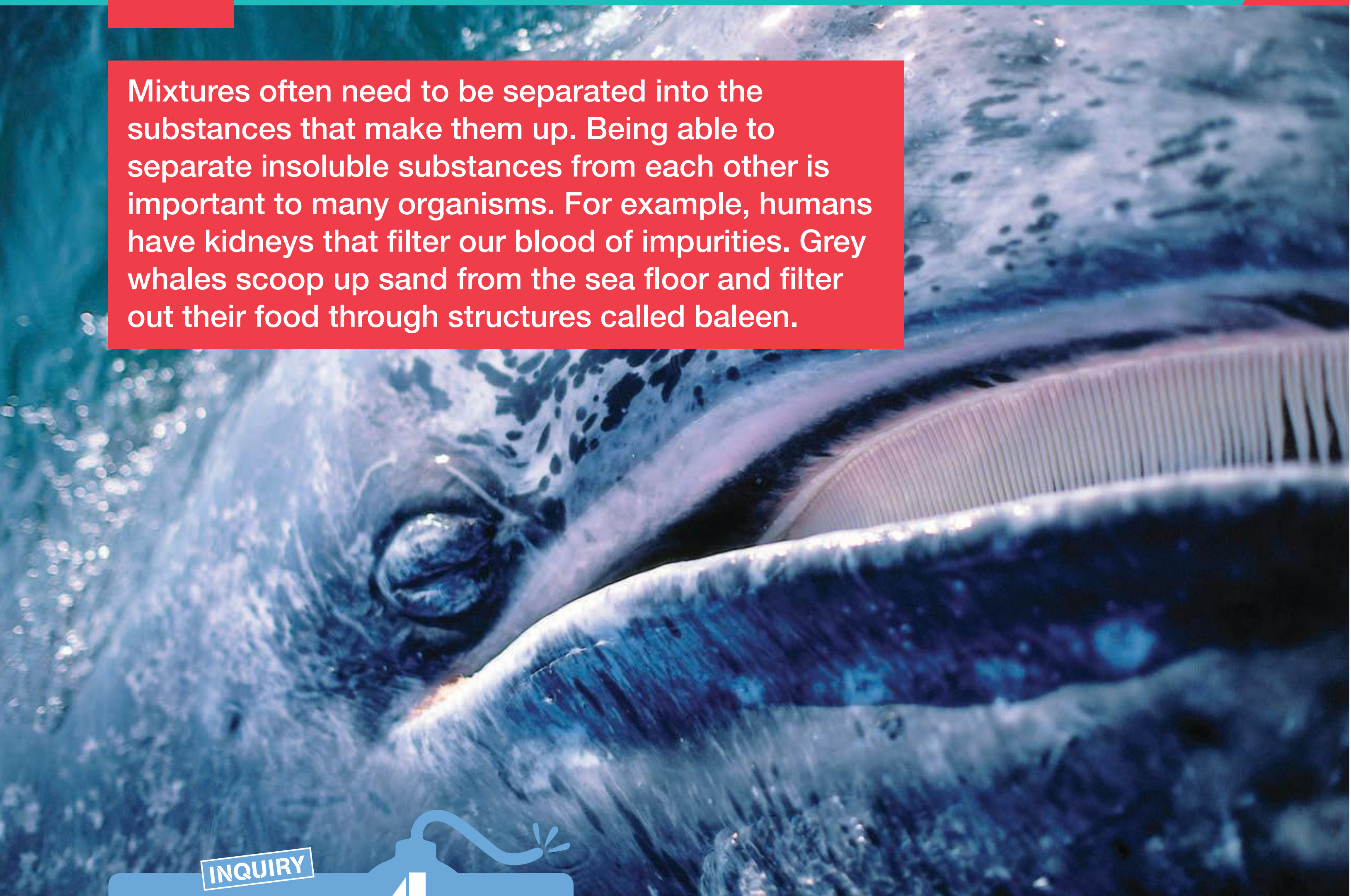
Record your results and observations in your workbook.

Practical review

1 **Construct** a conclusion for your investigation.

2 **Assess** whether your hypothesis was supported or not.

4.2 Separating insoluble substances



Mixtures often need to be separated into the substances that make them up. Being able to separate insoluble substances from each other is important to many organisms. For example, humans have kidneys that filter our blood of impurities. Grey whales scoop up sand from the sea floor and filter out their food through structures called baleen.

INQUIRY science 4 fun

Panning for gold

Could you find gold?

YES

Collect this ...

- metal bowl or old cereal bowl (shallow with gently sloping sides)
- fairly clean sand or loam soil
- small metal objects such as nails or washers
- bucket of water or hose

Do this ...

1. The small metal objects are your 'gold'. Mix them up with the soil and put the mixture in the bowl.
2. Half fill the bowl with water.
3. Hold the bowl with a hand on each side. Move the bowl around in a circular motion to swirl the water through the soil. The soil should start lifting up into the water.
4. Let the water wash over the sides of the bowl as you move it around. The aim is to wash some of the soil out of the bowl with the water.
5. Keep adding water and swirling the soil around so it is gradually removed from the bowl. You should see the 'gold' collecting on the bottom of the bowl.
6. See how pure you can get the 'gold'. You may have to practise to improve your technique.

Record this ...

Describe what happened.

Explain why you think this happened.

Magnetic separation

Your recycle bin at home contains a mixture of insoluble solids. It probably contains steel cans, glass jars, aluminium cans, paper, cardboard, plastic bottles and packaging. After collection, this mixture needs to be separated so that the different substances can be recycled and then re-used.

Magnets are a convenient way of separating any rubbish made of iron or steel. Iron is always attracted to magnets. As steel is more than 95% iron, it too is attracted to magnets. Magnets also attract the metals nickel and cobalt, but do not attract other metals such as aluminium, copper or gold or substances such as plastic, paper or glass. Magnetic attraction allows iron and steel to be easily removed from piles of rubbish, leaving the non-magnetic materials behind. One way in which magnets are used to separate rubbish is shown in Figure 4.2.1. Magnetic separation is also used in the mining industry and in the scrap metal business.

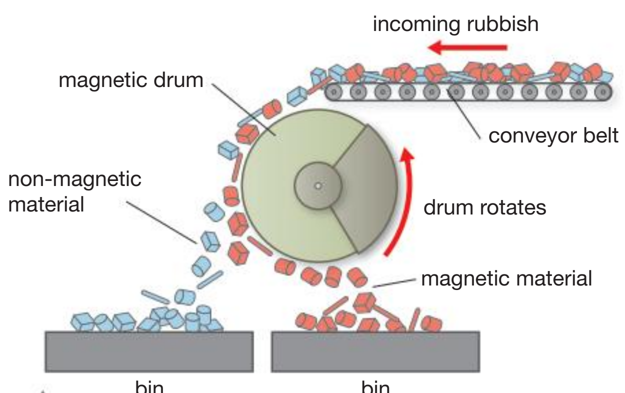


Figure 4.2.1 A rotating drum can be used to separate magnetic materials from municipal rubbish.

GO TO Unit 7.4

SciFile

Making non-magnetic metals magnetic

Non-magnetic metals can be made temporarily magnetic if they are good conductors of electricity. A strong magnet placed near to some rubbish can make an electric current flow through the metals. While the current flows through them, these metals are also magnetic. This allows another magnet to pull normally non-magnetic metal items such as aluminium cans and bottle tops out of the rubbish.

Gravity separation

Not all mixtures contain a collection of solids like those in your recycle bin. Many mixtures are suspensions which contain insoluble solids dispersed through a liquid. **Gravity separation** uses gravity to separate heavier substances from a suspension. The heavier particles sink to the bottom of the container. Gold panning (shown in Figure 4.2.2) uses gravity separation. The heavy gold particles drop to the bottom of the pan, allowing the lighter mud and water to be poured off.

GO TO Unit 7.3

Figure 4.2.2 Panning for gold uses gravity separation.

Decantation is a type of gravity separation that lets suspensions of solids or liquids separate naturally. The top layer can then be poured or scraped off. The top layer could be a:

- liquid, such as oil
- solid, such as plant material like leaves and twigs in soil
- liquid, if a heavy solid has settled to the bottom.

Decanting is used in a kitchen to pour off cooking water from vegetables in a saucepan. Sometimes sediment will collect at the bottom of a bottle of wine that has been left to stand. Pouring the bottle into a glass container (a decanter) leaves the sediment in the bottle. Decanting is used in many industries. Figure 4.2.3 on page 150 shows one method used in science laboratories.

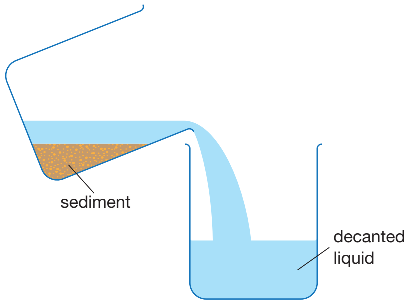


Figure 4.2.3 Decanting pours off the liquid to leave the solids behind.

Sieving

A sieve is a barrier with holes in it. Small solid particles can get through, but large ones cannot. The process is called sieving. A colander is a sieve that is used in the kitchen to strain water from food. Likewise, large lumps in flour can be removed before baking by sifting the flour through a strainer, or flour sifter. The fishing net shown in Figure 4.2.4 is also a sieve.

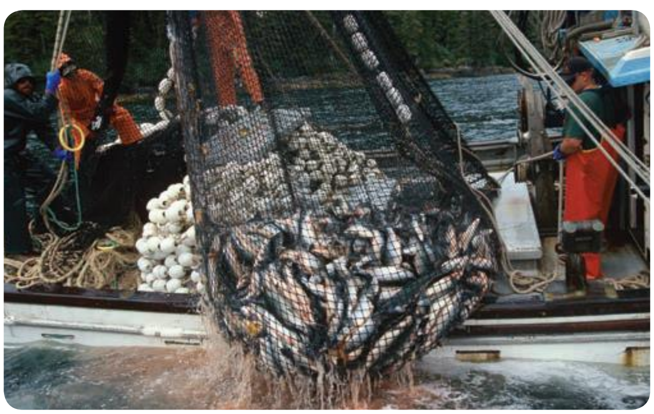


Figure 4.2.4 A fishing net is a kind of sieve. The small fish and water go through while the larger fish get stuck in the net.

Sieves are graded to a specific size for the job they do. They are used in mining to ensure that only rocks of the correct size enter a rock crusher. They are also used to grade soil into its different-sized particles to classify the soil being studied.

SciFile: Human filters

Your kidneys filter your blood and produce urine. Your whole blood supply passes through your kidneys in about 1 hour. This means your blood has passed through your kidneys about 24 times in a day. From this you make about 1 litre of urine.

GO TO Pearson science NSW 8 Unit 3.4

Filtration

Filtration, also known as filtering, is a widely used method of separating:

- solids from gases
- solids from liquids
- liquids from gases
- liquids from other liquids.

Filtration uses a **filter**. A filter is like a sieve in that it is a barrier with many, many small holes (often microscopic in size) in it. These holes are smaller than the particles being separated and so these particles get caught in the filter. However, smaller particles pass straight through. Many filters are a mesh of fine fibres like cotton wool. Others include rock with fine pores (small holes) in it.

Filters are used to separate coffee grounds from filter coffee. Likewise, tea bags are a type of filter that allows water to move through them while keeping the tea leaves in the bag. The face mask shown in Figure 4.2.5 is a filter that separates dust from air. A similar filter is used in most vacuum cleaners. The filtered, clean air is then blown back into the room. Filters can also be found in air conditioners, washing machines, dryers, swimming pools, car engines, fuel systems and air cleaners.

Filters are also used in the laboratory. Several different methods are used, but the most common uses filter paper.

Figure 4.2.5 People working in dirty or dusty environments stop dust from entering their airways by wearing face masks.

4.3

Folding a filter paper

There are two methods to fold filter paper. The method you choose depends on the material you are filtering. The conical fold is shown in Figure 4.2.6.

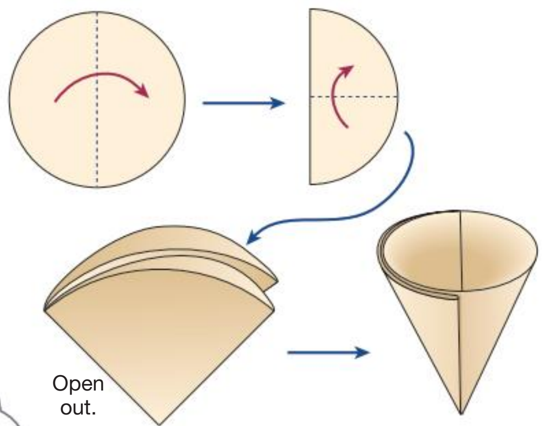


Figure 4.2.6 How to make a conical fold for filter paper

The other method of folding is called fluting. This is shown in Figure 4.2.7.

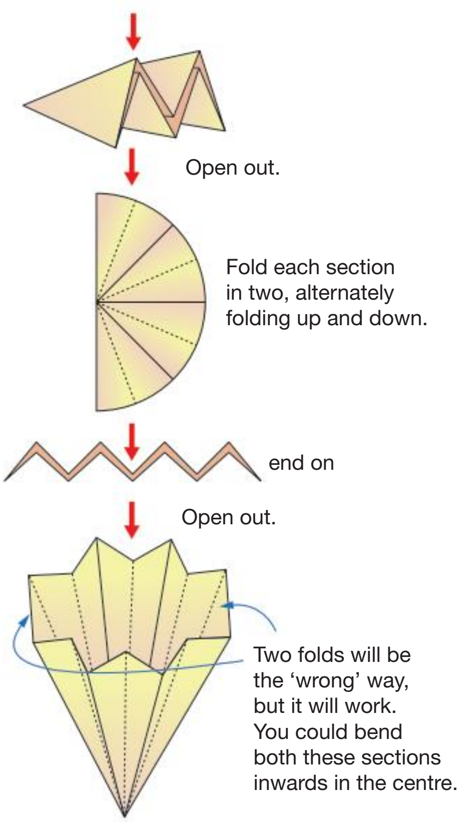


Figure 4.2.7 How to fold a fluted filter paper

Fluting increases the amount of surface in contact with the liquid and increases the filtration rate. It is useful for very fine suspensions that can block many of the holes in the paper.

How to filter

To filter, set up the equipment as shown in Figure 4.2.8.

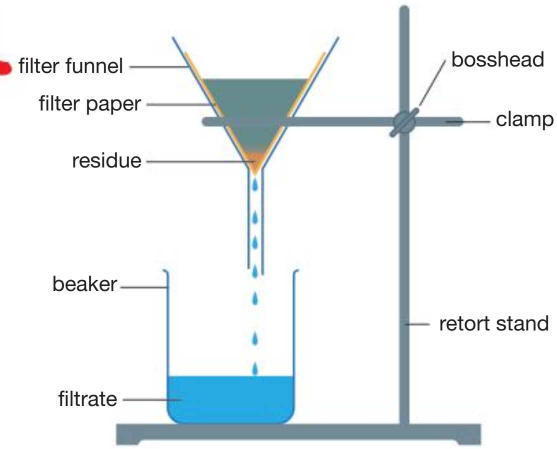


Figure 4.2.8 A special filter stand can be used instead of a retort stand and clamp

Some rules to follow when filtering are:

- Do not let the liquid in the filter go over the top of the paper, or solids will enter the filtrate.
- Do not touch the filter while filtering —it will break and solids will enter the filtrate.

4.4

Prac 1 p. 155
Prac 2 p. 156

Centrifuging

A simple **centrifuge** is shown in Figure 4.2.9. It has chambers that are spun very fast around a shaft. Any tiny particles suspended in the liquid are forced to the sides and then to the bottom of each chamber.

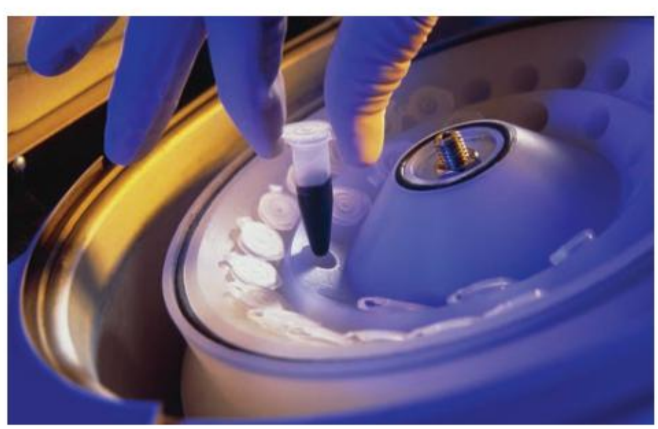


Figure 4.2.9 A simple centrifuge is used to separate substances in the laboratory.

A common use of a centrifuge is in the spin cycle on a washing machine, in which the clothes are spun very fast in the bowl. Figure 4.2.10 shows how this works. Water is forced out of the clothes and through the holes in the bowl. It then drains away and is pumped out of the machine. In a similar way, salad spinners are used in the kitchen to dry washed lettuce.

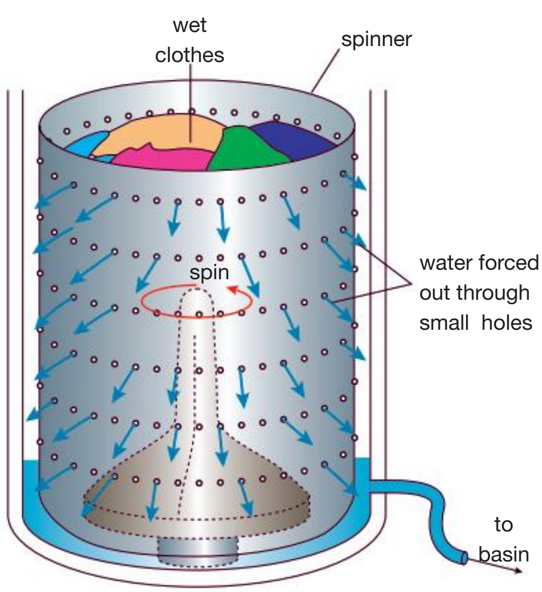


Figure 4.2.10 A washing machine spin cycle acts as a simple centrifuge.

There are many other designs for centrifuges. Some very complicated ones are used in mining. Centrifuging is also widely used in laboratories.

Centrifuging blood

Blood transfusions are often needed to replace blood lost in serious accidents and during major surgery. However, sometimes the blood collected at blood banks (Figure 4.2.11) is centrifuged instead. This is done to separate it into red and white blood cells and liquid plasma, shown in Figure 4.2.12. These components are then used directly or are further separated to treat particular health conditions.

Plasma is used to treat burns patients. Some other conditions don't require plasma but instead need particular chemicals extracted from it. For example, chemicals called clotting factors are extracted from plasma to treat people who have haemophilia. Patients with this disease can bleed to death because their blood does not clot to seal a cut.

Patients with anaemia have insufficient red blood cells in their blood. They can be given whole unseparated blood but this can stress their heart if they also have heart problems. Instead, they are given transfusions of red blood cells because these place less stress on the heart.

Figure 4.2.11 Blood is being collected from these blood donors. In Australia many people donate their blood to the Red Cross Blood Bank to save the lives of others.

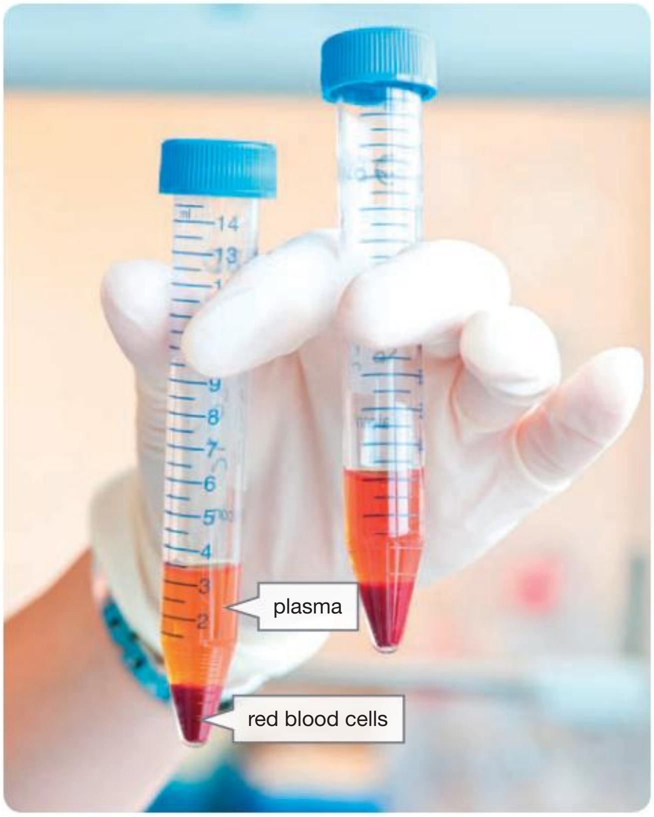


Figure 4.2.12 Blood that has been centrifuged separates out into layers.

4.2 Unit review

Remembering

1 **List** examples of sieving and filtering around your home.

2 **Name** an example of centrifuging that is used at home.

3 **State** at least two methods of separation that can be used to separate a:
- a solid from another solid
- b solid from a liquid
- c liquid from another liquid.

Understanding

4 **Describe** how magnetic separation can be used to separate magnetic and non-magnetic metals from household rubbish.

5 **Explain** why particles of gold fall to the bottom of the pan when panning for gold.

6 a **Describe** what a paper filter would look like if you could magnify it enough.
- b **Explain** how it works to filter out particles.

7 **Explain** why filtration cannot separate sugar from water.

8 **Draw** a diagram that shows how to set up equipment for filtration.

Applying

9 **Identify** a method of separation that could be used for the following situations.
- a You want some fine clean sand without any sticks or stones from the soil in your garden.
- b You drop some nails into the sand in your backyard.
- c You drop some hundreds-and-thousands into the flour your mum is using for a cake.
- d The gravel border along the driveway at home has become covered by bark, and leaves and fine sticks are mixed with the gravel.
- e Your tea bag breaks in your cup of tea.

Analysing

10 **Compare** gravity separation and centrifugation by listing their similarities and differences.

11 **Compare** filtering and sieving.

12 **Compare** the two different methods of folding filter paper by listing the advantages and disadvantages of each.

13 Car air cleaners are structured as shown in Figure 4.2.13.

Figure 4.2.13

- a **Compare** the structure of the air cleaner with that of a fluted filter paper.
- b **Describe** why this design is effective as an air cleaner.

Evaluating CCT

14 When car tyres are replaced, the installer attaches small weights to the wheel rim to check that the wheel is balanced, with an even mass distribution all around. This is because anything that spins fast and is unbalanced can put an enormous stress on the shaft it is attached to. **Propose** how this could apply to a centrifuge if it was not used properly and was unbalanced.

15 **Propose** a reason why vehicle air, fuel and oil filters need to be changed regularly.

16 You are fixing your skateboard and accidentally drop a steel wheel nut into a drain that is too deep to put your arm in. **Propose** a method of recovering the nut from the drain.

17 Some washing machines do some test spins before starting the spin-dry cycle. After doing this, the machine may not spin the clothes but instead agitate them back and forth for a while, before trying another test spin. **Propose** a reason why the machine has been designed to do this.

Creating CCT

18 In the laboratory, you are given a mixture of sugar, sand and gravel. **Design** a way of separating these three substances.

19 **Construct** a table in which you:

a **list** each of the five methods of separation in this unit

b **describe** how each method works

c **specify** an example where it may be used.

Inquiring

1 Research what an *eddy current* is. Search the internet for videos that show eddy currents being used to separate aluminium cans and aluminium foil from other recycled rubbish. Describe an eddy current and what happened in the video. ICT

2 Research two separation methods used in blood banks or the wine industry.

Present your findings as a digital presentation that includes relevant photographs. ICT

3 Research a method of cleaning up oil spills in the ocean. Such methods could include the use of sorbents, separating devices, dispersants or skimming. Figure 4.2.14 shows one method of cleaning up an oil spill.

Present your findings in digital form in which you briefly outline the procedure for the method you have chosen to research, and how the method works. ICT

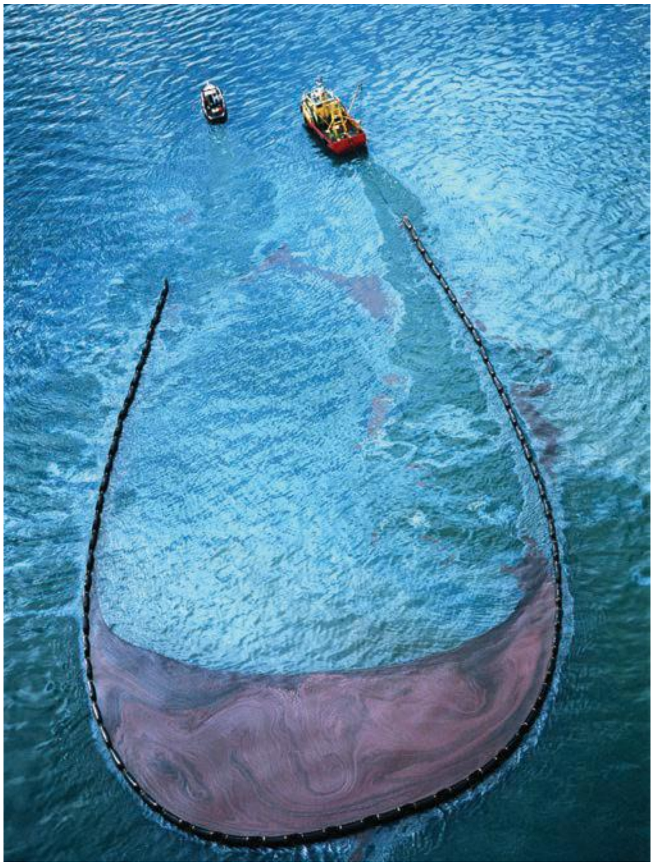


Figure 4.2.14 Cleaning up ocean oil spills can be achieved by several methods. This string of polystyrene floats (called a boom) has trapped oil floating on the ocean's surface.

Prac 3 p. 156

4.2 Practical investigations

1 Comparing filters

Purpose

To compare conical and fluted filter papers.

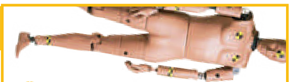
Hypothesis

Which filters better—a conical filter paper or a fluted filter paper? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 1 spatula sand
- 1 spatula copper carbonate ($CuCO_3$)

- 1 spatula
- 2 funnels
- 4 filter papers
- 4 × 100 mL beakers
- 2 stirring rods
- 2 stopwatches or timers
- retort stand, bosshead and clamp or filter stand



SAFETY

Copper carbonate is toxic so do not touch, sniff or taste it.

Procedure

1. Place two funnels in the clamp or filter stand. Place a beaker under each funnel to collect the filtrate.
2. Fold one filter paper into a conical shape and the other into the fluted shape (as shown in Figure 4.2.15). Place each filter in a funnel.
3. Collect one spatula of sand and place it in 40 mL of water in a beaker. Repeat for the other beaker.
4. Now pour the contents of one beaker into the conical filter paper. Start the timer as soon as the first water goes into the conical filter paper.
5. Pour the same amount of water from the other beaker into the fluted paper. Start the second timer as soon as the water goes into the fluted filter.
6. Add more of the sand and water mixture to each filter paper until all of the liquid has been filtered. Stop the timer when the filter stops filtering. Leave any remaining sand in the beaker. Note the time taken for each filter, and how clear the filtrate is.
7. Repeat steps 1–6 with new filter papers, but this time use copper carbonate instead of sand.

Results

1. Record the appearance of the filtrate, for both the sand and the copper carbonate.
2. Record the time it took for all of the liquid to pass through each filter.

Practical review

1. **Compare** the rate at which the two differently folded filter papers filtered each of the mixtures.
2. **Construct** a conclusion for your investigation.
3. **Assess** whether your hypothesis was supported or not.
4. **Propose** a reason why one folding method was better than the other.

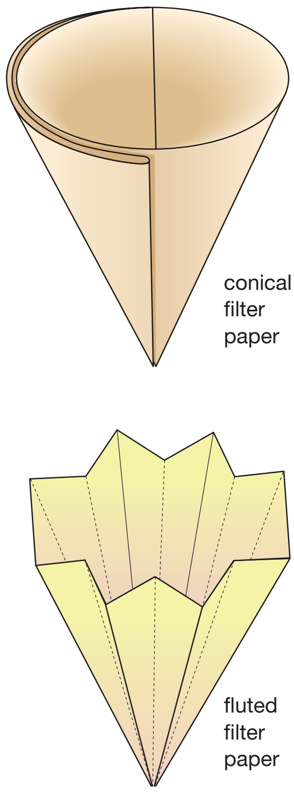


Figure 4.2.15

4.2 Practical investigations

STUDENT DESIGN

2 Separating solids

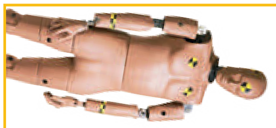
Purpose

To separate a mixture of sand, salt and iron filings.

Materials

- 1 spatula sand
- 1 spatula salt
- 1 spatula iron filings

- 100 mL beaker
- 3 spatulas
- magnet (wrapped in plastic)
- a choice of equipment such as filter paper, funnels, extra beakers



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1. Use different spatulas to measure out one spatula each of sand, iron filings and salt into a beaker. Use one of the spatulas to mix the three solids together well.
2. Design a method to separate these three solids from each other.
3. Write your procedure in your workbook.
4. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

- Salt is soluble in water but sand isn't.
- Make sure that the magnet stays covered in its plastic.

Practical review

Construct a report using the headings listed in Unit 1.4.

GO TO Unit 1.4

STUDENT DESIGN

3 Oil spills

Sorbents are materials that can soak up substances. Sorbents are commonly used to soak up oil that has spilled into the sea, rivers or lakes.

Purpose

To compare three different sorbents that could be used to clean up oil spills.

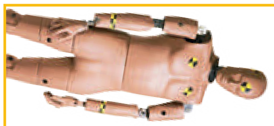
Hypothesis

Which sorbent do you think will soak up more oil—paper towel, cotton balls or a sponge? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 50 mL cooking oil
- detergent (for cleaning up)

- equal masses of cotton balls, paper towel and kitchen sponge
- 3 plastic cups
- 2 wide-mouth jars
- tweezers
- access to timer



SAFETY

A Risk Assessment is required for this investigation.

Procedure

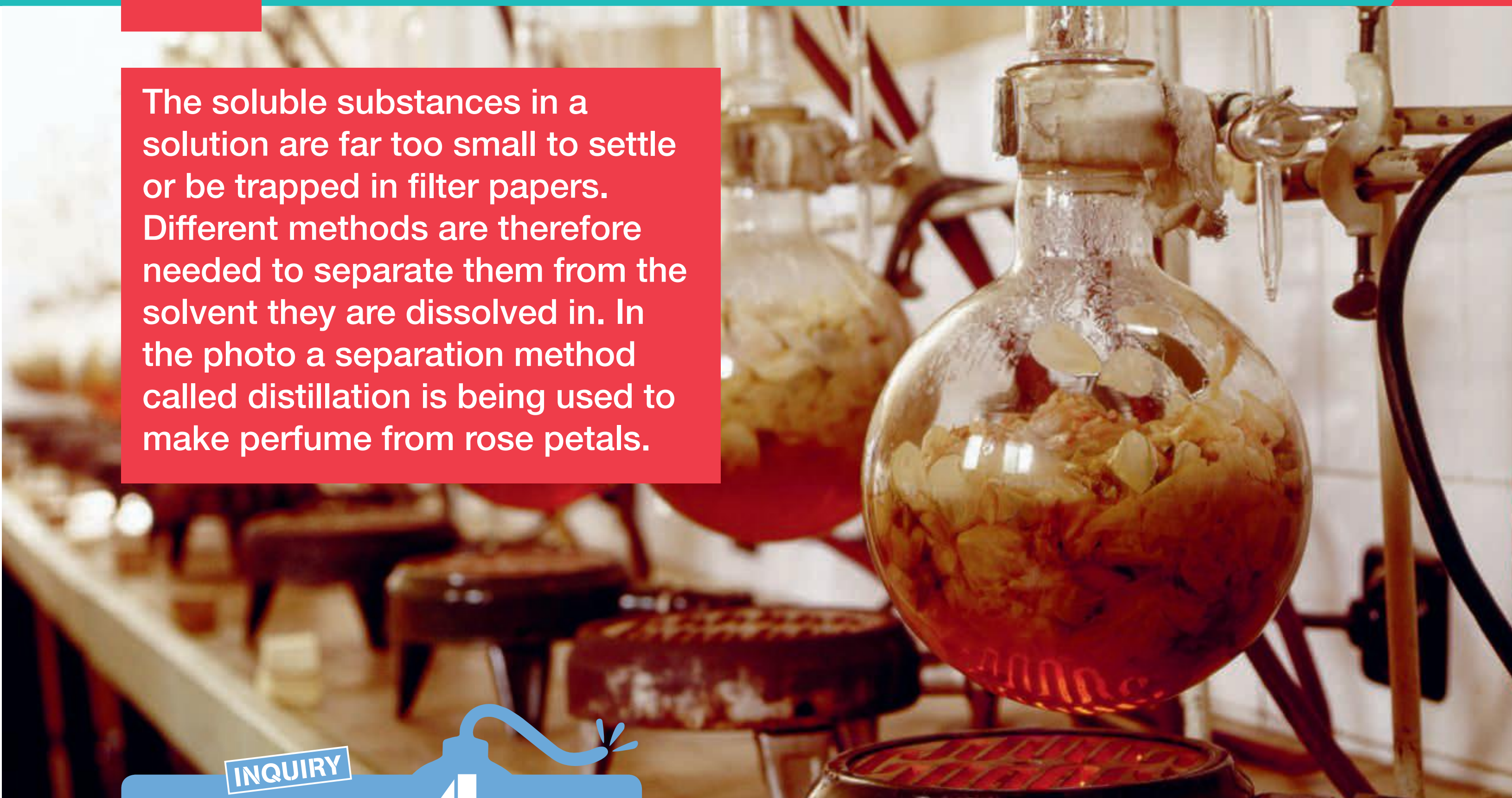
1. Carefully read the list of materials provided.
2. Design a method that will allow you to compare how well cotton balls, paper towel and a kitchen sponge absorb cooking oil that has been mixed with water.
3. Write your procedure in your workbook.
4. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Practical review

1. **Construct** a conclusion for your investigation.
2. **Assess** whether your hypothesis was supported or not.
3. **Construct** a report using the headings listed in Unit 1.4.

GO TO Unit 1.4

4.3 Separating soluble substances



The soluble substances in a solution are far too small to settle or be trapped in filter papers. Different methods are therefore needed to separate them from the solvent they are dissolved in. In the photo a separation method called distillation is being used to make perfume from rose petals.

INQUIRY
science 4 fun

Separating colours

YES

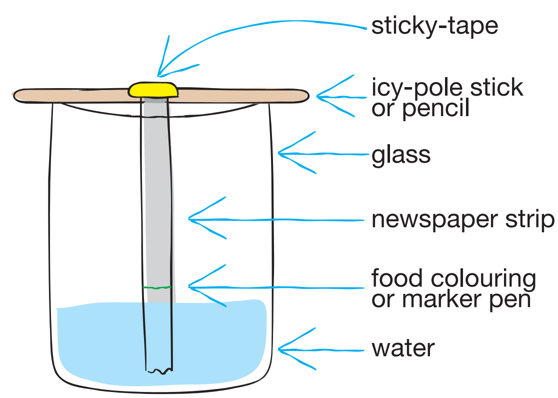
Are inks in marker pens and food colours made of just one pure substance?

Collect this …

- water
- food colouring (green is good)
- marker pen
- sheet of newspaper
- pair of scissors
- 4 narrow drinking glasses
- sticky-tape or Blu Tack
- four pencils (hexagonal cross-section is better than round) or icy-pole sticks

Do this …

1. Cut four blank strips of newspaper. Each strip should be a few centimetres taller than your glass.
2. Across two of the paper strips, make a line with the felt-tip pen 3 cm from the end. Repeat this for the other two strips using food colouring.



3. Set up the paper as shown. It is best to put the water in first. The water level must be below the coloured line on the paper.
4. When the water has almost reached the top of each strip, take the strips out and let them dry.

Record this …

Describe what happened.

Explain why you think this happened.

Chromatography

Chromatography is a process that can separate a mixture by making it move through another substance such as a gel, column of liquid or strip of paper, as shown in Figure 4.3.1. Here, water is the solvent. It dissolves the dyes from ink or food dyes and carries the colours with it as it moves up the paper.

Chromatography works because different chemicals in mixtures are attracted to the paper by different amounts. Substances that are strongly attracted to the paper are harder for the solvent to move along. These substances do not move very far. Weakly attracted substances move the furthest.

Chromatography is very important in industry. It is used to find out what is in oil and gas, and to identify pollutants.

Chromatography is also used by pharmaceutical manufacturers to analyse plants and animals for possible useful medical drugs and to test the quality of their products. Environmental scientists use chromatography to identify chemical pollutants.

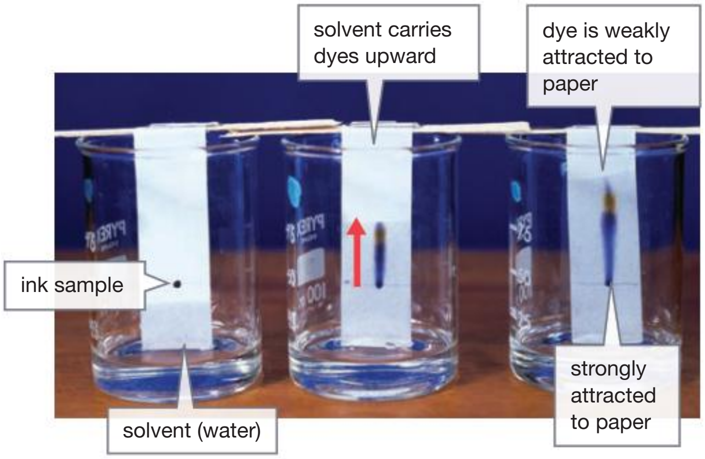


Figure 4.3.1 Paper chromatography separates mixtures such as inks and dyes.

Lawbreakers beware!

SciFile

Chromatography can help catch drug cheats in sports by identifying banned drugs in urine.
If you write a letter with a particular pen, then chromatography can be used to identify the ink you used and match it to your pen.

INQUIRY science 4 fun

Candy crystals

Can you grow big candy crystals?

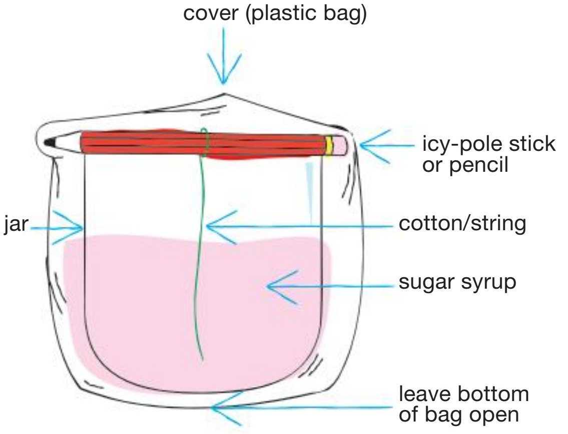
YES

Collect this …

- sugar (sucrose)
- water
- food colouring (optional)
- flavouring (optional)
- clean glass jar
- clean cotton or string
- pencil or icy-pole stick
- metal saucepan
- stove

Do this …

1. Pour 3 cups of sugar and 1 cup of water into the saucepan.
2. Heat, stirring constantly, until all the sugar has dissolved. Try not to boil the solution. A few drops of food colouring and ½ teaspoon of flavouring can be added, but this may slow your crystal formation.
3. Cool the sugar syrup in the refrigerator until it is at about room temperature.
4. Soak the string in the syrup and then hang it to dry in the air.
5. Set up your equipment as shown in the diagram.



6. You can eat the candy after the week. Do not eat the string.

Record this …

Describe what happened.
Explain why you think this happened.

Evaporation

Evaporation is the change of state that occurs when heat causes a liquid to change into a gas. It is a natural process that dries up pools of water on the road and clothes on a line. Water boils at 100°C but it does not need to be 100°C for water to evaporate. Water evaporates at all temperatures above 0°C, meaning that wet clothes will dry at any temperature above 0°C. However, evaporation speeds up at higher temperatures. This explains why clothes dry more quickly on a hot day than a cold one.

If the water has any solute dissolved in it, then evaporation will leave that solute behind. For example, sea water is an aqueous solution of salt dissolved in water. After swimming in the sea, the water on your skin evaporates, leaving a thin layer of salt behind.

Evaporation is commonly used in the laboratory to separate a solvent from its solute. The solution can be left in the air to evaporate using the heat of the room, but a Bunsen burner or hotplate speeds the process up. Figure 4.3.2 shows how this can be done. The solute is left behind in the evaporating dish, while the solvent (usually water) is lost to the air. This means that you can only collect the solute.

Figure 4.3.2 You can collect the solute from a solution by using an evaporating dish and evaporating off the solvent.

Prac 1 p163

Crystallisation

The solute left behind by evaporation often forms crystals. You can see some different crystals in Figure 4.3.3. Crystals have distinctive shapes because the solute particles lock into one another like pieces of a jigsaw. As the solvent evaporates, the solution becomes more and more concentrated. (Cooks commonly use evaporation to concentrate the flavours of their sauces.) Eventually the solution becomes so concentrated that it is saturated. The solute particles start to lock in with one another, and the crystals grow as more of the solvent evaporates. This process is called **crystallisation**.

Smaller crystals form when the solvent evaporates quickly. In contrast, larger crystals form when the solvent evaporates slowly.

Figure 4.3.3 Crystals come in a variety of different shapes. They form because the solvent evaporated, leaving solute crystals behind.

Evaporation and crystallisation are used in industry to remove soluble substances from solutions and to purify substances. For example, salt producers make salt by using the heat from the Sun to evaporate water from pools of salt water. This leaves crystals of salt behind to be collected (Figure 4.3.4).

Figure 4.3.4 Salt crystals recovered from sea water have been scraped into piles.

Crystallisation is also used in industry to purify substances such as pharmaceuticals (medical drugs). A solution may have unwanted substances dissolved in it as well as substances that are wanted. The unwanted substances are called **impurities**.

The particles of impurities generally do not have the same shape as the solute particles. So if you crystallise the solute, the impurities generally will not have the right shape to lock into the growing crystals (Figure 4.3.5). Instead, the impurities stay in solution and the crystals formed stay pure.

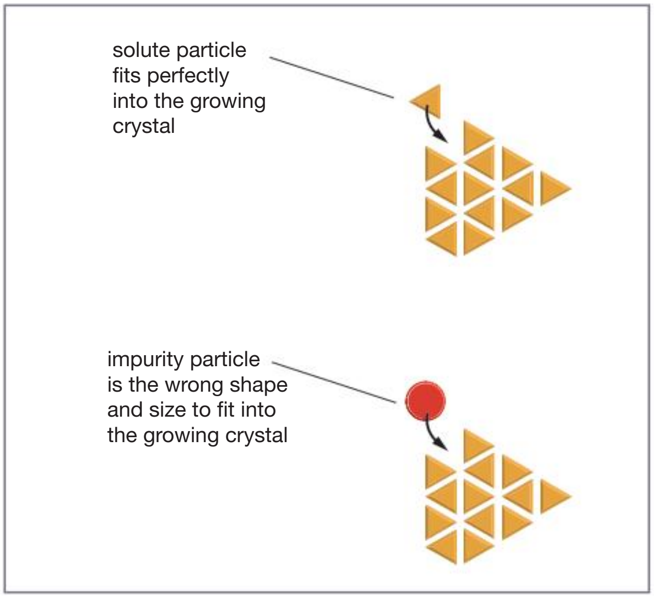


Figure 4.3.5 Impurities have the wrong shape to lock into crystals. Crystallisation is often used to purify substances such as medical drugs.

Distillation

Evaporation is the process in which a liquid turns into a gas. Condensation is the opposite: a gas cools to form a liquid. **Distillation** uses both evaporation and condensation to separate substances.

Evaporation loses the liquid solvent to the atmosphere, but sometimes you need to keep the liquid as well. In distillation, the gas is condensed back into a liquid so that it can be collected. If the solvent is water, distillation first evaporates off the water. It then cools the water vapour so that it condenses back into liquid water. The apparatus that converts the gas back to the liquid is called the condenser. Figure 4.3.6 shows a special apparatus called a Liebig condenser that is often used in the laboratory.

Smelling nice — SciFile

The oldest written records of perfume being made by steam distillation date to around 1000 CE. The Persian scientist Avicenna is said to have invented the process to make rose water. There is now a perfume named Avicenna in his honour.

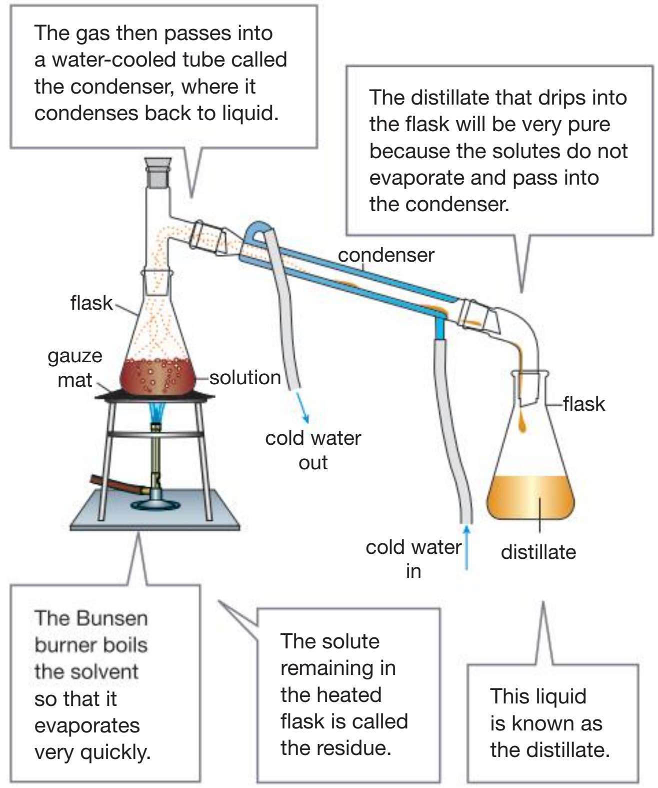


Figure 4.3.6 Distillation is often carried out in the laboratory using a Liebig condenser.

Distillation is able to separate several liquids from each other if they have different boiling points. For example, alcohol has a boiling point of 78°C while water boils at 100°C. These two liquids can therefore be separated by distillation. All of the alcohol will evaporate from the mixture first (at 78°C), leaving the water behind. The water will then evaporate off at 100°C, leaving behind whatever solute was dissolved in it.

As well as separating solutions in laboratories, distillation is used in:

- producing alcoholic drinks such as vodka and bourbon
- separating crude oil into petrol, diesel, lubricating oils and other components
- removing impurities from drinking water
- separating oxygen, nitrogen and argon from air for industrial use
- perfume manufacture.

Prac 2 p.164 | 4.5 | 4.6

4.3 Unit review

Remembering

1 **Recall** methods of separating mixtures by matching each method with its correct description. Choose from A, B or C.
  a chromatography
  b evaporation
  c distillation
  A A process using evaporation and condensation to separate and recover both solute and solvent
  B A process that can separate a mixture by making it move through another substance like a paper strip
  C A process in which heat changes a liquid into a gas, allowing recovery of the solute but not the solvent

2 From the examples in this unit, **name** the separation process used to:
  a separate different coloured substances from food colouring or ink
  b collect salt crystals from seawater
  c make alcoholic drinks like gin and whisky.

Understanding

3 **Explain** the process by which chromatography can separate substances.

4 **Explain** the process by which distillation can separate a solute and a solvent and allow you to recover both substances.

5 You are making copper sulfate crystals in the laboratory by evaporating water from a solution of copper sulfate. **Describe** how you could:
  a make the crystals rapidly
  b form larger crystals by evaporating the water slowly.

6 **Draw** a diagram that shows how crystallisation stops impurities from becoming part of a growing crystal.

Applying

7 **Identify** a separation method that could be used for each of the following purposes:
  a To purify water from a washing machine enough to drink it
  b To recover the sugar from a bag that you accidentally dropped into a saucepan of water while you were cooking.

8 **Identify** the process used in the science4fun on page 157 to separate the colours in marker pen inks or food colouring.

Analysing

9 If you are lost in the bush and have no drinking water, you can make a 'bush still' to try to collect some.
  a **Compare** the 'bush still' shown in Figure 4.3.7 with distillation apparatus.
  b **Explain** how it can be considered an example of distillation.

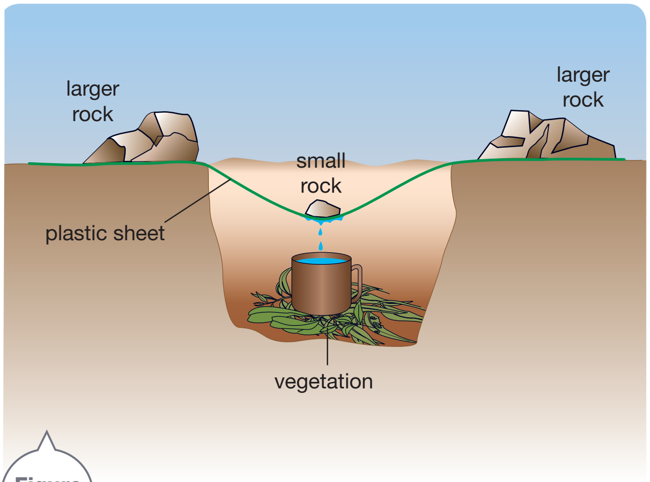


Figure 4.3.7

10 **Compare** evaporation of water and boiling of water.

11 Two identical solutions are allowed to evaporate. One evaporates slowly. The other evaporates quickly. **Compare** the size of crystals formed from each solution.

Evaluating CCT

12 A whisky maker wants to reduce the amount of water in a mixture to give a higher concentration of alcohol. **Justify** the choice of distillation rather than evaporation as a separation method. Note that alcohol boils at 78°C and water boils at 100°C.

13 When you dry your bathers after swimming in the sea, they are crisp with salt. However, if you rinse them in fresh water first, they dry clean and salt-free. **Propose** why the two methods of drying produce such different results.

14 Candy crystals are formed in the science4fun on page 158.
   a **Identify** the process that allows these crystals to form.
   b **Propose** a way of making even larger candy crystals.

15 a **Outline** why impurities tend not to join with crystals formed through evaporation.
   b Pure crystals are often left behind once all the solvent has evaporated. Impurities are left behind too. **Propose** a way of separating these impurities from the pure crystals.

Creating CCT

16 **Construct** a card game of nine cards in which each card describes a different method of separation.
- Use no more than five lines.
- Do not use diagrams.
- Do not use the name of the method of separation or similar words.
- Write the separation method on the back so that someone else can check what it was later.

Inquiring

1 Research how:
- salt is collected from commercial salt pans
- liquid nitrogen or liquid oxygen is made
- crude oil is cracked using fractional distillation.

Present your findings as a flow diagram outlining the major steps involved in the process.

2 There is a cave in Chihuahua, Mexico, known as the Cave of Crystals. It contains crystals 11 metres long (the largest crystals ever found). Research the cave and its crystals to find:
- the substance that makes up the crystals
- the shape of the crystals
- the special conditions that allowed such huge crystals to form.

Present your findings as a digital presentation (for example, PowerPoint). ICT

3 Some people wear odour-eating innersoles in their shoes to stop them getting too smelly. These innersoles use a process called adsorption to remove soluble substances that cause smell from the sweat that builds up in shoes. Research adsorption to find:
- how adsorption works
- what activated carbon is (Figure 4.3.8)
- how charcoal tablets are used to control ‘traveller’s diarrhoea’
- other examples of how adsorption is used to separate substances.

Present your research in digital form with photographs and diagrams. ICT

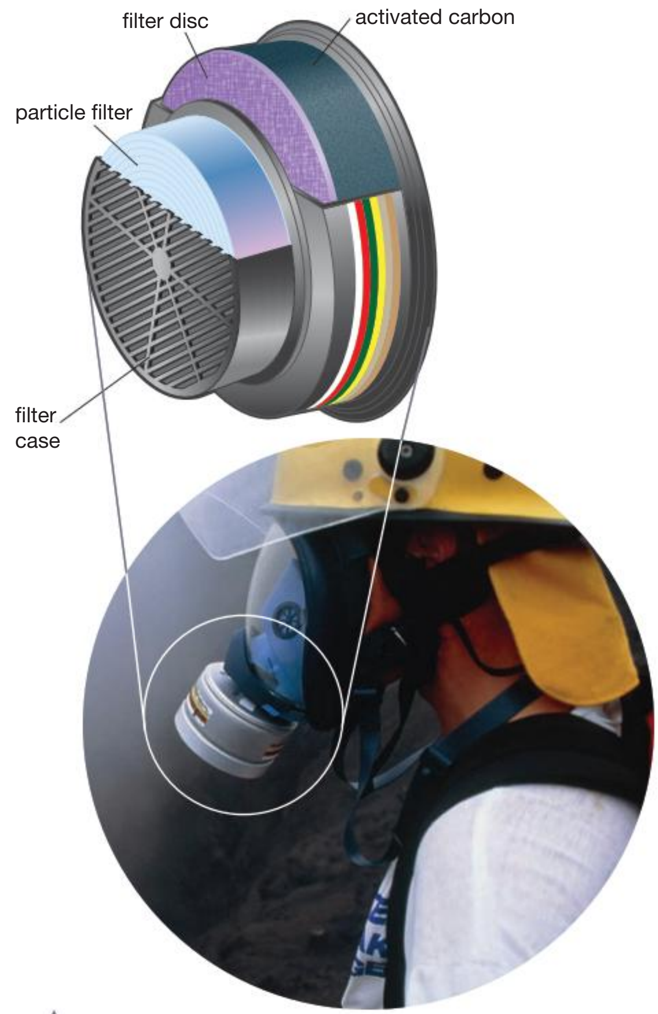


Figure 4.3.8 This face mask has a carbon filter for adsorbing poisonous gases.

4.3 Practical investigations

1 Fast and slow evaporation

Purpose

To grow copper sulfate crystals and compare their sizes when formed by fast and by slow evaporation.

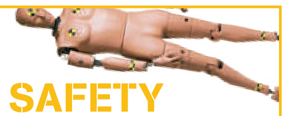
Hypothesis

Which do you think will produce larger crystals—slow cooling or fast cooling? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- 50 mL copper sulfate solution ($CuSO_4$)

- 2 evaporating basins
- 100 mL beaker
- Bunsen burner, bench mat, tripod and gauze mat



SAFETY

Copper sulfate is toxic so do not touch, sniff or taste it.

Tie long hair back. Turn the Bunsen burner flame to yellow when it is not being used. Allow equipment to cool before packing it away.

Procedure

Slow evaporation

1 Pour some copper sulfate into one of the evaporating basins until it is about one-quarter full. Set it aside somewhere in the room where it will not be disturbed. Observe what happens over the next day or so.

Fast evaporation

2 Collect about 50 mL of copper sulfate solution in your beaker, and set up the equipment as shown in Figure 4.3.9. Do not turn on the Bunsen burner yet.

3 Pour copper sulfate solution into your evaporating basin until it is about half full.

4 Heat the solution with a hot flame with the Bunsen burner airhole about half open, watching carefully that material does not 'spit' out of the basin. If it does spit, close the collar on the Bunsen burner a little, or use the gas hose to move the Bunsen burner carefully in and out of the tripod.

5 When only a small pool of the liquid is left, turn the Bunsen burner off. The rest of the liquid will evaporate with the heat left in the basin.

6 Allow the basin to cool for several minutes.

Practical review

1 **Describe** the crystals formed by fast and slow evaporation.

2 a **Construct** a conclusion for your investigation.

b **Assess** whether or not your hypothesis was supported.

3 Figure 4.3.9 shows the equipment used in this prac in three dimensions (3D). **Construct** a scientific diagram that shows it in two dimensions (2D).

GO TO Unit 1.3

4 **Use** the results from this prac to **explain** the formation of salt crystals around the edges of salt lakes.

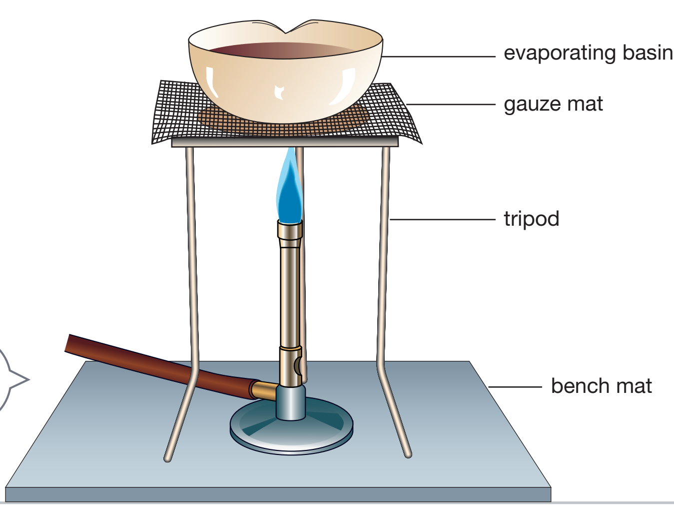


Figure 4.3.9

4.3 Practical investigations

STUDENT DESIGN

2 Chromatography investigations

Purpose

To use chromatography to separate food dyes.

Hypothesis

What colours do you think make up the coloured shells of Smarties or M&Ms? Before you go any further in this investigation, pick a colour you will test and write a hypothesis in your workbook.

Materials

- selection of different coloured Smarties or M&Ms

- filter paper
- eyedropper
- other equipment as selected by students (such as 250 mL beakers)

SAFETY

A Risk Assessment is required for this investigation. Do not eat or taste the Smarties or M&Ms.

Procedure

1 Design an experiment that will use chromatography to separate the colours that make up the candy shell of a Smartie or an M&M. Figure 4.3.10 might give you some ideas.

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

In your experiment:

- use water as a solvent
- raise the filter paper on something (such as a beaker).

Results

Record what you saw.

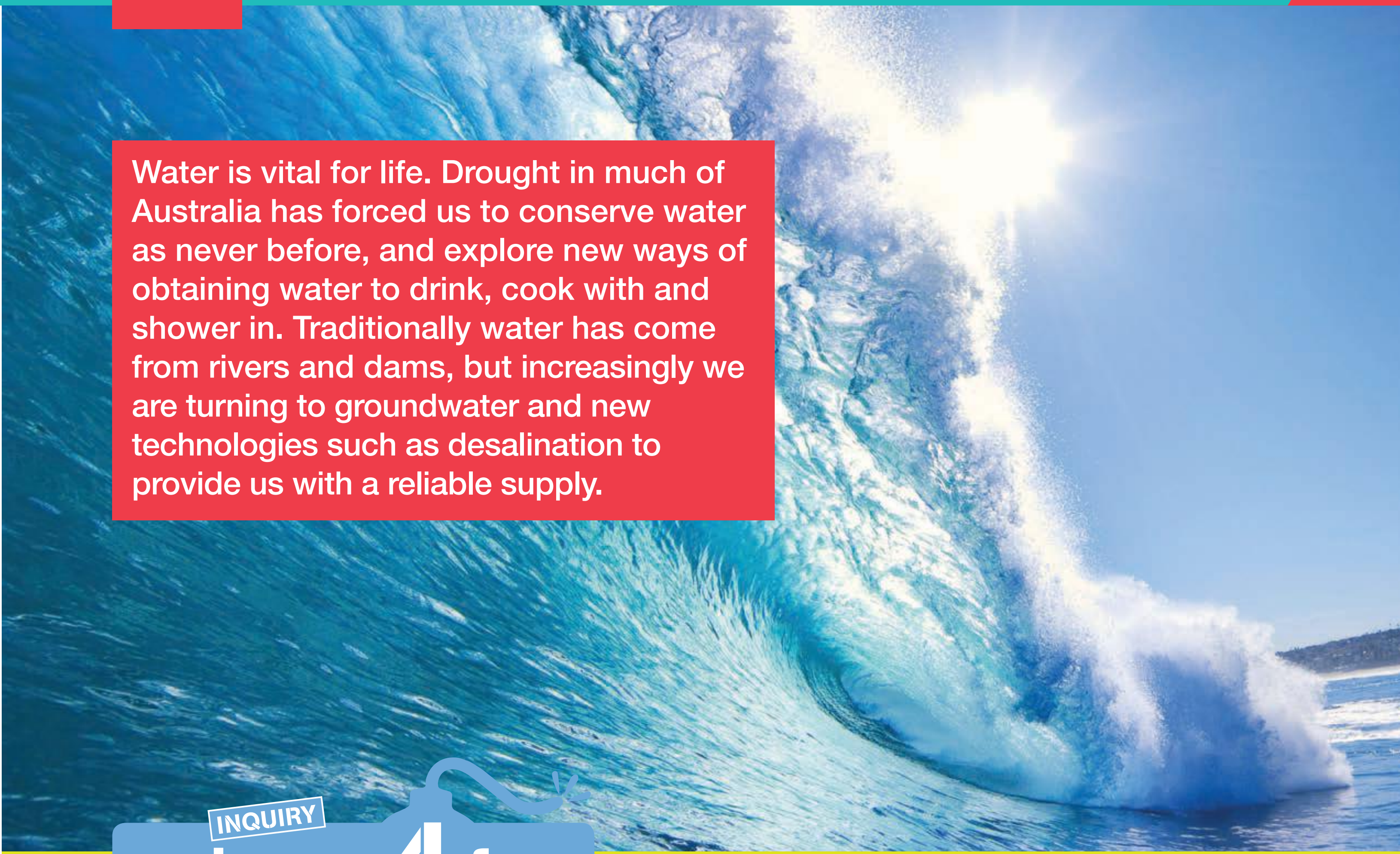
Practical review

1 **Construct** a conclusion for your investigation.

2 **Assess** whether your hypothesis was supported or not.

Figure 4.3.10 A forensic scientist inspects the pigments used in different black industrial dyes. A drop of dye was placed in the centre of a piece of filter paper and chromatography separated its colours to form rings.

4.4 Water as a solvent



Water is vital for life. Drought in much of Australia has forced us to conserve water as never before, and explore new ways of obtaining water to drink, cook with and shower in. Traditionally water has come from rivers and dams, but increasingly we are turning to groundwater and new technologies such as desalination to provide us with a reliable supply.

INQUIRY science 4 fun

Cleaning water

Can dirt clean water?

YES

Collect this …

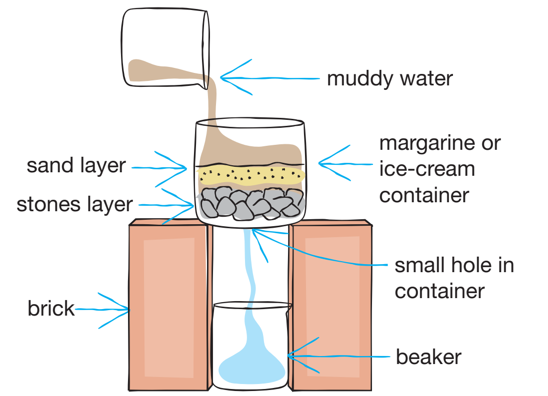
- some fairly clean sand
- some small stones like blue metal or road gravel
- bucket of muddy water
- ice-cream or margarine container
- some bricks or rocks for a stand
- 3 beakers to catch liquid

Do this …

1 Set up your equipment as shown.

2 Pour some muddy water in and let it pass through into the container at the bottom. Put this sample aside.

3 Repeat step 2, but instead of setting the sample aside, pour it through the sand and stones again.



4 Continue pouring the collected sample through the sand and stones until the sample you collect at the bottom has little suspended mud in it.

5 Compare this final sample with the original sample you set aside.

Record this …

Describe what happened.

Explain why you think this happened.

Is water pure or a mixture?

The term *water* means different things to different people. To scientists, water is a pure chemical with the chemical formula H_2O. However, to the rest of the community, water is what comes out of a tap and is found in rivers, lakes, swimming pools, rain and the sea.

In these cases, 'water' is not pure but is an aqueous solution with H_2O water as its solvent, or a suspension with H_2O water as its dispersion medium. Sometimes it's both. For example, seawater is H_2O but it also has dissolved salt (forming an aqueous salt solution), sand floating around in it (forming a suspension), and organisms ranging from microscopic bacteria to seaweed and fish in it. Seawater also has dissolved oxygen in it, which is used by all the organisms that live there, and dissolved carbon dioxide, which is used by seaweed.

Water in rivers and lakes has dissolved oxygen, as well as fish, yabbies and bacteria and possibly particles of dirt (forming a muddy suspension). Swimming pools contain dissolved chlorine or other treatment chemicals.

Tap water is a mixture of many substances. Some of these enter the water naturally through contact with soil and rock. Others are added deliberately by water authorities to protect public health. So what is in your water depends on the source of the water, and how it was treated. Water filters like the one shown in Figure 4.4.1 can be used to remove impurities in areas where this is a problem.

Figure 4.4.1 Some people use filters to clean their water of impurities.

SciFile

Water world

Of the world's water, 98% is salt water in the oceans. Of the world's fresh water, 77% is ice.

Water and life

Water is the most important substance needed for life. It is essential, for without it all living things die. This is because living things are made of microscopic building blocks called cells. Cells contain chemicals dissolved in water. These chemicals carry out the reactions needed for life. To do this, the chemicals need to be able to move quickly around the cell. This can only happen if they are dissolved in water. If the cells lose all their water then the chemicals stop moving around and the cells die. The whole organism then dies.

SciFile

Too much water

It is possible to drink too much water. A man in the UK died after drinking about 7 litres of water in a short period. Excessive amounts of water like this can cause a condition where sodium is flushed out of the body and brain cells are damaged.

Water in daily life

Water is the solvent that dissolves the detergent and soap that helps you to wash yourself, shampoo your hair and to wash clothes, dishes and cars. It is the solvent that dissolves the sugars, flavourings and colourings in soft drinks and fruit juices. Water is used in cooking and food preparation and keeps the plants in the garden alive.

Water in industry

Water allows dissolved chemicals to move around and so it allows chemical reactions to take place. For this reason, water is used as a solvent in many industries that make substances such as foods, medicines, fertilisers, paints, pesticides, adhesives and paper (Figure 4.4.2). The final product from these industries may even be an aqueous solution such as a cleaning fluid or dye.

Water is also used as a solvent in mining. For example, leach mining uses a series of wells to inject water or an aqueous acid solution into rocks below ground. The mineral being mined is dissolved and is then pumped up to the surface. Some copper minerals and types of salt are mined this way. Leach mining is shown in Figure 4.4.3.

The processing of many metals also requires water. For example, copper is extracted by passing an electric current through an aqueous solution that contains dissolved copper.

Figure 4.4.2 Water is used as a solvent in industry to make many products such as medicines, dyes, drinks and fertilisers.

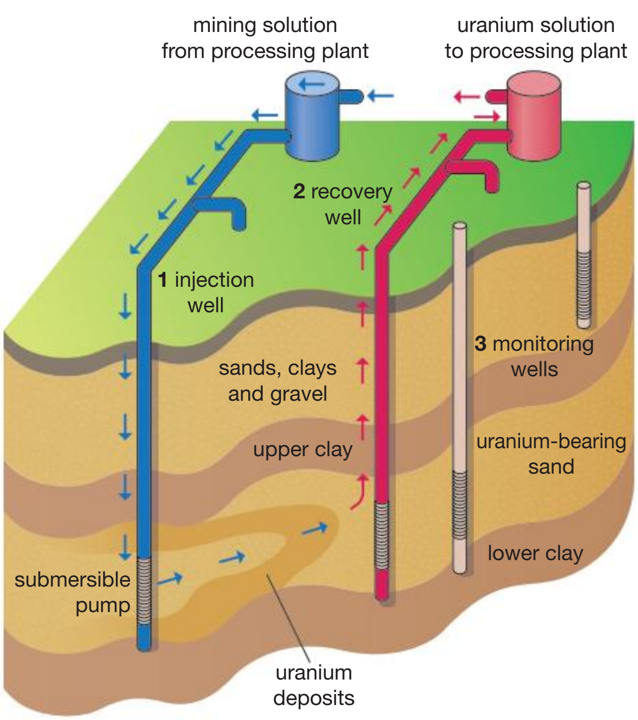


Figure 4.4.3 Leach mining uses water to dissolve underground minerals. The dissolved mineral is pumped back to the surface.

Water in the environment

Minerals containing calcium, iron, phosphate, potassium and zinc are essential for life.

These minerals enter water when rocks break down. Plants absorb water and so they absorb these minerals too. The minerals pass into animals whenever they eat plants or when they drink water from a stream, river or lake.

Water also dissolves minerals containing copper and lead in the rocks. These minerals are toxic (poisonous) when they are at high levels. High levels of salt (sodium chloride) are also toxic to many organisms and are a threat to farmers' crops. You can see this in Figure 4.4.4.

Figure 4.4.4 In much of Australia, salt is a threat to crops and native animals and plants. Salt has made much of this farm unproductive.

High levels of phosphates and nitrates found in farm run-off and wastewater from homes and industry may enter waterways, threatening the environment. High levels of these chemicals cause algae to grow. This growth is known as an algal bloom (Figure 4.4.5). It removes much of the oxygen from the water, killing animals such as fish.

GO TO Unit 3.3 GO TO Unit 3.4

Figure 4.4.5 An algal bloom is caused by high levels of phosphates and nitrates entering water from fertilisers and poor wastewater treatment.

Water sources

In Australia, some homes, farms and factories collect their own rainwater in tanks. The water for everyone else comes from a number of sources:

- Rivers—Rivers are the way rainfall gets to the sea. Sometimes this water is pumped out directly to provide water to a town or to irrigate a farm. Much of Adelaide's drinking water is pumped from the Murray River (Figure 4.4.6).

Figure 4.4.6 The Murray–Darling is Australia's largest river system, with a combined length of about 3700 km. Most of its water is used for irrigation. Adelaide uses some of the remainder for drinking water.

- Dams and lakes—Rivers flow into natural lakes or artificial reservoirs (formed by building a dam across a river). The water is stored for later use by nearby towns and cities. For example, Sydney gets most of its water from Warragamba Dam while Albury gets it from Lake Hume.
- Groundwater—This is rainwater that has seeped into the soil and rocks to build up in special layers of rock called aquifers. The top layer of water in the soil is called the water table. Groundwater is reached by drilling a bore. The water then rises naturally or is pumped to the surface. Figure 4.4.7 shows how this is done. Sometimes a windmill is used to power the pump.

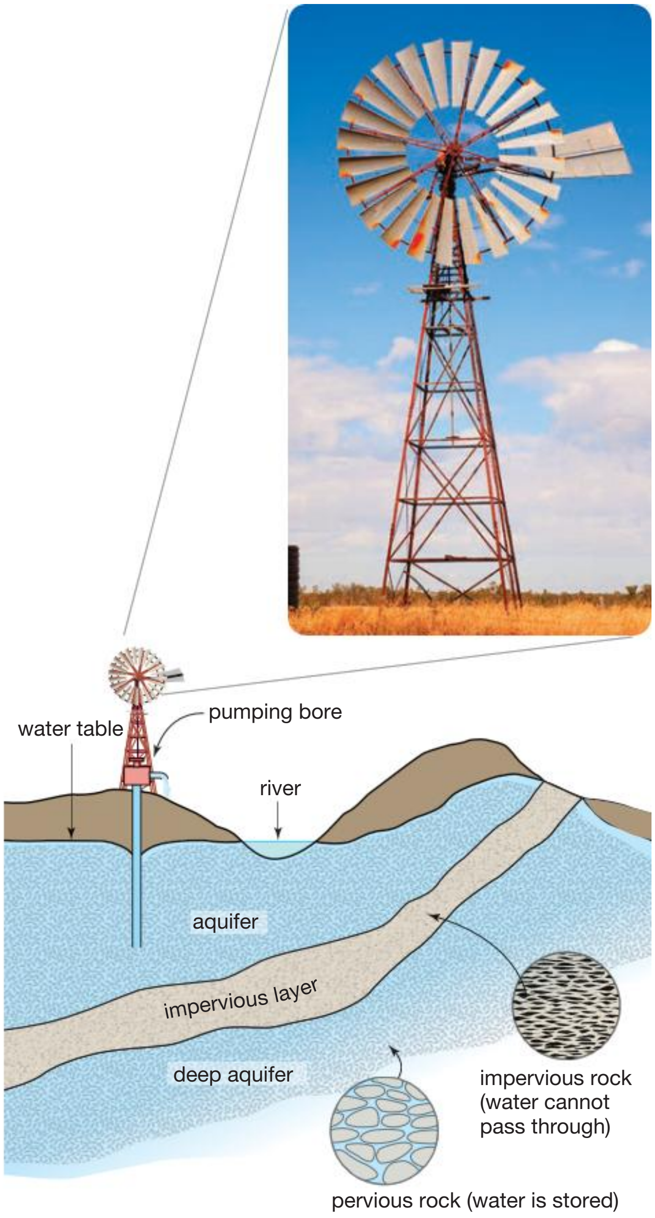


Figure 4.4.7 Aquifers have rock layers containing water. Windmills are often used to pump groundwater to the surface.

Whatever its source, the water obtained is never pure. It also contains other substances. Most of these substances come from the rocks and soil that the water passes over.

These unwanted substances can cause health and other problems if not removed before the water is used. For example, rubbish washed from gutters into rivers, dams and lakes encourages microscopic disease-causing bacteria to grow in the water. Likewise, pollutants might be toxic. The high salt content of groundwater rusts away hot water systems and washing machines, often causing them to burst. Clay and other sediments can also block pipes and clog motors.

Water treatment

Water fit to drink is called **potable water**, while water unfit to drink is known as non-potable. Water from dams and groundwater goes to a treatment plant before it is supplied as potable water to homes and businesses.

There are five stages of water treatment:

- Flocculation—The fine solid particles like clay are separated out of the water. Chemicals called flocculants are added to make the tiny clay particles clump together. These clumps either float and are skimmed off, or sink to the bottom so the water can be drained off.
- Filtration—The water is pumped through filters to remove any remaining particles.
- Sterilisation—Chlorine is added to kill micro-organisms like bacteria.
- Balancing pH—The pH level (the measure of acidity) is adjusted so the water is not acid or alkaline.
- Fluoridation—Fluoride is added to reduce the chance of tooth decay.

Prac 1
p. 175

Desalination

Dams, lakes and groundwater may not be able to supply all of Australia's needs in the future. This is because the water in them comes from rainfall, and rainfall is declining in many parts of the country. Another source of drinking water is salt water, such as seawater or water from salt lakes or salty rivers. Before we can drink this, the salt must be removed. Desalination is the process of removing salts such as sodium chloride from the water.

Desalination can be achieved by distillation, but this process is expensive and so is rarely used on a large scale. A newer method is reverse osmosis, a process using filtration. Salt water is placed under high pressure, which forces it through a very fine filter or membrane. The membrane has microscopically small holes that only the water particles pass through. The salt is left behind. In this way the salt is separated from the water. Sydney's new desalination plant at Kurnell (Figure 4.4.8) processes its salt water this way.

Sewage

Sewage is wastewater from places like kitchens, bathrooms, toilets and laundries.

In Australia, two methods are used to remove and process sewage:

- The **sewerage system**—This is a system of underground pipes that carry the sewage away to a waste treatment plant, which makes the water safe enough to pump into the ocean or to be used to irrigate crops and vegetable gardens. A typical sewage treatment plant is shown in Figure 4.4.9 on page 170.
- Septic tanks—These tanks process the sewage from houses and businesses located beyond the sewerage system. They are made up of a series of tanks, usually buried somewhere close to the building. Processed water soaks through the bottom of the final tanks to join groundwater in the aquifers. You can see how a typical septic tank works in Figure 4.4.10 on page 170.

Prac 2
p. 175

Figure 4.4.8 Sydney's desalination plant will eventually provide the city with 15% of its water.

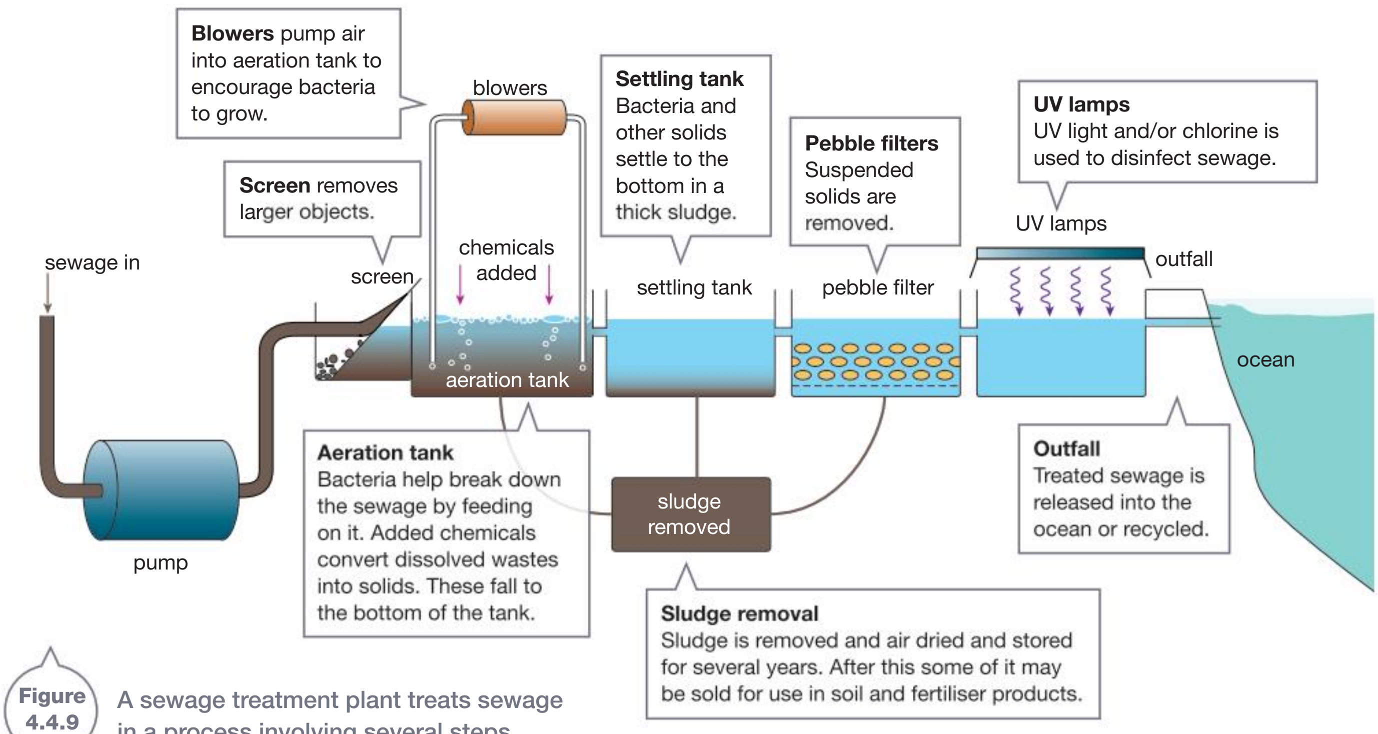


Figure 4.4.9 A sewage treatment plant treats sewage in a process involving several steps.

SciFile

The world's smelliest job?

Septic tanks have to be emptied out from time to time when the solids build up too much. Trucks with long hoses and pumps are used. The hose is pushed into an inspection hole at the top of the tank. However, occasionally the worker has to take the lid off the tank to clear blockages. You need a strong stomach and an ability to cope with bad smells in that job.

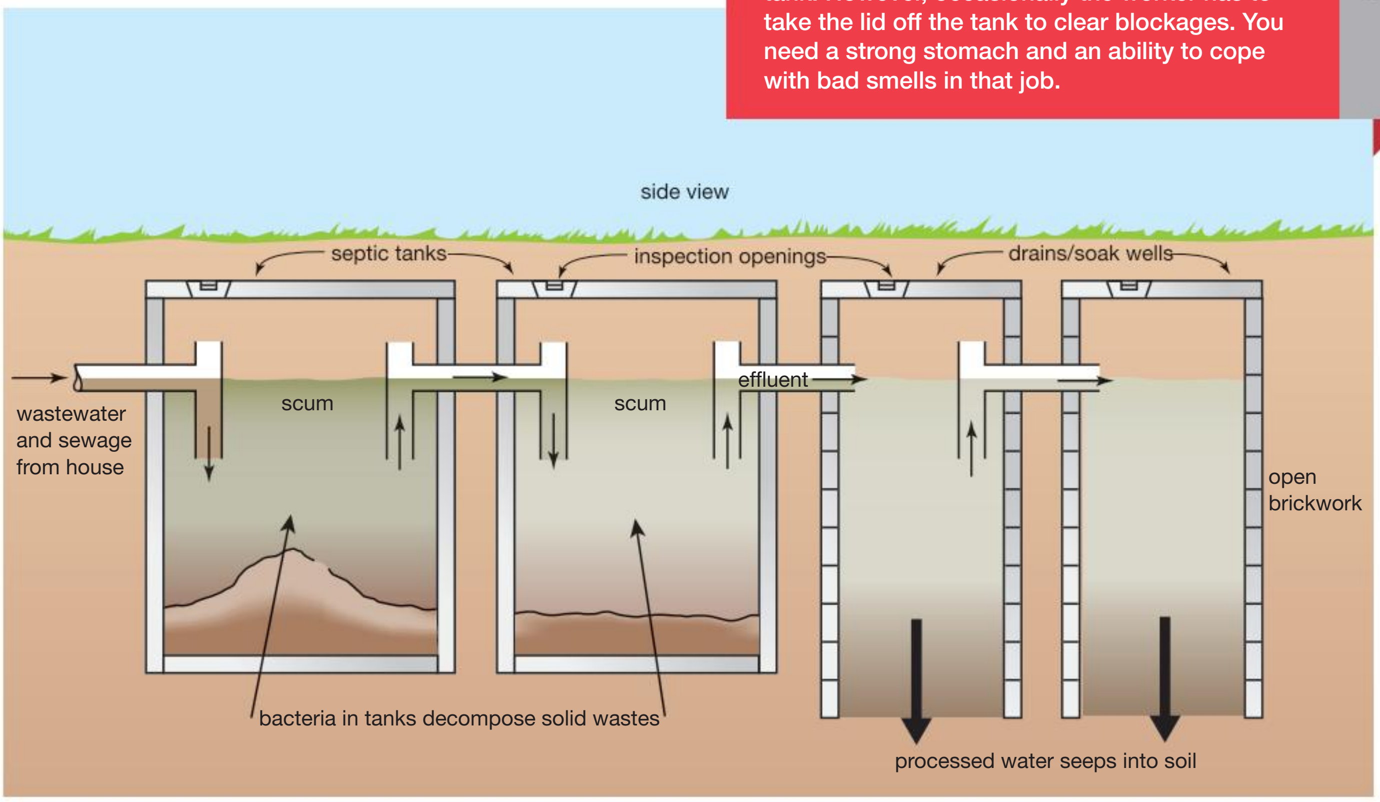


Figure 4.4.10 Septic tanks consist of tanks and soak wells. Processed sewage then seeps into the ground.

LEARNING ACROSS THE CURRICULUM

SUSTAINABILITY

DRINKING RECYCLED SEWAGE

At present in Australia, recycled sewage water is only used for irrigation of crops and public parks. However, the Australian Government has stated that it is almost certain that we will soon use recycled sewage for drinking water.

WHY IS IT BEING CONSIDERED?

Australia is the driest inhabited continent (Figure 4.4.11). With regular droughts and an increasing population we simply do not have enough water available to meet the demand. This is why water authorities are trying to find alternative water supplies and looking for ways to reduce water usage. At present water usage is increasing rather than decreasing.

Figure 4.4.11 Parts of Australia are very dry. Recycling sewage is a possible solution to our shortage of water.

SHOULD WE USE IT?

The proposals have caused a lot of debate. For example, Toowoomba residents in south-east Queensland rejected the proposal to recycle their wastewater. One reason against using it is the 'yuk factor'. This means people don't like the thought of drinking recycled water. However, tests have shown that people cannot taste the difference between tap water, bottled water and recycled water.

Water authorities in Australia believe that there is no scientific or health reason against recycling wastewater for drinking. This is based on the conclusions of much scientific research. Recycled wastewater is successfully used to top up drinking water supplies in the United States, Singapore and Namibia.

HOW WOULD IT BE DONE?

Some methods of recycling wastewater are shown in Figure 4.4.12. The main proposal at present is that Australia should adopt indirect potable (drinkable water) re-use. This means first sending wastewater to a water treatment plant. There it is highly treated to make it safe. The highly treated water is then pumped back into an existing drinking water source such as a reservoir, river or aquifer. The reservoir or aquifer helps treat the water by natural processes going on there, such as filtration by soil particles and decomposition by bacteria. Then, when the water is needed, it is pumped out of the reservoir to another water treatment plant just as at present.

Reverse osmosis is one of the processes that can be used for recycling sewage. In Toowoomba, for example, the wastewater would have been treated using filtration, reverse osmosis, ultraviolet disinfection and oxidation processes to destroy micro-organisms. Reverse osmosis is already used around the world to provide water for industry, as well as drinking water on ships.

4.7

REVIEW

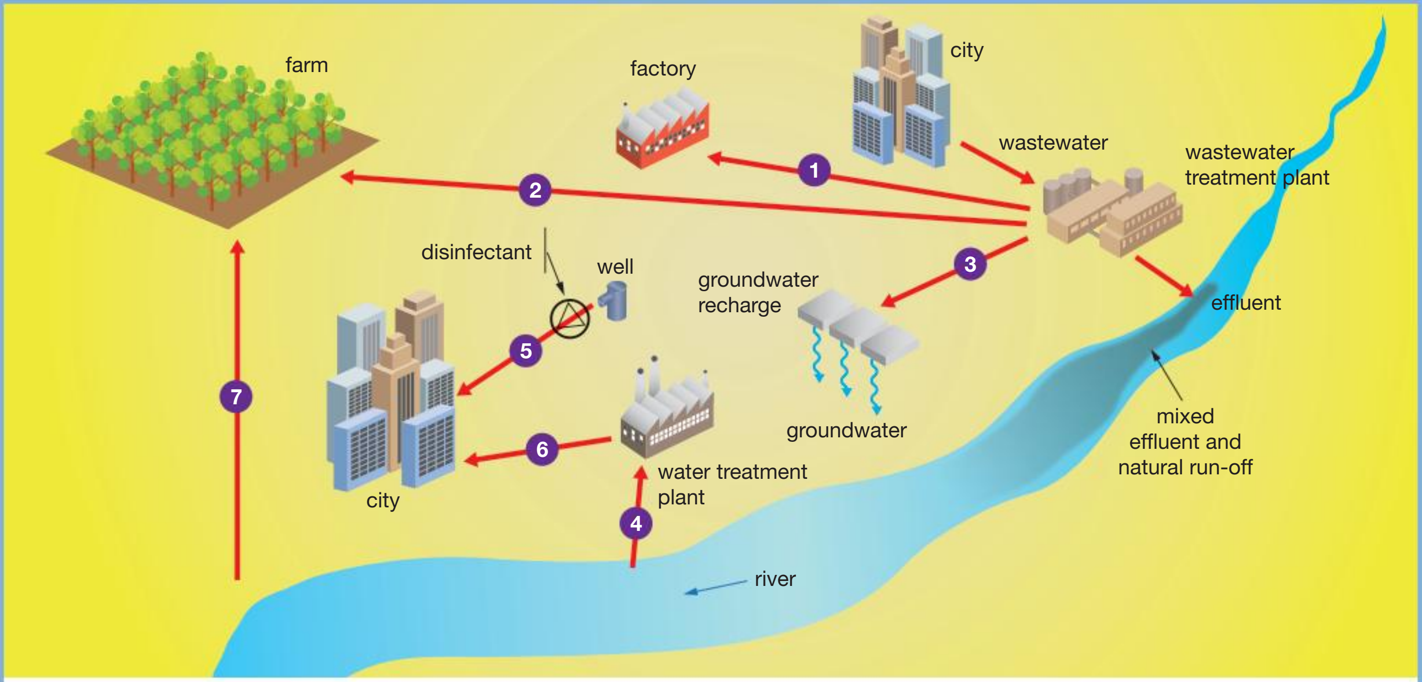
1 **Define** the term *potable*. L

2 **Explain** why some authorities are looking at sewage as a potential source of drinking water.

3 **Name** the process used to recycle sewage.

4 **List** the advantages and disadvantages of using recycled sewage as a major water supply.

5 **Assess** whether NSW should plan to use recycled sewage in the future.



1 Direct industrial re-use
2 Direct agricultural re-use
3 Groundwater recharge
4 Indirect potable re-use from river
5 Indirect potable re-use from well
6 Potable water supply system
7 Indirect agricultural reusable re-use from river

Figure 4.4.12 Some possible methods of recycling wastewater

4.4 Unit review

Remembering

1 **List** ten uses of water as a solvent in industry.

2 **State** the origin of groundwater.

3 **List** the steps in water treatment before it can be used for potable water.

4 **List** the steps in sewage treatment before the water is ready to use for irrigation.

5 **Name** the reservoir that provides most of the water to:
  a Sydney
  b Albury.

Understanding

6 **Define** these terms. L
  a potable
  b non-potable
  c flocculant
  d desalination

7 You wouldn't stay alive for long without water in you. **Explain** why.

8 **Explain** how the action of water on rocks can benefit living things.

9 **Outline** the role of water in the process of leach mining.

10 a **Describe** the desalination process known as reverse osmosis.
  b **Name** the site of the first such desalination plant in NSW.

Applying

11 **Identify** four separation methods used in the sewage treatment plant in Figure 4.4.9 on page 170.

12 a **Explain** how the arrangement of different sized particles like sand and pebbles in the science4fun on page 165 can clean muddy water.
  b **Identify** the separation technique being used in the science4fun.

Analysing

13 **Compare** the benefits of water as a solvent with the problems caused by water as a solvent.

Evaluating CCT

14 **Propose** a reason why camping and fishing are often prohibited near dams.

15 Your basins at home have an 'S' bend in the water pipes below the drain hole, as shown in Figure 4.4.13. The bend keeps some water trapped in it. When you flush the basin the trapped water is pushed out and replaced by new water. You have a similar water trap in your toilet. **Propose** some reasons why a water trap is needed in basins.

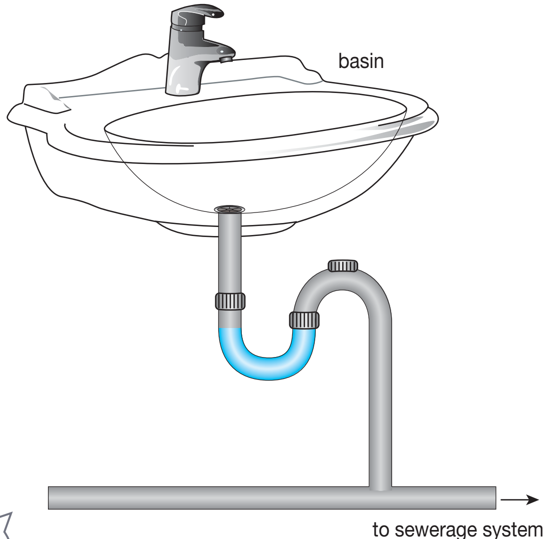


Figure 4.4.13

16 Much of the sewage of Sydney was once released untreated through long pipes into the ocean near Manly, North Bondi and Malabar. **Propose** a list of problems this might have caused.

17 Water flowing through the ground may be underground for hundreds or thousands of years before it is removed from a bore or until it reaches the surface in a spring. In contrast, the water in shallow lakes or dams does not remain there for long. **Use** this information to **propose** why the concentration of dissolved salts is much higher in groundwater than in most surface water.

4.4 Unit review

18 In the past, some detergents contained phosphates. However, they are not used now due to the environmental problems they caused. **Justify** the decision to ban phosphates from detergents. S

19 Septic tanks require bacteria living in them to break down the wastes. The soil filters out solids and dissolved materials and keeps the groundwater clean. **Propose** a reason why owners of septic tanks should not tip the following down the sink:

a disinfectants and bleaches

b paint.

20 If the store of water in dams is decreasing (Figure 4.4.14), **propose** a reason why we do not just use more groundwater to supply potable water.

Creating CCT

21 **Construct** a model showing how the water trap works in a kitchen sink. Use plastic containers and plastic piping for your model and test it out with water.

Inquiring

1 Find the water authority website from your nearest major city and locate the latest data on the water levels in the dams. Find:

- if the water storage has been better this year than last year
- what the trend has been in water storage for the last five years
- if the water authority is concerned about the level in the dams this year.

Present your findings as a report.

2 Research how a typical flushing toilet and a composting toilet work to:

- compare the two types of toilet
- describe the environmental advantage of a composting toilet
- propose a reason why flushing toilets are popular in cities while composting toilets are not.

Present your findings as a series of labelled diagrams.

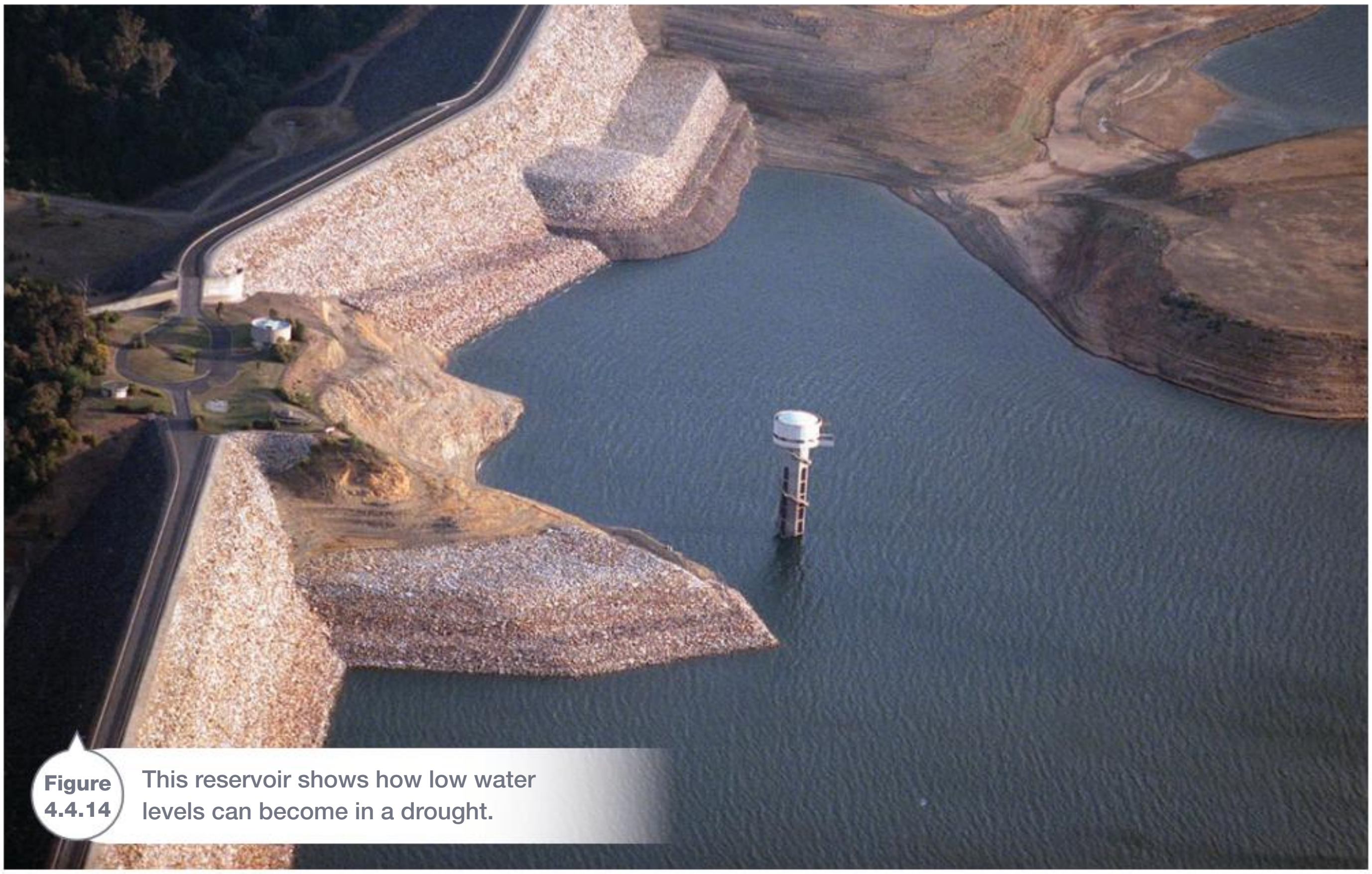


Figure 4.4.14 This reservoir shows how low water levels can become in a drought.

4.4 Practical investigations

1 Flocculation

Purpose

To compare different chemicals as possible flocculating agents.

Materials

- muddy water
- test flocculants in dropper bottles
  - potassium aluminium sulfate (alum)
  - aluminium sulfate
  - sodium carbonate
  - sodium hydrogen carbonate
  - sodium chloride
  - iron(II) sulfate
  - calcium chloride

- 2 × 100 mL beakers
- filter funnel
- filter paper
- filter stand
- test-tube rack
- 7 small test-tubes

SAFETY

All the chemicals should be considered to be toxic, so do not touch, sniff or taste them.

Procedure

1. Filter the muddy water to remove large particles.
2. Use the filtrate to half fill the seven test-tubes. Label each tube with a code so you know which flocculant you will add to it.
3. Add five drops of your first test flocculant to the first test-tube, the second to the second test-tube, and so on. Record your observation on each test-tube in a table.
4. Filter one of the clearest test-tubes and observe the filtrate and residue.

Practical review

1. **Identify** the test materials that appeared to be flocculants.
2. **Assess** whether there is any way of telling from this test which substance was the best flocculant.
3. **Explain** how this experiment is relevant to our lives.

STUDENT DESIGN

2 Sewage treatment

Purpose

To design and construct a model of a sewage treatment plant.

Materials

- 500 mL of a mixture of water, vegetable oil, mud, sand, gravel and paper

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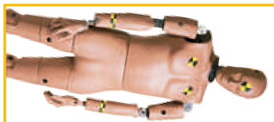
- equipment chosen by students



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1. In your group, decide what are the essential features of a sewage treatment plant.
2. Design a model of a sewage treatment plant. The method of separation should model the processes used in a real sewage treatment plant.
3. Draw your design in your workbook and write how you intend to separate the mixture.
4. Before you start any practical work, assess your model and how it will work. List any risks that it might involve and what you might do to minimise those risks. Show your teacher your design and your assessment of its risks. If they approve, then collect all the required materials and start work.

Practical review

1. **Compare** your model with a real sewage treatment plant.
2. **Evaluate** the performance of your design.
3. **Discuss** the relevance of this practical activity to everyday life.

4 Chapter review

Remembering

1 **State** an example where each of the following devices may be used.
- a centrifuge
- b reverse osmosis plant
- c paper chromatography
- d Liebig condenser
- e septic tank

Understanding

2 **Outline** how you could separate oil and water.

3 A student adds 10 grams of solid X to 100 mL of pure water, but only 1 gram dissolves. N
- a **Describe** this solution.
- b **Calculate** how much X would settle on the bottom of the container.

4 a **Describe** the process of decantation.
- b **State** when you would use it.

5 You are given a mixture of salt and sand. **Explain** the separation methods you would use to recover both.

6 Imagine you were given a mixture containing salt, sand, iron filings and water. **Outline** how you could separate and recover all the substances.

7 Imagine you need to know if two coloured liquids are the same substance.
- a **Describe** a method you could use at home to try to find out.
- b **Explain** how you would decide if the two liquids are different.

Applying

8 You have a solution containing blue dye.
- You filter some of the solution through filter paper. There is no residue in the filter paper and the filtrate is blue.
- When you filter some of the solution through a fine carbon filter, the filtrate is colourless.
- When you take this carbon filter and shake it in methylated spirits, the liquid turns blue.

Apply your knowledge of separation techniques to **outline** what is happening at each step.

Analysing

9 **Compare**:
- a solutions with suspensions
- b evaporation with distillation
- c evaporation with crystallisation.

Evaluating CCT

10 The physical properties of a mixture influence the type of separation method used. **Use** examples to **justify** this statement.

11 When you add 20 g of substance Z to 50 mL of water, only 5 g dissolves. N
- a **Calculate** how much of the solid Z on the bottom would dissolve if you added 50 mL more water to the container.
- b **Predict** what would happen to the amount of Z on the bottom if you added 200 mL more water to the original solution.

12 Which of the following would be the best way to dispose of 500 mL of cooking oil? **Justify** your answer.
- A Pour it down the sink.
- B Flush it down the toilet.
- C Mix it with detergent and put it in the sink.
- D Soak it into paper and put it in the bin.

13 **Assess** the following statement made by a scientist:

Water is essential as a solvent in daily life, industry and the environment.

14 a **Determine** whether you can or cannot answer the questions on page 138 at the start of this chapter.
- b **Assess** how well you understand the material presented in this chapter.

Creating CCT

15 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

mixture	solution	insoluble
filtration	gravity	distillation
evaporation	sewage	water treatment
water recycling		

4.8 4.9

Thinking scientifically

Q1 A mixture of salt, sand and iron filings is to be separated. CCT

Salt can be dissolved in water but sand and iron filings cannot.

Iron filings are attracted to a magnet but salt and sand are not.

Joe used the following steps to separate the substances.

Step W Add water to dissolve the salt.

Step X Filter the mixture to remove the solids.

Step Y Evaporate the water away from the solution.

Step Z Use a magnet to remove the iron filings.

Which of the following shows the order in which Joe should carry out the steps to separate the salt, sand and iron filings successfully?

A W then X then Y then Z
B X then Y then Z then W
C Y then Z then W then X
D Z then W then X then Y

Q2 Jan tested how well certain substances dissolved in cold and hot water. CCT
Her results table is shown below.

Substance	Colour of substance	Did it dissolve in	
		cold water?	hot water?
E	White	No	No
F	Yellow	No	No
G	White	No	Yes
H	White	Yes	Yes
I	Brown	Yes	Yes

Identify which pair of substances could be separated from each other by dissolving one of them in hot water and then filtering out the one that didn't dissolve.

A H and I
B E and G
C G and I
D E and F

Q3 The following table shows four types of solution and two possible examples of each. Only one pair of examples is correct. Which pair of examples is correct? CCT

	Type of solution	Example 1	Example 2
A	Solid dissolved in a liquid	Grease dissolved in petrol	Oxygen dissolved in water
B	Liquid dissolved in another liquid	Oil dissolved in petrol	Sugar dissolved in water
C	Gas dissolved in a liquid	Oxygen gas dissolved in blood	Detergent dissolved in water
D	Gas dissolved in another gas	Oxygen gas dissolved in nitrogen gas	Water vapour dissolved in the air

Q4 Sand is a mixture of small rock fragments, minerals and the remains of living things. The following table shows some of the substances in a sample of sand and their characteristics. CCT

	Magnetic	Weight	Fragment size
Silica	No	Not heavy	Large
Coral and shell fragments	No	Not heavy	Large
Feldspar	No	Not heavy	Small
Magnetite	Yes	Very heavy	Small
Rutile	No	Very heavy	Small

Select the correct techniques and the order that would allow rutile to be separated from all other substances.

A Sieving then gravity separation
B Gravity separation then magnetic separation
C Gravity separation then sieving
D Sieving then magnetic separation

Glossary

Unit 4.1 L

Aqueous solution: solution that has water as its solvent

Concentrated

Concentrated: there is a lot of solute in the solvent

Dilute: when there is little solute in the solution

Disperse: when particles spread without dissolving

Dissolve: break up into tiny particles that are smaller than the eye can see

Dissolve

Insoluble: substance that does not dissolve in a particular solvent

Mixture: a substance made from two or more pure substances that have been stirred together and that can be separated to recover the original chemicals

Saturated: as much substance as possible is dissolved in a solvent

Soluble: able to be dissolved

Solute: a substance that dissolves to make a solution when we mix it into another substance

Solution: when a substance dissolves in another, forming a clear mixture

Solvent: a substance that dissolves another substance

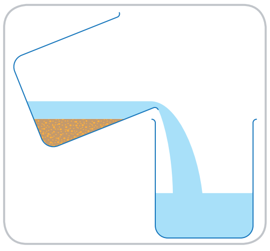
Suspension: mixture in which a substance will not dissolve in another and quickly separates out if left to stand

Unit 4.2 L

Centrifuge: device that spins very fast to separate solids from liquids, or liquids from other liquids

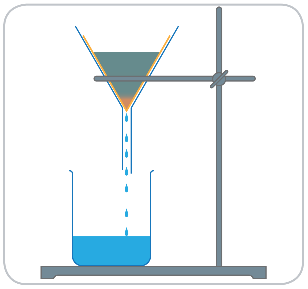
Decantation: separation by pouring liquid off the top of a mixture of solid in liquid, or liquid in liquid

Decantation



Filter: screen or membrane used in filtration

Filtration



Filtrate: liquid that passes through the filter paper

Filtration: separation of solids or liquids from a liquid or gas by using a barrier with holes smaller than the particles being separated

Gravity separation: a method of separating two components from a suspension by using the force of gravity to separate heavier particles to the bottom

Residue: solid left in the filter paper after filtration

Unit 4.3 L

Chromatography: a method of separating a mixture by making it move over or through another substance that stays still

Chromatography

Crystallisation: formation of crystals as a dissolved substance solidifies

Distillation: a process that uses evaporation and condensation to separate solids from liquids or liquids from liquids, enabling the recovery of both

Evaporation: a process that uses heat to make a liquid solvent change state to a gas, and leave behind the solute it had dissolved

Impurities: unwanted substances

Unit 4.4 L

Potable water: drinkable water

Sewage: wastewater from toilets, bathrooms, kitchens and laundries that may contain human waste and other organic chemicals or harmful chemicals

Sewerage system: system of pipes underground that collects wastewater from homes and businesses and takes it to treatment plants

5 Habitats and interactions

Have you ever wondered…

- why there are different types of plants and animals?
- why different organisms live in different places?
- how human actions affect other living things?

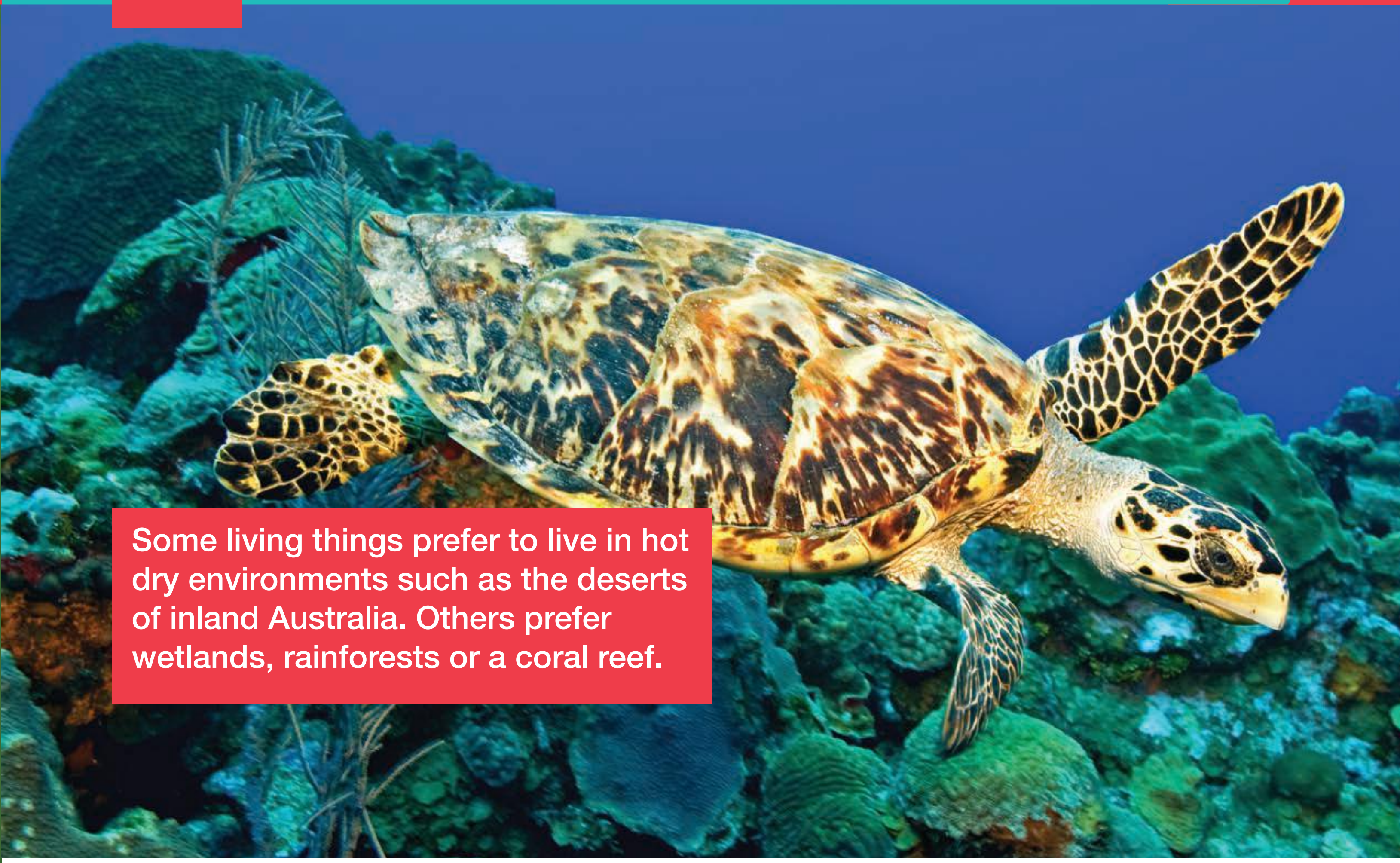
After completing this chapter students should be able to:

- explain how the features of some Australian plants and animals are adaptations for survival and reproduction in their environment L CCT
- construct and interpret food chains and food webs
- describe interactions between producers, consumers and decomposers in food chains and food webs
- describe beneficial effects that micro-organisms can have on living things and the environment
- predict how human activities can affect interactions in food chains and food webs CCT
- explain how scientific evidence and technological developments contribute to management of impacts of natural events on ecosystems L CC
- describe how scientific evidence has influenced the development of agricultural practices S L

ADDITIONAL

- debate why society should support biological research CCT EU PSC
- research the contributions of Australian scientists to the study of human impact on environments. S WE

5.1 Living places



Some living things prefer to live in hot dry environments such as the deserts of inland Australia. Others prefer wetlands, rainforests or a coral reef.

Habitats

All **organisms** (living things) have a place where they live. This is called their **habitat**. The habitat of an organism is its address. For example, your habitat includes your home, school and perhaps your sporting club.

Habitats are very varied. Figure 5.1.1 shows a wetland—one example of a natural habitat.

Every living thing has particular needs, and will live only where these needs are met by the resources available in the habitat. Some of the resources a habitat must provide for an organism to survive and reproduce include:

- food
- water
- shelter and living space
- a suitable temperature
- mating partners for reproduction
- gases such as oxygen.

Figure 5.1.1 The place where an organism lives is its habitat. This wetland will be the habitat for many different organisms.

For example, all the needs of the crocodile in Figure 5.1.2 on page 182 are met by the resources in the river and the surrounding river banks.

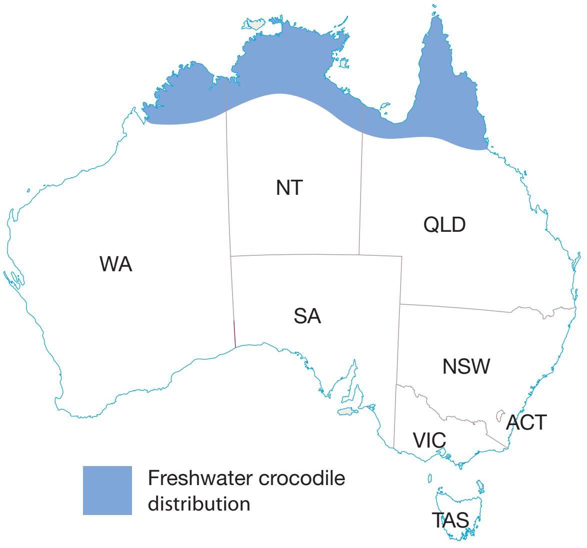


Figure 5.1.2 The Australian freshwater crocodile is found in freshwater creeks and rivers of northern Australia, where it can find the birds, frogs and fish that it eats. Female crocodiles need sandy riverbanks in which to dig nests in which to lay their eggs.

The needs of living things can be divided into two types:

- **biotic factors**. These are living factors that include partners for mating, organisms to eat, and organisms they may compete with for food and shelter.
- **abiotic factors**. These are non-living factors that include light, wind, soil, air and temperature.

The number of organisms of the same type, living in the same habitat, will vary over time depending on the availability of food, water, living space and mating partners.

Prac 1 p. 189
5.1

Adaptations

To survive in their habitat, organisms have adaptations. **Adaptations** are characteristics that assist organisms to survive and reproduce. Adaptations help organisms to get food and water, protect themselves, build homes and reproduce.

The position of the eyes and nostrils of a crocodile are adaptations. They allow the crocodile to breathe air and look for prey when the crocodile is almost totally submerged in the water.

The spotted-tail quoll shown in Figure 5.1.3 is a marsupial that lives in the wet and dry forests of eastern Australia, from Queensland through NSW to Tasmania. The quoll's colouring means that it is well camouflaged. This allows it to sleep in hollow trees and rock crevices without being seen by other animals that would hunt it for food. A quoll uses its sharp claws and teeth to catch rats, birds and reptiles but will also eat dead remains. Quolls are **nocturnal**, which means they are active and hunt at night. A quoll can see in dim light.

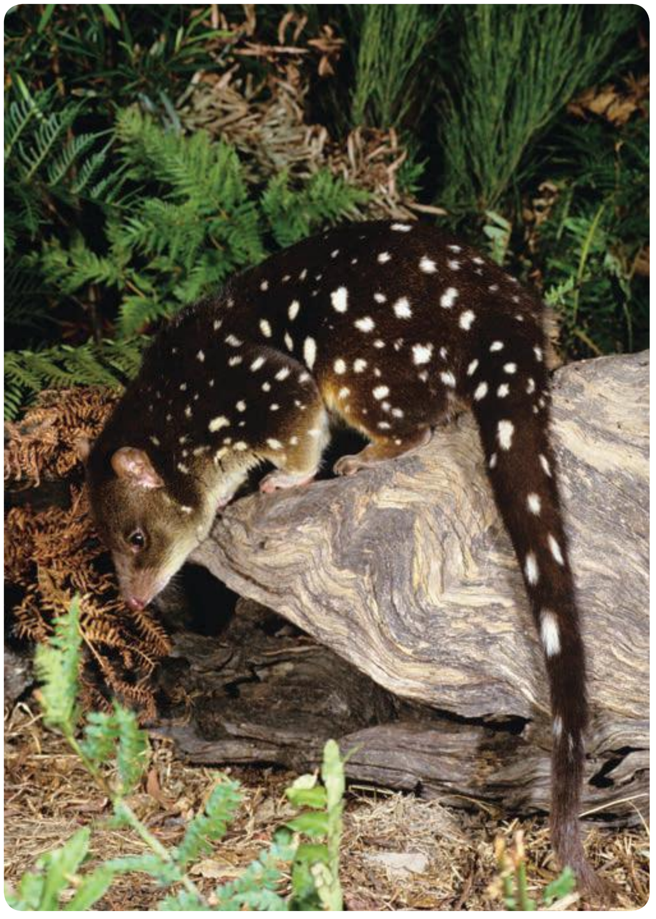


Figure 5.1.3 The spotted-tail quoll is the largest meat-eating marsupial on Australia's mainland.

Native trees growing in parts of Australia need to survive frequent fires. Some trees like eucalypts (gum trees) have buds buried deep within the trunk where they are protected from the heat of the fire. Normally these buds do not sprout. However, if a fire destroys most of the leaves on the tree, these buds grow and quickly cover the tree with new leaves. You can see this in Figure 5.1.4.

Figure 5.1.4 After fire destroyed the leaves of this gum tree, buds hidden deep in the trunk grew and produced new leaves.

All plants need light if they are to survive. Plants use the energy from sunlight to help them make their food. Plants growing in dense rainforests often have adaptations such as hooks on stems and leaves, or long, thin threads called tendrils to help them climb over other plants to reach the sunlight. *Smilax* (shown in Figure 5.1.5) is a common plant in Australian forests. It sends out tendrils that coil around neighbouring branches.

Figure 5.1.5 Tendrils are adaptations that enable *Smilax* to climb over other plants to reach the light.

Adaptations enable animals to:

- protect themselves from predators (camouflage)
- survive hot and cold temperatures, and wet and dry seasons
- move from place to place (flippers, legs and wings)
- catch and eat food
- take in oxygen
- reproduce.

Adaptations enable plants to:

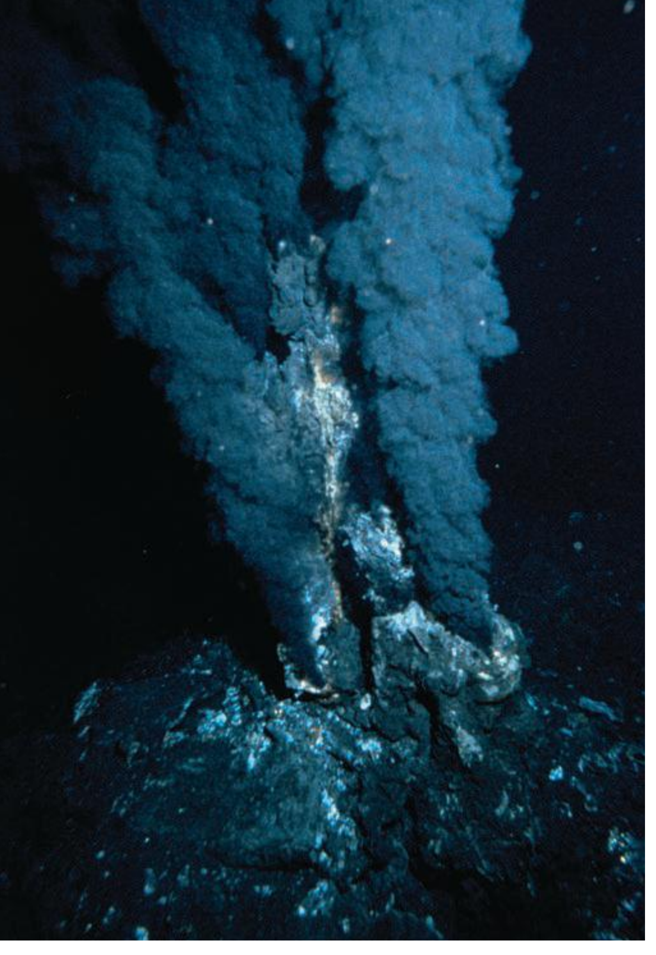
- protect themselves from grazing animals (toxins, spines and thorns)
- take in oxygen and carbon dioxide
- take in water (very long roots)
- capture light (large leaves)
- reproduce.

Prac 2 p.190
5.2

SciFile

It's hot!

Living things can be found in even the harshest habitats. A variety of bacteria have been found in superheated (up to 300°C) water that comes from volcanic vents called 'black smokers' on the ocean floor.



Where organisms live

Some organisms can live almost anywhere. They are able to find suitable habitats in a wide range of areas. For example, the red kangaroo shown in Figure 5.1.6 can be found in arid and semi-arid regions from the extreme north of the east coast, to the south-west of mainland Australia.

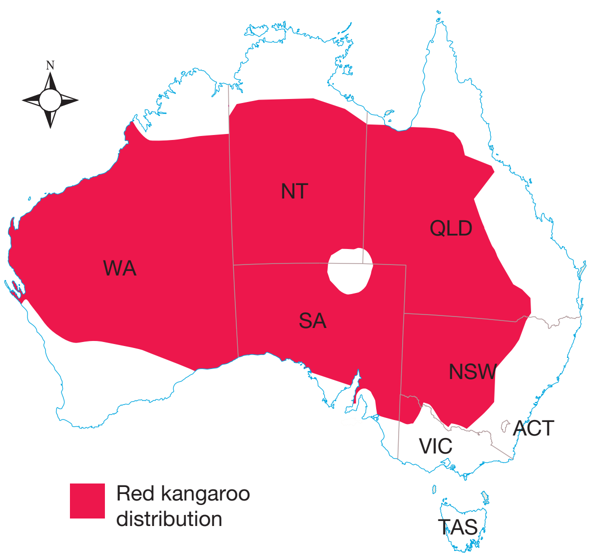


Figure 5.1.6 The red kangaroo lives in grassland, wooded areas and desert. Red kangaroos prefer open grassland with scattered trees that provide shade and shelter.

Other organisms live in very restricted areas. The mountain pygmy-possum is a threatened Australian marsupial. It is adapted to habitats found only in mountains at a height of over 1400 metres. Figure 5.1.7 shows the extent of the habitat in which the mountain pygmy-possum is found.

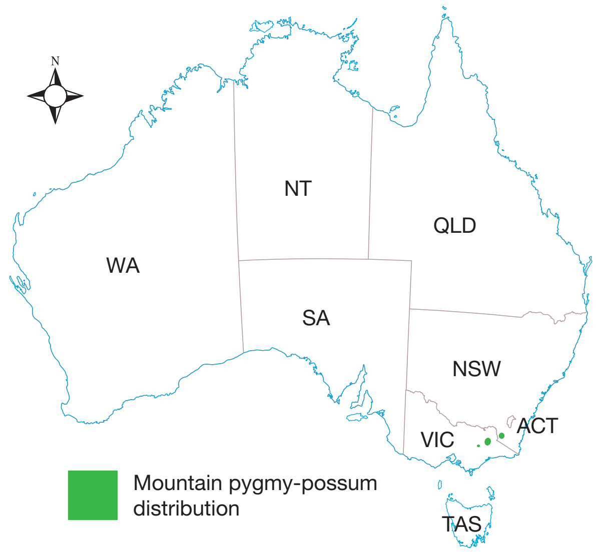


Figure 5.1.7 Spring and summer in the high mountains of NSW and Victoria are short. During this time the mountain pygmy-possum feeds on seeds and moths that are rich in fat. In winter the pygmy-possum hibernates under the snow.

SciFile

Strong poison

Although poison-arrow frogs are very small (about two centimetres long) they produce a very powerful poison. An amount smaller than a grain of salt can kill a human. Native hunters in South America use this poison on the tips of their arrows, which is how the frog got its name.

Environmental conditions

How well an organism survives depends on how well it is adapted to the environmental conditions in the area. The term **environment** is used to describe all the things that affect a plant or an animal in its habitat. Many biotic and abiotic factors may shape and change an environment, including:

- the temperature
- whether it is wet or dry
- whether it is windy
- the quality of the air
- the water quality
- the type of soil
- the plants, animals, bacteria and fungi that live there.

The study of the interactions between living things and their environment is called ecology. **Ecologists** are scientists who study these interactions.

Living together

The **biosphere** is the place where all life as we know it exists. The biosphere consists of the surface of the Earth and its atmosphere. The biosphere is made up of many ecosystems such as forests, wetlands or the coral reef shown in Figure 5.1.8.

Figure 5.1.8 A coral reef is a complex ecosystem with many different types of animals living together.

An **ecosystem** is a system formed by organisms interacting with each other and their non-living surroundings in a balanced way. In an ecosystem there are many habitats. The relationship between the biosphere, ecosystems and habitats is demonstrated in Figure 5.1.9.

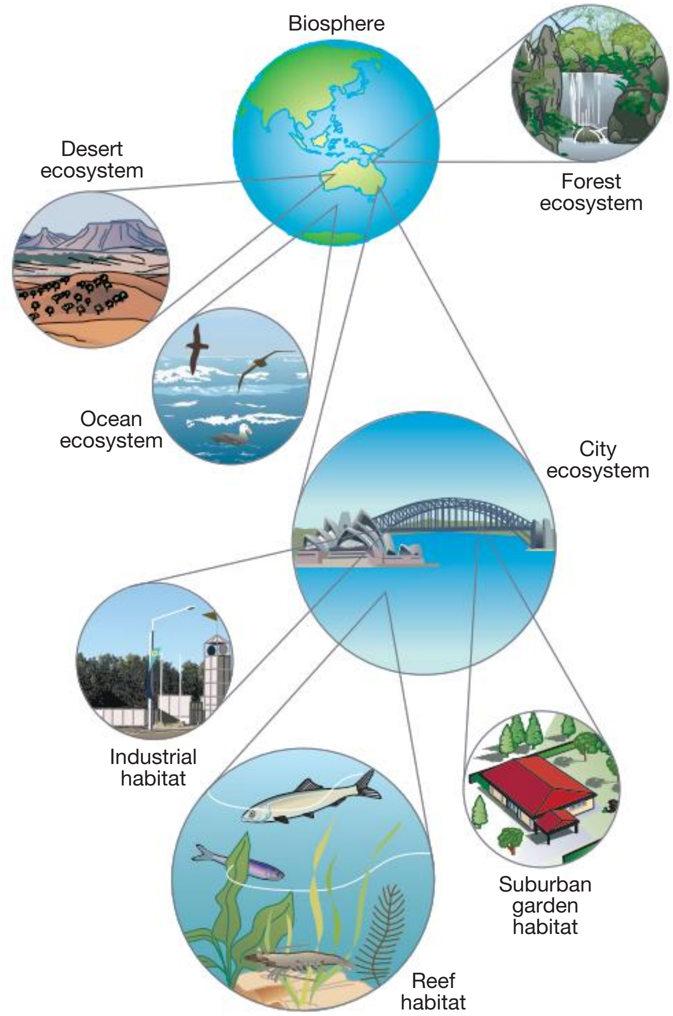


Figure 5.1.9 The relationship between the biosphere, ecosystems and habitats. In the biosphere there are many ecosystems. In an ecosystem there are many habitats.

SciFile

Epiphytes

Epiphytes are plants that grow on other plants. Epiphytes use host plants for support, but take nothing else from them. The epiphyte and the host plant are both able to make their own food; therefore an epiphyte is not a parasite. Common epiphytes are bird's nest ferns and staghorn ferns and some types of orchids.

The organisms in an ecosystem are interdependent. **Interdependent** organisms depend on each other for survival. There are three main types of interdependence or **symbiosis**.

1 **Commensalism:** An example is the cattle egret (Figure 5.1.10) hunting for food in fields among cattle or other livestock such as horses. As the cattle graze they move and in doing so stir up insects living in the grass. Cattle egrets follow the grazing cattle and feed on the insects that are disturbed. The egrets benefit from this relationship because the cattle have helped them find food. The cattle are unaffected by the egrets.

Figure 5.1.10 Cattle egrets feeding alongside cattle is a common sight in New South Wales.

2 **Mutualism:** This is an interaction where both the organisms benefit from the relationship and neither is harmed. In many cases, neither organism can exist without the other. Figure 5.1.11 shows lichen growing on a rock. Lichen consists of a fungus and algae growing together. The algae makes its own food using energy from sunlight and the fungus uses this food. The fungus provides the algae with a protected place to live.

5.3

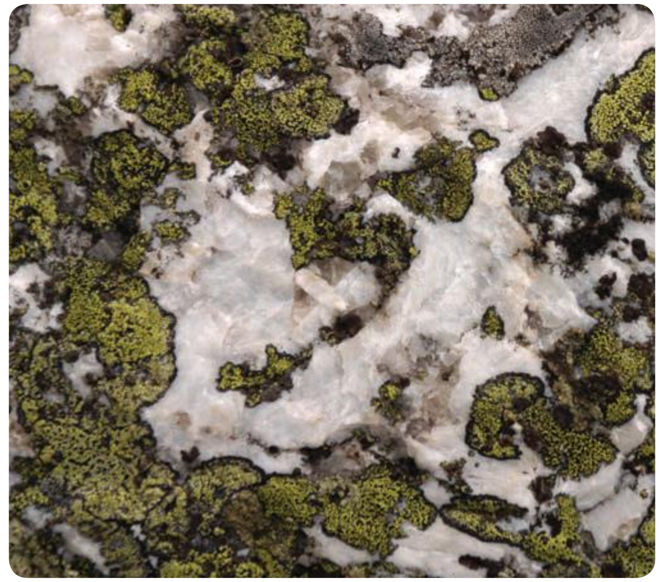


Figure 5.1.11 Lichen growing on a rock. The algae and fungus that make up lichen need each other.

3 **Parasitism:** This is an interaction where one type of organism (the **parasite**) lives on or in another type of organism (the **host**). The parasite obtains food and shelter from its host, but often harms or may even kill the host in return. Heartworm is a parasite that lives in the hearts of dogs. The worms breed rapidly and when present in large numbers can clog up the dog's heart. The worm uses the dog for shelter and food, but in the end the dog often dies. Figure 5.1.12 shows a dog's heart with a major infection of heartworm. Heartworm can be prevented by giving the dog a tablet regularly or an annual injection.

Figure 5.1.12 Heartworms infecting the heart of a dog. This heartworm is microscopic. However, adult female heartworms can grow to between 25 cm and 35 cm in length. Heartworms are parasites that can eventually kill their host.

5.1 Unit review

Remembering

L

1 **State** an alternative name for a *living thing*.

2 **List** the important things a habitat must provide so that organisms will be able to live there.

3 **List** the adaptations that help the following Australian animals catch their prey:
   a crocodile
   b spotted-tail quoll.

Understanding

L

4 **Define** the term *habitat*.

5 **Clarify** what an adaptation is.

6 **Explain** why some organisms are found over a very wide area, whereas others live in very restricted areas.

7 **Describe** possible causes of a change in the number and type of organisms living in an area.

8 **Outline** what scientists mean when they say that organisms are *interdependent*. L

9 The mountain pygmy-possum hibernates under thick snow during winter. **Explain** how each of the following adaptations would assist the possum to hibernate.
   a The mountain pygmy-possum has thick fur.
   b It stores fat from food eaten in summer.
   c Its metabolism (body functions) can be slowed until they nearly stop.

Applying

10 **Use** examples to **describe** two types of symbiosis.

11 **Identify** adaptations that allow:
   a eucalypts to survive bushfire
   b *Smilax* to reach sunlight.

Analysing

12 **Contrast** biotic and abiotic factors.

13 **Compare** the biosphere and an ecosystem.

14 **Classify** the following as commensalism, mutualism or parasitism. Give reasons for your answers that include a description of the benefit or harm to each of the organisms.
   a A leech sucking on the blood of humans and other mammals
   b A baby kangaroo attached to its mother's nipple
   c Cleaner fish taking the parasites off the gills of large carnivorous fish (Figure 5.1.13)
   d Bees carrying pollen from one flower to another as they collect nectar
   e Rainforest vines using hooks and tendrils to climb up large trees to reach the light.

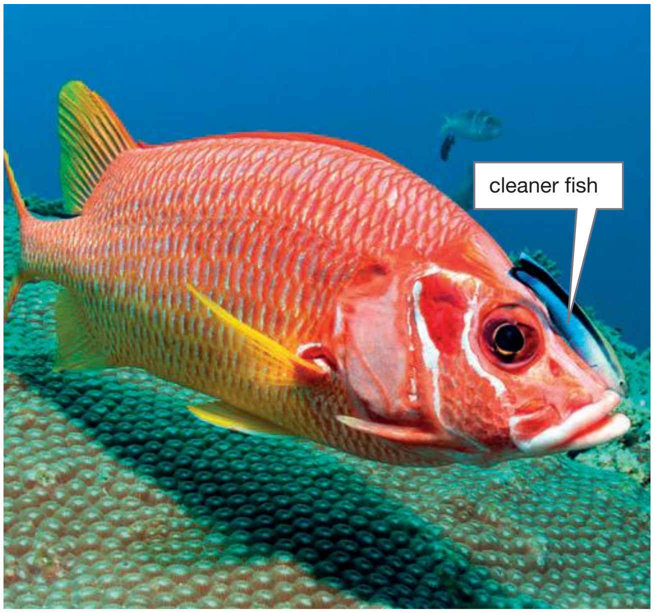


Figure 5.1.13

Evaluating CCT

15 **Use** your understanding of adaptations to **propose** why a particular type of organism cannot just move to another area if its habitat is destroyed.

16 Many Australian animals are nocturnal.
   a **Name** an animal that is nocturnal.
   b Nocturnal animals need particular adaptations. **Identify** one such adaptation.
   c **Propose** a list of advantages that an animal has from being nocturnal.

5.1 Unit review

17 **Propose** a list of adaptations that an animal or plant would need to live in:
- **a** an environment that is very hot
- **b** an environment that is very cold
- **c** an environment that has a large number of predators.

18 In a tropical rainforest, very little light reaches the ground because of the dense canopy formed by the trees. Imagine that one very large tree falls down.
- **a** **Deduce** the changes in abiotic factors that would occur in the area of the forest where the tree fell.
- **b** **Propose** ways in which the changes would affect the plants and animals living in the immediate area.

Creating CCT

19 Think about a koala living in the Australian bush. **Construct** a concept map of the biotic and abiotic factors that would be in the koala's environment. Include any adaptations that the koala would need to survive in its environment.

20 **Construct** a poster or digital presentation outlining the features of commensalism, mutualism and parasitism. Include at least two new examples of each. ICT

21 Work in a small group to **design** a coastal rockpool ecosystem. Attach a concept map showing how the organisms in the rockpool interact.

Inquiring

1 Research an Australian native animal. It could be a marsupial, bird, reptile, fish or some other marine creature. Whichever animal you choose, find:
- its common and biological names
- a map showing its distribution across Australia
- images or video of it and the typical habitat it lives in
- the biotic factors that affect its habitat (such as plants and other animals)
- abiotic factors that affect its habitat (such temperature and rainfall)
- the adaptations that help this animal to survive and reproduce successfully in its habitat.

Present your findings as a poster or PowerPoint presentation. ICT

2 Parasites can affect the health of humans. Research parasites and find:
- an example of a human parasite
- how humans become infected with a parasite
- the symptoms the parasite causes and the long-term effects on health.

Present your findings as a poster or PowerPoint presentation. ICT

5.1 Practical investigations

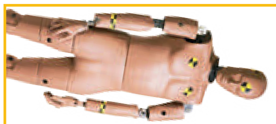
1 What lives in your schoolyard?

Purpose

To investigate the small organisms that are living in various habitats of the school grounds.

Materials

- small paintbrush
- protective gloves
- magnifying glass
- sweep net
- 4 m of string
- 4 small masses (such as stones)
- field guide
- large zip-lock plastic bags
- map of school grounds



SAFETY

Stinging insects might be captured, so gloves should be worn by the person who has to hold the net and shake the organisms into the plastic bag. If any are still caught in the net, avoid contact. Use a paintbrush to remove them.

Procedure

1 Choose the location for your experiment. If possible, each prac group should choose a location with a different type of ground cover. Draw a sketch of your location, noting the types of plants and the ground conditions. Take photographs if you can.

2 At your location, measure a square area that has sides of one metre. Mark the area using the string and weights. This is the area that will be swept.

3 Practise making a 'figure 8' swing in such a way that the opening of the net is always first to sweep the area.

4 At your test site, go back and forward over the area using the 'figure 8' motion until you have swept the entire square metre area.

5 Hold the bag halfway up to make sure that the organisms do not escape.

6 While another student holds the zip-lock bag, place the net over it, loosen your hold and turn it inside out into the bag. Carefully shake and remove the net from the bag, being sure to seal the bag so that the organisms do not escape.

7 Observe the organisms through the zip-lock bag and try to identify them using your field guide. Count the numbers of each type of organism.

8 Release any organisms that you have found.

Results

1 Record the time and date of your experiment and describe the area in which you made your observations.

2 Construct a table showing the appearance and number of each type of organism at your site.

3 Record your results along with those of other members of your class on your map of the school grounds.

4 As a class, prepare a poster of what lives in the school grounds.

Practical review

1 **Compare** the numbers and different types of organisms caught at the various sites.

2 **Identify** the site that was the most successful in terms of the:
   a number of organisms caught
   b variety of organisms caught.

3 **Discuss** the differences between the sites that could cause these variations.

4 **Identify** any other factors that could have led to this result.

5 **Classify** the organisms into groups according to the environmental conditions each preferred. Examples include dry or moist long grass or short grass, sun or shade.

6 a **Discuss** whether or not you would expect the same organisms in your sweep if you conducted this experiment at:
   i different times of the day
   ii other times during the year.
   b **Propose** reasons for any variation.
   c **Describe** a way of testing your predictions.

5.1 Practical investigations

2 Looking at earthworms

Purpose

To investigate how worms behave in their habitat.

Materials

- trowel
- gloves
- containers
- stereomicroscope or magnifying glass
- sheet of white paper or a white tile

SAFETY

Make sure that you are wearing gloves and that you don't directly inhale any dust.

It is important that the worms are treated with care and are not harmed during your investigation. Take care to look after them and then return them to where you collected them, once you have finished.

Procedure

1. Dig for worms in the garden. Choose a place where the soil is moist.
2. Place the worms in a container with some loose soil. Keep the worms moist at all times and make sure they don't escape.
3. In the classroom, gently place one of the worms on the white paper.
4. Look at the earthworm through a stereomicroscope. Make notes about its appearance. Sketch what you see.
5. Observe the way the worm moves.
6. Use the stereomicroscope or magnifying glass to look carefully at the underside of the worm close to its head.
7. Run your finger very gently from the back to the front of the worm's underside.
8. When you have finished, return the earthworm to a natural habitat under some leaves in a moist, shady location.

Practical review

1. **Describe** the shape of the worm and how this helps it move through the soil.
2. a **Describe** how the shape of the worm changed as it moved.
   b **Explain** how the change in shape helps the worm move forwards.
   c **Propose** what was happening inside the worm to cause these changes in shape.
3. a **Describe** what you felt and/or saw on the underside of the worm.
   b **Propose** how this feature could help the worm move.
   c **Deduce** why it is difficult to pull a worm from its burrow.
4. Worms are well adapted to living underground. **Identify** the adaptations you observed.
5. **Propose** reasons why you were required to return the worms to their natural habitat after the practical work.

5.2 Food chains and food webs

Healthy ecosystems usually contain many different habitats and a variety of organisms. The organisms living there interact in different ways. Food is one of the most important needs of all living things. Therefore one of the relationships between organisms is a feeding relationship. Some organisms do the eating. Other organisms are the food.

INQUIRY science 4 fun

Predators in the garden

Can I see predators at work in the garden?

YES

Collect this ...

- A magnifying glass could be useful but is not essential.

Do this ...

1. Sit quietly in the garden or in an area of parkland where there are flowers, bushes and trees, and where it is safe to sit.
2. Observe the insects, birds and other animals such as lizards that are moving around.
3. Use your magnifying glass to observe insects moving around on the plants.

Record this ...

Describe any situations where an animal was feeding.

Explain which organism was the predator and what was being eaten.

Predators and prey

For an organism to live in a particular habitat, that habitat must provide adequate food or nutrients. Plants make their own food. Animals must consume other animals or plants to get their food. Animals that eat other animals are called **predators**. For example, the dingo shown in Figure 5.2.1 is a predator of the hopping mouse. In this situation the hopping mouse is the **prey**—the animal that is eaten.

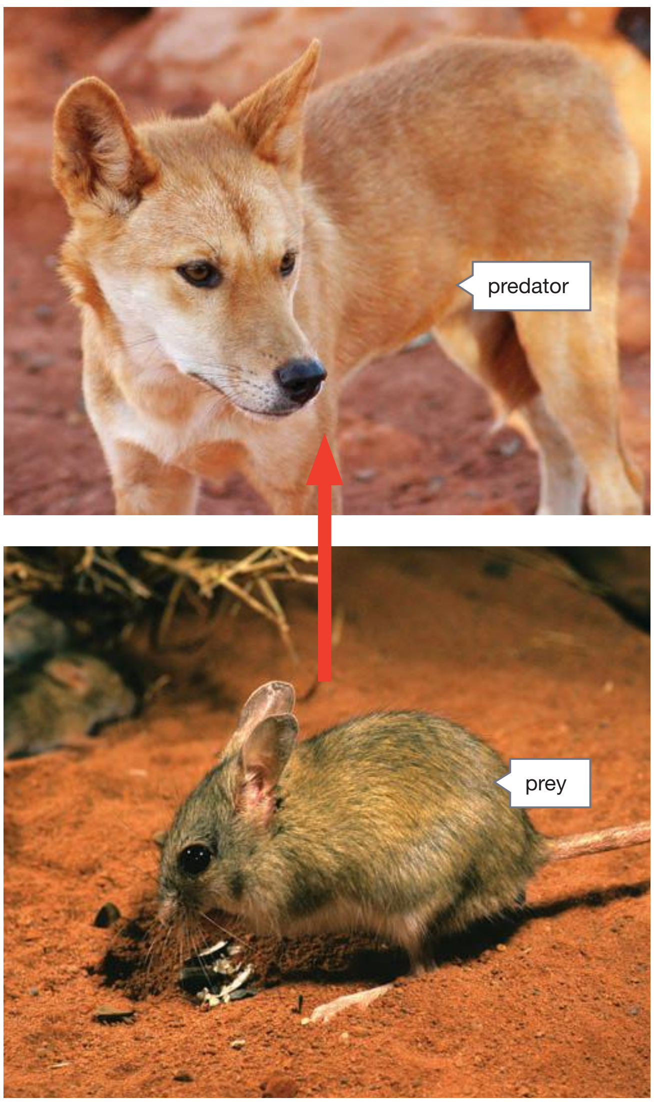


Figure 5.2.1 The dingo is the predator. It preys upon the hopping mouse as a food source.

If two animals eat the same sort of food and they live in the same habitat, then they must compete for their food; they are **competitors**. Rabbits were introduced into Australia during the 1830s and they compete with many native animals for food, living space, water and shelter. This makes the rabbits and wombats shown in Figure 5.2.2 competitors.

Figure 5.2.2 Wombats and rabbits compete for food, shelter, living space and water.

Food chains

Plants and animals use energy in growing and in day-to-day activity. This energy must come from somewhere. Plants get their energy from sunlight, and animals get their energy from the food they eat. For example, grass uses the energy from sunlight to make the food it needs to be able to grow. A grasshopper may eat the grass to get the energy it needs and a kookaburra might eat several grasshoppers to get the energy it needs. When the kookaburra dies, bacteria will help to decompose its body. The bacteria get the energy they need. The nutrients stored in the body of the kookaburra are returned to the soil and help more grass to grow.

This flow of energy from organism to organism is called a **food chain**. An example of a food chain is shown in Figure 5.2.3.

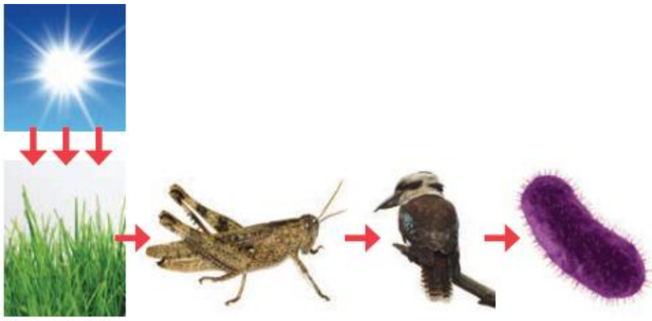


Figure 5.2.3 The energy in a food chain comes from the Sun. The food chain ends with bacteria or fungi.

A food chain is usually drawn as a simple flow chart like this:

Sun
↓↓↓
grass → grasshopper → kookaburra → bacteria

The direction of the flow of energy is shown by the arrows. The Sun is not an organism but it is included above as the original energy source.

Producers, consumers and decomposers

Food chains start with the Sun. The Sun gives out light energy. Plants trap the Sun's energy in their leaves using a chemical called **chlorophyll**. Chlorophyll gives plants their green colour. Plants then use the energy they have trapped, with water and carbon dioxide, to make a simple sugar called glucose. Oxygen is also produced. This process is called **photosynthesis** and is shown in Figure 5.2.4.

Plants can produce their own food and so they are called producer organisms or **producers**.

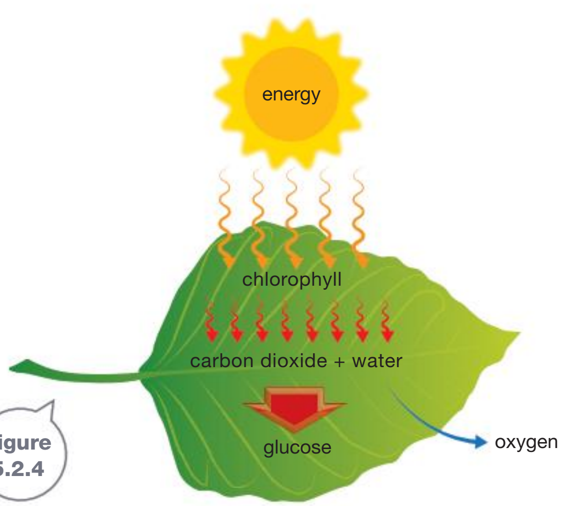


Figure 5.2.4 Energy comes in from the Sun. Energy is trapped by the chlorophyll. The energy is then used as carbon dioxide and water combine to produce glucose. Oxygen leaves the leaf as a waste product.

Animals cannot make their own food and must consume (eat) plants or other animals to get the energy and nutrients they need. Animals are therefore called **consumers**. Consumers such as grasshoppers, kangaroos and koalas that eat only plants are known as **herbivores** (Figure 5.2.5). Consumers such as lions, dingoes and kookaburras that eat only other animals are called **carnivores**. **Omnivores** are consumers that eat plants and animals. Humans, the bilby and some bears are examples of omnivores.

Figure 5.2.5 Koalas are herbivores. They only eat leaves from eucalyptus trees.

When a plant or animal dies without being eaten, its body is broken down by decomposers. **Decomposers** are organisms such as bacteria and fungi that are able to get the energy they need as they break down dead matter and waste products. You can see a type of fungus in Figure 5.2.6, helping to break down a dead tree stump.

Figure 5.2.6 The orange fungus on this tree stump is a decomposer organism. Fungi break down the materials that the tree is made from, returning these materials to the soil. Through this process fungi get the nutrients they need to live and grow.

In the food chain:

grass → grasshopper → kookaburra → bacteria

the grass is the producer, the grasshopper is a **first-order consumer** and the kookaburra is a **second-order consumer**.

In another food chain, a lizard could eat the grasshopper. The lizard could then be eaten by the kookaburra. The new food chain would look like this:

grass → grasshopper → lizard → kookaburra → bacteria

In this food chain, the lizard is the second-order consumer and the kookaburra is a **third-order consumer**.

5.4

Food webs

In the pond ecosystem shown in Figure 5.2.7, small fish live in constant danger of being eaten. If they go too close to the surface, birds might catch them. If they move away from the protection of the pond weeds, large fish will catch and eat them. The edge of the pond is also dangerous, because frogs and birds are always alert for an easy meal.

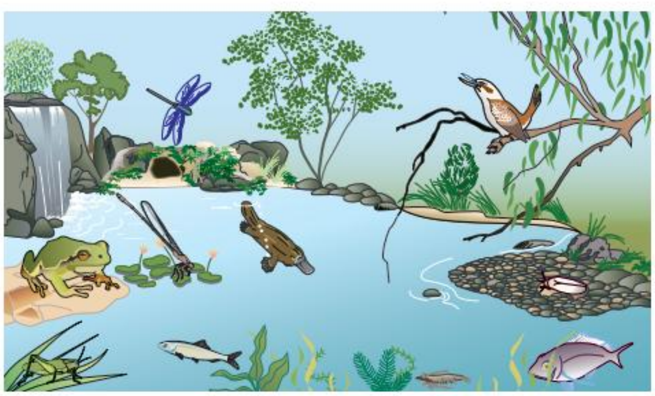


Figure 5.2.7 A pond ecosystem is home to a variety of organisms.

The small fish would be included in the food chains for most predators in and around the pond. This situation is common in many ecosystems. Each animal consumes a variety of foods, but is also the prey of a number of different predators.

Here are four possible food chains for the pond ecosystem.

pond weed → small fish → kookaburra → decomposer

pond weed → insect larvae → platypus → decomposer

pond weed → insect larvae → small fish → kookaburra → decomposer

pond weed → small fish → large fish → kookaburra → decomposer

Joining a number of food chains together produces a **food web**. One is shown in Figure 5.2.8.

Changes often occur in food webs as the populations of different organisms increase, decrease or disappear altogether. Some animals or plants might be in the pond for only a short time each year. For example, tadpoles might be an abundant food source for fish one week, but if they become frogs the next week they will no longer be available to the fish. They could instead be a food source for the kookaburra.

Prac 1 p. 197 5.5 5.6

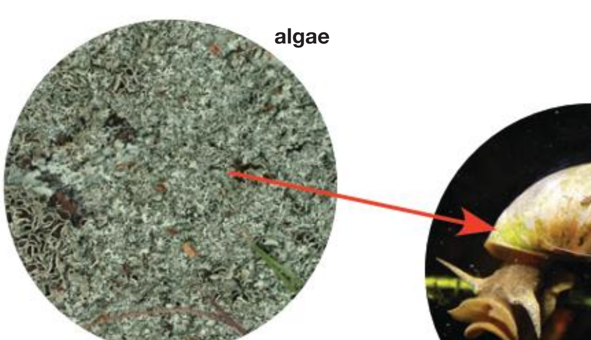
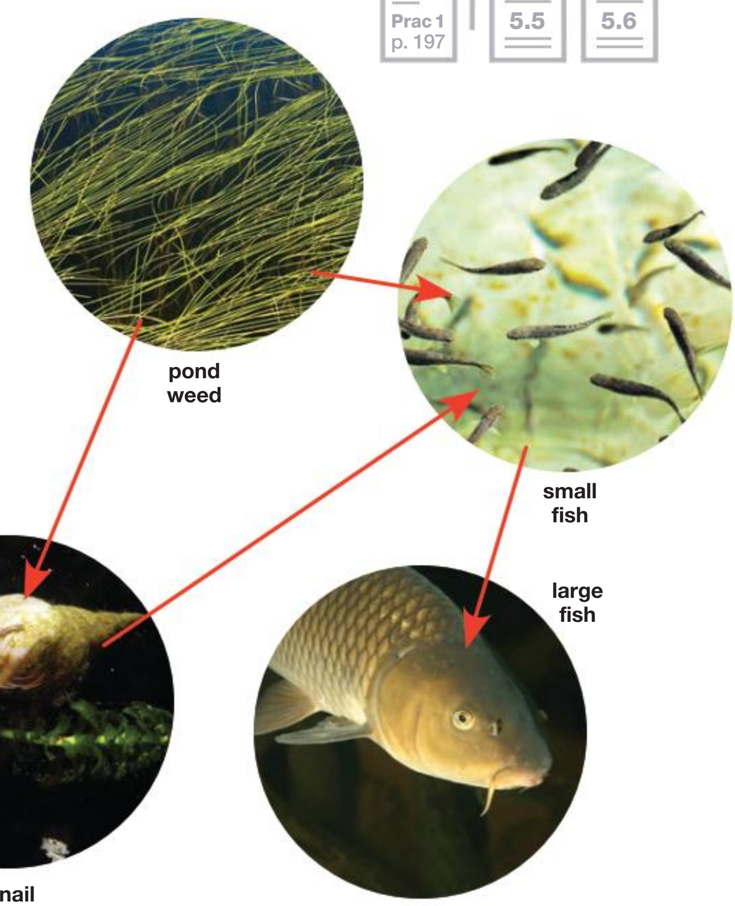



Figure 5.2.8 A food web clearly identifies what eats what in the whole ecosystem. There are at least three different food chains represented in the food web.

5.2 Unit review

Remembering

1 **State** what the arrows in a food chain indicate.

2 **Name** the process that plants use to make their food.

3 **State** where the energy in a plant's food comes from.

Understanding

4 **Define** the following terms: L
  a producer
  b consumer
  c decomposer.

5 **Explain** why all food chains begin with the Sun.

6 **Explain** why a producer is the first living thing in a food chain.

7 **Describe** an example of each of the following:
  a competition between two carnivores
  b competition between two herbivores
  c a predator and its prey.

Applying

8 a **Use** the food web shown in Figure 5.2.8 to **identify** the:
    i producers
    ii consumers.
  b **Draw** three food chains that are contained within the web.

9 Mangroves grow in 69 protected bays and river openings along the NSW coast. Figure 5.2.9 shows a typical food web for a mangrove forest.
  a **Use** this food web to **draw** a food chain that includes the:
    i pelican
    ii heron
    iii human.
  b In each food chain you have drawn, **identify** the producer, the first-, second- (and possibly third-) order consumers and the decomposers.
  c Imagine that the water the mangroves live in became so polluted that many of the crabs and prawns died. **Predict** what other organisms would be affected.
  d **Predict** what would happen to these other organisms.

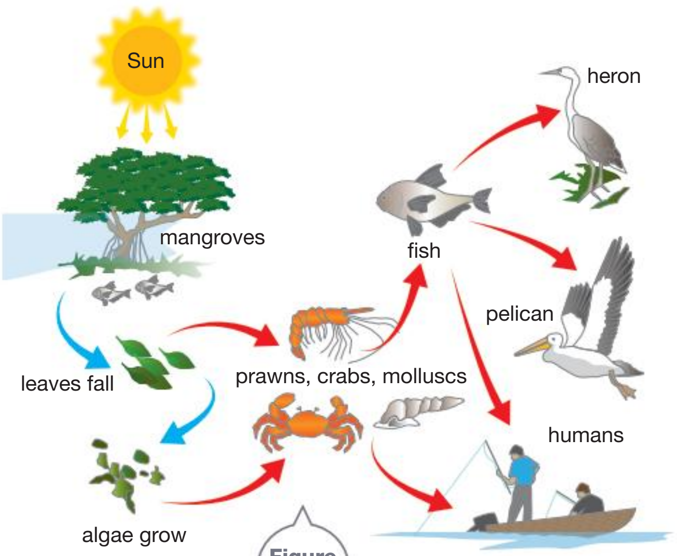


Figure 5.2.9

10 **Predict** what could happen in the food web shown in Figure 5.2.10 if the number of:
  a small birds decreased
  b large birds increased
  c plants decreased.

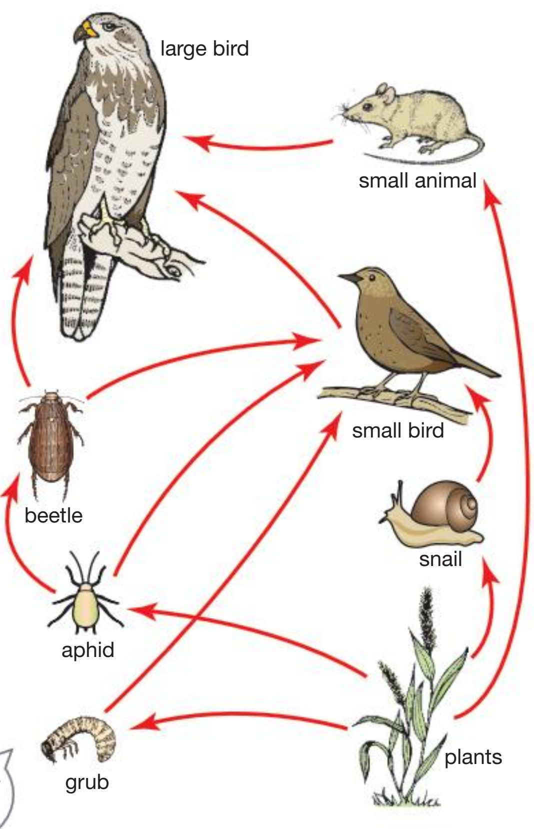


Figure 5.2.10

5.2 Unit review

Analysing

11 **Compare** a food chain and a food web.

12 **Compare** carnivores, herbivores and omnivores.

13 Humans and sharks are often said to be 'at the top of the food chain'.

- **a** **Propose** what this statement means.
- **b** **Discuss** whether humans *and* sharks can both be at the very 'top'.

Evaluating CCT

14 Predators will leave behind characteristic signs that tell you that they have been there.

Propose a list of signs that might be left behind by:

- **a** a Tasmanian devil
- **b** a spider.

15 **a** Figure 5.2.11 shows a Venus flytrap. This plant catches insects and uses them as a source of nutrients. **Propose** whether a carnivorous plant like a Venus flytrap should be known as a producer or a consumer.

- **b** **Justify** your response.

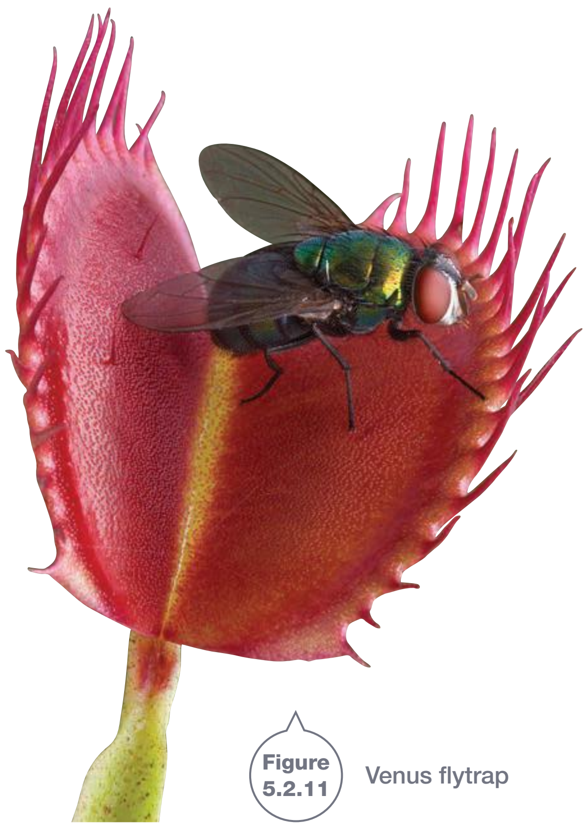


Figure 5.2.11 Venus flytrap

Creating CCT

16 **Use** the following information to **construct** a food web:

- algae (a producer)
- snail (eats algae)
- small fish (eats algae and snails)
- water beetle (eats small fish)
- frog (eats beetles)
- snake (eats beetles and frogs)
- decomposers.

17 Using a set of six cards, write your own name on one card. On the other cards write the names of five plants and animals that you could eat.

- **a** **Use** these cards to **construct** a food chain in which you are:
  - **i** a first-order consumer
  - **ii** a second-order consumer
  - **iii** the consumer at the end of the food chain.
- **b** **Discuss** how easy was it to make the food chains, and whether you had to make other cards.

18 Ecosystems rely on producers, consumers and decomposers. **Design** a role-play for each of the following situations.

- **a** All the consumers in an ecosystem are removed.
- **b** All the producers in an ecosystem are removed.
- **c** All the decomposers in an ecosystem are removed.

Inquiring

1 Research a habitat in which you are interested or that is relevant to your local area. Find:

- the plants and animals that live there
- what animal eats what.

Present your research as a food web for the habitat.

2 Research the food eaten by a koala, a great white shark, an emu and a Tasmanian devil. Deduce which of these animals would be most affected if one of their food sources disappeared.

Present your research as:

- a table that shows what each animal eats
- a written paragraph that clearly identifies the animal that you think will be most affected
- a written justification for your choice.

5.2 Practical investigations

1 Woolly web

Note: This is a whole class activity.

Purpose

To construct a food web and use it to investigate the effect of change.

Hypothesis

Which organisms in a food web do you think will be affected by a change in it—the organisms in the food web above or below the change?

Materials

- information about feeding relationships in a particular habitat
- small balls of wool or string (start with five for each student)
- cards to make labels
- marker pen
- paper clips (one per student)

Procedure

1. Each student selects an organism from the list of organisms found in the habitat.
2. Using a card and marker pen, create a name label so that you can be identified. Use a paper clip to attach it to your clothing.
3. Using the information about feeding relationships, identify the organisms that you will use as a source of food.
4. Start with the producer organisms. Connect the producers to the herbivores that eat them, extending the wool from the producer's right hand to the herbivore's left hand. The producer organisms and the herbivore hold opposite ends of a piece of wool. The wool represents an arrow in the food web.
5. The carnivores then connect to the herbivores they eat, by holding opposite ends of a piece of wool (wool from the right hand of the herbivore should extend to the left hand of the carnivore).
6. Any carnivores that eat other carnivores are then connected until all the feeding relationships are created by pieces of wool. The wool always goes from the right hand of the organism being eaten to the left hand of the predator.
7. Identify one organism that will be eaten—the prey. The student representing that organism gently pulls on one piece of wool so that the energy moves along the food chain from the prey to the predator. The predator then pulls on all of his/her strings so that the energy moves to the next level. Continue in this way until the energy reaches the consumers at the ends of all the food chains.
8. Repeat the exercise, starting with organisms at different levels in the food web.

Results

Observe the effect on other parts of the food web, of the changes you have made.

Practical review

1. **Describe** the effect of a change on the levels of a food web:
   a. above it
   b. below it.
2. **Propose** what could happen at higher levels in the food web if an organism disappeared from the habitat.
3. **Identify** any effect the organism's disappearance had on lower levels of the food web.
4. **Explain** why it is an advantage for organisms to have a variety of food sources.
5. **Identify** any of the higher-order consumers that would be left with no food source if one of the first-order consumers in your food web was to disappear from the area.
6. **Deduce** what will happen to your food web if a producer organism is removed from the area.
7. **Construct** a conclusion for your investigation.
8. **Assess** whether your hypothesis was supported or not.

5.3 Impacts on ecosystems

Environmental conditions in ecosystems change. Fire, flood, cyclone and drought may cause widespread changes that have both short-term and long-term consequences. Introduced animals change relationships within ecosystems.

Sustainable ecosystems

Ecosystems that are diverse and are able to provide the needs of the organisms living there over a long period of time are **sustainable ecosystems**.

In sustainable ecosystems (like the one in Figure 5.3.1) there are a wide variety of **species** (different types of organisms). There are many different habitats for these species. Most species have a variety of food sources, so if one food source is in short supply they can use another.

Natural ecosystems are sustainable ecosystems. Human activities can change ecosystems. This can result in sustainable or unsustainable environments. Humans can influence ecosystems so that species leave the ecosystem because their needs are no longer met. If the species cannot find a suitable place to live then it is in danger of becoming extinct.

Figure 5.3.1 The valleys of the Blue Mountains are sustainable ecosystems that provide habitats for a variety of species. The needs of those species are met by the resources of the ecosystem.

Traditional use of fire

Fire causes rapid changes in ecosystems. Fire has been an important part of Australian ecosystems since before humans lived on the continent. In large areas of Australia the plants are adapted to fire. For example, some plants need fire to release seeds from woody seed pods. Others plants recover quickly after fire has destroyed their leaves.

Indigenous Australians used fire as a tool for hunting. Kangaroos and wallabies escaping from the fire could be captured more easily by hunters. Traditional burning patterns used frequent cool fires, such as the fire in Figure 5.3.2. Forests were replaced by open woodlands and grasslands. There was an increase in grazing for animals, such as the kangaroos the Aboriginal people used for food. Plants used as food also flourished.

Figure 5.3.2 Traditional Aboriginal burning practices used cool fires that burned the grass and low shrubs without destroying the leaves at the tops of the tallest trees.

Different areas were burned at different times, leaving a mosaic pattern which provided a variety of habitats for different plants and animals. In turn, this provided a variety of foods for the Aboriginal people.

When Europeans arrived in Australia, traditional Aboriginal burning practices gradually stopped. Many of the ecosystems they had created changed.

Fuel reduction burning

To many people now living in Australia, fire is an enemy and something to be prevented. However, when there is a long time between fires, the amount of fuel available causes an intense fire like the one in Figure 5.3.3. When an intense fire goes through an area many of the native animals are incinerated and plants are killed.

Figure 5.3.3 Intense wild fires are very destructive and may cause the death of large numbers of plants and animals.

Regular burning is one way of reducing the amount of fuel available for a fire. This practice is called **fuel reduction burning** (FRB). A fire going through an area that has been burnt in the last three years will spread six times more slowly and is 20 times less intense than fire in an area that has not been burnt for 20 years. FRB turns an intense fire into a low-intensity fire. Firefighters can control low-intensity fires more easily. Animals such as kangaroos can escape from a slow-spreading low-intensity fire and move into unburnt areas. Lizards and other reptiles can escape by hiding under logs or in a hole. Birds may lose their nests but usually the breeding season is past before the fire season begins.

After a low-intensity fire, animals such as kangaroos and wallabies move back into the area within a few days. Plants quickly produce new shoots, as seen in Figure 5.3.4. These shoots provide food for the animals.

Figure 5.3.4 The Australian bush recovers quickly from a low-intensity fire. Animals return to the burnt area to feed.

Conservationists are concerned that frequent burning reduces the number of different types of living things able to survive in an area. Scientists in Western Australia have studied the effects of FRB in a variety of ecosystems and have found that the variety of living things is not affected. That is, the ecosystems in the burnt areas still have all the same types of plants and animals as before, but the actual numbers of individuals may be less.

Carefully planned burns can be used to create a variety of habitats. Unburnt areas provide a refuge for animals escaping the fire. Recently burnt areas provide habitats for animals that prefer open areas. The dense vegetation of areas left unburnt for a few years, provide small birds and other animals with protection from predators. Planned burns also create fire breaks that stop wildfires from burning particular habitats.

Botanists recognise that fire is a necessary part of the environment. Botanists study thousands of plants to find out what happens to the plants during a fire and how regrowth occurs after a fire has gone through. Using this information botanists hope to be able to work out how frequently burning should take place and how intense the fires should be to manage environments so that they are sustainable.

Fire monitoring technology

Different parts of Australia have different times of the year when fires are most likely to occur. These times are known as the **fire season**. In southern Australia the 2001–2002 fire season was a bad one and following it, Australian scientists and government agencies developed a new fire-monitoring system. This system uses satellites that have Moderate Resolution Imaging Spectroradiometer (MODIS) sensors. Using observations from these satellites, fires in remote areas can be identified and fires in less remote areas can be monitored. Emergency agencies can then decide how best to use their resources to the fight the fires effectively. Less than an hour after the observations are made using MODIS, the Water and Land Division of CSIRO has a picture of the location and intensity of fires, like the one in Figure 5.3.5.

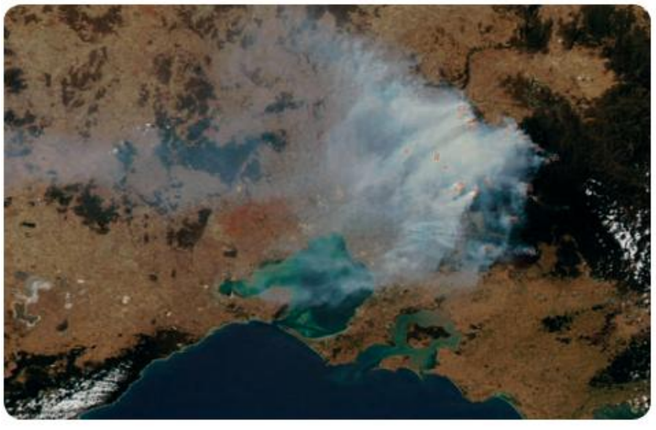


Figure 5.3.5 MODIS alerts firefighters to the outbreak of fires. Decisions can be made to fight the blaze or just monitor it if the fire is in a very remote area. Fires appear as red areas in the haze of smoke.

5.7

Floods

Floods change ecosystems. The usual image of Lake Eyre is of a dry bed of salt surrounded by desert, as shown in Figure 5.3.6. When water reaches the lake, a completely different ecosystem is established. After remaining in the sand for years, the seeds of wildflowers germinate, producing large areas of colour.

Fish and other aquatic animals flow into the lake with

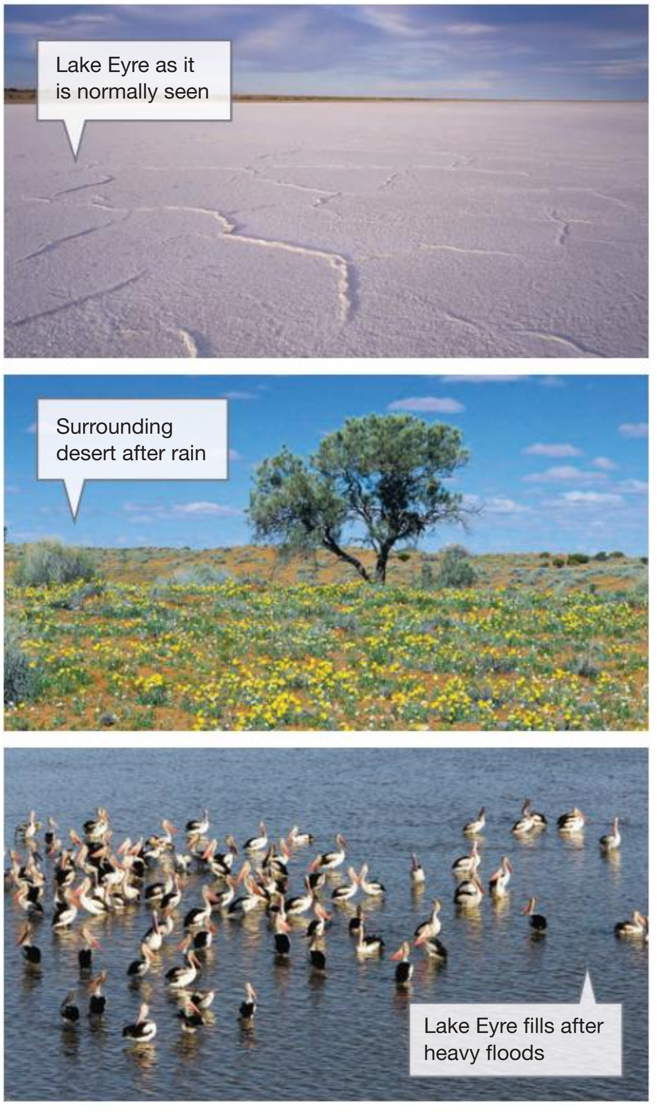


Figure 5.3.6 When water reaches Lake Eyre, the ecosystem is changed from dry desert to an area with many different organisms.

the flood waters. Thousands of water birds, such as pelicans, cormorants and ducks, fly in and start nesting and breeding. The young birds are an abundant food source for predators such as dingoes and kites. A desert ecosystem returns when the flood waters dry up.

Floods can destroy ecosystems. As Figure 5.3.7 shows, flood waters can carry large amounts of soil from the land, down rivers and into lakes and the ocean. The soil settles out of the water, covering coral reefs, sea grasses and other aquatic habitats. This covering is known as sediment. It prevents light from reaching the plants and smothers small animals such as corals. Many of the organisms living in these ecosystems die and the system is permanently changed.

Figure 5.3.7 Brown sediments moving from the river into the ocean. The sediments cover plants and animals on the ocean floor.

Flood plains

Flood plains are areas along the banks of rivers and streams that are flooded when water levels are high. Many Australian cities and towns are built on flood plains because in the past, transport by boat was easy, and it was also easy to get water and to dispose of wastes. An example is Gundagai (NSW), shown in Figure 5.3.8. Flood plains are also fertile and good for growing food crops. Regular flooding adds nutrients and moisture to the soils but also means that the towns and businesses are damaged.

As towns have increased in size, flood damage has increased. Floods such as the one that swamped Moree (NSW) in 2012 (Figure 5.3.9) cannot be prevented, but they can be managed to some extent.

Figure 5.3.8 Gundagai is built on the flood plain of the Murrumbidgee River. The flat land makes building easy but the town may be flooded when river levels rise.

Figure 5.3.9 Moree is flooded frequently. A flood plan is needed to protect as many homes and buildings as possible.

Any plan to manage the flood plains should consider different aspects of the situation.

- There are natural ecosystems on the flood plains that need to be conserved.
- People must still be able to live and work in the area without risking their lives or health.
- When a flood occurs, the cost of property damage should be kept to a minimum.

INQUIRY science 4 fun

Stopping the flood!

Why are sandbags effective at stopping flood waters?

YES

Collect this ...

- 2 small buckets of water
- 2 large shallow containers
- small bucket of soil
- 50 cm × 15 cm piece of cotton fabric

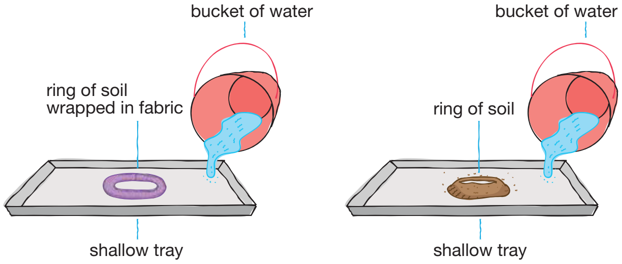
Do this ...

1. Using the fabric and half of the soil, make a long 'sausage' 3 cm in diameter of soil wrapped tightly in fabric.
2. Shape the 'sausage' into a circle and place it in the centre of one of the trays.
3. Use the remaining soil to create a circular wall in the middle of the second tray.
4. Carefully pour one bucketful of water into each of the trays to the outside of the wall you have created.

Record this ...

Describe what happened.

Explain why you think this happened.



Flood management

Flood management can take different forms.

- Raised banks called **levees** can be built to prevent water reaching buildings. Figure 5.3.10 shows a levee built around farm buildings.
- Channels can be dug to carry the water away more efficiently.
- The use made of the land takes into account the risk of flooding in the area.
- Pumps for water supply and sewage treatment are in areas that do not flood.
- Buildings are constructed with floor levels above flood levels. Figure 5.3.11 shows a highset Queensland home.

Figure 5.3.10 The levee built around the farm buildings protected them from flooding when the surrounding area was inundated.

Figure 5.3.11 Highset Queensland homes are built on stumps. Floodwater surrounds this home but the living area is still dry.

When floods occur they are not all the same height. Regional councils have flood maps drawn that show how likely it is that particular areas will flood. Using these maps, decisions can be made about the use of the land. For example, essential services such as hospitals, telephone exchanges and flood coordination centres should be placed in areas least likely to flood. Natural ecosystems could be maintained in the areas most likely to flood, or these areas could be used for playing fields and open space. Figure 5.3.12 shows the potential use of areas of a flood plain.

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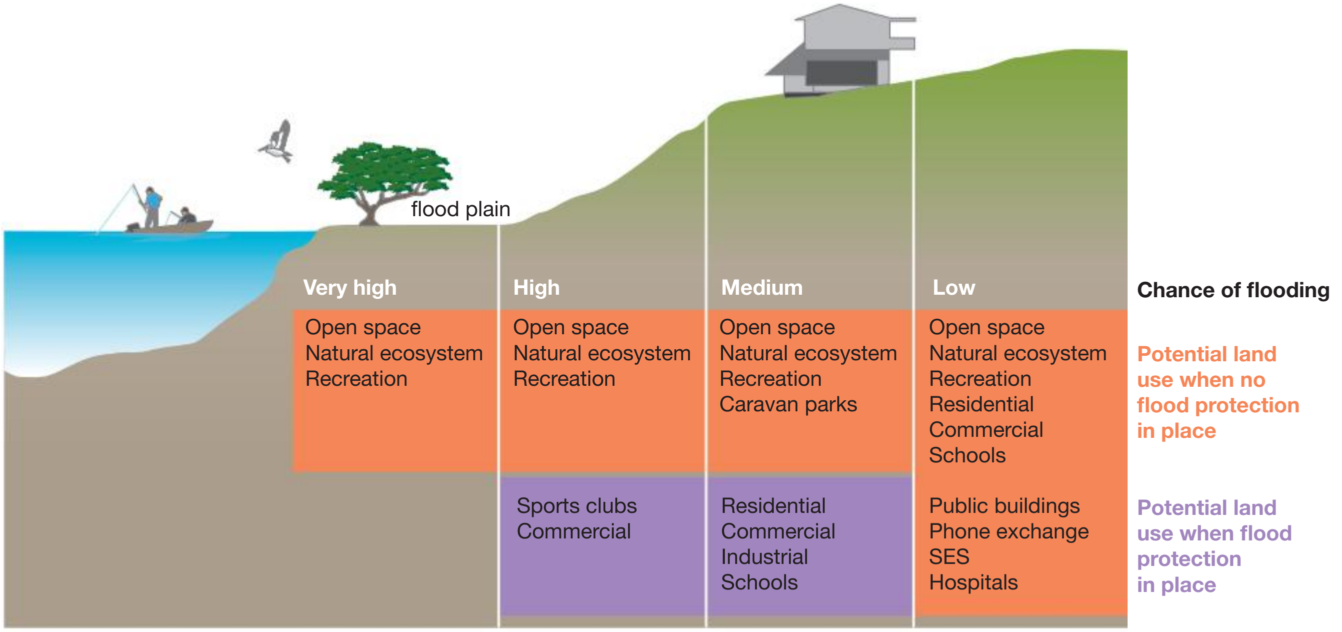


Figure 5.3.12 In a flood management plan, the use made of areas of land depends on the likelihood of the land flooding.

Introduced species

Many species of plants and animals have been introduced into Australia. These include:

- most of the animals and plants we use as food
- pet animals such as cats and dogs
- animals used for transport and recreation such as the horse and the camel
- many ornamental plants used in parks and gardens such as the jacaranda.

The wool, cotton and leather used to make clothes and furnishings come from introduced species. The majority of the introduced species have benefited humans. The same is not true for other introduced species such as the fox (Figure 5.3.13), the rabbit and the cane toad.

Figure 5.3.13 The fox was introduced into Australia from Europe in the 1860s to provide sport for hunters.

Animal control

Native animals such as dingoes kill lambs for food. Farmers build fences to protect their animals. Introduced animals such as rabbits compete with cattle and sheep for fodder.

Dingo fence

Dingoes were a problem for farmers in the late 1800s. Between 1880 and 1885 a fence was constructed to protect the sheep of southern Queensland from attack by dingoes. The path followed by the fence is shown in Figure 5.3.14 on page 204. The aim of the fence was to keep the dingoes out of the fertile areas of south-eastern Australia. The fence has brought benefits and disadvantages. The advantage is that fewer sheep are killed and eaten by dingoes. Also the numbers of emus and kangaroos are greater where there are no dingoes. The disadvantage is that the greater numbers of kangaroos and emus inside the fence compete with the sheep for the grass. This means that farmers cannot graze as many sheep per hectare.

Wild camels are damaging the dingo fence. Plans are in place to build a taller fence that is electrified.

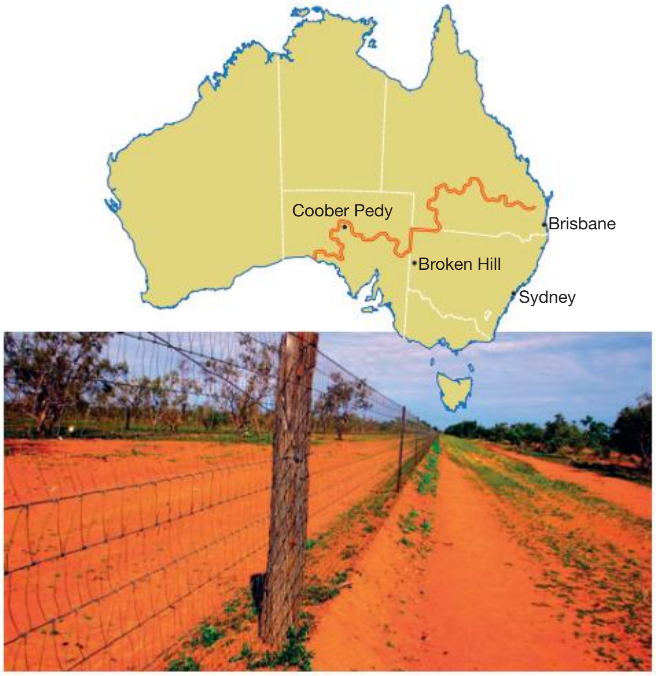


Figure 5.3.14 The dingo fence is 5614 kilometres long. It has successfully protected sheep and native animals from predation by dingoes.

Rabbit-proof fence

Rabbits were introduced to Australia with the arrival of European settlers in Botany Bay on the First Fleet in 1788. The number of rabbits was very small to begin with but a further introduction in 1859 caused their numbers to increase rapidly. By the late 1800s rabbits were a plague and had spread across into Western Australia. Rabbits were damaging crops and eating all the grass, leaving nothing for the cattle to feed on. By digging their burrows rabbits were causing millions of dollars worth of damage to grazing land. Sights like those seen in Figure 5.3.15 were common. To protect their livelihood, farmers trapped and shot the rabbits in large numbers.

Figure 5.3.15 In many parts of Australia rabbits were present in plague numbers. Rabbits were clearing grazing land so there was nothing left for the cattle to eat.

The rabbit-proof fence (shown in Figure 5.3.16) was built to protect crops and grazing land in Western Australia. Construction of the first section of the fence was started in 1901. There are three parts that make up the rabbit-proof fence. They stretch a total of 3253 kilometres. It is the longest unbroken fence in the world.

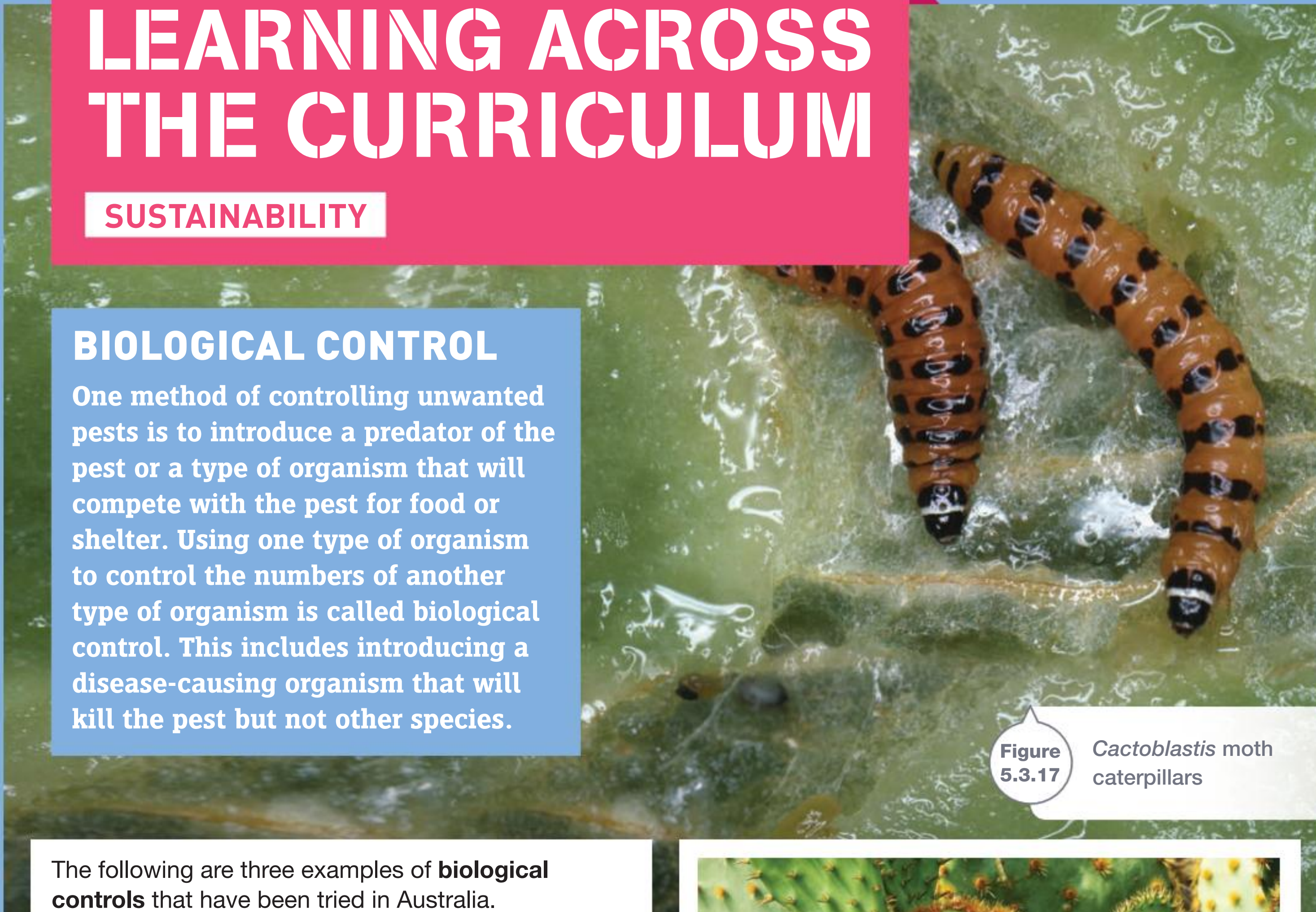
The rabbit-proof fence brought other benefits too. It has protected the livelihood of farmers by excluding dingoes, emus, foxes and feral goats. It also creates a 20-metre wide fire break along its total length.

In the 1950s a virus, the *Myxoma* virus, was introduced into the rabbit population. Large numbers of rabbits died and the importance of the fence was reduced.

Figure 5.3.16 Before the first section of the rabbit-proof fence was completed in 1934, rabbits were found to the west. A second and then third section of fence were built.

LEARNING ACROSS THE CURRICULUM

SUSTAINABILITY



BIOLOGICAL CONTROL

One method of controlling unwanted pests is to introduce a predator of the pest or a type of organism that will compete with the pest for food or shelter. Using one type of organism to control the numbers of another type of organism is called biological control. This includes introducing a disease-causing organism that will kill the pest but not other species.

Figure 5.3.17 *Cactoblastis* moth caterpillars

The following are three examples of **biological controls** that have been tried in Australia.

The *Cactoblastis* moth (Figure 5.3.17 and 5.3.18) was introduced into Australia in 1925 in an attempt to control the spread of the prickly pear cactus (Figure 5.3.19). The moths feed only on the cactus, and so they died out when they had eaten all the food. This was a big success and the problem of the cactus was solved within a few years. The cactus has not died out completely, but it is under control.

Figure 5.3.18 The *Cactoblastis* moth. The caterpillars (larvae) of this moth eat the prickly pear cactus.

Figure 5.3.19 The prickly pear cactus was brought to Australia by Captain Phillip on the First Fleet because it was a food source for a beetle that provided the red dye used for soldiers' uniforms. Later it was grown as cattle feed and as a pot plant in gardens. The cactus spread very rapidly and at one stage covered an area the size of the state of Victoria.

Figure 5.3.20 Plagues of rabbits can quickly destroy the land. Scientists tried to control the spread of rabbits in Australia with poisons and viruses.

Sometimes biological controls do not work as planned. An example of this is the biological control introduced to control rabbits in Australia (Figure 5.3.20). Rabbits eat crops and grazing lands, as well as burrowing (digging) through the soil until it can't be used for anything. In 1995 a virus, the calicivirus, was being researched as a possible method of control. The virus was accidentally released into the wild ahead of schedule. In the first few weeks, millions of rabbits died. Grazing land regenerated quickly. The results looked promising until it was realised that the foxes that relied on the rabbits for food were now eating small native mammals instead.

The most famous Australian biological control story is that of the cane toad (seen in Figure 5.3.21). Cane toads are native to South America and were first introduced in Australia in 1935 to control cane beetles. Cane beetles were accidentally introduced with imported sugar cane. As a control agent cane toads were a failure. They did not eat the cane beetle; instead the cane toads found many other things they preferred to eat. A cane toad eats anything it can swallow, including insects, mice, small snakes, lizards and even young cane toads. Poison from glands on its back kills many potential predators such as snakes and even crocodiles.

REVIEW

1 **Explain** why the cane toad was introduced into Australia.

2 **List** two reasons why the prickly pear was introduced into Australia.

3 **Explain** why the introduction of the *Cactoblastis* moth was considered a success while the introduction of the cane toad is considered to be a disaster.

4 The search for biological controls is just one part of biological research. **Propose** reasons why society should support biological research such as this. EU CCT PSC

Figure 5.3.21 Cane toads can be as big as 1.25 kg, live for up to 15 years and produce 40 000 eggs per year. Cane toad numbers are increasing rapidly. They are spreading across northern Australia towards the Western Australia border and down the east coast into northern New South Wales. This cane toad is eating a frog.

5.3 Unit review

Remembering

1 **State** the meaning of the following terms: L
- **a** fuel reduction burning
- **b** flood plain.

2 **Name** the method of controlling pests that uses natural predators.

Understanding

3 **Explain** the difference between a cool fire and an intense fire.

4 **Describe** changes in ecosystems caused by the traditional burning practices used by Indigenous Australians.

5 **a** **Explain** how Indigenous Australians created a mosaic pattern in the vegetation.
- **b** **Explain** the benefits of having the mosaic pattern.

6 **Explain** the benefits of fire reduction burning:
- **a** for the wildlife in an area
- **b** for the firefighters responsible for the area.

7 **Outline** the benefits to wildlife of planned burning programs.

8 **Explain** why many towns were built on flood plains.

9 **Describe** two ways that floods can be kept away from homes and other buildings.

10 **Discuss** the benefits and disadvantages of having the dingo fence.

Analysing

11 **Compare** a sustainable and an unsustainable ecosystem.

12 **Compare** the way Indigenous Australians used fire with the attitude of Europeans settlers to fire.

13 **Compare** two effects of floods on natural ecosystems.

14 **Compare** the reasons for building the dingo fence and the rabbit-proof fence.

Evaluating CCT

15 A wheat field is not a natural habitat. However, the wheat field provides a habitat for organisms. **Deduce** the types of organisms that would thrive in this habitat.

16 In some forests only the largest trees are taken out by loggers. **Propose** changes that removing only the largest trees would have on the other organisms living in the forest.

17 **Propose** ways that observations using MODIS can help protect Australian homes, industry and farming land.

18 Mini sandbags were constructed in the science4fun on page 202. **Propose** how full-size sandbags might be used in a flood.

19 In an area of the Flinders Ranges in South Australia, foxes were preying on the yellow-footed rock wallaby. In 1993, foxes were excluded from an area and for the next nine years the number of wallabies in the area was counted. The results are shown in Figure 5.3.22.
- **a** **Use** the information in the graph to **describe** N the effect on the wallaby population of removing the foxes.
- **b** **Propose** possible reasons why the numbers decreased in 2002.

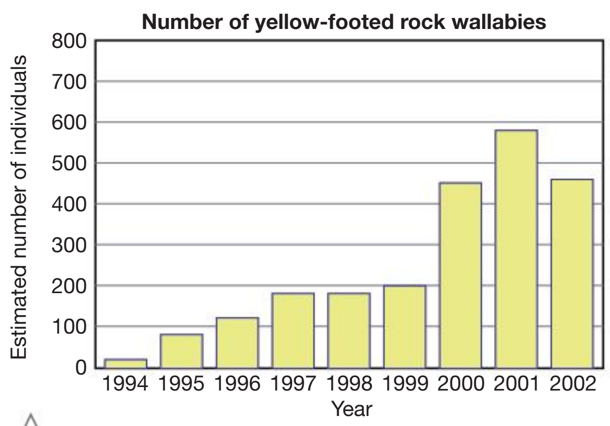


Figure 5.3.22

5.3 Unit review

20 The orange area on the map of Australia in Figure 5.3.23 shows where rabbits are to be found.

a **Deduce** how effective the rabbit-proof fence has been in preventing the spread of rabbits from the eastern states.

b **Justify** your answer.

Figure 5.3.23

21 a **Propose** ways in which construction of the buildings shown in Figure 5.3.24 has already affected natural ecosystems.

b **Predict** what could happen to organisms living in a creek downhill from the building site after a heavy rainstorm.

Figure 5.3.24

Creating CCT

22 **Design** an experiment that would demonstrate the effect of excluding a particular animal from an area (for example excluding cows, sheep or goats from an area of grazing land). You will need to decide:

- which animal or animals you are going to study
- how you are going to prevent these animals from getting into your study area
- what information you need to collect about the area at the beginning of the experiment so that you can make a comparison at a later date
- how long you think the experiment should go for
- how you will record your data.

Inquiring

1 Cyclones and drought also affect ecosystems. Research either a cyclone or a drought to find:

- how extreme a weather pattern needs to be before it is classified as a cyclone or a drought
- images or video of a cyclone and drought
- how they change ecosystems and the environment
- ways in which humans can minimise their effects.

Present your research as a digital document that includes images and video. ICT

2 Research how flood-prone your area is. Find:

- a flood map of your area
- the frequency of flooding over the last 50 years.

From your research:

- decide where the land use of the area may have to change
- suggest strategies that could be used to reduce the impact of flooding in areas.

Present your ideas in a report to the local council.

ADDITIONAL

3 Research the different scientific responses to the rabbit plagues in Australia. From your research:

- list the different techniques that have been used to get rid of the rabbits
- look at the advantages and disadvantages for the environment of each technique
- decide which of the techniques you think has been most successful.

Present your findings as a table. WE S

4 The cane toad has become established in many areas of northern Australia. Research:

- the effect that the cane toad has had on other living things in these areas
- strategies that have been used to control the spread of the cane toad.

Present your research as a written or Word document. ICT

ADDITIONAL

5.3 Practical investigations

STUDENT DESIGN

1 Effects of floods

Not all floods are the same. Flash floods flow though an area quickly and then the water returns to near-normal levels. Other floods are slow moving and it could be many days before water levels drop. Some floods carry a lot of mud in the water.

The type of flood causes different effects on materials found in buildings.

Purpose

To investigate the effects of flooding on natural and constructed environments.

Hints

In this investigation you could investigate one material and its behaviour in a flash flood, a flood that lasts a few days but leaves little mud behind, and a flood that lasts a few days and leaves the material under mud for a few more days.

Alternatively, you could look at the effect of one type of flood on a variety of materials.

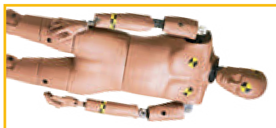
You could look at:

- only natural materials such as iron, or hard and soft wood
- manufactured building materials such as chipboard or MDF, steel and plastics
- soft furnishing materials such as carpet
- living plants such as grass or small shrubs.

Materials

Students could suggest their own materials or choose from the following list:

- growing plants such as a vegetable crop or grass
- soft timber such as pine
- hardwood such as eucalyptus
- chipboard or MDF
- iron
- steel
- plastics
- carpet



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1. In your groups decide which materials you will study.
2. Decide:
   - how you are going to simulate the flood
   - how long the flood will last
   - where you are going to set up your experiment
   - the information you will collect that demonstrates the effect of the flood. Photographs could be useful.
3. Write your procedure in your workbook.
4. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If your teacher approves, then collect all the requirements and start work.

Practical review

1. **Assess** your investigation and suggest ways that it could be improved.
2. **Construct** a report of your findings to share your results with the rest of the class.

5.4 Effects of industry

As the human population grows, cities get larger and industry expands. These changes mean that the area available for natural environments is reduced. Many species have been badly affected. However, many industries are now trying to make their operations more sustainable.

Loss of species diversity

Human actions have caused many native species to become extinct. A species is said to be **extinct** when nobody has seen it in the wild for over 50 years and the last known individual has died. In the past 200 years more than 125 species of Australian native plants and animals have become extinct. Hunting, changes to the environment, and habitat loss have caused many more species to become threatened.

Threatened organisms can be classified into one of three groups, depending on how great the threat to their survival appears to be.

- **Endangered species** are close to extinction and very small numbers remain. Examples are the helmeted honeyeater, the blue whale, the beaked gecko and the Leadbeater's possum (Figure 5.4.1).
- **Vulnerable species** are experiencing a rapid population decline and are in danger of becoming extinct if the drop in numbers continues. Examples of vulnerable animals are the mountain pygmy-possum, the giant Gippsland earthworm, the Mallee fowl, the bilby and the diamond python.
- **Rare species** have low numbers and are often spread out over a large area. Although the populations may be small, they are not decreasing. Rare organisms include the eastern wallaroo, the leafy sea dragon, the powerful owl and the alpine tree frog.

Figure 5.4.1 Threatened species of Australia

Effect of an industry

Sumatra is one of the islands of Indonesia. Its position is shown in Figure 5.4.2. It has a huge range of plant and animal species, some of which are found only on this island.

Figure 5.4.2 Sumatra is one of many islands that make up the country of Indonesia.

The Sumatran elephant, Sumatran tiger (Figure 5.4.3), Sumatran rhino and Sumatran orang-utan are four species that are critically endangered because their habitat is disappearing. These species live in the rainforests of Sumatra. However, Sumatra has lost almost 50% of its tropical rainforests in the past 35 years.

Figure 5.4.3 Sumatra is the only place where this tiger is found. It is the smallest of the tigers and there are fewer than 400 individuals left in the wild.

The rainforests of Sumatra are logged and burned, and then oil palm plantations (such as the one shown in Figure 5.4.4) are established. Indonesia is the world's largest producer of palm oil and the industry brings money into the country and provides employment for many people.

Figure 5.4.4 Palm oil plantations such as this one are replacing rainforest on the island of Sumatra. This is not a suitable habitat for the Sumatran tigers, orang-utans, rhinos and elephants.

INQUIRY science 4 fun

I need mining and forestry

YES

What products of the mining and forestry industries do you use every day?

Collect this ...

- paper and pencil

Do this ...

Look around your home or school and list the products that are made of:

- wood, paper and cardboard (from the forestry industry)
- metal (from the mining industry).

Record this ...

Describe the range of products you identified.

Explain how your life would be different without these products.

Logging

Trees growing in Australia's forests are a valuable source of timber. Timber is used in construction, furniture making and as wood pulp for the production of paper. Figure 5.4.5 shows how the forests, and the habitats the forests contained, are destroyed when the trees are removed. Animals' homes and food sources are lost. More light is able to reach the ground and the types of plants able to grow there change.

In New South Wales the aim is to manage the forests in a sustainable way. Sustainably managed forests should:

- provide timber both now and into the future
- protect forest environments to maintain biodiversity
- provide community amenities.

Figure 5.4.5 Large trees provide food and shelter for a variety of organisms. These organisms all lose their homes when old trees are cut down.

Mining

Mining is an important industry in New South Wales. Gold, copper, lead, silver and zinc are some of the metals mined. However, coal mining is the most important mining industry in the state. In 2010–11, NSW produced 205 million tonnes of coal, and coal exports are an important source of income. Locally mined coal produces 89 per cent of the total electricity needs in NSW.

Mining occupies a very small proportion of the total area of NSW. However, mining has the potential to cause major damage to environments. Many coal mines are open-cut mines such as the one shown in Figure 5.4.6. In open-cut mining the surface soil and rock is scraped away to access the resource underneath. All the habitats that were there are destroyed. There have also been situations where poisonous chemicals from the mines pollute waterways, causing damage to these habitats and the organisms that live in them. Loose soil also washes into rivers and creeks and destroys the habitat of water plants, which cannot grow in muddy water.

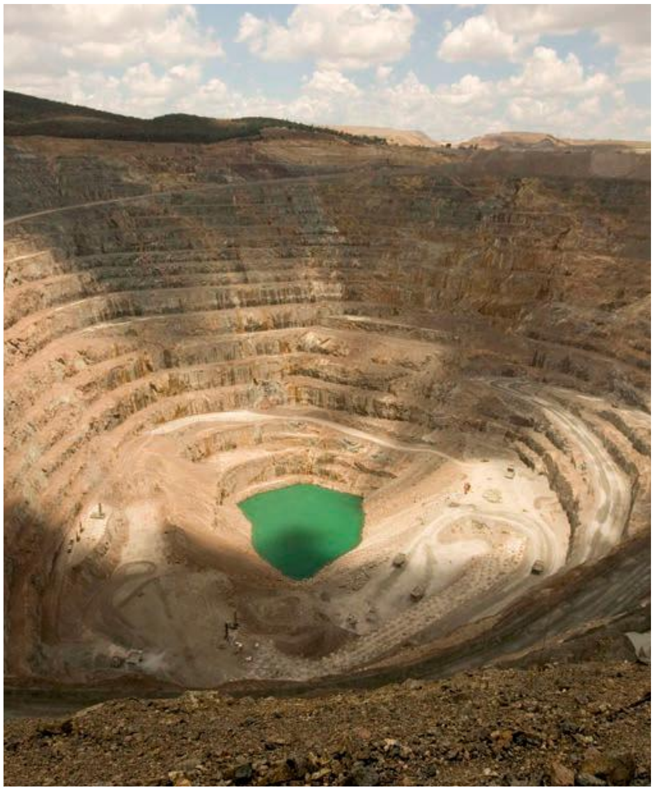


Figure 5.4.6 Open-cut mines remove all the vegetation from the surface. The soil and vegetation have to be replaced when mining is finished, but that is too late for the animals that have lost their habitat.

The mining industry in NSW is controlled by state and federal regulations. The aim of these regulations is to minimise any harmful effects on the environment. Before mining projects are approved, possible effects on aspects of the environment such as water, biodiversity, air quality, noise and greenhouse gas emissions are assessed. The possible effects on the environment are balanced against benefits to the community and the economy. For example, a mining company and state authorities will work together to reduce and repair some of these harmful environmental effects.

Agriculture

In Australia, a large proportion of the total land area has been cleared of native vegetation (the plants that usually grow there). The land is now used to graze animals or to grow crops such as the wheat seen in Figure 5.4.7. These agricultural areas provide very different habitats from the native vegetation. Fertilisers and pesticides used on the crops may wash into rivers from the farmland, causing changes in river and wetland ecosystems.

5.8 5.9

Figure 5.4.7 Vast fields of wheat cannot provide the same habitats as those provided by native vegetation.

Scientists have developed new varieties of crops and breeds of animals better able to cope with Australian conditions. Scientists have also developed ways of growing consistently good quality fruit and vegetables that can be produced as cheaply and quickly as possible.

Salt-tolerant wheat

In parts of Australia soils have a high salt content. The salt occurs naturally, but some land management practices have brought the salt closer to the surface. Not all plants can grow in salty soils and as the area of salty land increases the amount of food produced decreases. If salt reaches the leaves of wheat, the plant cannot carry out photosynthesis.

Durum wheat, shown in Figure 5.4.8, is used to make pasta and couscous. Durum wheat is particularly sensitive to salt and about 69 per cent of Australia's wheat-growing area is affected by salinity.

In 2012, Australian scientists from the University of Adelaide produced a variety of durum wheat that is able to grow in soil with high levels of salt. The scientists created the new variety by using two varieties of wheat as the parent plants and growing plants that have characteristics of both parents. The parent plants used were:

- a modern variety of durum wheat that produces a large amount of grain—it has a high yield.
- an ancient wheat variety that has the ability to remove the salt from the water as the water moves from the roots to the leaves. However, the old variety has a low yield.

The new variety of wheat scientists have created has characteristics of both parent plants—the high-yield characteristic of modern wheat, and an ability to tolerate salt. It has taken about 15 years of research to create this new variety. Now that scientists have been successful in making salt-tolerant durum wheat, they hope to use this knowledge to create a variety of bread wheat that is able to grow in salty soils.

Figure 5.4.8 Durum wheat is used to make pasta. Its yield is very low when it is grown in salty soils.

Droughtmaster cattle

Cattle are not native to Australia and most were imported from Europe. The conditions in Australia are very different from Europe and farmers often struggled to keep their cattle in good condition for the beef market. In the early 1900s, pioneer cattle breeders in North Queensland saw a need for cattle that:

- could tolerate hot weather
- could make best use of the limited nutrition provided by the native pasture grasses
- could walk long distances to access water and feed
- were resistant to ticks
- produced good quality meat
- give birth to their calves easily.

Brahman cattle, seen in Figure 5.4.9, originally came from India. They have more sweat glands than European cattle, which makes them better able to tolerate hot weather. Their oily skin helps repel insect pests and they are more resistant to parasites and disease.

Shorthorn cattle are a breed from the United Kingdom that produce good meat. Some of the original Australian Shorthorns came from England with the First Fleet. By 1820 the NSW colonies were self-sufficient in meat by grazing Shorthorns.

Cattle breeders mated Brahman cattle with beef Shorthorn. This process of mating one breed of cattle with another is known as **cross breeding**. At each generation the offspring that showed the best characteristics were selected and then mated. After many years of cross breeding, animals with all the desired characteristics were produced.
This new breed was called Droughtmaster. It is found in all Australian mainland states, with the largest numbers north of the New South Wales border. It is able to cope with harsh conditions and is now the second-most common breed in Australia.

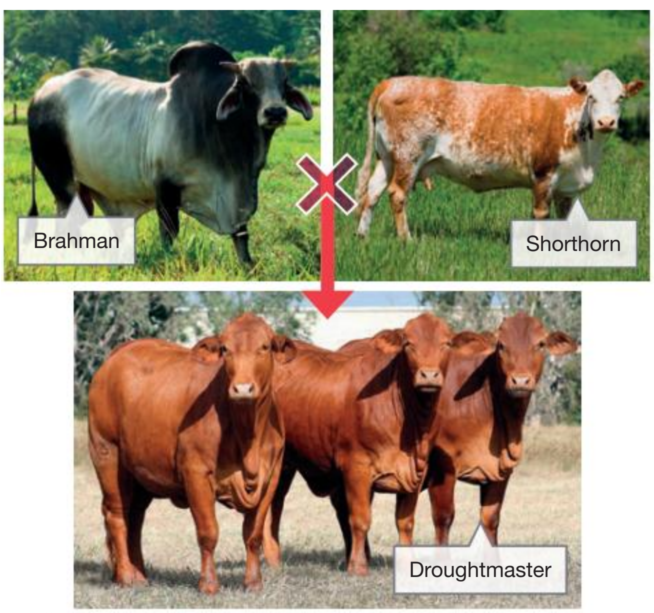


Figure 5.4.9 Droughtmaster cattle have characteristics of both Brahman and Shorthorn cattle. The red colouring is not just in their coat, it is also in their eyes giving them protection against eye cancer.

Cloning plants

When you think of reproduction you probably think of babies being born that have two parents—one male and one female. The babies grow up to be adults that are like both parents in some ways but are not exactly the same as either parent. Plants also reproduce using a male and a female, but some plants can also reproduce using parts of only one parent plant. When they reproduce in this way the offspring (babies) are exactly the same as the parent. The offspring are **clones** of each other.

Cloning of plants has been used by farmers and gardeners for centuries.

The advantages of cloning include:

- Thousands of plants can be produced from one parent plant.
- The best plants can be selected for cloning—plants that are resistant to disease or produce larger, sweeter or more colourful fruit.
- The quality of the plant or the fruit is known from the beginning.
- Cloned plants all grow at the same rate and therefore all fruit is ready for harvest at the same time.

The disadvantages of cloning:

- All plants are identical therefore all will be likely to be attacked by the same pests and affected or possibly die from the same diseases.
- Cloned plants are often sterile. This means that they do not produce seeds from which new plants can be grown. If the plant population was wiped out there would be no way of growing plants to replace them.

Banana suckers

Banana trees grow suckers—young trees growing from the base of the parent tree as shown in Figure 5.4.10.

Figure 5.4.10 Banana trees grow from suckers produced by the parent plant. The fruit from the suckers and parent are equal in taste and other qualities.

The bananas you buy in the shops have all been grown by suckers and are all exactly the same. A disadvantage of them being the same is that all the trees will be affected in the same way by disease. There are diseases of banana trees that could destroy the whole banana crop in Australia. This is why there are restrictions about bringing banana trees into Australia from overseas and moving banana trees around the country. An advantage of the trees being the same is that the fruit they produce is also the same and bananas in the shops are all of the same quality.

Grafting fruit trees

People who grow fruits such as apples, oranges, avocados and grapes need to guarantee the quality of the fruit they produce. Horticulturalists are scientists who study the growing of plants. Horticulturalists grow fruit trees from seed. These trees have different characteristics. When the horticulturalists find a tree that produces very good quality fruit they will take cuttings from the tree. **Cuttings** are part of the stem, leaf or root that is able to grow into a new plant. Hundreds of cuttings can be taken from the same parent tree. These cuttings are grafted onto existing root stock using the technique shown in Figure 5.4.11. A large orchard with hundreds of trees all producing fruit of the same quality can be established relatively quickly.

Figure 5.4.11 Twigs for fruit trees with desirable characteristics are grafted onto the root and trunk of an established tree.

Garden plants by cutting

Many of the plants you find at a nursery, garden centre or hardware store, like the plants in Figure 5.4.12, are grown from cuttings. These cuttings are not grafted. They are treated so that a leafy shoot produces roots and becomes a complete new plant. Thousands of plants all identical to each other are produced from a single parent plant. By using cloning gardeners can be sure that the plants they buy have the characteristics they want.

Prac 1 p. 219 Prac 2 p. 220 Prac 3 p. 221

Figure 5.4.12 The hundreds of plants in this nursery are grown from cuttings from a parent plant that has the characteristics the growers want.

Urbanisation

Towns and cities are built on land that was once a natural ecosystem. The native vegetation has been replaced with houses, shops, offices, industries, roads, and new parks and gardens. The animals that once lived there no longer have their habitat and have had to move away. However, there are some animals that live quite happily in urban areas and appear to thrive there. Possums such as the brushtail possum in Figure 5.4.13 are a common sight in cities.

Figure 5.4.13 Possums thrive in cities. They often live in the space between the ceiling and roof of houses and use vegetable gardens and fruit trees as a source of food. They are often seen travelling from place to place along electricity and telephone wires.

LEARNING ACROSS THE CURRICULUM

SUSTAINABILITY

Figure 5.4.14 The green and golden bell frog is a threatened species that was once found in the Ravensworth State Forest.

REGROWING A FOREST

Ravensworth State Forest is one of the largest areas of remnant woodland in the Hunter Valley of New South Wales. Remnant vegetation is native vegetation that has survived when areas around have been changed by activities such as grazing or forestry.

A number of threatened species live in this forest such as the squirrel glider and the spotted-tail quoll, as well as several species of bats. The green and golden bell frog (*Litoria aurea*), shown in Figure 5.4.14, is a threatened species that lived in Ravensworth forest in the past. Existing ponds have been improved with the aim of reintroducing this frog and other amphibians to the area.

Ravensworth State Forest was used for grazing and as a source of timber for more than 100 years. Logging ceased in 1986 and grazing was stopped in 1995. However, a coal mine was established in the area in 1993 and it is still in production. To compensate for disturbing the forest, the mining company purchased 430 hectares of neighbouring land, which has now been included as part of Ravensworth State Forest.

The company that owns the mine is working with government bodies and experts from the University of Newcastle to reconstruct areas of forest. The aim is to create more sustainable habitats for threatened species and other species living in the area. Scientists are carrying out research to find the best ways of:

- conserving the existing plant and animal life in the area
- restoring the grazing land and logged forest as near as possible to sustainable woodland forest.

In the future, the reconstructed habitats will be linked to other areas of natural vegetation. The aim is to provide corridors along which native animals can move as they search for food and breeding areas.

Topsoil that was originally taken from the mine site has been spread in areas to allow natural regrowth of native plant species from seeds in the soil. A wide variety of plants is now found in the area. These vary from tall trees to small shrubs and grasses. This variety provides many different habitats for animals. Surveys have shown that more than 220 species of animals now live in Ravensworth State Forest.

REVIEW

1 a **Explain** what the term *remnant vegetation* means. L

b **Explain** why the woodland in Ravensworth State Forest is called remnant woodland.

2 **Describe** benefits for the native animals of the work being carried out in Ravensworth State Forest.

3 **Explain** the importance of using soil from the area in areas that were once grazed.

5.4 Unit review

Remembering

1 **List** three ways in which humans can affect ecosystems.

2 **Name** two Australian species for each category below:
  a endangered
  b vulnerable.

3 **Name** the breed of cattle developed to meet Australian conditions.

4 **Recall** the characteristic that helped the new variety of durum wheat survive in Australian soils.

5 **Name** three methods of producing cloned plants.

6 Look around you. **List** ten objects or materials in the classroom that have been obtained from mining or forestry.

Understanding

7 **Define** the following terms: L
  a cross breeding
  b cloning.

8 a **Define** the term *open-cut mining*. L
  b **Explain** how this type of mining causes damage to the environment.

9 **Explain** why the movement of banana plants around Australia is controlled.

10 **Describe** the advantages to Australian agriculture of having salt-tolerant wheat.

Applying

11 **Identify** the useful characteristics of Droughtmaster cattle that came from:
  a Brahman cattle
  b Shorthorn cattle.

12 **Identify** the advantage to a gardener of buying cloned plants to plant as a hedge round the boundary of a garden.

Analysing

13 **Compare** the three groups of threatened species.

Evaluating CCT

14 Are all introduced species pests? **Justify** your answer.

15 A farmer was planning to grow fruit trees on part of his land. **Deduce** his reasons for planting grafted trees rather than trees that had been grown from seed.

16 a Bananas and some mandarins have been developed that do not produce any seeds. **Explain** why the lack of seeds could be a disadvantage to farmers growing these fruits.
  b **Propose** a reason for seedless fruit being developed.

17 **Propose** reasons for Australian cattle needing to be able to walk long distances when European cattle do not.

Creating CCT

18 A wildlife corridor is a strip of native vegetation that links patches of bushland. In many cases the patches of bushland are no longer big enough to provide for all the needs of organisms living in this habitat. Linking the patches of bushland allows animals to reach their food sources, shelter and breeding grounds.

In Figure 5.4.15 on page 218, there are several isolated patches of bushland. Your task is to modify this area to include wildlife corridors. Some conditions on the use of the land are also listed in the figure. **Design** this area to include wildlife corridors so that the animals can move between the various areas. You may need to consider how to form links across roads.

5.4 Unit review

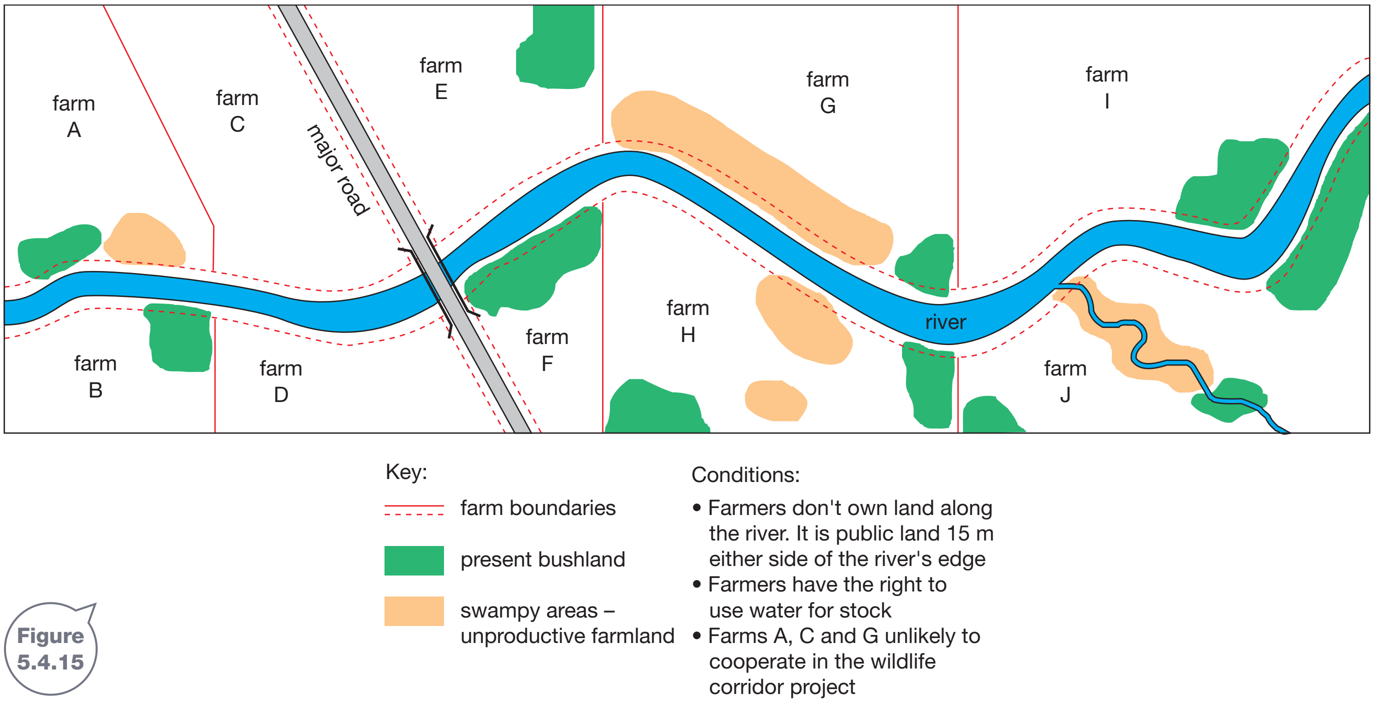


Figure 5.4.15

Inquiring

1 Research a local environmental management project.
- Outline the project.
- Describe the reasons the project was set up and the expected benefits to the community.
- Identify the types of scientists involved in the project and the role that each scientist has.

Present your research as an illustrated Word document. ICT

2 Research the causes of organisms becoming threatened.
- Find the names of species living in New South Wales that are classified as threatened.
- Select one of the organisms from the list and find:
  - – its normal habitat
  - – the changes occurring that are causing the numbers of the organism to decrease
  - – the influence of human activity on these changes.
- Propose action that could be taken to conserve this organism.

Present your research in digital form or as a poster. ICT

ADDITIONAL

3 Identify one Australian scientist who is studying the impacts of humans on environments. Find:
- the research this scientist is involved in
- the human impacts identified by the scientist
- the changes in human behaviour that the scientists suggests have to be made.

Present your findings as an illustrated Word document. S WE ICT

4 Identify areas of scientific research referred to in this unit. Investigate one of these areas further. Create a list of reasons this research:
- should be supported
- is not as deserving of support as other areas.

Present your research in the form of a report. S WE

ADDITIONAL

5.4 Practical investigations

1 Taking cuttings

Purpose

To grow new plants from cuttings.

Materials

- healthy parent plant (geranium, pelargonium or coleus) large enough to provide 5 cuttings
- rooting hormone
- soilless potting mix such as vermiculite (enough to fill the pots)

- scalpel or single-sided razor blade
- 5 small plant pots or yoghurt containers with holes pierced in the base
- 5 plastic bags large enough to fit over the pots
- pencil
- marker pen
- camera (optional)

SAFETY

Take care with sharp instruments.

Do not inhale the rooting hormone or dust from the potting mix as it may contain bacteria or other contaminants.

Procedure

1. Label the pots 1 to 5.
2. Fill each of the five pots with potting mix.
3. Use the pencil to make a hole at least 3 cm deep in the middle of the potting mix. This is where the cutting will be placed.
4. Cut off 5 pieces of stem about 8–10 cm long. The stems should have leaves but no flowers.
5. Carefully cut off all but the top four leaves.
6. At this stage you could take a photograph of your cuttings.
7. Dip the cut end of your cuttings into the rooting hormone. If the stem is dry you may have to moisten it to make sure the hormone sticks to it.
8. Carefully place one cutting into each of the pots and press the potting mix firmly round the cutting.
9. Give the pot enough water to dampen the potting mix thoroughly.
10. Place a plastic bag over each pot. This will act like a mini greenhouse (Figure 5.4.16).

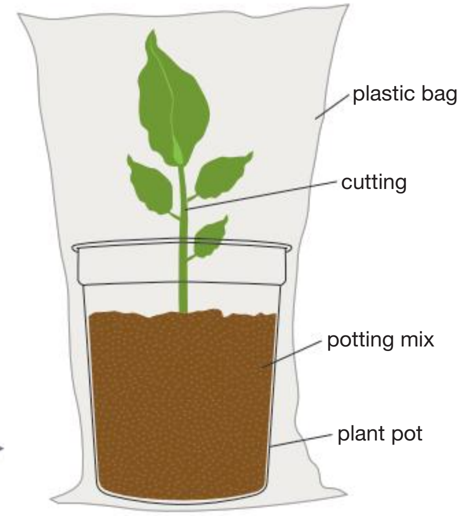


Figure 5.4.16

11. Put the pots in a warm light position.
12. After one week observe and record any changes in the cuttings. Carefully remove the cutting in pot 1 and note any evidence of root growth. Take a photograph of the cutting.
13. Repeat step 12 each week for four more weeks observing the root growth in each of the numbered pots in turn.

Results

Record the changes you observed in the cuttings such as new leaves, an increase in height or evidence of roots.

Practical review

1. **Propose** a reason why it was important that some leaves were present on your cuttings.
2. **Describe** the changes in the cutting. You could keep a photographic record.
3. **Deduce** how your results may have been different if rooting hormone was not used.
4. **Propose** a relationship between changes in root growth and changes in the upper part of the plant.
5. **Compare** your results with those from other groups.
6. **Assess** your experimental method and suggest improvements.

5.4 Practical investigations

STUDENT DESIGN

2 Plant cuttings

Purpose

To compare the success of producing cuttings from different plants.

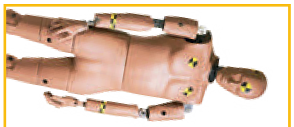
Hypothesis

Do all plants succeed in producing new individuals from cuttings or are some better than others? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

Access to plants that can be grown from leaf and stem cuttings. Possible plants include:

- geranium
- pelargonium
- coleus
- African violet
- hibiscus (Figure 5.4.17)
- crepe myrtle
- azalea
- begonia.



SAFETY

A Risk Assessment is required for this investigation.

Figure 5.4.17 Hibiscus plant

Procedure

1. Research which plants can be grown from leaf and/or stem cuttings.
2. Design an experiment that tests which plant produces cuttings most successfully.
3. Write your procedure in your workbook.
4. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If your teacher approves, then collect all the required materials and start work.

Hints

You will have to decide what you mean by success. It could be how quickly roots are produced or the number of roots produced or the percentage of cuttings that result in new plants.

Results

Construct a table showing what you measured and the results you obtained.

Practical review

1. **Describe** the criteria you used to decide which plant was most successful.
2. **Identify** which type of plant was most successful according to your criteria.
3. **Compare** your findings with those from other groups.
4. **Construct** a conclusion for your investigation.
5. **Assess** whether your hypothesis was supported or not.

STUDENT DESIGN

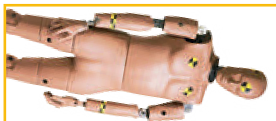
3 Taking control of plants

Purpose

To investigate the effect of changes in light on the growth of plants.

Materials

- a range of plants, such as grass, alfalfa, cress
- different coloured cellophane (blue, green, red, clear)
- cardboard box
- black paper
- digital camera
- measuring tools (rulers, balances, measuring cylinders)
- light source



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1. Decide whether you want to study the effect of the direction from which the light is coming, or the effect of the quality of light that is reaching the plant. This will be the controlled variable.
2. Use some of the above materials or materials you select to design a way of controlling the amount or quality of light that is reaching the plants.
3. Think about ways in which all the other variables can be kept the same.
4. Decide how you are going to measure or record the response of the plant. The digital camera could be useful for this purpose.
5. Check that the experiment you have designed is a fair test.
6. Write your procedure in your workbook.
7. Before you start any practical work, assess your procedure. List any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If your teacher approves, then collect all the requirements and start work.

Hint

Quality refers to how bright the light is. The plants could be in full sunlight, in heavy shade or somewhere in-between.

Results

Present your results in a way that identifies patterns.

Practical review

1. **Compare** the reaction of different plant species to the variable you studied.
2. **Identify** situations where plants in a natural environment could be exposed to changes in the direction or quality of light.
3. **Discuss** your results in relation to how changes in the environment can affect plants.
4. **Deduce** whether your procedure could be used by ecologists to investigate plant behaviour.
5. **Discuss** the things that worked well and those that didn't in this experiment.
6. **Assess** how the experiment could be improved.

5 Chapter review

Remembering

1 **State** why a producer organism is normally part of every food chain.

2 **Recall** the original source of energy for food chains.

3 **List** these in order from largest to smallest:

habitat, biosphere, ecosystem.

4 **List** these groups of organisms from the ones that are most threatened to the ones that are least threatened:

rare, vulnerable, endangered.

5 **Recall** the three outcomes of sustainably managed forests.

Understanding

6 **Explain** why the habitat of an organism is sometimes referred to as its address.

7 **Modify** these scrambled sentences and rewrite with the words in the correct order.

a ecosystem are All things an living in interdependent.

b may feeds A is off organism parasite that kill its an host and it.

c and sensitive Plants to environment animals changes are their in.

8 Figure 5.5.1 shows a food web where an eagle is the consumer at the top of the food chains.

a **Predict** what would happen to the number of eagles in the area if foxes were introduced. (Note: foxes would eat koalas, birds and kangaroos.)

b **Modify** the food web to include the foxes.

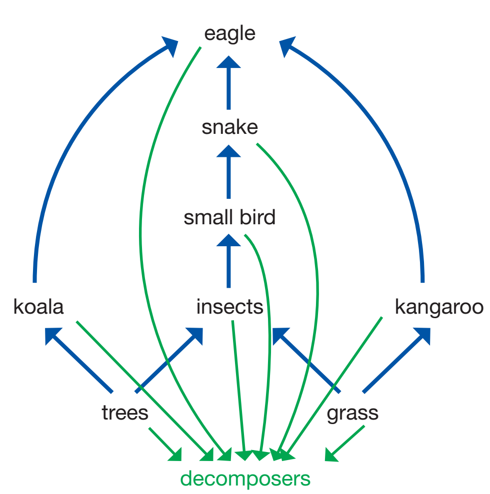


Figure 5.5.1

9 **Explain** why it is necessary to produce new breeds of animals and varieties of plants for Australian conditions.

Analysing

10 **Compare** the role of prey and predator in a habitat.

11 **Classify** the organisms in the following list as either producers or consumers:

cat, magpie, rose, eucalypt, sparrow, worm, ant, grass, daisy.

12 **Classify** the following as biotic or abiotic environmental factors in a wetland ecosystem:

water birds, water temperature, crocodile, rate of water flow, amount of salt in the water, water plants, frogs, fish. Present your answer in a table.

Evaluating CCT

13 Lantana is a large flowering shrub that is native to Central and South America. It was introduced to Australia in 1841 as an ornamental garden plant that could be cut into a hedge. In the wild it grows rapidly along creek banks. It forms very dense bushes that prevent light from reaching the ground. Lantana grows in areas that are difficult to access and is not easy to remove. It has a prickly stem and the leaves are poisonous to livestock if eaten. Its seeds are contained in a cluster of fleshy black berries that birds love to eat.

Use the information about Lantana to answer these questions:

a **Propose** ways in which Lantana could affect the growth of native plants.

b **Propose** ways in which Lantana could affect the number and species of native animals living in an area.

c **Propose** actions that could be taken to prevent the spread of this plant.

14 Figure 5.5.2 shows the changes in the numbers of different animals found in an area for a period of 40 years. You are asked to interpret the information in this graph.

a **Identify** the general trend in the population of the native animals (red-necked wallaby and eastern grey kangaroo).

b **Identify** the general trend in the population of the rabbit—an introduced species.

c **Compare** the changes in the rabbit population with the changes in the population of the eastern grey kangaroo.

d **Deduce** what may have caused the drop in grey kangaroo numbers in 1885.

e **Identify** the animals that are competing with the eastern grey kangaroo for food.

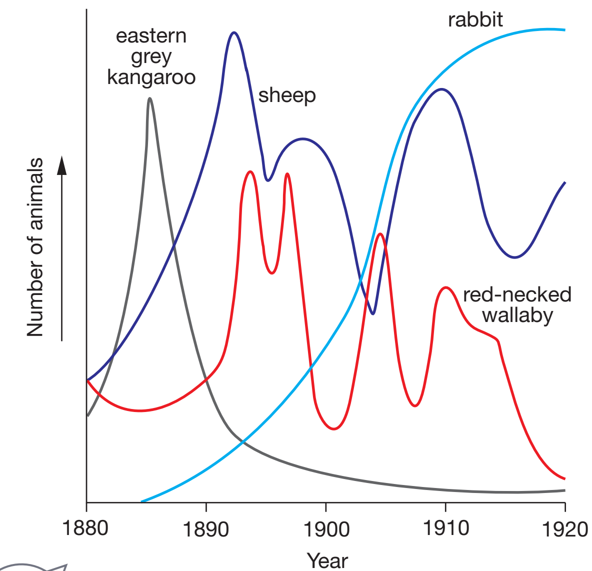


Figure 5.5.2

15 **Use** the information in Figure 5.5.3 to answer the following questions.

a **Identify** the organisms that compete with each other for food.

b **Deduce** which organism would be affected most by the use of insecticides (chemicals that kill insects).

c **Propose** the consequences for the remaining organisms in the food web if bandicoots became extinct in the area.

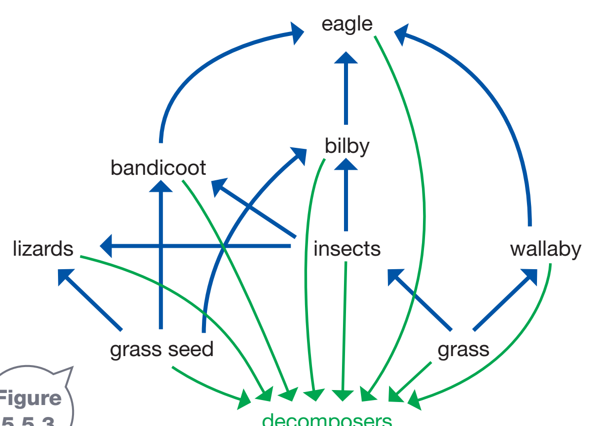


Figure 5.5.3

16 **Propose** reasons why humans are able to live in so many environments.

17 a **Use** information from the chapter to **identify** ways that human activity affects ecosystems.

b **Classify** the effects as positive or negative.

c **Propose** how the negative influences would make the ecosystem unsustainable.

d **Propose** how the positive influences increase the sustainability of the ecosystem.

18 In northern Australia there is a distinct wet season and a dry season. The wet season may last for three months and during this time there may be floods. In the dry season there may not be any rain at all.

a **Propose** the effect on farmers managing a cattle property in this area.

b **Recommend** strategies these farmers could use to overcome any difficulties you identified.

19 **Propose** the benefits for farmers of producing apples from grafted trees instead of trees grown from seeds.

20 a **Determine** whether you can or cannot answer the questions on page 180 at the start of this chapter.

b **Assess** how well you understand the material presented in this chapter.

Creating CCT

21 a **Use** the following lists of organisms to **construct** food chains. Under the name of each organism, **label** it as a producer or a consumer.

b **State** whether it is a first-order, second-order or third-order consumer.

i grass, snake, frog, grasshopper

ii eucalypt, kookaburra, caterpillar

iii shark, large fish, small fish, snail, water plants

22 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

environment	biotic factors
abiotic factors	habitat
food chain	producer
consumer	photosynthesis
endangered species	adaptation

5.10 5.11

Thinking scientifically

Q1 Environmental factors may be biotic (living) or abiotic (non-living). **Identify** the list that has these sorted correctly. CCT

A *biotic:* soil, predators, living space, bacteria, parasites

abiotic: water, prey, light, wind, rock

B *biotic:* prey, living space, parasites, predators, wind

abiotic: soil, water, bacteria, light, rock

C *biotic:* soil, predators, rock, bacteria, light

abiotic: water, parasites prey, wind, living space

D *biotic:* predators, prey, bacteria, parasites

abiotic: water, living space, light, wind, rock, soil

Q2 The fish shown in Figure 5.6.1 is adapted to its habitat; it has characteristics that assist it to survive in its environment. Which characteristic will help it swim through the water? CCT

A the dark colour of its tail and fins
B the long spines in its back fin
C its streamlined shape
D its gaping mouth and small teeth

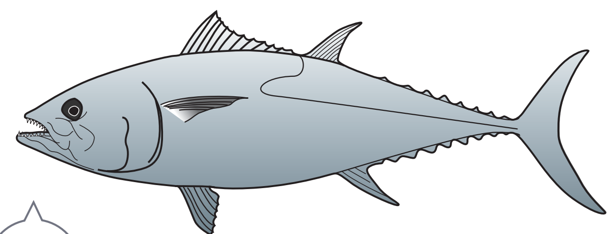


Figure 5.6.1

Q3 First-order consumers feed directly on producers. A producer can manufacture its own food from energy in sunlight. From the food web in Figure 5.6.2, **identify** the group of organisms that are all first-order consumers. CCT

A tadpole, water beetle, snail
B water beetle, frog, small fish
C kingfisher, snail and algae
D snail, tadpole, algae

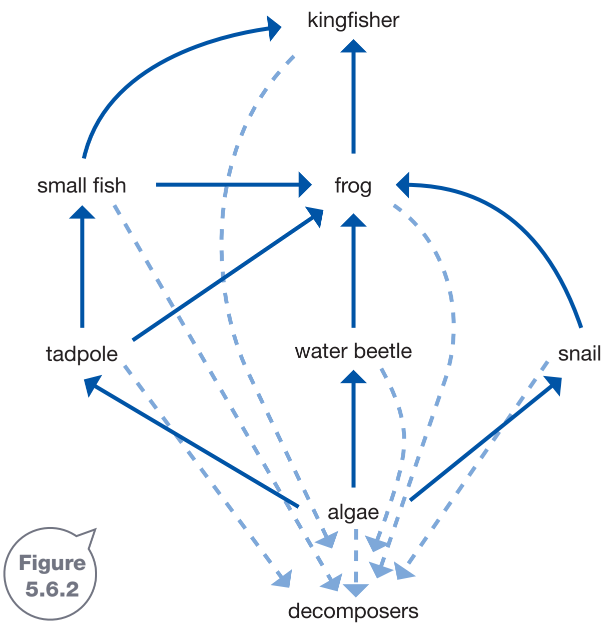


Figure 5.6.2

Q4 From the food web in Figure 5.6.2, **identify** the organism that is both a second-order and a third-order consumer. CCT

A small fish
B kingfisher
C frog
D snail

Q5 **Identify** the plant in Figure 5.6.3 that would be adapted to get the most water from its environment. CCT

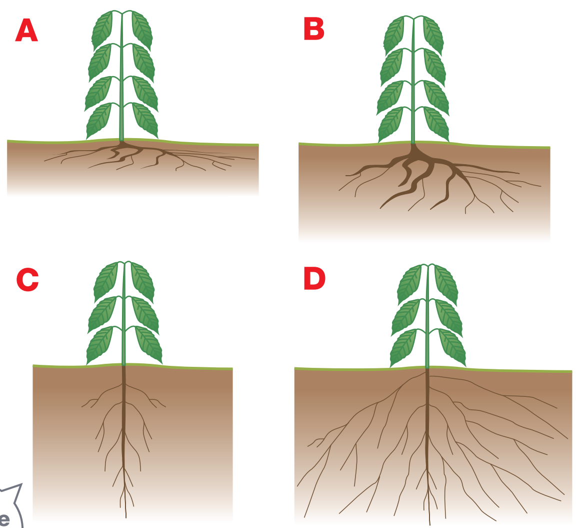


Figure 5.6.3

Glossary

Unit 5.1 L

Abiotic factors: non-living factors in the environment

Adaptations: characteristics that help an organism to survive in its environment

Biosphere: the place where all life exists; consists of Earth and its atmosphere

Biotic factors: living factors in the environment

Commensalism: an interaction between two organisms in which one of them benefits but the other one is not affected

Ecologists: scientists who study the interactions between living things and their environment

Ecosystem: a system formed by organisms interacting with each other and with their non-living surroundings in a balanced way

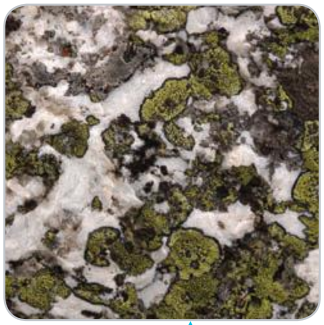
Environment: the term used to describe all the conditions that affect a plant or animal in its habitat

Habitat: the place where an organism lives

Host: an organism in or on which a parasite lives

Interdependent: depending on each other for survival

Mutualism: an interaction between organisms in which both the organisms benefit from the relationship and neither is harmed



Mutualism

Nocturnal: active or hunting at night

Organisms: all living things

Parasite: an organism that lives on or in a host, taking food or shelter from the host; the host gets nothing in return and may be harmed

Parasitism: an interaction in which one type of organism (the parasite) lives on or in another type of organism (the host); the host is usually harmed or even killed

Parasitism

Symbiosis: another name for interdependence

Unit 5.2 L

Carnivore: a consumer that eats only other animals

Carnivore

Chlorophyll: the chemical in plants that traps energy from the Sun and gives plants their green colour

Competitors: organisms that have the same food source and live in the same habitat

Consumers: organisms that must eat other organisms to get the energy and nutrients they need; animals are consumer organisms

Decomposers: organisms that get the energy they need by breaking down dead matter and waste products

First-order consumer: a consumer that eats a producer

Food chain: the flow of energy from organism to organism in a series of feeding relationships

Food web: a number of food chains combined

Herbivore: an animal that eats only plants

Herbivore

Omnivore: an animal that eats both plants and animals

Omnivore

Photosynthesis: the process used by plants to make their own food

Predator: an animal that eats other animals

Prey: an animal that is eaten by a predator

Producer: an organism able to manufacture its own food; plants are producer organisms

Second-order consumer: a consumer that eats a first-order consumer

Third-order consumer: a consumer that eats a second-order consumer

Unit 5.3 L

Biological control: a method of controlling unwanted pests by using a natural predator or disease

Fire season: times of the year when fires are most likely to occur

Flood plain: area along the banks of rivers and streams that is flooded when water levels are high

Flood plain

Fuel reduction burning: regular burning to reduce the amount of fuel available for a fire

Levee: raised bank built to prevent water reaching buildings

Levee

Species: the term used to describe different types of living things

Sustainable ecosystem: an ecosystem that is diverse and able to provide for the needs of the organisms living there over a long period of time

Unit 5.4 L

Clones: individuals that are exactly the same as each other

Cross breeding: the process of mating one breed of plant or animal with another breed of that plant or animal (e.g. cattle)

Cutting: part of the stem, root or leaf that is able to grow into a new plant

Endangered species: species that are close to extinction and very small numbers remain

Endangered species

Extinct: term used to describe a species that has not been seen in the wild for over 50 years, and of which the last known individual has died

Horticulturalist: a scientist who studies the growing of plants

Rare species: species that has low numbers, often spread out over a large area; the population is not decreasing

Remnant vegetation: native vegetation that remains unchanged when surrounding areas have been changed by activities such as grazing or forestry

Vulnerable species: species that is experiencing a rapid population decline and is in danger of becoming extinct if the drop in numbers continues

Vulnerable species

6 Classification

Have you ever wondered ...

- why living things are put into groups?
- how scientists make sense of millions of living things?
- what the differences are between cats, reptiles, birds and fish?

After completing this chapter students should be able to:

- construct keys to represent patterns or relationships CCT N L
- identify reasons for classifying living things
- classify a variety of living things on the basis of structural features
- use simple keys to identify a range of plants and animals L
- outline the structural features used to group living things including plants, animals, fungi and bacteria
- identify examples of micro-organisms

ADDITIONAL

- design and construct simple keys to identify a range of living things CCT

- identify an example where classification has changed as a result of new evidence
- classify a range of plants and animals using a hierarchical system. L

6.1 What is classification?

When you say to a friend ‘I’m going to the shops’ your friend knows that you are going to a shop and not to the beach, to school or to see a movie. They may ask ‘What type of shop are you going to?’ You could answer the video store, a shoe shop or dress shop, or you might name the specific store. What you are doing here is using different levels of classification. You are going from the large group that includes all shops to smaller groups by type of shop and then to an individually named shop.

INQUIRY science 4 fun

Your pencil case

YES

How could the things in your pencil case be classified?

Collect this ...

- the contents of your pencil case

Do this ...

1. Tip the contents of your pencil case out on the table.
2. Sort the contents into groups and give names to each group.
3. List the items included in each group under the group name.
4. Re-sort the contents into different groups, and again list the items included in each group.

Record this ...

Describe how you decided what to include in the groups.

Explain which of the groupings was most useful.

You use it every day

Classification is the process of putting things into groups. It is a skill needed in many areas of life, not only in science.

Next time you walk round a supermarket, think about the way products are grouped. Biscuits are all in the same aisle, with the savoury biscuits separated from sweet and chocolate biscuits. Canned items are usually together, but the canned fruit is separated from the baked beans and soups, and fresh fruit is organised as in Figure 6.1.1.

Figure 6.1.1 Fruit and vegetables in the supermarket are sorted into groups. This makes it easier to find the type of vegetable you need or the variety of orange you prefer to buy.

Music you download onto your iPod is classified in a variety of ways. This allows you to find the music by searching via artist, album, composer or genre (such as rock, pop and dance).

In a library, the fiction and non-fiction books are in different areas. The non-fiction books are then placed in smaller groups according to their subject, and the fiction books are sorted in alphabetical order of the author's surname.

Sorting things in this way makes it easier to find a particular item. Imagine what shopping day would be like if the hundreds of supermarket items were placed on the shelves at random! Similarly it would be nearly impossible to find a song by your favourite band or a book by your favourite author if there was no organisation to the way the songs were ordered and books were placed.

Which group?

As an individual you are classified in many different ways for different purposes. You are classified as male or female, according to your year at school (such as Year 7 or 8), as part of a particular family (for example the Robinsons or the Singhs), as living in a particular suburb (for example Coogee, Bankstown or Ryde) or city (such as Wagga Wagga, Newcastle or Albury) or state (Western Australia, Tasmania or New South Wales). The group you are placed in depends on the reason you and others are being grouped. You are part of all these groups at different times.

SciFile

Just a moment

Time is classified with years being divided into 12 months, which are divided into days, hours, minutes and seconds. But what is a moment? According to an old English system of classifying time, a *moment* is one and a half minutes.

Groups change

Plants and animals are often grouped in different ways too. For example, the grass making up a garden's lawn is looked after and encouraged to grow. However, if the grass escapes from the lawn area and into the flower beds, the grass is now considered to be a pest and is dug out or even poisoned. The plant that is wanted in one place is a **weed** in another place. *Weed* is not a name given to a special group of plants, but is a classification for any plant growing where it is not wanted (like the one in Figure 6.1.2). To one person a plant may be wanted; to another it is a weed.

Many plants have been introduced into Australia from overseas. Some introductions were intentional and have brought benefits. Many food crops, such as wheat, potatoes, tomatoes and apples, were introduced by early European settlers and are still cultivated and controlled.

Figure 6.1.2 A weed is just a plant growing where it is not wanted.

Other introduced plants have created problems. Lantana (*Lantana camara*) has a pretty flower and was introduced to Australia in the 1840s. You can see it in Figure 6.1.3. It now grows out of control in parts of New South Wales and Queensland and has already invaded over 4 million hectares of farmland, woodlands and forests. This is an area about two-thirds the size of Tasmania! Scientists believe that, if not controlled, lantana could invade an area of 35 million hectares across New South Wales, Queensland, Western Australia and Northern Territory. Lantana spreads rapidly and is toxic to livestock that try to eat it. For these reasons, lantana is classified as a Weed of National Significance.

Animals have also been introduced to Australia for food (for example cattle and sheep), transport (for example horses and camels), hunting (such as rabbits and foxes as shown in Figure 6.1.4) and to control other pests (the cane toad was introduced to control a beetle ruining sugar cane crops). Some of these animals have become a major problem for Australian wildlife. Foxes eat wildlife, rabbits eat vegetation normally eaten by wildlife, while poisonous cane toads will kill any snakes, crocodiles and birds that eat them. These 'animal weeds' are known as **pest species**.

Figure 6.1.3 Lantana (*Lantana camara*) is a weed species introduced from South America.

Figure 6.1.4 The red fox (*Vulpes vulpes*) is a pest but it does help to control another pest species—the rabbit.

Why classify?

Scientists classify things to make it easier to communicate with other people. Giving an object, substance or organism a name ensures everyone knows what they are discussing.

In order to classify something, you have to find out its characteristics and make a judgement about how similar it is to other things.

Figure 6.1.5 Chemists group substances according to their characteristics. Copper is classified as a metal, along with iron and tin. Amethysts form purple crystals and can be grouped with other crystalline substances such as sugar and salt.

Classification is an important skill used in all branches of science. Scientists observe ways in which objects are similar and group them together. Chemists classify substances such as those in Figure 6.1.5 and group them using names such as metal or non-metal, and acid or base. Geologists classify rocks as sedimentary, igneous or metamorphic (Figure 6.1.6), and astronomers classify heavenly bodies into groups such as stars, planets, comets and meteors.

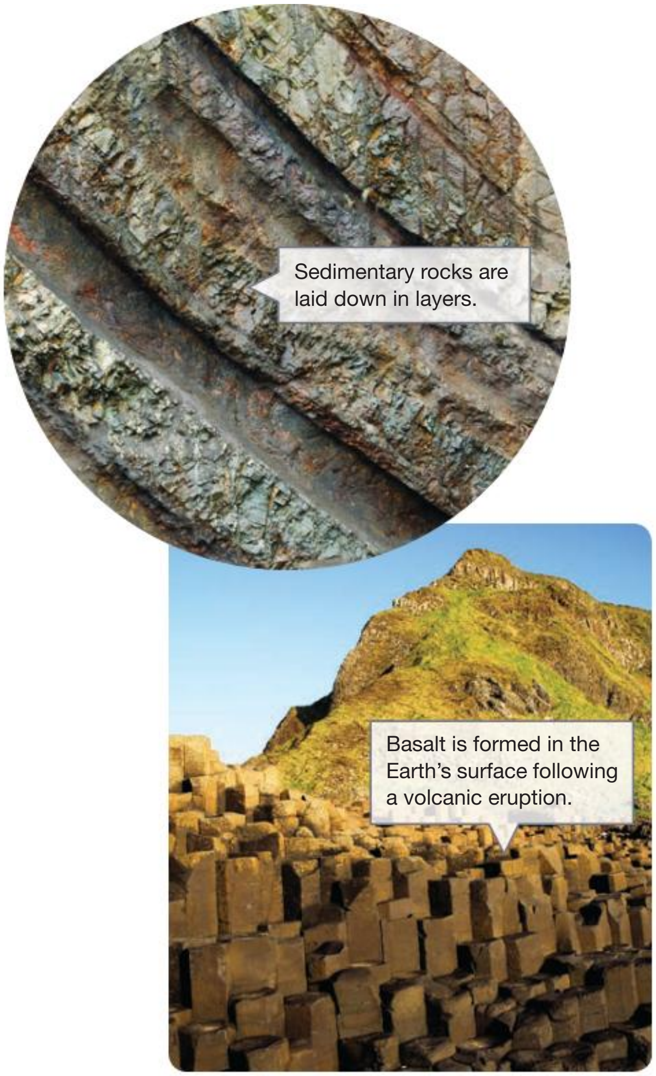


Figure 6.1.6 Geologists classify rocks using characteristics such as how hard they are, their colour, and how they were formed.

Introducing keys

Biologists classify living things. Scientists who specialise in grouping and naming living things are known as **taxonomists**, and the science of grouping and naming things is called **taxonomy**. Once the characteristics of organisms have been described this information can be used to develop a key. A key is a tool that can then be used to identify unknown organisms.

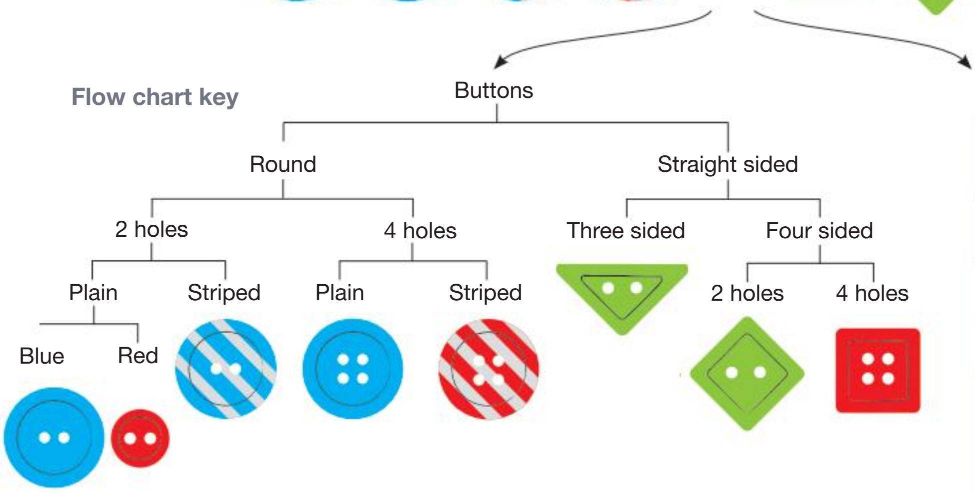
The simplest type of key is a dichotomous key. The word *dichotomous* means *cut in two*. A **dichotomous key** is a series of choices that leads to the identification of an object. At each stage of using a dichotomous key you are given two choices. Each choice leads to another two choices and so on, until there are no more choices and the object is identified.

Keys work best if the features used to make the choices are easy to observe, with everyone knowing exactly what they mean. Take height as an example. A person's height is easy to observe, but words such as tall or short can be interpreted in different ways. You would probably describe someone taller than you as 'tall'. As Figure 6.1.7 shows, that same person might be described as short by an even taller person. Therefore tallness is not a good and reliable feature for a key. Descriptions of height such as 'greater than 1.5 metres in height' are more reliable.

Figure 6.1.7 Qualitative descriptions, such as tall or short, are subjective, with different interpretations, but quantitative measurements are not.

Two ways of writing keys are as flow charts or tables. Buttons have been used to construct the two keys shown in Figure 6.1.8 on page 232.

Figure 6.1.8 These buttons can be classified using different keys.



Flow chart key

Table key

1a	Has a round shape	Go to 2
b	Has straight sides	Go to 6
2a	Has 4 holes	Go to 3
b	Has 2 holes	Go to 4
3a	Striped	
b	Plain coloured	
4a	Striped	
b	Plain coloured	Go to 5
5a	Blue	
b	Red	
6a	Three-sided	
b	Four-sided	Go to 7
7a	Two holes	
b	Four holes	

SciFile

Harmless or deadly?

It is important to be able to tell the difference between Australian snakes so that the correct antivenom can be given for a snake bite. Of the world's top ten deadliest snakes, six are native to Australia. These include the brown snake, death adder and copperhead. At the top of the list is the inland taipan whose venom is the most deadly in the world.

Strong keys

Some features or characteristics are better to use in a key than others. Size, colour and shape can change as an organism grows and develops, or may vary within the same kind of organism. Structural features make a much stronger key that can be used at any time, regardless of age of the organism. It is easy to construct a strong key for something like the buttons because they do not change. People and other living things do change with time and environmental conditions. If a key is to be used both now and at some time in the future then it has to use features that will not change.

Look at the two faces in Figure 6.1.9. There are two easily observed differences between these two girls. Only one has a pony tail, and therefore long hair. The other has short hair and no pony tail. One has blue eyes and the other brown eyes. You could use any of these differences to separate them in a key; however, only one of the differences would give you a strong key. The girl with the pony tail and long hair could wear her hair down or cut her hair short. The other girl could grow her hair longer. One difference will always be the same—the difference in eye colour. It is the difference in eye colour that will give you a strong key.

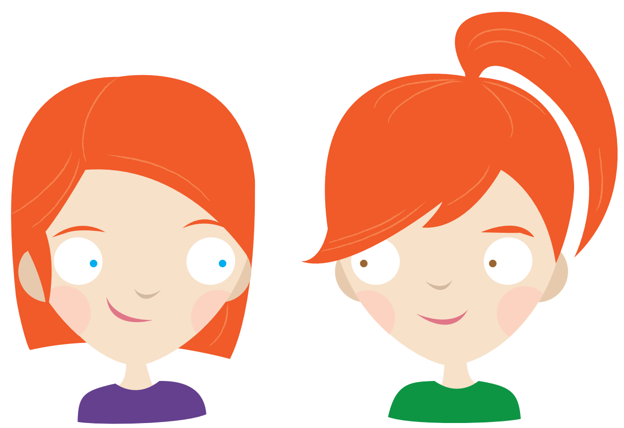


Figure 6.1.9 Characteristics for a strong key should be easy to observe and not change over time. Consider the differences you can observe between these two girls.

Prac 1 p. 236 | Prac 2 p. 236 | 6.1 | 6.2 | 6.3

WORKED EXAMPLE
Constructing a dichotomous key

Problem

Use the four shapes in Figure 6.1.10 to create a dichotomous key.

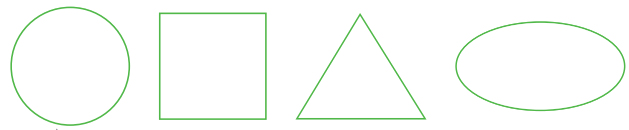


Figure 6.1.10

Solution

Both a table key (Figure 6.1.11) and a flow chart key (Figure 6.1.12) can be constructed using these shapes.

1a	Has straight sides	Go to 2
b	No straight sides	Go to 3
2a	Has four sides	Square
b	Has three sides	Triangle
3a	All diameters are equal	Circle
b	Diameters are not all equal	Oval

Figure 6.1.11 Table key

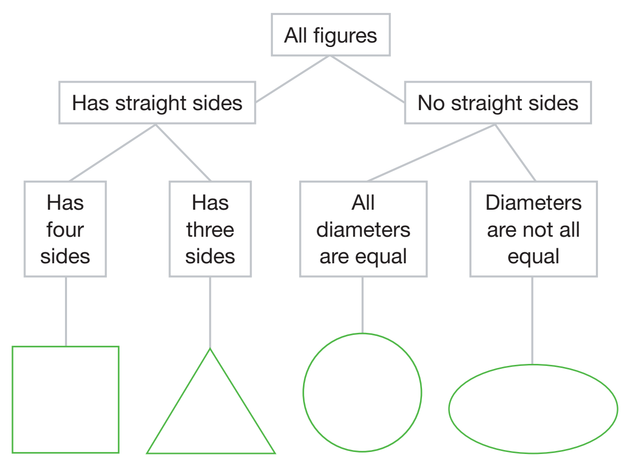


Figure 6.1.12 Flow chart key

Practice

Triangles can be classified as equilateral, isosceles or scalene. Equilateral triangles have three equal sides and angles. Isosceles have two equal sides and angles. Scalene triangles have no equal sides or angles. **Construct** a table key and a flow chart key that could be used to classify triangles.

6.1 Unit review

Remembering

1 **State** why we need to group things together.

2 **Name** the type of key in which there are two choices at each step.

3 **Name** the type of scientist who names and classifies living things.

4 In the science4fun activity on page 228, the contents of a pencil case are classified.
- a **State** two criteria that could have been used to produce strong keys in this activity.
- b **State** a criterion that would not have produced a strong key.

Understanding

5 **Explain** how classification makes shopping at the supermarket easier.

6 **Explain** what is meant by a *strong key*.

7 **Predict** what could happen if a key used features that were not obvious or reliable.

8 a Some plants are called *weeds* while others are not. **Describe** how you could decide whether something is a weed or not.
- b Would *weed* or *not a weed* be a good alternative to use in a key? **Explain** your answer.

Applying

9 a **Use** the key shown in Figure 6.1.13 for 'Form of transport' to **describe**:
  - i a motorbike
  - ii rollerblades.
- b **Modify** the key so that it includes a tricycle.

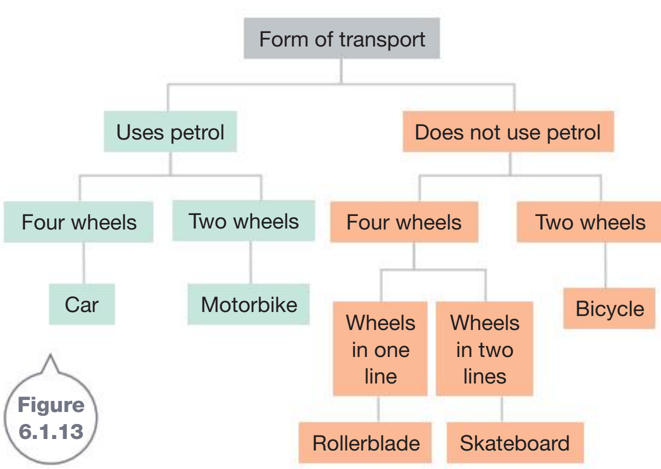


Figure 6.1.13

10 The shapes in Figure 6.1.14 could be grouped in more than one way. **Identify** the structural features that would best separate these shapes into classification groups.

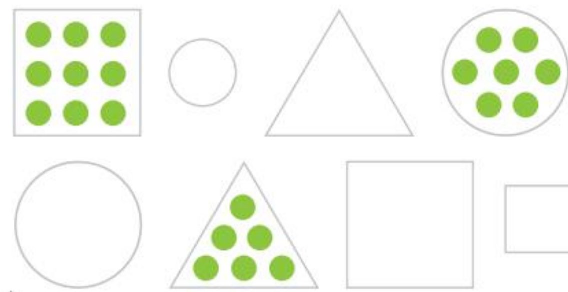


Figure 6.1.14

Analysing

11 **Classify** the following objects into three groups.

pencil	boot
book	chalk
comic	shoe
crayon	sandal

12 a **Classify** the five objects shown in Figure 6.1.15 into two groups in at least three different ways.
- b For each grouping, **describe** the features you used for the grouping.
- c **Discuss** the usefulness of each feature you chose.

Figure 6.1.15

13 **Compare** how easy it is to use table keys and flow charts.

14 **Analyse** the cars in a car park and **list** characteristics that could be used to classify them.

Evaluating CCT

15 In the property section of some newspapers, houses are listed under their suburbs.

- **a** **Explain** how this makes it easier for people to buy a house.
- **b** **Propose** other ways houses could be listed.

16 **a** In the key shown in Figure 6.1.16, **identify** which features make it a strong key and which are not useful.

- **b** **Justify** your decisions.

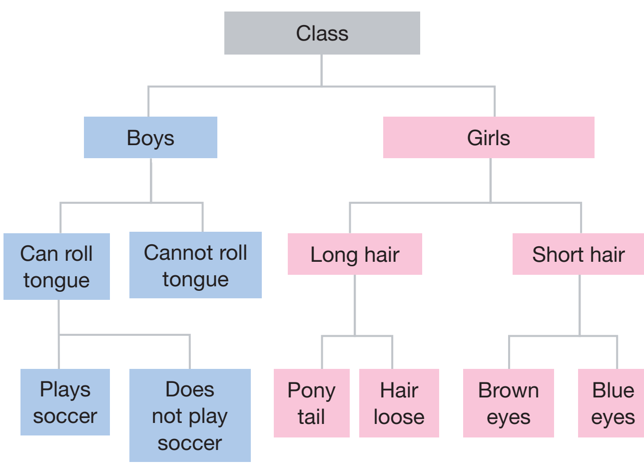


Figure 6.1.16

17 **a** **Identify** which of the following characteristics would be useful when constructing a key to identify varieties of dog:

- loud bark/quiet bark
- pink tongue/black and pink tongue
- short hair/long hair
- large ears/small ears
- wags tail/does not wag tail
- black/brown
- straight hair/curly hair
- hair hangs over eyes/hair not over eyes.

b **Justify** your choices.

Creating CCT

18 **Construct** a key using these terms:

cricket	playing field
soccer	tennis racquet
chess	netball
tennis	hockey stick
squash court	

19 **a** **Construct** keys that could be used to identify the objects from Figure 6.1.14 and 6.1.15.

- **b** Share your key with other members of the class. **Compare** the choices that were used.

Inquiring

1 In most newspapers there is a section for advertisements called 'Classifieds'.

- Recall the meaning of the word *classification*. L
- List some of the headings used in this section.
- Explain how the headings help people find what they want to buy.
- Research how eBay, the *Trading Post* and Gumtree classify what is being sold online. ICT
- Compare the key used in the newspaper with one of those sites.

Present your findings as a list of answers to the above tasks.

2 Visit two or more supermarkets to research the way:

- the meat is classified
- frozen foods are classified.

Present your research as a plan that could be used by the workers who stack the goods into these fridges and freezers.

6.1 Practical investigations

1 Sorting pasta

Purpose

To construct a dichotomous key using pasta.

Materials

- 6 different types of pasta
- paper and pencil

Procedure

1 Describe each type of pasta, making a note of the similarities and differences.

2 Use the differences to construct a dichotomous key.

Results

Present your key as both a table and a flow chart.

Practical review

1 **Describe** any difficulties you had in sorting the types of pasta.

2 **Explain** why you selected the characteristics you used to create the key.

3 Ask another student to try using your key. Afterwards, **discuss** with them any improvements you could make to the key.

STUDENT DESIGN

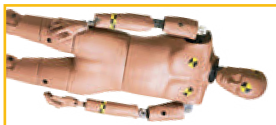
2 Class key

Purpose

To construct a dichotomous key to identify each member of the class.

Materials

- class members



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Brainstorm and list differences that could be used to distinguish between class members.

2 Decide if these differences would make a strong key.

3 When you have decided on the first choice, the members of the class should form the two groups.

4 For one of these groups, decide on the next choices that will allow each student to be identified.

5 Repeat for the other group.

6 Record the choice used at each step.

7 Construct the key showing this classification.

8 Some less obvious characteristics that could be used to classify the class are:

- ability to roll tongue
- ear lobes attached or free
- length of second toe compared to big toe
- dimples in cheek
- dimple in chin
- widow's peak.

9 Now use these characteristics to organise the class first into two groups, then four, then eight and so on.

Practical review

1 **Explain** why a class member who is absent on the day the key was created could not be identified using the class key.

2 **Predict** what would happen if you tried using the key to identify that class member.

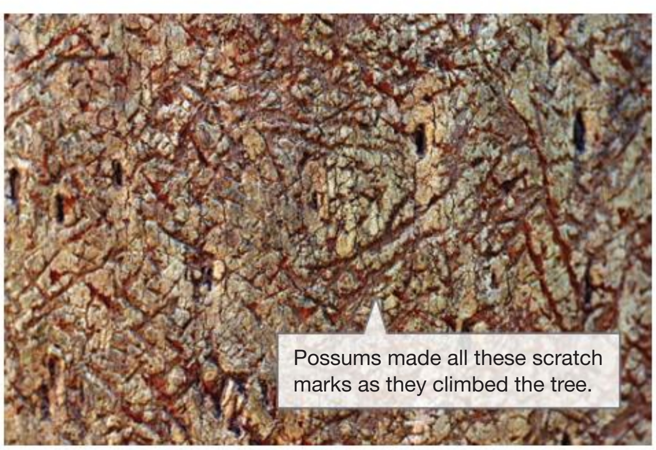
6.2 Animal kingdom

About 1.7 million different types of living things or organisms that live on Earth have been identified and described. It is easier to find products in a supermarket when they are grouped, and in a similar way it's easier to describe and talk about all the living things on Earth if they are sorted into groups. Taxonomists classify organisms into groups by using the characteristics they have in common. One group you probably already know something about is the animal kingdom.

INQUIRY science 4 fun

Evidence of animals

Can you tell if animals are present even if you cannot see them?



Possums made all these scratch marks as they climbed the tree.

Collect this ...

- a magnifying glass (optional)
- notepad and pen or digital camera.

Do this ...

1. Make careful observations as you walk to and from school, wander round the school grounds, go to a park, beach or for a walk in the bush.
2. Record evidence that animals have been there. The evidence could include holes in leaves where they have been eaten, footprints, soil and gravel thrown up by ants making a nest, scratches on bark where claws have been used to climb trees, and shells or crab sand balls on the beach.

Record this ...

Describe the place or places where you saw most evidence of animal activity.

Explain why the animals were likely to have been there.

Kingdom

The first level of classification sorts living things into a small number of groups. Each group has a very large number of organisms in it, and each organism shares important characteristics with others in their group. Although similar in many ways, the organisms in each group still have many, many differences. **Kingdom** is the name given to the group at this first level of classification.

Taxonomists have sorted all living things into five kingdoms. One kingdom is the animal kingdom. You could probably produce a long list of animals that would include kangaroos, rosellas and snakes. However, bees, worms and jellyfish are animals too. Four members of the animal kingdom are shown in Figure 6.2.1.

Figure 6.2.1

The boy and his dog are both members of the animal kingdom, as are the frog and the bee sitting on its head.

The organisms of the animal kingdom are then divided into smaller groups according to the characteristics of the animal.

Animal phyla

Animals are often described as **vertebrates** (animals with backbones) or **invertebrates** (animals without backbones). Although this difference is very important, these terms are not always used in the scientific classification of animals. Scientists have made a large number of observations of living things. The presence or absence of a backbone is only one of the observations.

Using the similarities and differences these observations reveal, taxonomists have grouped all the known members of the animal kingdom into nine smaller groups. Each of the smaller groups is known as **phylum** (plural **phyla**). The nine phyla are shown in Figure 6.2.2.

Animals
- Poriferans
- Cnidarians
- Echinoderms
- Annelids
- Nematodes
- Platyhelminths
- Molluscs
- Arthropods
- Chordates

Figure 6.2.2

Eight of the animal phyla in this key do not have backbones. The phylum Chordates includes all the animals with backbones.

Poriferans

Poriferans are commonly called sponges. A typical sponge is shown in Figure 6.2.3.

Poriferans live in the water and most are found in marine environments. They are full of holes (pores) through which water passes, carrying their food. They filter the food out of the water, and for this reason they are known as filter feeders. The wastes along with water are pushed out through an opening at the top of the sponge.

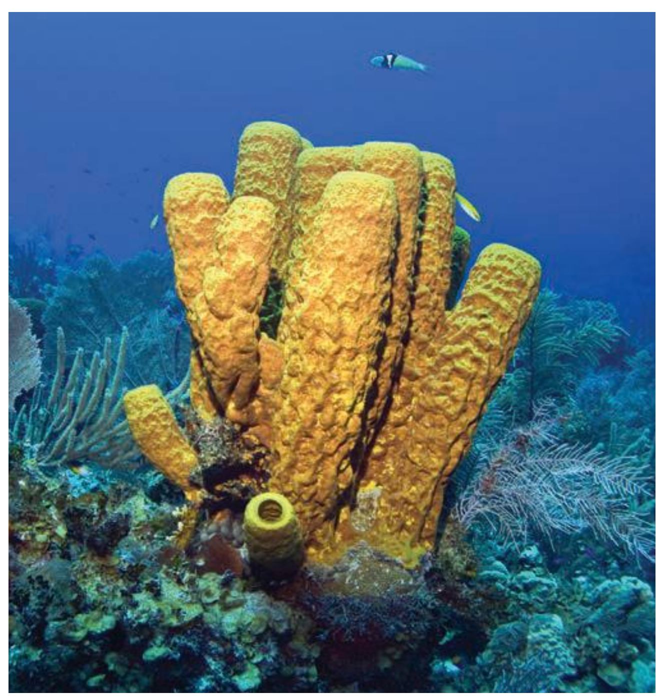


Figure 6.2.3

This yellow tube sponge grows to about 80 cm tall. It pushes so much water through its body as it feeds that divers can feel a current of water near the top of it.

Cnidarians

Jellyfish, sea anemones and coral polyps belong to the **cnidarians**. They have radial symmetry and only one body opening. Food goes into the body through this opening and waste comes out of the same opening. Cnidarians have stinging cells, which they use to catch food. Cnidarians are not interested in using humans for food, but the poison from their stinging cells will cause you intense pain (and in some cases could kill you) if you get tangled in their tentacles. Figure 6.2.4 shows one particularly deadly species of cnidarian.

Figure 6.2.4 The venom produced by the stinging cells of the box jellyfish (*Chironex fleckeri*) is one of the most poisonous in the animal kingdom. The poison causes the animals that tangle in the tentacles to have a heart attack. This can happen to humans too. The box jellyfish is responsible for 100 human deaths per year.

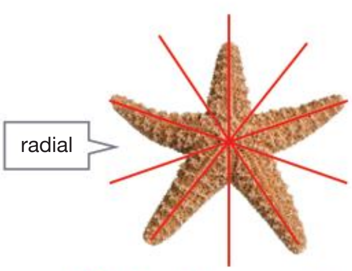
SKILL BUILDER

Symmetry in organisms

Organisms are often described as having radial symmetry or bilateral symmetry.

Radial symmetry

A cut in any direction through the middle will result in identical halves.



Bilateral symmetry

There is only one position where a cut produces identical halves.

Echinoderms

Starfish, brittlestars, sea urchins and sea cucumbers belong to the **echinoderms**. They all live in the ocean, often near the coast. Starfish, brittlestars and sea urchins have a spiny skin, which you can see in Figure 6.2.5, but the skin of sea cucumbers is leathery. One thing common to all echinoderms is that they have radial symmetry.

Figure 6.2.5 There are over 6000 species of echinoderm. This picture shows two species: an orange starfish, and the black spines of a sea urchin. All echinoderms have a chalky layer under their skin, which forms a protective armour.

Annelids

The most familiar **annelid** is the earthworm, shown in Figure 6.2.6. Other annelids are leaches and ragworms (often used as bait for fishing). Look closely at an annelid and you will see rings along the length of its body. These rings are segments or divisions within the body, and give the group their common name of 'segmented worms'. These animals have bilateral symmetry. Annelids are found in water and in damp places on land.

Figure 6.2.6 Annelids have two body openings—one at the front where food enters and one at the back from which wastes leave.

Nematodes

Nematodes are 'roundworms'. They have bilateral symmetry like annelids, with long tapered bodies that are pointed at each end, but they do not have segments. They are commonly found in damp soil, in water, and as parasites in the bodies of other organisms. **Parasites** are organisms that live on or in another organism, called a host. They get their food from the host, but the host gets nothing in return and may be harmed. Heart worm, a common disease of dogs, is caused by a nematode. Even humans can be hosts to parasitic nematodes, like the one shown in Figure 6.2.7.

Figure 6.2.7 *Ascaris lumbricoides* is a parasitic nematode that inhabits the human intestine. They can grow up to 35 cm in length. You would know if you were infected with them because they cause stomach pain, vomiting and diarrhoea.

Platyhelminths

Platyhelminths are flatworms. They have bilateral symmetry with the body flattened top to bottom (Figure 6.2.8). They live in water or very moist places.

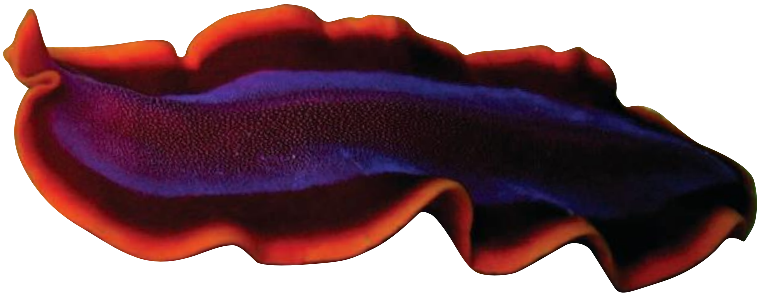


Figure 6.2.8 There are over 12 000 species of platyhelminths. Some are scavengers, cleaning up the wastes in the oceans and waterways, some eat microscopic animals, but many are parasites.

Molluscs

Molluscs are members of the second largest phylum in the animal kingdom. Snails, slugs, oysters and mussels belong to this group. All of them live in water or in very moist places. They come in a wide variety of shapes and sizes, but all have bilateral symmetry, have well developed internal organs, and have a muscular foot which they can use to move along. Some molluscs have a shell for protection like the snail in Figure 6.2.9.

Figure 6.2.9 The protective shell of the snail is clearly visible. What cannot be seen is the rough tongue-like structure the snail uses to rip apart the leaves on which it feeds.

Arthropods

Arthropods form the largest animal phylum, with over one million species described. This phylum includes:

- insects
- scorpions and spiders (Figure 6.2.10)
- crustaceans like prawns, crabs, lobsters and Balmain bugs.

Figure 6.2.10 Flies and spiders, crabs, prawns and millipedes are all arthropods.

Arthropods are found everywhere—on land, in the air and in water. They are able to survive on dry land because they have a waterproof **exoskeleton**—a skeleton on the outside of the body. The skeleton does not bend, so the limbs of arthropods (legs and antennae) are jointed to allow the animals to move. Inside, the body is divided into segments. These are sometimes visible as lines across the exoskeleton.

6.4

Chordates

Most of the larger animals you see around you can be described as vertebrates. Dogs, cows, birds, fish and humans are all vertebrates. All vertebrates belong to the same phylum, the **chordates**.

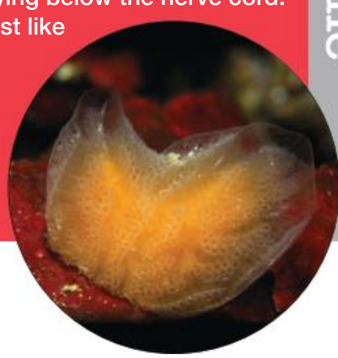
Chordates have a nerve cord running down their backs, which gives this group its name. Most chordates have skeletons inside their body (an **endoskeleton**), and most of the chordates have a series of small bones protecting the nerve cord. The small bones are called **vertebrae**, and together they are called the **vertebral column** or backbone. The group of chordates that has a backbone is commonly called the vertebrates. The bird shown in Figure 6.2.11 is an example of a chordate.

Figure 6.2.11 Birds are examples of chordates. They have a spine and spinal cord.

SciFile

Spineless?

All chordates have a nerve cord but not all have a backbone to protect it. Some have a rod of cells known as a notochord lying below the nerve cord. Adult sea squirts look just like a bag of jelly. They filter food from the water and then squirt out the water when they are finished with it.



All chordates have bilateral symmetry. They are divided into classes based on a range of characteristics that includes the way they breathe, their skin covering, body temperature, and how they reproduce. The eight classes of chordates are shown in Figure 6.2.12.

Chordates
- Chordates without backbones
- Agnatha
- Chondrichthyes
- Osteichthyes
- Amphibians
- Reptiles
- Aves
- Mammals

Figure 6.2.12 Classes of chordates

There are three classes of chordates that are commonly called fish: Agnatha, Chondrichthyes and Osteichthyes. They all live in water and breathe using gills. They are **ectothermic**, which means that their body temperature varies with the temperature of the water they live in.

Agnatha

The **agnatha** are jawless fish. There are many fossils of jawless fish, but the only living representatives are hagfish and lampreys like the one in Figure 6.2.13. They have an internal skeleton made of **cartilage**. This is more flexible than bone—it is cartilage in the wobbly bit at the end of your nose. Agnatha have a fin along their backs. Their mouth is a round sucker, lined with horny teeth, which they use to attach themselves to other fish. All agnatha are parasites.

Figure 6.2.13 Lampreys are shaped like an eel. Their mouth is like a suction cup that attaches the parasite to its host. The horny teeth inside the sucker scrape the skin away so that the lamprey can suck blood.

Chondrichthyes

Sharks and rays belong to the class of chordates called **chondrichthyes**. Their skeleton is also made of cartilage, which gives them their common name of cartilaginous fish. Unlike the jawless fish, they have proper jaws and teeth. Sharks and rays have fins on the side of their bodies as well as along their backs as shown in Figure 6.2.14, and this helps them to be agile swimmers.

Figure 6.2.14 Rays are members of the class Chondrichthyes. Their side fins are extended to resemble wings.

Osteichthyes

The **osteichthyes** are bony fish. They have fins on the back and sides of their body and have proper jaws and teeth. What makes them different from the other fish is their skeleton made of bone. Tuna, goldfish, eels, sea horses and lungfish all belong to this group. Figure 6.2.15 shows a barramundi, an example of a bony fish.

Figure 6.2.15 The barramundi (*Lates calcarifer*) is found in river estuaries and in the ocean around the north of Australia, from Fraser Island, Qld in the east around to Shark Bay, WA in the west.

6.5

Amphibians

Frogs, like the one shown in Figure 6.2.16, toads, newts and salamanders are all amphibians. **Amphibians** are chordates that live both in and out of water. Their eggs are laid in water, and the larvae or tadpoles must live in water because they breathe through gills. The body then changes shape in a process called metamorphosis, allowing the adult to live on land, breathing air using lungs. Their lungs are not very effective, and amphibians also take in oxygen through their skin. To be able to do this their skin must remain moist.

Figure 6.2.16 Amphibians must keep their skin moist, and usually live near water or in very moist places. They are all ectothermic, and therefore they are not found in very cold areas.

Reptiles

Reptiles such as snakes (Figure 6.2.17), crocodiles and lizards are ectothermic, and have a dry, scaly skin. They breathe using only their lungs. Generally they lay eggs with a leathery shell on land. While most spend their whole life cycle on land, there are exceptions. Sea snakes spend all their lives in water, and some cannot move on land at all. Sea snakes do not lay eggs; instead they give birth to live young. Some land snakes and lizards also do this.

Figure 6.2.17 The common death adder (*Acanthophis antarcticus*) is widespread throughout New South Wales. They feed on small animals such as frogs and birds but are not shy of humans and may attack if disturbed.

Aves

Aves is the biological name for birds. Birds are different from other groups because they have feathers covering their body and lay hard-shelled eggs. All birds have wings, including those that can't fly, like the penguins in Figure 6.2.18. (Bats are the only other chordates with wings, but they are mammals.) Birds are **endothermic**, meaning that they generate their own heat and are able to control their body temperature. This allows them to remain warm in cold environments.

Figure 6.2.18 Most birds can fly, even birds as big as flamingos (*Phoenicopterus roseus*). Although penguins, such as this Humboldt penguin (*Spheniscus humboldtii*), cannot fly, they move their wings to swim in the same way as other birds move their wings to fly. Penguins are, in effect, flying underwater.

Mammals

The class **Mammals** includes all the animals that have a body covering of hair, and feed their babies on milk produced by the mother. Like birds, mammals are endothermic. Mammals are divided into three subclasses based on the way they reproduce. All three of these subclasses are represented by animals found in Australia.

- **Placentals** are mammals that nourish the baby inside the mother's body by a placenta and the baby is born at a more mature stage. Placental mammals include seals, dingoes, horses, humans, humpback whales and flying foxes (Figure 6.2.19).
- **Monotremes** lay eggs; this subclass consists of two species of echidna (one species is shown in Figure 6.2.20) and the platypus.
- **Marsupials** such as the wombat in Figure 6.2.21 give birth to a tiny undeveloped young that climbs into the pouch where it is fed on milk. The young marsupial grows and completes its development in the pouch.

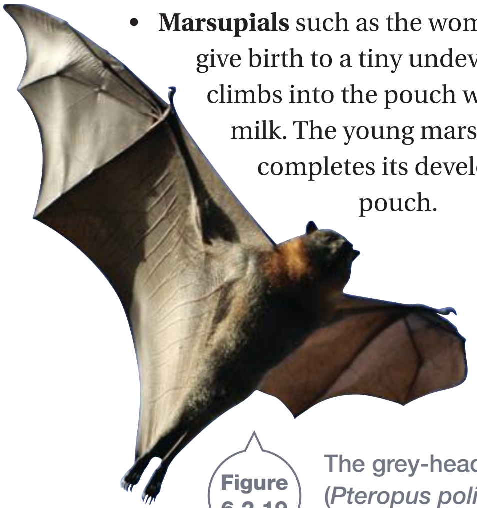


Figure 6.2.19 The grey-headed flying fox (*Pteropus poliocephalus*) is a placental mammal found in Australia.

Figure 6.2.20 A short-beaked echidna (*Tachyglossus aculeatus*) is a mammal that lays eggs—a monotreme. Monotremes are found only in Australia and New Guinea.

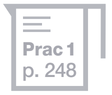


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Figure 6.2.21 The hairy-nosed wombat (*Lasiorhinus krefftii*) is one of the 140 species of Australian marsupials. Most of the world's species of marsupials are Australian.

ADDITIONAL

LEARNING ACROSS THE CURRICULUM

CRITICAL AND CREATIVE THINKING

Figure 6.2.22 When explorers first described a platypus it caused problems for taxonomists.

IS THIS A REAL ANIMAL?

Leading up to the seventeenth century, naturalists in Europe had described, named and classified many living things. They were confident that they understood the animal kingdom and that their classification system would be able to include any new species that were discovered. Explorers to Africa and America tested these ideas when they brought back creatures never seen before, such as giraffes, opossums, hippopotamuses and armadillos (Figure 6.2.23). A bigger stir was yet to come!

Figure 6.3.23 Animals such as the armadillo (*Dasypus novemcinctus*) and the hippopotamus (*Hippopotamus amphibius*) tested European scientists' systems of classification.

In 1798 the Governor of New South Wales, John Hunter, watched an Aboriginal hunter spear a small amphibious creature in the Hawkesbury River, near Sydney. Hunter sent the skin to England, where scientists described this strange creature as having characteristics of a fish, bird and quadruped (four-footed animal). It was about the size of a cat, had a bill like a duck, four short legs and webbed feet. They had not seen anything like it before and it did not fit into their classification system.

Other specimens of skins, like the one in Figure 6.2.24, and skeletons arrived and were examined by Dr George Shaw, an experienced naturalist. He wondered if the animal was a hoax or trick. At that time, Chinese sailors had a reputation for their skill in stitching together parts of different animals to create a non-existent animal that they then sold to European sailors. Despite very close examination, George Shaw could not find any evidence of this being a hoax. There were no cut marks or stitched parts.

Figure 6.2.24 Using dried skins like this one, European scientists tried to imagine what a platypus looked like and how it lived. It is not surprising that they were confused at first.

Complete, preserved specimens arrived in 1800, accompanied by descriptions from people who had observed the animal. Shaw was then able to confirm that the animal was no hoax and no freak of nature. It was a new type of animal. The question then became whether it was a mammal. The animal:

- had fur like a mammal
- was warm-blooded (endothermic) like a mammal and a bird
- had a beak like a bird
- lived in water like an amphibian.

At this stage the scientists did not know that the platypus laid eggs (like a bird or reptile) and produced milk for its young (characteristic of a mammal). It was many years before scientists were able to gather all the information they needed to describe this new animal in detail and decide how to classify it. A new group of mammals was created—the monotremes. This group includes the platypus (shown in Figure 6.2.25) and echidna.

REVIEW

1 **Explain** why scientists first thought that the skin of the platypus was a hoax.

2 **Propose** why the classification systems of the eighteenth century were not able to include animals such as the giraffe, the kangaroo or the platypus.

3 **Discuss** reasons for the platypus being so difficult to classify.

SciFile: Using electricity

When the platypus dives to find food it closes its eyes and nostrils. It cannot see, nor can it smell its prey. The platypus searches for food using its electro-sensitive beak. The beak is so sensitive it can detect tiny electrical signals from the muscles of small arthropods and worms as they move around.

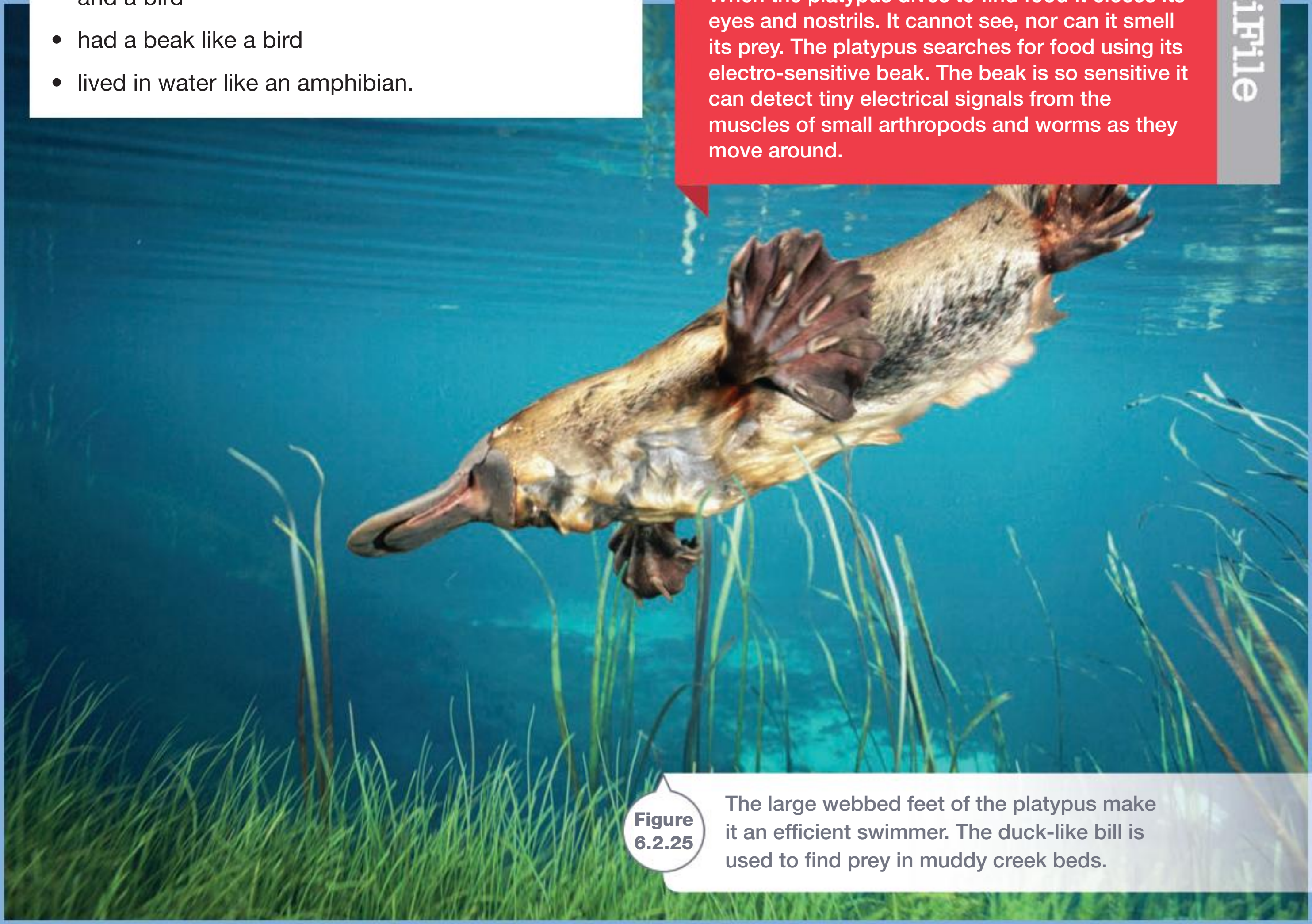


Figure 6.2.25 The large webbed feet of the platypus make it an efficient swimmer. The duck-like bill is used to find prey in muddy creek beds.

6.2 Unit review

Remembering

1 **List** the nine phyla of animals.

2 **Name** the phylum that describes the largest number of types of animals.

3 **Name** the phylum to which humans belong.

4 **List** evidence that would show that animals are living in the garden.

Understanding

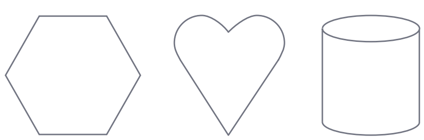
5 **a** **Describe** the difference between an exoskeleton and an endoskeleton.
b **Name** a group of animals that has an exoskeleton.
c **Name** a group of animals with an endoskeleton.

6 **Explain** why frogs need to live in damp places but lizards can survive in dry areas.

Applying

7 **a** Copy Figure 6.2.26 into your workbook, then **modify** it to show their lines of symmetry.
b For each diagram, **identify** whether it represents radial or bilateral symmetry.

Figure 6.2.26



8 An African elephant can have a mass of 5000 kg and the mass of a blue whale can reach 190 000 kg. **Calculate** the number of times heavier a blue whale is than an elephant. N

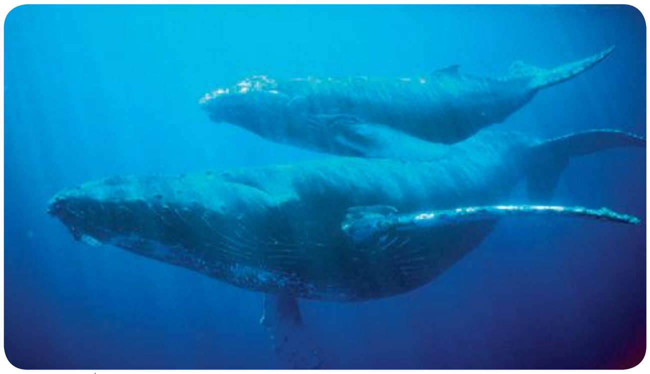


Figure 6.2.27 The largest mammal on Earth is the blue whale.

Analysing

9 **Compare** annelids with nematodes by listing their similarities and differences.

10 **Contrast** an endothermic animal with one that is ectothermic.

11 **Compare** the characteristics used to classify:
a a shark and a barramundi
b a frog and a lizard
c a kangaroo and a platypus.

12 **Contrast** platyhelminths and nematodes.

13 **Use** the following description to **classify** the organism.

This organism was collected from the ocean. It has a soft body with long tentacles. After I touched the tentacles my hand was stinging.

Evaluating CCT

14 Examine the animals shown in Figure 6.2.28.
a **Classify** each into a phylum.
b **Justify** your decisions.

i

ii

Figure 6.2.28

15 **Propose** reasons why animals without a skeleton often live in water.

16 **Select** information from the pages on animal classification to complete the table below.

Phylum	Where it lives	Symmetry	Number of body openings	Type of skeleton	Other features

Creating CCT

17 Copy the Venn diagram in Figure 6.2.29 into your workbook. **Use** this to **compare** the three chordate classes commonly called fish.

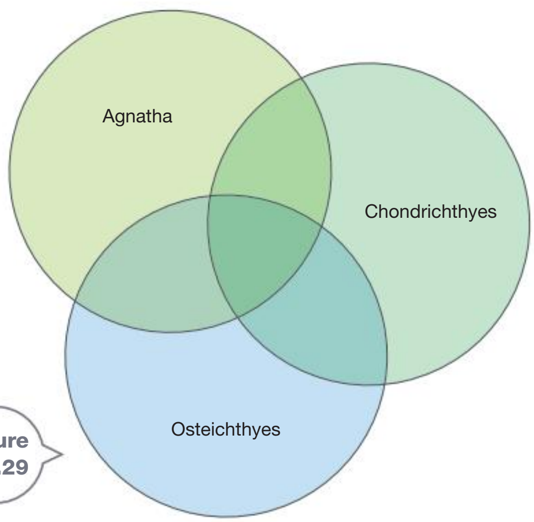


Figure 6.2.29

18 **Construct** a mnemonic to help you remember the animal phyla.

Inquiring

1 Research the platypus to find answers to the following questions.
- What does it feed on?
- Where does it nest and have its young?
- Does it incubate the eggs like a bird? If not, how does it protect its young?
- How does it feed its young?

Add some more of your own questions to the list.

Present your findings as a set of answers to the questions.

2 Find how the stings on the tentacles of jellyfish work.

Present your findings as a set of labelled diagrams.

3 Research an animal of your choice. Find:
- which phylum it belongs to
- the structural features that place it in that phylum
- where it lives
- how it feeds and what it feeds on
- ways in which it is important for humans
- another five animals that belong to the same phylum
- differences between these five animals and the animal you researched.

Present your research as a poster, information leaflet or PowerPoint presentation. ICT

4 Research the arthropods.
- Find out the ways in which taxonomists divide the arthropods into smaller groups known as classes.
- List the characteristics used by scientists to separate the classes.
- Find images or video of animals in each class.
- Identify two classes of arthropods that include animals that can be harmful to humans.
- Explain why these harmful animals (and other members of the class) are important in other ways.
- Construct a dichotomous key for the phylum.
- Have other members of the class use your dichotomous key. Evaluate the usefulness of your key based on feedback.

Present your findings as a poster or digital presentation. ICT

6.2 Practical investigations

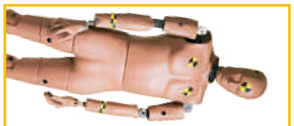
1 Classifying animals

Purpose

To use structural features to classify animals into their different phyla.

Materials

- multiple photos or printouts of animals from the 9 different phyla (at least 2 animals per phylum)
- assorted skeletons, shells, preserved specimens, fossils



SAFETY

The liquids used to preserve some older animal specimens are hazardous so do not use any specimens preserved this way.

Procedure

1 Copy the table from the Results section into your workbook.

2 Around the laboratory are photos, skeletons, preserved specimens and fossils of a variety of different animals. Move around the laboratory and for each animal record:
   - its name/s (common and/or biological)
   - the type of specimen you looked at (photo, skeleton, preserved specimen or a fossil)
   - its distinctive characteristics and structural features.

Results

1 Use your observations to complete the results table. An example has been provided for you as a guide.

2 Use the characteristics and structural features to identify the phyla for each animal you looked at.

Animal	Specimen type	Characteristics or structural features	Phyla
e.g. starfish	e.g. preserved	e.g. radial symmetry	e.g. echinoderm

Practical review

1 a **Name** the phyla that were easiest to identify.
  b **Explain** what made them easy to identify.

2 **Name** any phyla that might easily be confused with one another.

3 a **List** any difficulties you had in classifying the animals.
  b **Explain** a situation where one of these difficulties led to an incorrect identification.

6.3 Other kingdoms

You are probably familiar with plants as a group but may not know as many plant names as animal names. It is likely that you will have seen fungi in the form of mushrooms you eat and bracket fungi on trees. You are less likely to be familiar with organisms from the other two kingdoms – Monerans and Protists – because they can only be seen using a microscope.

INQUIRY science 4 fun

Plants you eat

What parts of plants do you eat?

YES

Collect this ...

- samples or images of various fruits and vegetables such as cauliflower, capsicum, cucumber, pea, celery, carrot, broccoli, apple

Do this ...

1. For each fruit or vegetable, decide which part of the plant it represents. For example, is it the root, stem, leaf, leaf stalk, flower, fruit or seed?
2. Make a list of fruits and vegetables with the name of the plant part beside it.

Record this ...

Describe the part of plants that is most commonly eaten.

Explain why this might be the case.

Plant kingdom

The plant kingdom, like the animal kingdom contains a large number of very different organisms. Some are shown in Figure 6.3.1.

Figure 6.3.1 The tall trees and the ferns growing under them are all members of the plant kingdom. So is the New South Wales waratah, the state flower of New South Wales.

The organisms in the plant kingdom are classified by the way they reproduce and whether or not they have organised systems for transporting substances such as water through the plant.

Instead of the kingdom being subdivided into phyla as in the animal kingdom, the plant kingdom has **divisions**. The divisions are then divided again into classes.

Plant divisions

Figure 6.3.2 shows the divisions and classes of the plant kingdom.

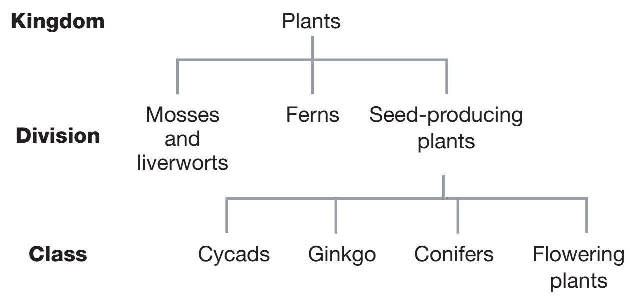


Figure 6.3.2 Key to the plant kingdom

Mosses and liverworts

Liverworts and **mosses** (such as those shown in Figure 6.3.3) are usually very small because they do not have any tissues to transport water or nutrients through the plant. They absorb water from the atmosphere through their leaves. Therefore, they mostly live in damp places where they are not in danger of drying out. Mosses reproduce using single cells called **spores** that grow into a new moss plant.

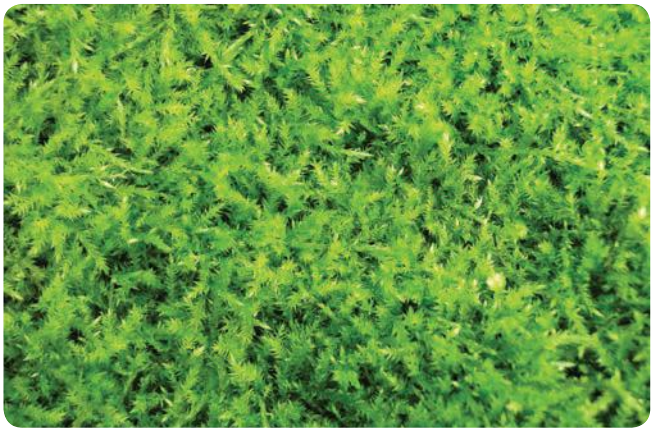


Figure 6.3.3 Mosses are low-growing plants forming a mat on a rock, tree or soil surface.

Spores are produced in special structures known as **sporangia**. Moss sporangia can be seen in Figure 6.3.4. They grow from the top of the leafy moss plant. The spores develop in the capsule at the end of the stalk. When the spores are ripe the capsule opens and the spores are blown out by the wind. When the spore lands in a suitable area, the spore will grow into a new moss plant.

Figure 6.3.4 The capsule and the stalk together form the moss sporangium. The spores develop inside the capsule.

Ferns

Ferns have a vascular system for transporting food and water throughout the plant. They also reproduce using spores produced in structures known as sporangia, like those in Figure 6.3.5.

Figure 6.3.5 The spores are produced in the dark spots (sporangia) on the back of the fern leaf.

Ferns have been around for a very long time. The first ferns appeared on Earth about 360 million years ago – long before flowering plants. Ferns vary in size. Azolla (seen in Figure 6.3.6) is a water fern that is only a few centimetres across. In contrast, tree ferns such as the lacy tree fern in Figure 6.3.7 can grow to a height of 15 metres.

Figure 6.3.6

Azolla may be small but it grows very rapidly. It quickly covers the surface of a pond or lake giving it a pinkish tinge.

Figure 6.3.7

The lacy tree fern (*Cyathea cooperi*) is one of the tallest tree ferns. It is an Australian native plant commonly found in New South Wales.

Largest flower

SciFile

The largest flower in the world is found in South-East Asia. It can be up to one metre in diameter and weigh 11 kg. Its name is *Rafflesia arnoldii*. Its smell is like rotting meat.

Seed-producing plants

Seed-producing plants reproduce using seeds. Seeds are more complex than spores. One cell within the seed becomes the new plant. There are many other cells in the seed. These other cells provide food for the developing plant until the leaves are formed. The division of seed-producing plants has four classes:

- **cycads** (Figure 6.3.8)
- **ginkgo** (Figure 6.3.9)
- **conifers**
- **flowering plants**.

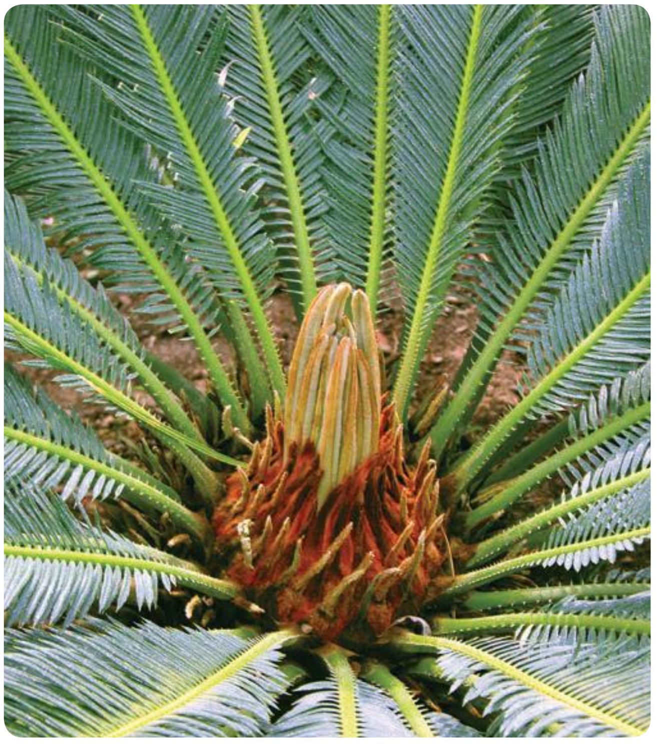


Figure 6.3.8

Cycads have separate male and female plants. The male plant produces pollen in cones. The female cone produces the seed and provides some protection for the seed as it develops.

Figure 6.3.9

Ginkgo biloba is sometimes called the maidenhair fern tree. It is the only living member of its class.

Ginkgos have separate male and female trees. Male trees produce pollen in cones, and female trees produce seeds in fruit with a fleshy, smelly coat.

Most conifers produce the male (pollen-bearing) and female (seed-bearing) cones on the same tree. Cypress, fir and pine belong to this class. Australian conifers include the hoop pine (*Araucaria cunninghamii*), Huon pine (*Lagarastrobos franklinii*) and Wollemi pine (*Wollemia nobilis*).

The Wollemi pine is an ancient tree. It has been found in fossil records dating back 90 million years. Living trees were discovered in 1994 in the Blue Mountains 200 kilometres west of Sydney. You can see a Wollemi pine in Figure 6.3.10.

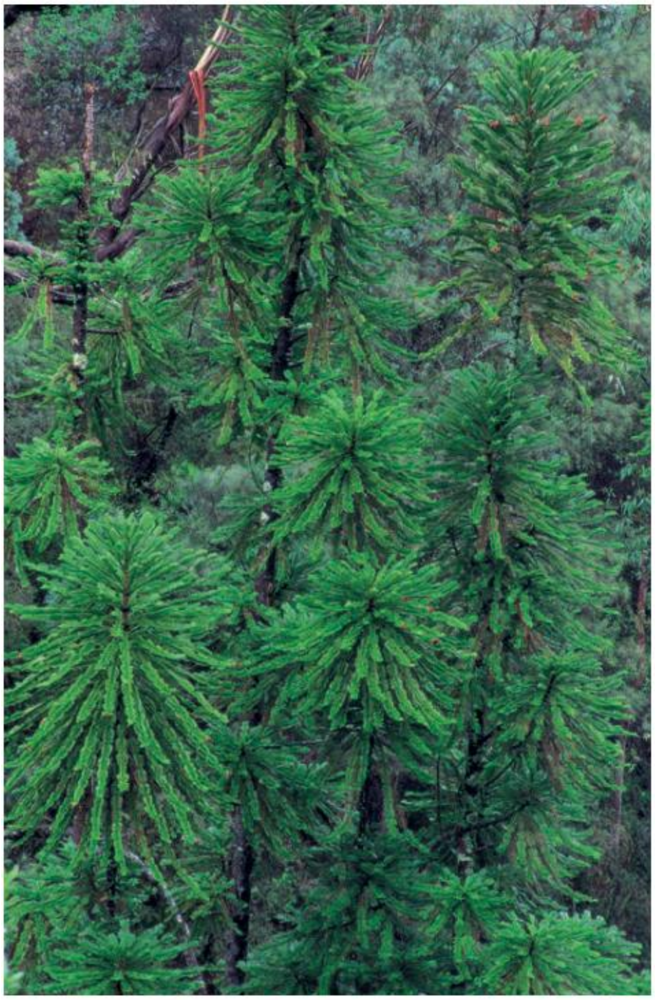
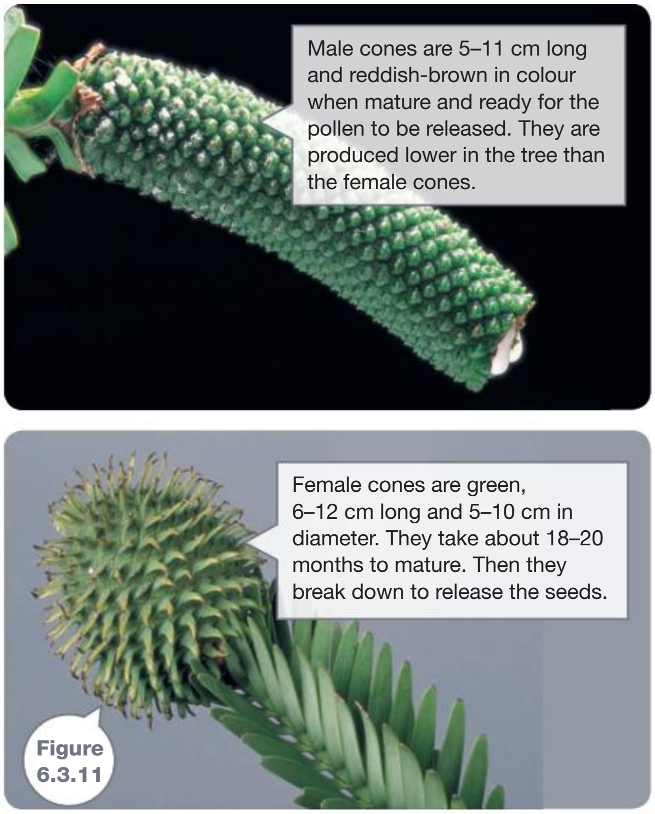


Figure 6.3.10 The Wollemi pine grows to a height of 40 metres. It produces multiple trunks from the base. This characteristic has helped it survive fires and other natural disasters.

Prac 1 p. 258

The male cones and female cones of the Wollemi pine seen in Figure 6.3.11 are produced on the same tree. Each of the points on the female cone is the end of a scale. One seed develops on each scale. The seeds are protected in the cone until ready to be released. Then the mature cone breaks down releasing the seeds. The seeds are small with thin papery wings. The wings help the seeds to blow in the wind.



Male cones are 5–11 cm long and reddish-brown in colour when mature and ready for the pollen to be released. They are produced lower in the tree than the female cones.

Female cones are green, 6–12 cm long and 5–10 cm in diameter. They take about 18–20 months to mature. Then they break down to release the seeds.

Figure 6.3.11

Flowering plants produce seeds fully protected inside the female part of the flower, which is known as the ovary. Many of the flowers produced by flowering plants are used to attract pollinators such as bees, flies, moths, birds or bats. Grasses, with less showy flowers, are pollinated by wind.

SciFile: Tiny flowers

Although this daisy looks like one flower, it is in fact hundreds of florets (small flowers) of two different types. Ray florets make up the parts that look like petals. Disc florets make up the central part.

About 65 per cent of all flowering plants are pollinated by insects. Flowers have many characteristics that help them to attract insects, such as having bright colours, a perfume and nectar.

Shaking the pollen out

SciFile

Hibbertia is a common flower in coastal sand dunes. Its pollen is released by vibrations caused by the buzzing of certain bees. The blue banded bee and many Australian carpenter bees hold on to the plant and buzz, causing the plant to vibrate so the pollen is released.

Nectar is a sugary liquid some insects use as food. When an insect visits a flower to collect the nectar, pollen sticks to its body. The insect then carries the pollen to the next flower. The shape of the flower limits the variety of insects that can pollinate it. For example, nectar at the base of a long tube-shaped flower can only be reached by insects with long mouthparts such as butterflies, moths and bees.

GO TO Pearson science NSW 8 Unit 4.2

6.6

Fungi kingdom

Mushrooms, toadstools and the bracket fungi shown in Figure 6.3.12 are **fungi** that are big enough to be easily seen. Other fungi, such as the yeast in Figure 6.3.13, are so small that they can only be seen through a microscope—they are **microscopic**.

Figure 6.3.12 You may have seen fungi such as these bracket fungi on the trunks of dead trees. The blue-green mould growing on this orange is also a fungus.

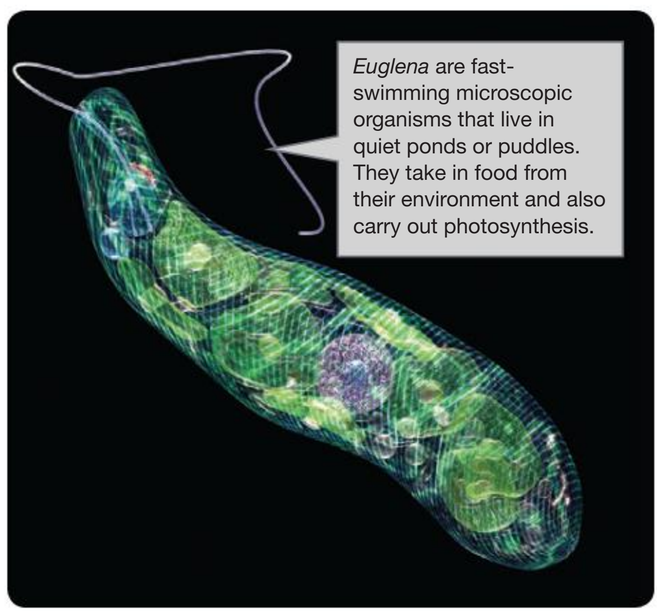
Figure 6.3.13 Yeast is a fungus used in the manufacture of beer and to make bread rise. This image shows yeast magnified ×2260.

Fungi cannot make their own food, and therefore they must feed on other organisms. Fungi are the main cause of decay (or rotting) in fruit and vegetables. Fungi are **decomposers** responsible for breaking down wastes like faeces and dead organisms and returning the nutrients they contain to the environment.

Fungi are the source of some medicines. For example the antibiotic penicillin is prepared from *Penicillium*, a blue-green mould. Penicillin is used to fight bacterial diseases.

Protist kingdom

Most organisms in the **protist** kingdom live in water. One type is shown in Figure 6.3.14. The protists are more diverse than any other kingdom, and they are grouped together because they do not fit any other kingdom.



Euglena are fast-swimming microscopic organisms that live in quiet ponds or puddles. They take in food from their environment and also carry out photosynthesis.

Figure 6.3.14 At their front end euglena have a single whip-like tail known as a **flagellum** that pulls the organism through the water, like a propeller pulling an aircraft through the air.

Protists vary in the way they move, the way they feed, and how they live. Some contain the green pigment chlorophyll and can make their own food. Others catch and eat food from the water around them. Protists, in turn, become an important source of food for many aquatic organisms. Most protists are not harmful to humans, but some cause disease. These diseases tend to be more common in tropical climates. For example, amoebic dysentery, which causes severe pain and diarrhoea, is caused by drinking water contaminated with protists.

Some protists such as volvox (Figure 6.3.15) form colonies.

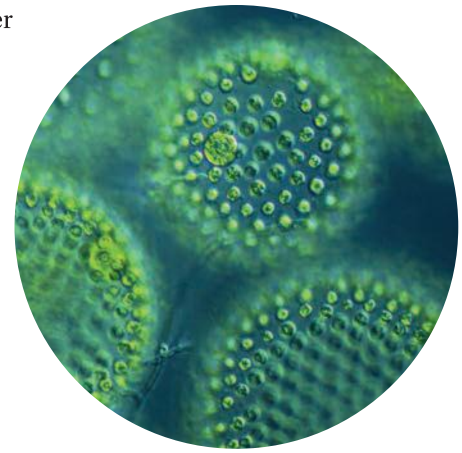


Figure 6.3.15

Some protists such as this volvox live in colonies. Each individual has flagella and chloroplasts and can make its own food. Individuals are held together by a jelly-like substance, and they all swim around together using their flagella in a coordinated way.

Monera kingdom

The **monera** kingdom includes all the organisms known as bacteria. You can see some bacteria in Figure 6.3.16. This kingdom is so diverse that some taxonomists believe it should be divided into two kingdoms or even into three major groups.

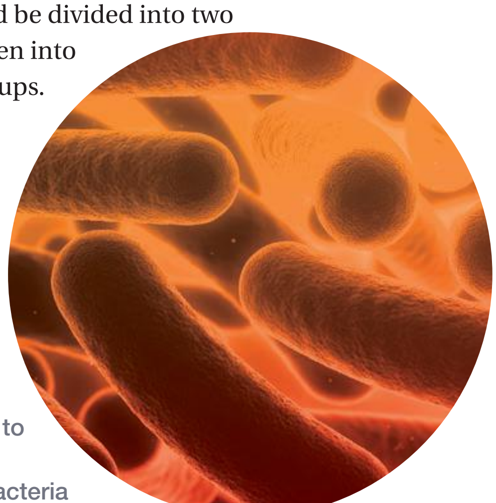


Figure 6.3.16

Bacteria belong to the monera kingdom. The bacteria here have been magnified and the image coloured so that they can be seen clearly.

Many people associate bacteria with disease and infections, but most bacteria are harmless and some are actually good for you. *Lactobacilli* are bacteria that occur naturally in dairy products. Bacteria also live in your intestines where they help your digestion. Along with fungi, bacteria are decomposers responsible for breaking down wastes and returning the nutrients they contain to the environment.

Most bacteria rely on other organisms for their food. Examples are the decomposers and the bacteria that live inside your body. However, bacteria such as cyanobacteria or sulfur bacteria make their own food.

Bacteria live in many different places, ranging in temperature from hot springs (Figure 6.3.17), where the temperature reaches 300°C, to the ice fields of Antarctica.

Figure 6.3.17

The water in this bubbling geyser is very hot. Bacteria able to live in temperatures between 50°C and 60°C form a brown scum at the edge of the water.

A closer look at kingdoms

Dogs, mosquitoes and jellyfish obviously belong to the animal kingdom, while wattles, tree ferns and pine trees are obviously plants. However, outward appearances aren't always an accurate way of classifying living things. To accurately identify the kingdom an organism belongs to, you need to look through a microscope at what makes up the organism. You need to look at its cells.

Cells

All living things are made up of building blocks called **cells**. Cells are so small that they can only be seen using a microscope. All living things in the plant and animal kingdoms are made up of many cells. They are **multicellular**—*multi* means many. Some fungi are also multicellular but other fungi have only one cell making the entire living thing. These fungi are **unicellular**—*uni* means one. All living things in the monera and protist kingdoms are unicellular.

GO TO Pearson science NSW 8 Unit 2.2
GO TO Pearson science NSW 8 Unit 2.3

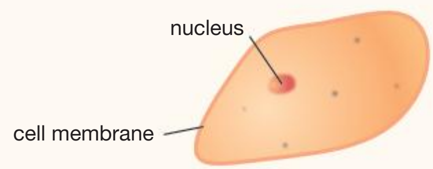
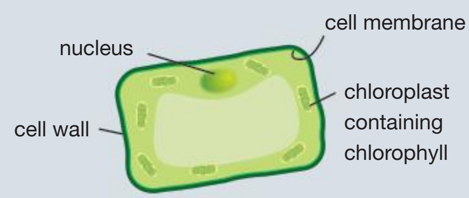
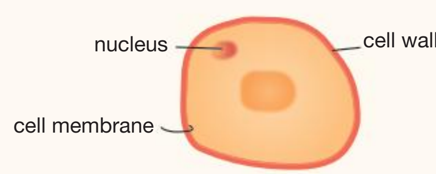
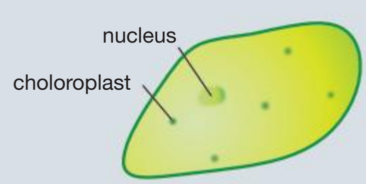
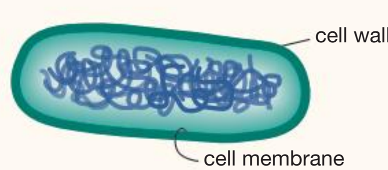
The cells of all organisms have parts in common:

- cell membrane—the 'skin' that holds the cell together.
- nucleus—the control centre of the cell.
- cytoplasm—a watery, jelly-like mixture that contains many smaller parts.

However, not all cells are the same. When cells are looked at using a microscope, differences can be seen. These differences are used to place the organisms in different kingdoms. How the organism feeds is another characteristic used to separate the kingdoms. The main characteristics of the five kingdoms are shown in Table 6.3.1.

Prac 2
p. 258

Table 6.3.1 Characteristics of the five kingdoms

Kingdom	Characteristics		Examples
Animal	Animals are made up of many cells. Their cells have a membrane forming the boundary of the cell, a nucleus and cytoplasm inside the cell. Animals obtain their energy by feeding on other living things.		Pelican, human, frog, spider, jellyfish
Plant	Plants are made up of many cells. Their cells have a cell wall outside the cell membrane. The cell wall helps support the plant and give it its shape. Many plant cells also contain tiny structures called chloroplasts in the cytoplasm. Chemicals within the chloroplasts give plants their green colour. Using these chemicals, plants are able to manufacture their own food from carbon dioxide and water—a process called photosynthesis.		Grass, daisy, gum tree, moss
Fungi	Fungi can be made up of many cells or a single cell. The cells of fungi have a cell wall and do not contain chloroplasts. Fungi feed mostly on dead material from other living things		Moulds, toadstools, mushrooms, yeast
Protist	Protists are single-celled organisms. Protist cells may be plant-like or animal-like.		Protozoa, algae
Monera	Monerans are single-celled organisms. Their cells have a cell wall but do not have a clearly defined nucleus. All monerans are very simple and microscopic.		Bacteria, cyanobacteria

6.3 Unit review

Remembering

1 **Name** the building blocks of all living things.

2 **List** the kingdoms with single-celled organisms.

3 **Name** the kingdom in which you will find all the organisms without a distinct nucleus in their cells.

4 **Name** the classes of seed-bearing plants.

5 Humans regularly eat plants as part of their diet. Usually they don't eat the whole plant but just a part of it. **Name** two plants from which we eat their:
- a leaves
- b stalks
- c seeds
- d roots
- e fruit.

Understanding

6 a **Describe** the characteristics that plants and fungi have in common.
- b **Explain** why plants and fungi are in different kingdoms.

7 **Describe** one problem and one benefit of fungi.

8 **Describe** the plant kingdom, highlighting the features that make it different from the other kingdoms.

Applying

9 **Identify** the main difference between organisms that are *unicellular* and those that are *multicellular*. L

Analysing

10 **Compare** the characteristics used to classify:
- a a moss and a fern
- b a pine tree and a flowering gum tree
- c a fern and a pine tree.

11 **Compare** the protist and monera kingdoms.

12 Explorers in a previously unknown area have found some very strange organisms. These are two descriptions from one of their notebooks. **Classify** these organisms into their correct kingdoms.
- a The organism was shaped like a semicircle with a radius of about 8 cm. It was found on the side of a tree. Looking through the microscope, I could see many cells that all looked very much alike. There was a distinct cell wall. The cells were colourless.
- b The organism was seen when I looked at some water under a microscope. It was still very small when I had the microscope on its highest power. I could see that the organism was unicellular but I could not see a distinct nucleus.

13 **Use** the following descriptions to **classify** these plants.
- a It is less than one centimetre tall and when the leaves were examined under a microscope no vascular tissue could be seen.
- b Dark spots were visible on the back of the leaf and there was vascular tissue running along the middle of the leaf.
- c It is a tree over 20 m tall that has needle-like leaves and produces seeds in cones on its branches.

Evaluating CCT

14 One organism was described as *macroscopic*. Another organism was described as *microscopic*. **Propose** what is the main difference between them. L

15 The Wollemi pine was discovered in 1994.
- a **Deduce** the characteristics taxonomists would have used to decide which plant group it belonged to.
- b **Justify** your answer.

16 Plants that produce nectar are giving something to the insects that pollinate them. **Propose** why this relationship between plants and insects has come about.

Creating CCT

17 **Construct** a mnemonic or rhyme to help you remember the divisions of the plant kingdom.

Inquiring

1 Humans use many plants as a source of food. However there are many other uses made of plant materials.
- In groups or as a class, brainstorm uses made of plants or products of plants.
- For each use or product decide which division of the plant kingdom is being used.
- Select one use or product and research:
  - which plants are used
  - where the plants are grown
  - other materials that may be used in the same situation
  - the advantages and disadvantages of using plant material in that situation.

Present your research as a pamphlet advertising that plant or plant product.

2 *Giardia* is a protist with two nuclei and is an intestinal parasite. *Euglena*, also a protist, moves by using a flagellum, but it also contains chloroplasts and manufactures its own food by photosynthesis. Slime moulds, such as *Physarum polycephalum*, behave like amoebas, can be seen without a microscope and have many nuclei. Scientists include these organisms (Figure 6.3.18) and many others in the protist kingdom. Research these and other unusual protists, then debate approaches to their classification.
- Identify ways in which the organisms you have selected are similar and therefore should be classified together.
- Identify ways in which the organisms are different.
- Propose difficulties that taxonomists could have in trying to create new kingdoms for these unusual organisms.
- Propose arguments for and against placing all these organisms in one group.

Present your research and proposals as a list of dot points.

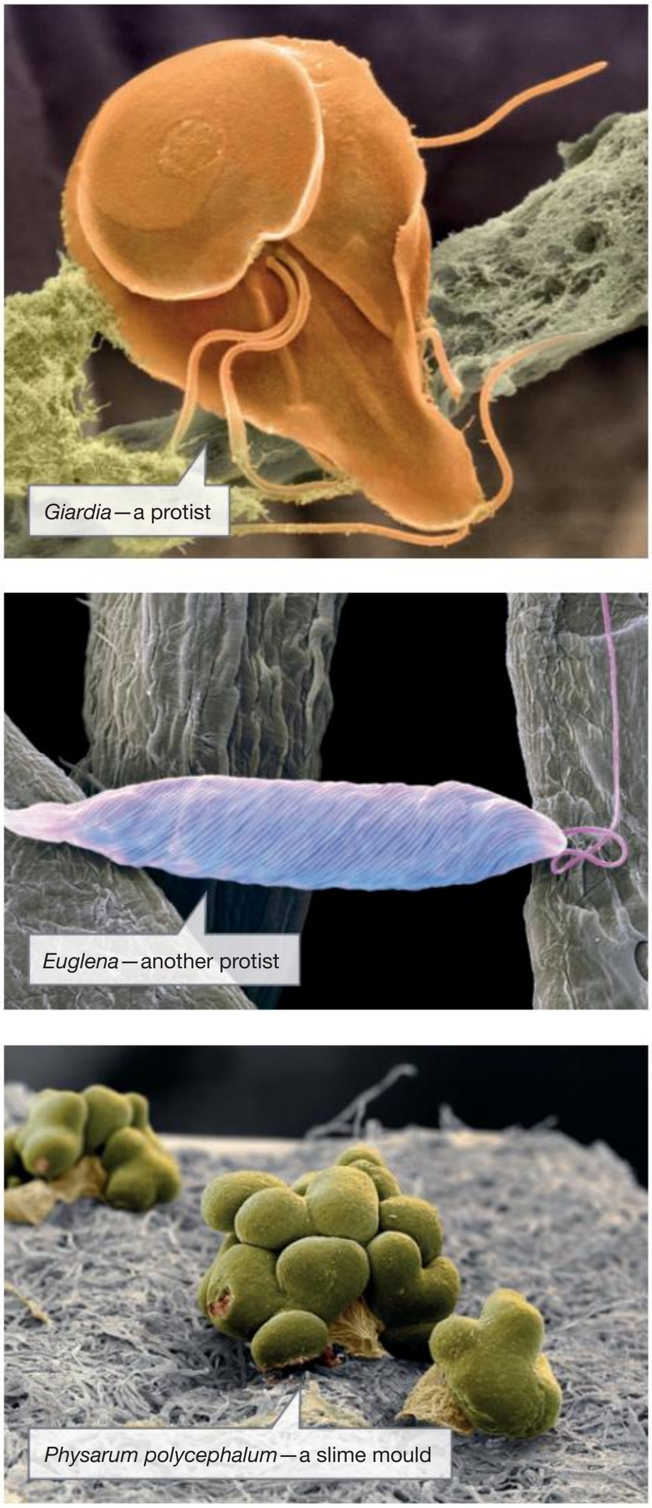


Figure 6.3.18

6.3 Practical investigations

1 Classifying plants

Purpose

To construct a classification key for plants found in your local area.

Materials

- a description of and samples from plants found at home or in the school grounds, as well as a description and a photograph of each if possible
- Note: If you took photographs of all your samples you could use the plants from all the groups in the class and create a more comprehensive key.

Procedure

1 Sort your plants into two groups, according to one characteristic that each plant either has or doesn't have. Write down the characteristic you used to group your plants.

2 Using a different characteristic each time, repeat this process, splitting each group of plants again and again until you have each plant on its own in a separate group. You will need a large area to separate them each time. Then you can name them, or give them a letter. Write down the characteristic you used to group your plants each time.

3 Use each of your identified characteristics in steps 1 and 2 to design a key for other students to use to identify your plants.

4 Hide the names or letters at the end of your key, then give your samples and key to a student who did not work on the key with you. Ask them to try to identify each plant from your key.

Practical review

1 **Assess** how easy your key was to use in identifying the plants.

2 **Identify** if some features were easier to use than others for identifying plants.

3 **Use** the information gathered to improve your key, and then ask another classmate to use it for you. **Assess** whether your key is more effective this time.

4 **Explain** why you did or did not find it easy to construct the key.

5 **Propose** other information that would have been of benefit to you.

STUDENT DESIGN

2 Pictorial key

Purpose

To create a picture wall that represents the kingdoms.

Materials

- digital camera or mobile phone with inbuilt camera
- sticky-tape or Blu Tack
- cardboard
- marker pen

Procedure

1 Brainstorm where it would be possible to find representatives of the five kingdoms.

2 Decide which kingdoms you will be able to photograph for yourselves.

3 Make a name card for each of the kingdoms and attach it to the wall.

4 Take photographs of 3 or 4 different representatives of each kingdom and attach them to the wall under the name card.

5 Try to sort the photos within the plant and animal kingdoms into smaller groups. You could also add information about the classification of the organism to the back or underneath the photograph.

Practical review

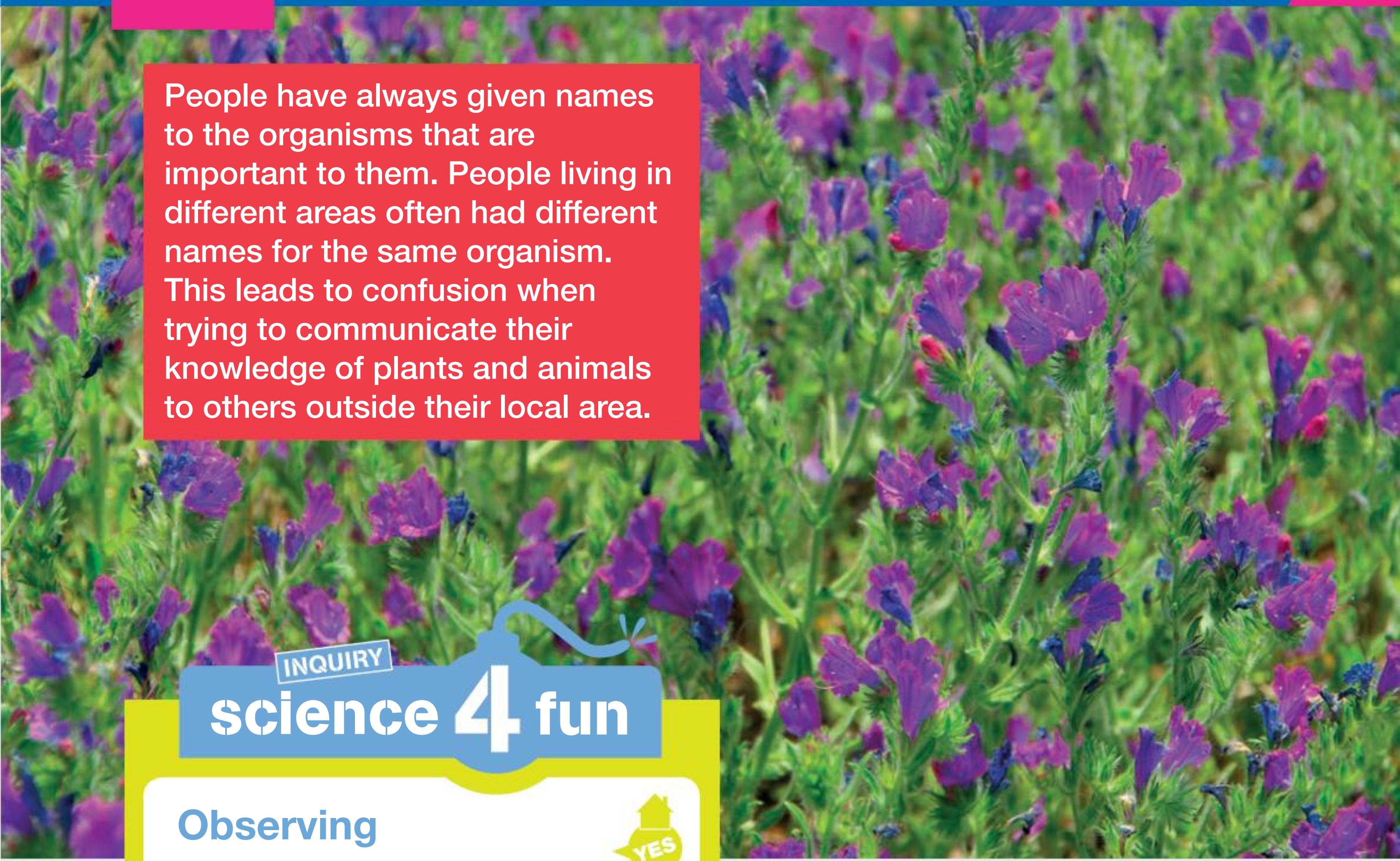
1 **Compare** the number of photographs you have for each kingdom.
   a **State** which kingdom was most difficult to photograph. **Explain** why this was so.
   b **State** whether there was a kingdom that you could not photograph for yourselves. **Explain** why you couldn't.
   c **State** which kingdom was the easiest one to photograph. **Explain** why this was so.

2 a **Describe** the photograph you find most interesting.
   b **Explain** why it interests you.

3 **Discuss** whether your photographs truly represent the variety of organisms in that kingdom.

ADDITIONAL

6.4 Classification in practice



People have always given names to the organisms that are important to them. People living in different areas often had different names for the same organism. This leads to confusion when trying to communicate their knowledge of plants and animals to others outside their local area.

INQUIRY

science 4 fun

Observing

Collect this ...

- a pet animal, or a place where you can observe an animal closely
- paper and pencil
- digital camera (optional)

Do this ...

1. Imagine that your life could depend on knowing as much as you can about this animal. Observe the animal very closely. No observation is too small. Remember that observing uses more senses than just sight.
2. Record as many observations as you can of the animal.

Record this ...

Describe any new things you learnt about the animal.

Explain how much time and care it would take to learn all there was to know about the habits of an animal in the wild.

Common names

The plant with the purple flower in the above photo is a European plant with the common name 'purple bugloss'. It was introduced into Australia and has become a major weed in New South Wales, South Australia, Western Australia and Victoria. As it spread it has become known under different names. It is still known as purple bugloss but other common names now include Riverina bluebell, salvation Jane, Paterson's curse, blueweed, blue echium, Lady Campbell weed, plantain-leaf, viper's bugloss and purple peril. Scientists avoid confusion by using only one scientific name for the plant—*Echium plantagineum*.

The Australian native animal with the scientific name *Macropus robustus* is shown in Figure 6.4.1 on page 260. It too has a variety of different common names. These include common wallaroo, euro, eastern grey wallaroo, red wallaroo, roan wallaroo, Barrow Island wallaroo, hill kangaroo and biggada.

Figure 6.4.1 *Macropus robustus* is known by at least eight different common names but has only one scientific name.

Standardising names

Figure 6.4.2 shows a portrait of the Swedish scientist Carl Linnaeus (1707–78). In the eighteenth century he collected many plants that had not been found before. At that time scientists used descriptions as a way of naming living things and as new organisms were discovered, the descriptions would become longer.

For example, *Canis* is part of the scientific name for a dog (a canine). If a new species of dog was found in the woods, then it could be the 'canine' that 'lives in woods'. If another canine was found living in the woods it would have to be described differently. It could be the 'canine' that 'lives in woods; dark coat in winter; found only in the north'—and so the names expanded.

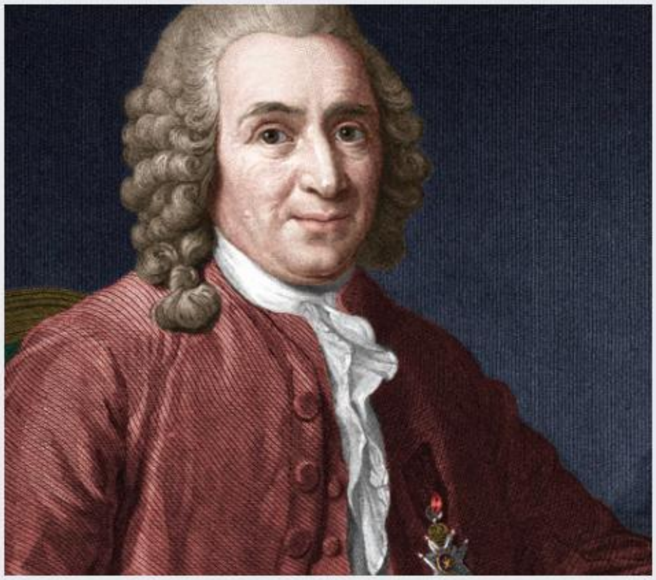


Figure 6.4.2 Carl Linnaeus developed the binomial system for naming living things. Linnaeus is also known as Carl von Linné.

Another example is the carnation in Figure 6.4.3. It needed nine words to describe it: *Dianthus floribus solitaris, squamis calycinus subovatus brevissimis corollus crenatis*. It literally means the dianthus that has single flowers with very short scales and toothed petals.

Figure 6.4.3 Linnaeus renamed the carnation so that it had only two names: *Dianthus caryophyllus L*.

Linnaeus thought that there must be a better system. He organised the classification of organisms into a hierarchy, with kingdom at the top and species as the lowest level. **Genus** is the name given to the level above **species**. The name given to an organism would be the name of the genus to which that organism belonged, followed by one descriptive name for the species—this way each living thing would only have two names. With this, binomial naming (also known as binomial nomenclature) was born.

Latin was used as the language for naming because it was a language then understood by all well-educated people throughout Europe. Also, it was not a spoken language, and therefore the meanings of the words did not change. Words develop slightly different meanings and spellings over time when a language is spoken. This does not happen in Latin.

Binomial nomenclature is now used internationally regardless of the language spoken in the country the organism or scientist comes from. The system has been used for plants since 1753, for animals since 1758, and for bacteria since 1980.

SciFile

Linneaus and Banks

Linnaeus corresponded with the botanist Joseph Banks, who sailed to Australia with Captain Cook on the *Endeavour* in 1768. Also on board was Daniel Solander, one of Linnaeus's students. Between them Banks and Solander collected more than 1000 species of plants new to science. The banksia is an Australian native plant named after Banks.

Scientific naming

When scientists discover a new organism they observe it carefully, describe it, look for ways in which it is similar to species they know, and then decide which group it belongs to. Once this has been decided they give it a name. The name will be used by all scientists throughout the world to describe a particular organism.

The name given to a newly described organism is not random. Taxonomists use a binomial naming system that gives every species a unique two-part name. The first part of the species name tells you the genus to which the organism belongs, and always starts with a capital letter. The second part tells you the species within that genus. This part of the name always starts with a lower case letter. When the names are typed, italics are used. When names are written, they are underlined.

For example, *Panthera leo*, *Panthera onca*, *Panthera pardus* and *Panthera tigris* (Figure 6.4.4) all belong to the same genus. They all have the same first part to their name. If they are in the same genus then they must be fairly similar to each other. However, they are not all the same species. You can tell that because the second part of their name (their species name) is different. You are more likely to recognise the animals by their common names: lion, jaguar, leopard and tiger.

6.7

Levels of classification

Kingdom is the first level of classification. The kingdoms are divided into smaller groups in which the organisms are more similar, as Figure 6.4.5 shows. The second level of classification is into phyla (singular phylum). In the plant kingdom the phyla are often called divisions.

- Phyla and divisions are then divided into **classes**.
- Classes are divided into **orders**.
- Orders are divided into **families**.
- Families are divided into genera (singular genus).
- Genera are divided into species.

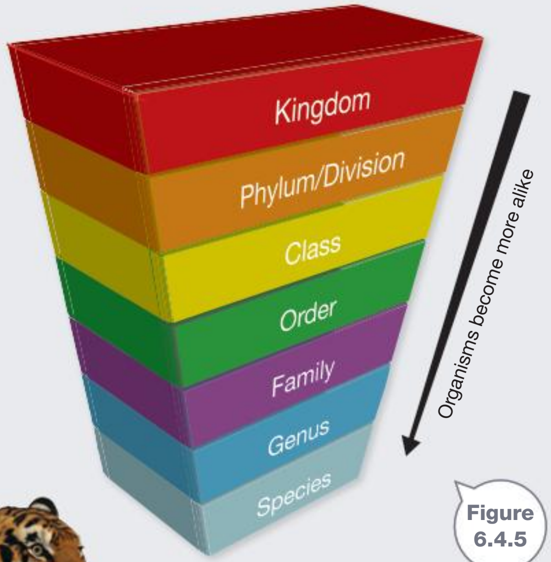


Figure 6.4.5 Organisms are classified first into broad groups—kingdoms. At each new level of classification, the organisms become more similar.

Figure 6.4.4 All these species belong to the same genus, *Panthera*.

WORKED EXAMPLE
Constructing a mnemonic

A mnemonic is a way of helping you remember things. One way of trying to remember a list is to make a sentence with each word starting with the first letter of each word in the list.

Problem

Construct a mnemonic to remember the order of the groups in biological classification.

Solution

One possible mnemonic is shown below.

Keep	Placing	Cake	Orders	For	Good	Students
Kingdom	Phylum	Class	Order	Family	Genus	Species

Practice

Construct another mnemonic that would help you remember the order of the groups in biological classification.

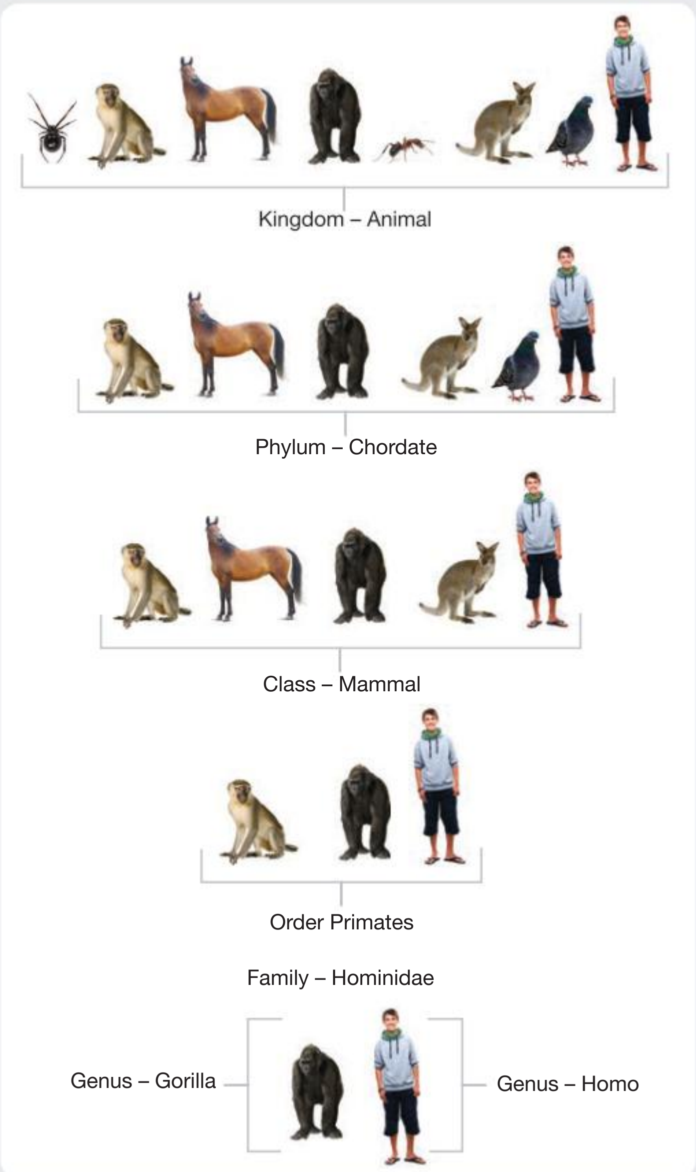


Figure 6.4.6 Gorillas and humans are the two animals in this group that have most characteristics in common.

Moving down through the levels in the classification system, the groups become smaller in that they have fewer types of living things in them. Figure 6.4.6 shows how organisms become more similar as you move through the levels of classification.

Organisms of the same species are most similar, but they are not identical. Look around at the people in your classroom or in the street. All the individuals in Figure 6.4.7 belong to the same species (*Homo sapiens*), but you can easily see that they are not all identical.

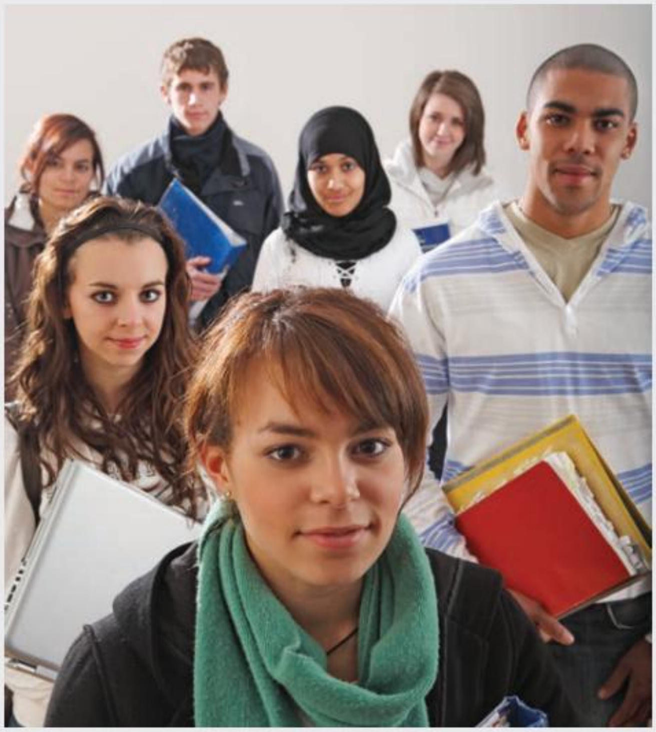


Figure 6.4.7 All humans belong to the one species but they are not all identical.

Classifying Australian organisms

When European scientists came to Australia they described and named the plants and animals they found here. Taxonomists have given all Australian species a scientific name.

The red kangaroo, the eastern grey kangaroo and the common wallaroo have characteristics in common and this is reflected in their classification illustrated in Table 6.4.1. All belong to the same kingdom, phylum, class, order and family. The classification also shows that according to scientists the eastern grey kangaroo and the common wallaroo are most alike. They also belong to the same genus.

Table 6.4.1

Common name	Red kangaroo	Eastern grey kangaroo	Common wallaroo
			
Kingdom	Animal	Animal	Animal
Phylum	Chordate	Chordate	Chordate
Class	Mammal	Mammal	Mammal
Order	Diprotodon	Diprotodon	Diprotodon
Family	Macropod	Macropod	Macropod
Genus	*Magaleia*	*Macropus*	*Macropus*
Description of species	*rufa*	*giganteus*	*robustus*
Scientific name	*Magaleia rufa*	*Macropus giganteus*	*Macropus robustus*

Table 6.4.2

Common name	Red-bellied snake	Box jellyfish	Funnel-web spider
			
Kingdom	Animal	Animal	Animal
Phylum	Chordate	Cnidaria	Arthropod
Class	Reptile	Cubozoa	Arachnid
Order	Squamata	Cubomedusae	Aranaea
Family	Elapidae	Carybdeidae	Hexatheloidea
Genus	*Pseudechis*	*Carybdea*	*Atrax*
Description of species	*porphyriacus*	*rastonii*	*robustus*
Scientific name	*Pseudechis porphyriacus*	*Carybdea rastonii*	*Atrax robustus*

How similar or different other animals are can be seen in their classification. The red bellied snake belongs to the same phylum as the kangaroos and wallaroo. However the box jelly fish and funnel web spider have only the kingdom in common. These classifications are shown in Table 6.4.2.

The Sydney blue gum, grey iron bark, Wollemi pine and lacy tree fern all belong to the plant kingdom. The classification in Table 6.4.3 shows that the gum tree and iron bark are closely related. The other plants are different at the level of division.

Table 6.4.3

Common name	Sydney blue gum	Grey iron bark	Wollemi pine	Lacy tree fern
				
Kingdom	Plant	Plant	Plant	Plant
Division	Magnoliophyta	Magnoliophyta	Pinophyta	Pteridophyta
Class	Magnoliopsida	Magnoliopsida	Pinopsida	Pteridopsida
Order	Myrtales	Myrtales	Pinales	Cyatheales
Family	Myrtaceae	Myrtaceae	Araucariaceae	Cyatheaceae
Genus	*Eucalyptus*	*Eucalyptus*	*Wollemi*	*Cyathea*
Description of species	*saligna*	*paniculata*	*nobilis*	*cooperi*
Scientific name	*Eucalyptus saligna*	*Eucalyptus paniculata*	*Wollemi nobilis*	*Cyathea cooperi*

Prac 1 p268

ADDITIONAL

LEARNING ACROSS THE CURRICULUM

ABORIGINAL AND TORRES STRAIT ISLANDER HISTORIES AND CULTURE

Figure 6.4.8 Bush tucker

INDIGENOUS CLASSIFICATION

Indigenous people all over the world have complex and sophisticated classifications of plants and animals, but they do not look like the system used by Western science. Indigenous classifications help the people of a tribe or local area to communicate about the plants and animals that are important to them.

The Indigenous people of Australia have sophisticated classification systems that suit the way they live in their environments. The classifications take into account relationships the Indigenous people recognise between the living and non-living parts of the environment, and group together things that are used in similar ways.

The classification system used by the Yolngu of Arnhem Land (Northern Territory) begins by creating two groups—things that have life, and things that do not. Things that have life are further divided into three groups:

- things that move themselves, such as the Sun and planets, or the water and fire shown in Figure 6.4.9
- things that breathe and reproduce. This group includes all plants and animals except humans.
- humans.

THINGS THAT BREATHE AND REPRODUCE

Things that breathe and reproduce are then subdivided into nine different sets. For example:

- *guya* is the name for a group that includes all fish
- *dharpa* is all plants with woody stems
- *warrakan* includes all land or freshwater mammals, birds and reptiles, with the exception of snakes. Figure 6.4.10 shows some warrakan.
- *bäpi* is the group to which snakes, legless lizards and worms belong.

Some of the nine groups are further subdivided. For example:

- *guya* are subdivided according to where they live: near the surface of the water, near the bottom, in rivers, in fresh water, or among reefs and rocks
- *warrakan* are grouped according to whether they fly, walk, crawl or slide.

Figure 6.4.9 The Yolngu people of Arnhem Land classify fire as 'something that could move itself'.

Figure 6.4.10

The Yolngu group animals according to how they move. Birds and bats are in the same group—the *warrakan butthunamirr*—because they can both fly. Biological classification uses differences between birds and bats to place them in separate groups at the level of phylum. Galahs are named *Eolophus roseicapillus* and the lesser long-eared bat is named *Nyctophilus geoffroyi*.

COMPARING CLASSIFICATIONS

The hierarchy of classification used by the Yolngu is similar to, but much simpler than, the biological classification. The classification of three finches found in Arnhem Land can be used as an example.

The scientific classification is shown in Figure 6.4.11.

Kingdom	Animalia (Animals)
Phylum	Chordata (Chordates)
Class	Aves (Birds)
Order	Passeriformes (Perching birds)
Family	Frigillidae (Finches)
Genus	*Poephila*

Species	*Poephila personata* Masked finch	*Poephila acuticauda* Long-tailed finch	*Poephila bichenovii* Double-barred finch

Figure 6.4.11 Scientific classification of finches

The classification of the Yolngu is shown in Figure 6.4.12. It is a lot simpler.

There are no specific names for the different finches: they are all *lidjildji*. They only give specific names to things that are of special use or significance.

Thing that has life

Thing that breathes and reproduces

Warrakan

Lidjildji (finches)
(All finches have the same name)

Figure 6.4.12 The Yolngu have a simple classification of the finches of northern Australia.

REVIEW

1 **Specify** what sorts of animals are included in the following terms.
   a *guya*
   b *warrakan*

2 **State** the Yolngu name for: L
   a plants with woody stems
   b snakes and lizards.

3 **Explain** why the Yolngu people do not have names for all the different birds.

4 **Identify** issues that could arise if Indigenous Australians from one area were discussing hunting for food with a tribe from a different area.

5 a **Propose** whether the five kingdom biological classification of living things would be of use to Indigenous Australians.
   b **Justify** your answer.

6 **Deduce** reasons for there being many different Indigenous classification systems for living things in Australia.

7 The Yolngu people classified *warrakan* according to whether they moved by flying, walking, crawling or sliding. **Propose** why this classification was useful to them.

Prac 2 p. 268

ADDITIONAL

6.4 Unit review

Remembering

1 **State** the first level in biological classification of living things.

2 **List** these levels of classification into order from the one in which there is the greatest number of different types of organisms to the level in which the organisms are most similar.

family genus class phylum

3 **Name** the scientist who developed the binomial system of classification.

Understanding

4 **Describe** some of the difficulties that could arise if only common names were used for plants and animals.

5 a **Explain** what the term *binomial nomenclature* means. L

b **Explain** why the term *binomial nomenclature* is an appropriate description for the system scientists use to name living things.

Applying

6 Below are the names of four plants:

- *Acacia gunnii*
- *Tristania conferta*
- *Eucalyptus gunnii*
- *Acacia conferta.*

Although you probably do not know what the plants look like, **identify** the ones that are most closely related.

7 **Demonstrate** how biological names should be written by rewriting the names below correctly. In each example, the genus and species are in the correct order.

a Pan Troglodytes

b homo sapiens

c banksia Robur

Analysing

8 **Compare** a group of organisms that all belong to the same phylum with a group of organisms that all belong to the same family.

9 As people explore new environments, they find new organisms that have to be described and named. **Discuss** the advantages of having the binomial system of classification compared to the system used before Linnaeus.

Evaluating CCT

10 The eastern pygmy-possum (*Cerartetus nanus*), the common brush-tailed possum (*Trichosurus vulpec*), the mountain pygmy-possum (*Barramysula parvus*) and the short-eared possum (*Trichosurus caninus*) are all possums found in New South Wales.

a **Identify** the possums that are most similar.

b **Explain** why you made that choice.

c **Propose** a reason for them all being commonly known as possums when biologists classify them differently.

11 Refer to the following plant names:

- *Eucalyptus robusta*
- *Grevillea banksii*
- *Metrosideros robusta*
- *Grevillea ericifolia*
- *Eucalyptus banksii*

a i **Identify** which of the listed organisms would be most closely related to *Grevillea robusta.*

ii **Justify** your response.

b i **Select** other species in the list that are related to each other.

ii **Explain** your selection.

c i **State** how many species are represented in this list.

ii **Justify** your response.

d i **State** how many different genera (plural of genus) are represented in the list.

ii **Justify** your response.

12 The magpie with the biological name *Pica pica* (Figure 6.4.13) is a common bird in Europe. *Cracticus tibicen* (Figure 6.4.14) is a familiar Australian bird and is also commonly known as the magpie. Biologists do not consider these two birds to be similar. **Propose** reasons for the European magpie and the Australian magpie both having the same common name.

Figure 6.4.13 The European magpie (*Pica pica*)

Figure 6.4.14 The Australian magpie (*Cracticus tibicen*)

13 Four organisms A, B, C and D all belong to the same kingdom.

A and D belong to the same class.

A and C belong to the same genus.

B and C belong to the same order.

a **Deduce** which two organisms are most alike.

b **Use** this information to answer the question: 'Do organisms A and B belong to the same order?'

c **Justify** your decision.

Creating CCT

14 **Construct** a concept map showing the characteristics of the five kingdoms.

Inquiring

1 A classification system for plants used by Indigenous Australians was into 'plants used for medicine' and 'plants used for food'. Use library and internet resources to discover more about the use of plants for medicine and discuss the idea that other cultures in other places and at other times would have used a similar classification.

Present your findings as a poster.

2 Make contact with an Indigenous community in your area and arrange a meeting. Devise questions to ask the community to enable you to gather first-hand information about:

- how they classify living things
- ways in which information is gathered and passed on
- ways in which plants and animals are important to the community apart from as food.

Present your findings as a poster or digital presentation to share the information with other groups in the school. Include in your presentation the most surprising thing that you learned about the way that the local Indigenous community classified living things. ICT

3 Talk to people from the Indigenous population in your local area to learn some of their stories that describe the special relationship that the Indigenous people have with the land and the native plants and animals.

ADDITIONAL

6.4 Practical investigations

1 The names I know

Purpose

To explore ways in which classification systems could have evolved.

Materials

- paper
- pencil

Procedure

1 Make a list of the living things that are regularly part of your life.

2 If you know the name, use it—for example *dog*, or *apple*. If you do not know specific names, use group names such as *tree* or *bug*.

3 Share your list with others and combine all the lists into one.

4 Think of ways in which you could group the things you have on your list. For example, you could have *pets* or *food*.

5 If you have a very long list in some groups, subdivide it into smaller groups by making a second level of classification.

6 Construct a key for the items in your lists. Go only as far as you think is useful. You do not have to separate out each item.

Practical review

1 a **Identify** which type of classification your key most resembled—biological classification, or one more like that used by Yolngu people.
b **Explain** why this was the case.

2 a **Compare** the items for which you had specific names and those for which you had group names.
b **State** which of these would be more important to you in terms of survival.

3 a **Compare** the list you started with and the final list used for the classification.
b **Estimate** how much of your list was the same as the lists from the others in your group.

4 a **Identify** the groups where there was the greatest amount of overlap.
b **Explain** why there was so much overlap.

5 a **Identify** the groups where there was most difference.
b **Explain** why there was so much difference.

2 Classifying weather

Purpose

To compare calendars.

Materials

- pen
- paper

Procedure

Part A

1 Analyse the information presented in calendars from two Indigenous groups: the Wardaman people of Northern Territory and the Brambuk people of Victoria (Figure 6.4.15).

2 Compare the calendars with the temperature and rainfall statistics from the Australian Bureau of Meteorology (Figure 6.4.16) for Katherine in the Northern Territory near where the Wardaman people live, and Ararat in Victoria near where the Brambuk people live.

Part B

3 Create a personal calendar by drawing a circle at least 10 cm in diameter. Divide it into 12 equal segments. Label the segments with a month of the year.

4 Into the calendar place the events that are important to you and that occur at the same time each year. Consider events such as sports seasons, birthdays, family holidays, school terms, and seasons of the year.

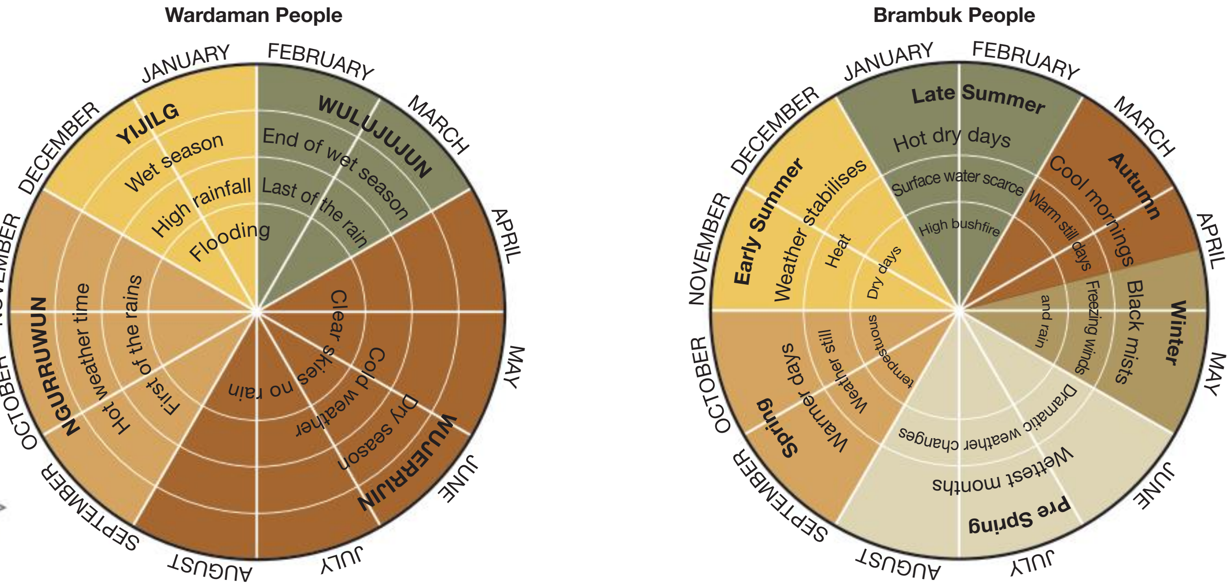


Figure 6.4.15

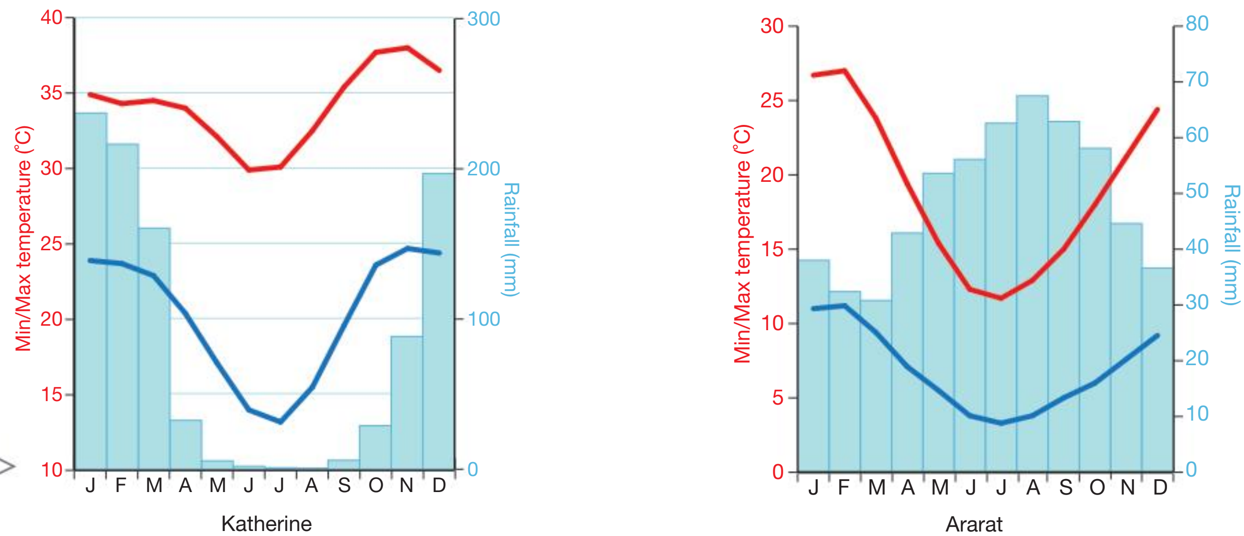


Figure 6.4.16

Practical review

Part A

1 **Explain** what information is classified in the calendars and graphs.

2 **Compare** the information included in the two Indigenous calendars. **Propose** reasons for any differences.

3 **Propose** ways the information used to construct the calendars was collected.

4 **Explain** how the Bureau of Meteorology collects temperature and rainfall statistics.

5 **Compare** the calendar of the Wardaman people with the statistics for Katherine, and the calendar of the Brambuk people with the statistics for Ararat. **Assess** the accuracy of the information gathered by the Indigenous people.

6 **Discuss** the uses made of the calendars in Indigenous society and the uses made of the information from the Bureau of Meteorology in society today.

Part B

7 **Compare** the information included in your calendar and the Indigenous calendars.

8 **Propose** reasons for any differences.

6 Chapter review

Remembering

1 **State** the number the number of kingdoms in the system of classification used in this book.

2 **List** the names of the kingdoms.

3 **Name** the type of scientist who places things in groups.

4 **List** examples of classification you experience most days.

5 **List** the three classes of animals that are often grouped together as fish.

6 **Recall** each phylum of animals described as follows.
   a Has stinging cells
   b Has an exoskeleton
   c Has a single muscular foot
   d Has a nerve cord

Understanding

7 **Define** the term *classification*. L

8 **Explain** why the products in supermarkets are not arranged in alphabetical order.

9 **Explain** how classification is used in:
   a clothing shops
   b online music stores.

10 **Explain** why characteristics such as hair length or style, or the presence of facial hair, would not make a strong key.

11 **Describe** the characteristics that cause plants and animals to be placed in separate kingdoms.

12 **Gather** information from Unit 6.3 about the protists and **explain** why this kingdom could be called the 'kingdom of misfits'.

Applying

13 The two animals in Figure 6.5.1 look very different. Refer to Table 6.3.1 on page 255 to **explain** why they are both classified as animals.

Figure 6.5.1

14 **Identify** characteristics that could be used in a key to identify the creatures in Figure 6.5.2.

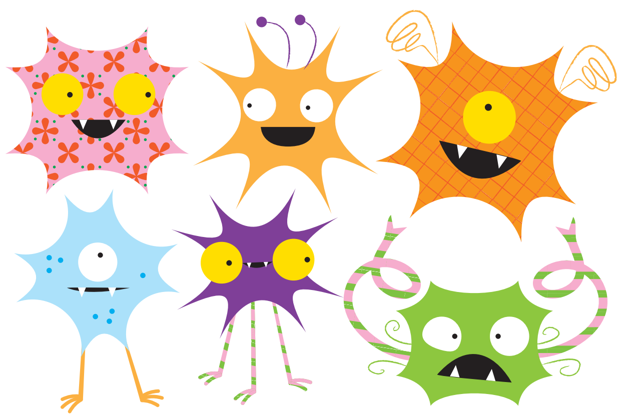


Figure 6.5.2

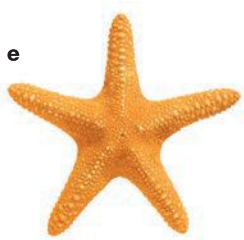
15 **Identify** the kingdom and phylum to which the organisms shown below belong.

a


b


c


d


e


Analysing

16 **Contrast** the following kingdoms:

- **a** plant and animal
- **b** monera and protist
- **c** plant and fungi.

17 **Use** the following information to **classify** each of these organisms into a kingdom and, if possible, phylum/division.

- **a** Found when pond water was examined under a microscope. It is green and appears to be a number of cells grouped together within a thin 'skin'. Flagella are visible attached to each cell. A nucleus is visible within each cell.
- **b** Large organism standing about two metres tall. A soft brown hair covers its body. It had a pouch-like structure on the front of the body. At times a small head appeared out of the pouch.
- **c** Small green leaves are arranged in a spiral around something that looks like a stem but it has no vascular tissue. This organism is about one centimetre tall. It was found in the shade behind a rock.

18 **Analyse** the key in Figure 6.5.3 to **identify** its strengths and weaknesses.

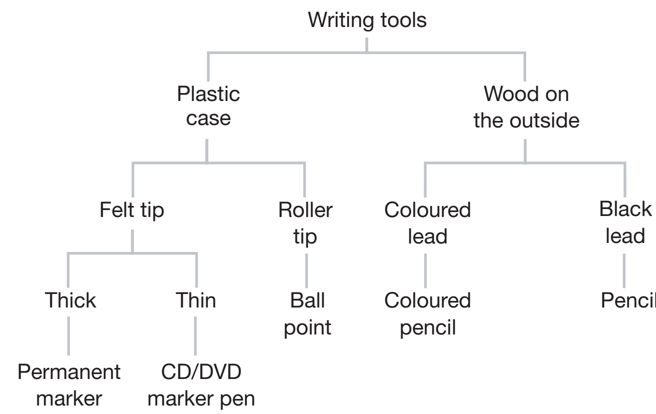


Figure 6.5.3

Evaluating CCT

19 **a** **Determine** whether you can or cannot answer the questions on page 227 at the start of this chapter.

b **Assess** how well you understand the material presented in this chapter.

Creating CCT

20 **Apply** your knowledge of keys to **construct** a strong key for the creatures shown in Figure 6.5.2.

21 **Use** the following ten key words to **construct** a visual summary of the information in this chapter.

kingdom	species
classification	taxonomy
dichotomous key	plants
animals	protists
monera	fungi

6.8

Thinking scientifically

Two students were given this information about some animals and asked to put them into groups.

Animal	Number of legs	Number of pairs of wings	Number of body parts	Other characteristic
Spider	8	0	2	Poisonous
Fly	6	2	3	Feeds on nectar
Tick	8	0	2	Feeds on blood
Scorpion	8	0	2	Poisonous
Mosquito	6	2	3	Feeds on blood

Jo's groups
Spider Scorpion
Fly Tick Mosquito

Kai's groups
Spider Scorpion Tick
Fly Mosquito

Q1 Which characteristic did Jo use to create the groups? CCT

A Number of legs
B Number of pairs of wings
C Number of body parts
D Other characteristic

Q2 Which characteristic did Kai use to create the groups? CCT

A Number of legs
B Number of pairs of wings
C Number of body parts
D Other characteristic

Q3 Students created this key for their group. CCT

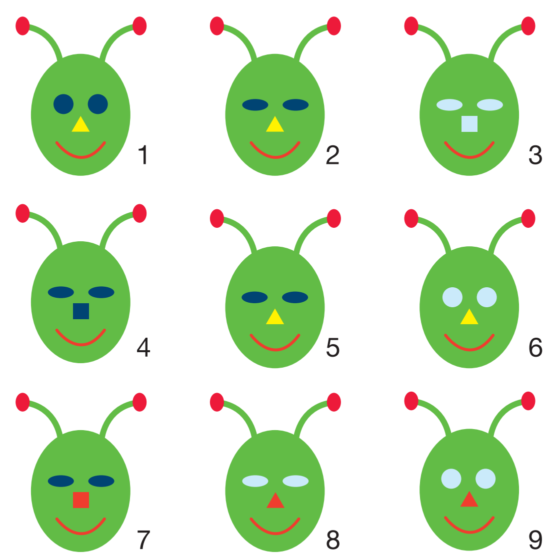
1	**a**	Male	Go to 2
	b	Female	Go to 5
2	**a**	Straight hair	Go to 3
	b	Curly hair	Go to 4
3	**a**	Can roll tongue	Mark
	b	Cannot roll tongue	Yasu
4	**a**	Brown eyes	Hans
	b	Grey eyes	Jack
5	**a**	Straight hair	Jane
	b	Curly hair	Mai

How many people in the group have straight hair?

A 1
B 2
C 3
D 4

Q4 The aliens below belong to three different family groups. Which two aliens belong to the same family? CCT

A 1 and 5
B 2 and 3
C 4 and 6
D 5 and 8



Q5 Which alien belongs to the same family as alien 9? CCT

A 8
B 6
C 7
D 3

Glossary

Unit 6.1 L

Classification: the process of putting things into groups

Dichotomous key: a key with two choices at each stage

Pest species: an animal species that causes problems and is not wanted in an area

Taxonomist: a scientist who specialises in grouping and naming things

Taxonomy: the science of grouping and naming things

Weed: a group name for any plant growing where it is not wanted

Unit 6.2 L

Agnatha: jawless fish with an internal skeleton made of cartilage; examples are hagfish and lampreys

Amphibians: chordates that live both in and out of water

Amphibians

Animal: one of the five kingdoms of living things; multicellular organisms with cells that have a membrane as the outer layer and a distinct nucleus

Annelids: phylum of the animal kingdom consisting of the segmented worms; for example, an earthworm

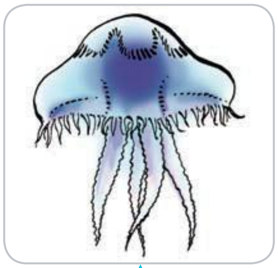
Arthropods: animals with an exoskeleton and jointed limbs; examples are crabs and insects

Aves: animals with feathers covering their body; lay hard-shelled eggs and are endothermic

Cartilage: flexible material from which the skeletons of Agnatha and Chondrichthyes are made

Chondrichthyes: fish with proper jaws and teeth, a skeleton made of cartilage and fins on the sides of their bodies as well as along their backs; examples are sharks and rays

Chordates: animals with a nerve cord running down their backs, and an endoskeleton



Cnidarians

Cnidarians: animals with radial symmetry, one body opening and stinging cells; examples are jellyfish, sea anemones and coral polyps

Echinoderms: radially symmetrical animals, most of which have spiny skin; examples are starfish, brittlestars, sea urchins and sea cucumbers

Echinoderms

Ectothermic: describes animals with a body temperature that varies with the temperature of their surroundings

Endoskeleton: a skeleton inside the body

Endothermic: describes animals with a body temperature controlled internally

Exoskeleton: a skeleton on the outside the body

Invertebrates: animals without backbones

Kingdom: the first level of classification

Mammals: a class that includes all the animals that have a body covering of hair and feed their babies on milk produced by the mother

Marsupials: a subclass of mammals that give birth to immature young that are suckled in a pouch; examples are koala, kangaroo and wombat

Molluscs: phylum of animals that are bilaterally symmetrical, have well-developed internal organs, and have a muscular foot which they use to move along

Monotremes

Monotremes: a subclass of mammals that lays eggs; examples are echidna and platypus

Nematodes: phylum of the animal kingdom consisting of the roundworms

Osteichthyes: the bony fish; examples are tuna, barramundi, eels, sea horses and lungfish

Parasite: organism that lives on or in another organism called a host; it gets its food from the host, but the host gets nothing in return and may be harmed

Phylum (plural **phyla**)**:** the second level of classification of living things, below kingdom and above class

Placentals: a subclass of mammals that nourish the baby inside the mother's body by a placenta, and in which the baby is born at a more mature stage; examples are dingo, horse and human

Glossary

Platyhelminths: phylum of the animal kingdom consisting of the flatworms

Platyhelminths

Poriferans: phylum of the animal kingdom consisting of the sponges

Reptiles: animals with scales covering their body; ectotherms, most of which lay eggs with leathery shells

Reptiles

Vertebrae: the individual bones of the vertebral column

Vertebral column: the series of small bones protecting the nerve cord found in most chordates

Vertebrates: animals with backbones

Unit 6.3 L

Cells: the building blocks of all living things

Conifers: plants that bear their seeds on cones and have male and female cones on the same tree; example cypress, fir and hoop pine

Cycads: plants that bear their seeds in cones and have male and female cones on separate plants

Decomposers: bacteria and fungi responsible for the natural breakdown of wastes

Division: the level below kingdom in the classification of plants

Ferns: plants that reproduce using spores and have a vascular system for transporting food and water throughout the plant

Ferns

Flowering plants: plants that produce seeds fully protected inside an ovary

Flagellum (plural **flagella**)**:** whip-like tail of single-celled organisms

Fungi (singular **fungus**)**:** one of the five kingdoms of living things; multicellular or unicellular organisms with a cell wall as the outer covering and a distinct nucleus

Fungi

Ginkgos: trees with separate male and female plants. Pollen is produced in cones. The female tree produces fleshy-coated seeds. *Ginkgo biloba* is the only living member of this class

Liverworts: plants with no vascular tissue that reproduce using spores

Macroscopic: able to be seen without the help of a microscope

Microscopic: cannot be seen without the help of a microscope

Monera: one of the five kingdoms of living things; single-celled organisms without a distinct nucleus

Mosses: plants with no vascular tissue that reproduce using spores

Multicellular: made of many cells

Plant: one of the five kingdoms of living things; multicellular organisms with a cellulose cell wall as the outer layer and a distinct nucleus

Protist: one of the five kingdoms of living things; single-celled organisms with a distinct nucleus

Seed-producing plants: plants that reproduce using seeds

Sporangia: special structures in which spores are produced

Spores: single cells that grow into a new moss plant, fern or fungus

Unicellular: made of only one cell

Unit 6.4 L

Class: the level under phylum in the classification of living things

Family: the level in the classification system below order and above genus

Genus (plural **genera**)**:** the level in the classification system below family and above species

Order: the level in the classification system below class and above family

Species: the last level of classification of living things

Look who is using science

PROFESSIONAL DANCER

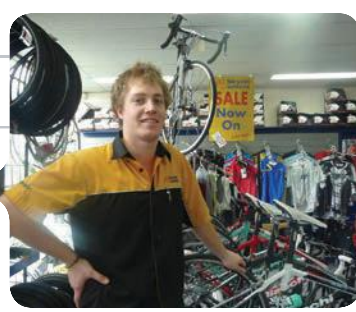
My name is Brianna Lees and I am a professional dancer.

As a dancer I need to understand how to keep my balance during rapid changes of motion and energy transfer. I began to learn how to do this at a young age, when I had lessons in several dance styles, and learnt more about forces when I completed a two-year Diploma of Dance and Performance.

A lot of my time is spent auditioning for parts in musicals, shows, corporate events and children's entertainment. My work involves choreography, costume fittings, rehearsals and usually eight performances a week.

Most aspiring dancers have a part-time job to support themselves in case they are unsuccessful in an audition. I teach dance technique in schools part-time. The industry is very competitive, but being a dancer is rewarding. You work hard, and the moments performing on stage make the physical training and auditions worthwhile. It is satisfying to make an impact on an audience and have your efforts appreciated.

BIKE MECHANIC



My name is Scott Jones and I work at a bicycle store.

My day at work is taken up with servicing bikes, serving customers, checking stock and assembling new bikes to place them on the floor.

When servicing bikes, I lubricate and degrease the gears first, and check that everything is running smoothly. Bike riding is a very social activity. Most mornings I meet up with a riding group and about 30 of us do a road ride, usually around the beach. On my days off, I enjoy mountain biking around beach areas or in the hills. Different types of bikes are better suited to road riding and mountain biking, and over the years I have collected a shed full. I'll always keep a connection with this job because I get great rates on buying new bikes and I like working with people who have similar interests to my own.

TRUCK DRIVER

My name is Trevor Worland. I own a transport logistics company and manage the storage and distribution of products to clients.

When I am organising my deliveries, it is important that I don't exceed the maximum weight my truck can carry. The truck won't accelerate or stop as quickly when it is carrying a heavier load, and I need to take corners more slowly. The weight of the load needs to be evenly distributed, otherwise goods can be damaged and the performance of the truck is affected. I check my tyres to keep them at their maximum pressure because this makes a big difference to the way the truck handles and it also saves fuel. I enjoy my work because I am my own boss and can work flexible hours. I meet lots of people in my job, see many sights, have endless opportunities, and never have two days the same.

7 Forces

Have you ever wondered ...

- why cars are designed with crumple zones?
- why competitive swimmers wear a cap or shave their head for a race?
- why clothes crackle after being tumble dried?

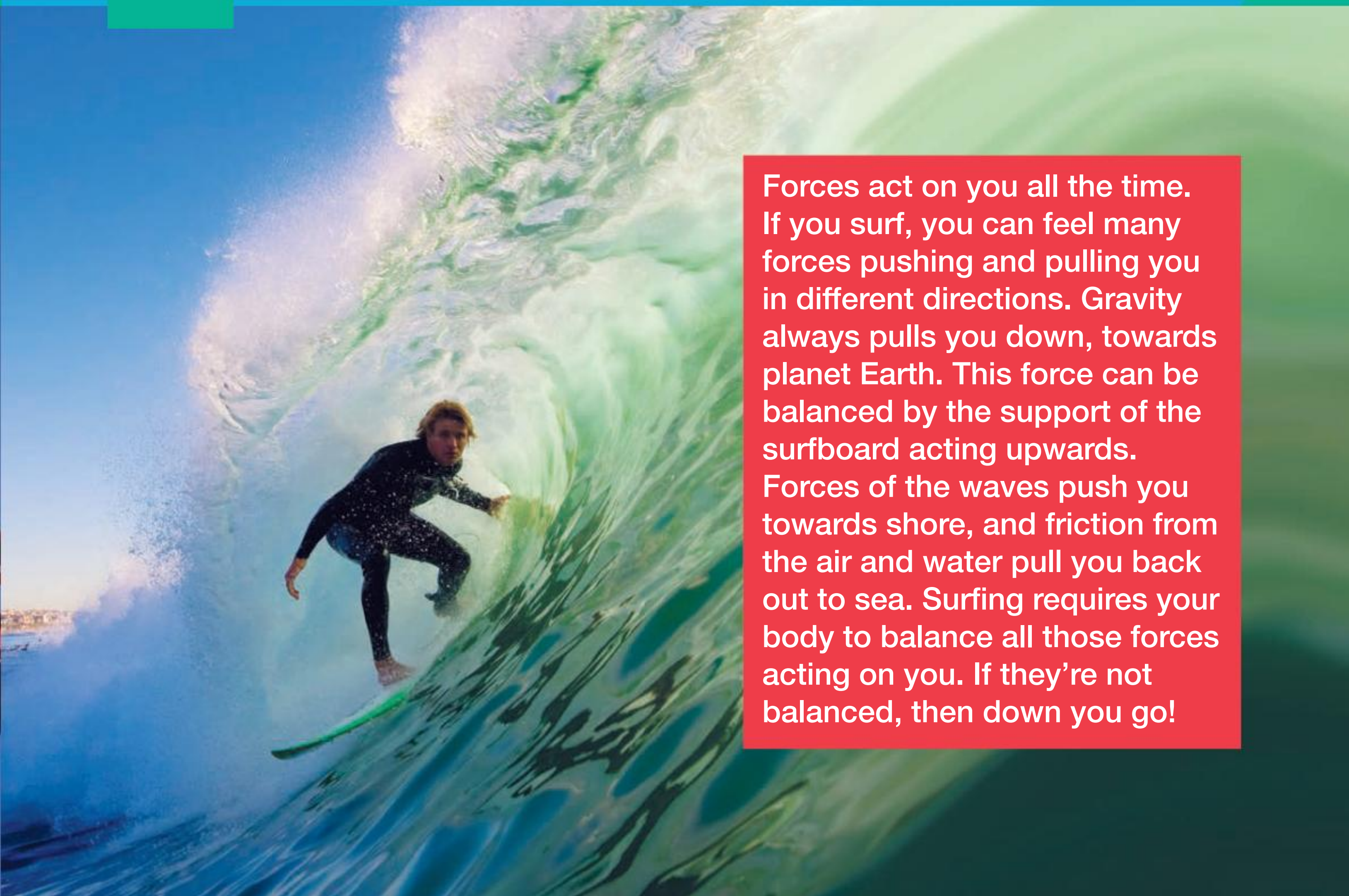
After completing this chapter students should be able to:

- identify changes that take place when particular forces are acting
- predict the effect of unbalanced forces
- describe how technological developments have reduced impact forces in car safety features and footwear design ICT CCT
- analyse situations where friction opposes motion and produces heat N
- investigate factors that influence the size and effect of friction
- use the term 'field' in describing forces acting at a distance L
- identify that gravity pulls objects towards the centre of Earth
- describe situations where gravity acts as an unbalanced force
- distinguish between the terms 'mass' and 'weight' L
- describe what happens when magnets are brought close together
- investigate how magnets and electromagnets are used CCT
- describe ways objects become charged
- describe how charged objects behave when brought close to each other
- investigate situations where the effects of electrostatic forces can be observed such as lightning strikes CCT

ADDITIONAL

- investigate specific forces in terms of size and direction
- research ideas about Earth's magnetic field and its effects.

7.1 What are forces?



Forces act on you all the time. If you surf, you can feel many forces pushing and pulling you in different directions. Gravity always pulls you down, towards planet Earth. This force can be balanced by the support of the surfboard acting upwards. Forces of the waves push you towards shore, and friction from the air and water pull you back out to sea. Surfing requires your body to balance all those forces acting on you. If they're not balanced, then down you go!

Push, pull or twist

A **force** is a push, a pull or a twist. This is shown in Figure 7.1.1.

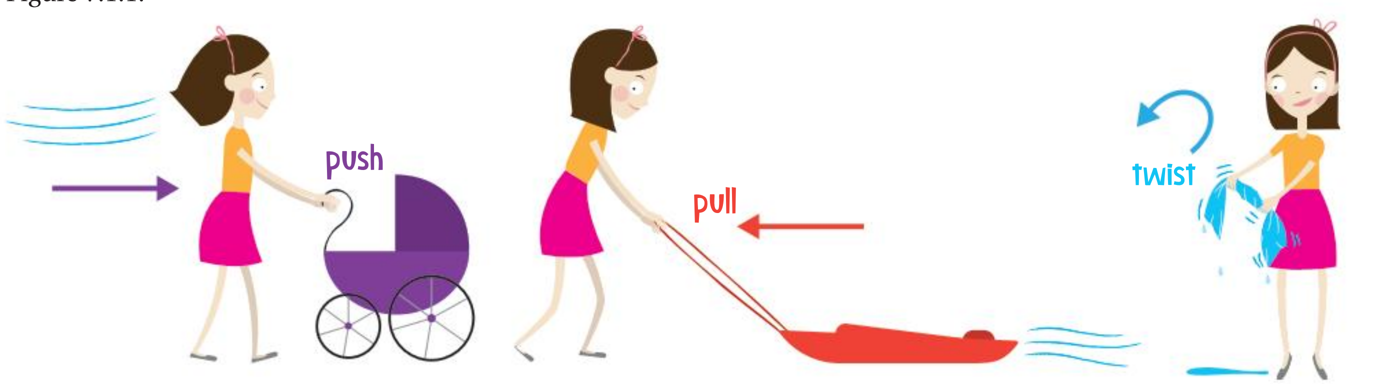


Figure 7.1.1 A force is applied when something is pushed, pulled or twisted.

Force is measured using a unit called the **newton** (symbol **N**). This unit is named after the English scientist Sir Isaac Newton (1642–1727). It takes a force of about 1 N to lift an apple.

What forces do

All around you, things move, or are in motion. Whenever there is a change in motion, a force has acted. Some examples are shown in Figure 7.1.2.

Figure 7.1.2 Forces are needed to cause a change in the motion of an object.

Measuring forces

A spring balance can be used to measure a force. The larger the pulling force, the more the spring is stretched and the higher the reading on the scale. The spring balance shown in Figure 7.1.3 operates in this way. Bathroom scales use a spring that is squashed or compressed to measure force.

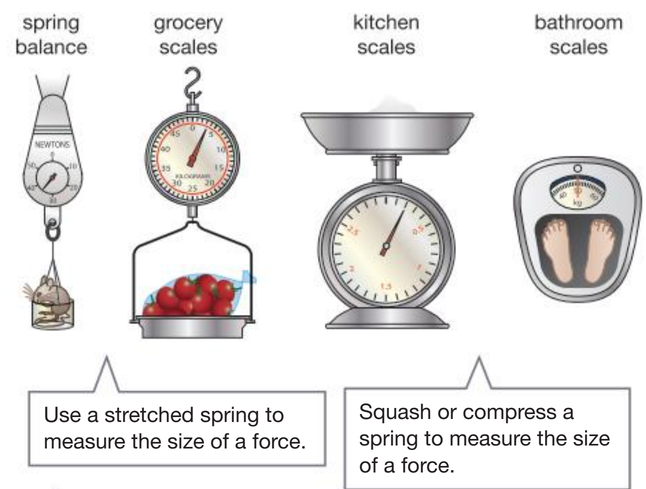


Figure 7.1.3 The ability of springs to stretch and squash allow a weight force to be measured.

SKILL BUILDER

Drawing forces

Many forces can act on an object at the same time. You can show these forces in a diagram such as Figure 7.1.4 by representing each as an arrow.

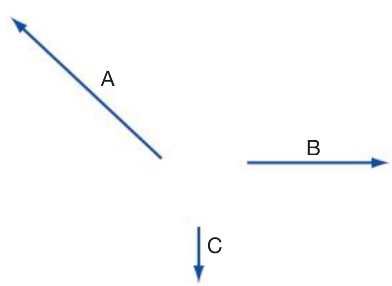


Figure 7.1.4 Forces are represented by arrows that show the direction in which the force acts. The size of the arrow represents the size of the force, so the bigger the arrow, the bigger the force. Force **A** is the largest of these three forces and force **C** is the smallest.

Balanced forces

The forces acting on an object can be balanced or unbalanced. When sitting on a chair, the force of gravity pulls you downwards, towards Earth. The chair supports you by pushing upwards. This balances the downwards force of gravity. This balancing act is shown in Figure 7.1.5.

Figure 7.1.5 The downwards force of gravity is balanced by the upwards support force from the chair. The forces acting on this person are balanced.

Balanced forces don't always mean that the object is stopped—it might be travelling at the same speed without changing directions. Consider Nishika, about to ride her bike. To take off, Nishika must accelerate, pedalling fast and hard to produce a force large enough to push her forwards. She needs to overcome the friction caused by the roughness of the road and by the air that she pushes through. To speed up, Nishika keeps accelerating. Her pedalling needs to provide a driving force that is bigger than the force of friction acting in the opposite direction. As Nishika continues her journey, she may travel at a constant speed without slowing down or speeding up. When this happens, the forwards force from her pedalling is cancelled out by the friction forces pushing her backwards. At this stage, her motion is constant and all of the forces acting on her are balanced, as shown in Figure 7.1.6.

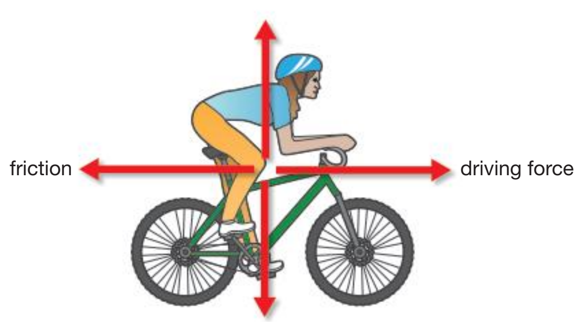


Figure 7.1.6 At this stage of the ride, Nishika travels at a constant (even) speed. All of the forces acting on her are balanced. This is indicated by the force arrows being the same length in each direction.

Unbalanced forces

Whenever the forces acting on Nishika are unbalanced, her motion will change. Motion always changes in the direction of the unbalanced force, as can be seen in Figure 7.1.7. This means that the forces are unbalanced when Nishika:

- starts moving (by pedalling fast and hard)
- speeds up (by pedalling faster and harder)
- slows down (by using the brakes)
- comes to a stop (by using the brakes)
- changes direction (by turning the handlebars).

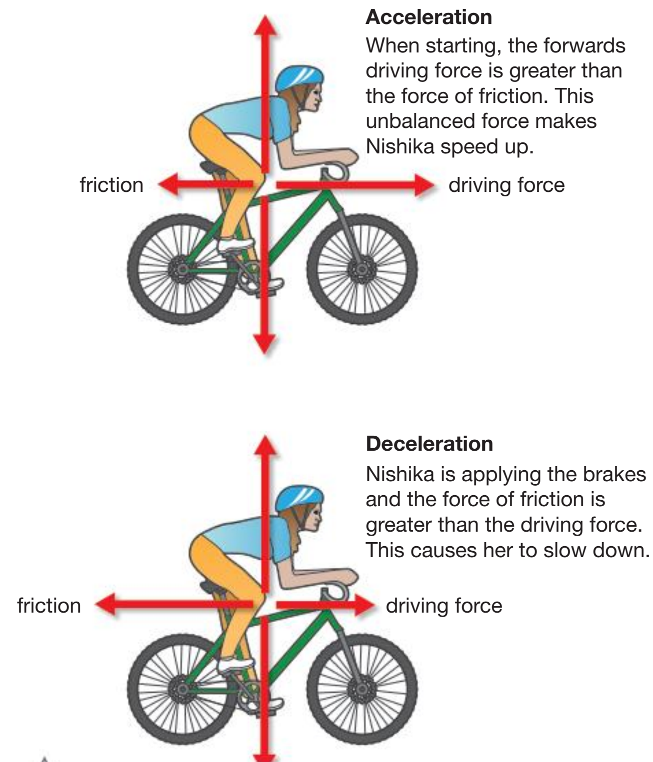


Figure 7.1.7 Nishika's motion will change whenever the forces acting are not balanced.

Prac 1 p. 285
7.1

Inertia

If you put your schoolbag down in your bedroom, it will stay there until something happens to it. Someone could lift it, push it or pull it to make it move; but if left alone, your schoolbag will stay as you left it. This ability of the schoolbag to remain unchanged is called its **inertia**. Everything and everyone possesses inertia. Inertia can be described as the tendency to resist any change in motion.

INQUIRY science 4 fun

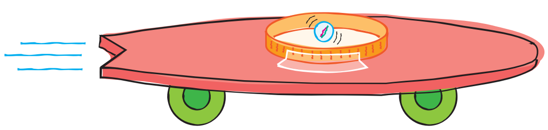
Starting and stopping

YES

What happens to your body as a car starts and stops?

Collect this …

- skateboard or toy truck
- jar lid
- masking tape
- marble



Do this …

1 Tape the jar lid to the skateboard or toy truck.
2 Put a marble or ball bearing in the lid.
3 Observe what happens to the marble when you push the skateboard/truck forwards; stop it, or push it around a corner.

Record this …

Describe what happened to the marble in each case.

Explain why you think this happened.

SciFile

Marathon impacts

It is estimated that in the course of a typical marathon, a runner will take around 25 000 steps and so their feet will experience around 25 000 collisions with the ground!

Reducing impact force

Forces act on you all of the time. If these forces are balanced, then you will be still, or moving at a constant speed. If the forces are not balanced, then your motion will change. Some of the forces that act on you in a collision can be large enough to break bones or damage internal organs.

Reducing impacts in sport

If you are riding a skateboard along the footpath and catch a wheel on a stone then your skateboard can stop moving. However, you will continue moving forwards until something makes you stop. Unfortunately this is likely to be the hard surface of the footpath ahead.

A properly fitted helmet, mouthguard and elbow, wrist and knee pads reduce the size of impact forces on you when something goes wrong while skateboarding, rollerblading or rollerskating. These accessories (shown in Figure 7.1.8) absorb some of the impact force in a collision and reduce the risk of serious injury.

Figure 7.1.8 Professional skateboard riders wear devices to lessen the impact force in a collision.

Footwear is also designed to reduce the force involved in the collision between a person’s foot and the ground when walking, running or playing sport. The type of shoe worn needs to be suited to the type of activity. Running shoes are designed to cushion the toe and heel because it is these parts of the foot that are most affected by the impacts involved while running. Cushioned heels also spread the force over a larger area of the sole of the foot. Figure 7.1.9 shows the cushioning support of a running shoe. Shoes worn in sports that require fast changes from side to side require more grip on the soles and need to provide lateral (sideways) support and stability.

Figure 7.1.9 Cushioning of the sole of a shoe absorbs impact from running forces. A raised arch prevents the foot from rolling inwards.

Car safety features

When a car stops suddenly, its passengers continue to move forwards until they hit something that stops them. This is inertia at work. If the windscreen, dashboard or steering column stops them then they will usually hit the object head-first. This concentrates impact forces on their brain and they can be seriously injured or killed.

Crash testing is used to assist the development of safer cars and to inform consumers of the safety rating of new cars on the market. Figure 7.1.10 shows what happens to crash test dummies the instant after a car hits a wall at 56 km/h. The ANCAP (Australasian New Car Assessment Program) uses a system of star ratings of 1 to 5 stars to indicate how safe a car will be in an accident.

SciFile

High impact

An average 1.2 million people around the world die in road deaths each year, with another 50 million injured. The number of road accident fatalities in Australia has fallen from a peak of 30.4 per 100 000 people in 1970 to 6.9 per 100 000 people in 2009.

The simplest way of preventing serious injury is to wear a seatbelt. A seatbelt holds you in place during a collision and minimises the impact forces on you by spreading them across your chest. Being slightly elastic, seatbelts also reduce the impact force on your chest. Airbags (front, side and curtain) and front and rear crumple zones, as shown in Figure 7.1.11, reduce impact forces even further.

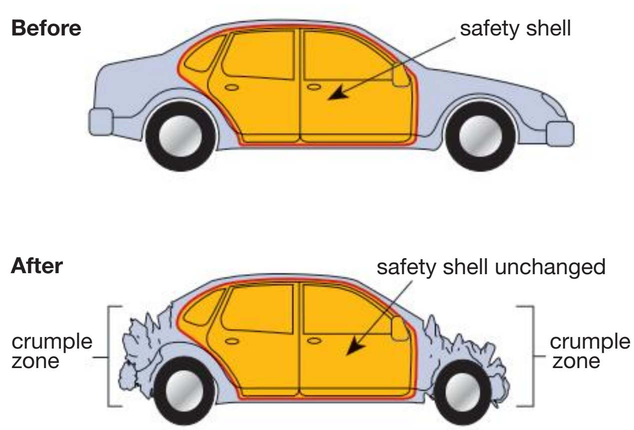


Figure 7.1.11 The passenger shell of a car is usually made from steel to protect its passengers. The engine compartment and the boot are made to collapse on impact. This reduces impact forces and causes the energy to be spread more evenly in the case of an accident.

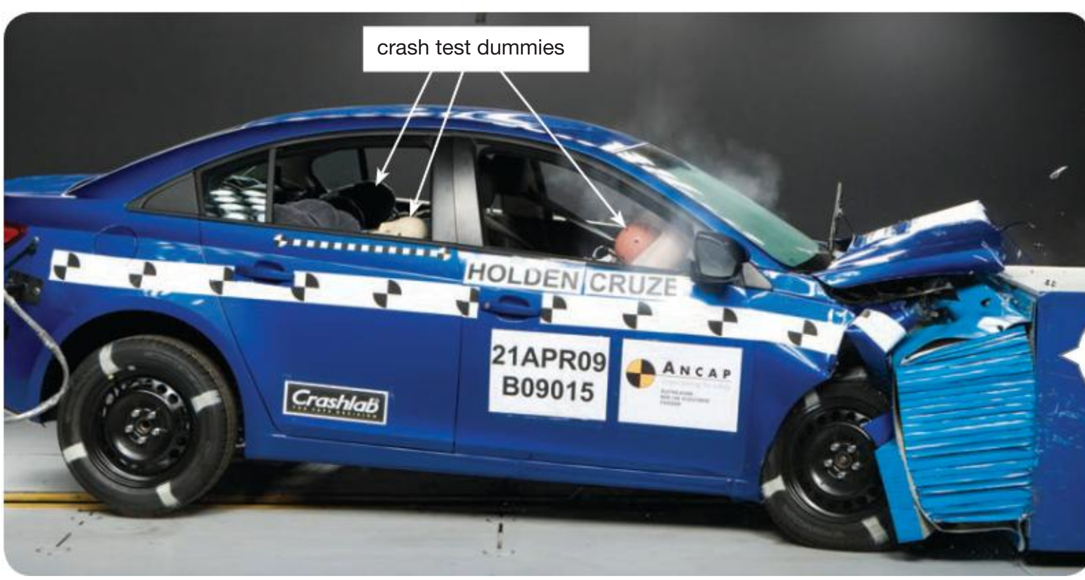


Figure 7.1.10 Crash testing in a laboratory enables scientific measurement of the forces in a collision.

It's better to avoid a car accident in the first place and so modern cars include **active safety features**. These features are designed to reduce the chance of an accident occurring.

They include:

- good quality tyres inflated to the correct pressure
- high-intensity headlights
- automatic or swivelling headlights
- well-maintained windscreen wipers and washers
- automatic windscreen wipers
- a well-maintained braking system
- ABS (anti-lock brakes)
- brake assist
- cameras and sensors for reversing
- traction control
- Electronic Stability Control (ESC)
- night vision.

Passive safety features are designed to lessen the impact of a force if and when an accident does occur. They include:

- correctly adjusted 3-point seatbelts and seatbelt reminder lights
- front and side airbags
- crumple zones
- side impact protection systems
- laminated windscreens
- no sharp features protruding from the dashboard of the car.

Some common passive and active safety features are shown in Figure 7.1.12.

Prac 2 p. 286
Prac 3 p. 287
Prac 4 p. 287

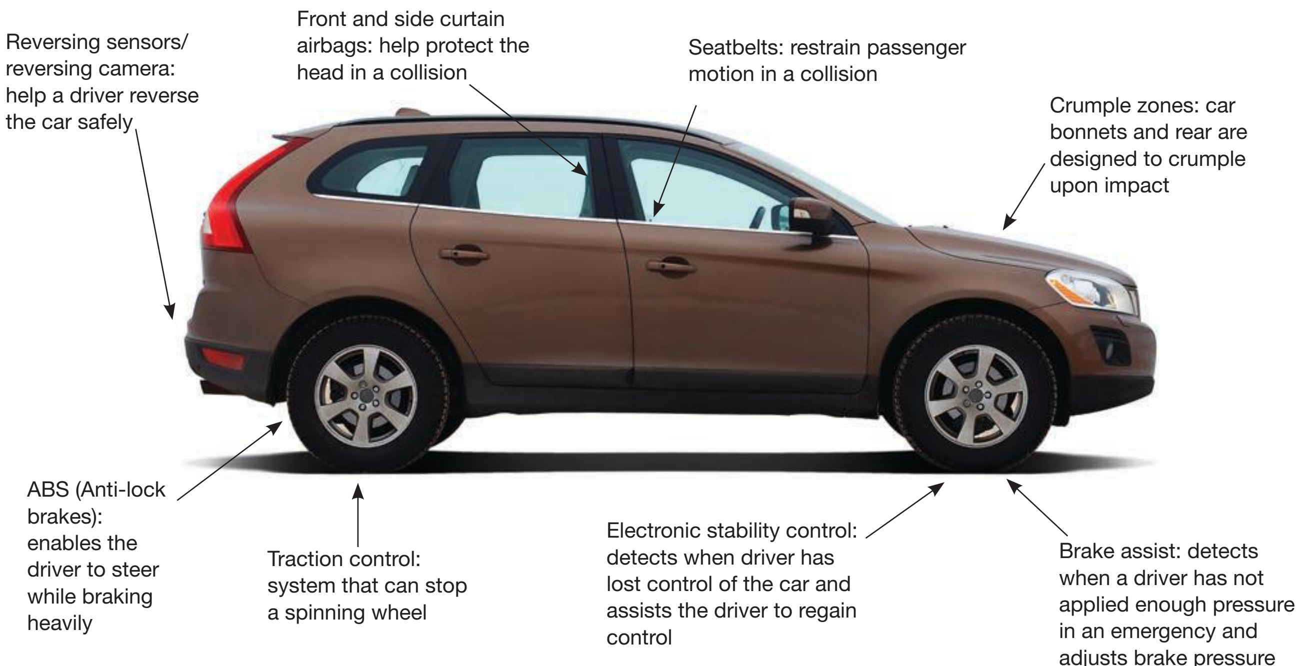


Figure 7.1.12 Active safety features lessen the chance of a collision occurring. Passive safety features reduce the impact of forces in the case of a collision.

7.1 Unit review

Remembering

1 **State** which word from the list below correctly completes each statement.

push motion newton force spring

- **a** All around us, things move or are in ____.
- **b** Whenever there is a change in motion, a ____ has acted.
- **c** A force can be a ____, a pull or a twist.
- **d** A force can be measured using a ____ balance.
- **e** The unit used to measure force is called the ____.

2 **List** five ways a force can change motion.

3 **State** whether the following are true or false.

- **a** If the forces acting on an object are balanced, then it is not moving.
- **b** You supply a force when you squeeze a tube of toothpaste.
- **c** Helmets, elbow pads and sunglasses all reduce the impact of forces in a collision.
- **d** In a front-on collision, passengers continue to move forwards once the car has stopped.

4 **List** the following forces in order from smallest to largest.

- **a** A car accelerating down a road
- **b** Typing a text message on a phone
- **c** Turning a key in a lock
- **d** Cutting a slice of bread from a loaf
- **e** Pushing a couch across the floor
- **f** A rocket launching into space.

Understanding

5 **Describe** an example of a force that:

- **a** speeds up an object's motion
- **b** changes an object's direction.

6 **Explain** how a spring balance is used to measure force.

7 The grocery and bathroom scales shown in Figure 7.1.3 on page 278 both use a spring to measure the size of a force. **Outline** how the spring is used in each case.

8 Refer to Figure 7.1.6 on page 279 of Nishika riding a bike.

- **a** **Name** the forces acting on Nishika when she travels at a constant speed.
- **b** **Explain** why the opposing arrows on this force diagram are shown equal in size.

9 **Describe** the role of each of the following safety features in protecting passengers of a car in an accident: airbags, anti-lock brakes, reversing sensors, electronic stability control and seatbelts.

10 **Explain** why cars are designed with crumple zones.

Applying

11 **Identify** the direction of movement of objects acted upon by these forces: N

Force to left (N)	Force to right (N)	Force upwards (N)	Force downwards (N)	Direction of movement
10	10	10	0	
20	30	0	0	
25	5	15	15	
30	30	10	50	
40	40	100	100	

12 Mylinh pushes a full shopping trolley with a force of 220 N and her four-year-old son also pushes with a force of 90 N. N

- **a** **Calculate** the total pushing force acting on the trolley.
- **b** Mylinh continues pushing the trolley without realising her son has run in front of the trolley. **State** what pushing force she needs to apply to stop the trolley from moving.

Analysing

13 **Classify** each of these actions as a push, pull or twist force.

- **a** Sweeping the floor
- **b** Dragging a heavy sports bag along the floor
- **c** Throwing a cricket ball
- **d** Hitting a golf ball
- **e** Tightening wheel nuts on a car
- **f** Closing your front door from the inside of the house
- **g** Closing your front door from outside your house

14 Forces can be represented by arrows.

a Compare the forces shown in Figure 7.1.14 by stating which:

- **i** force is the largest
- **ii** two forces are the same size
- **iii** two forces act in the same direction.

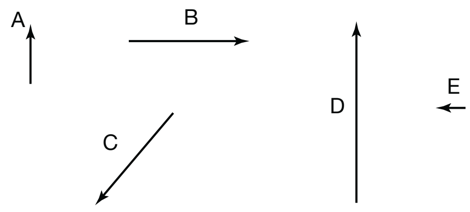


Figure 7.1.12

b If forces B and E acted on an object, **predict** which direction the object would move.

Evaluating CCT

15 In the science4fun on page 280, a marble is placed on a jar lid. If this lid is moved forwards, the marble rolls backwards.

a **Describe** a situation in which you have experienced this type of motion.

b If you were in a car that was suddenly pushed forwards due to a collision, **propose** which safety feature would offer you some support.

Inquiring

1 Whenever an unbalanced force acts on an object, the motion of the object changes. This means that the object may start moving, stop moving, speed up, slow down, change direction or even change its shape.

- Use a search engine to find images of objects that are involved in each of the six types of changes of motion listed above, OR use computer animation to show objects undergoing each type of change in motion.
- Add labelled arrows to each of your images or animations to show where you think a force is acting.
- Identify the direction of the unbalanced force that acts in each case and use this to explain its change in motion.

Present your images or animation digitally. ICT

ADDITIONAL

2 Search the internet to find the size (measured in newtons) and direction of specific forces. You could choose something like:

- the weight of an 80 kg adult
- the weight of a 2 tonne car
- the weight of a large commercial jet liner such as the Airbus A380
- the force required to open a door
- typical friction forces of car or bike tyres moving across different surfaces such as bitumen, concrete or grass
- the typical force required to walk
- the force of a dog bite
- the force on a car colliding at 60 km/h with a wall.

Select five specific forces and present the information you find as a diagram or image with labelled arrows added to them to show the direction the force(s) is/are acting. ICT

ADDITIONAL

7.1 Practical investigations

1 Looking at forces

Forces act all around you, all of the time. Whenever the shape or motion of an object changes, you know that an unbalanced force has acted.

Purpose

To observe a range of forces in action.

Materials

- lump of Plasticine
- textbook
- tennis ball
- plastic cup
- pencil case
- ruler
- bucket
- table tennis ball
- balloon
- woollen fabric
- magnet
- paper clip
- plastic straw

Procedure

1 Copy the table into your workbook.

2 Complete each of the tasks in the table, recording your observations as you go.

Results

Record all your observations in the appropriate columns of your table.

Practical review

1 A force was acting in each task. **Explain** how you knew.

2 **List** any objects that changed shape as a result of the force.

3 **State** whether any of these changes in shape were permanent.

4 **State** whether the tennis ball changed its shape at any stage of its journey.

5 **Discuss** whether a table tennis ball could remain stationary even when two people blow air on it from two straws.

Task		Changes observed in the motion or shape	What produced the force?
a	Prop up one end of a textbook to make a ramp. Roll a tennis ball down it.		
b	Rub woollen fabric against an inflated balloon, and bring the balloon towards someone's hair.		
c	Point an end of a bar magnet towards a paper clip.		
d	Drop a tennis ball and try to catch it when it bounces.		
e	Blow a table tennis ball across a bench using a plastic straw.		
f	Use a straw to blow bubbles in water in a cup. (Do not drink it.)		
g	Push your pencil case across the bench using a ruler.		
h	Squash a lump of Plasticine.		
i	Push an inflated balloon into a bucket of water and then let the balloon go.		

2 Crash test dummies

Purpose

To model crash test dummies and describe their motion in different types of collisions.

Hypothesis

What do you think will happen to a dummy that is on a trolley that collides with a wall? What do you think will happen to dummies on trolleys that are in a head-to-tail collision? Before you go any further with this investigation, write a hypothesis for each question in your workbook.

Materials

- about 50 g of Plasticine
- talcum powder

- trolley
- toothpicks
- block of wood
- ruler or measuring tape
- ramp
- books or bricks to make ramp and a barrier
- video camera or mobile phone

Procedure

Part 1: Collision with a barrier

1 Construct a model crash test dummy of a person from Plasticine and toothpicks.

2 Set up a ramp to a height of about 50 cm. Place a brick 30 cm in front of the ramp as shown in Figure 7.1.14.

3 Place crash dummy A on a trolley. Lightly powder the dummy with talcum powder to prevent it sticking to the trolley.

4 Release the trolley from the top of the ramp, and watch the motion of dummy A carefully (or record its motion) as it hits the brick.

5 Repeat the test three times and record your observations.

Part 2: Collision between two vehicles

6 Join with another group. Remove the brick and place one trolley and dummy B in its place.

7 Release dummy A from the top of the ramp and record what happens to dummies A and B when the trolleys collide.

8 Repeat this test three times.

Practical review

1 Part 1: Collision with a barrier
  - a **Describe** changes in the motion of dummy A on impact.
  - b **Explain** these changes in terms of inertia.
  - c **List** any safety features that would protect dummy A in this impact.

2 Part 2: Collision between two vehicles
  - a **Describe** changes in the motion of dummy A on impact.
  - b **Explain** these changes in terms of inertia.
  - c **List** any safety features that would protect dummy B in this impact.

3 a **Construct** a conclusion for your investigation.
  - b **Assess** whether your hypothesis was supported or not.

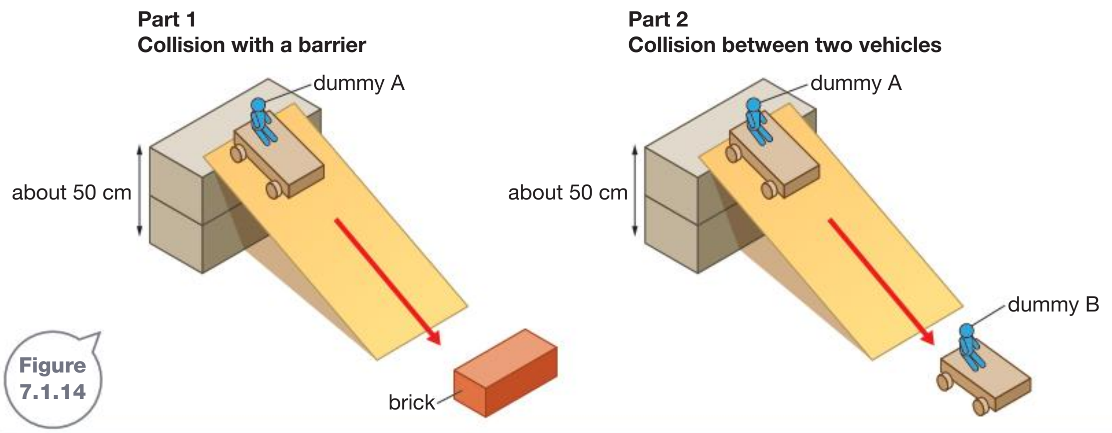


Figure 7.1.14

STUDENT DESIGN

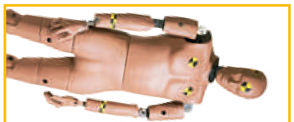
3 A force-measuring device

Purpose

To construct a device that can measure the size of a force.

Materials

Students could select materials such as elastic bands, springs, or other elastic material in their design. Figure 7.1.15 could give some ideas.



SAFETY

A Risk Assessment is required for this investigation.

Figure 7.1.15

Procedure

1 Design a device that will stretch or compress when acted on by a force.

2 Write your procedure in your workbook.

3 Before you start any practical work, assess your procedure. Assess any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Hints

Once you have assembled your device, you will need to calibrate it. This means that you need to make a scale that links the extension or compression of your device with a reading of force measured in newtons (N). To calibrate your device, you need to know that the reading of a hanging 100 g mass corresponds to a force of 1 newton.

Results

In your workbook, draw a diagram of your force-measuring device.

Practical review

1 **Explain** what is meant by the term *calibration*.

2 **Assess** the effectiveness of your design for measuring forces.

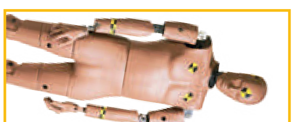
3 **Propose** any improvements you could make to your design.

STUDENT DESIGN

4 Marble run

Purpose

To build a structure that will apply different forces to a marble.



SAFETY

A Risk Assessment is required for this investigation.

Materials

Students could select materials such as:

- elastic bands
- springs
- cardboard boxes
- funnels
- marble
- wooden ramps
- balloons
- cardboard tube
- icy-pole sticks

Procedure

1 Design a structure that will cause a marble dropped onto or into it to speed up, slow down, change direction, and finally come to a stop.

2 In your workbook, draw a diagram of the structure you plan to build.

3 Before you start any practical work, assess your structure and how you will build it. Assess any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your plan and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

Record your observations about the journey of the marble.

Practical review

1 **Assess** how effective your design was in making the marble speed up, slow down, change direction and finally stop.

2 **Propose** any improvements you could make to your design.

7.2 Friction—a contact force

Things that are moving continue to do so unless a force makes them stop. The force that makes most moving objects stop is friction. Friction exists whenever two surfaces are in contact. Friction is the force that provides the grip needed by cars, bikes, trucks and your shoes to get moving, change direction and slow down. Friction can be a problem. It causes machines with moving parts to heat up, which wastes energy.

INQUIRY science 4 fun

Warming up

YES

Collect this ...

- block of wood
- piece of sandpaper

Do this ...

1 Rub your hands together as quickly as you can for a minute. How do they feel?

2 Now rub a piece of sandpaper back and forth over a piece of wood for a couple of minutes. Feel the surface of the wood.

Record this ...

Describe what happened in each case.

Explain why you think these observations happened.

What is friction?

If you roll a soccer ball along a patch of grass, then it will slow down and eventually stop. The force that slows it down is **friction**. Friction occurs whenever one object tries to move over another. Because it occurs between surfaces in contact, friction is called a **contact force**. Friction acts in an opposite direction to motion, as shown in Figure 7.2.1.

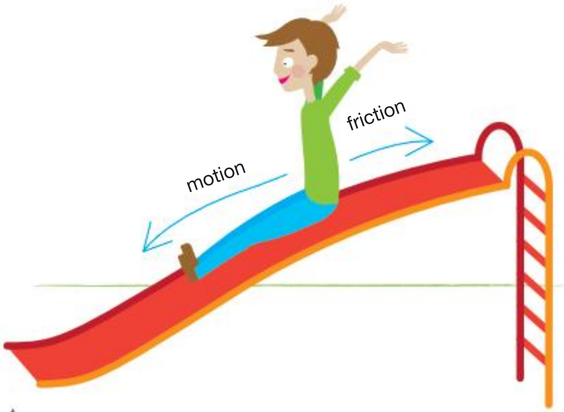


Figure 7.2.1 Friction always acts in the opposite direction to motion.

Two sheets of sandpaper will appear to 'stick' when you try to slide them over each other. This is because the grit on one sheet grabs and catches bumps on the other. This causes friction, and collisions between these bumps create heat.

All surfaces have bumps on them, even 'smooth' materials such as glass or steel. Figure 7.2.2 shows the microscopic bumps on the 'smooth' surfaces of a contact lens. An ice sheet is a very smooth surface (Figure 7.2.3). Try to walk on ice and you will slip because the friction is so low. You may have already worked this out and suffered a few bruises as a result!

Figure 7.2.2 These ridges are microscopic bumps on the surface of a plastic contact lens, viewed with an electron microscope.

Figure 7.2.3 The puck used in ice hockey will travel long and fast along the ice unless it is blocked. This is because of the low friction between the ice and the puck.

Factors affecting friction

Friction depends on:

- how rough the surfaces in contact are
- how hard the surfaces are pushed together.

The greater the weight of a sliding object, the greater the force of friction, as shown in Figure 7.2.4.

Prac 1
p. 294

Figure 7.2.4 Greater friction exists between the heavier box and the floor than between the lighter box and the floor. This makes the heavier box harder to move.

Useful friction

When you walk, you push your foot backwards against the ground. The force of friction acts in the opposite direction to push you forwards. For this to happen, there must be enough traction, or grip, between your feet and the ground, otherwise you will slip. This is shown in Figure 7.2.5. Without friction you could not walk, run, ride a bike or travel in a car, and you could not pick things up (Figure 7.2.6).

Figure 7.2.5 Friction enables us to walk.

Figure 7.2.6 The ridges and grooves seen in your fingerprints increase the friction between your fingers and the objects you grasp.

Unwanted friction

You rely on friction in your daily life, but it also has some unwanted effects. Moving parts, such as those in a machine, are gradually worn away and made thinner by friction. Friction also produces heat. Much of the energy put into a machine, such as a car, an aircraft, a mixer or an electric knife, is converted into heat caused by friction. This makes the machine less efficient and wastes energy, because it is not being converted into the useful forms of energy required. The friction of moving parts in a car engine would quickly cause it to overheat if the car did not have a radiator. A car radiator releases excess heat to the air that passes through it as the car drives along.

Friction between an object and the air around it slows its motion. This type friction is called **air resistance**, or drag. A wind tunnel, such as that shown in Figure 7.2.7, can test how well an object cuts through the air.

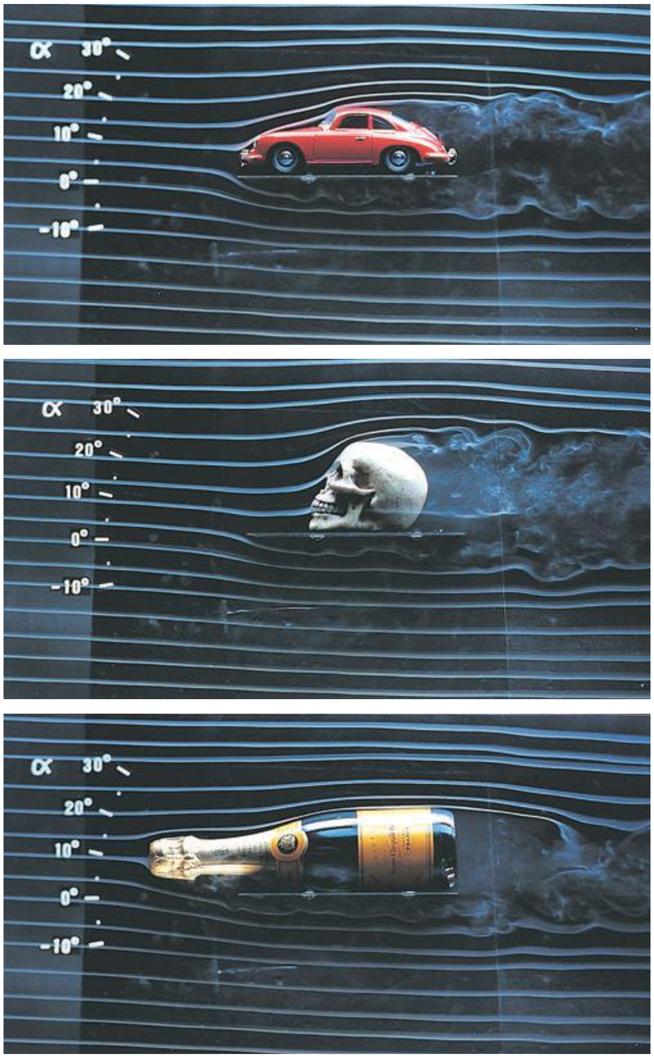


Figure 7.2.7 Drag occurs at the front of an object where air bunches up as it moves forward, and also behind it, where there is a space needing to be filled.

Reducing friction

Reducing friction makes machines more efficient, cheaper to run and longer lasting. Friction can be reduced by a number of different methods. Some are shown in Figure 7.2.8.

GO TO Pearson science NSW 8 Unit 5.2

Removalists use trolleys to shift refrigerators because rolling surfaces produce less friction than sliding surfaces. Skateboards and rollerblades have ball bearings inserted into the hub of their wheels, allowing them roll more freely over the axle.

An effective way to reduce friction is to stop moving parts being in contact with each other. A hovercraft travels on a blanket of air with very little friction.

You may have slipped on spilt grease or oil at home. These substances are called **lubricants**. By adding grease to ball bearings, or putting oil into a car, we reduce the friction between moving parts. Polishing a surfboard helps to make its surface smoother and will reduce friction.

Vehicles such as cars and aircraft are all designed to have a streamlined shape. These shapes allow air to flow over and around them more freely, and reduce drag.

Figure 7.2.8 There are a number of ways friction can be reduced.

SciFile

Low-drag shark

These are shark scales. Each is made from dentine, is coated in dental enamel and measures about a half a millimetre. The base of each scale is made from bone and attaches the scale to the shark's skin. The shark's scales reduce churning of the water as the shark moves, and allow it to glide more smoothly as it seeks its prey.

SciFile

Swimsuit friction

Swimmers have always tried to reduce their friction with the water. Men shave their heads, legs and chests and swimmers often wear full-body swimsuits. In 2009, swimmers competing in the World Titles in Rome were allowed to wear hi-tech polyurethane swimsuits, resulting in 43 new world records. These suits are now banned in competition.

Prac 2 p. 295
Prac 3 p. 296
7.2
7.3

7.2 Unit review

Remembering

1 **State** three everyday activities you couldn't do without friction.

2 **State** whether the following are true or false.
   a Friction acts in the same direction as an object's motion.
   b The greater the weight of the sliding object, the smaller the force of friction it experiences.
   c Friction makes a machine more efficient.

Understanding

3 **Identify** the surfaces that are in contact when friction acts:
   a when you kick a football
   b when you swim at the beach
   c as you walk down the street
   d as two people push a broken-down car.

4 In your own words, **explain** why friction exists.

5 Without friction, you could not pick up an apple. **Explain** why.

6 **Explain** why a car needs a radiator to operate effectively.

7 **Explain** why it is easier to push a toy chest along the floor when it is empty than when it is full.

8 **Explain** why ball bearings are used within the hubs of skateboard wheels.

9 Your grandmother has asked you to shift her refrigerator to the other side of the kitchen. **Describe** three ways you could reduce friction to make the task easier.

10 A mountain bike is designed to be considerably heavier than a road bike. **Explain** why this is the case, considering the typical surfaces each is used on.

11 When rubbing a piece of sandpaper over a block of wood as explained in the science4fun on p. 288, the wood and sandpaper heat up.
   a **Name** the process that produced this heat.
   b **Predict** whether using a coarse or fine sandpaper would produce more heat.

Analysing

12 Figure 7.2.9 shows an ice-skater performing a routine on ice.
   a **Compare** the level of friction that would be present on the ice and on a footpath.
   b **Discuss** how this difference allows the ice-skater to move differently on the ice.
   c The base of an ice skate is a narrow blade. **Explain** how this shape helps to lessen friction.

Figure 7.2.9

13 **Analyse** the following and rate them in order from those that would experience the most friction to those that would experience the least.
   - A couch being dragged across carpet
   - A waxed pair of skis travelling on snow
   - An ice-hockey puck hit across the ice
   - A child's tricycle being pulled along the footpath

Evaluating CCT

14 A minibus is travelling along a flat road. **Use** Figure 7.2.10 to answer the questions below.

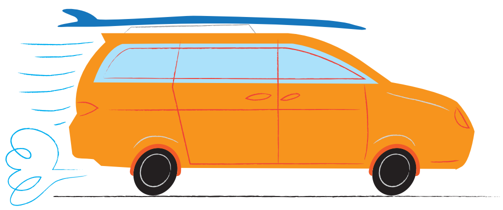


Figure 7.2.10

a **Name** two sources of friction that are acting on the vehicle.

b **State** the direction in which these forces act.

c **Describe** what the driver should do to maintain the speed of the minibus.

d The surfboard is now removed from the roof-rack.

  i **Explain** whether the friction acting on the minibus would increase or decrease.

  ii **Justify** your answer.

e **Predict** what would happen if the tyres on the minibus were not properly inflated. **Use** friction to **justify** your answer.

15 The blades of an electric mixer are hot after beating some cream. **Justify** why this has happened in terms of friction.

16 Weightlifters rub chalk onto their hands before attempting a lift. The chalk absorbs any sweat on the weightlifter's palms.

a **Propose** why weightlifters use this chalk.

b **Predict** what could happen if they use too much chalk on their hands.

Creating CCT

17 Imagine that you wake up one morning and the force of friction no longer exists. **Construct** a role-play, story or a flow chart in which you **describe** what happens when you attempt five everyday tasks, such as getting dressed, brushing your teeth, cooking and eating your breakfast, getting to school, and sitting in class.

Inquiring

1 Some animals move through water as they swim, some animals move through air as they fly and some animals move over land as they run.

- Find images of at least three animals of each type listed above.
- Describe the outer covering of each of these animals. Propose how these layers and the shape of the animal assists it in reducing friction as it moves.
- Search to find and download footage of three animals in motion.
- Describe the shape of the animal in motion. Do any of these animals have a streamlined shape while moving?
- Draw a diagram of a new type of animal that either swims or flies. Explain which features it has that assist in reducing friction as it moves.

Present your research in the forms indicated in each part above.

2 Research polar bears, particularly their feet:

- Identify the structure of a polar bear's foot (shown in Figure 7.2.11).
- Explain how this increases friction between the bear's foot and the ice.
- Find images of the soles of the feet of three other animals.

Present your images as a poster or slideshow. ICT

Figure 7.2.11 The underside of a polar bear's foot

7.2 Practical investigations

1 Friction and mass

Purpose

To investigate how increasing mass affects the size of friction.

Hypothesis

Do you think there will be more or less friction associated with pulling a larger mass than a smaller mass? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- wooden block with hook
- spring balance or force sensor
- 200 g masses

Procedure

1 Copy the table below into your workbook.

2 Place the wooden block on a benchtop.

3 Attach the spring balance to the block of wood as shown in Figure 7.2.12.

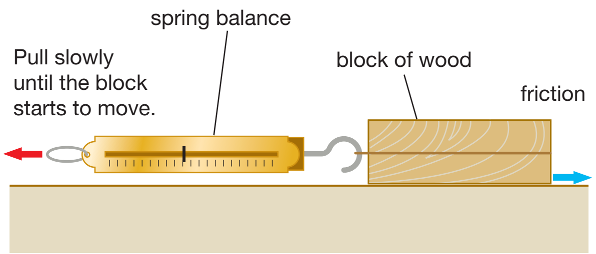


Figure 7.2.12

4 Measure the size of the force needed to keep the block moving at a constant speed. This is equal to the force of friction. Record this in your results table.

5 Repeat step 4 twice and record the results.

6 Add a 200 g mass on top of the block of wood. Measure the friction between the block and the benchtop three times and add these results to the table.

7 Repeat the friction measurements for 400, 600, 800 and 1000 g (1 kg) masses on the block, recording three results for each test.

Results

1 Calculate the average of your results in the table. (Add the three forces and divide by three.) N

2 Construct a line graph showing your results. Place mass added to the block on the horizontal axis (0, 200, 400, 600, 800, 1000 g) and the friction force on the vertical axis (in newtons). N

Practical review

1 **Describe** what happened to the size of the force of friction as the mass on the wooden block increased.

2 **Discuss** a situation in which you have noticed this link between friction and mass.

3 **Propose** any improvements that could be made to the design of this experiment.

4 a **Construct** a conclusion for your investigation.

b **Assess** whether your hypothesis was supported or not.

Object moving	Friction force measured (N)			Average friction (N)
	Trial 1	Trial 2	Trial 3	
Wooden block				
Wooden block + 200 g				
Wooden block + 400 g				
Wooden block + 600 g				
Wooden block + 800 g				
Wooden block + 1000 g				

2 Reducing friction

Purpose

To reduce the force of friction between a block of wood and a wooden ramp.

Hypothesis

Which materials do you think will have the greatest and the least friction when a wooden block is slid across them? Rank the materials you are testing in order from the one you think will produce the least friction to the one that produces the greatest friction when a block slides along it. Before you go any further with this investigation, write your ranking in your workbook.

Materials

- wooden block
- wooden ramp
- various materials to place on the ramp, such as:
  - linoleum square
  - carpet square
  - sandpaper
  - waxed paper
  - other materials as approved by your teacher
- protractor
- 3 pieces of dowel

Procedure

1. Copy the table in the Results section into your workbook.
2. In the second column of your results table, enter the details of each surface you are testing. With permission, you may also test the block on 2 tablespoons of cooking oil.
3. Place the wooden block on a marked position near the end of a plank of wood.
4. Slowly lift the end of the plank that the block is on, holding the other end of the plank on the benchtop as shown in Figure 7.2.13.

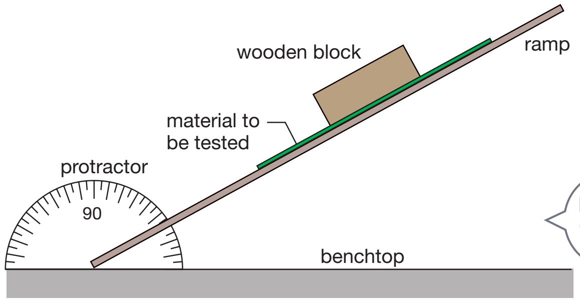


Figure 7.2.13

5. Use the protractor to measure the angle at which the block first starts to slide down the plank.
6. Repeat the test using the wooden dowels as rollers, and then test each surface you have available.

Results

1. Record your results in the table.

Experiment number	Set-up of equipment	Angle at which block starts to slide down ramp
1	Wooden block on ramp	
2	Wooden block placed on dowel rollers on ramp	

2. Construct a bar or column graph that compares the angle at which the block started to slide for each surface.

Practical review

1. The larger the angle at which the block started to move, the larger the friction between the block and the ramp. **Assess** whether you were correct in predicting which block experienced the most friction.
2. **Assess** whether you were correct in predicting which experienced the least friction.
3. **Construct** a diagram on which you label the direction of friction acting on the block.
4. **Identify** two examples where lubricants, rollers or waxing are used to reduce the force of friction.
5. a **Construct** a conclusion for your investigation.
   b **Assess** whether the ranking you made in your hypothesis was correct or not.

STUDENT DESIGN

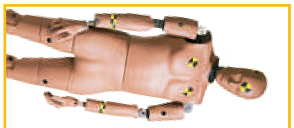
3 Investigating friction in the home

Purpose

To investigate the friction produced when operating a household device.

Materials

- household furniture and devices dependent on specific investigation



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 Decide which sliding or other mechanism you will examine. For example:
   - a door handle as it turns
   - a suitcase moving on rollers
   - the runners in a drawer as it slides.

2 In your workbook, write a procedure explaining how you intend to examine the mechanism.

3 Before you start any practical work, assess your procedure. Assess any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then start work.

Results

In your workbook, draw a diagram that shows where friction is experienced.

Practical review

1 **Describe** how the mechanism examined works.

2 **Propose** ways in which the friction in the device might be reduced.

7.3 Gravity—a non-contact force

On the Giant Drop on the Gold Coast, passengers fall 120 metres (39 storeys) in 5 seconds, reaching speeds of 135 km/h! A magnetic braking system stops them just before they hit the ground. In everyday life, you don't experience gravity quite as dramatically as these passengers, but you do feel its effects constantly.

INQUIRY science 4 fun

Centre of mass

YES

The centre of mass or centre of gravity is a point where you can imagine all of an object's mass is concentrated. This point can be inside or outside the object. Where is your centre of mass when you sit and when you bend down?

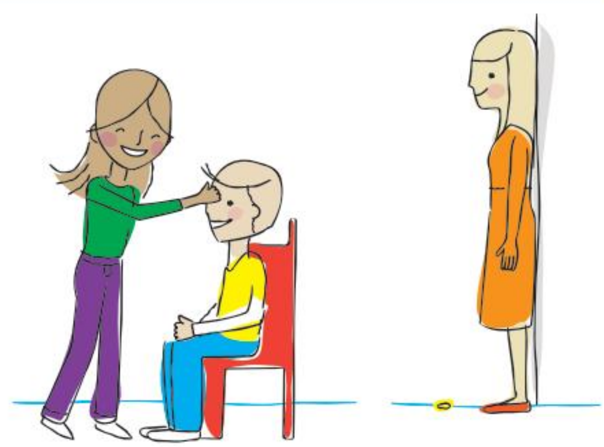
Collect this …

- chair
- wall
- coin

Do this …

Part A

1. Place the back of the chair against a wall.
2. Your partner is to sit on the chair, with their feet flat on the floor in front of the chair.
3. Put your thumb on their forehead.
4. Ask your partner to stand up.



Part B

1. Stand with your back to a wall.
2. Your partner is to put a coin on the floor, near your feet.
3. Try to pick up the coin.

Record this …

Describe what happened.
Explain why you think this happened.

What is gravity?

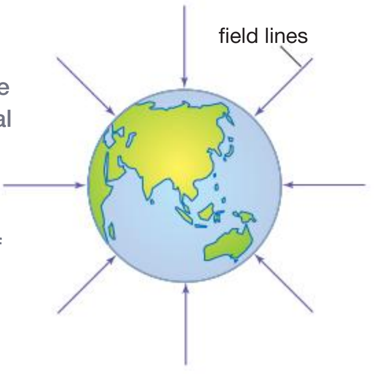
All objects attract each other. There is a force of attraction between you and your schoolbag, as there is between you and everything around you. **Gravity** is this force of attraction. The more mass a pair of objects have, the stronger the pulling force of gravity between them. As a result, you are pulled strongly towards the Earth (just like the skydiver in Figure 7.3.1) and the Earth is pulled strongly towards you. The Earth has much more mass than you, so the pull you exert on it is barely noticeable. However you can feel its pull! It's what causes you to fall off a skateboard. In comparison, you and your schoolbag have a much smaller mass, so the force between you and your bag is very small.

Figure 7.3.1 A force of attraction called gravity pulls this skydiver towards Earth.

Gravitational fields

If you throw a ball into the air, you know it will fall back to Earth. If an object lies within a region called the Earth's **gravitational field**, then a gravitational force will act upon it. This region is called a **force field**. Gravity acts through a force field, without direct contact. It can be described as a **non-contact force**. Figure 7.3.2 shows the direction of the Earth's gravitational field.

Figure 7.3.2 These field lines show the direction of a gravitational field around Earth. Any mass inside this field will pulled by gravity in this direction. The strength of the gravitational force field reduces as distance from the Earth increases.



The planets of our solar system lie within the Sun's gravitational field. As a result, they are pulled towards the Sun by a gravitational force. This force is not strong enough to pull Earth or any of the other planets onto the Sun, but it is strong enough to keep them from escaping into deep space. Planets orbit the Sun in elliptical paths as shown in Figure 7.3.3. Similarly, our Moon and various artificial satellites are pulled into an orbit of the Earth because they lie within Earth's gravitational field.

GO TO Unit 8.3

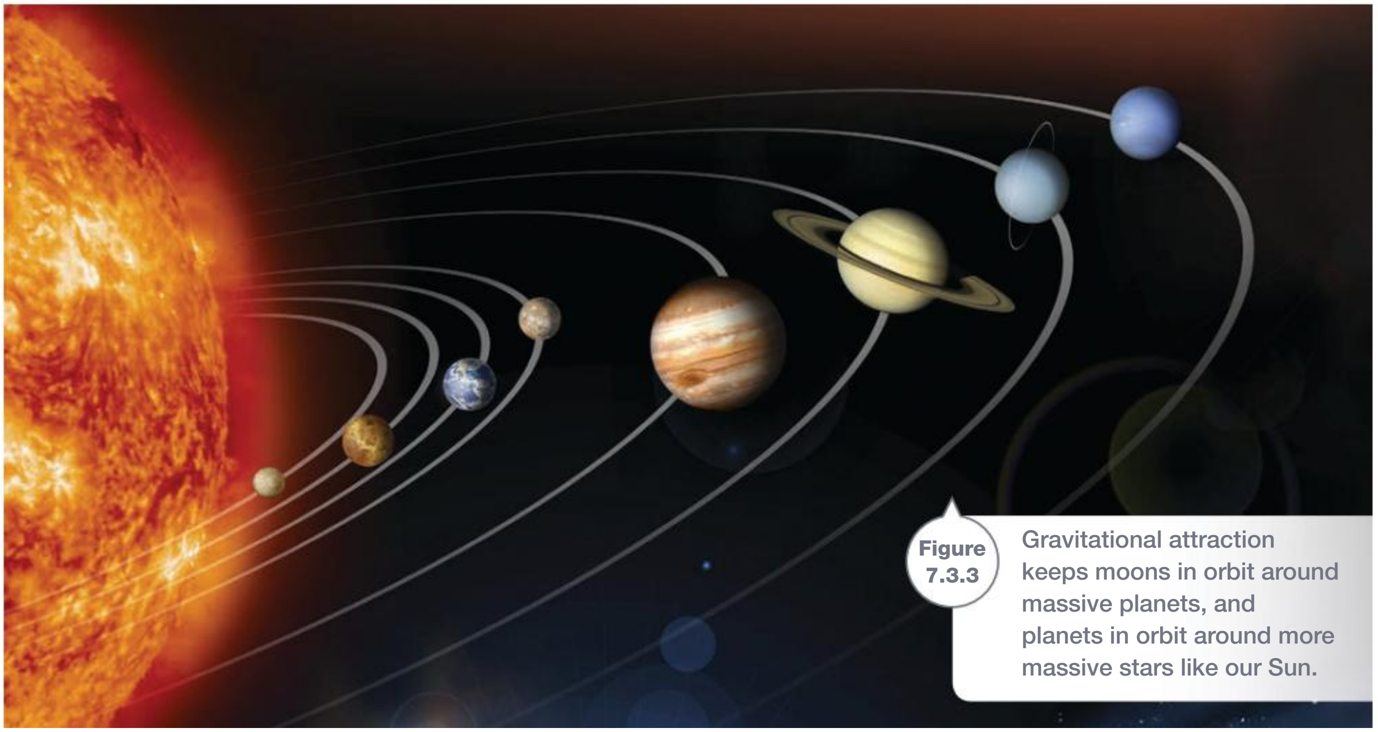


Figure 7.3.3 Gravitational attraction keeps moons in orbit around massive planets, and planets in orbit around more massive stars like our Sun.

Comparing mass and weight

In everyday language, mass and weight mean the same. However, to scientists they are very different quantities.

Mass

Mass is the amount of matter in an object. Your mass remains the same if you travel to other planets, because the matter you are made from remains the same. Mass is measured in kilograms (kg). Smaller masses, such as the ingredients of a cake, are measured in grams (g). The mass of a large object, such as a car or truck, is measured in tonnes (t).

Weight

Weight is the name given to the pulling force of gravity on an object. Because it is a force, weight is measured in newtons (N). Your weight depends not only on your mass, but also on the strength of the gravitational field of the planet or moon you are on. For this reason your weight on the Moon (Figure 7.3.4) is only one-sixth that on Earth.

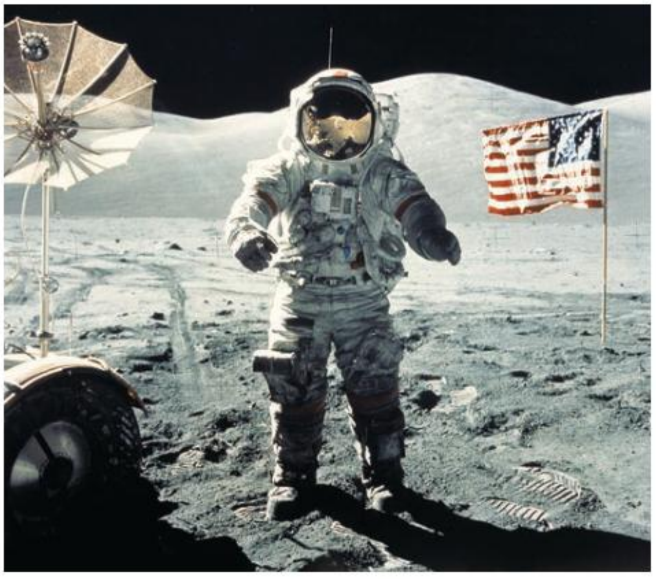


Figure 7.3.4 In 1972 Eugene Cernan became the last person to stand on the Moon. The Moon has less mass than Earth, and so it has a weaker gravitational field. Although Cernan's mass is unchanged, his weight is less on the Moon than on Earth.

Falling

If you drop an autumn leaf and a stone from the same height, you'd be fairly sure that the stone would hit the ground first. For many centuries, this caused people to believe that heavier things fell faster than lighter ones. The Italian scientist Galileo Galilei (1564–1642) performed experiments with falling objects. He realised that the reason some things fell faster was not because they weighed more, but because they had a smaller surface area than other things. Air is pushed out of the way as an object falls. An object with a small surface area experiences less air resistance as it cuts through the air compared to an object with a larger surface area. If there was no air, any two objects, even a feather and a hammer, would fall at the same rate. This is shown in Figure 7.3.5.

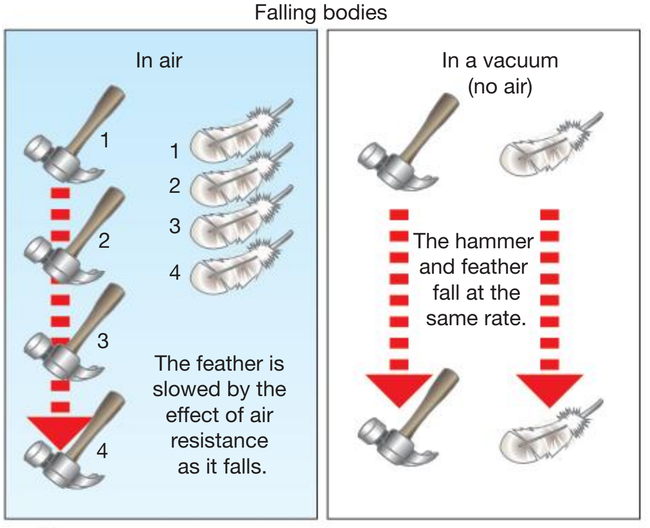


Figure 7.3.5 As predicted by Galileo, a feather and a hammer will fall at the same rate if dropped in a vacuum.

Real or legend?

SciFile

At the time of Galileo Galilei, people believed that heavier objects fell faster than lighter objects. Galileo believed that all objects were affected equally by gravity, but fell at different rates due to differences in the air resistance affecting each. Legend has it that Galileo dropped two balls made from the same material but of different masses from the Leaning Tower of Pisa to prove his point.

A leaf has a greater surface area than a stone of the same mass. Hence it experiences a greater force of friction (air resistance) when falling in air. This slows its motion and causes it to flutter as it falls (Figure 7.3.6).

Figure 7.3.6 A leaf flutters as it falls, because it has a relatively large surface area and experiences more air resistance than other more compact objects.

SciFile

Light as a feather?

In 1971, Apollo astronaut David Scott dropped a feather and a hammer from the same height at the same time while on the Moon's surface. They hit the ground at exactly the same time, as predicted by Galileo.

Terminal velocity

As an object's speed increases, its air resistance also increases. This means that the air resistance on a falling object increases as it falls. Eventually, the air resistance acting on the object equals its weight force. When this happens, the forces acting on the object are balanced and the object then falls at a constant speed. This speed is called **terminal velocity**. This situation is shown in Figure 7.3.7.

The terminal velocity of a skydiver without a parachute is far too great to survive a landing on Earth. Opening a parachute provides a much larger surface area, which greatly increases the force of air resistance and slows the skydiver down.

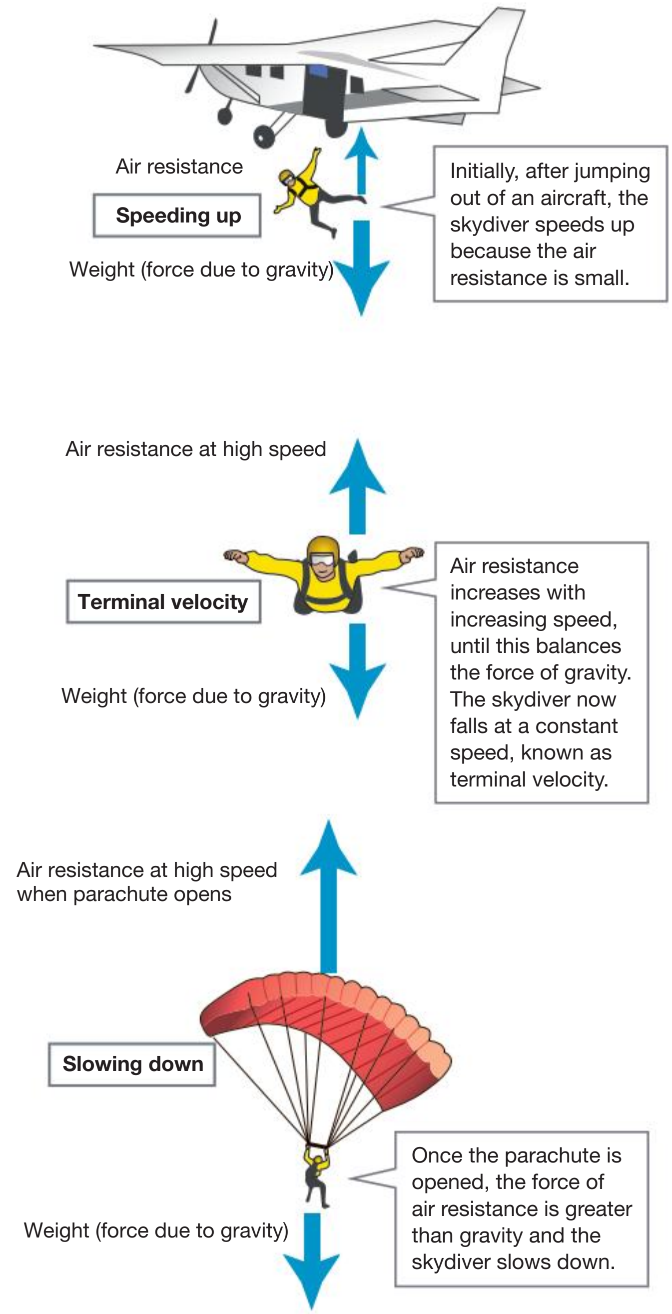


Figure 7.3.7 The motion of a skydiver depends upon the relative sizes of the forces of air resistance and weight.

Prac 1 p. 303 | Prac 2 p. 304 | 7.4 | 7.5 | 7.6

7.3 Unit review

Remembering

1 **Recall** gravity by selecting the correct term to complete the following sentences.
  a Gravity is a contact/non-contact force.
  b Gravity pulls/pushes objects towards the Earth.
  c All objects naturally attract/repel each other.
  d Objects of the same mass fall at different speeds due to their weight/surface area.

2 **State** the unit used to measure mass.

3 **State** the unit used to measure weight.

4 **Name** the force that slows down an object as it falls.

Understanding

5 **Explain** what a force field is, giving two examples.

6 The lines in Figure 7.3.8 represent Earth's gravitational field.

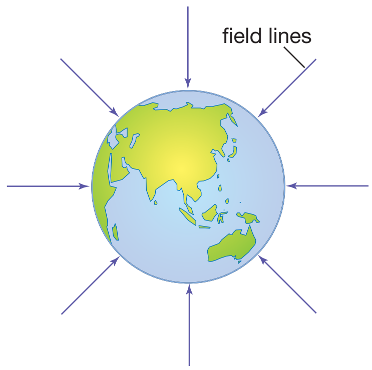


Figure 7.3.8

  a **Describe** what happens to an object that is located in the region of this field.
  b **Describe** what happens to the strength of this gravitational field as an object moves further away from Earth.
  c **Explain** why gravity is called a non-contact force.

7 Two forces act on a skydiver falling towards Earth.
  a **Name** these two forces.
  b **Use** a force diagram to help you **explain** at what stage of the fall the skydiver is accelerating, or speeding up, as they travel towards Earth.
  c Eventually the two forces are balanced. **Explain** how this affects the skydiver and **state** what this motion is called.

Analysing

8 Gravity pulls people downwards regardless of where they are on Earth. **Discuss** how this is possible. **Use** a diagram to assist in your response.

9 a **Compare** how your body would feel when walking on the Moon compared to walking on Earth.
  b **Explain** why you would feel this way.

10 **Compare** mass and weight by listing their similarities and differences.

11 A tennis ball, a cricket ball and a shot put are dropped at the same time. The path of the tennis ball as it falls is shown in Figure 7.3.9.

Analyse where the other two balls would be at the same time as the tennis ball (ignore air resistance).

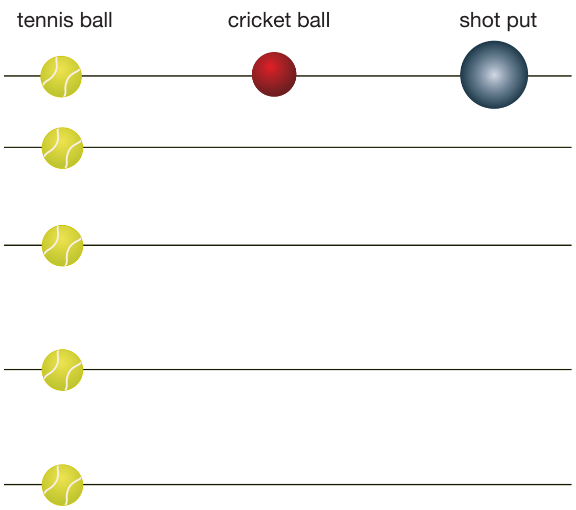


Figure 7.3.9

Evaluating CCT

12 Is there gravity on the Moon? **Justify** your answer.

13 a **Propose** three different ways that a person's mass could change throughout their life.
  b **Propose** how a person's mass could remain the same, but their weight changes.

14 Min-Jee drops a leaf and a small rock from the top of a playground slide.
   a **Predict** which will hit the ground first.
   b **Assess** whether gravity acts differently on objects because of their different mass.
   c **Predict** what Min-Jee would observe if her experiment was repeated on the Moon.

15 When you get up from a chair (such as that shown in the science4fun on p. 297) you push your body forwards.
   a **Propose** where the position of your centre of gravity is when you are sitting on a chair.
   b **Explain** why you think you move forwards when standing up from a chair.

Creating CCT

16 According to the ancient Greek philosopher Aristotle, heavy objects contain more gravity than light objects, so they fall faster. **Construct** a response to Aristotle in which you disagree with his viewpoint.

17 Imagine what would happen if instead of being an attractive force, gravity was a repulsive force that pushed objects away.

   Construct three diagrams showing what could happen to things around you if this was the case.

Inquiring

1 You may have heard of the term *zero gravity* to explain what happens to astronauts on a mission in space. Research what is meant by this term.
   - Define the term *zero gravity*. L
   - Describe situations in which zero gravity would exist.
   - Search for footage of astronauts in a zero gravity environment.
   - Explain how astronauts train to prepare their bodies to tolerate zero gravity conditions.
   - Various experiments have been conducted in zero gravity environments. Describe two such experiments.

   Present your research in digital form with links to relevant videos. ICT

2 Many extreme sports depend upon the thrill of falling to enhance the experience of the sport.
   - Find a video of some extreme gravity situations, such as a vertical drop theme park ride, bungee jumping or skydiving
   - Discuss which safety precautions are necessary in order to safely participate in each of these sports.

   Present your research in digital form with links to relevant videos. ICT

7.3 Practical investigations

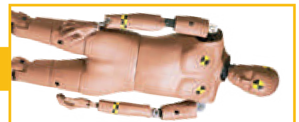
1 Look out below!

Purpose

To investigate if heavier objects fall faster than lighter ones.

Materials

- metre ruler
- Blu Tack
- foam or rubber
- a number of unbreakable objects of different size
- sheet of butcher's paper
- 50 g mass
- electronic balance



SAFETY

Be careful not to drop objects where they could fall on someone.

Note: If possible, use a motion sensor or light gates to complete this experiment more accurately.

Procedure

1. Copy the table below into your workbook.
2. Measure the mass of each object and record the masses in your results table (shown below).
3. Predict what will happen when each object falls. Record your predictions in the table.
4. Mark a height of 2 metres on a wall with a piece of Blu Tack. Place some foam or rubber at its base. This is your 'drop zone' to test how fast each object falls.
5. Drop the 50 g mass and another item from the height marked on the wall as shown in Figure 7.3.10.
6. Record whether the object landed at about the same time, slower or faster than the 50 g mass. Repeat the test if you are unsure.
7. Repeat, using the 50 g mass and every object to be tested, and record your results.
8. Drop the 50 g mass and the sheet of A4 paper (held horizontally) and record your result.
9. Crumple the sheet of paper into a loose ball and repeat the test.
10. Finally, scrunch the loose ball into the tightest ball you can and do the test again.

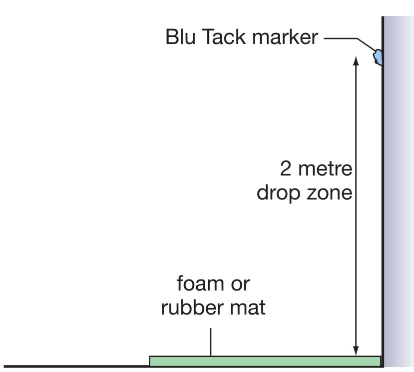


Figure 7.3.10

Results

Record all your masses, predictions and measurements in your table.

Practical review

1. **Assess** how accurate your predictions were.
2. **State** whether most objects fell at the same rate as the 50 g mass, or faster, or slower.
3. a **State** which object fell the slowest.
   b **Propose** a reason why this was the slowest.
4. a **Name** the objects that fell faster than the 50 g mass.
   b **Propose** reasons why.
5. **Propose** a reason why the 50 g mass was used in every experiment.
6. a **Summarise** how the shape of the sheet of paper changed how it fell.
   b **Explain** why.
7. **Draw** a conclusion for this activity.

Falling object	Mass (g)	My predictions	Landed		
		Will fall the same/faster/ slower than the 50 g mass	about the same time as 50 g mass	before the 50 g mass	after the 50 g mass

7.3 Practical investigations

STUDENT DESIGN

2 Robocopter investigation

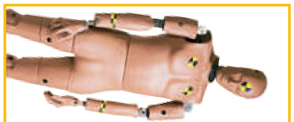
A robocopter is a paper construction that spins as it falls when it is dropped from a height.

Purpose

To make a robocopter and then determine how one variable affects the time that it takes the robocopter to fall.

Materials

- sheets of cardboard
- ruler
- pencil
- scissors
- stopwatch
- paper clip



SAFETY

A Risk Assessment is required for this investigation.

Procedure

1 A template for a robocopter is shown in Figure 7.3.11. The completed model is shown in Figure 7.3.12. To build your robocopter, cut a copy of the template onto a piece of cardboard.

2 Cut along solid lines and fold along dotted lines as shown by the arrows.

3 Place a paper clip at the base to complete the robocopter.

4 Drop this robocopter from the same height three times, timing how long it takes to fall in each case.

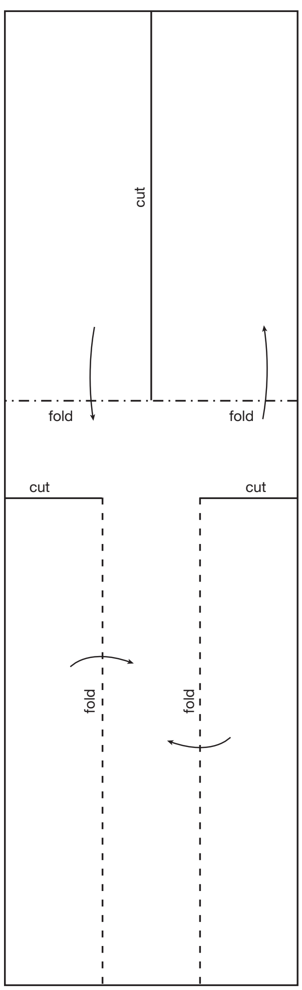


Figure 7.3.11

5 Now investigate what affects the drop time of the robocopter. First, decide which variable you will change. You could:
- change the length of its blades
- add more paper clips to its base
- make different-sized robocopters
- make robocopters from different thicknesses of paper or cardboard.

6 Write your procedure in your workbook.

7 Assess any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results

Record your results in a table and show these in a graph.

Practical review

1 **List** the forces on your robocopter when it is falling.

2 a **Construct** a conclusion for your investigation.

b **Assess** the method you used in your investigation.

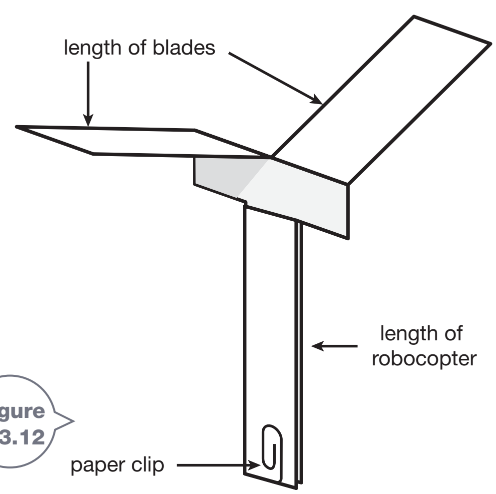


Figure 7.3.12

7.4 Magnetic and electric fields

A non-contact force acts through a region of space called a force field. When you drop an object, it is pulled towards the Earth due to the Earth's gravitational force field. A balloon can be charged and attract a thin stream of water that lies within its electric field. A magnet can attract a tub of nails if they lie within its magnetic field. Powerful electromagnets can lift heavy steel.

INQUIRY

science 4 fun

What magnets attract

Can you guess which materials around you are attracted by a magnet?

YES

Collect this ...

- bar magnet or fridge magnets
- selection of objects such as paper clips, thumb tacks, nails, plastic spoons, cans, coins, chalk, marbles, safety pins, pens, toothpicks

Do this ...

1. Predict which items you think will be attracted by the magnet.
2. Test to see which objects are attracted and which are not.

Record this ...

Describe whether most of your predictions were correct.

Explain which types of substances are more likely to be attracted to a magnet.

Magnetic fields

A magnet pulls, or attracts, materials containing the metals iron, cobalt or nickel. Steel is made from iron, and so steel is also attracted to a magnet. The horseshoe magnet shown in Figure 7.4.1 on page 306 attracts the steel filings from a distance away. This happens because the steel filings were positioned within its magnetic field. A **magnetic field** is the space around a magnet where a magnetic force is experienced. The steel filings were pulled by a magnetic force in the direction of the magnetic field.

The ends of a magnet are called **poles**. If a magnet floats in water, then one end spins to face the Earth's north pole. This end is the north pole of the magnet. The opposite pole of the magnet is the south pole. If a magnet is cut in half, each half still has a north and a south pole. The magnetic field is strongest at the poles of a magnet.

A magnetic field is normally invisible to us. Its shape and strength can be determined either by passing a compass around a magnet, or by examining a sprinkling of iron filings around a magnet. Figure 7.4.2 shows that magnetic field lines point from the north to the south pole.

Figure 7.4.1 This horseshoe magnet is placed near a mixture of steel and copper filings. Only the steel filings are attracted to the magnet; the copper remains in the pile below. Magnets can be used to separate magnetic metals from a mixture of substances.

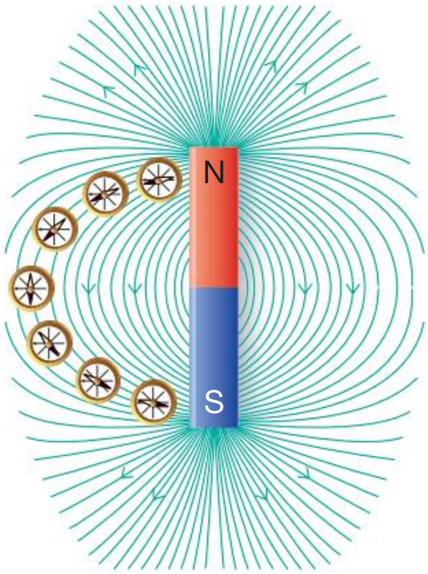


Figure 7.4.2 Magnetic field lines do not cross, and always run from the north to the south pole of a magnet.

INQUIRY science 4 fun

Seeing magnetic field lines

YES

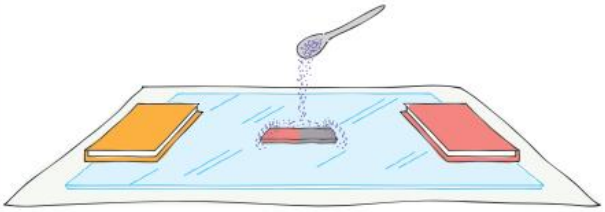
Can you see a magnetic field?

Collect this …

- collection of magnets
- thin books
- stiff, transparent plastic
- white paper
- iron filings

Do this …

1 Place a bar magnet on a sheet of paper.
2 Put the plastic sheet over this and flatten its edges with some books.
3 Sprinkle about a teaspoon of iron filings onto the plastic sheet.
4 Lightly tap the sheet to spread the iron filings. What pattern can you see?
5 Gather up all the iron filings and then test a different magnet.



Record this …

Describe each pattern you saw.

Explain why you think these formed.

Magnetic field lines:

- show the direction that a compass would point
- always run from the north pole to the south pole
- do not cross
- represent a strong magnetic field when they are bunched closely together
- represent a weak magnetic field when they are spaced further apart.

SciFile

In-built navigation

Many animals, such as honeybees, dolphins, tuna, whales and pigeons, contain tiny crystals of a magnetic material in their brains or stomachs. These act as tiny internal compasses, preventing the animal from getting lost and helping them find their homes.

Attraction and repulsion of poles

Magnetic poles may be attracted to each other, or repelled by a magnetic force. Poles that are the same are called like poles. Like poles will push away, or repel each other. Poles that are different are called unlike poles. Unlike poles pull together, or attract each other. These situations are shown in Figure 7.4.3.

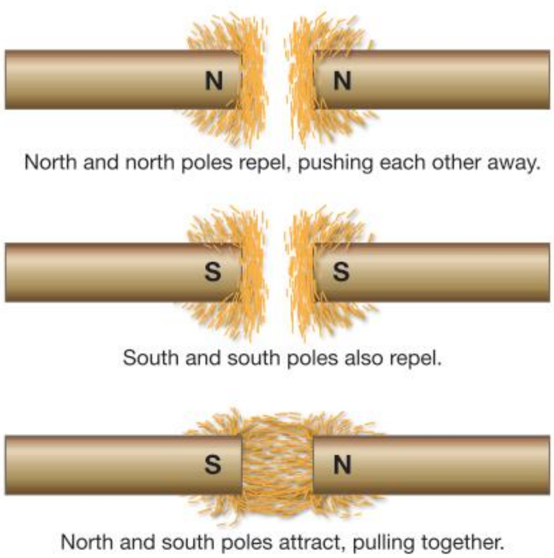


Figure 7.4.3 Magnetic poles that are like (NN or SS) will repel, whereas magnetic poles that are unlike (NS) will attract. We can then say that unlike poles attract while like poles repel each other.

SciFile

Floating on air

The repulsion of magnetic poles can make things float. This is called magnetic levitation. Maglev trains float about 10 cm above their tracks. They can reach speeds of 500 km/h because they operate with very little friction.

7.7

Prac 1 p. 315

Magnetic domains

The metals iron, nickel and cobalt are attracted to magnets, while all other substances are not. Scientists believe that inside each of these metals are tiny magnetic particles called **domains**. Each of these acts like a mini-magnet, and has a north and a south pole. In a piece of magnetised iron, the domains all point in the same direction. This makes the metal act like a magnet. The domains in a piece of unmagnetised iron point in random directions, as shown in Figure 7.4.4.

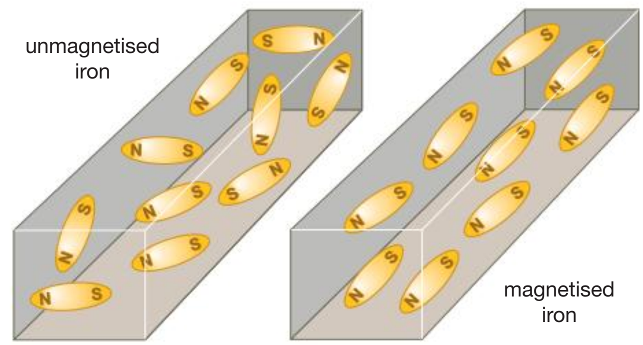


Figure 7.4.4 Domains are like mini-magnets. When they line up, they form a magnet with a north and a south pole. When they point in random directions, the metal has no magnetic properties.

Types of magnets

Temporary and permanent magnets

If you stroke an iron nail many times in the same direction with a bar magnet, then the nail begins to act like a magnet itself. This happens because you have pulled all of its domains into line. After a while, the effect wears off and the domains point in random directions once again. In this case, the nail is called a **temporary magnet** because it only acts like a magnet for a short period of time. **Permanent magnets** can be made by hitting or heating the metal to make the domains stay in this arrangement.

Magnets made from soft iron lose their magnetism more easily than magnets made from cast iron. Data stored on the magnetic strip on a credit card can be lost when placed near a strong magnetic field. If a magnet is heated or dropped, its domains may be knocked out of alignment, destroying its magnetism.

Electromagnets

In 1820, the Danish scientist Hans Oersted (1777–1851) made an unexpected discovery. While explaining to his students that he did not believe there was any link between magnetism and electricity, he placed a compass near a wire through which an electric current was flowing. To his surprise, he saw the compass needle move. Oersted realised that electricity flowing through a wire creates a magnetic field around it. If the wire is wound into a coil, it produces a much stronger magnetic field. Inserting a piece of iron inside the coil increases its strength even further. Such a device is called an electromagnet and is shown in Figure 7.4.5. It acts like a bar magnet.

An electromagnet is a temporary magnet, because when the electricity in the wire is switched off, the magnetic field is also switched off.

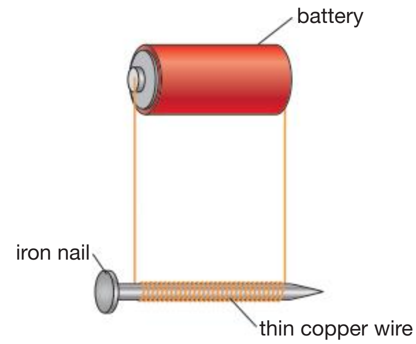


Figure 7.4.5 An electric current in the wire creates a magnetic field. This field can be turned on and off with the current. Coiling the wire and adding an iron core insert increases the strength of the electromagnet.

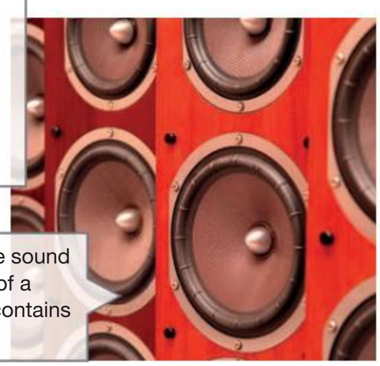
Uses of magnets

Magnets and electromagnets are used in many everyday devices and are used in most modern technologies. They are in every household appliance that has an electric motor. They are used to store information in computers and tablets, and on EFTPOS and credit cards. Figure 7.4.6 shows some examples of how magnets are used.

Prac 2
p. 316

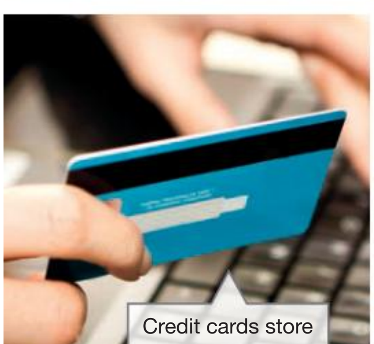
Figure 7.4.6

A drill has an electric motor. All electric motors contain an electromagnet. Hairdryers, food processors and remote controlled toy cars are other examples of devices with motors.



All speakers produce sound due to the vibration of a central cone which contains an electromagnet.

Induction cooktops use electricity to focus a magnetic field above the points on the cooktop where the food is heated. Pots and pans used on the cooktop must be made from iron or steel. Only the contents of the pots heat up. This gives an energy saving of around 30%.



Credit cards store information on a magnetic strip.

An MRI (magnetic resonance imaging) machine is used to look inside the human body to check for disease or injury. The patient lies inside a huge donut-shaped electromagnet. Diseased tissue behaves differently from normal tissue in a magnetic field.

ADDITIONAL

Earth's magnetic field

Earth itself has a magnetic field. It behaves as though it has a huge bar magnet in its centre like that shown in Figure 7.4.7. Scientists believe Earth's magnetic field is generated by molten rock moving inside Earth's core.

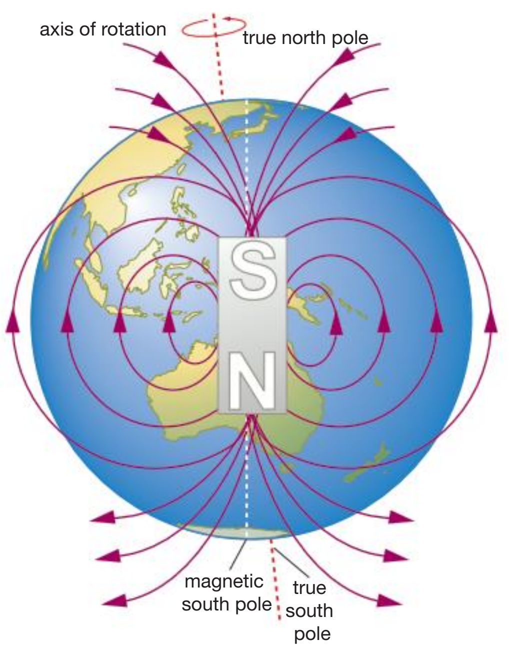


Figure 7.4.7 Earth is surrounded by a magnetic field. The poles of the imaginary bar magnet inside Earth create magnetic north and south poles, which lie about 3000 km from the geographical north and south poles.

ADDITIONAL

Electric fields

Force fields also exist around electric charges. To understand **electric fields**, you first need an understanding of the atom and its internal structure.

What is an atom?

Everything around us is made up of tiny particles called **atoms**. Atoms themselves are made up of even smaller particles called protons, neutrons and electrons. Neutrons are found deep within an atom in a region called the nucleus. They have no charge. Protons are also found in the nucleus and have a positive charge (+). Electrons move in the space around the nucleus as shown in Figure 7.4.8. They have a negative charge (–). Usually an object has equal numbers of protons and electrons. It has no overall charge and is said to be neutral.

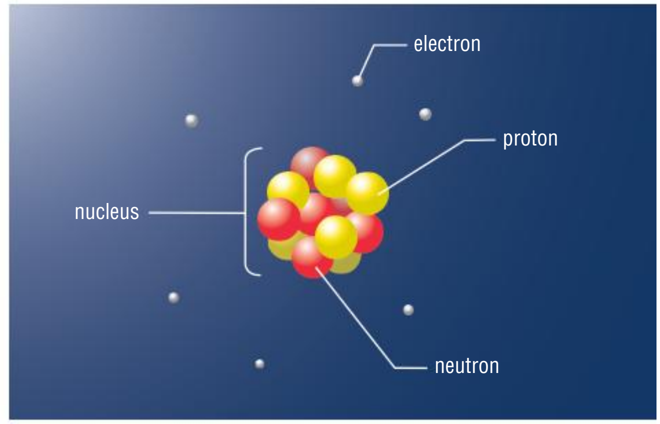


Figure 7.4.8 An atom consists of three types of smaller (subatomic) particles, called protons, neutrons and electrons.

SciFile

Splitting hairs

The atoms that make up everything around you are so small that you would need to line up about one million of them to stretch the width of a human hair.

Charging up

If one material is rubbed against another, electrons may move from one substance onto the other. If this happens, the number of protons and electrons in each is no longer balanced. Some materials, such as plastic, rubber and wood, will build up charge when rubbed with another substance. Such materials are called electrical **insulators**. Electrons cannot flow freely through them. The reason electrical wires are covered with plastic is because plastic is an effective electrical insulator. Metallic objects do not build up a static charge, because electrons can flow through them. These materials, such as a copper electrical wire, are called electrical **conductors**.

Figure 7.4.9 on page 310 shows that when a glass rod is rubbed with a silk cloth, electrons move from the glass rod onto the silk cloth. The glass rod has lost electrons and is now **positively charged**, because it has more protons than electrons. The silk cloth has gained electrons and is **negatively charged**, having more electrons than protons. When an object becomes charged (has unequal numbers of protons and electrons), we say that it has **static electricity**.

A force field called an electric field exists around any object that is charged. Any charged object positioned within this field will experience a force, called an **electrostatic force** (or an electric force).

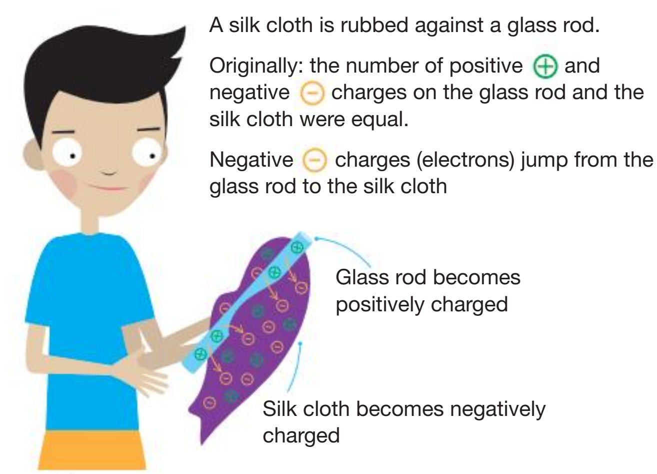


Figure 7.4.9 Electrons are rubbed from the glass rod and jump onto the silk cloth. As a result, the glass rod becomes positively charged and the silk cloth is negatively charged.

Figure 7.4.10 Objects with like charge are repelled, and objects with unlike charge are attracted.

Prac 3 p. 317

Prac 4 p. 317

If you rub a balloon with a silk cloth, electrons rub off the silk and onto the balloon. Both the silk cloth and the balloon are now charged, and are surrounded by an electric field. Figure 7.4.10 shows what happens when these charged objects are placed next to each other. If placed inside an electric field, two objects with different types of charge will attract each other, while those with the same type of charge will repel. Note that a charged object may also attract a neutral object.

A machine called a Van de Graaff generator separates charge by friction between a moving rubber belt and a plastic pulley. Negative charges are released to flow through to the ground, while positive charges are transferred onto the dome of the generator. The girl touching the dome of the generator in Figure 7.4.11 becomes positively charged. Her hair stands up because each strand of hair is repelling the hair around it!

Figure 7.4.11 Each strand of this girl's hair is positively charged and is repelling all of the hair around it.

Static discharge

Static electricity describes a build-up of charge. If you walk across carpet on a dry day and touch a metal door handle, you could get a shock. Friction between your feet and the carpet rub electrons from the carpet onto you, making you and the carpet both charged. Normally, this charge gradually leaks back out of your shoes to the ground, or into the air, and you become neutral once more. If there is a big build-up of charge, or if you wear rubber-soled shoes that stop the charge from escaping, extra electrons can jump from you to the metal door handle as a spark. You feel this as a small electric shock. If you were to touch another person while charged, electrons would jump onto this person and you would both feel a static shock.

7.8

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Dazzling fashion

The Sp4rkl3 skirt is a piece of clothing with a difference: it really shines! This skirt contains circuitry and layers of Teflon and nylon. As the wearer moves around, these layers generate static electricity which can be discharged to power rows of LEDs that are studded into the fabric.

LEARNING ACROSS THE CURRICULUM

PERSONAL AND SOCIAL CAPABILITY

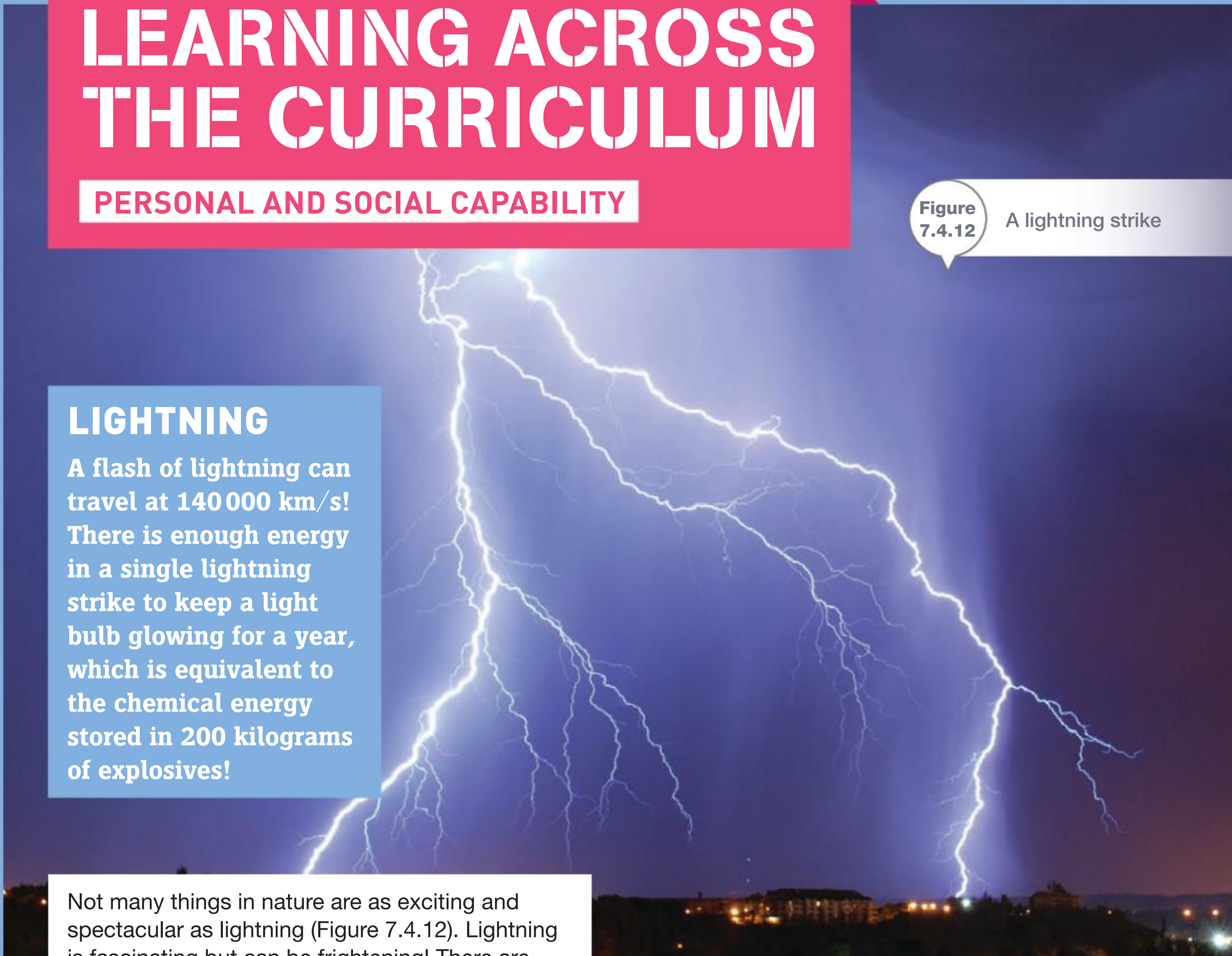


Figure 7.4.12 A lightning strike

LIGHTNING

A flash of lightning can travel at 140 000 km/s! There is enough energy in a single lightning strike to keep a light bulb glowing for a year, which is equivalent to the chemical energy stored in 200 kilograms of explosives!

Not many things in nature are as exciting and spectacular as lightning (Figure 7.4.12). Lightning is fascinating but can be frightening! There are about one hundred lightning strikes every second throughout the world. Each year about fifty Australians are struck by lightning, and about ten die. Up to thirty are injured while using landline telephones during storms. Lightning can be deadly as it can cause your heart to stop or you can stop breathing.

Lightning itself is a giant spark. It is similar to the small shocks you receive from static electricity but on a much larger scale. Clouds consist of water droplets and ice crystals. Normally, they have the same number of negative and positive charges. That is, the clouds are electrically neutral. During a thunderstorm, the charges separate and drift apart. The bottom of the cloud becomes strongly negative due to a build-up of electrons. The top becomes strongly positive as it loses electrons. When enough static electricity builds up, electrons jump to another region of the cloud, to another cloud or to the ground. This process is shown in Figure 7.4.13.

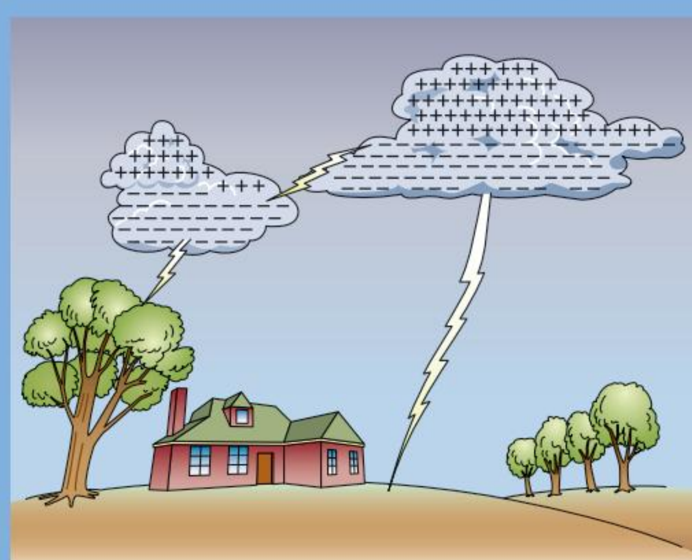


Figure 7.4.13 Lightning is a giant spark or flow of charge that can occur between clouds, within the same cloud or from a cloud to the ground.

Figure 7.4.14 The movement of hot ash particles from a volcanic eruption can generate the static charge needed to produce lightning.

The heat from the lightning flash causes the surrounding air to heat rapidly, and it expands explosively, causing the sound of thunder.

Other atmospheric events, such as a volcanic eruption, a bushfire or a dust storm, can also produce the build-up of static charge needed to create a lightning strike. Figure 7.4.14 shows lightning produced during a volcanic eruption.

Lightning tends to strike the tallest object in a particular area. If you are caught in a thunderstorm, don't shelter under a tree. If the tree is hit by lightning, electrical charge can jump from the tree to the body of anyone standing nearby in what is called a 'side-flash'. The best ways to avoid being struck by lightning are to stay indoors or shelter inside a car while not touching any metal. If outdoors, keep away from high objects or structures such as fences, rails or small metal shelters. If caught in the open, crouch down with your feet together. If you are indoors, stay away from windows, electrical wiring, sinks, metal pipes and the telephone.

REVIEW

1 **Name** the particles that flow to produce a lightning strike.

2 **Outline** how lightning is produced.

3 **Propose** what precautions you should take if you find yourself in a severe thunderstorm:

a in an open field

b inside a house.

4 **Explain** how thunder is produced.

5 Light travels at about 300 000 km/s and sound travels at about 340 m/s. **Use** this information to **explain** why you don't usually hear thunder at the instant you see the flash of lightning. N

7.4 Unit review

Remembering

1 Copy each statement, and **state** which term in italics correctly completes each sentence.

a A magnetic force is a *contact/ non-contact* force.

b As you get closer to a magnet, the size of the magnetic force *increases/ decreases.*

c A north pole of one magnet is attracted to the *north/ south* pole of another magnet.

d A magnet is *strongest/ weakest* at its poles.

2 **List** five places you could find a magnet in your home.

3 **Name** three metals that would be attracted to the magnet in the science4fun activity on page 305.

4 Atoms consist of two types of charged particles.

a **State** the name of a positively charged particle.

b **State** the name of a negatively charged particle.

5 If a plastic ruler loses electrons when it is rubbed with a piece of woollen fabric, **state** whether it has become positively or negatively charged.

Understanding

6 **Explain** how Oersted realised that an electric current could create a magnetic field.

7 **Explain** why a steel ball bearing is attracted to a magnet.

8 In the science4fun activity on page 306, iron filings are sprinkled around a bar magnet. **Draw** a diagram to show the magnetic field you would expect.

Applying

9 **Identify** whether the magnets in Figure 7.4.15 will attract or repel in each case.

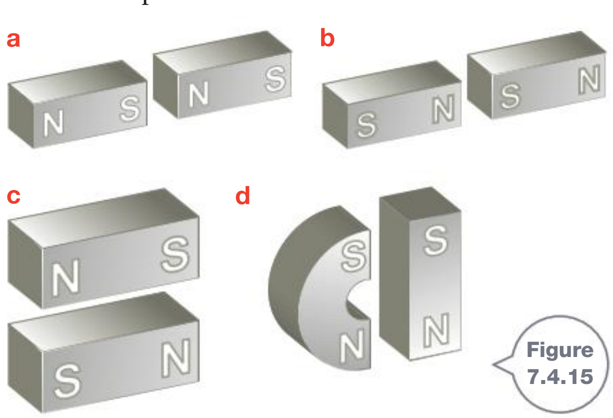
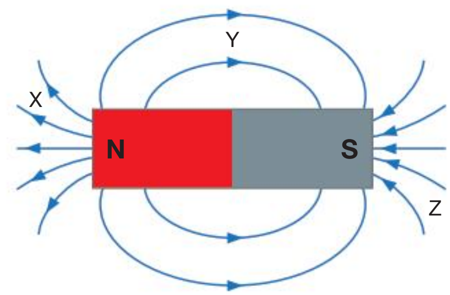


Figure 7.4.15

10 **Use** the magnetic field shown in Figure 7.4.16 for the following questions.

Figure 7.4.16



a Would a compass placed at X point to the left or right?

b i In which position, X, Y or Z, would an iron nail be attracted to the magnet with the most force?

ii In which of these positions is the magnetic field strongest?

iii How do you know this from the diagram?

11 In Figure 7.4.17, **identify** a: N

a positively charged object

b negatively charged object

c neutral object.

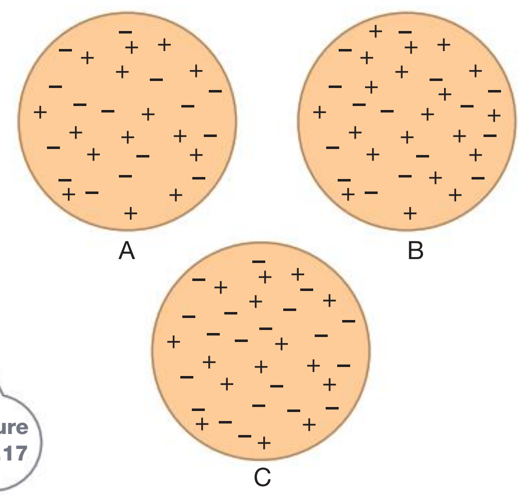


Figure 7.4.17

12 In each of the following situations, **identify** which two surfaces are rubbing together to produce static electricity.

a Hundreds-and-thousands stick to the walls of the plastic bottle in which they are stored.

b After driving to a shop, you get a shock as you close the car door.

c Your clothes crackle as you lift them out of the clothes dryer.

7.4 Unit review

Analysing

13 The bar magnet and the horseshoe magnet shown in Figure 7.4.18 are attracted to each other.

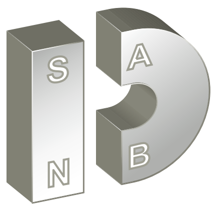
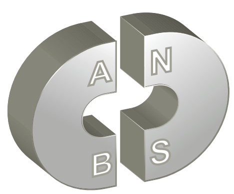
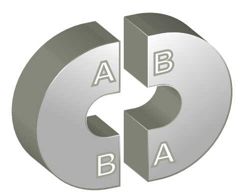


Figure 7.4.18



Combination A



Combination B

- **a** **Analyse** Figure 7.4.18 to **identify** whether each of the combinations A and B will attract or repel.
- **b** **State** whether you needed more information to decide if combination B attracted or repelled.

14 **Classify** each of the following materials as an electrical conductor or an electrical insulator.

- **a** aluminium foil
- **b** polystyrene cup
- **c** plastic ruler
- **d** glass rod
- **e** copper pipe
- **f** rubber hose

Evaluating CCT

15 **Propose** why you are asked to turn off mobile phones while putting petrol in a car.

16 Ralph and Julia are walking along the red carpet to an Academy Awards ceremony. Upon touching a gold banister, Julia receives a nasty static shock.

- **a** **Analyse** why Julia got a shock.
- **b** **Propose** how she could prevent this from happening again.

Creating CCT

17 Lying on a bench in front of you is nail A, which is not magnetised, and nail B, which has been treated to become a temporary magnet.

- **a** **Construct** a diagram to show the possible domains inside nails A and B.
- **b** **Construct** another diagram to show how you would expect the domains of nails A and B to look tomorrow.

Inquiring

1 The spectacle of lightning strikes around a volcanic eruption or through a dust storm is very dramatic. Search for photos of such an event.

Present your photos as an electronic album. ICT

2 Static electricity can lead to very dangerous situations. Research and:

- describe two situations in which a stray spark could be very dangerous
- describe some of the precautions that are taken to prevent a spark being produced in these situations.

Present your research as a written or Word document. ICT

ADDITIONAL

3 The Earth's magnetic field has long been used as a navigation guide by people and various species of wildlife. Research and find:

- an image showing the structure of Earth's magnetic field
- what scientists believe causes Earth's magnetic field
- what protection is provided by Earth's magnetic field
- the meaning of the term *geomagnetic reversal*
- evidence of past geomagnetic reversal
- predictions about how Earth's magnetic field may change in the future.

Present your findings in digital form. ICT

ADDITIONAL

7.4 Practical investigations

1 Magnetic shielding

Purpose

To test which materials a magnetic field can pass through and which materials block a magnetic field.

Materials

- 50 g mass
- paper clips
- cotton thread
- Blu Tack, Plasticine or sticky-tape
- bar magnet
- retort stand, bosshead and clamp
- sheets of different materials such as cardboard, plastic, aluminium foil, iron, steel, tin, wood, glass, copper

Procedure

1 Set up the equipment as shown in Figure 7.4.19.

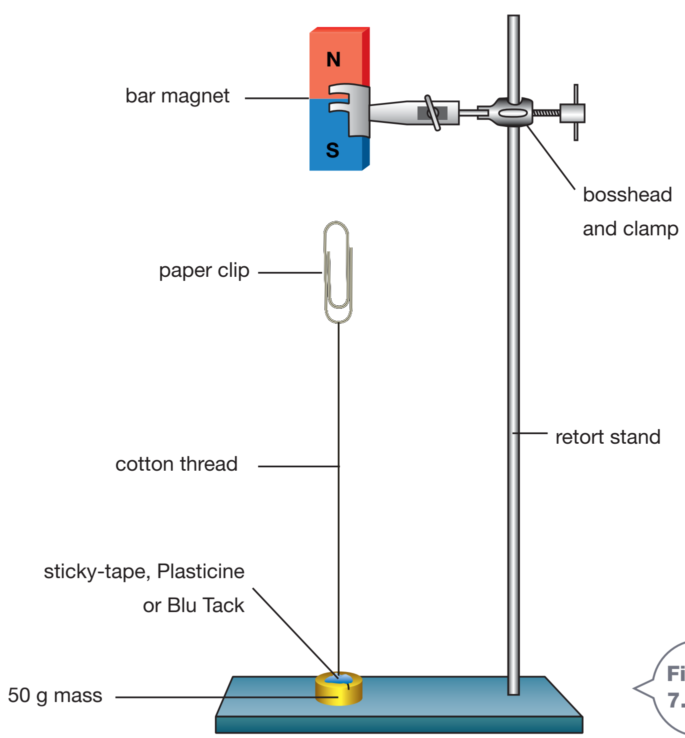


Figure 7.4.19

2 Find the maximum distance that can be left between the paper clip and the magnet before the paper clip falls.

3 Insert each different sheet between the paper clip and the magnet and record what happens in your results table.

Results

In your workbook, construct a table like that shown below to record your observations.

Material	Paper clip stayed/dropped

Practical review

1 In terms of the strength of a magnetic field, **explain** why the paper clip fell when the distance between it and the bar magnet increased.

2 **List** the materials that allowed a magnetic field to pass through them.

3 **List** which materials acted as a magnetic shield.

4 Magnetic fields can damage sensitive electronic equipment. **Propose** a use for materials that act as magnetic shields.

7.4 Practical investigations

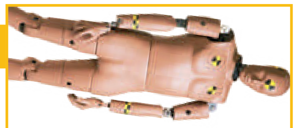
2 Making an electromagnet

Purpose

To make an electromagnet and test how its strength can be increased.

Materials

- 6 V lantern
  a power pack
- large nail or bolt
  (at least 7 cm long)
- compass
- paper clips
- switch
- 2 insulated wires (one long) with alligator clips



SAFETY

Take care when connecting your circuits.

Procedure

1. Copy the table from the Results section into your workbook.
2. Test to see if the nail on its own will pick up any paper clips.
3. Connect the shorter wire from the battery or power pack to the switch.
4. Carefully wind the long wire 10 times around the nail as neatly as you can.
5. Connect one end to the switch and the other to the power supply as shown in Figure 7.4.20.

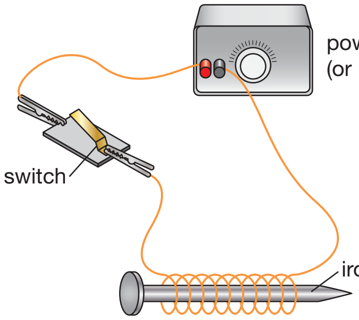


Figure 7.4.20 Setting up your circuit with the electromagnet

6. Set the power pack to 6 volts DC.
7. Press the switch down and record the number of paper clips raised for each number of turns of the wire.
8. Repeat steps 4–7 increasing the number of coils as shown in the table.
9. Test which end of the nail is the north pole and which is the south pole using a compass.
10. Reverse the connections to the power supply and repeat step 9.

Results

Record your results.

Number of turns on wire	Number of paper clips picked up
0	
10	
20	
30	
40	
50	

Practical review

1. **State** the effect of the number of turns of the wire on the number of paper clips picked up.
2. **Describe** what happened to the poles of the electromagnet when the connections were reversed.

3 Investigating static electricity

Purpose
To explore static electricity.

Materials
- plastic comb
- sheet of paper
- woollen material
- balloons
- string
- retort stand and clamp

Procedure
1. Rub the plastic comb vigorously on the woollen material. Bring it close to some tiny pieces of paper. Write down what happens.
2. Turn a water tap on and carefully turn it down to get the finest stream that you can of steadily flowing water. Rub the comb with the woollen material and hold it close to the stream of water. Draw a diagram to show what you observe.
3. Blow up a balloon and rub it with the woollen material. See if you can make the balloon 'stick' to the wall.
4. Blow up a second balloon. Attach a piece of string to each of the balloons and then tie these to a retort stand. Rub both balloons with the woollen material. Draw a diagram to show what happened.

Results
Record your observations for each step in the procedure.

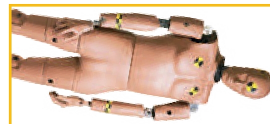
Practical review
1. **Explain** why you could pick up the pieces of paper with the comb.
2. **Describe** what happened to the stream of water when the charged comb was brought near to it.
3. **Explain** why the water behaved in this way.
4. **Propose** an explanation for your observations in the two balloon activities.

STUDENT DESIGN

4 Magnetising a nail

Purpose
To magnetise a nail and test a related variable.

Materials
- nail
- bar magnet
- paper clips



SAFETY
A Risk Assessment is required for this investigation.

Procedure
1. Design an experiment that will magnetise a nail by stroking it repeatedly (in the same direction) with a bar magnet.
2. Decide on a variable to investigate. You could investigate:
   a. whether the number of paper clips attracted varies depending on how many times the nail was stroked, or
   b. if the time the nail remains magnetic varies for the number of strokes made.
3. Write your procedure in your workbook.
4. Before you start any practical work, assess your procedure. Assess any risks that your procedure might involve and what you might do to minimise those risks. Show your teacher your procedure and your assessment of its risks. If they approve, then collect all the required materials and start work.

Results
Record your observations.

Practical review
1. **Outline** what is happening inside the nail:
   a. when it is being stroked by the permanent magnet
   b. when it loses its magnetism.
2. **Construct** a conclusion for your investigation.
3. **Assess** the method you used in your investigation.

7 Chapter review

Remembering

1 **State** whether the following are true or false.
   a Gravity is a contact force.
   b Weight is measured in kilograms.
   c The north pole of a magnet will attract the north pole of another magnet.
   d The magnetic field of a magnet is strongest at its poles.
   e A proton has a negative charge.
   f An electric field exists around a charged particle.

2 **List** four examples of a pushing force.

3 **Name** a surface that has little friction.

4 **State** whether an electromagnet is a temporary or permanent magnet.

Understanding

5 **Explain** the difference between a contact force and a non-contact force. Give an example of each type.

6 **Explain** how dropping a magnet could destroy its magnetism.

7 If a comb pulled through your hair becomes negatively charged, **predict** the charge of your hair.

8 If you rub a CD with a cloth to clean it, you may notice dust drifting towards it and landing on its surface. **Describe** why this happens.

Applying

9 The diagrams shown in Figure 7.5.1 show forces acting on objects A, B, C and D.
   a **Identify** whether the forces are balanced or unbalanced in each case.
   b In the case of any unbalanced forces, **predict** the direction in which the object will move.

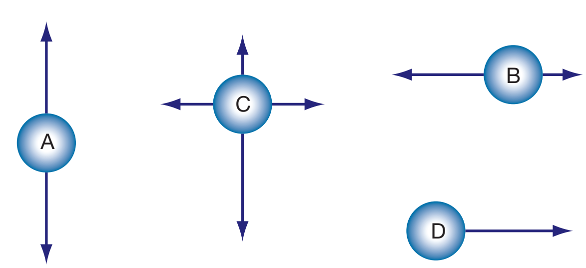


Figure 7.5.1

10 Figure 7.5.2 shows a graph that compares the braking distances of new and old tyres for different road surfaces and weather conditions. **Use** it to answer the questions that follow.

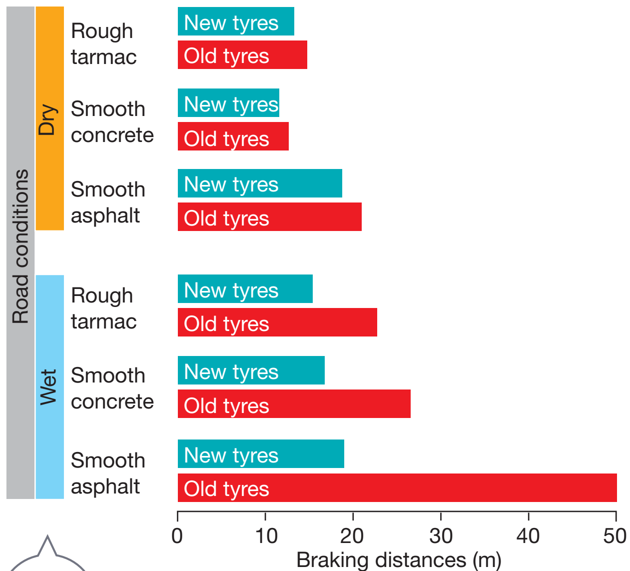


Figure 7.5.2

   a **State** which combination of factors produces the longest braking distance.
   b **State** reasons for the result in terms of forces.
   c **Describe** the weather conditions under which tyre performance varies the most.
   d **State** whether new or old tyres vary the most in performance.
   e **Explain** why old tyres are not as effective in stopping a car as new tyres.

Analysing

11 **Analyse** the force diagram in Figure 7.5.3.

- **a** **State** in which direction the boat is moving.
- **b** **Predict** what will happen to the speed of the boat when many fish have been caught in the net.
- **c** If the boat is travelling at a constant speed, **compare** the size of the thrust and drag forces acting on the boat.

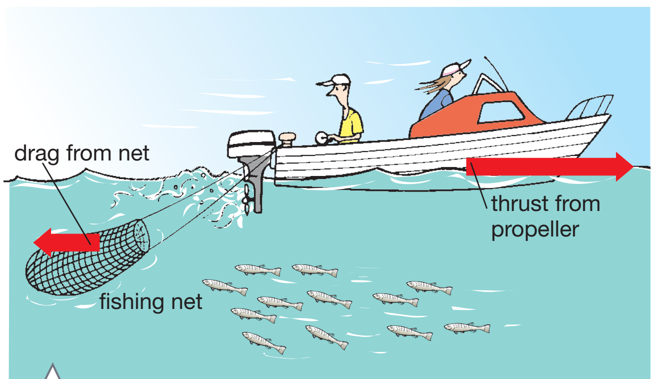


Figure 7.5.3

Evaluating CCT

12 Mariah flicks a coin across the stone benchtop in her kitchen. Later that day, she tries to flick the same coin across sand at the beach.

- **a** **Predict** which coin would travel the greater distance.
- **b** **Justify** your prediction.

13 Figure 7.5.4 shows three blocks of wood resting on different surfaces. If you were to pull each by its hook, **propose** which block would move with the least friction and which block would move with the most friction.

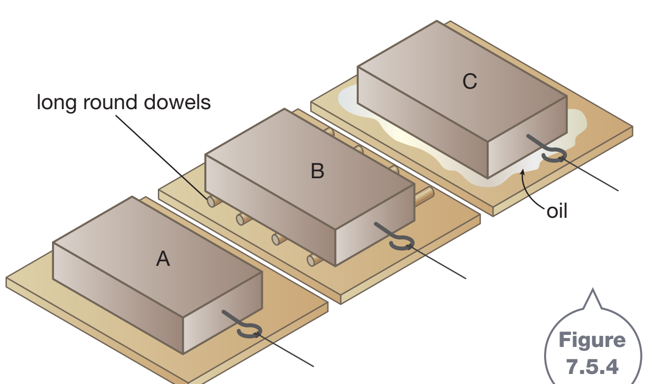


Figure 7.5.4

14 A length of wire is used to make coils A, B and C shown in Figure 7.5.5. An iron nail is inserted into Coil C.

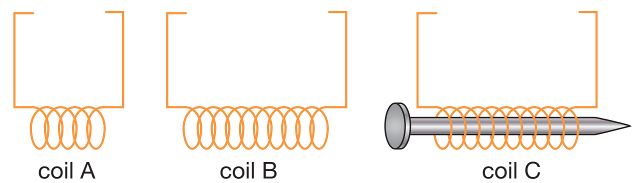


Figure 7.5.5

- **a** **Propose** which of the three would produce the strongest electromagnet when connected to a power supply.
- **b** **Justify** your response.

15 **a** **Determine** whether you can or cannot answer the questions on page 276 at the start of this chapter.

- **b** **Assess** how well you understand the material presented in this chapter.

Creating CCT

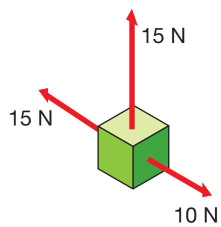
16 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

gravity	mass
weight	friction
inertia	force
force field	motion
magnetic field	electric field

7.9

Thinking scientifically

Q1 The total force acting on an object can be found by comparing the overall horizontal and the overall vertical forces. A box is acted upon by three forces as shown below. CCT



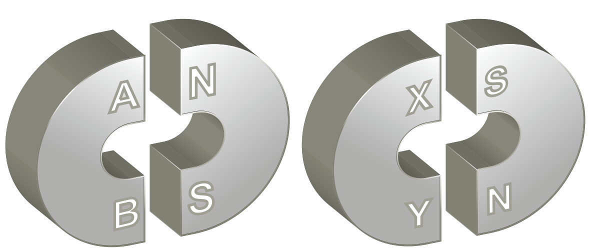
In which direction will the box move as a result of these forces?

A Upwards and to the left
B Upwards and to the right
C Downwards and to the left
D Downwards and to the right

Q2 Select which alternative below does not reduce friction between surfaces: CCT

A Lubricating a bike chain
B Shifting furniture using a trolley
C Using chains on car tyres when driving on snow or ice
D Oiling a door hinge

Q3 Siobhan finds two horseshoe magnets in her school laboratory that do not have their poles marked correctly. One has poles labelled A and B, while the other has poles labelled X and Y. She tests each using a third horseshoe magnet and finds the following combinations attract. CCT



Knowing that opposite poles attract, select which of the following pairs of poles will attract.

A X and B; Y and A
B X and A; X and B
C Y and A; Y and B
D X and A; Y and B

Q4 Active safety features placed in a vehicle are designed to reduce the chance of an accident occurring. Passive safety features lessen the impact of a force if a collision does occur. CCT

Select which of the following alternatives lists only active safety features:

A seatbelts, ABS (anti-lock brakes), night vision, headrests
B ESC (electronic stability control), reversing cameras, good headlights
C airbags, ESC (electronic stability control), reversing cameras
D seatbelts, ABS (anti-lock brakes), reversing cameras

Glossary

Unit 7.1 L

Acceleration: increase in speed (verb: accelerate)

Active safety features: features in a car that are designed to reduce the chances of an accident occurring

Deceleration: decrease in speed (verb: decelerate)

Force: a push, pull or a twist that can change an object's motion

Force

Inertia: the tendency of an object to resist change in its motion

Newton (N): unit used to measure force

Passive safety features: features in a car that are designed to lessen the impact of a force in an accident

Unit 7.2 L

Air resistance: or **drag:** friction that acts on an object moving through the air

Contact force: force that acts between two objects that touch, or are in contact; for example, friction

Friction

Friction: force that acts against an object's motion

Lubricants: fluid, such as oil, used to reduce friction between moving parts

Unit 7.3 L

Force field: region of space in which an object will experience a non-contact force

Gravitational field: region of space in which an object will experience a force due to gravity

Gravity: force of attraction between any two objects, for example the Earth and a person

Mass: the amount of matter in a substance (measured in kilograms)

Non-contact force: force that acts on an object from a distance

Terminal velocity: the point at which a falling body ceases to accelerate, but falls at constant speed, because its weight is balanced by air resistance

Terminal velocity

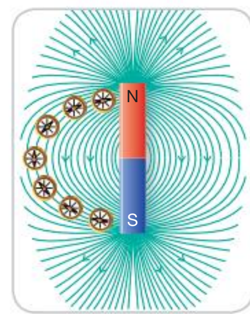
Weight: the force of gravity pulling on an object, measured in newtons

Unit 7.4 L

Atoms: tiny particles that make up all matter

Conductor: substance through which electrons can flow, such as metal

Domains: small regions inside a magnet that each behave as a mini-magnet, with a north and a south pole



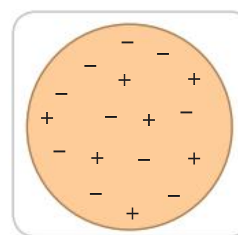
Magnetic field

Electric field: region around a charged object in which another object will experience a force

Electrostatic force: force experienced inside an electric field (also called electric force)

Insulator: substance through which electrons do not flow, such as plastic

Magnetic field: region around a magnet in which a magnetic force is experienced

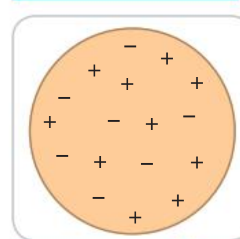


Negatively charged

Negatively charged: having more negative charges (electrons) than positive charges (protons)

Permanent magnet: a material that remains magnetic for a long period of time

Poles: ends of a magnet, may be a north or a south pole



Positively charged

Positively charged: having more positive charges (protons) than negative charges (electrons)

Static electricity: a build-up of electric charge

Temporary magnet: a material that keeps its magnetism for a short period of time

8 Earth in space

Have you ever wondered...

- how we know that the Sun is the centre of the solar system?
- how the gravitational pull of the Sun affects the planets?
- why we have seasons?
- what causes day and night?

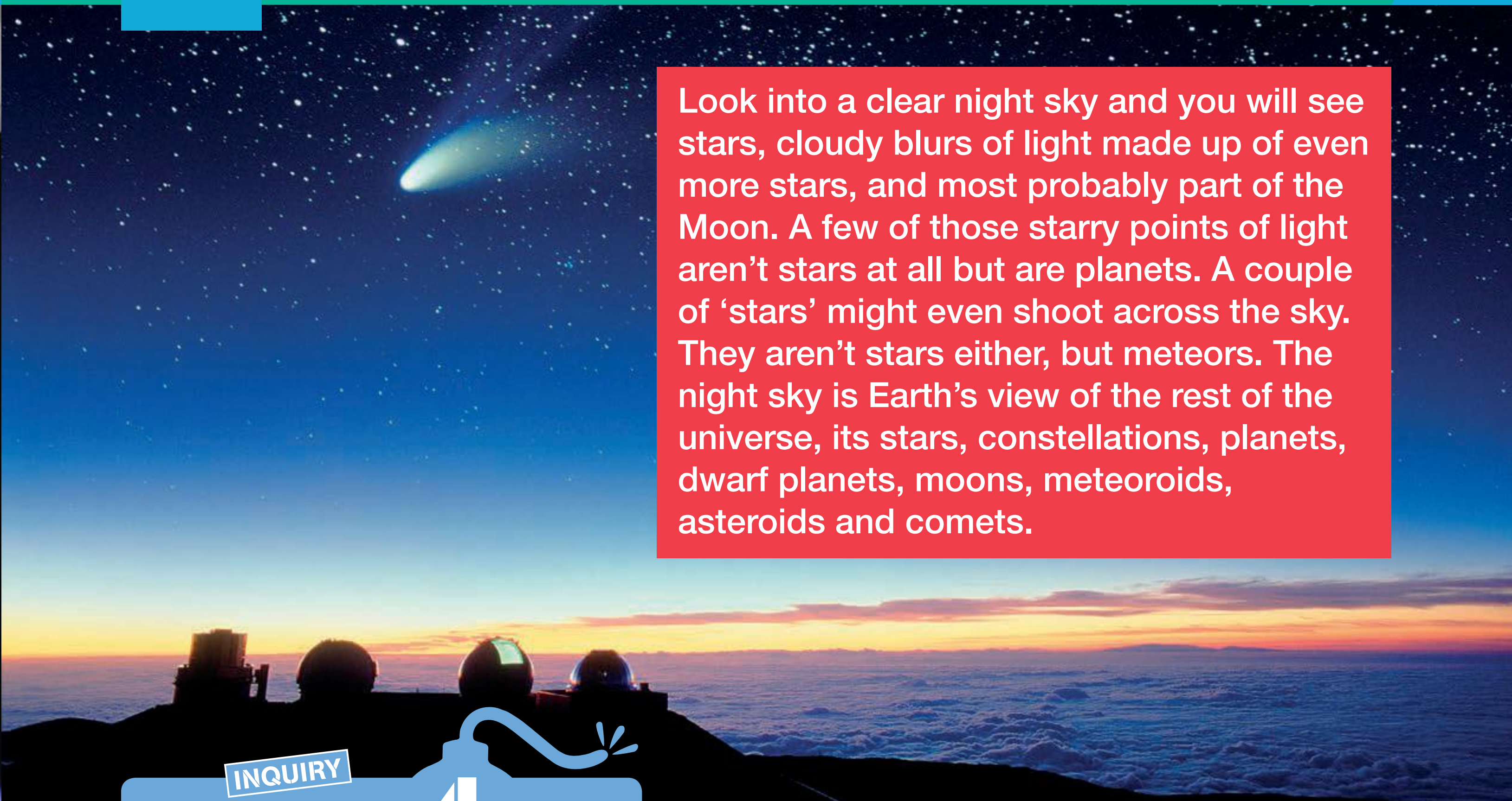
After completing this chapter students should be able to:

- compare current and historical models of the solar system to show how models are modified or rejected as a result of new evidence CCT
- demonstrate how different cultures have contributed to our understanding of the solar system IU DD
- describe how technological advances have increased our understanding of the solar system ICT
- identify changes that take place when particular forces are acting
- use the term 'field' in describing forces acting at a distance L
- identify that Earth's gravity pulls objects towards the centre of the Earth
- explain Earth's day and night, seasons and eclipses

ADDITIONAL

- describe how the forces of the Sun and the Moon cause tides on Earth.

8.1 The night sky



Look into a clear night sky and you will see stars, cloudy blurs of light made up of even more stars, and most probably part of the Moon. A few of those starry points of light aren't stars at all but are planets. A couple of 'stars' might even shoot across the sky. They aren't stars either, but meteors. The night sky is Earth's view of the rest of the universe, its stars, constellations, planets, dwarf planets, moons, meteoroids, asteroids and comets.

INQUIRY **science 4 fun**

Liquid craters

Meteorite strikes have marked the Moon with many craters (Figure 8.1.1). Many have peaks in their centre. What forms them?

Collect this …

- water
- drinking glass
- drinking straw

Do this …

1 Put a small amount of water in the glass.

2 Place one end of the straw in the water and then block the other end with your finger.

3 Keep your finger on the straw while you remove it. It should be holding some of the water.

4 Release the pressure of your finger so that a couple of drops fall back into the glass.

5 Carefully observe what happens to the surface of the water as the drop falls in, particularly at its centre.

Figure 8.1.1 Some meteorites have so much energy that they melt the Moon's rock, causing it to slosh around and to form a small peak in the centre of the crater. Droplets form a similar peak when they hit liquid water.

Record this …

Describe what happened.

Explain why you think this happened.

Observing the night sky

Although most people can see about 2000 stars in the night sky with the naked eye, the exact number depends on the weather, how close you are to the bright lights of a city, and whether or not the Moon is in the sky.

Not all those bright points of light are the same: some have different colours, some are much brighter or much dimmer than others and some move at different speeds. If you use a telescope, then some of these differences become even more apparent. These visible differences arise because not every point of light in the night sky is a real star. While most points of light are stars, a handful are planets, and a few might be meteoroids or comets.

The Moon

When it is visible, the Moon is the biggest and brightest object in the night sky. The Moon doesn't make its own light but acts like a giant mirror in the sky, reflecting sunlight down to you. This is the light you see. Sometimes you will see the Moon's full face (known as a full Moon) with its craters and 'seas'. At other times, you will only see half of it (a quarter Moon) or a slice of it (a crescent Moon). These different views of the Moon are known as its **phases**. These are shown in Figure 8.1.2. The Sun lights up half of the Moon but we on Earth don't always see that half: what phase you see depends on how the Moon, Sun and Earth are arranged in space.

Prac 1 p. 330

8.1

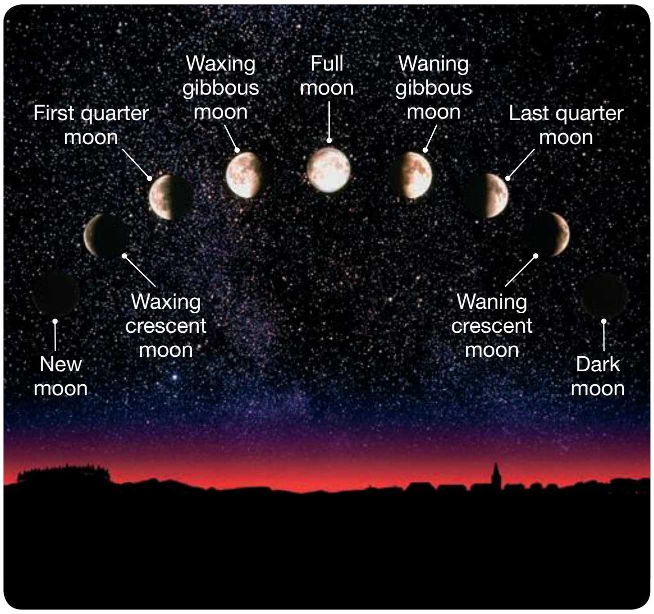


Figure 8.1.2 A composite image taken of the Moon and its phases over 30 days. The cycle repeats itself every 30 days (roughly one month).

Stars

Stars are massive burning balls of hydrogen gas. Hydrogen is explosive but the light and heat that comes from stars is not from 'normal' hydrogen explosions. It comes from nuclear explosions instead! A nuclear reaction (called a fusion reaction) converts hydrogen into helium, releasing enormous amounts of energy as heat, light and radioactivity as it does so.

The nearest star to Earth is the Sun, being 'only' 150 million kilometres from us. At this distance, the light and heat from those nuclear explosions takes just over 8 minutes to reach us.

The other stars you see in the night sky are much, much, much further away. After the Sun, the next closest star is Proxima Centauri. It is approximately 40 million million kilometres away and it takes 4.2 years for its light to reach us on Earth. The other stars you see are even further away—the light from some of them takes millions of years to reach us!

SciFile

Close but you can't see it!

Proxima Centauri is not far from Alpha Centauri, a double star system that forms one of the pointers leading to the Southern Cross. Proxima Centauri is so close to Alpha Centauri that it is sometimes considered to be part of the same star system. You can see Alpha Centauri in Figure 8.1.3. However, Proxima Centauri itself is so faint that it cannot be seen with the naked eye.

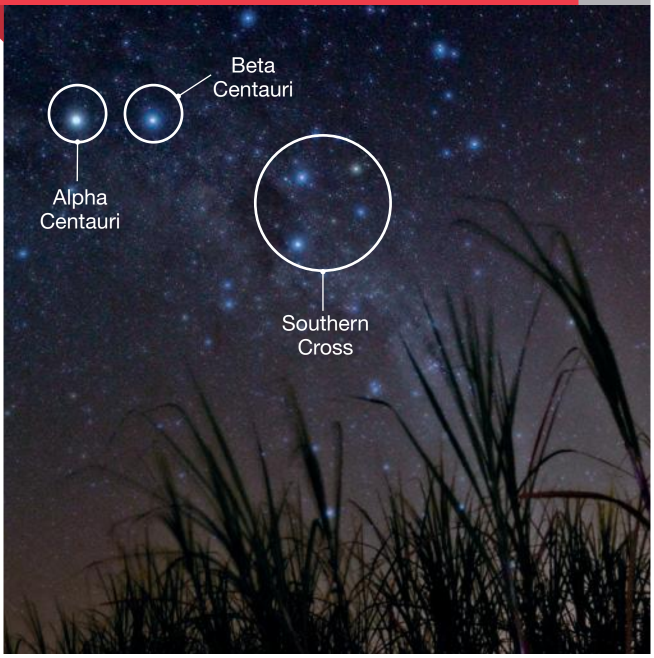


Figure 8.1.3 After the Sun, Proxima Centauri is the closest star to Earth. Proxima Centauri is near Alpha Centauri but it is too faint to see in this image.

The Milky Way

A band of light runs across the night sky from one horizon to the other. In ancient times, people thought that this looked like a road made of milk. That's why it was named the **Milky Way**. You can see it in Figure 8.1.4. Scientists now know that this white band is the light from more than 200 billion stars. Most of these stars are too far away to be seen distinctly or individually from Earth, but their combined glow is one of the most spectacular features of the night sky.

Figure 8.1.4 A long time-exposure image of the Milky Way. The light pollution caused by buildings and street lighting makes it difficult to see in the city.

SciFile

Starry, starry day

The stars are always there in the sky whether it's night or day. However, you can't see them in daylight because they can't compete with the intense brightness of the Sun.

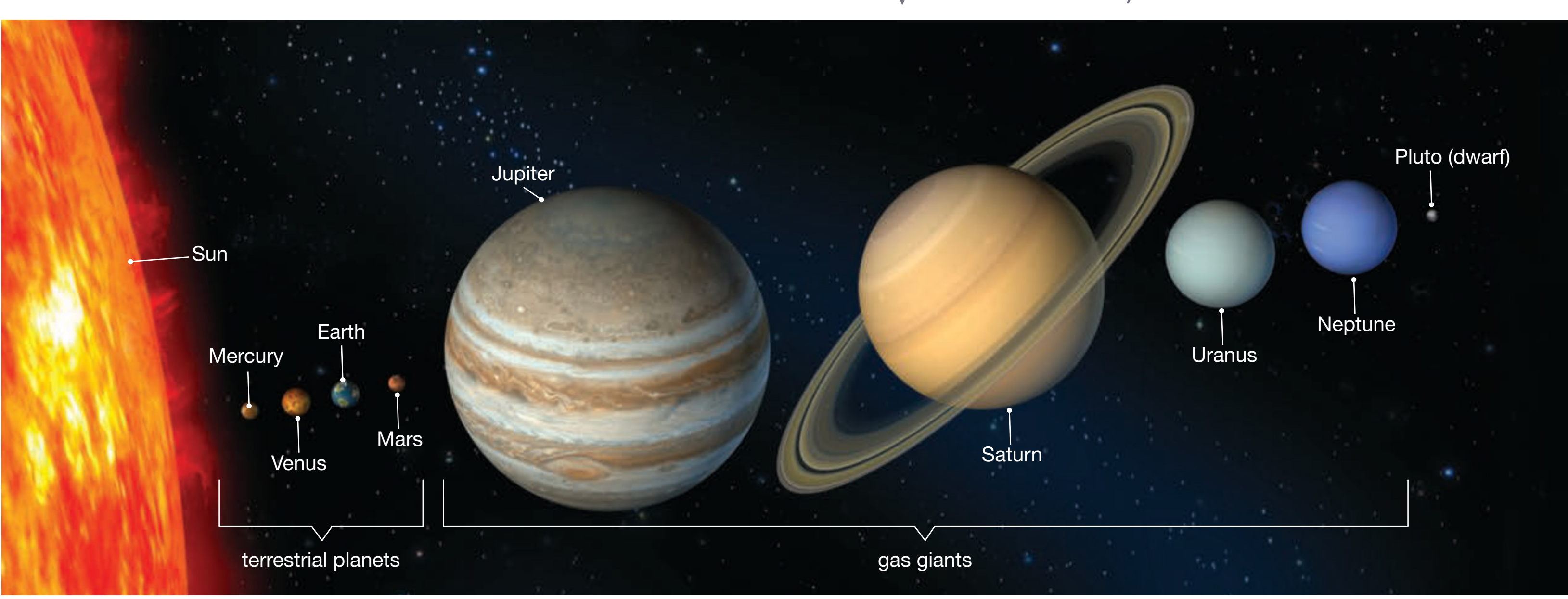
Planets

Planets are very different from stars. There are no nuclear explosions on the planets and so planets do not make their own light. Instead, they reflect light falling on them from the Sun. This allows us to see them in the night sky. They're seen as points of light that look very much like real stars.

Figure 8.1.5 shows the planets that travel around the Sun. Together, they form the **solar system**. Although the planets of the solar system are far from Earth, they are much closer to us than the stars.

Mercury, Venus, Earth and Mars are the closest planets to the Sun. These are known as the **terrestrial** (meaning Earth-like) planets. All these planets are rocky with a hard surface. Mercury, Venus and Mars are relatively close to Earth and are often seen in the night sky as a bright or coloured point of light. Mercury and Venus are usually visible before dawn as morning 'stars' or just after sunset as evening 'stars'. At these times, Venus is the brightest 'star' in the sky. Mars appears as a red-coloured 'star'.

Figure 8.1.5 The eight planets of the solar system can be classified as either terrestrial or gas giants. Pluto is not a planet but is considered to be a dwarf planet. (The distances in this image are not drawn to scale.)



The outer planets of Jupiter, Saturn, Uranus and Neptune are huge balls of gas with a small and rocky core. For this reason, they are commonly known as the **gas giants**. While Jupiter and Saturn can be seen as 'stars' with the naked eye, Neptune and Uranus can only be seen from Earth using a telescope.

Prac 2
p. 331

Other things you might see

The Moon, stars and planets are not the only things you might see in the night sky. Other things are up there that look like stars too.

Artificial satellites

Artificial satellites orbit (travel around) Earth, looking like 'stars' travelling slowly across the night sky. They have been placed in orbit as space stations and for purposes such as communication and for observing the weather on Earth's surface. The International Space Station (ISS) makes its own light, but this is too dull to be seen from Earth. You see satellites because they reflect sunlight back to you. You can see the ISS and another satellite in Figure 8.1.6.

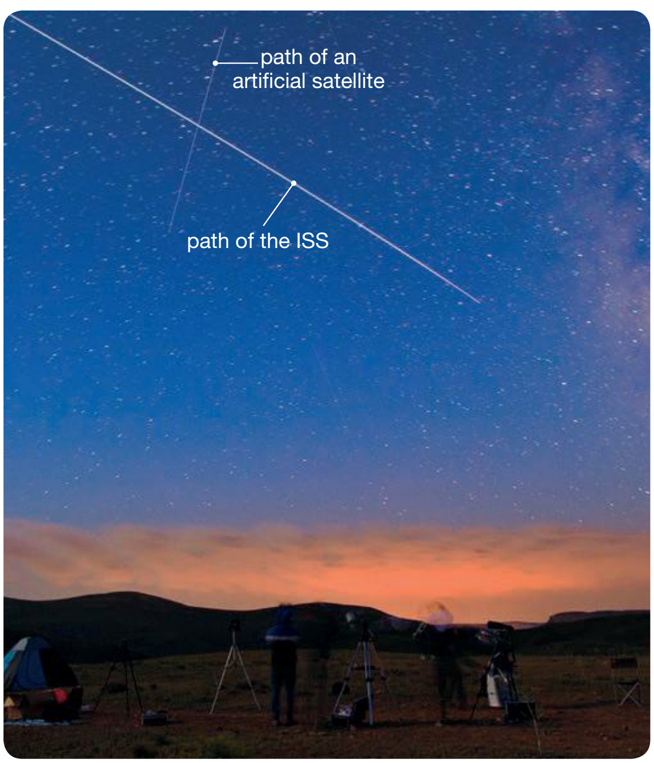


Figure 8.1.6 A time-exposure image of the International Space Station (ISS) and another satellite moving across the sky. The solar panels of the ISS reflect sunlight making it almost as bright as Sirius, the brightest star in the night sky.

Shooting stars

You may have seen something that looks like a star shooting across the night sky. Most fizzle out before they hit the horizon. These 'shooting stars' are space debris or rocks burning up in our atmosphere as they plunge towards Earth.

A small rock or particle of debris in space is called a **meteoroid**. They can range in size from a grain of sand to a rock 10 metres across.

Occasionally, the path of a meteoroid will bring it close enough to Earth for it to be pulled in by Earth's gravity. As the rock falls through Earth's atmosphere it reaches speeds of more than 15 kilometres per second! The meteoroid quickly compresses the air in front of it, causing the air to heat up. This in turn heats up the rock, much like when your bicycle pump gets hot when you quickly pump up a tyre. The enormous heat generated turns the meteoroid into a blazing fireball known as a **meteor** or 'shooting star' (Figure 8.1.7). Most meteors are so small that they burn up completely in the atmosphere. This is why most shooting stars fizzle out before they reach the ground.

However, if a meteor is large then part of it might reach the ground before it has completely burnt up. The part that reaches the ground is called a **meteorite**. Most meteorites are small, but on very rare occasions Earth is struck by a large meteorite. Occasionally, these large meteorites are **asteroids** that have strayed from the **asteroid belt**. This belt is a band of rocky objects that orbit the Sun between Mars and Jupiter. The destruction the meteorite causes depends on its size. Smaller meteorites form craters while larger ones can have devastating effects. For example, there is strong evidence that a major meteorite impact caused the extinction of the dinosaurs 65 million years ago.

Figure 8.1.7 A meteor burning up as it travels through the atmosphere.

Meteors from comets

SciFile

Astronomers usually don't know when a small meteoroid might hit Earth's atmosphere. This makes the appearance of most 'shooting stars' very unpredictable. However, some meteors are caused by Earth passing through debris left behind by comets. These are much more predictable events. Sometimes they form meteor 'showers' like the one in Figure 8.1.8.

Figure 8.1.8 A time-exposure image of a meteor shower. Meteor showers happen when Earth passes through the debris left by a comet. Fragments of the comet burn up in Earth's atmosphere and appear like a 'shower' of shooting stars.

Russian strikes

SciFile

In 2013, a meteor exploded at a height of 30 kilometres above the city of Chelyabinsk in Russia, shattering windows and injuring at least 1200 people. Astronomers estimate that the meteor had a mass of around 10 tonnes, was about 3 metres in diameter and travelling at a speed of 50 000 km/h! In 1908, an even bigger meteor exploded above the largely uninhabited region of Tunguska, Russia, devastating more than 2070 square kilometres of forest.

Comets

Comets are part of the solar system because they also travel around the Sun. Comets don't appear often but when they do they are among the most spectacular sights in the sky (Figure 8.1.9). **Comets** are 'dirty snowballs' made of ice mixed with carbon dioxide and other substances. They have a head (known as a coma) and a long shining tail. One of the most famous comets is Halley's Comet. It reappears in the night sky approximately every 76 years. Its most recent appearance was in 1986.

Figure 8.1.9 The spectacular Comet McNaught crossed the skies of both the northern and southern hemispheres in 2007.

8.1 Unit review

Remembering

1 **Name** the type of nuclear reaction that powers stars.

2 a **Name** the nearest star to Earth.
  b **State** how long it takes its light to reach Earth.

3 **Name** the bright band of light that can be seen in the night sky.

4 a **State** how many stars are visible to the naked eye.
  b **List** factors that affect the number of stars able to be seen.

5 **List**:
  a the terrestrial planets
  b the gas giants.

Understanding

6 **Explain** why moonlight can be considered to be sunlight.

7 **Explain** why planets are sometimes mistaken for stars.

8 **Calculate** the year in which Halley's Comet is likely to be next seen from Earth. N

9 **Explain** why comets and meteor showers are often observed together.

Applying

10 One set of planets is also known as the rocky planets. **Identify** the planets that are most likely to belong to this set.

11 A drop of water is dripped into a glass of water.
  a **Predict** the pattern that would result.
  b **Use** your prediction to **explain** why craters formed when meteors struck the Moon.

12 The table below shows the average distances of the planets of the solar system from the Sun. Assume that all the planets are lined up in order from Mercury to Neptune. **Use** this information and:
  a **name** the closest planet to Earth
  b **list** the planets from closest to Earth to most distant from Earth.

Analysing

13 **Contrast**:
  a a planet with a star
  b a star with the Milky Way
  c a meteor with a meteorite
  d a meteoroid with a comet.

Evaluating CCT

14 You see many bright points of light in the night sky.
  a **List** the different types of things they could be.
  b **Assess** how likely it is to see each type and **list** them again in order from most likely to least likely.

15 A meteor and a comet look similar in many ways. **Propose** a way of telling them apart.

16 There are very few photos or videos of individual 'shooting stars' but lots of meteor showers.

17 Figure 8.1.10 shows Meteor Crater in Arizona, USA. Its name is scientifically incorrect.
  a **Propose** a reason why.
  b **Propose** a better name for it.

Figure 8.1.10

Planet	Earth	Jupiter	Mars	Mercury	Neptune	Saturn	Uranus	Venus
Distance from Sun (millions of km)	150	778	228	58	4498	1427	2870	108

18 It would be easy for astronauts to move about on the surface of Mars, but it would be impossible for them to do so on Jupiter. **Propose** reasons why.

Creating CCT

19 Joe wants to demonstrate why planets 'shine' in the night sky using a torch, a mirrored disco ball and a basketball. **Construct** a diagram showing how he could do it.

Inquiring

1 Research one of the planets of the solar system to find:
- its distance from the Sun
- a cutaway diagram showing the composition of its interior and atmosphere (if any)
- the names of its moons (if any)
- a photo or artist's impression of its surface
- basic details of a mission that has visited the planet (such as launch date, year of contact, fate of mission).

Present your research in any form you wish.

2 Spacecraft have successfully landed on asteroids and have attempted to sample dust and gases of comets. Research the *NEAR Shoemaker*, *Galileo*, *Hayabusa*, *Deep Impact*, *Rosetta* and *Dawn* missions to find:
- when each was launched
- what each visited (comet or asteroid)
- what eventually happened to each mission.

Present your research as a table.

3 Halley's Comet is named after the astronomer Edmund Halley. Research Edmund Halley and Halley's Comet to find:
- Halley's nationality, year of birth and death
- why the comet it was named after him
- whether Halley ever actually saw the comet himself
- a photo of Halley's Comet on its most recent visit
- an image of the part of the Bayeux tapestry that shows Halley's Comet
- the date and location of the tapestry
- the fate of the *Vega 1* and *Vega 2* spacecraft, which both flew by Halley's Comet in 1986.

Present your research in digital form with relevant text and images. ICT

4 Research the 2013 or 1908 meteor explosion above Russia. Find:
- a map showing where it happened
- photos or video of the meteor or of the devastation.

Present your research as two email attachments that can be sent to your teacher. ICT

Figure 8.1.11 In 1999, NASA's spacecraft *Galileo* successfully flew past Io, one of Jupiter's moons.

8.1 Practical investigations

1 Simulating impact craters

Purpose

To model the surface of the Moon by forming impact craters and simulating erosion.

Materials

- 4 cups of damp sand or flour
- small plastic box or tray (such as a lunch box or take-away food container)
- several marbles or ball bearings (of various sizes if possible)
- tweezers
- piece of tissue paper or cloth
- large sheet of plastic (to clean up mess)
- digital camera or mobile phone with camera function

Procedure

1. Lay out the tray on the large sheet of plastic or set up outside.
2. Fill the tray with flour or sand to a depth of 2–3 cm. Keep at least one cup aside for later.
3. Drop a marble or ball bearing into the flour or sand to make an impact crater.
4. Using tweezers, carefully remove the marble or ball bearing. Avoid changing the shape of the crater.
5. Repeat steps 3 and 4 with marbles of different sizes from different heights until a pattern of overlapping craters has been formed.
6. Sketch or photograph the crater pattern.
7. Simulate volcanic activity by sprinkling the remaining flour or sand over a section of the crater pattern. Sketch or photograph this section.
8. Simulate erosion by lightly dragging the tissue or cloth over a section of the tray.
9. Sketch or photograph the crater pattern.
10. Simulate earthquakes by lightly tapping the side of the tray.
11. Drop several more marbles or ball bearings.
12. Sketch or photograph the crater pattern.

Results

If you took photos, print them out and label important features that you see in them.

Practical review

1. Can you tell from the crater patterns you made which craters were formed earlier and which were formed later? If so, **explain** how.
2. **Propose** what effect each of the following would have on the pattern of impact craters:
   a. volcanic activity
   b. erosion
   c. earthquakes.
3. It is possible to identify which impact craters were formed after volcanic activity, erosion and earthquakes. **Propose** what the landscape would look like if a crater was formed after each type of activity.
4. **Use** information gained from this activity to **predict** what astronomers could learn from the pattern of impact craters on a moon or a planet.

2 Toilet paper solar system

Purpose

To construct a scale model of the solar system that shows the distance between the planets.

Materials

- 300-sheet roll of toilet paper
- pen or pencil (not a felt-tipped pen)

Procedure

1. Unroll a little of the toilet roll. At the very start of the first sheet, draw and label the SUN.
2. Unroll the toilet roll a little further. At the end of the fourth sheet, draw a small planet. Label it MERCURY.
3. The table below shows where you need to draw and label the other planets of the solar system. The scale being used here is 1 sheet = 15 million kilometres or 1 : 15 000 000. Using this scale, Neptune should be drawn at the edge of the final sheet on the roll.

Planet	Distance (millions of km)	Toilet sheets
Mercury	58	4
Venus	108	6.5
Earth	150	10
Mars	228	15.5
Jupiter	778	52
Saturn	1427	95.5
Uranus	2871	193.5
Neptune	4498	300

Practical review

1. **List**:
   a. the four terrestrial planets
   b. the four gas giants.
2. **Identify** which planets are closest to each other. Are they the terrestrial planets or the gas giants?
3. The asteroid belt is about 450 million kilometres from the Sun. **Identify** and mark on your toilet paper solar system where the asteroid belt would be found.
4. **Compare** this model solar system with Figure 8.1.5 on page 325. **Discuss** why pictures like this are not drawn to scale.

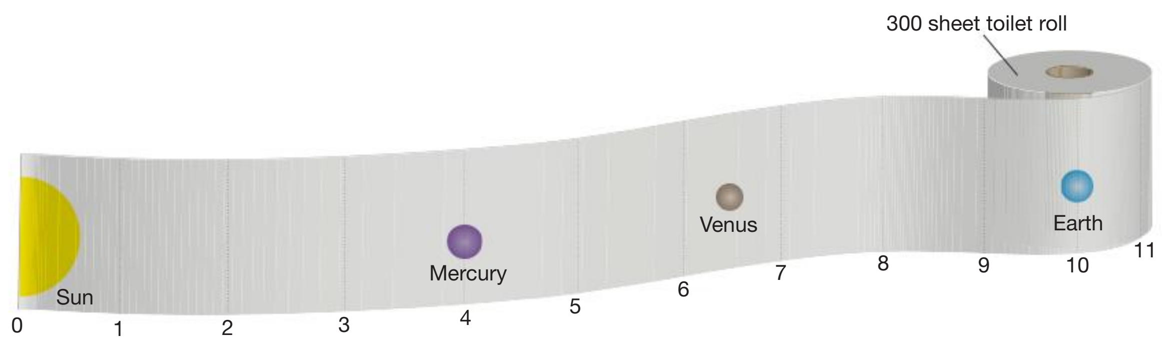


Figure 8.1.11

8.2 Discovering the solar system

We now take it for granted that Earth and its seven planetary neighbours orbit the Sun. However, this is a relatively new idea. Our understanding of the solar system and Earth's place in the wider universe has changed through time. Changes have happened because of the ideas, discoveries and new inventions of scientists from different countries and diverse cultures.

INQUIRY science 4 fun

Skywatch

YES

Collect this …

- sky map (from *Pearson Science NSW 7 Activity Book* Worksheet 8.2, or similar)
- binoculars (if available)

Do this ….

1 Wait until the Sun has been down for at least half an hour.

2 Find a spot outside where you can see the sky and where there are as few street and house lights as possible.

3 Face south and find the Southern Cross and the pointers. The Cross may be upside down or lying on its side.

4 If the Moon is in the sky, look at the details of its surface (use binoculars if available).

5 Use the sky map to identify as many constellations as you can.

Record this …

Describe what you saw.

Explain how some stars might actually be planets or something else.

Constellations

Throughout history, different groups of people in different parts of the world have looked at the same stars and grouped them together in different ways. The pictures and patterns they have recognised have varied from one culture to another. These patterns are known as **constellations**. The Southern Cross is a constellation that can only be seen all year round in the southern hemisphere. For this reason, its five stars appear in the flags of a number of countries located south of the equator (Figure 8.2.1).

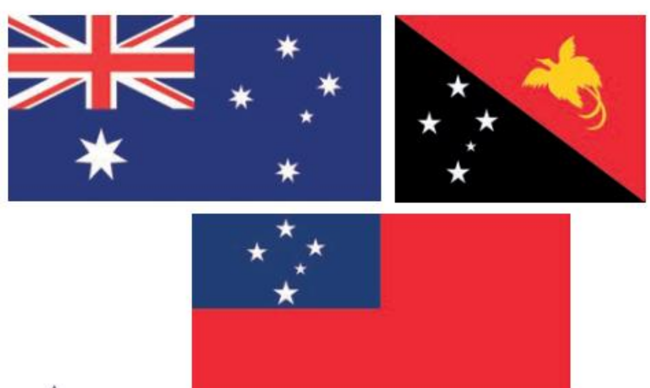


Figure 8.2.1 The flags of Australia, Papua New Guinea and Samoa

Finding the South Pole

In ancient times, navigators used the Southern Cross to locate the South Pole. You can do this too. First you need to locate the South Celestial Pole. This is the point in the southern night sky around which all the stars seem to rotate. You can find it using two different methods:

Method 1: Extend the main axis of the Southern Cross four times.

Method 2: Extend the main axis. Construct another line out from the middle of the pointers as shown in Figure 8.2.2. The South Celestial Pole is where the two lines meet.

Once the South Celestial Pole is located, drop a line to the horizon; where it hits is the South Pole.

8.2

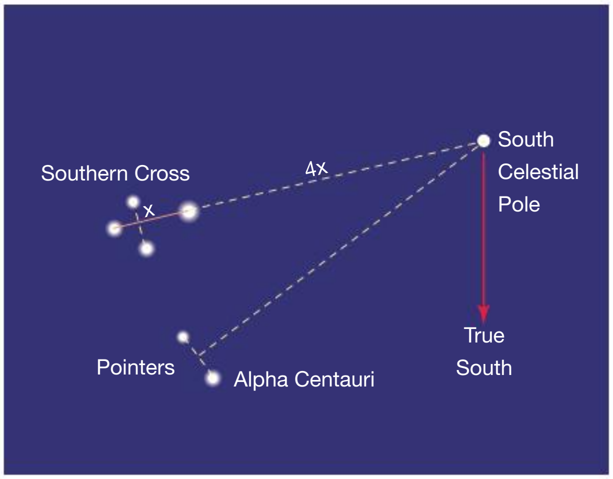


Figure 8.2.2 How to use the Southern Cross to find the South Pole

Structure of the solar system

Explaining the motion of the Earth, Moon, planets and stars has been a puzzle that has taken many centuries to solve. Every day, the Sun, Moon and stars rise in the east and set in the west. By itself, this evidence suggested that they all travel around Earth. However, the planets move differently from the stars. Since ancient times, **astronomers** saw that the five visible planets (Mercury, Venus, Mars, Jupiter and Saturn) take months or years to travel across the night sky from east to west. Their motion held the key to our understanding of the structure of the solar system and Earth's place in it.

The geocentric model

To many ancient astronomers, the motion of the Sun, Moon, stars and planets suggested that the Earth was at the centre of the universe with everything orbiting around it in circular paths. This model is shown in Figure 8.2.3 and is called the **geocentric model**. This model puts the Earth (*geo-*) at the centre (*-centric*) of the universe. The Greek philosopher Aristotle (384–322 BCE) clearly described the geocentric model in the third century BCE. Since this model matched everyday experience, his ideas were generally accepted. However, not all astronomers agreed.

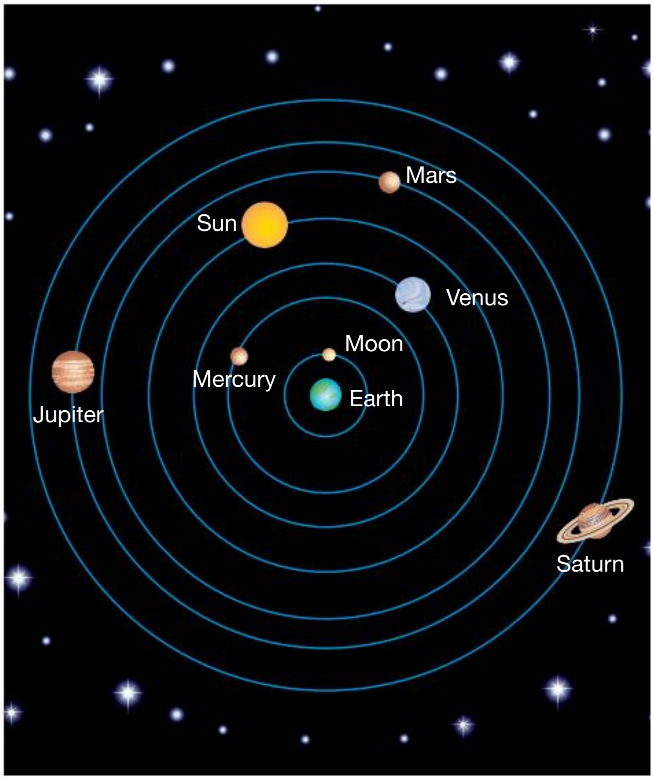


Figure 8.2.3 The geocentric model places Earth at the centre of the universe. The Moon, Sun, other planets and stars all revolve in orbits around it.

The heliocentric model

In about the second century BCE, the Greek philosopher Aristarchus (310–230 BCE) suggested that the Sun and not the Earth was the centre of the universe. This model is known as the **heliocentric model** (*helio-*= Sun) and is shown in Figure 8.2.4.

However, predictions made with the heliocentric model did not match astronomical observations of the time. Hence, very few astronomers supported Aristarchus or his model.

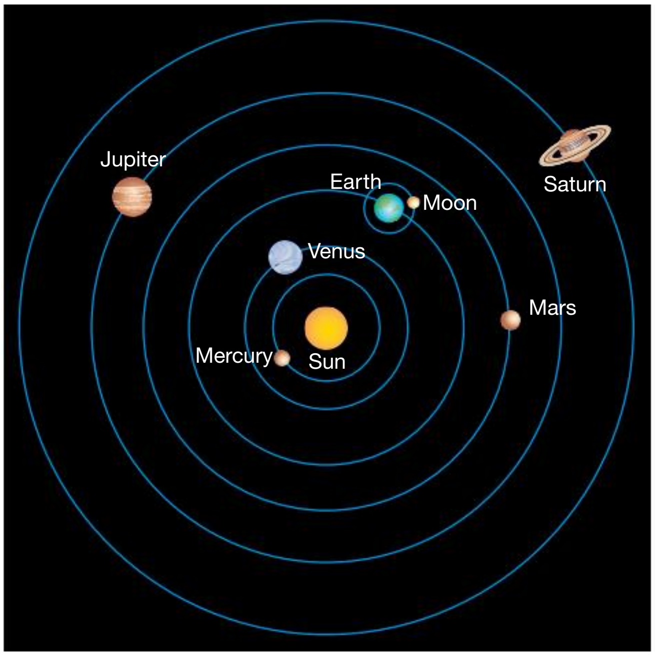


Figure 8.2.4 The heliocentric model of the solar system places the Sun at its centre. The Earth and other planets revolve around it.

Retrograde motion

Although the geocentric model made sense to the ancient astronomers, they observed that the planets sometimes seemed to turn around and move backwards! This strange looped motion is shown in Figure 8.2.5 and is known as **retrograde motion**.

Figure 8.2.5 When viewed over a couple of months, the motion of Mars seems to loop back on itself: it shows retrograde motion.

In the first century CE the Greek philosopher Claudius Ptolemy refined the geocentric model so that it could explain retrograde motion. His model is shown in Figure 8.2.6.

Ptolemy's refinements did not agree perfectly with observations but it was close enough. Most scientists in Europe accepted his version of the geocentric model. Support for the geocentric model was so strong that in 1543 a book by Polish mathematician Nicholas Copernicus supporting the heliocentric model was banned in many countries.

Copernicus used the heliocentric model to explain retrograde motion. He assumed that all the planets orbited the Sun at different speeds. This would change their relative positions when viewed from Earth, sometimes making them appear to move backwards.

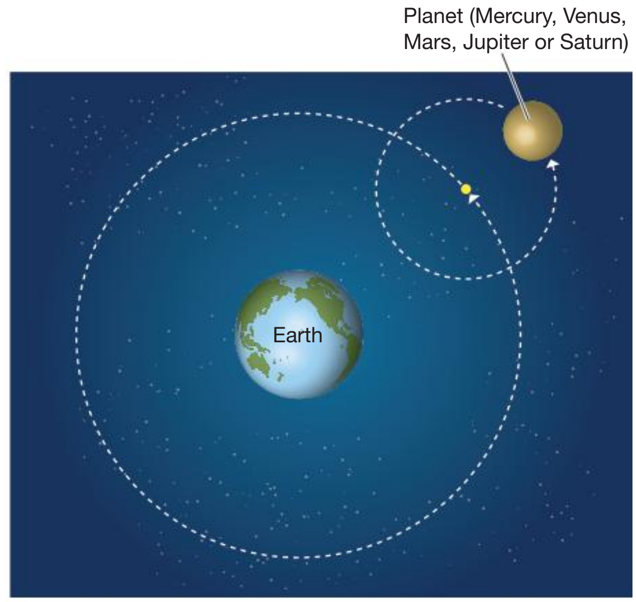


Figure 8.2.6 In Ptolemy's revised model of the universe, each planet travelled in a circle centred on a point that orbited the Earth.

The telescope challenges ideas

Before Italian scientist and mathematician Galileo Galilei built his telescope in 1609, astronomers viewed the night sky with nothing more than their own eyes. Galileo used his telescope to discover:

- craters on the Moon (Figure 8.2.7)
- the rings of Saturn
- the four largest moons of Jupiter—which showed that not everything in the universe orbited Earth
- that the planet Venus went through phases just like the Moon. This observation could only be properly explained if Venus was orbiting the Sun and not Earth.

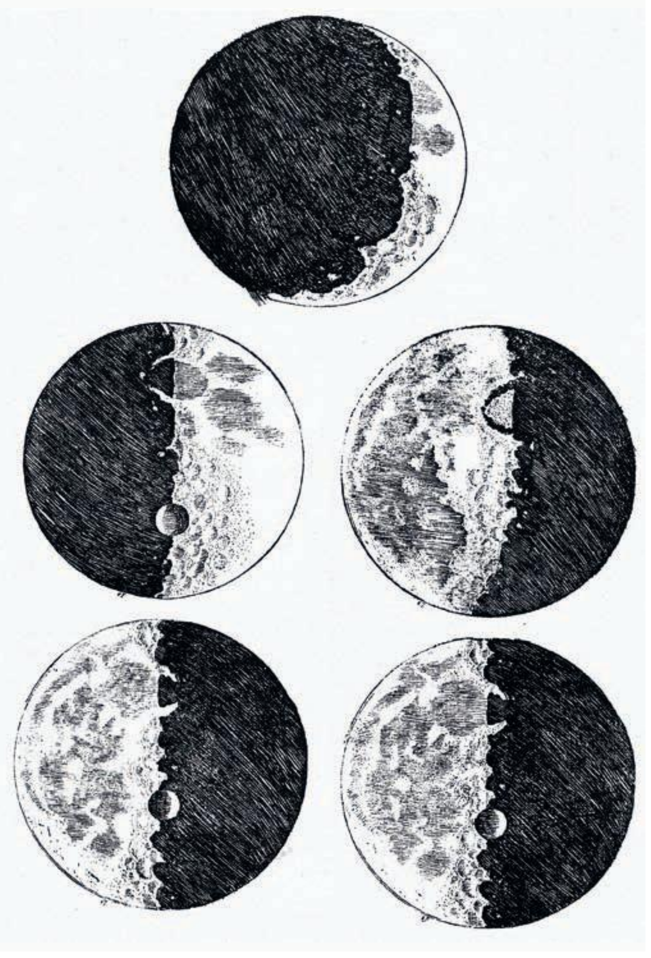


Figure 8.2.7 Although Galileo did not invent the telescope, he was the first person to use it for astronomy. These are some of his drawings of the Moon in different phases and its craters that were visible.

Galileo's observations led him to challenge the geocentric model and instead support the heliocentric model of Copernicus. Galileo lived in Italy at a time when religious authorities were very powerful. His outspoken manner brought him into conflict with the authorities and he was imprisoned and banned from publishing his ideas and from writing to other scientists.

Galileo relied on his scientific technique and observations and not on the accepted way of thinking of his time. For this he is recognised as the 'father of modern science'.

In 1596, the German mathematician Johannes Kepler (1571–1630) produced a heliocentric model that closely matched existing astronomical data. His model assumed that planetary orbits were elliptical rather than circular. This was a revolutionary idea—at that time, circles were believed to have special, almost mystical, properties.

Like Copernicus and Galileo before him, Kepler was fiercely attacked by religious authorities. However, people in countries like Germany and England where religious ideas were changing were much more open to his ideas.

In 1687, the great English scientist and mathematician Isaac Newton (shown in Figure 8.2.8) proposed a law that described the force of gravity. It was known as the universal law of gravitation and it explained how the heliocentric model would work. Support for the opposing geocentric model quickly disappeared.

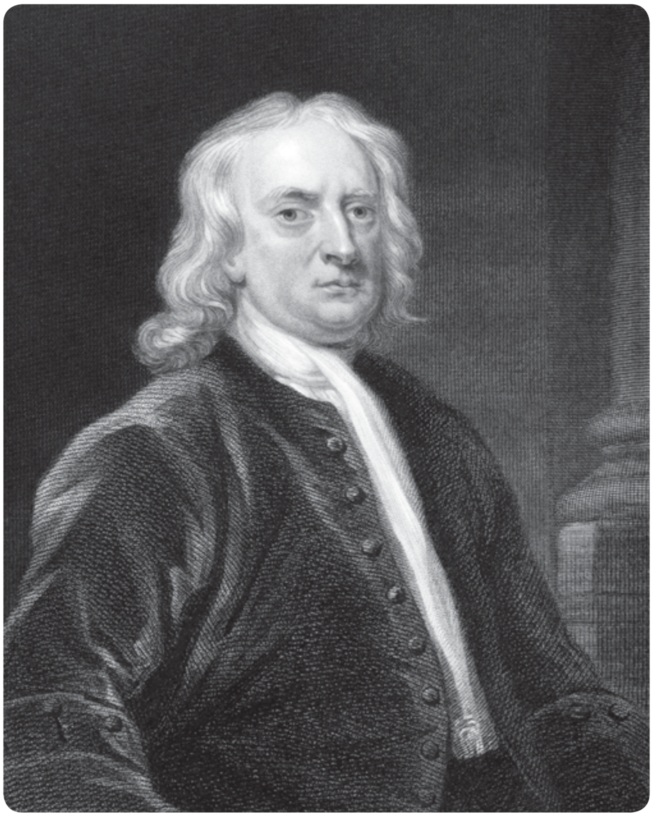


Figure 8.2.8 Isaac Newton (1642–1727) developed laws that explained forces, gravity and the motion of the planets. He is considered to be one of the greatest scientists of all time.

Prac 1 p. 342

8.3

Discovering the outer planets

The planets Uranus and Neptune cannot be seen with the naked eye and so a telescope was required to discover them. The German-born British astronomer William Hershel (1738–1822) used a telescope in 1781 to discover the planet Uranus, and German astronomer Johann Galle (1812–1910) used one to observe Neptune in 1846.

> **What's causing that?** SciFile
>
> The existence of Neptune was predicted before it was actually seen! In 1845, the French astronomer Urbain Le Verrier and Englishman John Couch Adams both used their telescopes to track the orbit of Uranus. They noticed that it was a little 'warped'. This could only happen if another planet (Neptune) was further out, pulling Uranus a little towards it.

Discovering the dwarf planets

Pluto was discovered in 1930 by American astronomer Clyde Tombaugh (1906–1997). It was quickly classified as the ninth planet of the solar system. In 1992, it was then found that Pluto was part of the Kuiper Belt, a band of relatively small objects orbiting in the Sun at the outer edge of the solar system. Over the next 10 years, other Pluto-sized objects were discovered. Some of these are shown in Figure 8.2.9.

For astronomers, this raised a difficult question—if Pluto is a planet, then should these objects be classified as planets too? If so then the solar system would have 12 planets and possibly more!

In 2006, the International Astronomical Union solved this problem by defining a planet as a celestial body that:

- is in orbit around the Sun
- has sufficient mass and gravity (is big enough) to be nearly spherical (round)
- has enough gravity to clear the neighbourhood around its orbit of dust, rock and other objects.

Pluto orbits the Sun and is roughly spherical but it is part of the Kuiper Belt. This means that it has failed to clear its orbit. For this reason, Pluto is no longer considered to be a planet but is now classified as a **dwarf planet**. Haumea, Eris and Makemake are also classified as dwarf planets, as is the asteroid Ceres located in the asteroid belt between Mars and Jupiter.

Prac 2 p. 343
Prac 3 p. 343

Exploring the solar system

The development of rockets in the mid-twentieth century allowed us to leave Earth and explore the solar system directly. The Apollo missions that landed on the Moon between 1969 and 1972 had human crews. Apollo XI was the first to land. You can see one of its astronauts (Buzz Aldrin) on the Moon's surface in Figure 8.2.10.

> **Still a planet to some** SciFile
>
> In 2009, the government of Clyde Tombaugh's home state of Illinois, USA, 'overruled' the International Astronomical Union. Within the state of Illinois at least, Pluto is still considered a planet and March 13 (the anniversary of its discovery) is celebrated as Pluto Day.

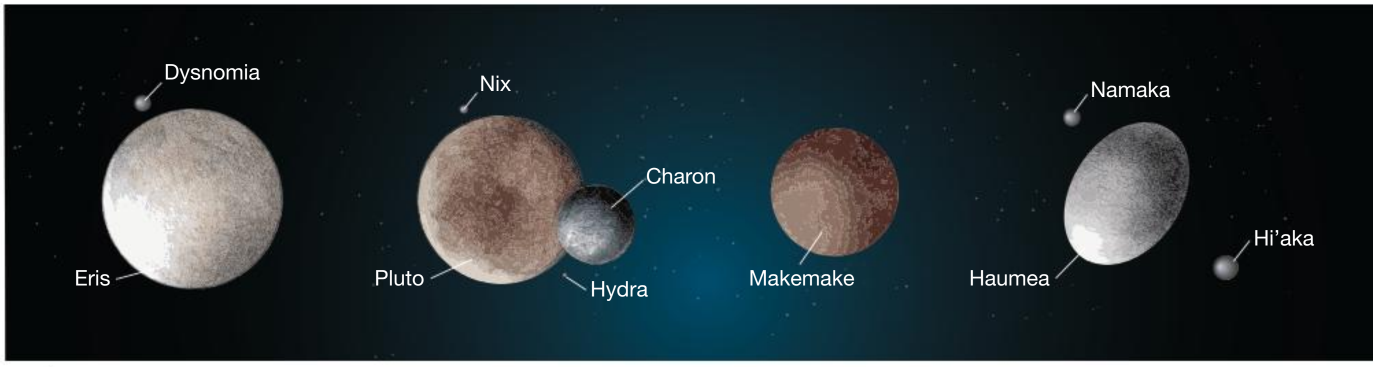


Figure 8.2.9 The Kuiper Belt contains a number of dwarf planets and similar-sized objects.

Since these missions, humans themselves have not ventured outside Earth's immediate orbit. All other space probes to the Moon and beyond have been without human crew, although many have carried robots. Some space probes have landed or crashed onto the planets or their moons. Others have flown by, taking photos and measurements as they did so. These missions continue to this day—one of the most recent being the *Curiosity* probe. It landed its rover on Mars in 2012.

Most of the missions of the twentieth century were sent by USA or USSR (now Russia). However, twenty-first century space exploration has become truly international, with countries such as India and China investing in their own space programs. The programs of countries such as France, Germany and Italy are coordinated through the European Space Agency.

Space exploration has allowed astronomers to make many important discoveries about the solar system that would have been impossible using telescopes alone. These include the following discoveries:

- Moon rocks have a similar composition to those found on Earth. This suggests that the Moon was once part of Earth.
- Water once flowed on the surface of Mars, depositing minerals such as gypsum.
- Jupiter has more than 60 moons ranging in size from Ganymede, with a diameter of about two-fifths that of Earth, to unnamed chunks of rock barely a kilometre across.
- One of Jupiter's moons (Io) is still volcanically active, sending plumes of material shooting hundreds of kilometres above its surface.
- The rings of Saturn appear solid when viewed from Earth but are made of countless pieces of rock ranging in size from dust to chunks metres across.
- The planet Uranus has a magnetic field that is, strangely, tilted at 60° to the angle of the planet's rotation.

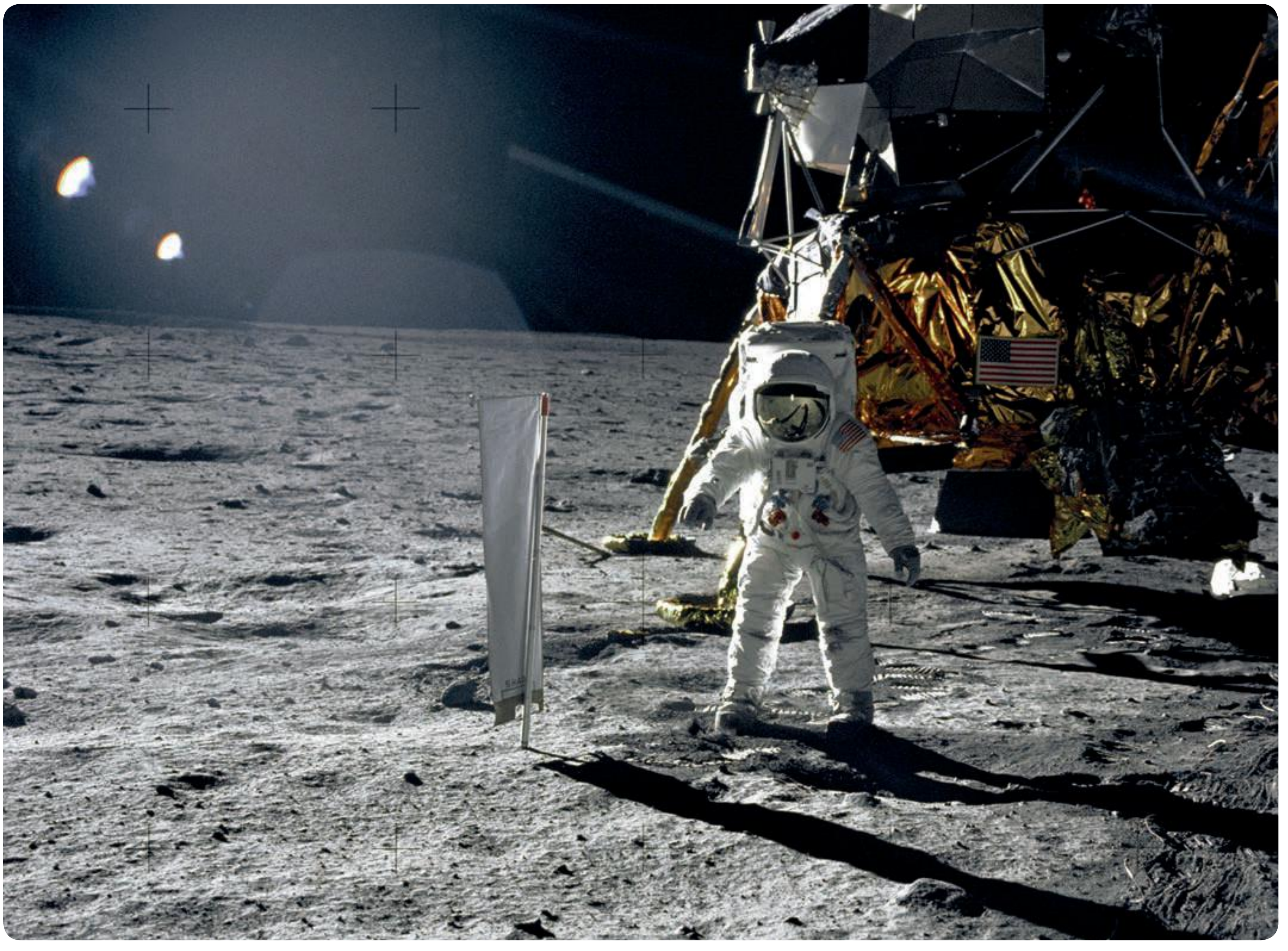


Figure 8.2.10 Buzz Aldrin from Apollo XI on the surface of the Moon.

LEARNING ACROSS THE CURRICULUM

INTERCULTURAL UNDERSTANDING

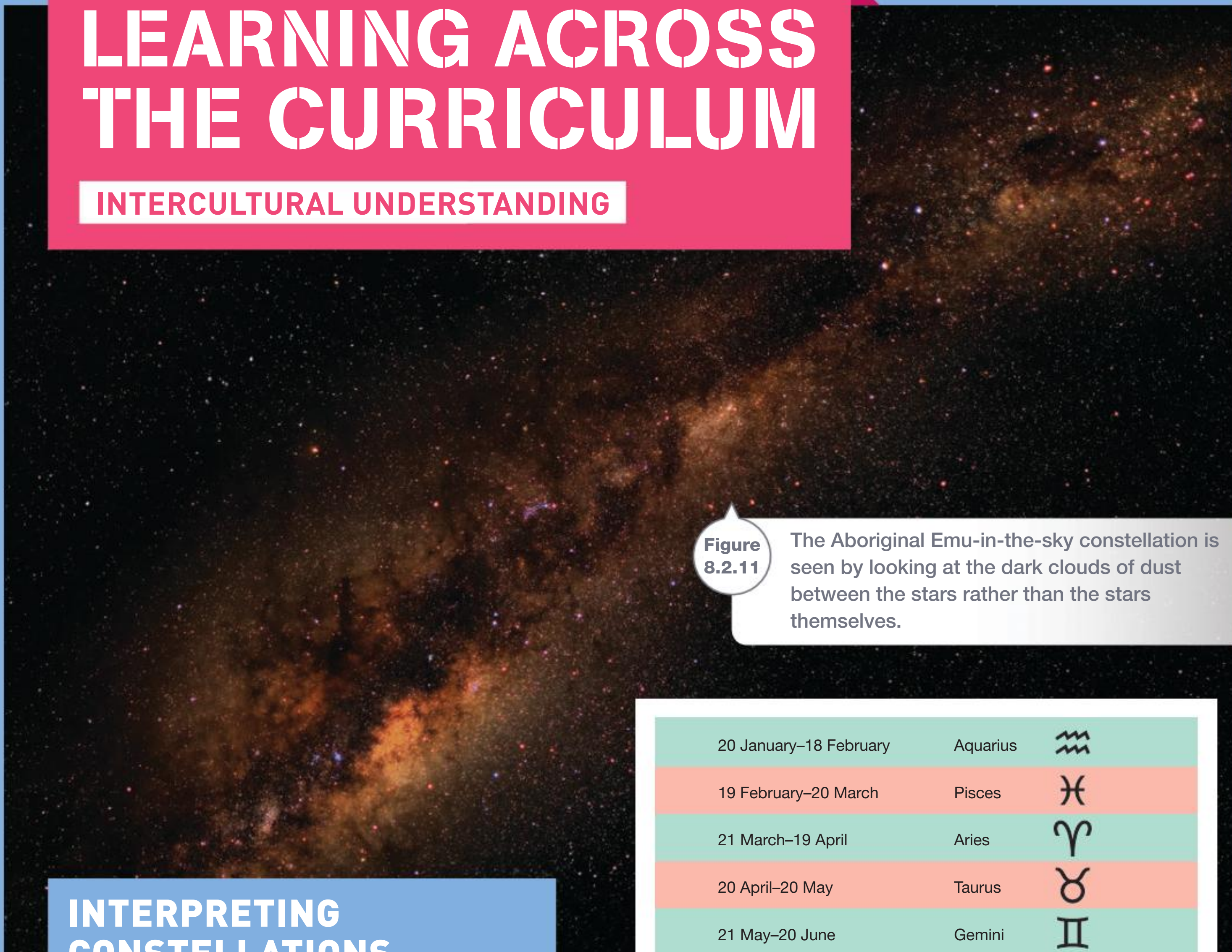


Figure 8.2.11 The Aboriginal Emu-in-the-sky constellation is seen by looking at the dark clouds of dust between the stars rather than the stars themselves.

INTERPRETING CONSTELLATIONS

Different cultures look at the sky in very different ways. To some, the stars might form a hunter, a saucepan or a canoe, while other celestial objects might be seen as an emu in the sky.

20 January–18 February	Aquarius	♒
19 February–20 March	Pisces	♓
21 March–19 April	Aries	♈
20 April–20 May	Taurus	♉
21 May–20 June	Gemini	♊
21 June–22 July	Cancer	♋
23 July–22 August	Leo	♌
23 August–22 September	Virgo	♍
23 September–22 October	Libra	♎
23 October–21 November	Scorpio	♏
22 November–21 December	Sagittarius	♐
22 December–19 January	Capricorn	♑

Figure 8.2.12 The zodiac is made up of 12 constellations.

THE ZODIAC

The ancient Greeks looked up at the patterns in the night sky and recognised familiar objects such as a scorpion, a bull and a lion. They gave special importance to the twelve constellations called the zodiac because they are the only constellations that the Sun appears to move through. These are the 'star signs' of astrology and are still known today by their Greek names such as Scorpio, Taurus and Leo. Figure 8.2.12 shows the signs of the zodiac with the dates traditionally associated with them.

8.4

ABORIGINAL CONSTELLATIONS

When looking for patterns in the stars, people are naturally reminded of objects they are familiar with from everyday life. It is not surprising that people from different cultures with different lifestyles would identify different constellations.

For example, consider the group of stars in Figure 8.2.13. The ancient Greeks called this group of stars Orion after a famous hunter from mythology. He is shown in Figure 8.2.14. The bright stars at the corners represent the hunter's hands and feet, the group of stars across the middle is his belt with a scabbard (a sheath or cover for the sword) sticking out of it. However, from the southern hemisphere this image appears upside down! For this reason, many Australians don't see a hunter but instead see a saucepan. As Figure 8.2.15 shows, Orion's sword is the handle of the Saucepan. The Yolngu people of the Northern Territory know this group of stars as Djulpan or the canoe, shown in Figure 8.2.16. Here, the sword/ saucepan handle represents a fishing lining trailing behind the canoe in the water.

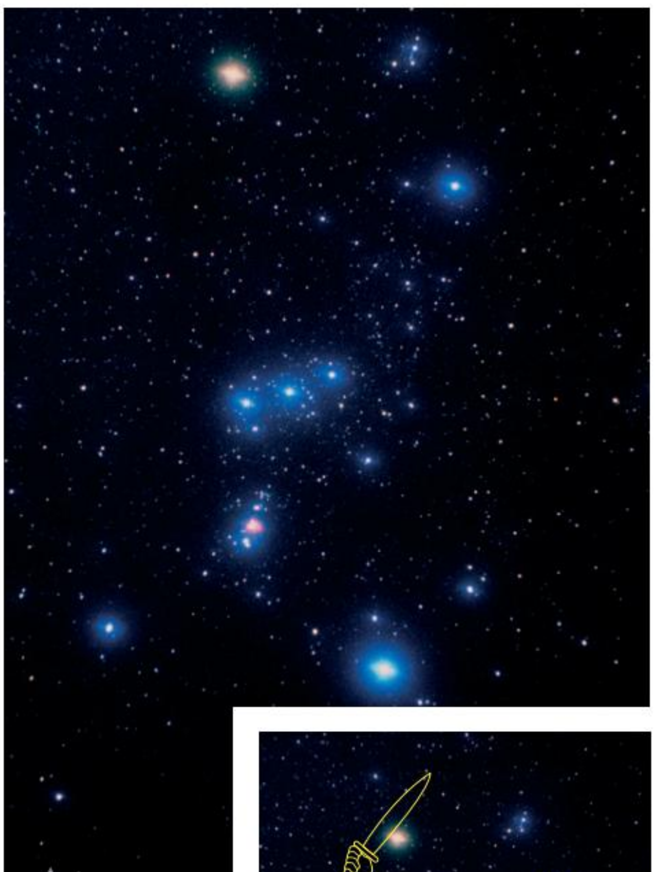


Figure 8.2.13 Orion is easy to identify in the southern sky.

Figure 8.2.14 Orion, the hunter

REVIEW

1 **List** four constellations of the zodiac.

2 **Explain** why the ancient Greeks and the Yolngu people saw different shapes in the same set of stars. IU

3 The Yolngu people identified the three bright stars in the centre of the constellation Djulpan as three fishermen sitting in a canoe. **Identify** what these three stars represent in the:

 a ancient Greek constellation Orion

 b the Australian Saucepan. IU

4 The Emu-in-the-sky constellation is considered unusual compared to many other constellations. **Explain** why.

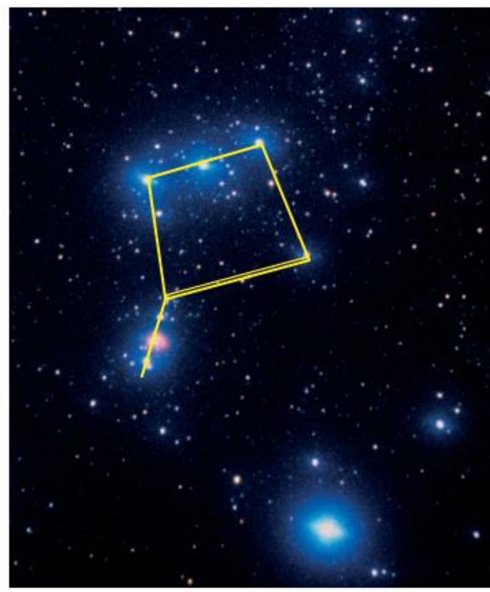


Figure 8.2.15 The Saucepan

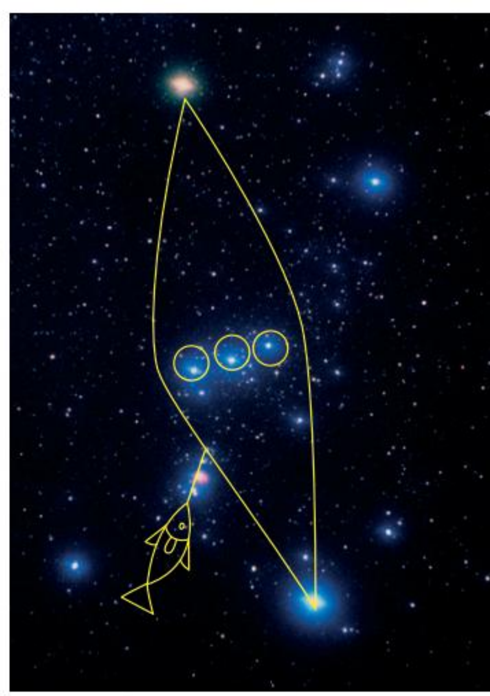


Figure 8.2.16 Djulpan, the canoe

8.2 Unit review

Remembering

1 **Name** three scientists who contributed to the development of the heliocentric model of the universe.

2 **Name** a star or constellation that can only be seen all year round in the southern hemisphere.

Understanding

3 **Explain** why only countries in the southern hemisphere have the Southern Cross on their flags.

4 **Define** the following:
- **a** constellation
- **b** dwarf planet
- **c** heliocentric model.

5 **Outline** why Pluto is no longer considered a planet.

6 **Explain** why Aristotle's model of the universe is described as *geocentric*.

7 **Draw** a diagram illustrating a method for locating the South Pole using the Southern Cross.

8 **Draw** a diagram illustrating the heliocentric model.

9 **Explain** why the heliocentric model was not originally accepted when it was first proposed by Aristarchus in the second century BCE.

10 **Describe** retrograde motion.

11 **Explain** why Ptolemy modified the geocentric model.

Applying

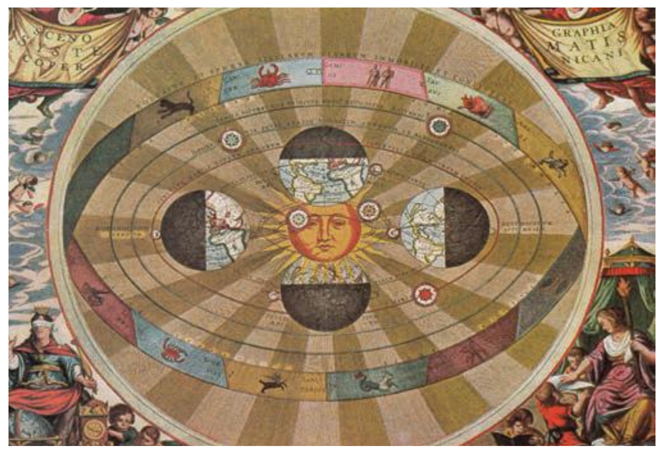
12 **Identify** an observation made by Galileo that suggests that not everything orbits Earth.

13 Earth's Moon is approximately the same size as Pluto. **Use** the definition of the International Astronomical Union to **explain** why the Moon is not classified as a dwarf planet.

Analysing

14 The asteroid belt is a collection of rocks of various sizes that orbit the Sun between Mars and Jupiter. The largest of these asteroids is known as Ceres. It is spherical with a radius of about 500 km (about half that of Pluto). **Use** the International Astronomical Union's definitions to **classify** Ceres as a planet or a dwarf planet.

15 The main illustration on page 332 shows the ancient Greek god Atlas carrying the universe on his back. Compare this to the painting below, which shows how scientists in the sixteenth century thought the universe was constructed.



- **a** **Identify** which of these pictures portrays the geocentric model and which shows the heliocentric model.
- **b** **Justify** your answer by referring to specific features of each illustration.

Evaluating CCT

16 The term *Copernican revolution* is sometimes used to describe any big shift in understanding. **Propose** a reason why.

17 Newton claimed that his achievements in explaining the solar system were due to the fact that he 'stood on the shoulders of giants'.
- **a** **Name** some of these giants.
- **b** **Propose** reasons why he made this claim.

Creating CCT

18 a **Construct** a diagram for a new constellation that would fit the star pattern shown in Figure 8.2.18. (You don't need to use every star.)

b **Name** your new constellation after what you think it looks like.

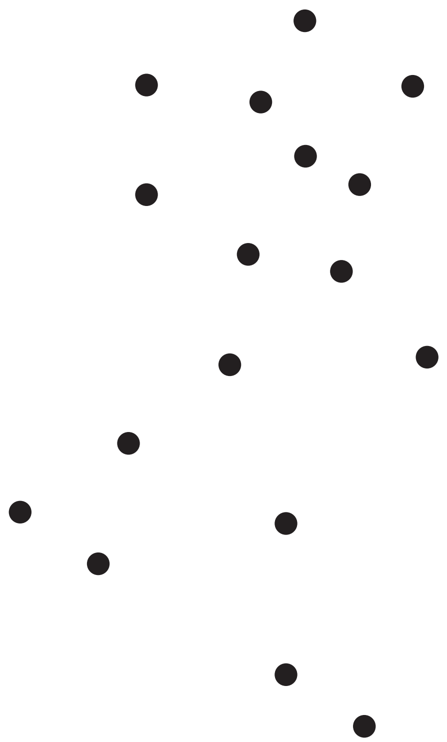


Figure 8.2.18

19 **Construct** a poster or presentation to explain to a group of younger students why Pluto is no longer considered to be a planet.

Inquiring

1 Search the internet to find and view animations showing how the heliocentric model explains retrograde motion. ICT

2 Some people believed that another planet exists in our solar system. They named it Planet X. Investigate theories about Planet X and find:

- why some astronomers originally thought that this planet must exist
- where Planet X was thought to be located
- what scientific discovery proved that Planet X does not exist.

Present your research as a poster or a digital presentation such as a PowerPoint. ICT

3 Research the following astronomers, classifying them as supporters of the geocentric model or the heliocentric model of the solar system:

- Heraclides Ponticus
- Pythagoras
- Khayyan
- Aristotle
- Tycho Brahe

Present the results of your research as a table.

4 Research a constellation recognised by a cultural group living in your local area. IU DD

- Find a diagram of the constellation.
- Retell any stories or legends associated with the constellation
- Identify the scientific names of the stars in the constellation.
- Identify any Western constellations that are associated with the same group of stars

Present your research as a poster or as a digital presentation such as a PowerPoint. ICT

8.2 Practical investigations

1 Constructing a telescope

Purpose

To construct a simple telescope.

Materials

- 2 biconvex lenses of different focal lengths (the greater the difference in focal lengths, the greater the magnification of the telescope)
- 2 cardboard tubes of diameter such that one tube fits snugly inside the other
- marker pen

SAFETY

Do **not** point your telescope at the Sun.

Procedure

1 Use the Skill Builder below to determine the focal length of each of the biconcave lenses. Record each focal length in your workbook.

2 The fatter, more curved lens should have the shorter focal length. Make it the eyepiece of your telescope. The flatter, thinner lens should have the longer focal length so make it the objective lens.

3 Tape each lens into the ends of the cardboard tubes as shown in Figure 8.2.19.

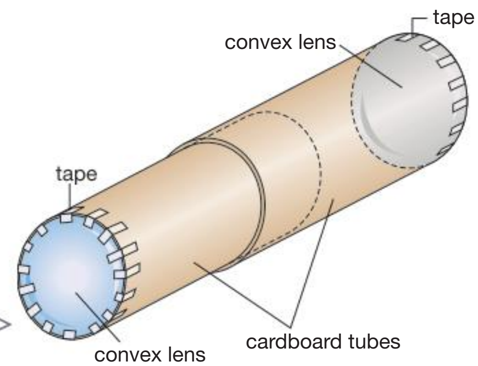


Figure 8.2.19

4 Add the two focal lengths. Adjust the cardboard tubes so that the distance between each lens corresponds to this distance.

5 Label the end of the telescope which has the lens with the shorter focal length, *eyepiece*. Label the other end of the telescope, *objective*.

6 Point the objective lens of the telescope at a distant object and look through the eyepiece lens. Sketch the image you observe.

7 Reverse the telescope (i.e. look through the objective lens). Sketch the image you observe.

SKILL BUILDER

Determining focal length

To determine the focal length of a biconcave lens, follow these steps:

- Hold your lens so that lots of light can enter it (perhaps stand in sunlight).
- Hold a blank sheet of paper behind your lens.
- Move your lens slowly back and forth (alternatively, move the sheet of paper back and forth) until the light passing through the lens has focused to a single bright point. Figure 8.1.20 shows what is happening.
- Measure the distance between the lens and the sheet of paper. This is the focal length of your lens.

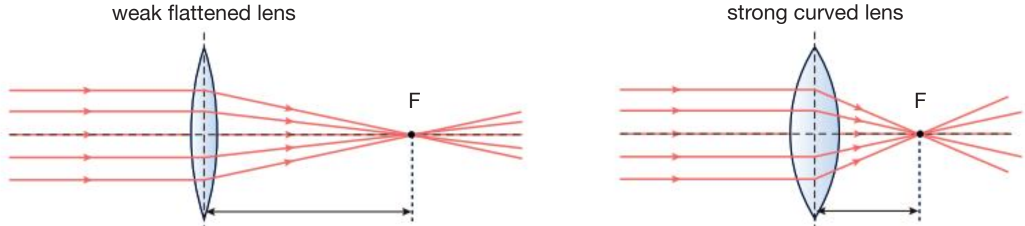


Figure 8.2.20

Parallel rays of light are brought together at a point called the focus (F) on the other side of a convex lens. The greater the curve of the lens, the stronger the lens is and the shorter its **focal length**, or distance between the lens and the focus.

Constructing a telescope continued on next page

Constructing a telescope continued

Results

1 Record the focal lengths of each lens then add them together. N

Fatter, more curved lens	= _____
+	
Flatter, thinner lens	= _____
Sum of focal lengths	= _____

Practical review

1 **Describe** the image sketched in step 6. The magnification of the telescope is how much it has increased the size of the image (such as doubled, tripled). Estimate the magnification of your telescope.

2 **Contrast** the images sketched in steps 6 and 7.

2 Visiting dwarf planets

Purpose

To use simulation software to observe a number of dwarf planets.

Materials

- computer or tablet computer
- a planetarium program or app such as GoSkyWatch Planetarium, SkyGlobe, Celestia or WorldWide Telescope ICT

Procedure

1 Set the program to show the sky as it will appear at 8 p.m. tonight from your home town.

2 Search for Ceres.

3 Zoom in until the image of the dwarf planet fills the screen. Sketch it.

4 Zoom out to identify and sketch any moons orbiting the dwarf planet.

5 Repeat steps 2–4 for other dwarf planets, such as Pluto, Eris, Makemake and Haumea.

Practical review

1 **List** the three characteristics of a planet.

2 Dwarf planets are not classified as planets because they do not have one of the characteristics of a planet. **Describe** the feature that most dwarf planets lack.

STUDENT DESIGN

3 Improving the telescope

Purpose

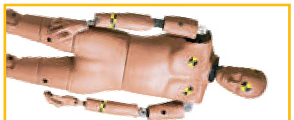
To improve the simple telescope constructed in prac 1.

Procedure

1 Design a telescope that will be better than the one constructed in prac 1.

2 Sketch your planned telescope in your workbook. Before you start building it, assess its design and construction. List any risks it might involve and what you might do to minimise those risks.

3 Show your teacher your design and your assessment of its risks. If they approve, collect all the required materials and start work.



SAFETY

A Risk Assessment is required for this investigation.

Hints

In your design:

- consider using curved mirrors instead of lenses for the objective
- try changing the focal lengths of the objective and eyepiece to alter the magnification of the telescope
- design apparatus that will allow the telescope to be kept still and focused on an object in the sky.

Practical review

1 **Compare** the image observed using your telescope with the ones observed using the simple telescope constructed in prac 1.

2 **Estimate** the magnification of your telescope.

3 **Evaluate** the success of this investigation. Was your telescope an improvement?

8.3 Gravity, tides and orbits

Gravity is the pulling force that makes you fall off your skateboard or your chair. It causes rain to fall and rivers to flow to the sea, and it is the force that causes our tides.

INQUIRY
science 4 fun

Drawing ellipses

YES

Can you draw an accurate ellipse?

Collect this …

- 2 pins
- sheet of cardboard or thick pad of paper (such as your workbook)
- length of string or cotton
- pencil or felt-tip pen

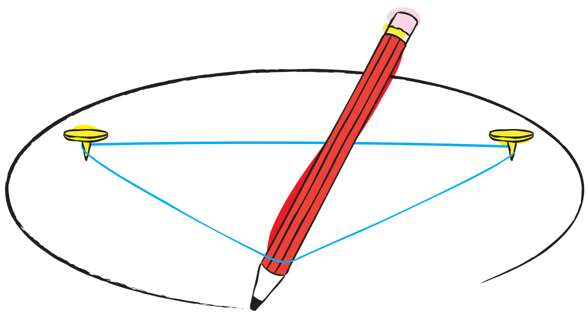
Do this …

1 Stick the pins well apart into the cardboard or pad of paper.

2 Tie the string or cotton into a loop so that it fits loosely over the two pins.

3 Use the pencil or felt-tip pen to stretch the loop out.

4 Keeping the loop tight, 'orbit' the pins with the pencil or pen, drawing as you go.



Record this …

Describe what happened.
Explain how this relates to the shape of orbits.

Gravity

While some forces make contact with the objects that they push or pull around, other forces act without touching. These non-contact forces act instead through force fields. As Figure 8.3.1 shows, magnets have magnetic force fields around them that attract objects containing iron. They also push or pull around other nearby magnets.

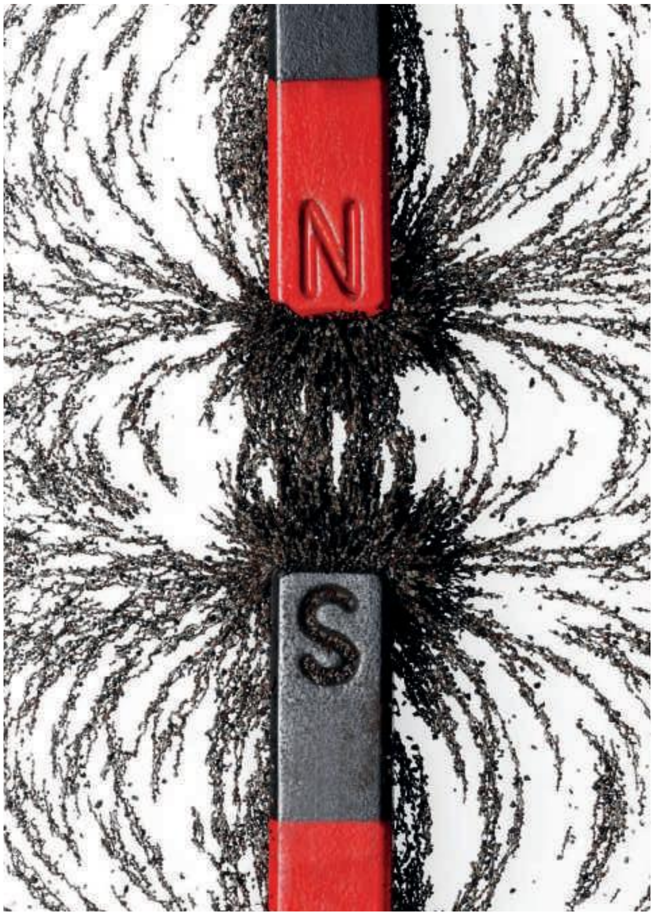


Figure 8.3.1 Iron filings align (line up) with the field lines around a magnet. The strong field lines between these magnets will pull them together.

GO TO Unit 7.3 GO TO Unit 7.4

Gravitational fields

Around every mass is a **gravitational force field** that attracts other masses. This attractive force is gravity, and it attempts to pull masses together. Matter is the stuff that everything is made up of, and matter has mass. You have mass, as does the person who is sitting next to you, the chair you are sitting on, and the pen you are writing with. They all have their own gravitational fields, and all of them are attracting each other. This force of gravity and its attraction is most obvious when you fall off your chair! The force of gravity between you and Earth has pulled you both together!

The effect of mass

Gravity is a force caused by mass. The bigger the mass, the stronger its gravitational field and the more it attracts other masses nearby. However, gravity is a very weak force, and a lot of mass is required before any attraction is noticeable: people, pens, chairs, and even cars, buildings and ships, are not massive enough to have much effect on other masses. This is why you don't get pulled towards the person sitting next to you or to a large skyscraper that you are walking past. Gravity is only noticeable when one of the objects is really massive, such as a planet, moon or star. These objects have strong gravitational fields around them that attract anything else that is nearby, including you. Earth has a gravitational field like that shown in Figure 8.3.2.

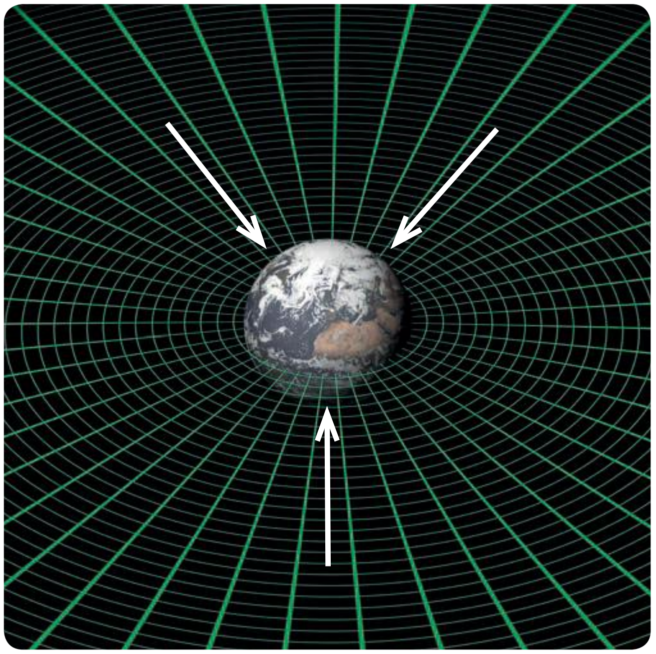


Figure 8.3.2 The gravitational field of Earth pulls masses towards its centre.

Prac 1 p. 351

The effect of distance

The gravitational fields around planets, moons and stars weakens rapidly as you move away from them. For example, Earth's gravitational field is a little weaker on the top of its highest mountain (Mt Everest), than at sea level. However, the difference is too small for you to notice and can only be detected by extremely sensitive instruments. By the time you get to the Moon, Earth's pull is weak, much weaker than at Earth's surface.

Orbits

The gravitational fields around planets, moons and stars are often strong enough to 'trap' other masses so that they travel continuously around them in a path known as an **orbit**. For example, Earth and the other planets of the solar system are 'trapped' by the gravitational field of the Sun and so they orbit it. Likewise, the Moon keeps orbiting Earth. This is shown in Figure 8.3.3. At least 63 moons orbit Jupiter, and millions of rock fragments, ice and dust form rings that orbit Saturn. You can see Saturn's rings in Figure 8.3.4.

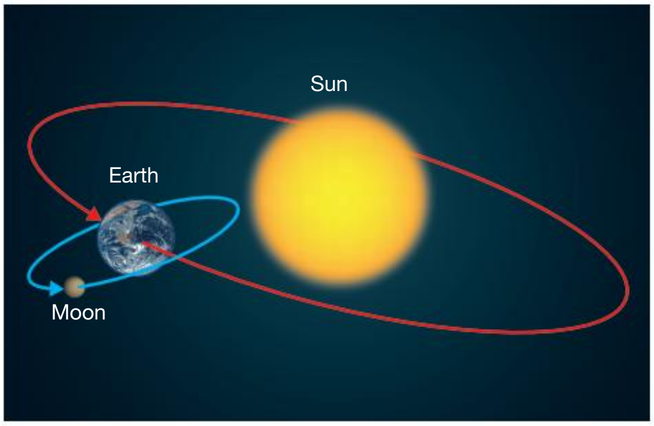


Figure 8.3.3 Earth orbits the Sun, and the Moon orbits Earth.

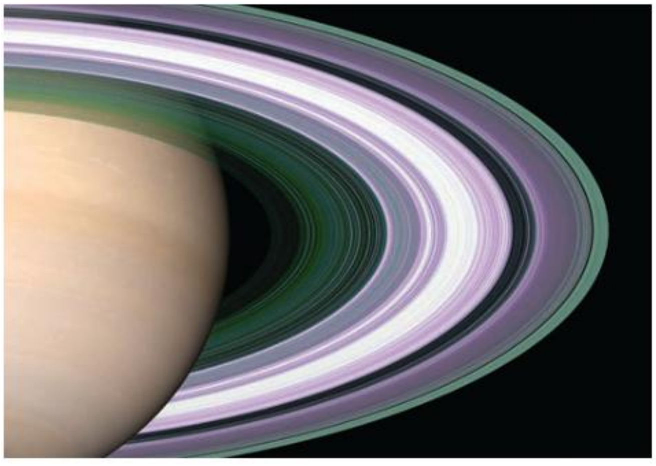


Figure 8.3.4 Fragments of rock, dust and ice orbit Saturn, forming a spectacular series of rings around the planet.

Objects that are in orbits like this are known as **satellites**. The planets of the solar system are natural satellites of the Sun, and the Moon is a natural satellite of Earth. Earth also has many artificial satellites, which have been placed in orbit by us humans. Some are used to transmit information such as internet and telephone conversations, while others scan the Earth for everything from erosion and bushfires to espionage (spying). The largest artificial satellite in orbit around Earth is the International Space Station (ISS), shown in Figure 8.3.5.

Figure 8.3.5 The International Space Station (ISS) is an artificial satellite orbiting Earth. It has a crew of six on board at most times.

Prac 2 p. 352

SciFile

Unstable orbits

If a satellite is travelling too slowly then it will slowly spiral in. This is what most artificial satellites eventually do. Likewise, if a satellite is travelling too fast then it will slowly spiral outwards. The Moon is doing this: it strays a tiny 3.8 cm away from Earth each year!

Explaining orbits

Imagine you are on the top of a tall mountain with a handful of tennis balls. Drop one and it will fall to your feet because gravity pulls it downwards. If you throw the ball horizontally, it still falls but it takes a curved path to the ground, landing at a distance away from you. Now imagine that you could throw the ball so fast that it kept on falling, never hitting the Earth. If you could do this then the ball would be in orbit. The ball will then keep 'falling' around Earth forever, needing no extra push or power to keep it orbiting.

Figure 8.3.6 shows how. An orbit like this can only happen outside Earth's atmosphere because there is no air resistance and therefore nothing to slow the satellite down.

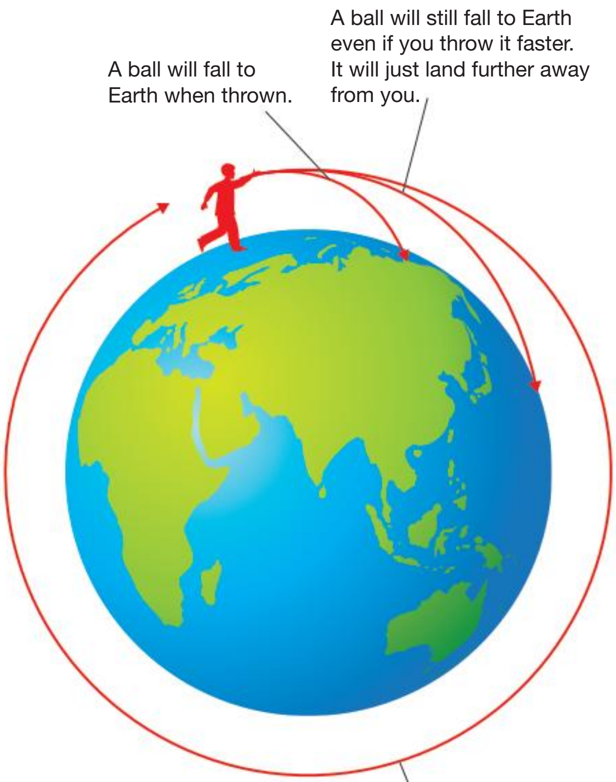


Figure 8.3.6 Throw an object slowly and it will land back on Earth. However, if you throw it from a high point and really fast, then it will continue to fall and keep missing the planet. The object will then be in orbit around Earth.

Orbits in the solar system

Orbits are elliptical in shape. **Ellipses** are oval-shaped closed loops. Some are long, thin ovals while others are almost perfect circles. For example, the orbits of Venus, Earth and Neptune around the Sun are nearly circular. Mars, Jupiter, Saturn and Uranus have more elliptical (stretched) orbits. Mercury and the dwarf planet Pluto have quite elliptical orbits. Comets from deep space are sometimes trapped by the gravitational field of the Sun and sweep around it in long thin orbits. Comets often orbit in a plane very different from that of the planets. A typical orbit of a comet is shown in Figure 8.3.7.

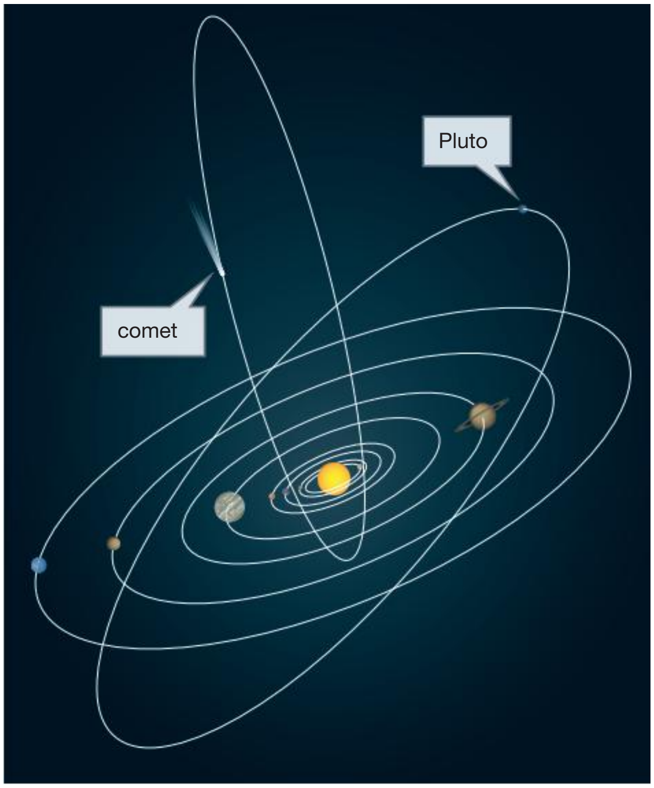


Figure 8.3.7 The dwarf planet Pluto orbits in a different plane from the rest of the solar system. Its long, thin elliptical orbit sometimes places Pluto closer to the Sun than Neptune. Comets usually orbit the Sun in a different plane too.

The Moon's orbit

The Moon orbits Earth once in approximately 30 days. This orbit is nearly circular and it constantly changes the arrangement of the Moon, Earth and the Sun in space. What we see of the Moon depends on their relative positions. Half of the Moon always faces the Sun, but we don't always see its full face. Instead, we see the Moon in one of its phases. One is shown in Figure 8.3.8.

Figure 8.3.8 How much of the Moon we see depends on the angle of the sunlight falling on it. This phase is called a gibbous Moon.

Sometimes the orbits of the Moon around Earth and Earth around the Sun cause all three bodies to align so that the Moon blocks sunlight from reaching Earth, or Earth blocks sunlight from reaching the Moon. When this happens, as **eclipse** occurs.

Solar eclipses

A **solar eclipse** occurs whenever light from the Sun is blocked by the Moon, casting a shadow onto Earth like that shown in Figure 8.3.9. Whatever part of Earth's surface is in shadow is plunged into darkness until the Moon moves out of the way again. Figure 8.3.10 shows the view from Earth when it happens. Solar eclipses can be complete (in the **umbra**, where the shadow is full and dark) or partial (in the **penumbra**, where the shadow is less dense).

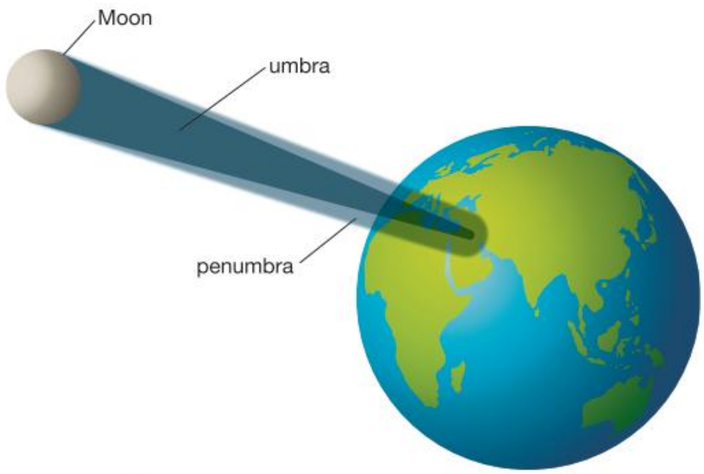


Figure 8.3.9 The Moon is too small to block light from the Sun over the entire Earth, and so its shadow falls on only part of Earth's surface. Only these parts experience a solar eclipse.

Figure 8.3.10 Astronomers use solar eclipses to view the corona or very outer layer of the Sun, and the solar flares that burst from it.

Lunar eclipses

During a **lunar eclipse**, the Earth blocks light from reaching the Moon. As the Moon passes along its orbit, it first passes through the penumbra, causing a partial lunar eclipse. It then moves through the umbra, forming a total lunar eclipse, before moving back into the penumbra and then back into the sunlight. Figure 8.3.11 shows how this happens. In Figure 8.3.12 you can see what the Moon looks like during a lunar eclipse.

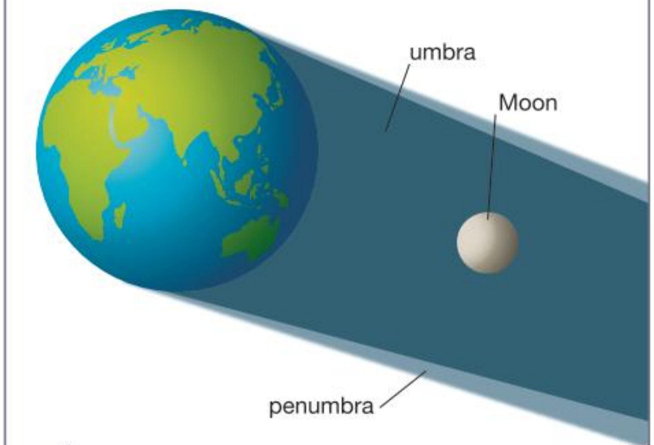


Figure 8.3.11 A lunar eclipse passes through different stages depending on what part of the Earth's shadow it is passing through.

Figure 8.3.12 Five images of the Moon during a total lunar eclipse as viewed in the northern hemisphere. The Moon does not disappear completely while it is in the umbra because it is lit by a little sunlight bent by Earth's atmosphere.

SciFile

A dragon ate the Moon!

The ancient Chinese and Vikings both thought that a lunar eclipse happened because the Moon was eaten: the Chinese thought a dragon did it, while the Vikings thought that a wolf ate it. Some American Indian tribes instead thought a bear was wandering through the sky, fighting the Moon whenever it blocked the path.

Tides

The Moon is the closest big mass to Earth. The gravitational pull of the Moon drags all the water in the oceans and seas towards it, causing a bulge on the side of Earth that faces the Moon. On the opposite side of Earth, the Moon's gravitational pull is much weaker. The combination of this weaker gravitational force and inertia means that another similarly-sized bulge of water forms on the side of the Earth facing away from the Moon.

GO TO Unit 7.1

These two bulges always point towards and away from the Moon. As the Earth rotates beneath the bulges, they appear to move westward across Earth's surface. We experience this as rising and falling **tides**. The bulges produce high tides—two each day. Similarly, the low points in-between the bulges produce low tides. You can see this in Figure 8.3.13.

The Sun's gravitational field also pulls water towards it, which changes the size of these tidal bulges. Figure 8.3.14 shows that the size of tides depends on how the Earth, the Moon and the Sun are arranged in space.

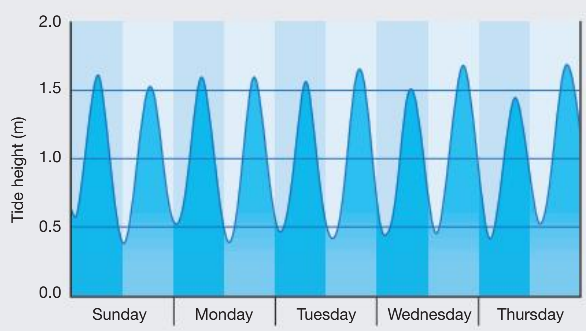


Figure 8.3.13 The coast usually has two high tides and two low tides each day. The height of each tide depends on the relative positions of the Earth, the Moon and the Sun.

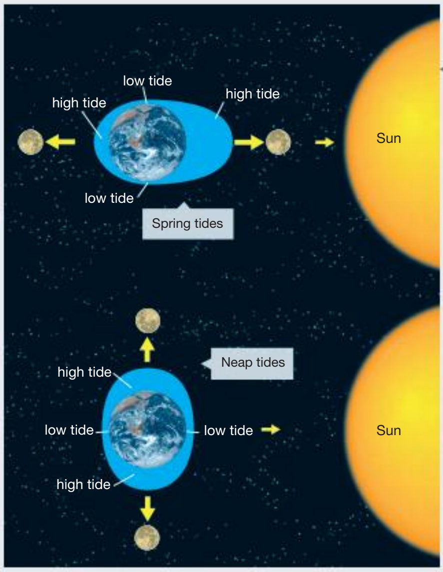


Figure 8.3.14 Spring tides are large because the gravitational pull of both the Moon and the Sun is in the same direction and the bulges from each add up. Neap tides are smaller because the Moon and the Sun are pulling in different directions.

More tidal variations

The continents of Earth partly block the westward movement of the tidal bulges across the planet and so the water must find ways in and around them. For this reason, different oceans and seas have different tide patterns. On some coasts, the tide will be so small that you will barely notice it while on other coasts tides are far more dramatic. For example, tides in the Mediterranean Sea only rise and fall about 3 cm while those at Derby in Western Australia are the second largest in the world at 11.8 m. Meanwhile, the Gulf of Mexico has only one high and low tide a day instead of the normal two—two tides a day are known as diurnal tides.

The shape of the coast also affects the timing and height of tides. For example, water needs to drain from coastal lakes and rivers before low tides become obvious. Likewise, it takes time for them to refill at the next high tide. This effect can be seen in Table 8.3.1. For example, tides upstream at the Gladesville Bridge in Sydney occur 15 minutes after tides nearer the ocean at Fort Denison opposite the Opera House. Likewise, the high tides in Lake Macquarie near Newcastle occur nearly three hours after Sydney's.

Table 8.3.1
Time lag of tides behind those at Fort Denison, Sydney Harbour

Place	Time lag of high tide after Fort Denison (Sydney)	Time lag of low tide after Fort Denison (Sydney)
Newcastle	0 (same time as Sydney's)	0 (same time as Sydney's)
Gladesville Bridge (Sydney)	15 min	15 min
Narooma	54 min	30 min
Lake Macquarie	2 h 50 min	30 min
Wiseman's Ferry (Hawkesbury River)	2 h 15 min	2 h 30 min

8.5

SciFile

Tidal waves

Tsunamis are gigantic waves that sometimes crash onto the shore after an earthquake has happened at sea. Sometimes tsunamis are incorrectly called tidal waves—before the wave hits, the water of the sea suddenly retreats making it look like the tide has just gone out. However, tsunamis have nothing to do with tides since they are not caused by the gravitational pulls of the Moon and Sun.

8.3 Unit review

Remembering

1 **List** two examples of forces that act through a field.

2 **List** five things around you that are pulling you with a weak gravitational force.

3 **Name** one thing that is currently pulling you with a strong gravitational force.

4 **Name** one:
   a natural satellite of the Sun
   b natural satellite of Earth
   c artificial satellite of Earth.

Understanding

5 **Explain** why you aren't pulled towards a wall despite there being a gravitational attraction between you and it.

6 **Rank** the following places in NSW from the one that would have the strongest gravity to the place with the weakest gravity.
   A On the top of Mt Kosciusko (2228 m above sea level)
   B Down the *Endeavour* mine at Cobar (900 m below sea level)
   C At the top of the Sydney Harbour Bridge (134 m above sea level)
   D On the beach at Coffs Harbour (sea level)

7 **Explain** why a satellite does not need to be powered to keep it in orbit.

Applying

8 The word *solar* is used whenever scientists discuss the Sun. **Use** this definition to **explain** how the following relates to the Sun:
   a solar system
   b solar eclipse.

9 When scientists refer to the Moon, they use the term lunar. **Use** this definition to **explain** how lunar eclipses are related to the Moon.

Analysing

10 **Contrast** a natural satellite with an artificial satellite.

11 **Contrast** the orbits of Pluto and comets around the Sun with the orbits of the planets of the solar system.

Evaluating CCT

12 One way of constructing an ellipse is shown in science4fun on page 344. **Propose** what would happen to the shape of the ellipse if the drawing pins were placed closer together.

13 Imagine that you shoot a gun horizontally off a tall mountain, the bullet going so fast that it goes into orbit around Earth. It could be extremely dangerous if you stay on top of the mountain. **Propose** why.

Creating CCT

14 The Moon orbits the Earth in approximately 30 days but solar and lunar eclipses don't occur every 30 days. Instead, we usually see the Moon in one of its phases.
   a A full Moon occurs whenever we see all of its face lit by the Sun. **Construct** a diagram showing how the Sun, Moon and Earth might be arranged so that a full Moon occurs without causing a lunar eclipse.
   b A new Moon happens when the far-side of the Moon is lit and we on Earth look at its unlit side. **Construct** another diagram that shows how this might happen without causing a solar eclipse.

Inquiring

1 Search the internet to find and view: ICT
- simulations showing the orbits of the planets of the solar system
- simulations showing the orbits of the Moon around Earth and Earth around the Sun
- live vision on NASA TV from the International Space Station in orbit around Earth.

2 Find the tide information for next seven days for NSW. Find the times and heights of the predicted high and low tides for:
- Sydney (Fort Denison)
- a beach, town or port on the north coast of NSW
- beach, town or port on the south coast of NSW.

Present the information you find as a table that can be used to compare the tides at each place.

8.3 Practical investigations

1 Go jump!

Each planet in the solar system has a different mass and so gravity depends on which planet you are on. This means that you can jump different heights on different planets. This assumes that the surface is solid!

Purpose

To calculate how high you could jump on another planet.

Materials

- metre ruler or tape measure
- calculator

Procedure

1. Choose a safe and clear space, perhaps outside.
2. One of your laboratory partners needs to hold the metre ruler vertically, with the 'zero end' touching the ground.
3. Another needs to be crouched down, with their eyes level with the ruler.
4. Stand next to the ruler and jump as high as you can.
5. Your lab partner needs to measure the height your feet got to in the jump.
6. Repeat two more times and record your jump heights.
7. Swap roles so that everyone in your group has a jump.

Results

1. Record all your jump heights in a table like the one shown below.

Name of jumper	Jump 1 (cm)	Jump 2 (cm)	Jump 3 (cm)	Average jump (cm)

2. Calculate your average jump height by: N
   - adding: Jump 1 + Jump 2 + Jump 3
   - dividing: by 3.
3. Calculate the height *you* could jump on the Moon and other planets by:
   - dividing: your average jump ÷ gravity. N

Planet or moon	Gravity compared to Earth's (Earth = 1)	Predicted jump height (cm)
Earth	1	
Moon	0.16	
Mercury	0.38	
Venus	0.91	
Mars	0.38	
Jupiter	2.36	
Saturn	0.92	
Uranus	0.89	
Neptune	1.1	

Practical review

1. **Identify** the celestial body/bodies on which you could jump:
   a. the highest
   b. the lowest
   c. about the same as on Earth.
2. Find the world records for various athletics, such as high jump and pole vault, then **calculate** what they would be on the other planets. N
3. Astronauts on the Moon were able to jump higher than on Earth but not as high as you calculated above. **Propose** reasons why.

8.3 Practical investigations

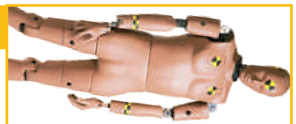
Orbits

Purpose

To use a model of an orbit and to determine the effect of changing gravity.

Hypothesis

Which satellite do you think will orbit faster—a satellite around a planet with high gravity or a satellite around a planet with low gravity? Before you go any further with this investigation, write a hypothesis in your workbook.



SAFETY

The rubber bung will be travelling fast in wide circles so make sure you wear safety glasses at all times and that you have plenty of room.

Materials

- plastic casing of ballpoint pen or short length of plastic or metal tubing
- string or strong cotton thread
- rubber bung with hole
- washers
- large open area

Procedure

1. Tie the string or cotton thread securely to the rubber bung by passing it through the hole a number of times and then knotting it tightly.
2. Pass the string or thread through the tubing and tie a couple of washers on the other end, as shown in Figure 8.3.14.
3. Find a place where there is plenty of room and swing the rubber bung horizontally around your head.
4. Swing it at a speed that keeps the washers at a constant level below the tubing.
5. Add more washers and repeat.
6. Carefully observe what happens to the speed and radius of the 'orbit' as more washers are added.

Practical review

1. **Identify** which part of this model represents:
   a. a satellite in orbit
   b. the force of gravity
   c. the planet around which the satellite orbits.
2. **Describe** what happened to the speed and radius of the orbit when the gravitational pull of the planet was increased.
3. a. **Construct** a conclusion for your investigation.
   b. **Assess** whether your hypothesis was supported or not.

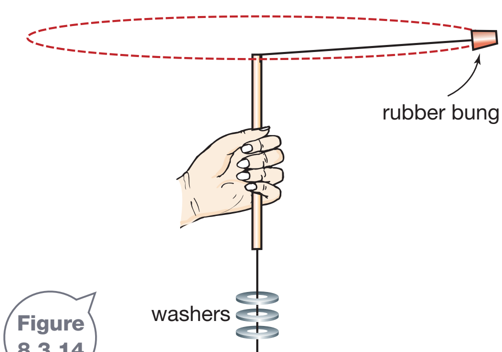
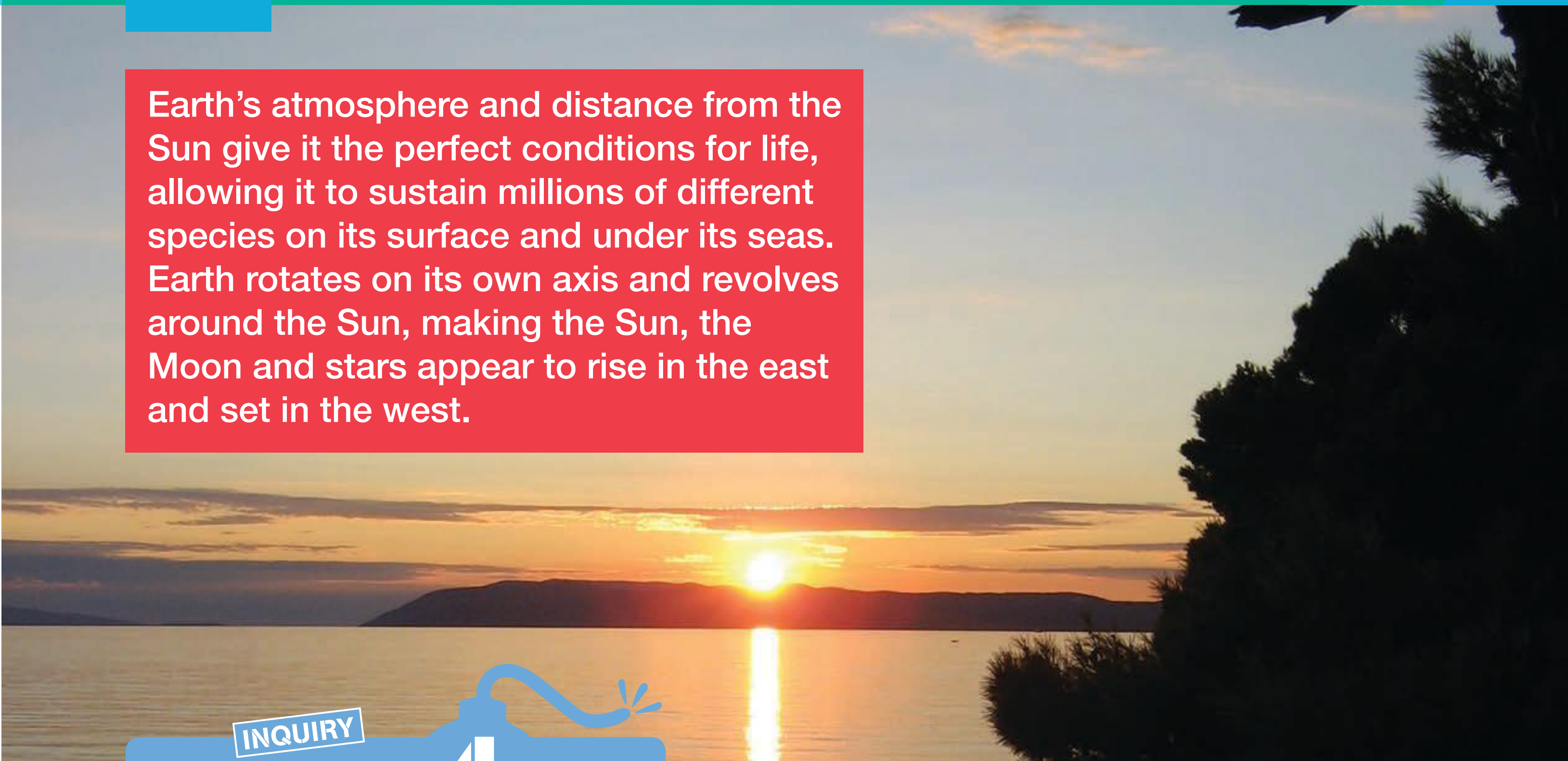


Figure 8.3.14

8.4 Earth



Earth's atmosphere and distance from the Sun give it the perfect conditions for life, allowing it to sustain millions of different species on its surface and under its seas. Earth rotates on its own axis and revolves around the Sun, making the Sun, the Moon and stars appear to rise in the east and set in the west.

INQUIRY science 4 fun

Make a sundial

YES

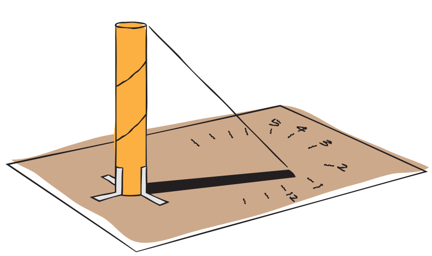
Can a sundial tell the time accurately?

Collect this ...

- sturdy sheet of cardboard or scrap timber
- sheet of A4 scrap paper
- sticky-tape
- felt-tip pen
- watch or clock
- compass (optional)

Do this ...

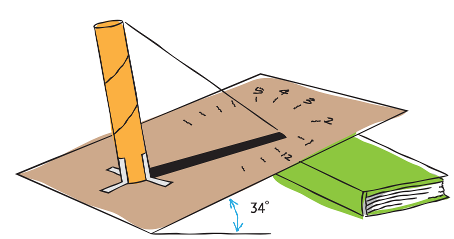
1. Roll up the A4 sheet of paper lengthwise to form a cylinder.
2. Secure it to the sheet of cardboard with strips of sticky-tape so that it stands upright.



3. Place your sundial in a spot where it gets sunlight most of the day.
4. Every hour, use the felt-tip pen to mark where the shadow falls on the cardboard or timber sheet. Write the time next to its mark.

To make your sundial more accurate:

5. Use a compass to find exactly where north is.
6. Use an atlas or search the internet for the latitude of where you live. For example, Sydney is 34°S. Use a protractor to measure out this angle and tilt the base so that it slopes away from north at this angle.



Record this ...

Describe what happened.

Explain how you could use your sundial to tell the time.

The Earth in space

Every day the Sun appears to rise in the east and set in the west, as do the Moon and stars. The Sun doesn't really move this way. Neither do the Moon or the stars. Instead, the Earth itself is spinning from west to east, making it appear that the Sun, Moon and stars move the other way. This can be seen in Figure 8.4.1.

Figure 8.4.1 Every five minutes another photograph was taken to produce this image of the Sun setting in the west.

Day and night

An imaginary line called the **axis** runs through the Earth from the North Pole to the South Pole. Earth rotates (spins) about this line, from west to east. The time taken for any planet to rotate about its axis is referred to as its **day**. Earth takes 24 hours to complete one rotation, and so one day on Earth is 24 hours. During this day, the Sun rises once in the east and sets once in the west.

As Figure 8.4.2 shows, at any time half of planet Earth is bathed in sunlight. This half experiences day. The other half is in the dark and so experiences night. As Earth rotates, some countries move into the light and others move out of it.

Prac 1 p. 359 | 8.6

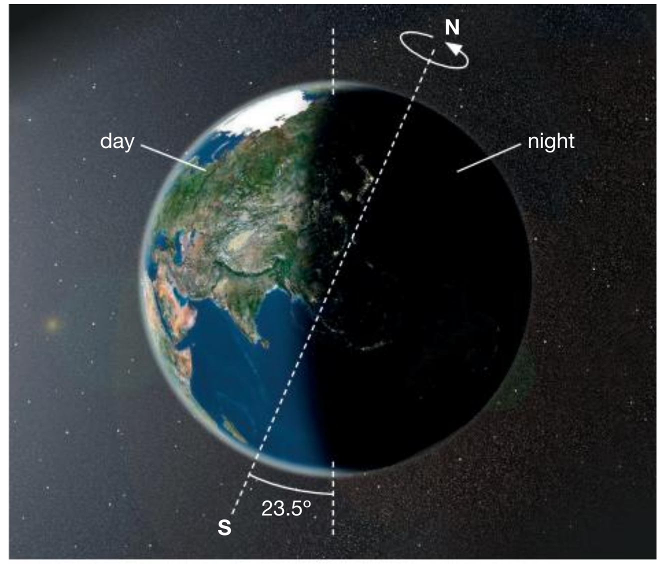


Figure 8.4.2 A day is the time it takes for Earth to spin around on its axis once completely.
As Earth spins, only half is bathed in sunlight at any one time. This half experiences daylight. The dark half experiences night.

The year

Like all the other planets in the solar system, Earth orbits the Sun. It travels at an average speed of 108 000 km/h and takes $365\frac{1}{4}$ days to complete one **revolution** (one complete orbit). A complete orbit is shown in Figure 8.4.3. The time taken by a planet to revolve around the Sun is known as its **year**. For Earth, a year is $365\frac{1}{4}$ days. The quarter day makes setting up a calendar very difficult and so a calendar year is normally taken as 365 days. However, every four years the calendar needs to 'catch up', so an extra day is added to make a leap year of 366 days. This extra day is 29 February.

8.7

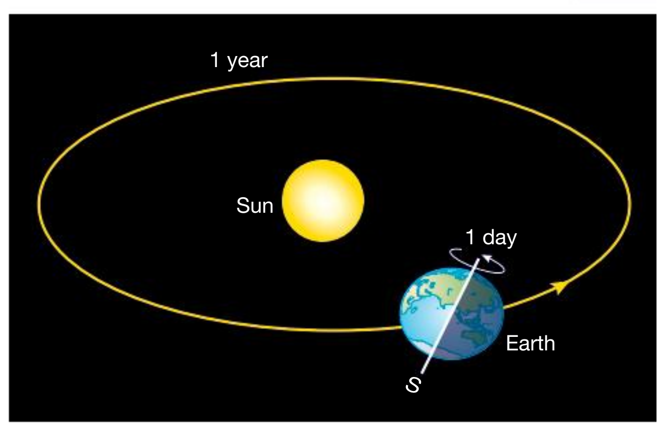


Figure 8.4.3 A year is the time it takes for Earth to completely revolve or orbit around the Sun.
A day is the time it takes to rotate completely on its own axis.

SKILL BUILDER

Leap years

Every fourth year is not always a leap year. Use the following key to predict whether a year is a leap year or not. N

Can the year be divided by 400 exactly?	If yes, then go to 2.
If not, can the year be divided by 100 exactly?	If yes, then go to 1.
If not, can the year be divided by 4 exactly?	If yes, then go to 2.
1	It's a normal year.
2	It's a leap year.

WORKED EXAMPLE
Leap years

Problem

Is 2016 a leap year?

Solution

2016 ÷ 400 = 5.04 (cannot be divided by 400 exactly)

2016 ÷ 100 = 20.16 (cannot be divided by 100 exactly)

2016 ÷ 4 = 504

This is a whole number and so 2016 is a leap year.

Practice N

Calculate whether the following years will be leap years.

a 2015

b 2020

c 2100

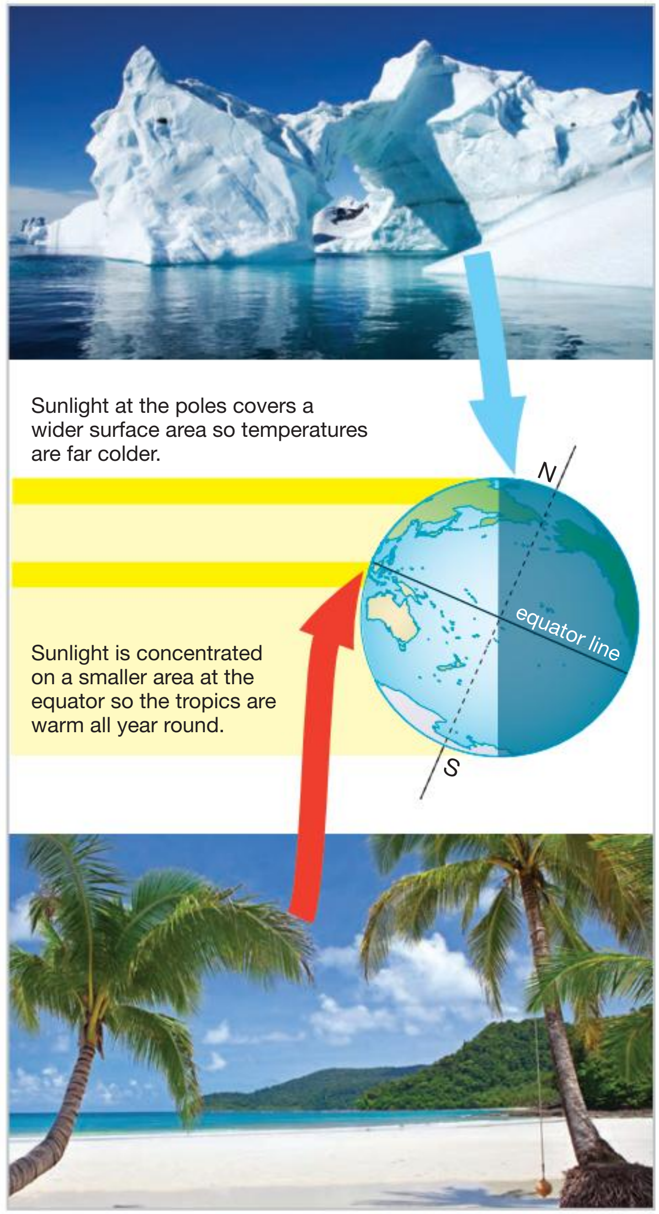


Figure 8.4.4 The Earth is spherical so sunlight hits its different regions at different angles. This results in different climates.

Climate

The regions around the equator always point towards the Sun, and the sunlight that falls on them is bright and its heat is concentrated. This makes it hot all the time with very little variation between the seasons.

The North and South poles are always the coldest part of the planet. As Figure 8.4.4 shows, any sunlight that falls on them is almost parallel to the Earth's surface, and so spreads over a large surface area. In their winters, the poles are pointed so far away from the Sun that it doesn't appear at all through the day. In contrast, there is daylong sunlight in the summer.

Australia is a huge continent that spreads from near the equator to the Southern Ocean. As a result, the country has a wide range of climates: far north Queensland, the Northern Territory and the Kimberley region of Western Australia are always hot, while Tasmania and southern Victoria are usually much cooler.

Prac 2 p. 360

Seasons

Earth's axis is not 'vertical' but is tilted at an angle of 23.5°. This tilt gives us our **seasons**. As Figure 8.4.5 shows, some parts of Earth point towards the Sun. This exposes them more, so that the sunlight falling on them is more concentrated. These parts experience summer. Other parts of Earth are pointed away from the Sun. In these regions the sunlight is spread over a larger area. This results in lower temperatures and winter.

Earth exposes different parts of its surface to the Sun as it moves along its orbit. Australia experiences summer from December through to March because this is when the southern hemisphere is pointed towards the Sun. Meanwhile, the northern hemisphere is pointing away from the Sun and is experiencing winter. The situation reverses six months later.

In summer, Earth's tilt causes the Sun to be more vertical in the sky at noon than in winter. This causes:

- more hours of sunlight in summer than in winter
- the position on the horizon where the Sun rises and sets to change slightly each day
- short shadows in summer and long shadows at exactly the same time of day in winter. Architects and builders use this fact to control the amount of sunlight that enters a house. Eaves, verandas and pergolas block the vertical summer sun, keeping the house cool. However, the more angled winter sun can get underneath them and enter the house to keep it warm.

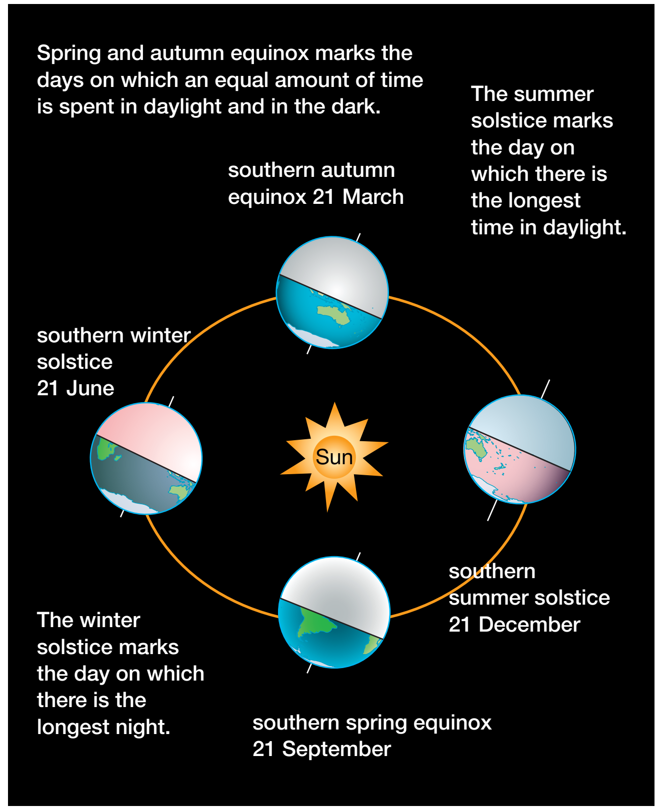


Figure 8.4.5 Earth's tilted axis causes sunlight to be more concentrated on some parts of Earth than others at different times of the year. This causes the seasons.

INQUIRY

science 4 fun

Simulating seasons

YES

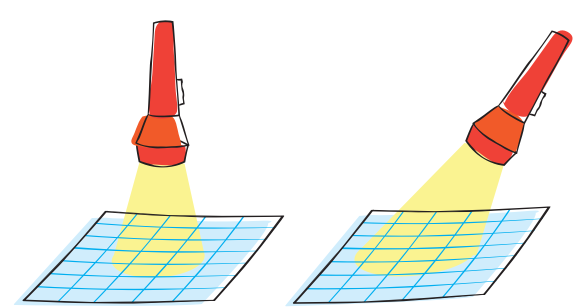
What happens when sunlight falls on Earth at an angle?

Collect this …

- torch
- sheet of paper (preferably graph paper or with a grid)
- 30 cm ruler

Do this …

1. Place the sheet of paper on the floor or on a desk or table.
2. Hold the torch 30 cm from the paper and shine its light directly onto the paper.
3. Trace around the 'pool' of light.
4. Repeat, but this time direct the torch so that its light falls on the paper at an angle.
5. Once again, trace around the 'pool' of light.



Record this …

Describe what happened.

Explain why you think this happened.

8.4 Unit review

Remembering

1 **State** which of the following is correct. Earth spins from:

A north to south **B** east to west
C south to north **D** west to east

2 **Recall** the following terms by matching each with the correct number of days:

A year	365
A 'normal' calendar year	366
A leap year	365.25 or $365\frac{1}{4}$

Understanding

3 **Define** the following terms: L
- **a** 1 day
- **b** 1 year
- **c** 1 revolution.

4 **Describe** the problems that would be caused if our calendar year was taken as $365\frac{1}{4}$ and not 365 and 366 days.

5 **Explain** why countries near the equator are usually much hotter than countries on other parts of Earth.

6 The equinox marks the time in the year that the length of day and night are exactly the same. **Predict**:
- **a** how many equinoxes occur each year
- **b** the seasons in which they occur.

7 **Explain** how a sundial works.

Applying

8 **Use** a sketch to help **define** the following terms:
- **a** Earth's axis
- **b** the equator
- **c** the poles.

9 Some people only have a birthday every four years. **Identify** the date on which they were born.

10 The surface of Earth is moving at incredible speeds due to its spin. **Identify** the part(s) on Earth's surface that are:
- **a** moving the fastest
- **b** just turning on the spot.

11 **Calculate** whether the following years were/will be leap years or not. N

a 1896 **b** 1900
c 2225 **d** 2400

12 **Use** the labels on the diagram shown in Figure 8.4.6 to **identify** the part(s) of Earth (A, B, C or D) experiencing:
- **a** summer
- **b** winter
- **c** a day in which the Sun is always in the sky
- **d** a day in which the Sun never appears.

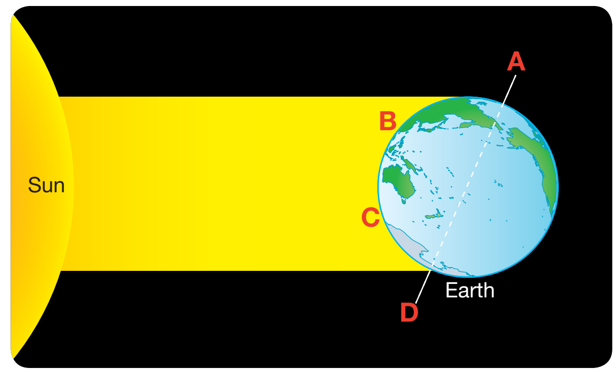


Figure 8.4.6

13 **a** **Use** Figure 8.4.5 to help you **predict** the season that Australia experienced on the following dates:
- **i** 21 March
- **ii** 30 June
- **iii** New Year's Day, 1 January
- **iv** Anzac Day, 25 April

b **Identify** what season the northern hemisphere would be experiencing on the same dates.

14 We can only celebrate the New Year at 12 midnight because our calendar years are rounded off at either 365 or 366 days. If we used $365\frac{1}{4}$ days for our calendar year, then New Year's celebrations would have to be celebrated at different times each year. N
- **a** **Calculate** how many hours there are in one quarter of a day.
- **b** The New Year began at 12 a.m. this year. If the calendar year was $365\frac{1}{4}$ days long, **calculate** the time it would occur:
  - **i** next year
  - **ii** the year after that.
- **c** **Calculate** how many years would pass before the New Year returned to 12 a.m.
- **d** **Use** this example to **explain** why the length of a calendar year is rounded to 365 or 366 days.

8.4 Unit review

Evaluating CCT

15 China has no time zones, despite being a country as large as Australia. **Compare** what a day would be like in its east and in its west.

16 Russia has 11 time zones. **Propose** a reason why. (A map will help.)

17 **Predict** from the list below, the set of results most likely obtained in the science4fun activity on page 356.

- **A** Direct torch: 48 squares; angled torch: 64 squares
- **B** Direct torch: 64 squares; angled torch: 48 squares
- **C** Direct torch: 64 squares; angled torch: 64 squares
- **D** Direct torch: 48 squares; angled torch: 48 squares

18 Not every 'turn-of-century' year is a leap year. N

- **a** **Calculate** whether the 'turn-of-century' years 1500, 1600, 1700 through to 2500 were/will be leap years or not.
- **b** **Propose** a reason why most 'turn-of-century' years are not leap years.

19 **Propose** what would happen to the seasons if Earth's tilt suddenly changed to:

- **a** 0° (no tilt at all)
- **b** 45° (more than now)
- **c** 10° (less than now).

Creating CCT

20 Science fiction and horror authors have long been fascinated by the idea of endless days and endless nights. Imagine a planet that spins only once in every orbit of its star. On it, forms of life have evolved very differently from those found on Earth. Think of what may live on the dark side and light side of the planet. Just as important, think of the forms of life that couldn't possibly exist. L
Construct a short story or a plotline for a blockbuster movie about:

- **a** a creature from one side travelling into the other (light to dark or dark to light)
- **b** a human landing on the planet and exploring both sides.

Inquiring

1 Not everyone experiences the year as divided into the four seasons summer, autumn, winter and spring. For example, people in the far north of Australia instead talk about the wet and dry seasons. Research the seasons and calendars used by the Aboriginal or Torres Strait Islander people in your local area.

Present your research as a table that compares what you found with the traditional European calendar we use every day.

2 Research times zones and seasons by finding:

- what the UTC and International Date Line are and why they are needed
- a map showing the main time zones that exist around the world
- the location of the International Date Line
- how long a day and year are on the other planets of the solar system
- the axis tilt of other planets in the solar system
- whether other planets in the solar system experience seasons.

Present your research as a Word document that includes relevant maps and tables. ICT

3 Research the times for the rotation and orbits of the Earth, Sun and Moon.

Present your findings on a diagram.

4 Al Battani was a tenth century astronomer who accurately measured the length of the year. Research Al Battani and find: IU

- his full name, years and place of birth and death
- where he lived and worked
- the length of the year as determined by him
- his other scientific and mathematical achievements
- the name of the Moon crater named after him
- how he has been honoured in science fiction.

Present the information you find as a series of dot points.

8.4 Practical investigations

1 Day and night

Purpose

To model day and night on Earth.

Materials

- balloon
- string or cotton
- felt-tip pen
- access to a globe
- access to a bright light (such as a projector, spotlight, data projector or similar)

Procedure

1. Blow up your balloon and tie it off so that no gas can escape. This is your Earth, and its tied-off end represents the North Pole.
2. Tie a length of string or cotton to the North Pole.
3. Use the felt-tip pen to draw on the balloon the position of the equator, South Pole and International Date Line.
4. Use the globe to check the shape and position of the major continents and copy them onto the balloon. Make sure you include Australia.
5. On Australia, write a large E on the east coast and a large W on the west coast.
6. Hang the balloon by the string in front of the bright light and slowly turn it from the 'west' (W) to 'east' (E) as shown in Figure 8.4.7.

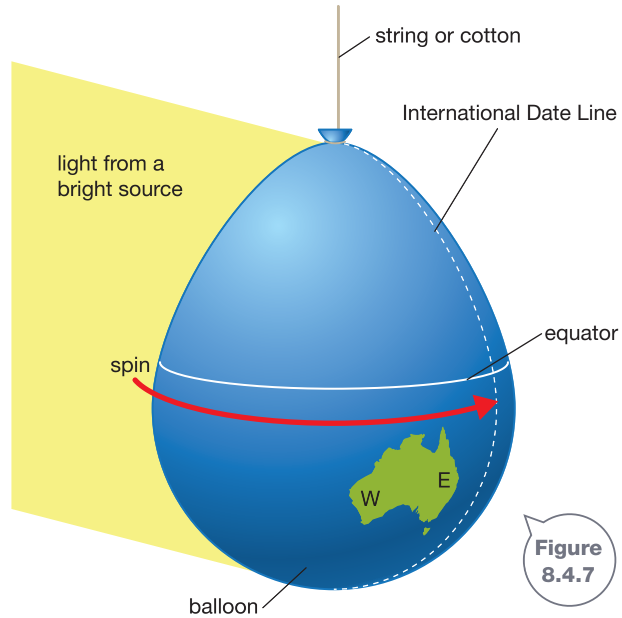


Figure 8.4.7

Practical review

1. The Sun rises in the east and sets in the west, but you rotated your 'Earth' in the opposite direction. **Explain** why there is a difference.
2. **Identify** which coast of Australia:
   a. first came into 'daylight'
   b. was the last to move into 'night'.
3. Perth is on a different time zone from Melbourne, Sydney and Brisbane, being two hours 'behind' them. **Use** your model to **explain** why different time zones are needed in Australia.
4. **Assess** how accurate this model is in showing Earth, its spin, and its day.

8.4 Practical investigations

2 Angles and temperature

Purpose

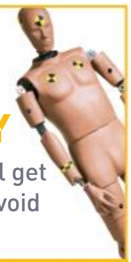
To test whether the angle of sunlight affects the surface temperature on Earth.

Hypothesis

Which do you think will heat up a thermometer faster—a lamp shining directly over it or a lamp shining at an angle? Before you go any further with this investigation, write a hypothesis in your workbook.

Materials

- lamp (such as a microscope lamp)
- 2 thermometers
- 2 blocks of wood
- black plastic
- sticky-tape



SAFETY

The lamp will get very hot so avoid touching it.

Procedure

1 Cut out two small identically sized sheets of black plastic and tape them onto wooden blocks so that they make pockets.

2 Secure a thermometer in each pocket, ensuring that it is touching the plastic sheet. Tape the thermometer to the board to secure it.

3 Place the two blocks the same distance from the lamp. Figure 8.4.8 shows the set-up.
  - Block A: Lay one block flat on the desk so that the light from the lamp falls on it at an angle.
  - Block B: Use some books to chock up the other block so that it is at an angle to the desk and the light falls directly on it.

4 Turn on the lamp.

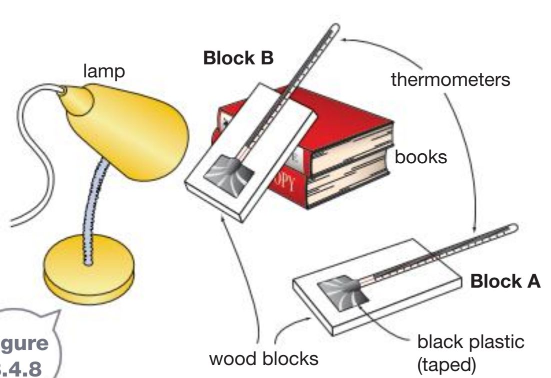


Figure 8.4.8

Results

1 Record the temperature of each thermometer every minute for at least five minutes.

2 Place your results in a table like the one shown below.

Time (min)	Block A	Block B
1		
2		
3		
4		
5		

Practical review

1 **Identify** which block (A or B) showed the greatest increase in temperature.

2 **Identify** which block (A or B) modelled the surface of the Earth in:
  a far north Queensland
  b southern Tasmania.

3 **Use** your results to **explain** why:
  a the tropics are found near the equator
  b icebergs are only found near the poles.

4 a **Construct** a conclusion for your investigation.
  b **Assess** whether your hypothesis was supported or not.

8 Chapter review

Remembering

1 **State** whether the following statements are true or false.
  a Only large masses like planets, stars and moons have a gravitational field.
  b The further you go out from a planet, the weaker its gravity becomes.
  c A day on Earth is the time it takes for Earth to revolve once around the Sun.
  d Earth has four seasons because of its tilted axis.
  e Pluto is a planet.

2 **List** the four planets that are known as:
  a terrestrial planets
  b gas giants.

3 **Name** two important scientists or philosophers who supported:
  a the geocentric model
  b the heliocentric model.

4 **List** evidence that caused the geocentric model to be dropped in favour of the heliocentric model.

Understanding

5 **Describe** what a 'shooting star' really is.

6 Encke's Comet was seen in April 2007 and again in August 2010. **Calculate** how long it takes for Encke's Comet to complete one orbit around the Sun. N

7 **Draw** a diagram that shows what retrograde motion is.

8 Neptune and Uranus were the last planets to be discovered. **Propose** a reason why.

9 **Outline** four important observations that space missions to the planets have brought.

10 **Explain** why constellations vary from one culture to another.

11 **Describe** the shape of an ellipse.

12 The Moon can still be seen during a lunar eclipse. **Explain** why.

13 **Explain** why Earth experiences four seasons each year.

14 **Describe** how the day and year are related to Earth's movement.

15 **Predict** what the world would be like if there were no time zones and everywhere was all at exactly the same time.

16 Copy and complete the table below to **summarise** some of the information from this chapter.

Type of object	Definition	Example
Planet	• Orbits the Sun •	Earth
Dwarf planet		Pluto
Comet		
Asteroid		
Meteor		
Meteorite		

Applying

17 You are about to fly between Perth and Sydney. **Identify** where in your flight gravity will be:
  a the least
  b the greatest.

18 Sanjay is a Year 7 student. He roughly sketched the diagram of the solar system shown in Figure 8.5.1, but forgot to add labels and didn't draw every orbit. **Identify** which of the orbits he drew most likely represents that of:
  a Earth (an inner planet)
  b the Moon
  c Neptune (an outer planet)
  d Pluto
  e Halley's comet.

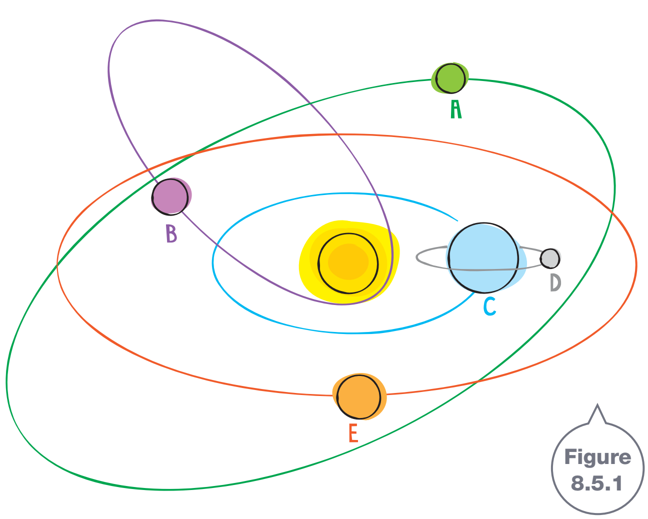


Figure 8.5.1

8 Chapter review

19 Everything around you has its own gravitational field.
   a **Identify** what mass affects you the most.
   b **Explain** why other things like the wall or the person sitting next to you don't influence you much.

Analysing

20 **Classify** the model presented in Figure 8.5.1 as either geocentric or heliocentric. **Justify** your answer.

21 **Calculate** whether you were born in a leap year or not. N

22 **Contrast**:
   a a comet with a meteor
   b the geocentric and heliocentric models of the solar system
   c an eclipse with an ellipse.

Evaluating CCT

23 Gravity always pulls you down. **Assess** whether this statement is true, false, or a bit of both. L

24 Geology is the study of the Earth, and the geocentric model has Earth at its centre. **Use** this information to **propose** a meaning for the prefix *geo-*.

25 The International Space Station (ISS) shown in Figure 8.5.2 orbits Earth 340 km above its surface. On board, astronauts float around in 'weightless' conditions. Two Year 7 students are arguing about what this means. Joe says this proves there is no gravity at the height of the ISS. Sarah disagrees, saying that there must be gravity at that height.
   a **Use** the evidence given above to **deduce** whether there is any gravity at the height of the ISS.
   b **Justify** your response.
   c Some scientists prefer to use the term *microgravity* to describe these conditions rather than *weightlessness*. **Assess** whether microgravity is a better term.

26 a **Determine** whether you can or cannot answer the questions on page 322 at the start of this chapter.
   b **Assess** how well you understand the material presented in this chapter.

Creating CCT

27 A mnemonic is a way of remembering the order of something. **Construct** your own mnemonic to help you remember the order of the planets of the solar system.

28 People in prehistoric times reacted to solar and lunar eclipses with amazement and fear because they did not know why they happened. Imagine you are one of these people seeing a solar eclipse for the first time. **Construct** a short news item for your local newspaper *Neanderthal News* or the current affairs show *Neolithic Nightly*. Your item must describe what you saw and how people around you reacted.

29 **Use** the following ten key words to **construct** a visual summary of the information presented in this chapter:

stars	constellation
gravity	orbit
ellipse	Sun
Earth	Moon
tides	comet

8.8

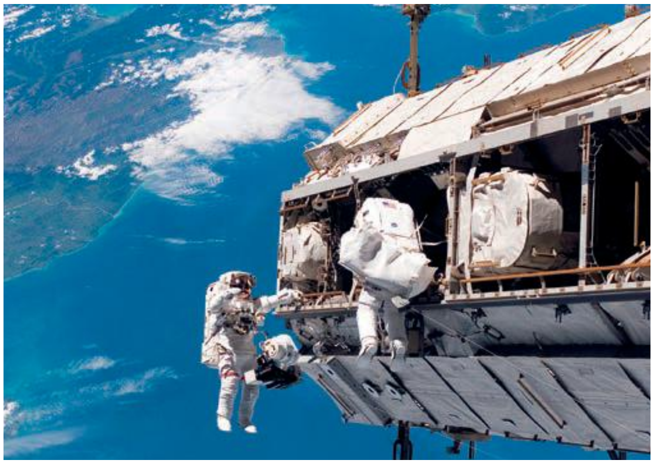


Figure 8.5.2

Thinking scientifically

The Bayer system is used to name stars within a constellation. It uses the Greek alphabet to name them, with alpha (α) being the brightest star. Beta (β) is used for the next brightest, gamma (γ) for the next and so on.

The two pointers of the Southern Cross are α-Centauri and β-Centauri. In another constellation are Alpha-Cygni and Beta-Cygni.

Q1 Use this information to state which of the following stars would be the brightest. CCT

- **A** α-Centauri
- **B** β-Centauri
- **C** Alpha-Cygni
- **D** Beta-Cygni
- **E** α-Centauri AND Alpha Cygni
- **F** β-Centauri AND Beta Cygni
- **G** α-Centauri is brighter than β-Centauri and Alpha-Cygni is brighter than Beta-Cygni but there is not enough information to tell whether α-Centauri is brighter than Alpha-Cygni or whether β-Centauri is brighter than Beta-Cygni.

The first six letters of the Greek alphabet are α (alpha), β (beta), γ (gamma), δ (delta), ε (epsilon) and ζ (zeta).

Q2 Use this information to identify which of the following lists its stars in the correct order from brightest to least bright. CCT

- **A** α-Crucis, δ-Crucis, Gamma-Crucis, Zeta-Crucis
- **B** β-Geminorum, Beta-Crucis, β-Cygnis, Beta-Orionis
- **C** δ-Geminorum, δ-Centauri, δ-Cygni, δ-Crucis
- **D** β-Geminorum, Gamma-Geminorum, Delta-Geminorum, ε-Geminorum

Density determines whether an object sinks or floats. Basalt rock has a density of around 3.0 g/cm^3 while the density of pure water is 1.0 g/cm^3. These densities suggest that a lump of basalt will sink when placed in water. The average density of a human is 1.01 g/cm^3. We are slightly denser than water and so will sink very slowly into it.

The table below shows the density of the eight planets of the solar system.

Planet	Density (g/cm^3)
Mercury	5.427
Venus	5.204
Earth	5.515
Mars	3.934
Jupiter	1.326
Saturn	0.687
Uranus	1.27
Neptune	1.638

Use the following key to answer questions 3 to 6.

- **A** Mercury, Venus, Earth, Mars
- **B** Mercury, Venus, Earth
- **C** Jupiter, Saturn, Uranus, Neptune
- **D** Saturn

Q3 Identify the planet(s) that are most likely to be rocky. CCT

Q4 Identify the planet(s) you would most likely sink into. CCT

Q5 Identify the planet(s) on which a lump of basalt would sink. CCT

Q6 Identify which of the planet(s) would float on water. CCT

Glossary

Unit 8.1

Artificial satellites: satellites placed into orbit by humans

Asteroid: an irregular rocky object in orbit around the Sun between the orbits of Mars and Jupiter

Asteroid Belt: a group of rocks that orbit the Sun in a band between Mars and Jupiter

Comet

Comet: a ball of ice, dust and rock that orbits the Sun in a highly elliptical orbit

Gas giants: the large planets of the outer solar system: Jupiter, Saturn, Uranus, Neptune

Meteor: a meteoroid that enters Earth's atmosphere, usually creating a bright streak across the sky as it burns up; a shooting star

Meteorite: a meteor big enough for part of it to hit the ground

Meteoroid: a small particle or body of rock that orbits the Sun near Earth's orbit

Milky Way: the galaxy in which the solar system is located

Phases: different shapes of the Moon as seen from Earth

Solar system: the Sun and all the planets, satellites, asteroids, comets and other bodies revolving around it

Terrestrial: Earth-like, rocky. The terrestrial planets are Mercury, Venus, Earth and Mars

Unit 8.2

Astronomer: a scientist who studies the stars, planets and other celestial objects

Constellation: a group of stars which form a recognisable pattern in the night sky

Dwarf planet: a small celestial body that is in orbit around the Sun and is nearly round in shape but with insufficient gravity to sweep its orbit

Geocentric model: model of the universe with Earth at its centre

Heliocentric model: model of the universe with the Sun at its centre

Retrograde motion: apparent loop-like motion of the planets as seen from Earth

Retrograde motion

Unit 8.3

Eclipse: the total or partial obscuring of one celestial body by another

Ellipse: oval shape

Gravitational force field: invisible field that causes masses to be attracted to each other

Lunar eclipse: when the Earth blocks sunlight from reaching the Moon

Orbit: path a planet takes around a star, or a moon or artificial satellite takes around a planet

Penumbra: less dense shadow of an eclipse

Satellite: object in orbit around another larger object

Solar eclipse: when the Moon blocks sunlight from reaching Earth

Tides: bulges in the ocean caused by the combined gravitational pull of the Moon and Sun

Umbra: full, dark shadow of an eclipse

Unit 8.4

Axis: the line connecting the North Pole with the South Pole. The Earth rotates around this axis

Day: the time a planet takes to rotate once completely on its own axis

Day

Revolution: one complete orbit around the Sun

Seasons: on Earth, summer, autumn, winter, spring; caused by the tilt of a planet's axis

Year: the time a planet takes to revolve once around the Sun

Index

Index

Index

Index