JACARANDA

SCIENCE QUEST 7

VICTORIAN CURRICULUM | REVISED EDITION

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VICTORIAN CURRICULUM | REVISED EDITION

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OVERVIEW

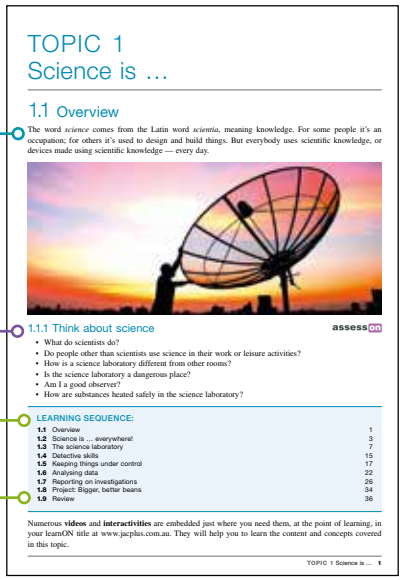
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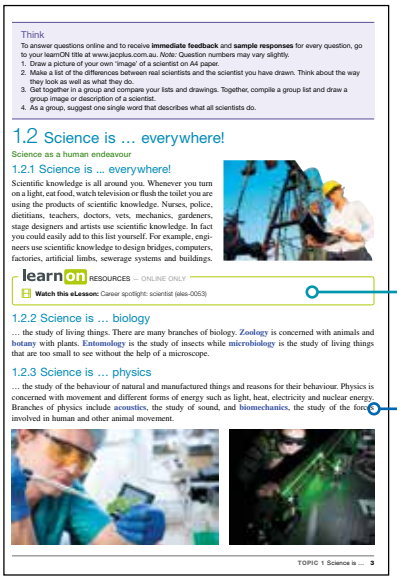
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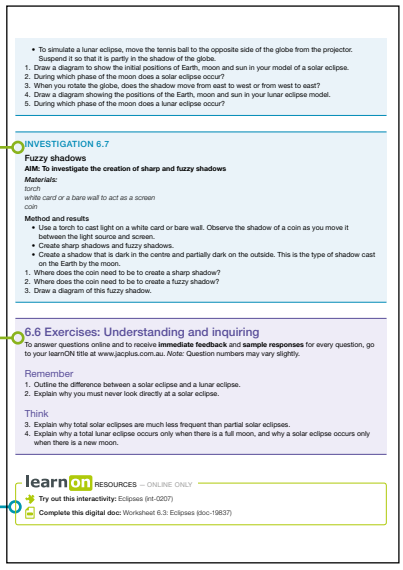
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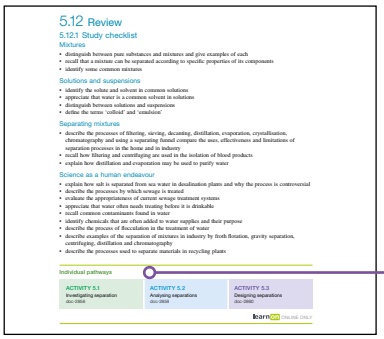
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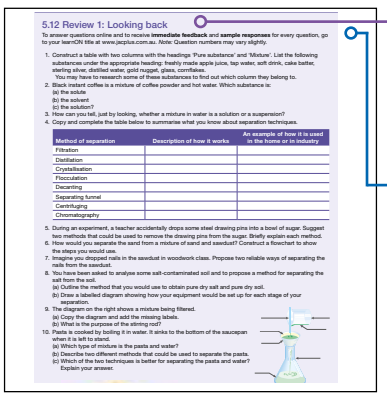
Carefully graded questions cater for all abilities.

Your FREE online *learnON* resources contain hundreds of videos, interactivities and traditional worksheets to support and enhance learning.





Individual pathway worksheets in each topic ensure consolidation of learning for every skill level.



Each topic concludes with comprehensive Review questions, in both print and online.

Answers and fully worked solutions are available online.

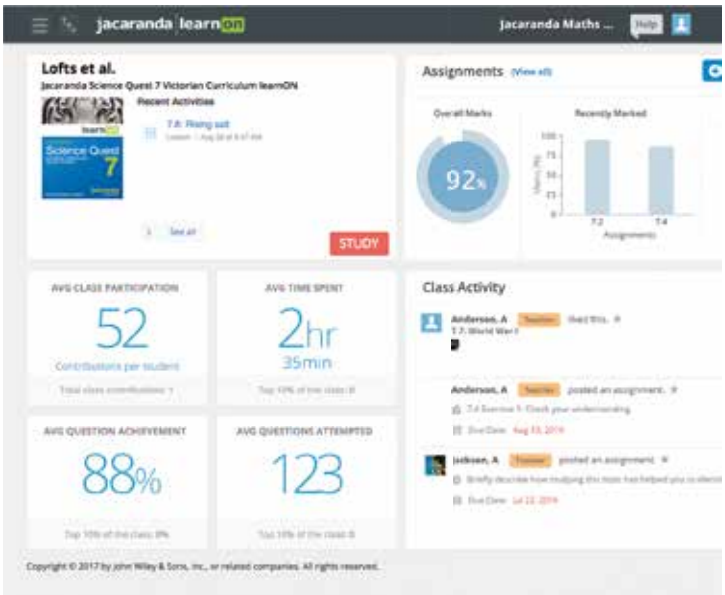
learnON

LearnON is Jacaranda's immersive and flexible digital learning platform that transforms trusted Jacaranda content to make learning more visible, personalised and social. Hundreds of engaging videos and interactivities are embedded just where you need them — at the point of learning. At Jacaranda, our 'learning made visible' framework ensures immediate feedback for students and teachers, with customisation and collaboration to drive engagement with learning.

Science Quest contains a free activation code for *learnON* (please see instructions on the inside front cover), so students and teachers can take advantage of the benefits of both print and digital, and see how *learnON* enhances their digital learning and teaching journey.

learnON includes:

- Students and teachers connected in a class group
- Hundreds of videos and interactivities to bring concepts to life
- Fully worked solutions to every question
- Immediate feedback for students
- Immediate insight into student progress and performance for teachers
- Dashboards to track progress
- Collaboration in real time through class discussions
- Comprehensive summaries for each topic
- Dynamic interactivities help students engage with and work through challenging concepts.
- Formative and summative assessments
- And much more …





PREFACE

To the science student

Science is both a body of knowledge and a way of learning. It helps you to understand the world around you: why the sun rises and sets every day, why it rains, how you see and hear, why you need a skeleton and how to treat water to make it safe to drink. You can't escape the benefits of science. Whenever you turn on a light, eat food, watch television or flush the toilet, you are using the products of scientific knowledge and scientific inquiry.

Global warming, overpopulation, food and resource shortages, pollution and the consequences of the use of nuclear weapons are examples of issues that currently challenge our world. Possible solutions to some of these challenges may be found by applying our scientific knowledge to develop new technologies and creative ways of rethinking the problems. It's not just scientists who solve these problems; people with an understanding of science, like you, can influence the future. It can be as simple as using a recycling bin or saving energy or water in your home.

Scientific inquiry is a method of learning. It can involve, for example, investigating whether life is possible on other planets, discovering how to make plants grow faster, finding out how to swim faster and even finding a cure for cancer. You are living in a period in which knowledge is growing faster than ever before and technology is changing at an incredible rate.

Learning how to learn is becoming just as important as learning itself. *Science Quest* has been designed to help you learn how to learn, enable you to 'put on the shoes of a scientist' and take you on a quest for scientific knowledge and understanding.

To the science teacher

This edition of the *Science Quest* series has been developed in response to the Australian curriculum for Science. The Australian curriculum focuses on seven **General capabilities** (literacy, numeracy, ICT competence, critical and creative thinking, ethical behaviour, personal and social competence, and intercultural understanding). The history and culture of Aboriginal and Torres Strait Islanders, Australia's engagement with Asia, and sustainability have been embedded with the general capabilities where relevant and appropriate.

Science Quest interweaves **Science understanding** with **Science as a human endeavour** and **Science inquiry skills** under the umbrella of six **Overarching ideas** that 'represent key aspects of a scientific view of the world and bridge knowledge and understanding across the disciplines of science'.

The Australian Science curriculum provides the basis for the development of a Science curriculum in schools throughout Australia. However, it does not specify what you do in your classroom and how to engage individual classes and students.

We have attempted to make the *Science Quest* series a valuable asset for teachers, and interesting and relevant to the students who are using it. *Science Quest* comes complete with online support for students, including answers to questions, interactivities to help students investigate concepts, and video eLessons featuring real scientists and real-world science.

Exclusively for teachers, the online *Science Quest* teacher resources provides teaching advice and suggested additional resources, testmaker questions with assessment rubrics, and worksheets and answers.

Graeme Lofts and Merrin J. Evergreen

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TOPIC 1
Science is ...

1.1 Overview

The word *science* comes from the Latin word *scientia*, meaning knowledge. For some people it's an occupation; for others it's used to design and build things. But everybody uses scientific knowledge, or devices made using scientific knowledge — every day.



1.1.1 Think about science

assessON

- What do scientists do?
- Do people other than scientists use science in their work or leisure activities?
- How is a science laboratory different from other rooms?
- Is the science laboratory a dangerous place?
- Am I a good observer?
- How are substances heated safely in the science laboratory?

LEARNING SEQUENCE:

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1.9	Review	36

Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

1.1.2 Your quest

Where's the science?

Work in a small team for this activity. For each of the photographs on this page, work together to write a paragraph about how scientists might be involved in the activity. Select a spokesperson to read the paragraph to the class.











Think

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. Draw a picture of your own 'image' of a scientist on A4 paper.
2. Make a list of the differences between real scientists and the scientist you have drawn. Think about the way they look as well as what they do.
3. Get together in a group and compare your lists and drawings. Together, compile a group list and draw a group image or description of a scientist.
4. As a group, suggest one single word that describes what all scientists do.

1.2 Science is … everywhere!

Science as a human endeavour

1.2.1 Science is ... everywhere!



Scientific knowledge is all around you. Whenever you turn on a light, eat food, watch television or flush the toilet you are using the products of scientific knowledge. Nurses, police, dietitians, teachers, doctors, vets, mechanics, gardeners, stage designers and artists use scientific knowledge. In fact you could easily add to this list yourself. For example, engineers use scientific knowledge to design bridges, computers, factories, artificial limbs, sewerage systems and buildings.

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Watch this eLesson: Career spotlight: scientist (eles-0053)

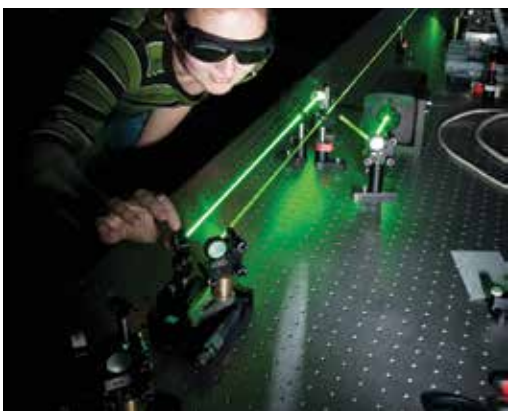
1.2.2 Science is … biology

… the study of living things. There are many branches of biology. **Zoology** is concerned with animals and **botany** with plants. **Entomology** is the study of insects while **microbiology** is the study of living things that are too small to see without the help of a microscope.

1.2.3 Science is … physics

… the study of the behaviour of natural and manufactured things and reasons for their behaviour. Physics is concerned with movement and different forms of energy such as light, heat, electricity and nuclear energy. Branches of physics include **acoustics**, the study of sound, and **biomechanics**, the study of the forces involved in human and other animal movement.





WHAT DOES IT MEAN?

Psych comes from the Greek word *psyche*, meaning 'soul' or 'mind'.

1.2.4 Science is … astronomy

… the study of the stars, the sun, the planets, their moons and other heavenly bodies such as comets and asteroids.



1.2.5 Science is … geology

… the study of the Earth and how it changes. A geologist might, for example, be concerned with how mountains are formed or with using rocks to trace the Earth's history. **Vulcanology**, the study of volcanoes, **seismology**, the study of earthquakes, and **palaeontology**, the study of fossils, are some of the branches of geology.



1.2.6 Science is … psychology

… the study of the mind and behaviour. Most psychologists are concerned with human thought and emotion, but some work with other animals. Branches of psychology include **sports psychology**, which deals with the motivation of athletes, and **forensic psychology**, which deals with psychology and the law.



1.2.7 Science is … chemistry

… the study of substances, what they are made of, how they are formed, how they change and what happens when they are combined. Branches of chemistry include **radiochemistry**, the study of radioactive substances, and **pharmacology**, the study of the effect of drugs on living things.



1.2.8 The people of science

Scientists can be found just about anywhere. They could be on a riverbank taking water samples, on a boat fitting dolphins with radio transmitters to track their movements, searching for fossils in outback cliffs, in a laboratory searching for the cause of a disease, beside a freeway measuring the effects of sound barriers — even in space investigating the effects of weightlessness.

HOW ABOUT THAT!

Not all scientists were high achievers at school. Some very famous scientists were average or below average school students. Albert Einstein is probably the most famous example. He did not talk until he was three years old. He left school at the age of 15 and went back later. He passed his university exams by studying the notes of his classmates.

Some scientists work in more than one branch. For example, a **biochemist** works in biology and chemistry, studying the substances in living things. A **biophysicist** might study the small electrical signals that travel from your ear to your brain, which enable you to hear.

1.2.9 Science and technology

Since prehistoric times, people have been making scientific discoveries that have improved the quality of life. The use of scientific ideas to design devices that make life easier is called **technology**. The invention

of the wheel is a good example of early technology. The scientific idea behind the wheel is that objects roll over surfaces more easily than they slide across them. The interaction of science and technology has been the driving force behind our modern technological world.

1.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think

1. Explain how people in each of the following occupations might use science in their daily work.
   (a) Nurse
   (b) Mechanic
   (c) Gardener
   (d) Chef
   (e) Architect
   (f) Police officer
2. What would each of the following types of scientist be mainly concerned with?
   (a) Biochemist
   (b) Geophysicist
   (c) Marine ecologist
3. List five devices that you have used today that would not have been invented without scientific knowledge.

Imagine

4. Look at the photo of this tennis player Lleyton Hewitt. Propose how each of the following scientists could improve his performance.
   (a) Nutritionist
   (b) Sports psychologist
   (c) Physicist
5. Imagine that you are given the chance to interview any scientist from the past or present. Who would you choose? Give reasons for your choice and prepare a list of questions that you would ask.



Investigate

6. What do the initials CSIRO stand for? What does this organisation do?
7. Find out what you need to study at school and afterwards to become a scientist or engineer.

1.3 The science laboratory

1.3.1 Getting to know the science lab

A map of the science room

- Sit quietly for a minute or two and look around the science laboratory.
- List as many differences as you can between the science laboratory and other general classrooms at your school.
- Draw a map of the science laboratory on a sheet of A4 paper, labelling each of the following items clearly.
  - student tables and work benches
  - teacher's desk or demonstration bench
  - gas taps
  - sinks
  - eye wash
  - fire blanket
  - doors
  - broken glass bin
  - power points
  - fume cupboard
  - fire extinguishers
  - sand bucket
  - rubbish bin

1.3.2 Laboratory equipment

Some of the equipment that you are likely to use in the science laboratory is illustrated on the next page.

- Use the illustrations to find each item of equipment in the checklist below. On a copy of the checklist, place a tick beside each item when you have found it.

Equipment	Use
Beaker	Container for mixing or heating liquids and other substances
Bosshead	Holds the clamp to a retort stand
Bunsen burner	Heats substances
Clamp	Holds objects at the required height on a retort stand
Conical flask	Container for mixing substances or collecting filtered substances
Evaporating dish	Container for heating small amounts of substances over a Bunsen burner
Filter funnel	Used with filter paper to filter substances
Gauze mat	Supports a container over a Bunsen burner while it is heated
Heatproof mat	Protects benches from damage
Measuring cylinder	Used to measure the volume of a liquid accurately
Retort stand	Used with a clamp and bosshead to hold equipment at the required height
Safety glasses	Protect eyes
Spatula	Used to pick up small amounts of solid substances
Stirring rod	Used to stir mixtures
Test tube	Container for holding, heating or mixing small amounts of substances
Test-tube holder	Holds a test tube while it is being heated
Test-tube rack	Holds test tubes upright
Thermometer	Measures temperature
Tongs	Used to hold small objects while they are heated or to pick up hot glassware
Tripod	Supports a gauze mat over a Bunsen burner
Watchglass	Holds small quantities of solids

Some equipment that you are likely to use in the science laboratory:

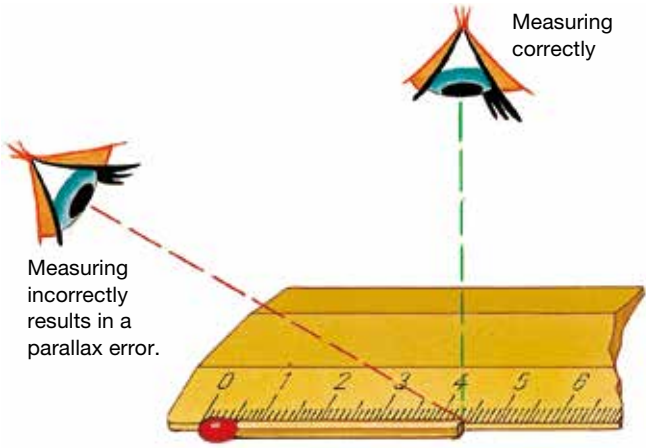


Parallax error

Measurements should always be made with your eye in line with the reading you are taking. When scales are read from a different angle, the reading is not accurate. This type of reading error is called **parallax error** (see the illustration on the opposite page).

Measuring volume

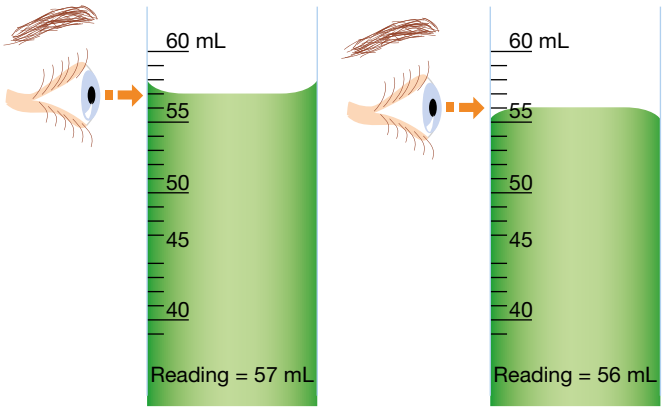
Liquids in containers such as measuring cylinders are often curved at the top edge. The curve is called a **meniscus**. The edges of the meniscus may curve up or down. We always measure the volume of liquids from the middle flat section of the meniscus.



Measuring temperature

A **thermometer** is used to measure temperature. The unit of measurement commonly used is degrees Celsius (°C). The thermometers used in schools are filled with alcohol, dyed red so that they are easier to read. When using thermometers, remember these points.

- Never rest the bulb of the thermometer on the bottom of a container being heated as the bottom may be hotter than the rest of its contents.
- Ensure that the liquid for which you are measuring the temperature fully covers the thermometer bulb.
- Read the thermometer with your eye level with the top of the alcohol column.

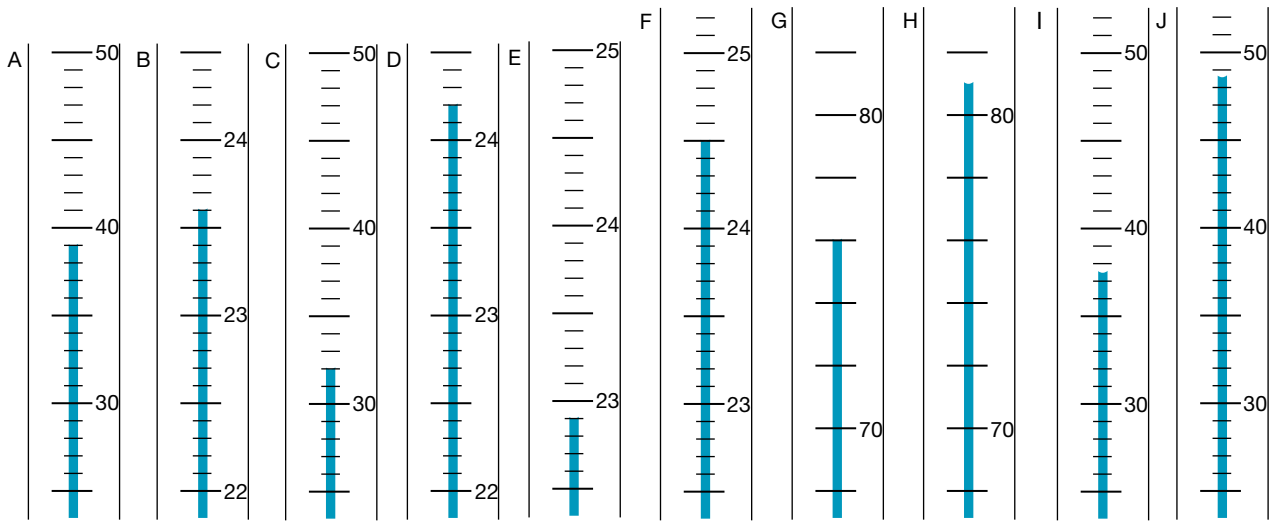


Reading scales

In science, a scale or set of numbered markings generally accompanies each measuring device. For example, your ruler measures length, and its scale has markings enabling you to measure with an accuracy of 0.1 cm. A laboratory thermometer has a scale that measures temperature with an accuracy of 0.5 °C.

When reading a scale, it is important to determine what each of the markings on the scale represents. Practise reading the scales below.

The temperatures measured by thermometers A and B are 39 °C and 23.6 °C, respectively. What are the temperatures measured by thermometers C to J?



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Try out this interactivity: Reading scales (int-0201)

Complete this digital doc: Worksheet 1.1: The science laboratory (doc-19787)

Complete this digital doc: Worksheet 1.2: Playing it safe (doc-19788)

1.3.3 Playing it safe

Doing experiments in science can be exciting, but accidents can happen if investigations are not carried out carefully. There are certain rules that must be followed for your own safety and the safety of others.

Handy hints

- Use a **filter funnel** when pouring from a bottle or container without a lip.
- Never put wooden test-tube holders near a flame.
- Always turn the tap on before putting a **beaker**, **test tube** or **measuring cylinder** under the stream of water.
- Remember that most objects get very hot when exposed to heat or a naked flame.
- Do not use tongs to lift or move beakers.

ALWAYS ...

- follow the teacher's instructions
- wear safety glasses and a laboratory coat or apron, and tie back long hair when mixing or heating substances
- point test tubes away from your eyes and away from your fellow students
- push chairs in and keep walkways clear
- inform your teacher if you break equipment, spill chemicals or cut or burn yourself
- wait until hot equipment has cooled before putting it away
- clean your workspace — don't leave any equipment on the bench
- dispose of waste as instructed by your teacher
- wash your hands thoroughly after handling any substances in the laboratory.



NEVER ...

- enter the laboratory without your teacher's permission
- run or push in the laboratory
- eat or drink in the laboratory
- smell or taste chemicals unless your teacher says it's ok. When you do need to smell substances, fan the odour to your nose with your hand.
- leave an experiment unattended
- conduct your own experiments without the teacher's approval
- put solid materials down the sink
- pour hazardous chemicals down the sink (check with your teacher)
- put hot objects or broken glass in the bin.



1.3.4 Working with dangerous chemicals

Your teacher will tell you how to handle the chemicals in each experiment. At times, you may come across warning labels on the substances you are using.

Always wear gloves and **safety glasses** when using chemicals with this symbol. Corrosive substances can cause severe damage to skin and eyes. Acid is an example of a **corrosive** substance.



These substances are easily set on fire so keep them away from flames. Methylated spirits is **flammable**.



Chemicals with this label can cause death or serious injury if swallowed or breathed in. They are also dangerous when touched without gloves because they can be absorbed by the skin. Mercury is a **toxic** substance.



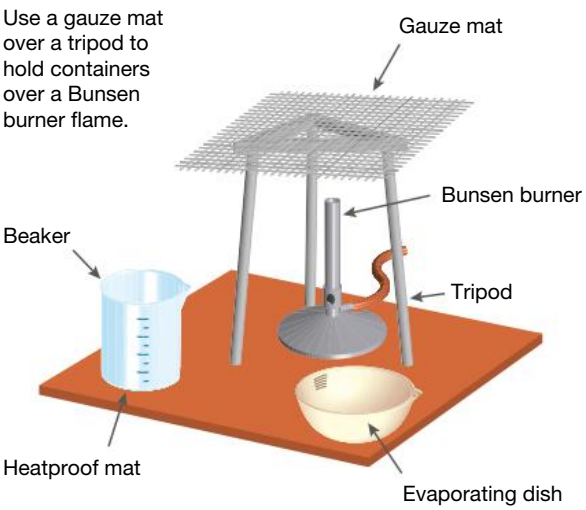
1.3.5 Heating substances

Many experiments that you will conduct in the laboratory require heating. In school laboratories, heating is usually done with a Bunsen burner. A Bunsen burner provides heat when a mixture of air and gas is lit.

Bunsen burners heat objects or liquids with a naked flame. Always tie hair back and wear safety glasses and a laboratory coat or apron when using a Bunsen burner.

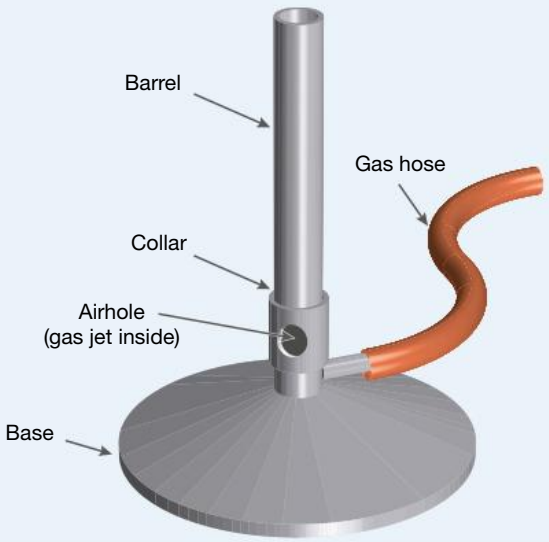
Heating containers

Beakers and evaporating dishes can be placed straight onto a gauze mat for heating. Never look directly into a container while it is being heated. Wait until the equipment has cooled properly before handling it.



A GUIDE TO USING THE BUNSEN BURNER

1. Place the Bunsen burner on a heatproof mat.
2. Check that the gas tap is in the 'off' position.
3. Connect the rubber hose to the gas tap.
4. Close the airhole of the Bunsen burner collar.
5. Light a match and hold it a few centimetres above the barrel.
6. Turn on the gas tap and a yellow flame will appear.
7. Adjust the flame by moving the collar until the airhole is open and a blue flame appears.
8. Remember to close the collar to return the flame to yellow when the Bunsen burner is not in use.



INVESTIGATION 1.1

Which flame is hotter?

AIM: To determine which is the hotter part of a Bunsen burner flame: blue or yellow

Materials:

Bunsen burner
matches
pieces of porcelain
clock or watch
heatproof mat
tongs
safety glasses

Method and results

- Light the Bunsen burner according to the guide on the previous page.
- Open the airhole.
- Hold a piece of porcelain over the flame with the airhole open.

1. Record roughly how long it takes for the porcelain to turn red-hot.
   - Let the porcelain cool on the heatproof mat.
   - Close the airhole.
   - Hold the porcelain in the yellow flame for a few minutes.
2. Describe the flame when the airhole is open. What colour is it? Does it make a noise?
3. Describe the flame when the airhole is closed. Is it easy to see?
4. Does the porcelain turn red-hot in the yellow flame when the airhole is closed?
5. What else do you notice about the porcelain after heating in the yellow flame?
6. Which is the hotter flame? What observations did you make that support your answer?

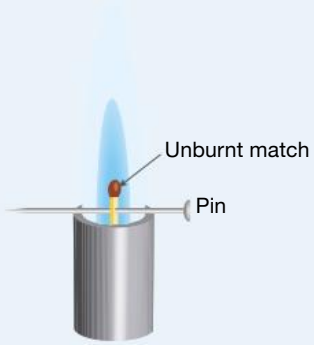
INVESTIGATION 1.2

Where is the hottest part of the flame?

AIM: To locate the hottest part of a Bunsen burner flame

Materials:

Bunsen burner
heatproof mat
matches
safety glasses
nichrome wire
tongs
pin



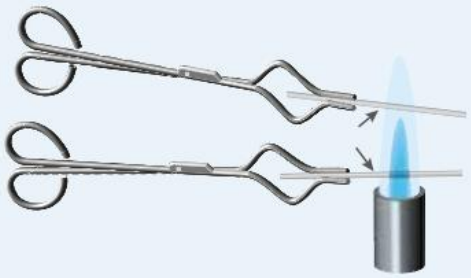
Method and results

Part A

- Use a pin to hang an unburnt match over the barrel of a Bunsen burner.
- Light the Bunsen burner according to the guide on the previous page.
- Turn the collar to produce a blue flame.
- Turn the Bunsen burner off and remove the match and pin with tongs.

Part B

- Re-light the Bunsen burner and turn the collar to produce a blue flame again.
- Use the tongs to hold the wire across the flame, close to the barrel of the Bunsen burner, and observe the wire.
- Move the wire up a little and continue observing.



1. What happens to the match hanging over the barrel? Explain why.
2. What colour does the wire become when held across the flame?
3. Is the colour of the wire different when it is held at the top of the flame?
4. Draw a diagram of the Bunsen burner flame, labelling the parts that are hottest.

Discuss and explain

5. Students often heat substances in a test tube with a Bunsen burner. Why would it be unwise to:
   (a) use a yellow flame rather than a blue flame
   (b) position the test tube at the base of a blue flame?
6. Why is the yellow flame often called the safety flame?

INVESTIGATION 1.3

Heating a substance in a test tube

AIM: To safely heat a substance in a test tube

Materials:

100 mL beaker	*Bunsen burner and heatproof mat*
matches	*safety glasses*
test tube	*test-tube rack*
test-tube holder	*food colouring*

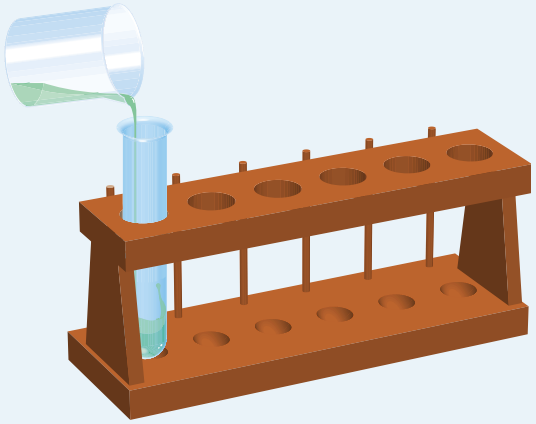
Method and results

CAUTION

Before you start heating, check the following:

- *If you have long hair, is it tied back?*
- *Are you wearing safety glasses?*
- *Is the Bunsen burner on a heatproof mat?*
- Carefully pour water from a beaker into a test tube to a depth of about 2 cm as shown in the diagram on the right. Add a drop of food colouring to make it easier to see.
- Light the Bunsen burner correctly and heat the test tube gently in the blue flame as shown at right. Remember that the open end of the test tube should be pointing away from you and your fellow students. The base of the test tube should be moved gently in and out of the flame. This prevents the liquid from splashing out of the test tube.
- Once the water has started boiling, stop heating and turn off the gas to the Bunsen burner. Place the test tube in the test-tube rack. Leave it there until it has cooled before emptying it and cleaning up.

Pouring a liquid into a test tube



Heating a test tube



Discuss and explain

1. Make a list of any changes you observed inside the test tube as you heated the water.
2. Why is the test tube placed in a test-tube rack rather than in your hand?

1.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

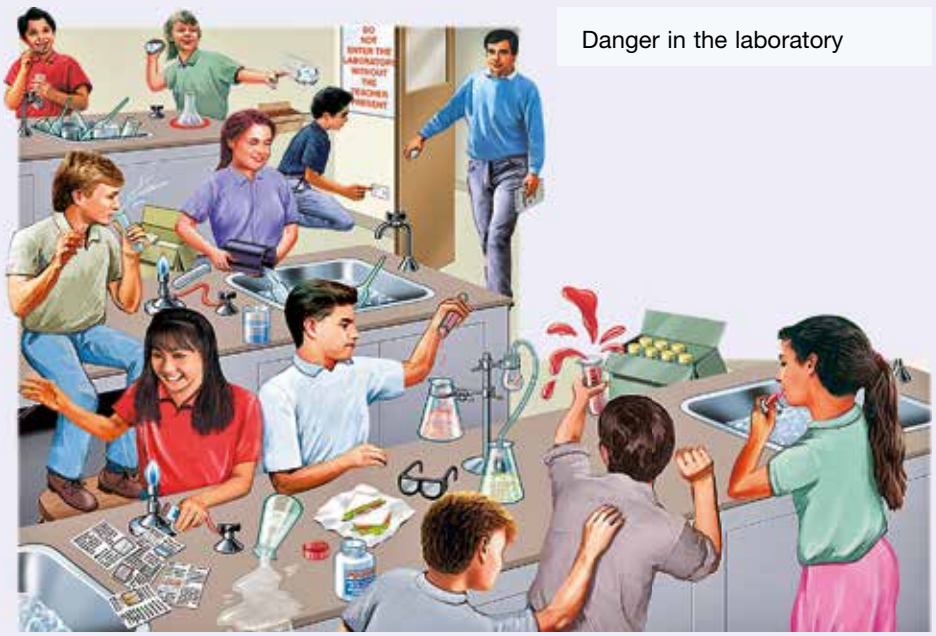
1. Outline the purpose of each of the following pieces of equipment.
   (a) Heatproof mat
   (b) Evaporating dish
   (c) Test-tube rack
   (d) Retort stand
2. Give three examples of equipment used when heating objects.
3. Explain why you should always wear gloves when working with corrosive substances.
4. If the teacher says it is safe to smell a chemical, what technique should you use?
5. Which colour flame of a Bunsen burner is hottest — the blue or the yellow?
6. What should you do if you cut or burn yourself in the laboratory?

Think

7. Identify which item of equipment you would use to:
   (a) hold a test tube that is to be heated
   (b) measure a volume of water exactly
   (c) transfer a small sample of a powder to a beaker
   (d) mix a sample of powder with water so it dissolves.
8. Look carefully at the picture of students in a laboratory on this page.
   (a) Identify at least five dangerous situations you can see.
   (b) Explain why each situation is dangerous.
9. The following statements are all incorrect. Rewrite them so that they are correct.
   (a) Matches can be safely washed down the sink.
   (b) Always point a test tube towards you when heating so you can see what is happening inside it.
   (c) Safety glasses need to be worn only when heating over a blue Bunsen burner flame.
   (d) Water spills do not need to be cleaned up because they are not dangerous.

Create

10. Select one of the safety rules and choose a strategy for publicising your message to the class. You might create a safety poster, video clip or play.



Danger in the laboratory

1.4 Detective skills

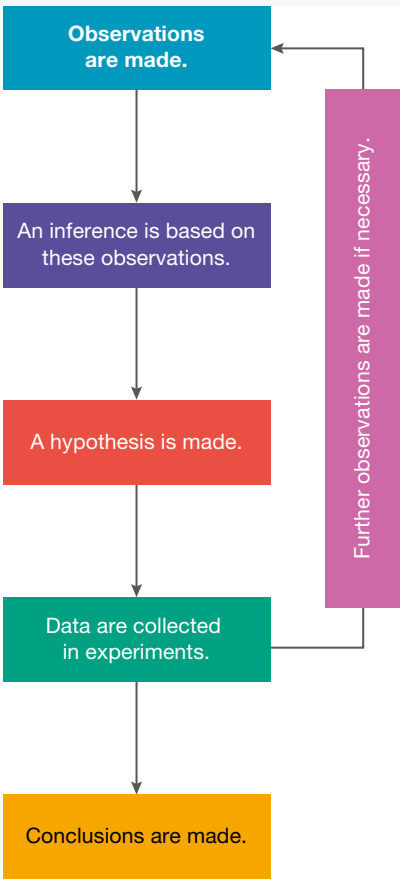
1.4.1 Detective skills

Crime scene investigators make **observations** at the scene of the crime. A footprint, the smell of perfume, an unusual sound or a warm log in a fireplace could provide clues to a crime.

The investigators also collect evidence so that they can make more observations in the laboratory. They use their observations to make an inference about what happened. An **inference** is a suggested explanation of what took place. But inferences are not always right. Further investigation is usually needed. The investigators often form a **hypothesis** about what happened. A hypothesis is an educated guess that can be tested by an experiment, further observations or measurement. After testing a hypothesis you might be able to form a **conclusion** about what happened. A conclusion is a final explanation of what took place. Sometimes the investigator has to return to the scene of the crime to gather more evidence to make further observations and start the process all over again before a conclusion can be formed.

The process used by crime scene investigators is used in almost all scientific investigations. Sometimes scientists form a hypothesis without making an inference first and sometimes no hypothesis is formed before an experiment.

This flowchart summarises the process of many scientific investigations.



1.4.2 Who or what did this?

To solve the mystery shown in the scene below, careful observations have to be made. Normally you are able to use all five senses to make observations. However, in this case you can use only your sense of sight.

1. Look carefully at the drawing and write down as many observations as you can that might help solve the mystery.
2. Make an inference about what happened.
3. Form a hypothesis about the mystery that can be tested by closer observation, measurement or an experiment. Explain how your hypothesis could be tested by a real crime scene investigator.
4. Why is it not possible to form a conclusion about who or what caused the mess using the drawing alone?

Who or what did it?



HOW ABOUT THAT!

One of the most famous detectives of all time was Sherlock Holmes. Together with Dr Watson he used observations and clever hypotheses to solve many crimes. Every hypothesis had to be tested until he could reach a conclusion about the crime. One of Sherlock's scientific tools was a simple magnifying glass. Of course, Sherlock Holmes didn't really exist — or did he?

INVESTIGATION 1.4

Are you a good observer?

AIM: To form a hypothesis about observation skills and test it

Materials:

candle and matches *jar lid*

Method and results

- Light a candle and place it on the lid of a jar. Write down as many observations as you can of the burning candle. Use all of your senses except the sense of taste. No chemicals should ever be tasted in the science laboratory!

CAUTION

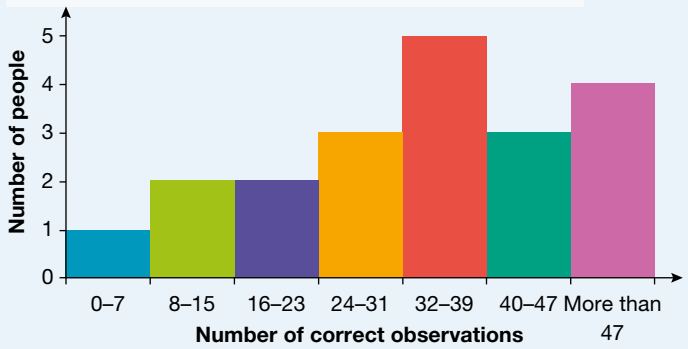
Do not touch the flame of the candle.

- Michael Faraday (1791–1867), a scientist famous for his discoveries in electricity and chemistry, made 53 observations of a burning candle. Take note of the number of observations you made.
- Use a table like the one below to record the number of observations made by the people in your class.

'Score' (number of observations made)	Number of people
0–7	
8–15	
16–23	
24–31	
32–39	
40–47	
More than 47	

- Construct a histogram like the one shown below to display your observations.

A histogram can be used to display observations.



1. How many observations did you record?
2. Form a hypothesis about whether you are a better observer than most people in your class.
3. Was your hypothesis supported by the data?

Discuss and explain

4. Write a conclusion to answer the question 'Am I a better observer than most people in my class?'

1.4 Exercises: Understanding and inquiring

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Remember

1. How is a scientist like a detective?
2. What is the difference between a hypothesis and a conclusion?
3. Which of your five senses can be used to make observations?

Think

4. Explain the difference between an inference and a hypothesis.
5. Read the following 'story' and state whether each sentence is an observation, inference or conclusion.
   (a) The dog in the house next door is barking.
   (b) There are no lights on in the house.
   (c) The owners must be asleep.
   (d) There could be a prowler in the backyard.
   (e) I heard the sound of breaking glass.
   (f) The dog is still distressed.

Imagine

6. Imagine that you have lost your senses of sight and hearing. Write a description, giving as much detail as you can, about walking through a remote forest. Don't forget that your observations can be made only with your senses of touch, taste and smell.

Investigate

7. Sit quietly in a nearby outdoor location and write down all of the things that you notice in two minutes. Use as many senses as you can, apart from the sense of taste.
   (a) Which sense did you use the most?
   (b) Compare your observations with those of your friends. Which sense did they use the most?
   (c) Which other senses did you use?

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Complete this digital doc: Worksheet 1.3: Observing and recording (doc-19789)

1.5 Keeping things under control

1.5.1 Being scientific

In order to answer a question scientifically, a controlled investigation needs to be performed. The investigation must also be reliable. The simple investigation of bouncing balls described on the next page illustrates how experiments can be both controlled and reliable.

Variables

There are many factors that affect how high a ball bounces after being dropped. They include:

- the height from which the ball is dropped
- the type of ball
- the type of surface the ball is dropped onto
- how much the ball has been used
- the method of dropping
- the technique used to measure the bounce height.

These factors are called **variables**. The variable that you are investigating is called the **independent variable**. In this investigation the independent variable is the type of ball. You are comparing balls of similar sizes made from different materials. The variable that you are measuring (the height of the bounce) is called the **dependent variable**.

Fair testing

Scientific investigations must be **fair tests**. In a fair test only one variable is changed at a time — the independent variable. In this investigation about the tennis ball bounce, that is the type of ball. All variables other than the dependent variable must be **controlled**; that is, they must be kept the same. If they were not, you couldn't tell which variable was affecting the height of the bounce. You might find it helpful when designing your own investigations to use a table like the one given below to identify all the variables.

Investigation: Which type of ball bounces the highest after being dropped on the ground?

Independent variable	• The type of ball
Dependent variable	• The height of the bounce
Controlled variables	• The type of surface the ball is dropped onto • How much the ball has been used (use brand-new balls) • The method of dropping • The technique used to measure the bounce height

INVESTIGATION 1.5

Bouncing balls

AIM: To plan, conduct and report on a scientific investigation in which variables are controlled

Materials:

tennis ball
rubber ball (about the size of a tennis ball)
cricket ball
baseball
any other ball about the same size as a tennis ball
one-metre ruler

Method and results

- The question you are trying to answer is 'Which ball bounces the highest?'. Prepare a table in which to record your results.

1. Write down a hypothesis.
   - Take care not to introduce unwanted variables. Make sure that the balls are dropped each time — don't accidently give them an extra push down. Also, think about which part of the ball you will measure the bounce height from.
   - You will be working in a small group, so decide who will drop the ball, who will make the measurements and who will record them.
   - Drop each ball from the same height and measure how high each one bounces. Now go ahead and answer the question — scientifically!
2. Write a report about your investigation using the headings on page 27.

1.5.2 Out of control

Sometimes it is not possible to control all of the variables that need to be controlled. These variables are called uncontrolled variables. These 'out of control' variables can make your **data** unreliable. In the bouncing ball investigation the size of the ball is uncontrolled. However, the effect of size is minimised by testing balls of approximately the same diameter.

WHAT DOES IT MEAN?

The word *data* comes from the Latin word *datum* meaning 'something given'. The English word *datum* means a single piece of information. *Data* means more than one piece of information.

1.5.3 Repetition and reliability

If you measured the bounce height of each ball only once, your result may not be reliable. Errors often occur in measurements due to carelessness, a minor change in method (for example in the way the ball was dropped) or inaccuracies in reading a scale. To reduce the effect of these errors, measurements should be repeated a number of times and an average calculated. The table below shows an example in which the bounce height of a wet tennis ball is compared with the bounce height of a dry tennis ball.

Include a control (left) to test whether wetting a ball (right) affects how high it bounces.



Comparing the bounce height of wet and dry tennis balls

Trial	Height of bounce (cm)	
	Wet tennis ball	Dry tennis ball
1	47	47
2	45	48
3	42	50
4	42	48
5	44	52
Average	44	49

The average of these measurements suggests that a dry tennis ball will bounce higher than a wet one. If you recorded only trial 1, you would form a different — and incorrect — conclusion.

1.5.4 Including a control

Some investigations require a **control** or a **control group**. For example, you might be investigating the effects of watering plants with salty water. You could use three different containers of water, each with a different amount of salt in the water. The independent variable is the amount of salt dissolved in the water. The dependent variable might be the height of the plant after ten days of watering. For reliability you observe at least three plants for each amount of salt. To fully investigate the effect of the salt in the water you need a control group of plants, to which you give water without any added salt. In a control group the independent variable (the salt) is not applied.

Some investigations require a control group.



1.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

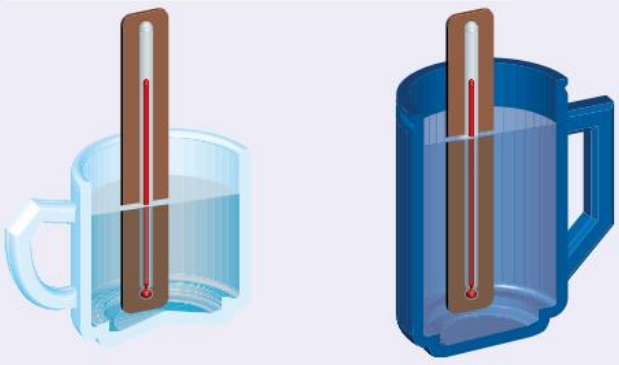
Remember

1. What is a variable?
2. Explain the difference between an independent variable and a dependent variable.
3. Why should only one variable at a time be changed in scientific investigations?

Think

4. Identify some variables that might affect:
   (a) how quickly a pot plant grows
   (b) the cost of an overseas airfare
   (c) the time it takes you to travel to school in the morning.
5. Advertisements for washing powders and liquids often claim that they are more effective than others. Imagine that you are conducting an experiment to test a range of washing powders and liquids.
   (a) Outline a method for your experiment.
   (b) List the variables you will need to control.
   (c) What variable will you change?
   (d) How will you compare the results of your tests?
6. Amy and Nguyen are trying to find out whether stoneware or glass cups are better for keeping water hot. The illustration below shows their experiment in progress.

Amy and Nguyen's experiment in progress



   (a) List at least two weaknesses in their experiment design.
   (b) Make a list of all the variables that could affect the results of Amy and Nguyen's experiment.
   (c) List any variables that Amy and Nguyen do not need to control.
   (d) Write a step-by-step outline of the procedure that they could use to find out which cups are better for keeping water hot.

Analyse and evaluate

Simon and Jessie performed an experiment to find out how effectively two plastic cups maintain the temperature of near boiling water. Their data are shown below.

Comparing plastic cups

	Temperature (°C)	
Time (min)	Simon's cup	Jessie's cup
0	90	90
10	47	58
20	29	39
30	22	31
40	20	26
50	20	23

7. Draw a graph to display the data in the table.
8. Which cup maintained the temperature of the water more effectively?
9. Estimate the temperature of the water in Simon's cup 15 minutes after timing commenced.
10. Use your graph to estimate how long it would have taken the water in Jessie's cup to drop to a temperature of 20 °C.

Brainstorm

11. In a small group, brainstorm and produce a list of problems that you could investigate scientifically at home or in the school laboratory without using expensive scientific equipment. You could start by thinking about investigations involving plants.

Investigate

12. Design an investigation to find out whether distances are easier to judge with two eyes than just one. You can do this by shooting for goal with a basketball or netball from a particular spot under three conditions:
    - left eye closed
    - right eye closed
    - both eyes open.

    To produce reliable results, more than one person should take the shooting test and each goal shooter should have several attempts.

    Plan and carry out your experiment. Write a formal report for the experiment including a table of results and a conclusion. In your discussion section:
    - identify the independent and dependent variables
    - describe the strategies you used to ensure that this was a fair test.
13. How is the bounce height of a tennis ball affected:
    (a) when it is damp
    (b) when it is hot
    (c) as it gets old and worn
    (d) by different tennis court surfaces?

    Design and perform an investigation to answer one or more of these questions.

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Complete this digital doc: Worksheet 1.4: Developing a fair test (doc-19790)

1.6 Analysing data

1.6.1 Using graphs

Values or measurements obtained from an investigation are called data. Having collected the data, it is important to present them clearly so that another person reading or studying them can understand them.

Organising data as a graph is a widely recognised way of making a clear presentation. It makes the information easier to read and interpret, and makes it easier to show trends and draw conclusions.

A graph, especially a line graph, can also be used to find values other than those used in the investigation. Line graphs can be used to make predictions. For example, using the line graph on page 24, you can predict how much salt can be dissolved at temperatures other than those actually measured.

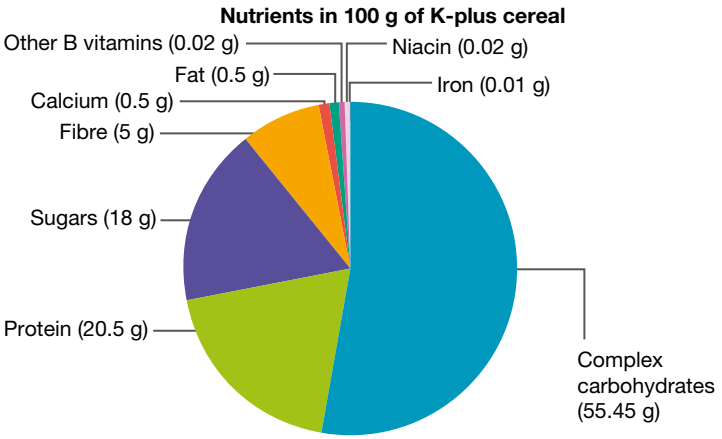
What is a graph?

A graph is a diagram that shows the connection between two or more things using dots, lines or bars. There are four different types of graph: a pie chart or sector graph, a bar chart or column graph, a histogram and a line graph.

1.6.2 Pie chart (or sector graph)

A **pie chart** (also known as a **sector graph**) is a circle divided into sections that represent parts of the whole. This type of graph can be used when the data can be added as parts of a whole. The example below shows the food types, vitamins and minerals that make up the nutrients in a breakfast cereal.

A pie chart

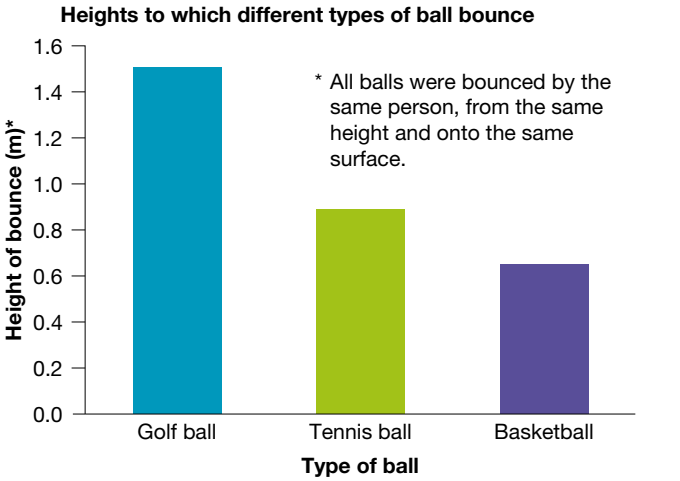


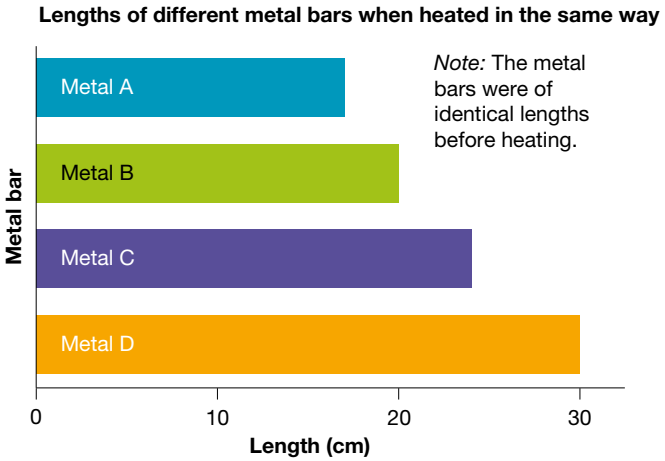
1.6.3 Column graph (or bar chart)

A **column graph** (also known as a **bar chart**) has two axes and uses rectangles (bars or columns) to represent each piece of data. The height or length of the bars represent the values in the data. The width of the bars is kept constant. This type of graph can be used when the data cannot be connected and are therefore not continuous.

The first example on the next page shows data on the average height to which different balls bounced during an experiment. Each bar represents a different type of ball. The second example on the next page shows the lengths of different metal bars when heated. Each bar represents a different metal bar.

Two column graphs (also known as bar charts)

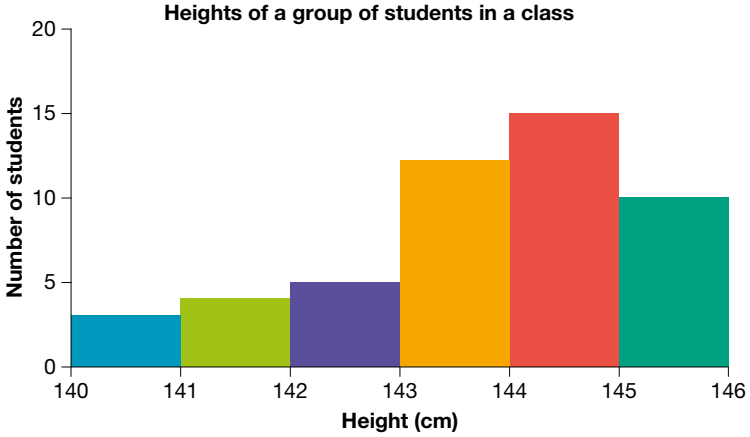




1.6.4 Histogram

Histograms are similar to column graphs except that the columns touch each other because the data are continuous. They are often used to present the results of surveys. In the histogram below, each column represents the number of students that reach a particular height.

A histogram

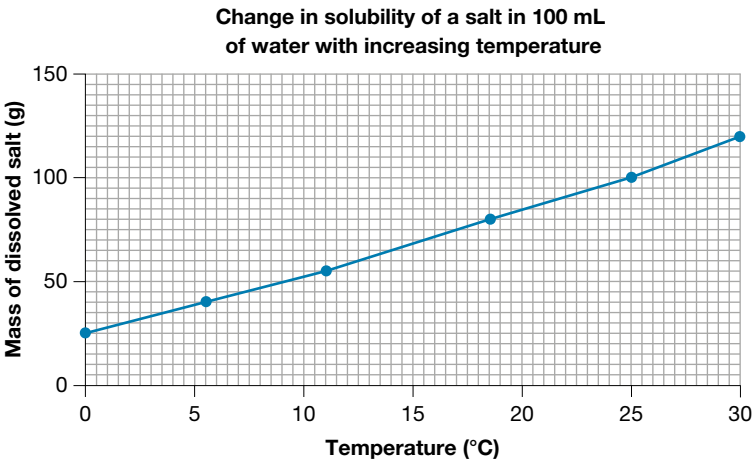


1.6.5 Line graph

A **line graph** has two axes — a horizontal axis and a vertical axis. The horizontal axis is known as the ***x*-axis**, and the vertical axis is known as the ***y*-axis**. The line graph is formed by joining a series of points or drawing a line of 'best fit' through the points. Each point represents a set of data for two variables, such as height and time. Two or more lines may be drawn on the same graph.

Line graphs are used to show continuous data — that is, data in which the values follow on from each other. For example, the line graph below shows the change in the solubility of a salt in water as the temperature of the water increases. (Solubility is a measure of the mass of a substance that can be dissolved in a liquid.)

A line graph



1.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Analyse this

1. Prepare a column graph using the following information on the nutrients present in a serving of ice-cream.

Nutrients in a 30 g serving of ice-cream

Nutrient	Amount (g)
Protein	2.00
Fat	6.00
Carbohydrate — polysaccharide	11.00
Carbohydrate — sugars	10.00
Cholesterol	0.02
Calcium	0.10
Potassium	0.80
Sodium	0.05

2. The following table gives the energy contained in various types of food.
   (a) Why are these data not suitable for graphing?
   (b) What would you need to do to make them suitable?

Energy content of foods

Food	Energy (calories)
Apple (medium)	75 000
Bread (1 slice)	70 000
Butter (1 tbsp.)	100 000
Chocolate cake (medium slice)	250 000
Cornflakes (1 serving)	75 000
Milk (large glass)	150 000
Orange (medium)	50 000
Sugar (1 tbsp.)	50 000

3. The following table shows the percentage composition of salts present in sea water.
   (a) Prepare a sector graph from this table.

Salt composition of sea water

Salt	Percentage (%)
Calcium carbonate	0.34
Calcium sulfate	3.60
Magnesium bromide	0.22
Magnesium chloride	10.90
Magnesium sulfate	4.70
Potassium sulfate	2.50
Sodium chloride	77.24
All others	0.50

   (b) Apart from sodium, the salts of which metal are the most abundant in sea water?
4. The following table shows the uses of plastics in Australia.
   (a) Select a suitable graph type and prepare a graph from this table.

Uses of plastics in Australia

Use	Percentage (%)
Agriculture	4.0
Building	24.0
Electrical/electronic	8.0
Furniture and bedding	8.0
Housewares	4.0
Marine, toys and leisure	2.0
Packaging and materials handling	31.0
Transport	5.0
Others	14.0

   (b) Choose two uses of plastic from your graph. For each use, state a particular item that is made of plastic.
   (c) There has been recent controversy about the waste products that humans create.
      (i) Can you suggest any uses of plastics that would contribute to waste products? List them and explain your choices.
      (ii) Can you suggest alternatives to reduce the amount of plastic waste products?
5. Prepare a column graph using the information in the table on the next page on the amount of energy required by males and females for various activities.
   (a) Why do you think males use more energy per hour than females for the same activity?

Amount of energy required for various activities

Activity	Energy used per hour by average female — 58 kg (kJ)	Energy used per hour by average male — 70 kg (kJ)
Sleeping	240	300
Sitting, reading, desk work and studying	360	450
Light activity, such as driving, playing piano and standing with only arms moving	480	600
Walking slowly and gardening; working as a shop assistant or machinist	720	900
Physical work, such as factory or farm labouring; sports, such as cycling, tennis and cricket	960	1200
Heavy physical work, such as loading, stacking and carrying; vigorous sports, such as jogging, basketball, hockey and football (activity that leads to sweating)	1440	1800
Very heavy physical work and vigorous sports, such as football, hockey, running and swimming (activity that causes free sweating, requiring short bursts of extreme energy)	2400–4800	3000 –7200

(b) The following list shows the activities for an average female for one day. How many kilojoules would this female need to consume to provide the energy for the day's activities?

Activity	Number of hours
Sleeping	8
Light activity	4
Sitting, reading and desk work	10
Gardening	1
Basketball	1

(c) If an average male spent a similar day, how much energy would he need?

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Complete this digital doc: Worksheet 1.5: Drawing a line graph (doc-19791)

1.7 Reporting on investigations

1.7.1 Reporting on investigations

When scientists conduct investigations, they need to write reports to tell other people about their work. When you conduct experiments, you need to write reports that allow others to understand what you did and to read about what you found out.

Your reports should include the following sections.

Aim

A statement about why you did the experiment

Materials

A list of the equipment and chemicals that were used

Method

An account of what was done. This will usually include a diagram showing how your equipment was set up. There should be enough details included to allow the reader to repeat your experiment.

Results

A presentation of your data. This might include a list of observations, or tables and graphs.

Discussion

An explanation of your results and a description of any difficulties you had with the experiment. This section might also include suggestions for improvements to the experiment.

Conclusion

A brief account of what you found out and how your findings relate to your aim. It is a good idea to read your aim again before you write your conclusion.

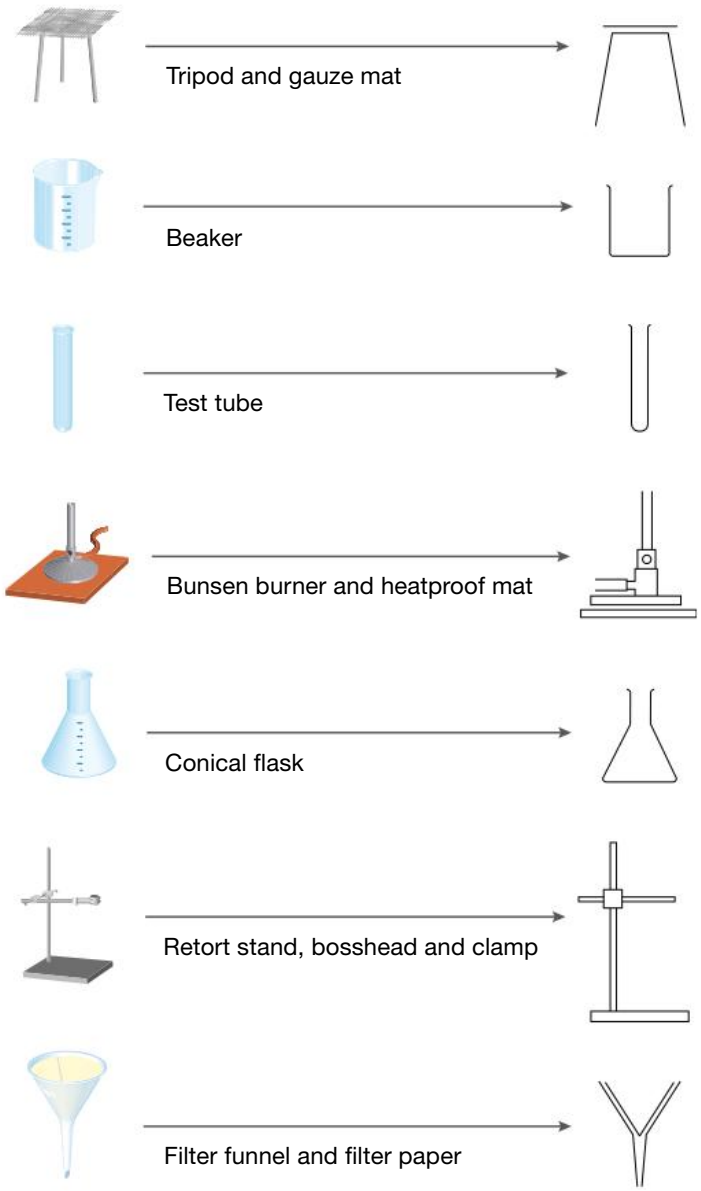
Drawing science equipment

When reporting your experiments, a good, simple diagram can make it much easier for the reader to understand what was done. There are some rules to remember:

1. Diagrams in scientific reports should be drawn in pencil.
2. Straight lines should be drawn with a ruler.
3. Each item of equipment should be labelled.

The diagram on the right shows how some commonly used items of equipment should be drawn.

Diagrams in scientific reports should be simple. In each case below, the apparatus is shown on the left and the diagram of this apparatus on the right.



1.7.2 Organising observations and data

When making a lot of observations, it is often helpful to organise them in a table. Observations and measurements that are organised in tables are easier to read. Tables also make it easier for you to draw graphs.

INVESTIGATION 1.6

Recording observations in a table

AIM: To record method and observations of simple experiments in a table

Materials:

4 test tubes
50 mL beaker
eye-dropper
vinegar
sodium carbonate
methylated spirits
starch suspension
safety glasses
test-tube rack
spatula
drinking straw
sodium bicarbonate
copper sulfate
limewater
iodine solution

Method and results

CAUTION

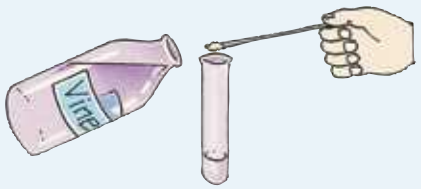
Safety glasses should be worn while conducting these experiments.

1. Draw a table like the one below to record your observations in each of the following activities.

Activity	Summary of what was done	Observations
1		
2		
3		
4		
5		

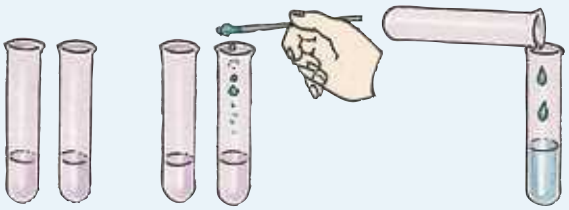
Activity 1

- Pour vinegar into a clean test tube to a depth of about 1 cm. Add a spatula full of sodium bicarbonate.



Activity 2

- Quarter-fill two clean test tubes with water. Add a dry spatula full of sodium carbonate to one test tube. Shake the tube until the sodium carbonate dissolves. Add a dry spatula full of copper sulfate to the other test tube and shake it until the crystals dissolve. Pour the contents of the second test tube into the first.



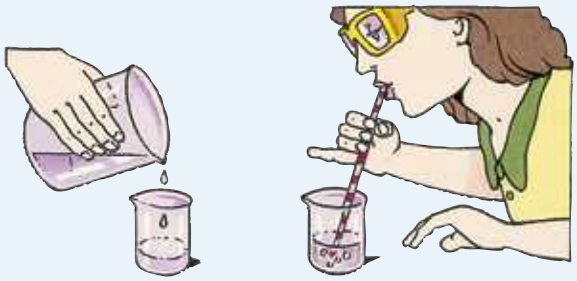
Activity 3

- Use an eye-dropper to put one drop of methylated spirits onto the back of your hand. Blow air gently across the back of your hand.



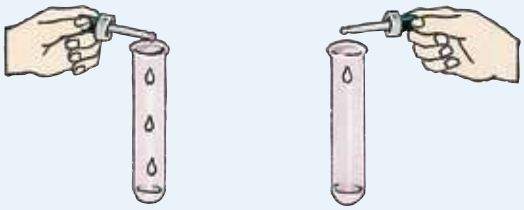
Activity 4

- Quarter-fill a very small beaker with limewater. Gently blow out through a drinking straw into the limewater. Be careful not to share straws.



Activity 5

- Put a few drops of starch suspension in a clean test tube. Add a drop of iodine solution.



CAUTION

Take care not to get iodine solution on your skin or clothes.

Discuss and explain

2. What senses did you use in making your observations?
3. Describe two safety precautions involved in this investigation.
4. Explain why it is important to use small quantities of chemicals when doing experiments like these.
5. Explain why it is useful to present the observations in a table.
6. In activity 4, you had to pour limewater into the beaker. If you took more limewater than required, why it is not a good idea to return any unused limewater to the original bottle?

INVESTIGATION 1.7

Graphing temperature

A line graph is a useful way to present the results of an experiment and gives an overall picture of the results. A line graph can also be used to predict values that occur between, or outside, those measured during an experiment.

AIM: To observe how the temperature of water changes while it is heated over a Bunsen burner

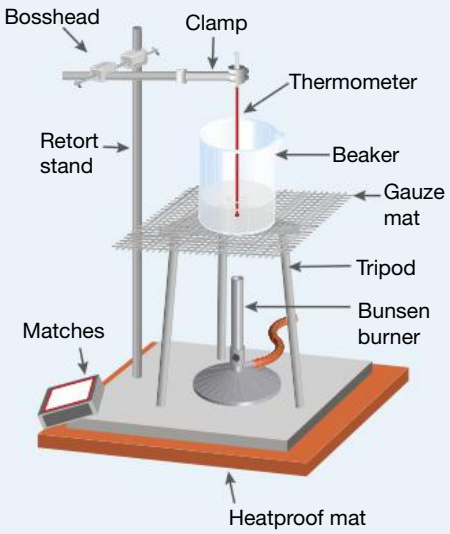
Materials:

100 mL measuring cylinder
250 mL beaker
Bunsen burner
heatproof mat
matches
tripod
gauze mat
stopwatch
safety glasses
retort stand, bosshead and clamp
thermometer or data logger and temperature sensor

Method and results

- Use a measuring cylinder to measure 100 mL of water.
- Pour the water into the beaker.

- Set up the equipment as shown in the diagram. Make sure that the bulb of the thermometer is not on the bottom of the beaker or out of the water.
- Wait for a minute to allow the thermometer to adjust to the water temperature.

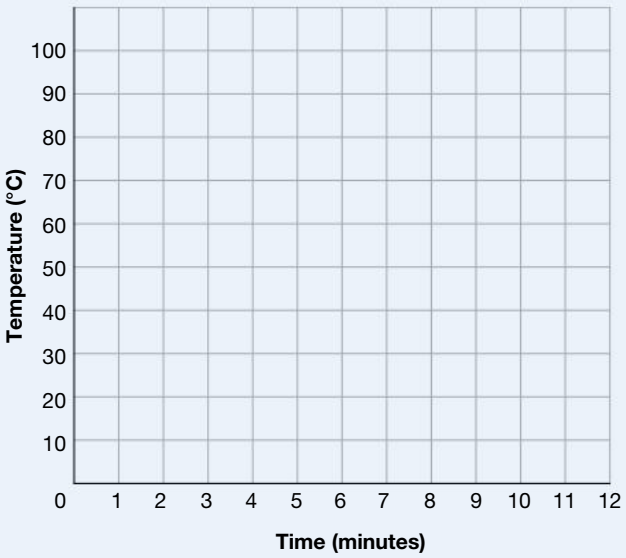


1. Measure the initial temperature of the water and record it in a table. The initial temperature is recorded when time is 0 minutes.

Time (min)	Temp (°C)	Time (min)	Temp (°C)
0		6	
1		7	
2		8	
3		9	
4		10	
5			

- Put your safety glasses on.
- Light the Bunsen burner according to the guide on page 11.
- Open the airhole and heat the beaker over a blue flame.

2. Measure and record the temperature of the water every minute for 10 minutes.
   - Turn off the Bunsen burner and allow the equipment to cool.
3. Plot a line graph of the data you have collected on a sheet of graph paper using labels like those below.



4. Draw a smooth line near as many points as possible to show the overall trend in the water temperature over time.

Discuss and explain

5. Why didn't you record the starting temperature of the water as soon as you poured the water into the beaker?
6. Describe in words how the temperature increased.
7. How does your graph compare with those of other groups?
8. Predict what would happen to the temperature of the water if you continued heating for another two minutes.

A good quality report of an experiment

Date: 29 February

Dissolving sugar

Aim:

To find out how much sugar will dissolve in hot water compared with cold water

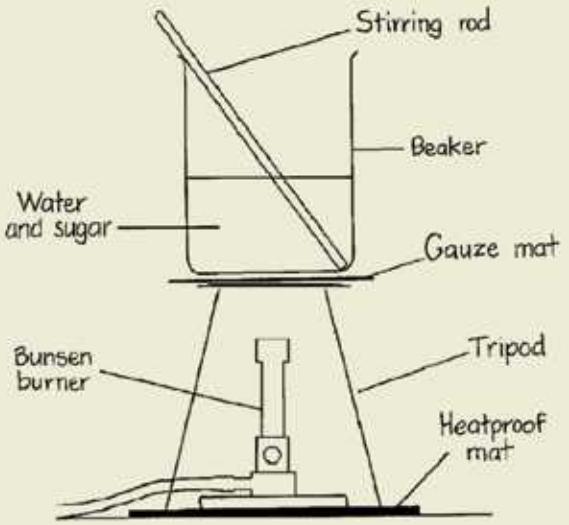
Materials:

Beaker, heatproof mat, Bunsen burner, tripod, gauze mat, matches, spatula, stirring rod, sugar, water

Method:

1. A spatula was used to add sugar to 100 mL of cold water in a beaker. The sugar was stirred and more added until no more would dissolve. The amount of sugar dissolved was recorded.

2. The mixture of sugar and water was heated with a Bunsen burner for 4 minutes and the extra amount of sugar that could be dissolved was recorded.



Results:

Amount of sugar dissolved in cold water = 2 spatulas
Extra amount of sugar dissolved in hot water = 4 spatulas
Total amount of sugar dissolved in hot water = 6 spatulas

Discussion:

I was able to dissolve more sugar in the hot water than in the cold water. A thermometer could have been used to measure the temperature of the water. The amount of sugar could have been measured more accurately by adding smaller amounts at a time.

Conclusion:

Three times as much sugar dissolves in hot water as in cold water.

1.7.3 Using technology: spreadsheets

A spreadsheet is a document that stores data in columns and rows. Spreadsheets used to be written on paper by hand. Shopkeepers and bank tellers needed to keep neat handwritten ledgers to record all transactions. Today, computers and software such as Microsoft Excel are used to create and edit spreadsheets. Spreadsheets can also be used to create graphs and charts at the click of a button.

Some spreadsheet terminology

In a spreadsheet, the data are organised in rows and columns. The columns are named using letters (such as column B) and the rows are named using numbers (such as row 3). Cells are the boxes in the spreadsheet. The cell reference tells us which column and row the cell is in. For example, cell B3 is in column B and row 3. The active cell is the cell you will type the data in. In Excel, it has a dark border around it. This is shown in the diagram below.

Cell B3 is the active cell.

	A	B	C
1			
2			
3			
4			
5			
6			
7			
8			

Working with Excel spreadsheets

When you create a spreadsheet, you need to decide how many columns and rows you will need and enter a suitable heading for each column. This is similar to designing a table. Make sure that you include units where relevant. When using Excel, you can format cells in a variety of ways by using the Format tool.

Entering formulae in Excel

If you want to do calculations on the data in a spreadsheet, you need to enter a formula. In Excel, a formula always starts with an equals sign (=). If you want the total of cell A2 and cell B2 to appear in cell C2, you

would type the formula '=A2+B2' in cell C2, and then press the Enter key. You can also use one of the many functions available in Excel. For example, it is much quicker to use the Average function to calculate the average of 50 numbers than to type in a formula to add the 50 cells and divide the total by 50. The Insert function button, *fx*, can be used to view the format required for particular functions.

Drawing graphs and charts

Drawing a graph using Excel is easy. Just highlight the data you want to graph, click on the Insert tab, select the type of graph you want to draw and then follow the prompts. Remember that a scatter graph (XY chart) is used to plot one set of values against another in Excel.

1.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Explain why scientists write reports about their experiments.
2. Under which heading of your report of an experiment should the following information be included?
   (a) Suggestions for improvements to your experiment
   (b) A reason for doing the experiment
   (c) Graphs and tables
   (d) A description of what you did
   (e) A statement saying what you found out by doing the experiment
3. Draw a neat, labelled scientific diagram of the following equipment. Water in a conical flask is being heated with a Bunsen burner. The conical flask is supported by a gauze mat on a tripod. The Bunsen burner is standing on a heatproof mat.

Understand

4. In the screenshot opposite, identify the letter pointing to:
   (a) cell C2
   (b) cell E5
   (c) the active cell
   (d) a formula
   (e) the Insert scatter graph button
   (f) the Insert function button
   (g) a column
   (h) a row.
5. List two advantages and two disadvantages of using a computer spreadsheet program to store data rather than keeping handwritten records in a book.

Think

6. Write a full scientific report on Investigation 1.7.
7. Draw a neat, labelled scientific diagram of the two sets of equipment that would be needed to safely perform the following activity.

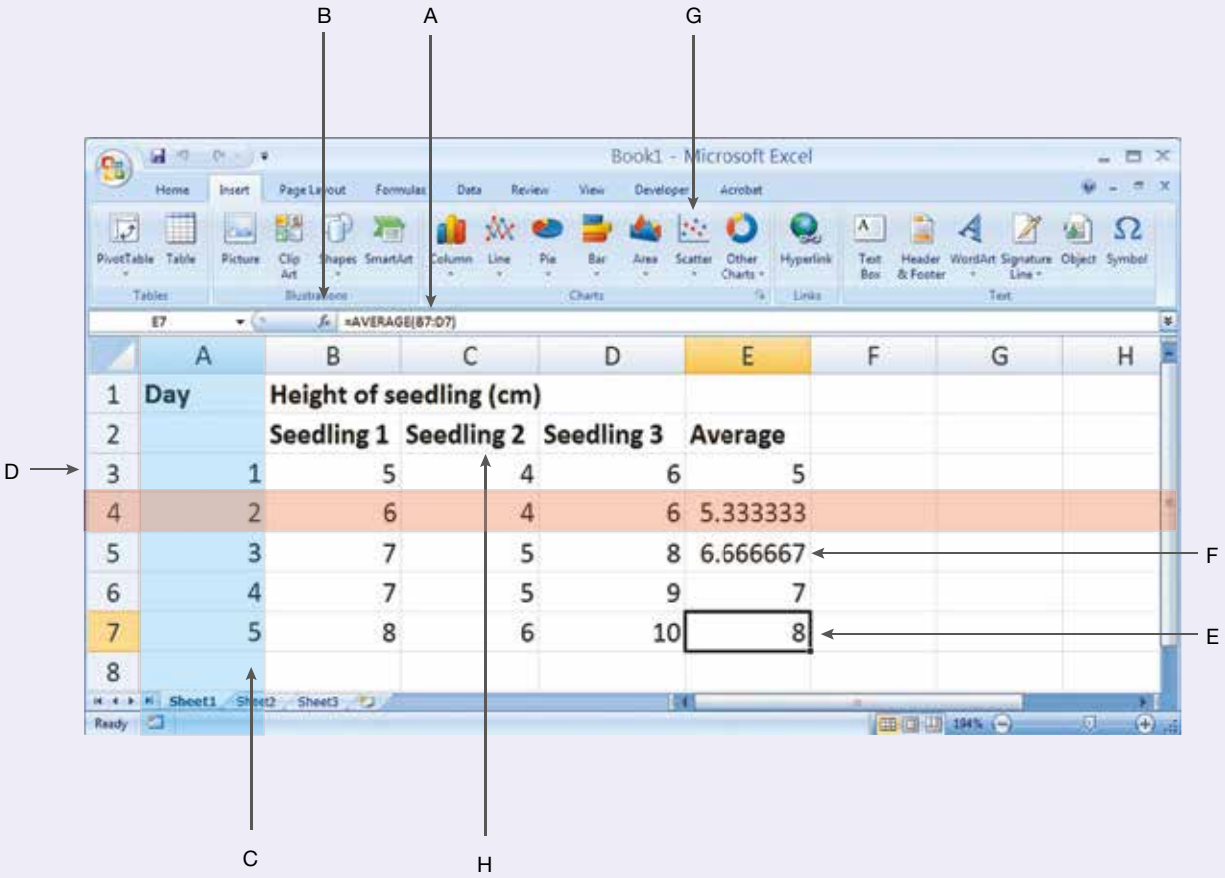
Part 1:

Muddy salt water is being poured from a beaker into a filter funnel (with filter paper). The filter funnel is resting in the opening of a conical flask.

Part 2:

The filtered salt water, now in an evaporating dish, is being heated by a Bunsen burner. The evaporating dish is supported by a gauze mat on a tripod.

8. A hypothesis is often included in a scientific report — usually under the 'aim' heading, immediately after the reason for carrying out the experiment. What is a 'hypothesis'?



Investigate

9. Design an experiment to investigate whether adding salt to water changes how the temperature rises when the water is heated. Write a scientific report outlining the design of your experiment.

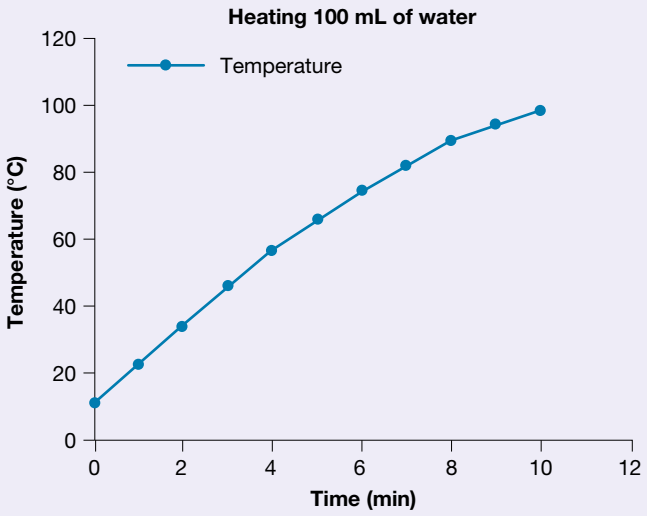
Analysing data

10. (a) Create a spreadsheet with the column headings 'Time (min)' and 'Temperature (°C)'. Enter your data from Investigation 1.7. You should end up with a table similar to the one below.

	A	B
1	Time (min)	Temperature (°C)
2	0	12
3	1	23
4	2	33
5	3	44
6	4	53
7	5	63
8	6	72
9	7	82
10	8	90
11	9	95
12	10	98
13		

(b) Use your data to create a scatter graph with the points joined by straight lines.

(c) Create a title for your graph. Label the *x*-axis 'Time (min)' and the *y*-axis 'Temperature (°C)'. You should obtain a graph similar to the one below.



11. Use the graph from question 10 to answer the following questions.
    (a) For how long did the experiment run?
    (b) What was the temperature of the water when the experiment began?
    (c) How long did it take for the water to boil?
    (d) How many readings were taken?
    (e) What would you expect the graph to look like after 10 minutes?
    (f) How would you expect the graph to change if only 50 mL of water was heated?
    (g) Sketch a graph of what the predicted results would be for a 200 mL beaker of water. Perform the experiment to check your predictions.

Create

12. (a) Collect the following data for each student in your class.
        (i) First name
        (ii) Gender
        (iii) Foot length (cm)
        (iv) Height (cm)
        (v) Favourite subject
        (vi) Country where mother was born
    (b) Enter the data you collected into a spreadsheet.
    (c) Click on the Insert tab, then use the Chart function button to construct a scatter graph (without joining points) showing foot length on the *x*-axis and height on the y-axis.
    (d) Use your graph to decide whether there is a relationship between foot length and height.

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1.8 Project: Bigger, better beans

Scenario

The local agricultural show will be running its annual competition to find the biggest bean plant and you are determined that this year you are going to win. In previous years, you have just planted your seeds in their pots, added some fertiliser, put them in the sun and watered them every day but, while the plants did grow, they didn't grow big enough to have a chance at the prize. As a good science student, you know that the growth of plants depends upon the process of photosynthesis, whereby light energy from the sun causes water and nutrients and carbon dioxide to be combined by the plant to produce oxygen and starch (which is a form of chemical potential energy). The plant then uses this starch to grow. So, if the growth of the plants depends upon how much starch is produced, maybe there's something you could do to the plants that would make them produce more starch and grow faster and bigger?

Your task

You will design and carry out an investigation that will test a number of different growth conditions (for example, different amounts of sunlight or different substances added to the soil) to determine which will give the greatest rate of growth over a three-week period of time. Your findings will be presented in the form of a scientific report.









1.9 Review

1.9.1 Study checklist

Science as a human endeavour

- describe how science is used in a range of occupations
- outline some of the branches of science and how they affect everyday life
- distinguish between science and technology

Introducing the laboratory

- identify and safely use a range of equipment to perform scientific investigations and collect data
- describe ways to reduce the risk to yourself and others in the laboratory

Planning and conducting investigations

- make inferences and testable hypotheses in the light of observations and measurements
- describe a logical procedure for undertaking a controlled experiment
- use repetition of measurement to increase the reliability of data
- form conclusions based on experimental results
- reflect on your methods and make suggestions for improvements to your investigations
- use a scientific report with clear diagrams where necessary to describe your investigations and their findings

Processing and analysing data and information

- make and accurately record observations and measurements using the appropriate equipment
- organise data clearly using tables
- construct an appropriate type of graph (e.g. column graph, pie chart, line graph) to present your data
- use tables and graphs to identify trends and patterns, and assist in the formation of conclusions
- identify data that support or discount a hypothesis

Individual pathways

ACTIVITY 1.1
Investigating
doc-6075

ACTIVITY 1.2
Analysing investigations
doc-6076

ACTIVITY 1.3
Designing investigations
doc-6077

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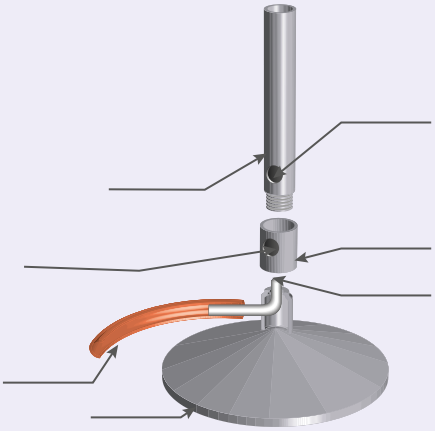
1.9 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. Match the following scientists with their work.

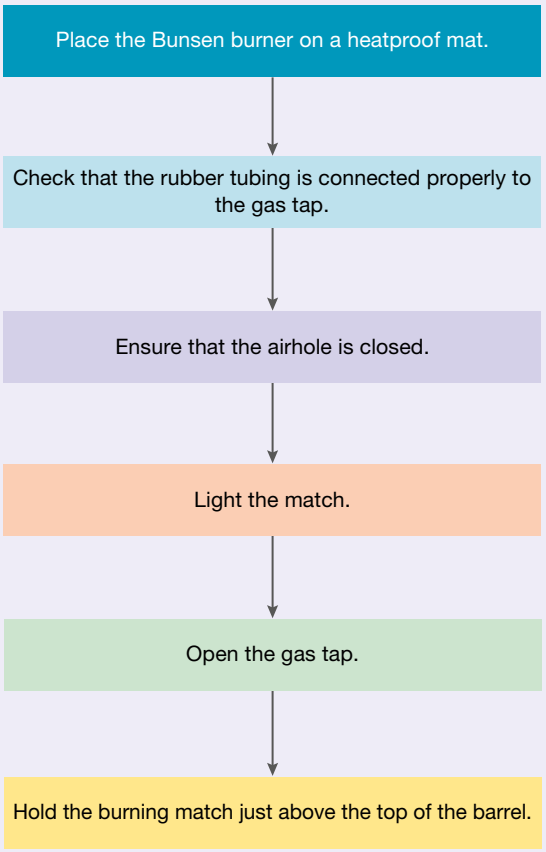
Scientist	Work
(a) Physicist	(A) Investigates how rocks and mountains form
(b) Chemist	(B) Studies living things
(c) Biologist	(C) Explains things like movement, heat and light
(d) Astronomer	(D) Studies how substances react with others
(e) Earth scientist	(E) Studies the sky

2. What does each of the following scientists study?
   (a) Seismologist (b) Biochemist (c) Entomologist
   (d) Botanist (e) Zoologist (f) Vulcanologist
3. Which of the scientists listed in question 2 could be correctly described as geologists?
4. Indicate whether each of the following actions is a 'do' or a 'don't' in the science laboratory.
   - Wear safety glasses while mixing chemicals.
   - Pour all substances down the sink when finished with them.
   - Run in the science laboratory.
   - Drink water from the taps in the science laboratory.
   - Tie long hair back before using a Bunsen burner.
   - Wait until the end of the lesson to tell your teacher that you have burnt yourself.
5. Write a list of all of the equipment that you would need to boil water in a beaker in your science laboratory. Draw a labelled scientific diagram to show the equipment in use.
6. Copy this diagram of a Bunsen burner and complete all of the missing labels.



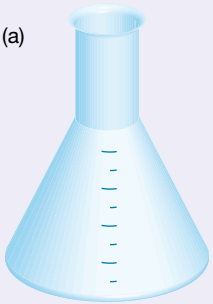
7. Rewrite the following sentences correctly by selecting the appropriate words in *italics*.
   (a) When lighting a Bunsen burner, light the match *before/immediately after* turning on the gas.
   (b) When using a thermometer to measure the temperature of a liquid as it is heated, place the bulb of the thermometer on the *bottom/near the centre* of the beaker.
   (c) When heating a test tube, hold the test tube using *tongs/a test-tube holder* at the *top/middle* of the test tube and *keep it steady/move it back and forth* over the flame.
8. The steps used to light a Bunsen burner can be displayed as a flowchart, as shown below. Use the information in the flowchart to construct a storyboard with six scenes to show how a Bunsen burner is lit correctly and safely.

Lighting a Bunsen burner



9. Name each of the items of equipment shown below.

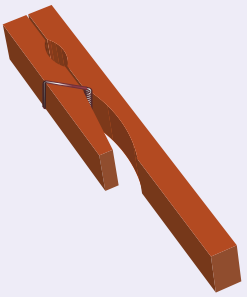
(a)



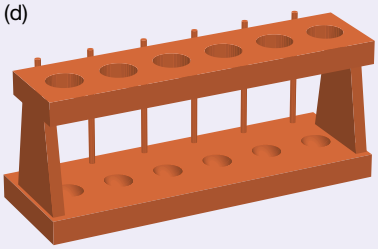
(b)



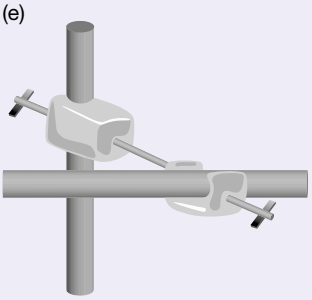
(c)



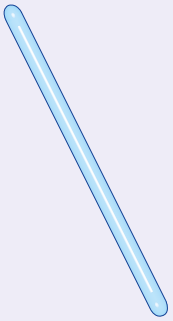
(d)



(e)

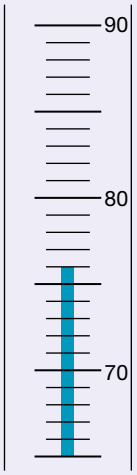


(f)

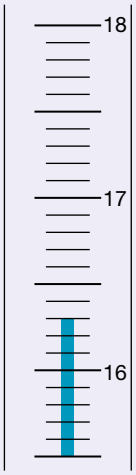


10. Kimberley and Glenn were walking past their neighbour's house when they noticed that a front window was broken. Glenn told Kimberley that somebody had probably thrown a ball through the window. They had a closer look and noticed clothes scattered all over the floor and drawers open. Kimberley noticed some blood on the broken glass. She told Glenn that the house had been burgled. Glenn agreed and they called the police.
    (a) List the observations that were made.
    (b) Who made an inference?
    (c) What was the inference and why was it suggested?
    (d) What conclusion was reached by Kimberley and Glenn?
    (e) Suggest a different conclusion based on the observations that were made.
11. What item of equipment would you use to measure:
    (a) the temperature of hot water
    (b) the mass of a small beaker of water
    (c) the volume of a small quantity of water?
12. Identify the temperature measured by each of the thermometers shown below.

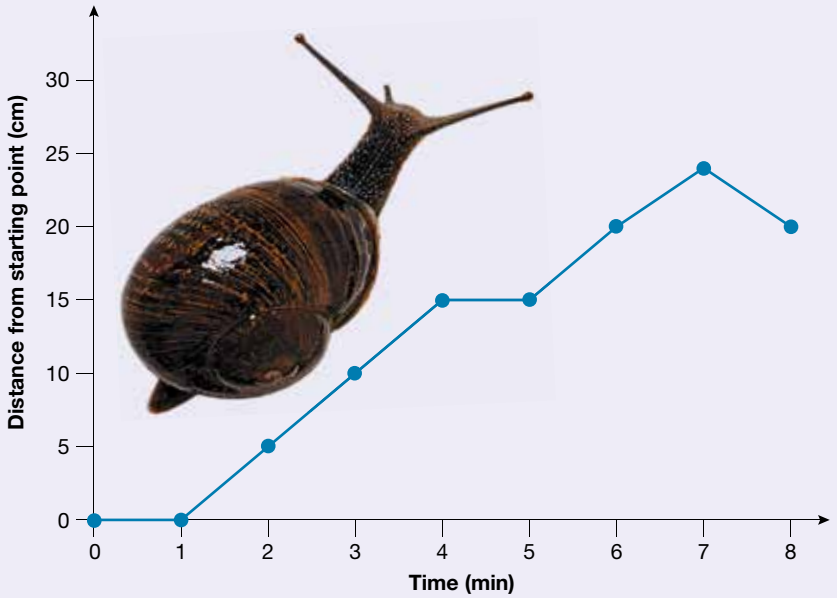
(a)



(b)



13. The graph below shows how far from the starting point a snail moves in an experiment.



(a) Calculate how far from the starting point the snail was 7 minutes after timing began.
(b) During what times did the snail not move at all?
(c) What does the graph tell us about the snail's movement between 7 and 8 minutes after timing began?
(d) Propose why a smooth line was not drawn in this graph.

14. Identify which of the following is an important safety rule in science.
(a) When smelling chemicals, place your nose carefully over the container.
(b) Dispose of all materials in the rubbish bin.
(c) When reading the volume of a liquid, always read the bottom of the meniscus.
(d) Point test tubes away from your eyes and away from your fellow students.

15. Equipment used for measuring the volume of liquids includes:
(a) conical flask, beaker, measuring cylinder.
(b) measuring cylinder, crucible, beaker.
(c) watchglass, filter funnel, conical flask.
(d) evaporating basin, test tube, beaker.

16. Luke was sick and tired of being bitten by mosquitoes. He counted several bites each evening when he sat outside to have dinner. He had heard that a burning citronella candle was a good way to keep mosquitoes away. Design an experiment to test Luke's idea. Identify the independent and dependent variables and the controlled variables needed to make this a fair test. Suggest a control for your experiment.

17. Huang and Tina conducted an investigation to find out whether radish plants grow better in the shade. They placed three seedlings under a verandah at the back of the house and another three in a sunny place in the front yard. All plants were planted in the same soil and were watered equally each day. Huang and Tina measured the height of each plant and the number of healthy leaves at the same time every second day.
(a) What was the independent variable in the investigation?
(b) What were the dependent variables?
(c) List the variables that should have been controlled.
(d) How could Huang and Tina improve the design of their experiment? List as many improvements as possible.
(e) In your opinion, did Huang and Tina conduct a fair test? Give reasons for your opinion.

18. Now that you've spent some time working on this chapter, think about the best way to describe a scientist.
(a) Draw a picture of your own image of a 'typical' scientist.
(b) Write your own description of a 'typical' scientist.
(c) Write a comment about how your image of a scientist has changed since you started working on this chapter.

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Complete this digital doc: Worksheet 1.6: Designing an experiment (doc-19792)

Complete this digital doc: Worksheet 1.7: Checklist (doc-19793)

assessON

Link to assessON for questions to test your readiness **FOR** learning, your progress **AS** you learn and your levels **OF** achievement.

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TOPIC 2
Learning keys

2.1 Overview

Do you have keys to unlock your own learning? What happens when you learn? In this chapter, we will explore different ways of learning and thinking. We will also introduce you to some 'thinking tools' and 'learning keys' to help you become a better learner.

2.1.1 Think about learning

assessON

- What are three different types of intelligence?
- How can you use an 'alphabet' key to help unlock your thinking?
- What are two ways of practising collaborative skills with your partner?
- What are potential benefits of being an active learner?



LEARNING SEQUENCE

onlineonly
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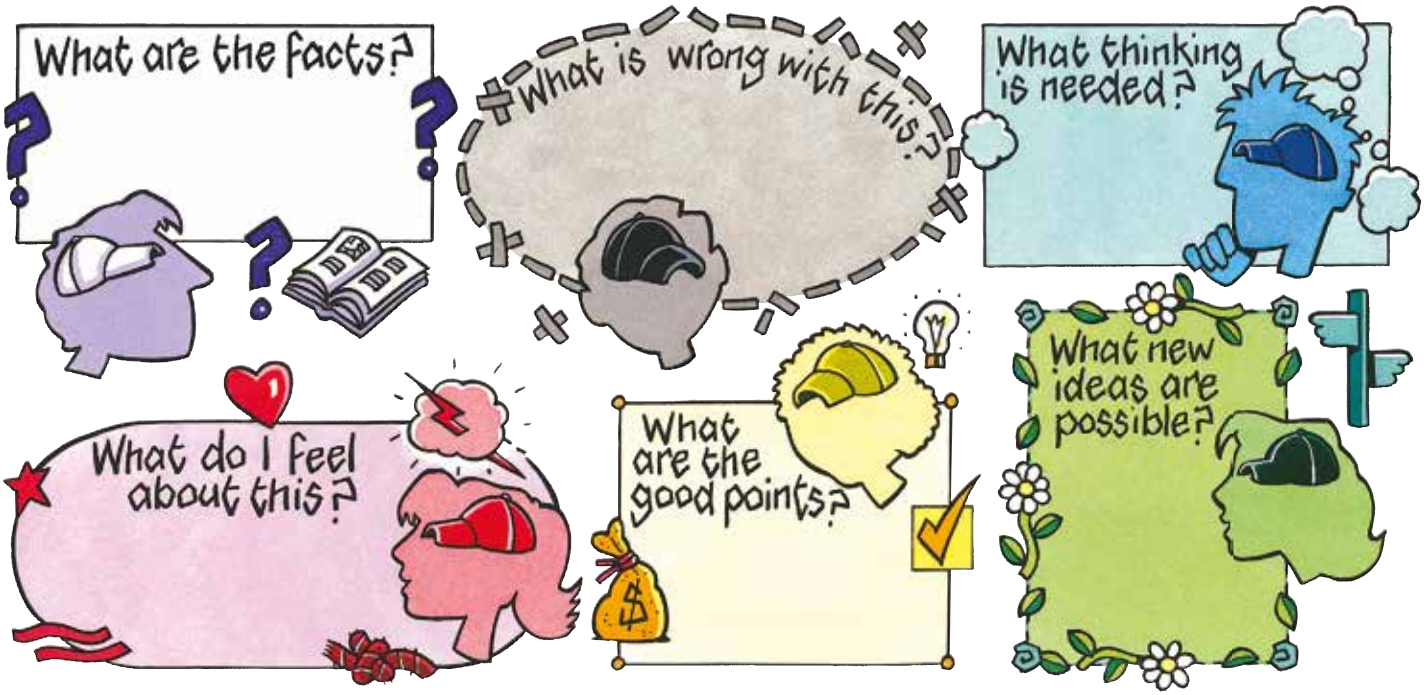
2.1 Overview
2.2 Tinkering with your toolbox
2.3 Intelligence multiplied
2.4 Thinking keys
2.5 Learning together
2.6 Unlocking learning
2.7 Question keys
2.8 Thinking tools: 'See Quest' tools
2.9 Thinking tools: Cluster maps and concept maps
2.10 Feeding your brain
2.11 Discovering your brain
2.12 Review

Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

2.1.2 Your quest

Thinking with different hats

There are a number of very useful tools that can help develop your thinking. One of these was created by a great thinker by the name of Edward de Bono. He created the idea of using different coloured **thinking hats** for different types of thinking. These hats don't even have to be on your head. The idea behind each hat just needs to be *in* your head.



THINK AND DISCUSS

Six thinking hats

- Look at the different types of questions that can be asked when 'wearing' the different coloured hats. These hats can be used to help direct your thinking about a particular problem in different ways.
- With your partner, select one of the following problems.
  - Unhealthy food in school canteen
  - Too much homework
  - Too much school litter
  - Sleepy students
- Using each coloured hat, write down an answer using that type of thinking.
- Taking turns, share your answers with your partner.
  1. How were your answers and those of your partner similar, and how were they different? Suggest some reasons for these findings.
  2. If you were to think about this particular problem again, how would your thinking be different?
- Suggest two other problem-type questions that could be used with the thinking hats.
- Add these to a class collective thinking jar, for some more 'hat thinking' at another time.

Problem:	Students are to wear only black coloured clothes to school.
Red hat:	How do you feel about wearing only black clothes to school?
Yellow hat:	What's good about the idea?
Black hat:	What's wrong with this idea?
White hat:	What information do you have (or need to have) on this idea?
Green hat:	What are some ways to help this to happen?
Blue hat:	What do you need to do next, or have done so far?

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Complete this digital doc: Worksheet 2.1: Your quest (doc-19794)

2.2 Tinkering with your toolbox

Science as a human endeavour



2.2.1 Tinkering with your toolbox

Can you describe when, where and how you learn the best? Do you know why?

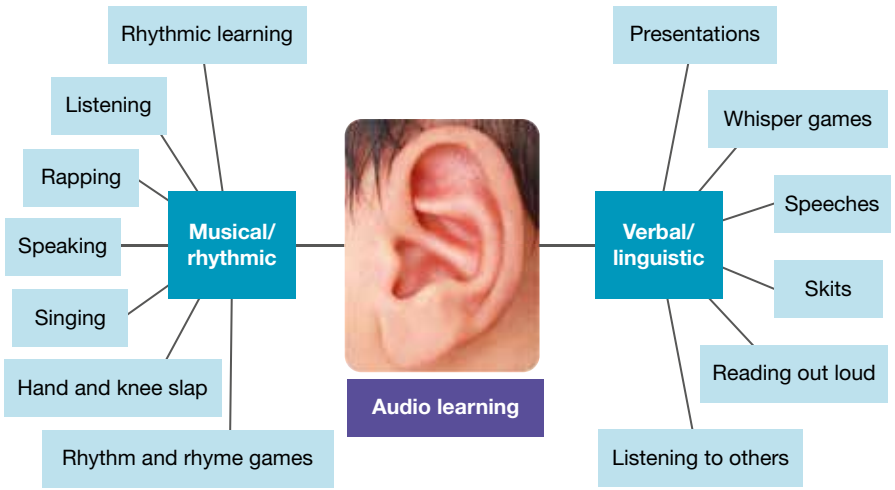
There are many factors that may influence how you learn and think, such as:

- visual — colour, lighting, shape
- audio — sound, music
- kinaesthetic — movement, dance
- interactive — social, teams.

These factors can link with the types of tools in your multiple intelligence toolbox. Although you may have a preference for some of these over others, it is important to try them all whenever you can.

2.2.2 Hear

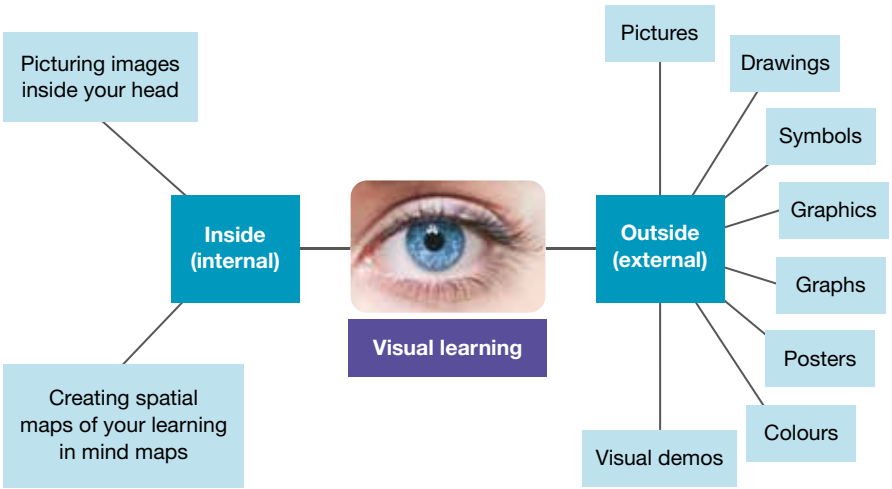
Audio learning can include musical/rhythmic and verbal/linguistic activities. Many melodies that you know well (such as *Row Row Row Your Boat*, *Twinkle Twinkle Little Star, Humpty Dumpty* and *Jack and Jill*) can be linked to new learning by rewriting the lyrics with keywords from your lesson or topic. Different types of music can also help you focus on the task that you are involved in.



2.2.3 Look

Visual learning can involve seeing an image in your mind or seeing with your eyes.

Looking at advertisements for various products, you will be able to see how they have used various visual cues to help you remember their product. The Nike sports clothing company, for example, has a tick symbol. How many symbols from other advertisements can you remember?



2.2.4 Smell

Smell and an awareness of aromas can help you become a very effective learner. Research suggests that peppermint, basil, lemon, cinnamon and rosemary enhance mental alertness. Lavender, chamomile, orange and rose calm nerves and encourage relaxation.

Your olfactory regions are rich in receptors for endorphins, chemicals that generate feelings of pleasure and wellbeing. You can distinguish odours with only tiny variations in their chemical structures. Can you think of examples of odours that make you remember something happy?

2.2.5 Do

Kinaesthetic learning can involve learning through movement, touch and feeling, role-plays, pantomime stories, puppet shows, stretching, building models, exercise, sign language, hands-on experiments and dance. Movement and activity are also important to get more oxygen to your brain so that you can think better.

2.2.6 Together

It can be fun to learn with others. Interactive or social learning can involve learning through sharing, peer teaching, collaboration, discussion, and learning in pairs, groups and teams, and can help in your own development of self-awareness and an awareness and empathy for others. Learning these sorts of interpersonal skills is very important for both your learning and sense of wellbeing.



Self

Not all learning needs to be with others. It is also important to learn how to learn on your own, by yourself. Solo thinking activities, such as imagery, journal writing, focusing and concentration exercises, self-assessment and reflection, are also important.

INVESTIGATION 2.1

Reviewing activities

AIM To use activities to help review a topic

Add-ons

- To start, one student comes to the front of the room and acts out or postures something that they have learned from the topic.
- Another student joins the first student to act out something they have learned, then other students do the same, creating a 'living sculpture'.

Brain ball toss

- Six to eight students stand in a circle facing each other about 3 metres apart.
- To start, one person tosses a ball or beanbag to anyone in the circle.
- The student who catches it asks a question about the topic, then throws the ball or beanbag to another student who must answer the question. They, in turn, throw the ball or beanbag to another student, and ask a new question (and so on).

2.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think, remember and create

1. Create a mind map to describe your ideal learning environment.
2. Create a poem or song to describe yourself as a learner.
3. Design a game that helps others find out the type of learner they are and what their ideal learning environment is like.

Investigate and design

4. (a) Record images that you have when you think of the aromas of the following.
   - (i) Freshly baked bread
   - (ii) Garlic
   - (iii) Strawberries
   - (iv) Orange juice
   - (v) Manure
   - (vi) Freshly baked chocolate cake
   - (vii) Freshly mown grass

   (b) Compare your images with a partner. How are they similar and how are they different?

   (c) Design an experiment to find out which aromas relax you and which ones make you mentally alert.

2.3 Intelligence multiplied

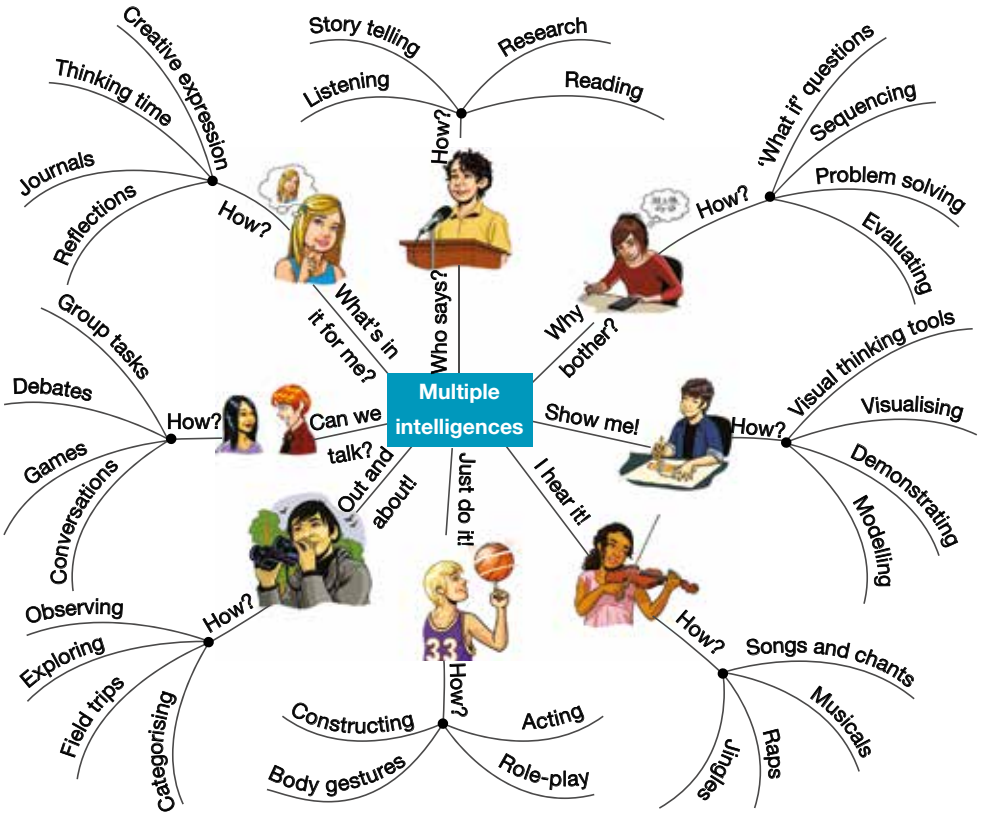
Science as a human endeavour

2.3.1 Intelligence multiplied

Did you know that it's not how smart you are that is important, but how you are smart? A great thinker by the name of Howard Gardner introduced a theory about eight different types of intelligence. He referred to these as:

- bodily/kinaesthetic intelligence
- verbal/linguistic intelligence
- logical/mathematical intelligence
- visual/spatial intelligence
- musical/rhythmic intelligence
- interpersonal intelligence
- intrapersonal intelligence
- naturalist intelligence.

By using a variety of strategies that use all types of intelligence, you can increase the effectiveness of your learning.



2.3.1 Mindful habits

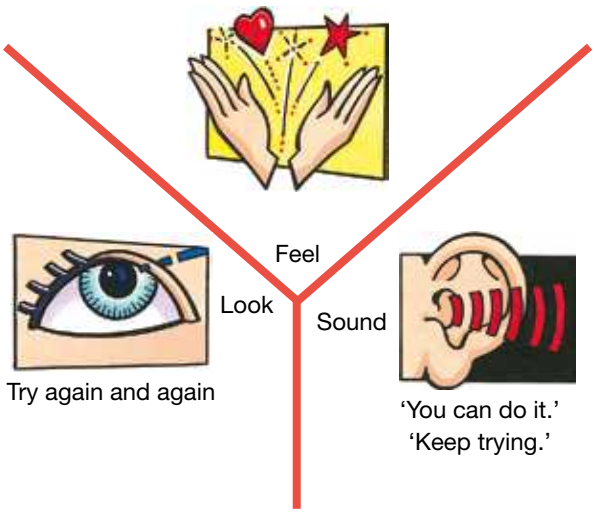
When on the 'road of life', it is a very good idea to be thoughtful about what you are doing. Sometimes it is less important to know something than to know how to act when you have that knowledge. Two 'mindful' thinkers Bena Kallick and Arthur Costa thought a lot about how some types of thinking and behaviour are more useful than others on our life's journey. They called these 16 types of thinking behaviours '**habits of mind**'. Why not use them on your journey on the road of life!



You can use your **multiple intelligences** to help you understand how to develop some very useful mindful habits. For example, using your verbal/linguistic, visual/spatial and intrapersonal intelligences, you can construct Y charts for what the mindful habits may sound like, look like and feel like. The following Y charts show you examples of this for 'persevering' and 'stopping and thinking before you leap'.

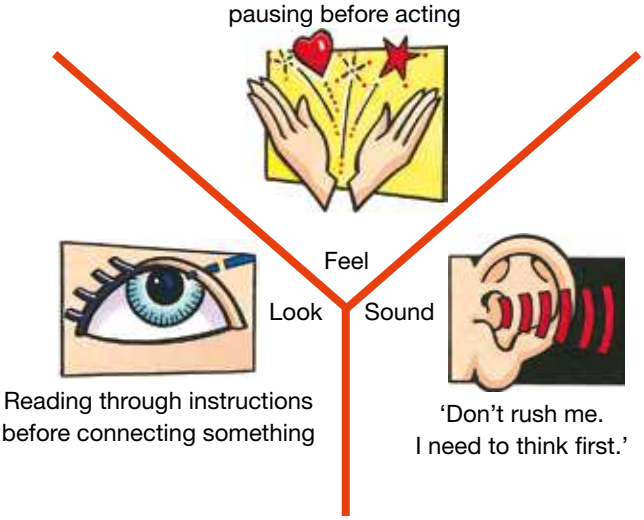
Persevering — persisting even when things get tough. Can you suggest other comments for this Y chart?

Giving it another go even though you want to give up



Stopping and thinking before you leap — considering the consequences first. Can you suggest other comments for this Y chart?

Taking a deep breath and pausing before acting



2.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Match each of the following statements to a multiple intelligence. For each type of intelligence, name a strategy that could be used to develop it.
   (a) What's in it for me?
   (b) I hear it!
   (c) Who says?
   (d) Just do it!
   (e) Why bother?
   (f) Can we talk?
   (g) Show me!
   (h) Out and about!
2. List three different mindful habits that you would like to focus on developing this month.
3. Which three multiple intelligences are used in a Y chart?

Think and discuss

4. (a) In your team, select three mindful habits.
   (b) Discuss how you could describe each of these mindful habits.

(c) For each mindful habit, brainstorm what it would 'look like', 'feel like' and 'sound like'. Record your brainstorm in a Y chart, cluster map or mind map.
(d) Compare your records with those of other teams.
(e) Make any modifications or additions you wish to your charts or maps.

5. Which mindful habits would be useful to develop your
   (a) logical/mathematical intelligence
   (b) musical/rhythmic intelligence
   (c) interpersonal intelligence
   (d) bodily/kinaesthetic intelligence?
6. Which mindful habit matches each of the following descriptions?
   (a) Working through frustration
   (b) Self-evaluating
   (c) Controlling quality
   (d) Wide-eyed
   (e) Adventurous
   (f) Cooperative
   (g) Trying hard to understand others
   (h) Curious
   (i) Diligent
   (j) 'Counting to 10' before acting
   (k) Looking at situations in alternative ways
   (l) Checking over your results several times
   (m) Compassionate
   (n) 'Hanging in there'
   (o) Laughing at yourself

Think and create

7. Use your musical/rhythmic or bodily/kinaesthetic intelligence to show three different mindful habits.
8. As a team, create examples of how you could teach a classmate something about 'mindful habits' using each of the different types of multiple intelligences.

Investigate

9. Find out the exact terms used by Kallick and Costa for the 16 habits of mind.
10. Find out more about metacognition and ways that you could do more of it yourself.

learnON RESOURCES — ONLINE ONLY

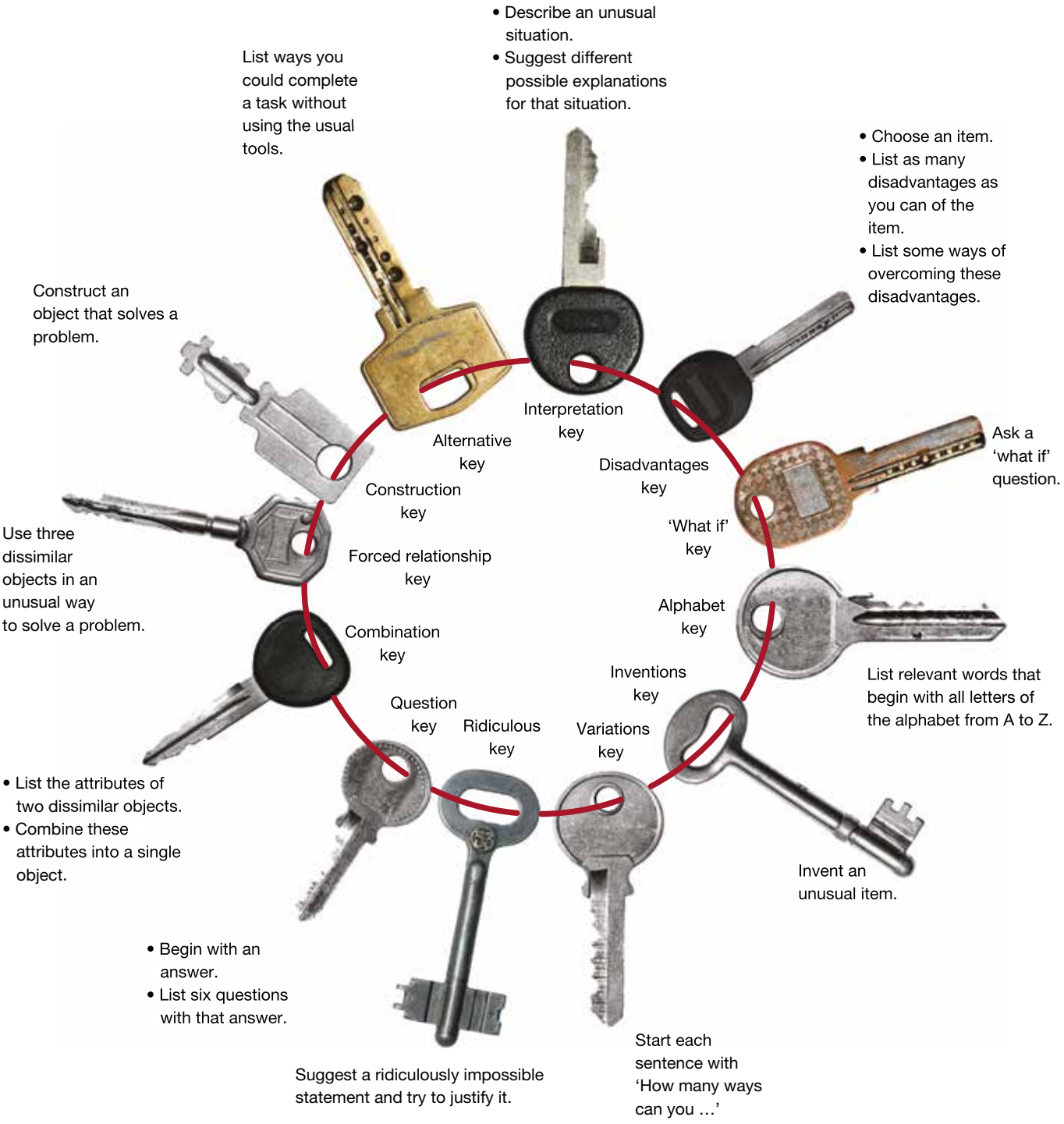
Complete this digital doc: Worksheet 2.2: Intelligence toolbox (doc-19795)

2.4 Thinking keys

Science as a human endeavour

2.4.1 Thinking keys

A creative thinker by the name of Tony Ryan developed the idea of '**thinking keys**' to unlock your thinking. The 12 thinking keys, and how they can be used, are shown on the next page. Different keys unlock different types of thinking. These keys can 'tune' or focus your brain into thinking about tasks, situations or problems in creative, logical or challenging ways.



These thinking keys can be used to:

- 'switch you on' — they can motivate you, get you excited or interested, or 'hook' you into thinking about something.
- 'open different doors' of your thinking — they can help you look at situations in different ways.
- 'unlock your thinking' — they can help you become more effective at thinking critically and creatively.
- 'unlock your feelings' — they can increase your interpersonal and intrapersonal experiences and help you to reflect.

2.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think and create

1. (a) Draw up a table with the column headings 'type of thinking key', 'switch you on', 'open different doors', 'unlock your thinking' and 'unlock your feelings'.
   (b) List all the thinking keys from the previous page in the first column.
   (c) Use a tick or cross in the other three columns to show which types of thinking each key may be used for.
   (d) Compare your results with those of others in your class.
   (e) Discuss reasons for any similarities or differences.
2. Use your 'what if' key to write a story about one of the following.
   (a) What if mosquitoes were the size of humans?
   (b) What if all plants were purple?
   (c) What if there were only female humans on Earth?
   (d) What if we could have holidays on Mars?
3. Use your 'disadvantages' key to unlock your thinking on a key, a test tube and a stapler.
4. Use your 'alphabet' key for one of the following.
   (a) Biological classification
   (b) Arthropods
   (c) An ecosystem
   (d) Water
   (e) Chemicals in your home
   (f) Food webs
   (g) Effects of rotation of the Earth
   (h) Effects of Earth's orbital motion around the sun
   (i) Weather and climate
   (j) Gravity
5. Use your 'variations' key to list as many ways as possible to do one of the following.
   (a) Hang out the washing
   (b) Get to school
   (c) Tell someone not to be a bully
   (d) Encourage a timid teammate to contribute to a discussion
6. Use your 'ridiculous' key to justify one of the following.
   (a) Children should be paid to go to school!
   (b) A ridiculous statement of your own choosing
7. Use your 'question' key for the following terms. Research the terms if you do not know what they mean.
   (a) Platyhelminthes
   (b) Arachnids
   (c) Diprotodon
   (d) *Bufus marinus*
   (e) Isobar
   (f) Convection
   (g) Colloid
   (h) Biodegradability
8. Use your 'interpretation' key for one of the following.
   (a) A fellow student with bright purple spots on their face
   (b) One of your teachers shrinking to the size of a coffee mug
   (c) A giant hole in the middle of your schoolyard
9. Use your 'combination' key to create items from two of the following.
   (a) Pen and sunglasses
   (b) Phone and a microwave oven
   (c) Paperclip and feather
10. Use your 'inventions' key for one of the following.
    (a) Banana peeler
    (b) Hat with four functions

(c) Attachment that can be worn on your finger to assist in your learning
(d) Earring with three functions

11. Use your 'construction' key to make a model of one of the following from household materials.
    (a) To show how mixtures can be separated
    (b) To illustrate how gravity affects objects on Earth
    (c) To demonstrate the water cycle
    (d) To show why we have seasons
12. Use your 'forced relationship' key to work out how to catch a cockroach with a match, a toothpaste tube and a mug.
13. Use your 'alternative' key to work out four ways to tie your shoelaces without using your hands.

learnON RESOURCES — ONLINE ONLY

Watch this eLesson: Unlocking learning: flowcharts, cluster maps and concept maps (eles-0856)

2.5 Learning together

Science as a human endeavour

2.5.1 Learning together



Who will your partner be today? How will they be selected? Once you have your partner organised there are lots of different ways in which you can interact.

There are also many different ways to 'pair up' to discuss your thoughts before they are shared with a larger group. It could be the 'shoulder partner' who sits next to you, or even a 'face partner' who sits behind or in front of you in class. You can even be paired with someone who is the same star sign or who has the same favourite learning colour or music. It's a good idea to work with as many different partners as you can to share your thoughts with throughout the year. You will learn a lot more and become a better thinker as you will have the opportunity to see things through different eyes and broaden the way that you see the world. Developing ways to communicate with your partners involves knowing what to say and when to say it.

2.5.2 Are you a good listener?

To communicate effectively with others also means being able to listen to others with respect, empathy and understanding. Do you really listen to what others are saying or are you rehearsing what you are going to say when it's your turn to speak? Are there other things going on that distract you from really listening to what is being said? What sorts of things do you find distracting? How could you be a better listener?

Are you easy to understand?

Are you a vague or specific communicator? Do you use specific terminology or do you overgeneralise? Do your thoughts spill out of your mouth in a jumble or are they organised and concise? What are some strategies that you could use to help you organise your thoughts? By organising your thoughts before you let them out, you can learn to express yourself with clarity and precision.

2.5.3 None of us is as clever as *all* of us!

You can learn a lot more when you learn with others. You learn not only the content of the topic you are studying, but also how to get along and work with other people. Developing helpful habits, such as well-developed social and collaborative skills, can be very useful throughout your life.

Getting along

There are many social skills that you can focus on developing during your teamwork. These include:

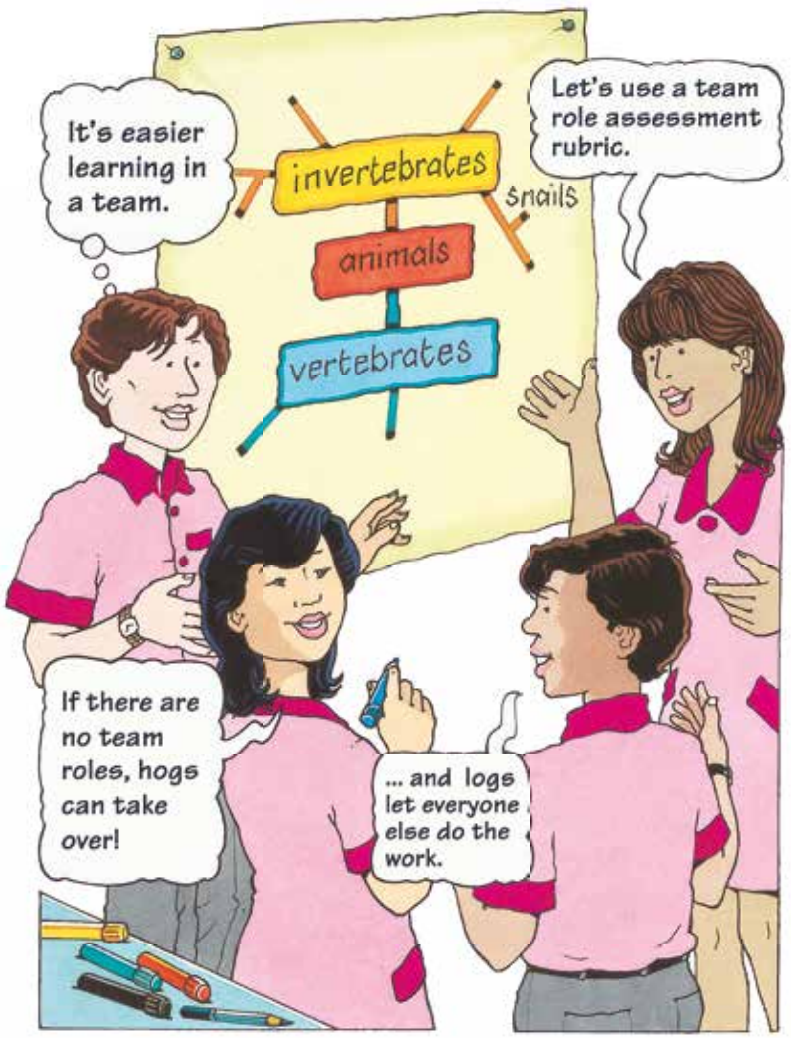
- resolving conflicts or disagreements respectfully
- controlling impulsive actions and comments that may hurt others
- looking at each other while you talk and using people's names
- using both non-verbal and verbal praise and encouragement
- actively encouraging others to be involved and feel valued.

Face to face

Some of the collaborative skills that you can develop while working as a team involve how you interact with your teammates. You can practise these by:

- actively listening with understanding and empathy
- being patient and understanding
- choosing fair ways to make decisions
- taking turns equally and not leaving anybody out
- criticising ideas rather than people
- sharing materials and equipment
- keeping each other focused and on-task
- being organised and well prepared, and managing time effectively
- helping others out when they have difficulties.

Often, establishing some learning team guidelines, such as 'only one person speaks at a time' or 'always being respectful of the feelings, opinions and space of others', can help you to interact effectively as a team.



Hogs and logs

One way to make teams work more effectively is to allocate roles. The illustration refers to diagram currently on previous page describes the various roles that can be allocated, including examples of the way a person in each role might talk or act. These roles help you to work effectively together, particularly if you are given a project or a discussion topic but not told exactly how to perform the project or discussion.



INVESTIGATION 2.2

Helpful habits

AIM: To learn some strategies for working in a team

1. In your team, discuss the following helpful habits and suggest (i) how they can be useful to both the individual and the team, (ii) some strategies that could be used to develop them, and (iii) some obstacles that make them difficult to achieve.
   (a) Persistence (optimism, sticking to the job, effort and hard work)
   (b) Confidence (failing wisely, taking responsible risks and speaking up)
   (c) Resilience (keeping perspective, maintaining your cool and bouncing back)
   (d) Organisation (goal setting and time management)
   (e) Social skills (tolerance, following instructions, resolving conflicts, managing impulsive behaviour)
2. Share and record the findings of your discussion with other teams and then collate them all into a class instruction and information booklet on helpful habits for your team activities.

2.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think and communicate

1. What is empathy? What do you think it means to listen with empathy? What does empathy look like, feel like and sound like? Show your teammates examples of how you could listen to someone with empathy.
2. In your team, brainstorm as many ideas as you can that:
   (a) would help you to listen to what others are saying
   (b) hinder or get in the way of listening to others.
   Summarise your brainstorm into a colourful mind map with diagrams, pictures or sketches.
3. Complete the following activity in a pair.
   (a) Partner A listens to partner B speak for three minutes about their favourite topic or hobby. Partner B must not interrupt, make any comments or ask any questions during this time.

(b) After the three minutes, partner B paraphrases what the speaker, partner A, said.
(c) Partner B may then make appropriate comments or queries.
(d) Repeat steps (a) to (c) with the roles reversed.
(e) Construct a PMI (plus, minus and interesting) chart to summarise your feelings and comments on this experience.

4. In a pair, act out the following:
   (a) What do all birds have in common?
   (b) You have found yourself in the year 2050. What is it like?
   (c) You have just discovered a new form of life under the microscope. What does it look like?
   (d) Gravity on Earth has increased by three times. How does this affect life on Earth?
5. Partner A of your team pair chooses one of the following activities. Partner B suggests some information. Partner A then adds another suggestion to build onto the answer. Then you both take turns building on each other's answers.
   (a) List the differences between mosquitoes and butterflies.
   (b) Describe a day in your life as an ant.
   (c) Recall all you can about snails.
   (d) Create a mind map to show all you know about spiders.
6. In a team, brainstorm as many different ways as you can to select partners within your class. If any of these are games, outline the rules that would be involved.
7. In pairs, suggest four reasons why a team of four enables more effective communication than a team of three members. Discuss your suggestions in a group of four.
8. Find someone in the class who matches one of the criteria in the list below. Get them to sign their name next to the criterion. No person can sign more than one criterion. As you are seeking out criterion–classmate matches, think carefully about how you are communicating with them. Think about both your verbal and non-verbal messages during your communication.
   (a) Likes to get up early
   (b) Loves music of the 70s
   (c) Watches old movies
   (d) Sends text messages more than three times a day
   (e) Keeps a diary or journal
   (f) Has a younger brother
   (g) Has a pet cat
9. In your team pair, take turns telling each other what you think about:
   (a) the benefits of eating breakfast
   (b) the reasons people decide to become scientists
   (c) life as an astronaut.

Create

10. Use the illustrations in this section to make up your own poster illustrating the roles, team talk and team actions.
11. In a team, consider how you think team members should be assessed on their effectiveness. Design a rubric similar to the one shown below to evaluate how well each member of the team did their job and how well the team worked together.

Think

12. Suggest how you can create a good relationship with other members of the team. Why not make a list of 'getting to know you' questions that you all can answer?
13. Make up your own team/group identity. Decide on a name, logo or a group cheer/handshake.
14. Brainstorm phrases and actions that would help you perform effectively in each of the cooperative roles shown in the previous illustration.

Example of an assessment rubric

	Score			
Role/task	**0**	**1**	**2**	**3**
A				Job always done really well
B	Not done			
C			Usually ok	
D		Sometimes job done well		

2.6 Unlocking learning

Science as a human endeavour

2.6.1 Learning can be scary!

Learning can be scary! It can be full of lots of words and experiences that are new to you. It can also be messy, frustrating, difficult and time consuming. So . . . why learn? Why bother?

If you are told something, does that mean that you have learned it?



2.6.2 Listening isn't learning

Teaching is more than telling, and learning is more than listening. Although you may learn many things by listening, just 'being told' is not the most effective way to learn. You may be able to remember some of what you heard, but you may not understand it. Think about the last lesson that you were in. What do you remember from it? What did you learn? What did you understand? What does it mean 'to understand'?

Are you an active or a passive learner?

Do you lift the lid on your brain and wait for information to be poured in? Are you a passive learner? If so, you may not be learning very much. You need to be actively involved in your learning to get the most out of it.

If you are an active learner then you have more chance of developing an understanding of what you are learning. You are more likely to be able to remember it and explain it to others. Very importantly, you will be better equipped to be able to transfer this learning into new situations. This is a very valuable life skill to develop. It is an especially important skill for a scientist.

If it gets too hard, do you just give up?

What do you do when you are introduced to something new? What do you think? Do you try to connect this new information to what you already know? If so, how do you go about it? Do you ever give up because it looks or sounds 'too hard'? If you do get stuck in your learning, what can you do to move on? What sorts of questions and strategies could you use to help get through the difficult and frustrating times in your learning?

2.6.3 Linking your learning

When possible, it is a good idea to try to link your new learning to your previous knowledge. At times, you may even find that your new learning may change how you think about things! As well as learning new things, it is worthwhile thinking about strategies that you used to 'move' from what you used to know to what you now know. This type of thinking about your thinking (metacognition) will help you to become a more active and effective learner.

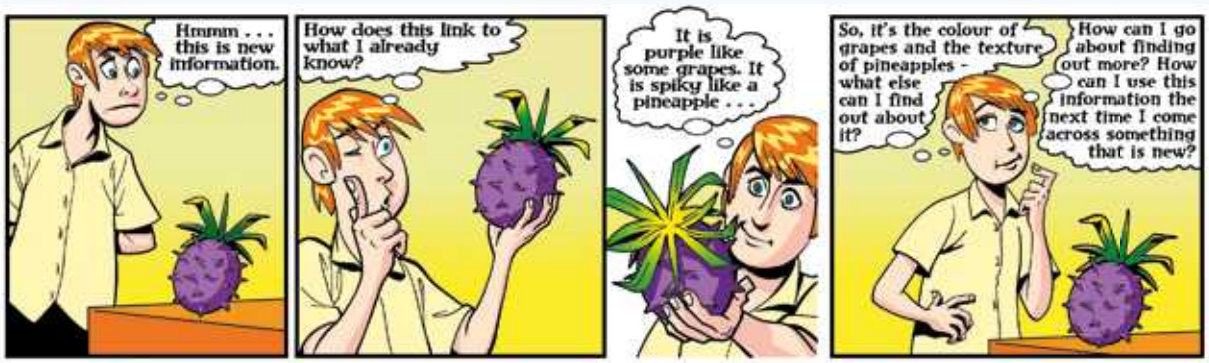
Recognising what is new is a great way to start learning

What do you do when you come across a word that you haven't seen before? Does it contain parts that you have seen before in other words? Do these parts of the word give you a hint about its meaning? Sometimes

this may be helpful — at other times, you need to find other ways to help you learn the new terms and link them to what you already know.

The first step is to recognise the new term. The next step is to remember what it means and what other terms or ideas it could be linked to. It may be helpful to talk to others and to tell them how you remember the term and hear how they go about it. This type of shared learning can be quite powerful in helping you to develop your scientific literacy. It can help you to learn new ways to be able to communicate what you know. Talking and sharing your learning can help you get closer to understanding what you are learning.

What do you think when you are introduced to something new?



2.6 Exercises: Understanding and inquiring

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Think, investigate and discuss

1. (a) Construct a table with two columns. Label the first column 'Learning question' and the second column 'My response'.
   (b) In the first column, write the questions from the *If it gets too hard, do you just give up?* section.
   (c) Add your responses to the questions in the second column.
   (d) With a partner or within a small group, discuss your responses.
2. Discuss with your partner or team how the 'habits of mind' (see section 2.3) may help you to be a more effective and active learner.
3. Create a cartoon to show what two of the following might look like in your classroom.
   (a) Passive learning versus active learning
   (b) Metacognition or 'being aware of your thinking'
   (c) Persevering when 'stuck' in your learning
   (d) Making links between 'old' knowledge and 'new' knowledge
4. (a) Make up your own set of term recognition cards. On one side write the following statements and on the other side add a coloured circle, as in the table below.

On front of card	On back of card
Never seen the term before	Red circle
Recognise the term	Orange circle
Recognise the term and can give definition or description	Yellow circle
Recognise the term and could help others to understand it	Green circle

(b) These cards can be used at the beginning and end of each topic you study. You can create your own list of the words in bold in the chapter or use a list supplied by your teacher. Score each term between 0 (never seen the term before) and 3 (recognise and could help others to understand the term). Use this to inform yourself and your teacher about where you are in your learning of these terms.
(c) Score each of the terms in the table below. Either as a class or in a team, hold up the card for each term. Share what you know about the terms with others in your team or class.
(d) Use a variety of sources to collect information on each of the terms and then construct a mind map or concept map to link them (you may add other terms that are not on the list).

How well do you recognise these terms?

Term	Term comfort zone (circle the appropriate score)			
Mollusc	0	1	2	3
Cnidarian	0	1	2	3
Arthropod	0	1	2	3
Amphibian	0	1	2	3
Annelid	0	1	2	3
Reptile	0	1	2	3
Vertebrate	0	1	2	3
Echinoderm	0	1	2	3
Marsupial	0	1	2	3
Nematode	0	1	2	3
Invertebrate	0	1	2	3
Monotreme	0	1	2	3

2.7 Question keys

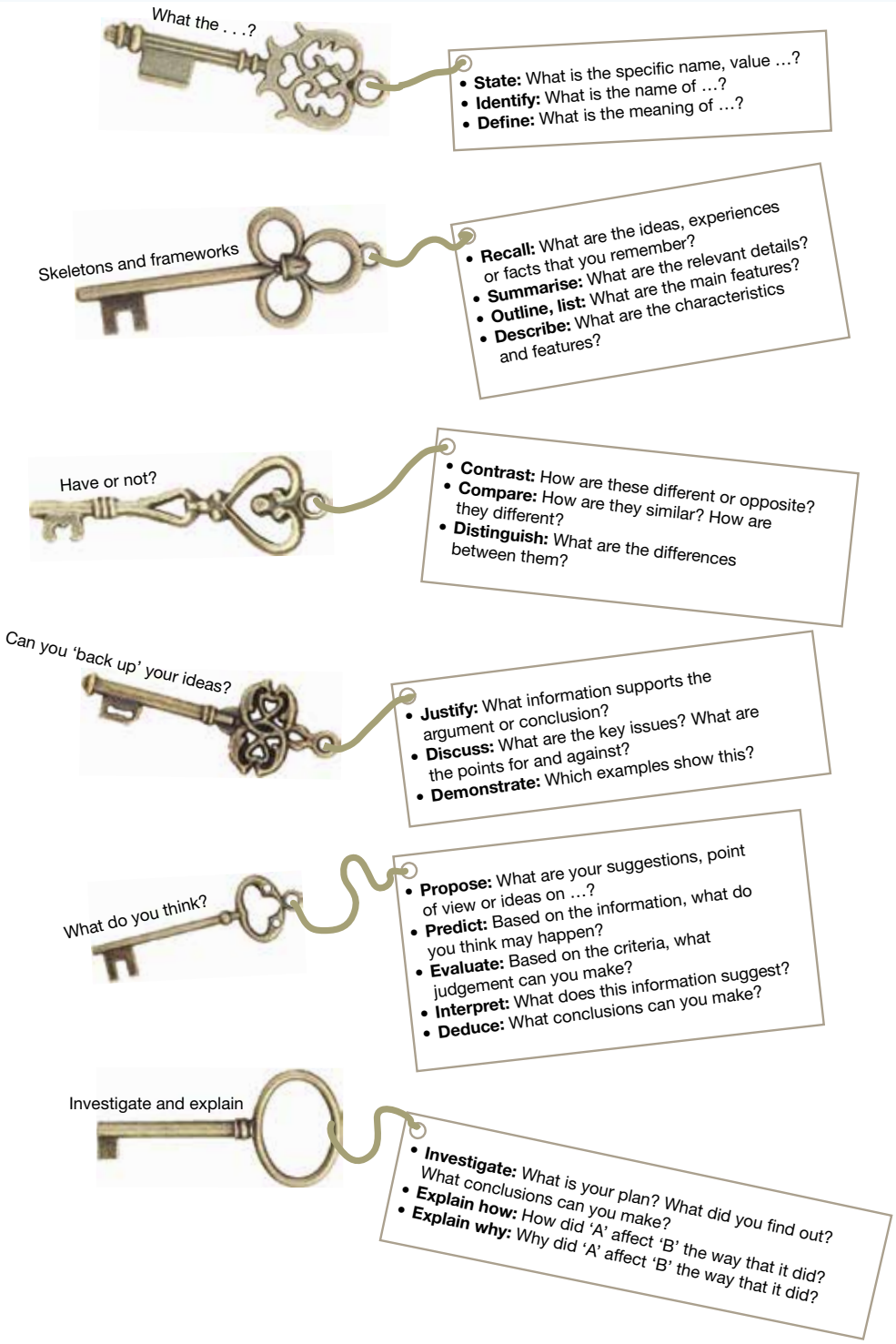
Science as a human endeavour

2.7.1 Levels of thinking

How do you find out what a question is asking?
How can you unlock it?
Are there any clues?
What are the words in questions that tell you what to do?

Some question words, such as ‘identify’, do not require much thinking and may just require you to recognise and recall a name or list of names. Others may require you to think quite deeply and make comparisons or predictions, while other question words may expect you to explain your reasoning and understanding. Yet others, such as ‘construct’ or ‘design’, may require you to build, create or investigate a particular object or problem.

Question keys can unlock what the question is asking.



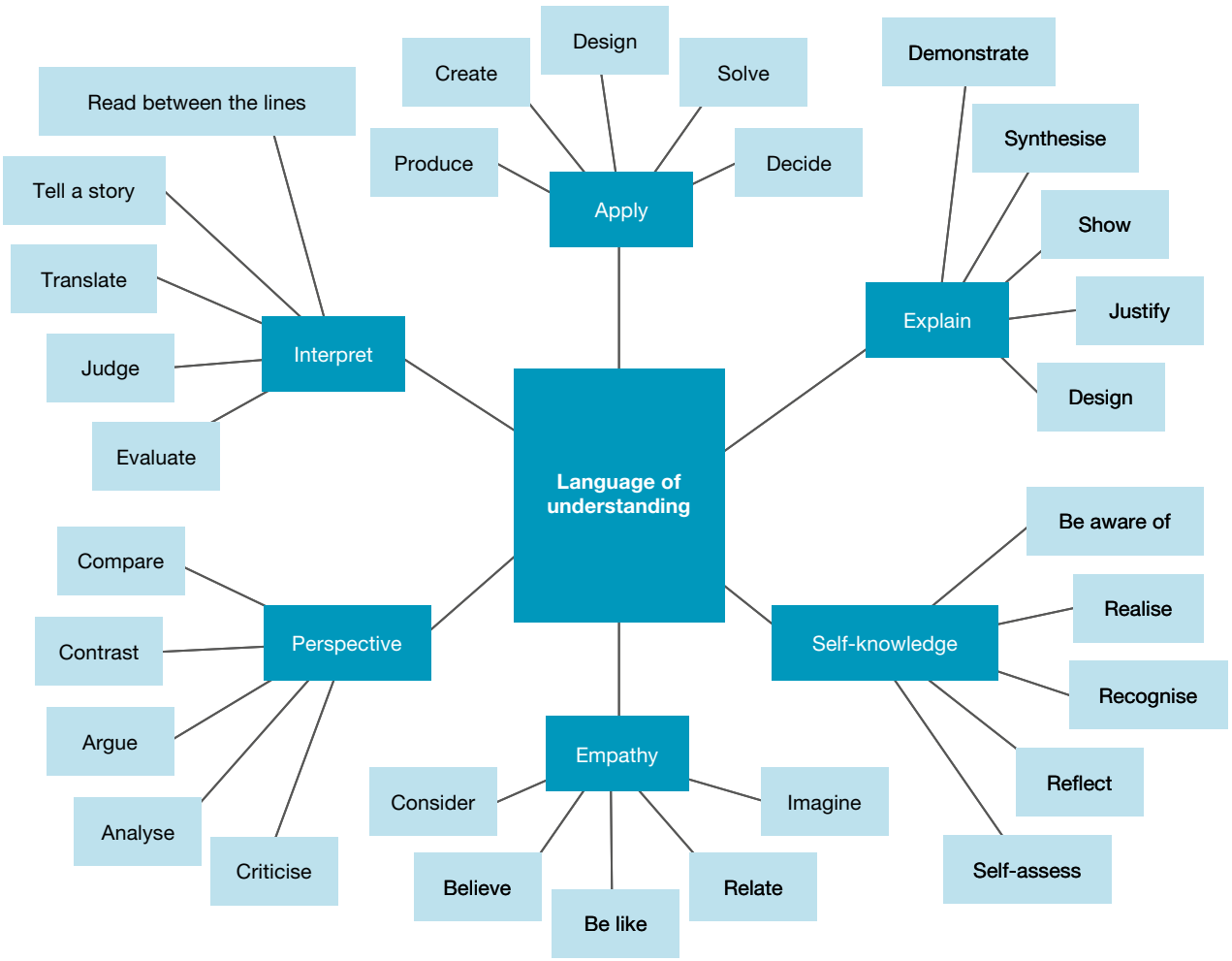
2.7.2 *Science Quest* question patterns

When you browse through the 'Understanding and inquiring' questions for each section in this text, you may see a pattern in the question terms that are used. In the 'Remember' sections, the information that you need to answer the question will be located somewhere in that section. You won't need other resources to find the answer. The question words that you will find in this section include: *define*, *identify*, *outline*, *which*, *list*, *what is*, *recall and describe* and *explain why*.

In the ‘Think’ sections, you need to consider the information in the pages of the section, but you may also need to think or discuss to be able to respond to the question. You may need to do something more with the information other than simply recall it. Examples of question words in these sections include: *identify*, *explain*, *state how*, *what would*, *calculate*, *classify*, *differentiate*, *justify*, *outline*, *summarise*, *construct*, *compare and contrast*, *propose* and *interpret*.

The ‘Analyse’, ‘Investigate’ and ‘Design and create’ sections often require you to think even more deeply about the question and your response. In the ‘Analyse’ sections you may need to *suggest*, *predict*, *evaluate* or *interpret*, whereas for the ‘Investigate’ sections you may need to *design* an investigation, *conduct* it and *explain* the results that you get. The ‘Design and create’ questions may require a different type of thinking. You may need to use your imagination and creativity to apply what you have learned to *design* and *create* or *construct* something.

When you are trying to make sense of words associated with understanding, it is helpful to divide them into categories. There are many different ways of doing this. You just need to find the way that suits you.



2.7 Exercises: Understanding and inquiring

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Remember

1. State two question words that could require you to respond with the name of something.
2. Identify the term used to ask you what the meaning is of something.
3. Distinguish between the terms 'contrast' and 'compare'.
4. Compare the terms 'predict' and 'evaluate'.
5. State one new question word that you learned today. Describe how you are going to remember it.
6. List the types of question words that you could find in each of the *Science Quest* 'Understanding and inquiring' sections (in the blue panels).

Think and discuss

7. Propose an idea for a school science excursion.
8. (a) Predict what you are going to have for dinner tonight.
   (b) Justify your suggestion in part (a).
9. Demonstrate that you understand the meaning of the term 'deduce'.
10. Explain how you go to school.
11. Explain why you go to school.
12. (a) Formulate five questions of your own about scientific topics.
    (b) Suggest how you could find out the answers to them.

Investigate

13. Etymology is the study of the origin of words. Find out about and report on one of the question words on these pages.
14. Create a rhyme, story, poem or song to help you remember the meaning or use of four question words on this page.
15. Research a current Australian scientific issue (for example, involving the environment, medicine, genetic engineering, nanotechnology or stem cell research) and use a PMI (plus, minus and interesting) chart to summarise the key points of the issue.

2.8 'See Quest' tools

2.8.1 Structuring your thinking

There are so many different ways to see and share what is happening inside your brain. Here are some tools that can be used to make your thinking visible so that you can share and discuss it with others.

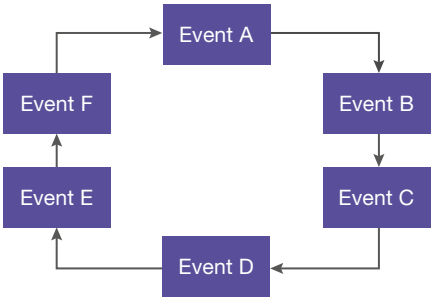
Like a builder, it is important for you to use the right tool to get the job done.

- **Storyboards**, **flowcharts**, **timelines** and **cycles** are useful tools to sequence your thoughts.
- **Matrixes** and **SWOT analysis charts** are useful when you want to classify or organise your thoughts.
- **Priority grids**, **target maps**, **continuums** or **pie charts** can be used to quantify or rank ideas.
- **Concept maps**, **PMI charts** and **Y charts** help you to visualise or reflect on an idea.
- **Venn diagrams** and **fishbone diagrams** are useful tools to focus your thoughts, such as when you need to analyse and compare things in order to make a decision.

There are also times when combinations of these tools can help you to use your brain and time more effectively.

Order or sequence

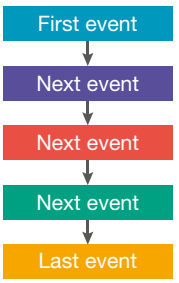
Cycle



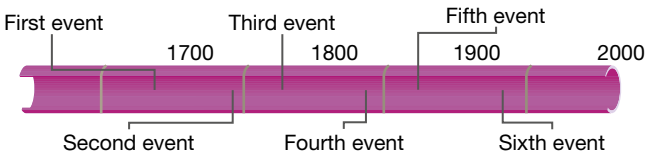
Storyboard

A	B	C
Outline of scene 1	Outline of scene 2	Outline of scene 3
D	**E**	**F**
Outline of scene 4	Outline of scene 5	Outline of scene 6

Flowchart

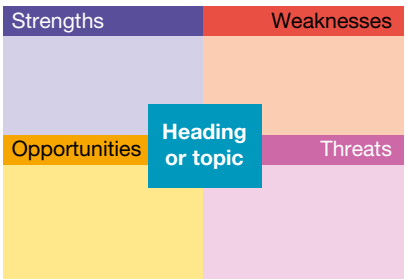


Timeline



Analyse or compare

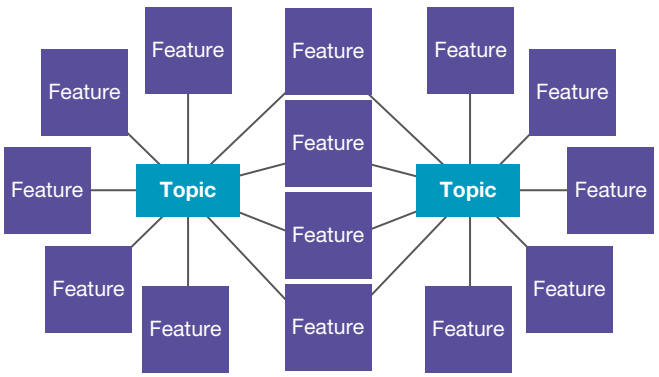
SWOT analysis



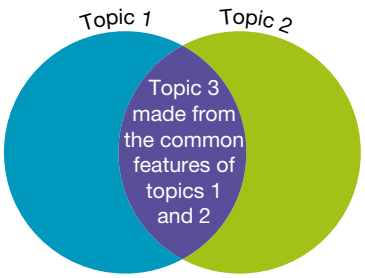
Matrix

Topic	Feature A	Feature B	Feature C	Feature D	Feature E
1	✓		✓	✓	✓
2		✓			✓
3		✓		✓	✓
4			✓	✓	✓

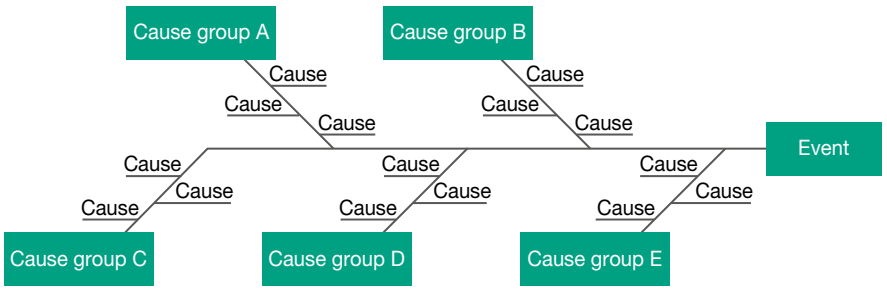
Double bubble map



Venn diagram

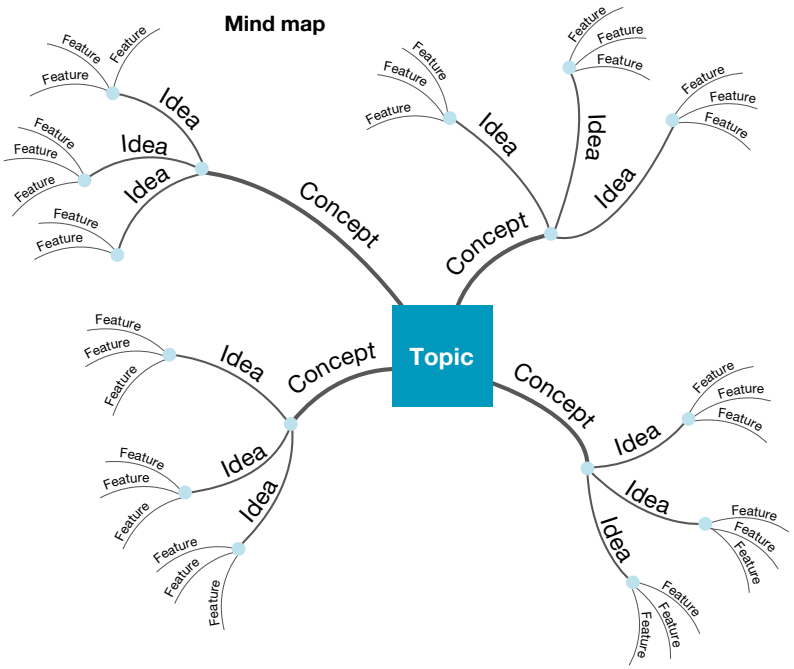


Fishbone diagram

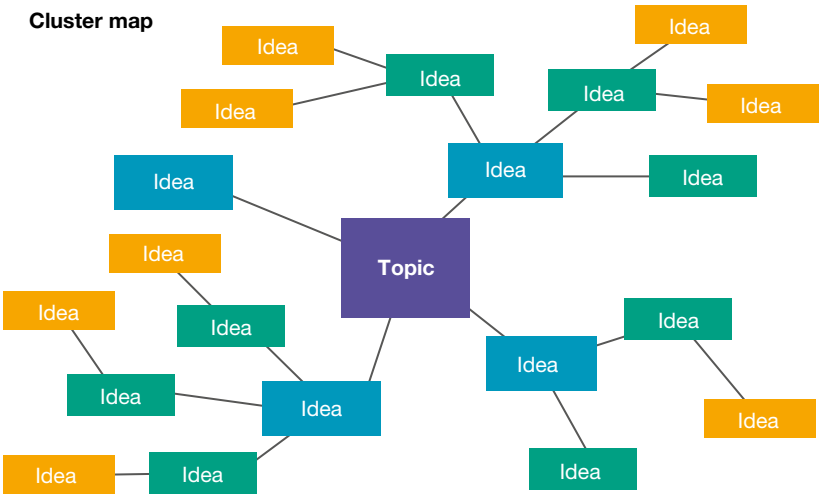


Visualise or reflect

Mind map

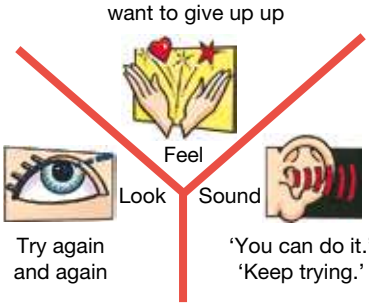


Cluster map



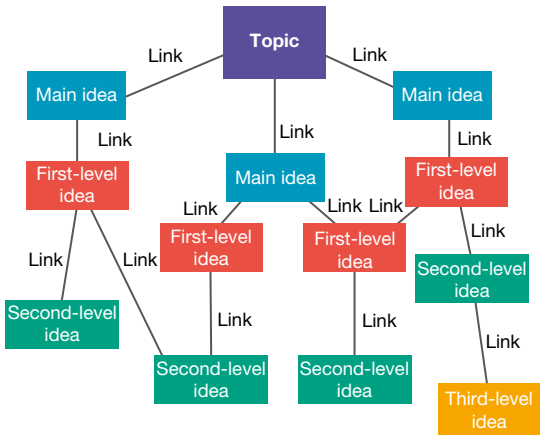
Y chart

Giving it another go even though you want to give up up



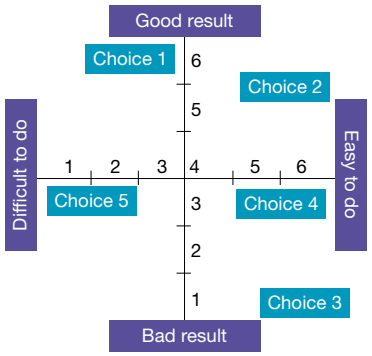
PMI chart

Topic/theme/idea		
Plus	Minus	Interesting
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•



Quantify or rank

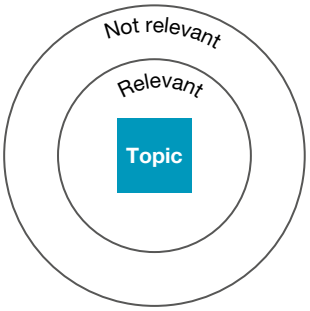
Priority grid



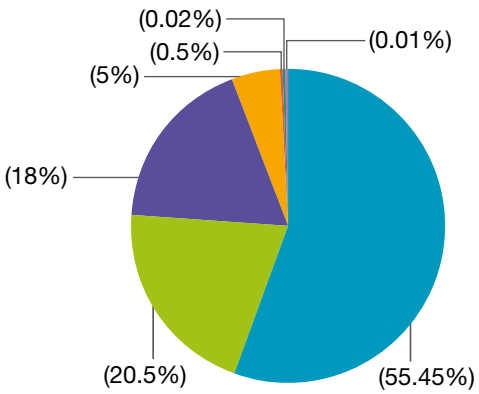
Continuum



Target map



Pie chart



2.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. State the visual thinking tools that are best for helping you to:
   (a) sequence your thoughts
   (b) classify information
   (c) quantify or rank ideas
   (d) analyse and compare.

Think and discuss

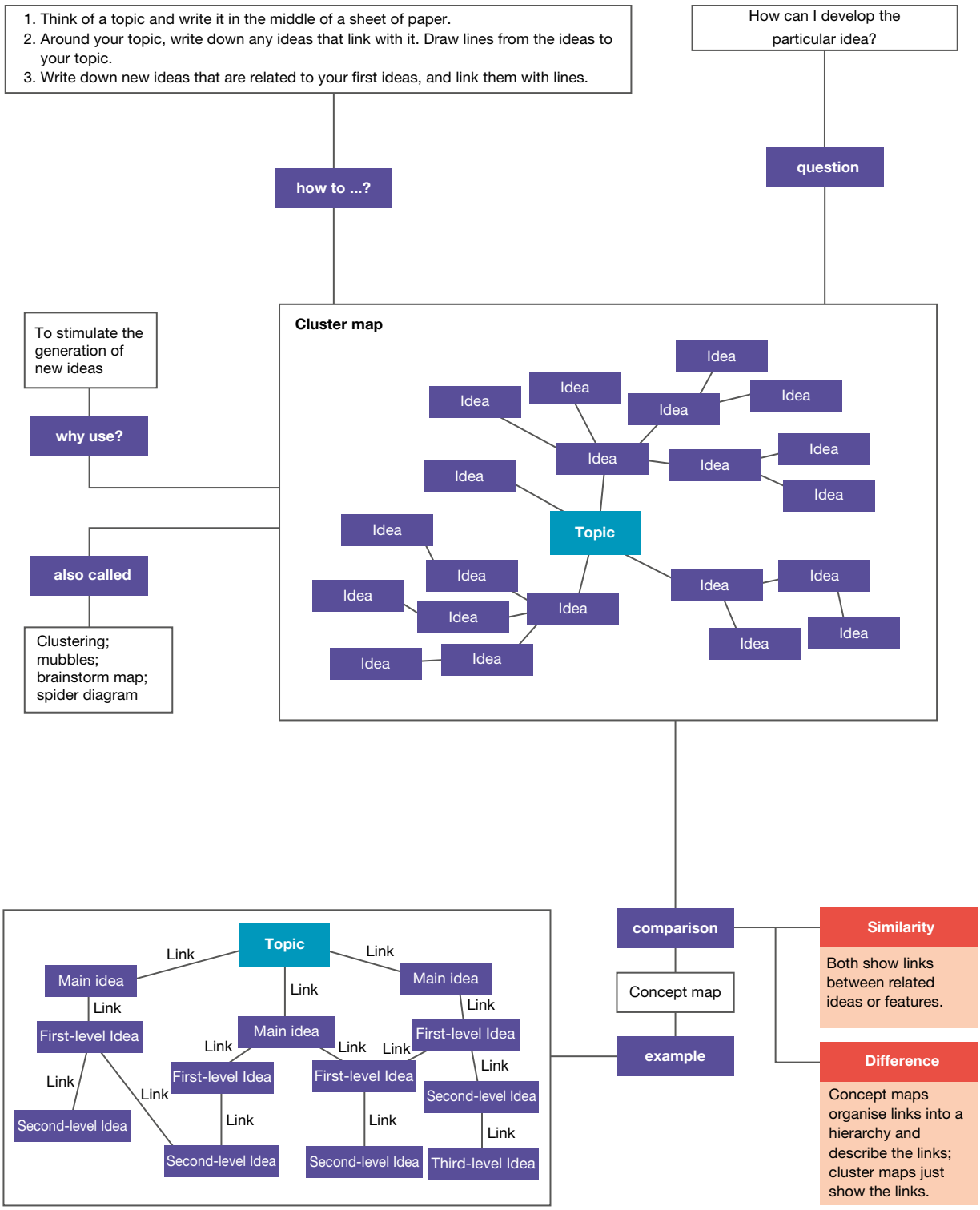
2. Select a different visual thinking tool to respond to each of the following.
   (a) To instruct someone how to tie a shoelace or a necktie
   (b) The similarities and differences between the stories of *Goldilocks and the three bears* and *Jack and the beanstalk*
   (c) The amount of chocolate eaten in a week for each member of your class

learnON RESOURCES — ONLINE ONLY

Complete this digital doc: Worksheet 2.3: Mapping your future (doc-19796)

2.9 Cluster maps and concept maps

2.9.1 Cluster maps and concept maps



2.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

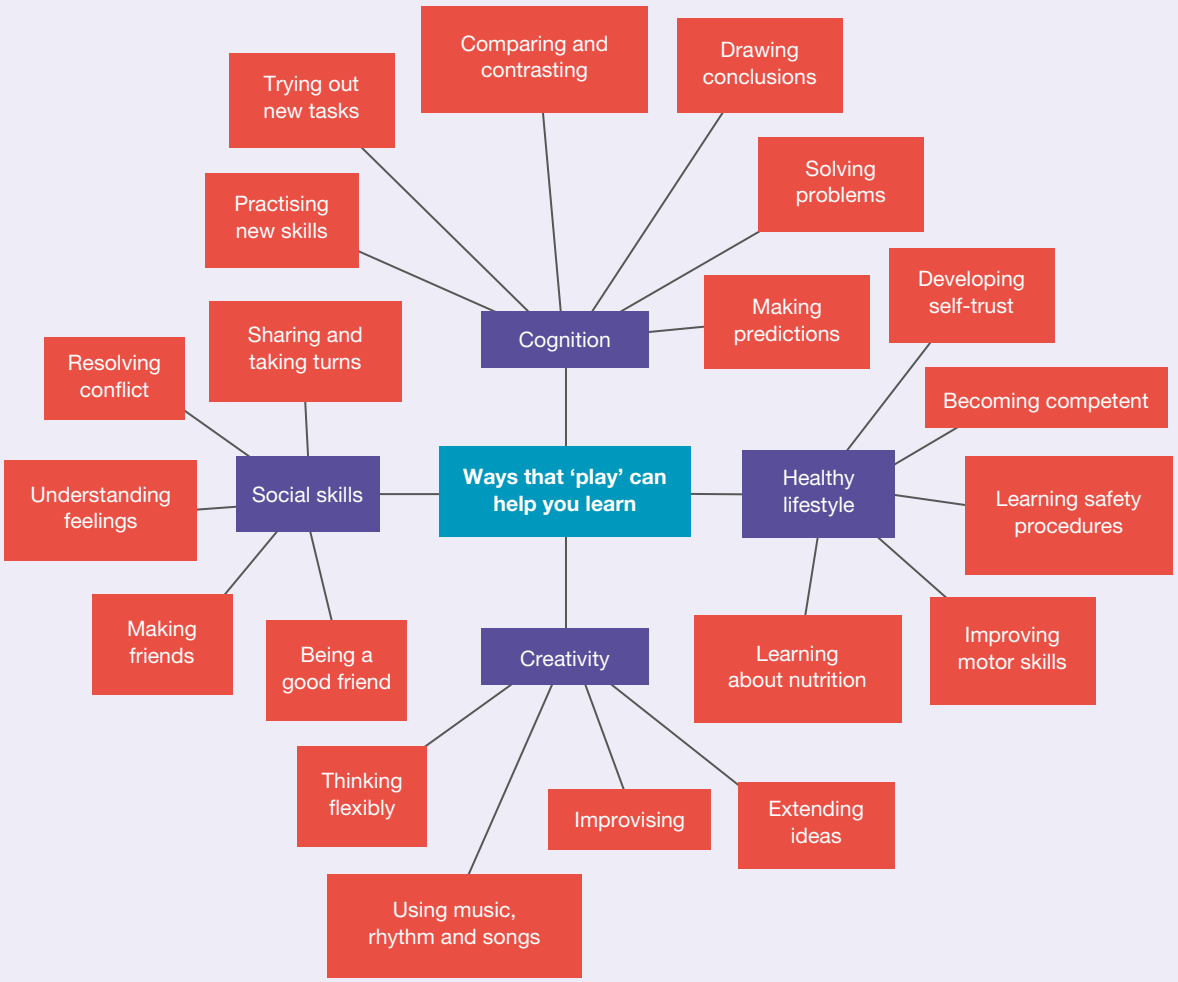
Think and create

1. (a) The cluster map below gives examples of how 'play' can help you to learn. Form teams of four and then divide into pairs. Each pair in the team has the task of constructing two cluster maps, based on two of the following 'play' themes: cognition, healthy lifestyle, creativity, social skills.

   Report back to your team with your maps and discuss each in detail. Add any other suggestions you wish to each map. Share and discuss the maps constructed by the entire class in a gallery of cluster maps.

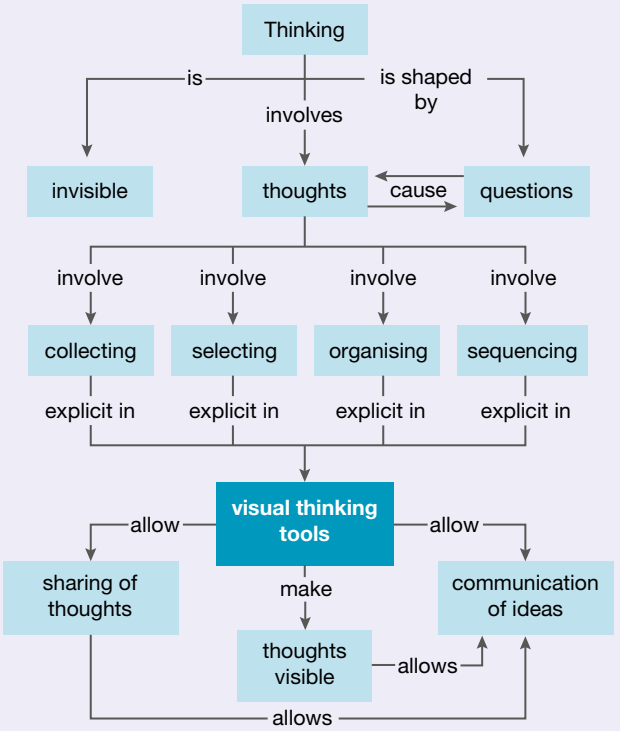
   (b) Divide the following themes within the class and construct assessment rubrics for each theme.

   (i) Being a good friend
   (ii) Resolving conflict
   (iii) Sharing and taking turns
   (iv) Making predictions
   (v) Improving fine motor skills
   (vi) Developing self-trust
   (vii) Thinking flexibly
   (viii) Extending ideas



2. The concept map at right shows how thinking tools can be used to:
   - show your thinking about your thinking
   - help you to think in different ways.

   (a) Suggest how concept maps can help you to communicate your thoughts and ideas with others.
   (b) Construct your own concept map on ways that help you to communicate your ideas.
   (c) Construct a cluster map to show ways in which asking questions can help you to learn.
3. (a) Create a cluster map for the information shown in section 2.11.
   (b) Compare and discuss your concept map with at least three others in the class.
   (c) On the basis of your discussions, modify your concept map to include your new ideas or links.
   (d) How effectively do you think you communicated your cluster map information to others? How effectively do you think others communicated information to you?
   (e) Suggest ways in which communication could have been improved.
   (f) Comment on how this question benefited, changed or added to your thinking.

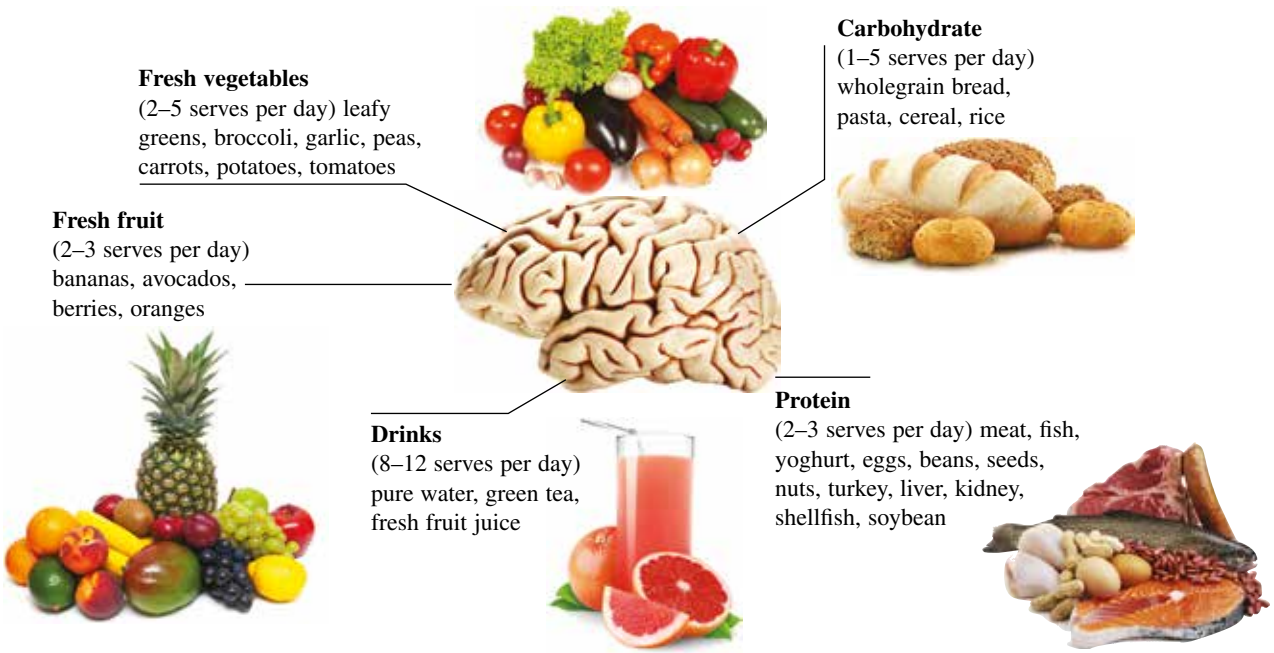


2.10 Feeding your brain

Science as a human endeavour

2.10.1 Brain 'food'

When your brain gets 'hungry', it needs oxygen and glucose as 'food'. Breathing helps you to feed your brain oxygen. You breathe more during exercise to ensure that your brain gets the oxygen it needs. You also feed your brain glucose from the foods that you eat.



HOW ABOUT THAT!

It is better for your brain if you nibble during the day, rather than having one or two big meals. Too much time between meals can cause loss of concentration and decreased alertness. Do you eat to get rid of hunger or boredom, rather than for optimal learning? Before you put that next piece of food into your body, think what else it can do for you!

2.10.2 Feeling thirsty?

Dehydration is a very common problem that is linked to poor learning. As the brain is made up of 80 per cent water, this is another very important 'food' for the brain. Dehydration can result in a loss of attentiveness, and then tiredness, laziness and sluggishness can set in.

When you feel thirsty it means that the amount of water in your body has dropped, and that the salt concentration in your blood is increasing. An increase in salt levels in your blood can lead to the release of fluids from your cells into your bloodstream. This can result in an increase in your blood pressure and increase in stress. Drinking water can decrease these effects within five minutes.



2.10.3 'Brekkie' for the brain

Some of the foods that you eat contain proteins. Protein foods that are best for boosting your alertness and mental performance include eggs, fish, turkey, tofu, pork, chicken and yoghurt. This is because proteins are made up of amino acids, which can have different effects on the brain. For example, the amino acid tyrosine enhances thinking, while tryptophan has a calming effect.

Your brain also uses tyrosine to make chemical messengers such as dopamine and norepinephrine, which are very important for alertness, quick thinking and fast reactions. Norepinephrine enables your body to 'get up and go' when action is required. This might be when you are riding a roller-coaster, are involved in an accident, or when there is a conflict from which you need to 'fight' your way out. At school, norepinephrine may be useful in doing maths calculations, maintaining your attention span and increasing your conscious awareness.

In these types of situations, norepinephrine is released all over your body and it increases the blood flow to your brain, which increases your alertness. Too much norepinephrine can make you feel 'hyper' and stressed; too little can cause drowsiness and make you feel 'out of it'. Foods in which tyrosine is found include meats, fish, eggs, tofu and milk products. If you want to get your day going, a 'thinking breakfast' including any of these would be a great start!

2.10.4 Minerals and your A, B, Cs

Vitamins that are very important to learning include vitamins A, C, E and most of the Bs. These vitamins assist our alertness, memory, visuo-spatial ability, attention span and planning/organisational skills.

Minerals that are important to learning include magnesium, sodium, potassium, zinc, iron, boron and selenium.

Other hungry-brain foods

Leafy green vegetables, salmon, nuts, lean meats and fresh fruits are some other brain foods.

A chemical called calpain is found in milk, yoghurt and leafy green vegetables (such as spinach and kale). It is thought to act as a 'cleaner' for spaces between your neurons, making transmission of neuron messages more efficient and hence helping the effectiveness of your learning.

2.10 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. State the two 'foods' that your brain is most hungry for.
2. What is the name of the chemical that is the sole source of fuel for your brain cells?
3. Why is dehydration linked to poor learning?
4. What effect can drinking coffee and tea have on the amount of water available to your brain?
5. List five examples of protein foods that are best for boosting your alertness and mental performance.
6. (a) List four foods that are sources of tyrosine.
   (b) What is the link between tyrosine and norepinephrine?
   (c) Suggest how norepinephrine is useful for your learning.
7. Name the chemical in milk and yoghurt that acts as a 'cleaner' for the spaces between your neurons.

Investigate and design

8. Design an experiment to find out which aromas relax you and which make you mentally alert.
9. (a) Research cookbooks for recipes that are good for your brain.
   (b) Make up a class 'brain food' cookbook.
   (c) Have each class member prepare a 'brain food' and have a class 'brain feast'.
10. In groups, design and make thinking breakfasts and lunches that you can share at school.
11. (a) Keep a diary for a week to determine which times of day you find learning and thinking the easiest and the hardest. Include what you have eaten and when in your diary.
    (b) Do you have learning highs and lows?
    (c) Does the type of food eaten or time it was eaten have any effect?
    (d) Compare your thinking and learning diary with other teammates. What are some interesting similarities and differences?

Investigate

12. Brainstorm a list of examples of thinking foods. Survey your school canteen or cafeteria to find out how many of these thinking foods they have.
13. (a) Megadoses of vitamins can be toxic. Find out the recommended amounts of vitamins A, B, C and E for your age group.
    (b) Many vitamin supplements are absorbed better if taken with some foods than with others. Find out which foods increase absorption and which decrease absorption.

2.11 Discovering your brain

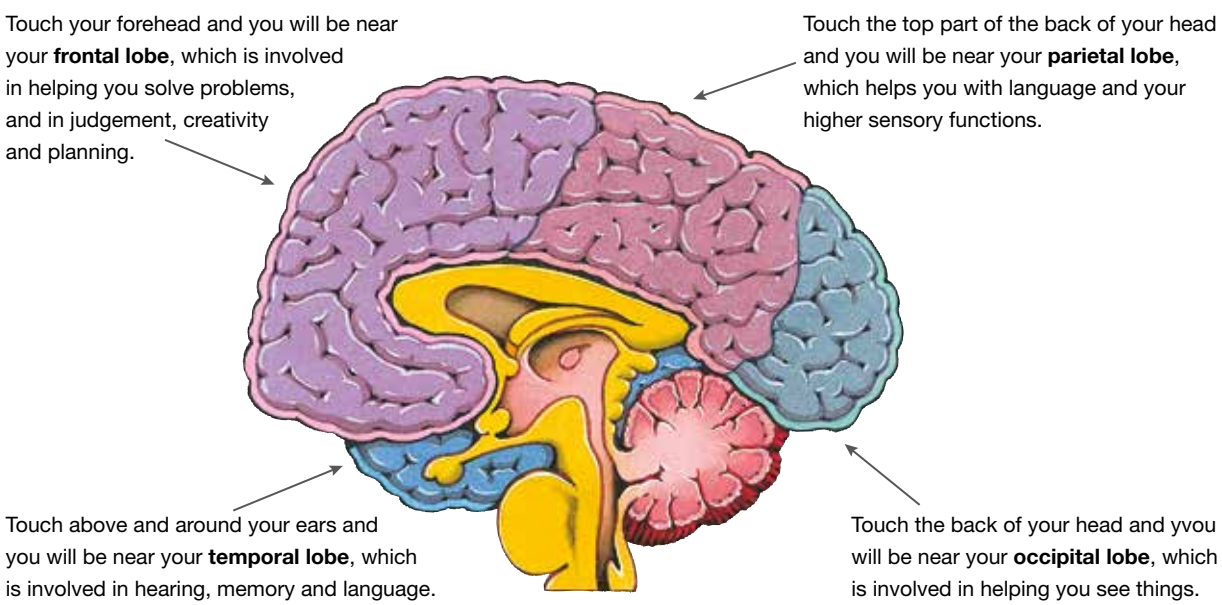
2.11.1 How often have you thought about your brain?

Throughout the day your brain is constantly registering your environment and monitoring vital signals such as your heart, hormone levels, breathing and digestion. It is also continually matching new learning with that from your past, and attaching emotions to each event and thought, to make patterns of meaning that make up the 'total picture'.

2.11.2 Celebrating your cerebrum

The largest part of the brain is called the **cerebrum**. It makes up about 80 per cent of your brain and is responsible for higher order thinking and decision making. Your cerebrum is made up of billions of nerve cells (called **neurons**), with four primary areas called **lobes**. The functions of the four lobes are described in the diagram below.

The four primary areas of your cerebrum are called lobes.

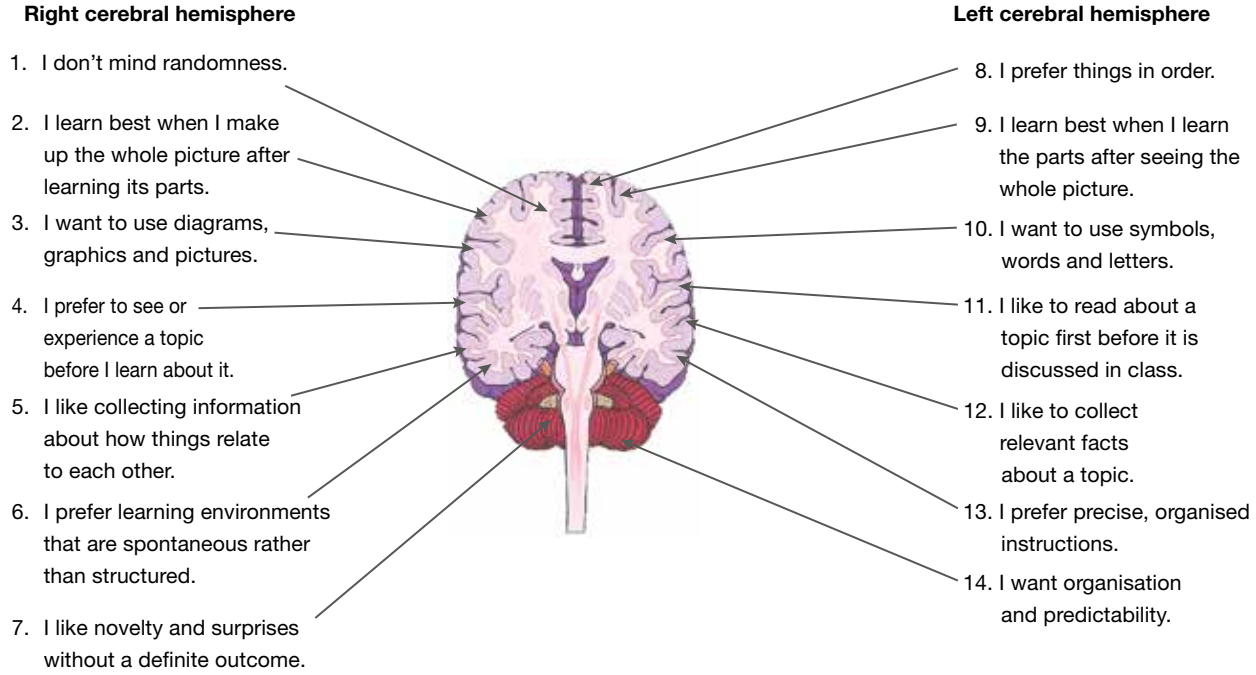


2.11.3 Left and right — two brains in one?

Your cerebrum is also divided into left and right sides or hemispheres. Although each hemisphere processes information differently, they are both involved in putting together the total picture of what you sense around you. For example, when you listen to someone speak, your left side processes words, definition and language. Research suggests that the right side processes the inflection, tones, tempo and volume of the speaker, which assists in getting meaning of the conversation rather than just the words.

Researchers also found there can be patterns relating to which side of your brain you favour throughout the day. It is not uncommon to switch from right-brain to left-brain dominance sixteen times a day!

When learning, you may be activating more of one hemisphere than another. However, for optimal learning, it's important to involve learning activities that include the strengths of both hemispheres (even if it can feel a little uncomfortable sometimes). This will allow you to focus on 'whole-brained' learning.



INVESTIGATION 2.3

Nostril breathing

AIM: To investigate the link between breathing and brain function

Did you know that, on average, you breathe through one nostril for about three hours until the tissue becomes slightly engorged, then you switch to the other? The nostril that you breathe through affects which brain hemisphere may be dominant. When your breathing is left-side dominant, your learning may be right-brain dominant, and vice versa.

Research has suggested that the information received by the brain from the 'dominant' nostril can change our interpretation of different smells. If our left nostril is the more active we will remember the smell more emotionally, whereas if our right nostril is more active we can describe the smell more objectively.

1. Outline what the research suggests (or claims) about use of different nostril sides and interpretation of smell.
2. Think about this suggested connection.
3. Construct a PMI chart (refer to section 2.8) to organise your data. Use 'P' = supports/agrees with the claim, 'M' = does not support/disagrees with the claim and 'I' = interesting information that is neither for nor against the claim.
4. Consult a variety of resources to gather relevant information that will help you to decide whether you agree with it or not.
5. Share your PMI chart with others in the class, adding any relevant points that you may have missed.
6. On the basis of your PMI summary, decide whether you agree or disagree with the research claim on the following scale: 0 = strongly disagree; 1 = disagree; 2 = agree; 3 = strongly agree.
7. As a class, be part of a human 'opinion' scale with the left wall of the classroom being '0' and the right wall being '3'. Chat with others near you about reasons for their views and then hear from your class members at other points along the scale.
8. Construct a suitable hypothesis for this research claim and design an experiment to test it. If possible, perform the investigation and share your findings with others. Reflect on your design and discuss ways in which you may improve it if you were to do it again. Suggest other relevant research questions that could be investigated.

2.11.4 Windows of your brain

Next time you enter your classroom, notice what you see around you. Are there any posters, plants, colours, objects or shapes? Because 80 to 90 per cent of all information absorbed by your brain is usually visual, changes in colour, size, contrast, shape and movement around your environment are very important. Your eyes can register 36 000 visual messages in an hour, and about 40 per cent of all the nerve fibres in your brain are connected to the retinas in your eyes.

2.11.5 Your brain is unique

Like your thumbprint, your brain is unique. Not only may it be a different size and weight from your friends, but the learning connections between cells in your brain are different. These connections are made as a result of your experiences and this forms your own personal 'cognitive map', which can change over time as you build up more experiences. This difference in our brain's 'internal wiring' can explain why people at the scene of the same accident can have such different eyewitness reports.

INVESTIGATION 2.4

Juggling jigsaws

AIM: To investigate the benefits of working in expert teams

In Juggling jigsaws, each member (or pair) of the team specialises in one specific part of the learning task. Once their part in the learning task is mastered, they become experts on it. The team then reunites and each expert (or expert pair) teaches the others in the team what they have learned.

Expert Team 1 challenge

Each member is to research a part of the brain that is mentioned in section 2.11. Find out the facts and any interesting research on this part of the brain and how it may be involved in learning. Share your findings with the rest of your Expert Team.

Expert Team 2 challenge

Each member is to find as many songs or poems about the brain as they can. Share your findings with the rest of your Expert Team.

Expert Team 3 challenge

Collectively this team needs to summarise information from section 2.10 and create a song with actions that they can teach to each other and then to the rest of the class.

Expert Team 4 challenge

This team needs to design a classroom that they consider will be an effective learning environment. They then need to build a model of this wonderful learning classroom.

INVESTIGATION 2.5

Setting goals, being persistent and failing wisely

AIM: To reflect on your learning in this chapter

Have you thought about your thinking and learning throughout this chapter? Have you reflected on the 'mountains and valleys' of your learning?

1. Construct a learning and thinking journal that includes answers to the following questions.
   (a) How, what, where and when have you learned most effectively?
   (b) Which of your social and collaborative skills were the most developed? Which of these skills would you like to focus on developing in your next unit of study?

(c) How well did you set goals and how well did you meet them?
(d) Were you persistent or did you give up when things got a bit too tough, hard or uncomfortable for you?
(e) Everybody fails at some time. It is okay to fail. The important thing is what happens after you fail. Have you failed wisely? What did you learn from failing? How could you use what you have learned to your advantage?

2. Select a classmate(s) you respect and have learned to trust during your recent learning. Listen to each other talk about some key points of this learning journey. Share and discuss each other's learning and thinking journals. Make constructive suggestions that may help each other's learning.
3. In a pair or team of four, suggest at least six slogans, pictures, visuals, cartoons, stories/fables, quotes or sayings that could be used as prompts to help you to become effective learners.
4. What do you think the Cheshire Cat in *Alice in Wonderland* meant when he said, 'If you don't know where you are going, any road will take you there'? Construct a bubble map to record your suggestions.

If you don't know where you are going, any road will take you there.



2.11 Exercises: Understanding and inquiring

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Remember

1. State the name of the most complex organ in your body.
2. List five functions of your brain.
3. How is your brain different from that of others in your class?
4. Name the part of your brain that is responsible for higher order thinking and decision making.
5. Draw an outline of your brain and label the four lobes of your cerebrum. Add to each label why the lobe is important.
6. What is another name for nerve cells?
7. Draw a picture that summarises the types of thinking in the two hemispheres of the brain.
8. Approximately what percentage of information received by your brain is visual?
9. List the important visual aspects of your learning environment.

Investigate and design

10. Swara yoga is a branch of yoga that develops an awareness of breathing through your nostrils. This involves learning to control your breath moving through your nostrils, to 'control' the activity of your brain hemispheres in a way that suits the type of activity that you are involved in.
    (a) Find out more about the practice of alternate nostril breathing. In your report include what you consider to be the advantages and disadvantages of doing this.
    (b) Design some activities that can test your nostrils, breathing and left- or right-hemisphere dominance.
    (c) A peak expiratory flow rate meter can be used by people with asthma to measure the volume of a whole breath. Draw the plans for your very own clever and creative invention that measures which nostril is being used more frequently. Make up a colourful brochure that could be used to market it to fellow students.

11. (a) Albert Einstein had an average-sized brain. Find out what other sorts of information has been found out about his brain. Which thinking hat are you using?
    (b) Present your information in a creative way. Which thinking hat are you using now?
12. Emotions can change the parts of your brain that are most active. Research and report on your findings as annotations on a diagram of the brain.
13. Select one of the environmental influences on learning listed below and find out what effects it may have on your body, and consequently your learning.
    - Colours
    - Type of lighting
    - Plants
    - Room arrangements
    - Seating options
    - Objects

Think and design

14. (a) Think of an activity, hobby or interest and prepare a presentation that introduces the topic by:
        (i) giving an overview ('big picture') of the topic, then introducing the sub-topic details
        (ii) giving details of the sub-topics and then the 'big picture'.
    (b) Which one was easier for you to put together?
    (c) Did you use more words, symbols and letters, or more pictures, graphs and charts?
    (d) Was there a lot of factual information on the topic?
    (e) How were your presentations similar to and different from those of others in the class?

Think, create and design

15. Use food, plasticine or other materials to make a labelled model of your brain.
16. Make up a song or poem to help you remember the functions and positions of the four different lobes of the cerebrum. Include some actions if you can.
17. Work out whether you are left- or right-brain dominant:
    (a) Give a mark out of 5 for each of the statements shown in the previous diagram for each hemisphere of the brain.
    (b) Add up the total score for each side. In which hemisphere of the brain did you score higher?
    (c) What does this mean in terms of your learning?

2.12 Review

2.12.1 Study checklist

Thinking hats, keys and tools

- list the colours of the six thinking hats and suggest a question that could be associated with each hat
- use the 'combination' key to design a hat with an unusual function
- describe the difference between the 'variations' key and the 'alternative' key and give examples of how each could be used
- suggest 'question' keys that require 'have or have not' comparisons
- outline the differences between the following 'question' keys: 'evaluate' and 'predict'; 'explain how' and 'explain why'; 'state' and 'describe'
- identify thinking tools that could be used for each of the following types of thinking: analyse or compare; visualise or reflect; order or sequence; quantify or rank

Types of learning and intelligence and your brain

- provide examples of activities that involve internal visual learning
- suggest examples of activities that involve verbal or linguistic audio learning
- list different types of multiple intelligence
- describe various 'mindful habits' in a Y chart

- suggest strategies that can be used to become an active rather than a passive learner
- name the main parts of the brain
- explain why protein foods are important for the brain and learning

Collaborative learning

- suggest ways in which communication skills can be improved
- suggest examples of social skills that team members can focus on to develop a more effective team
- describe examples of collaborative skills that are important for an effective team
- outline the difference between a team 'hog' and a team 'log' and suggest strategies to overcome their potential negative impact on teamwork

Individual pathways

ACTIVITY 2.1
Learning
doc-6078

ACTIVITY 2.2
Investigating learning
doc-6079

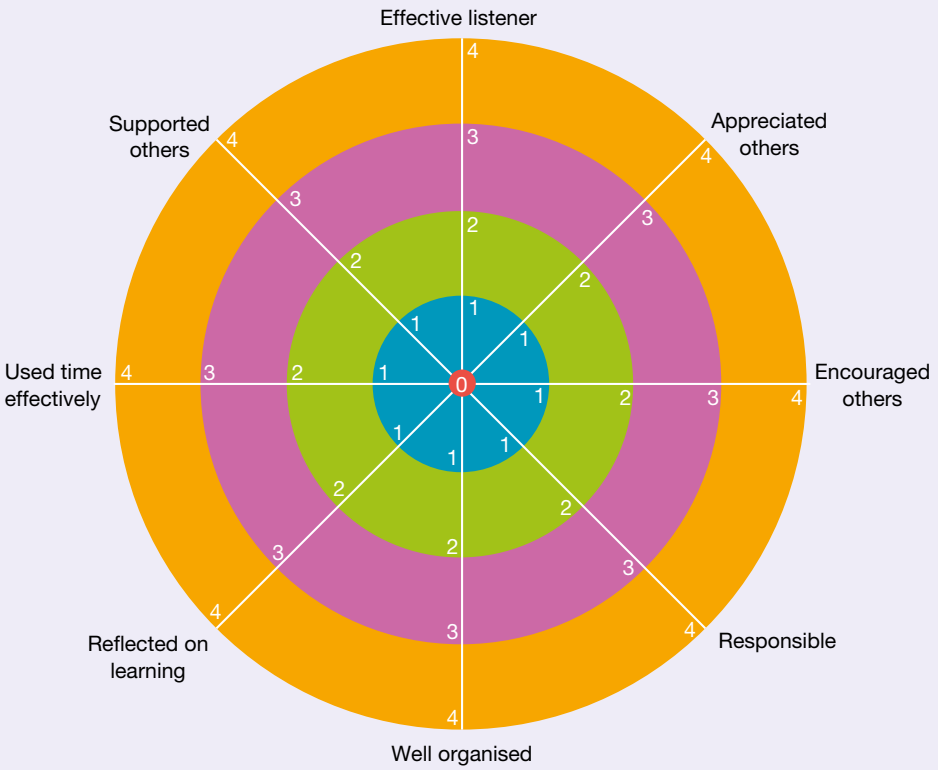
ACTIVITY 2.3
Developing learning
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2.12 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. Create a mind map to show what you have learned in this chapter.
2. If you were to begin the chapter again, what might you do differently and why?
3. Describe your ideal learning environment.
4. What type of learner would you describe yourself as?
5. (a) Use the diagram below to score how effective you think you have been as a team member during your learning about the brain. Give yourself a mark/dot out of 4 for each of the traits in the learning wheel below.



(b) Join the dots together to show your team profile.
(c) Comment on your strengths as a team member and suggest ways that you could improve in areas in which you did not score highly.

6. (a) Reflect on your learning style and find out your profile in the learning wheel below.



(b) What other sorts of learning factors are there? Make a list of them and construct another 'wheel of learning'. First find out your own learning profile and then get other team members to try it out.
(c) Compare your learning wheel with those of your teammates. Use a Venn diagram to show how they are similar and different.
(d) Survey the class to find out the overall pattern of the learning wheel. Is this the pattern that you would have expected? Discuss your view with others in the class. Suggest ways in which you could use this information.

7. Use the 'alphabet' key to summarise points that you have learned in this chapter.
8. Construct a cluster map or concept map to outline the following.
   (a) 'Ways to work as a team'
   (b) 'Learning how to learn'
9. Create a cartoon or picture book to explain why protein foods are best for boosting your alertness and mental performance. Include examples of foods that are good sources of protein.
10. Did you know that *crypto* means secret or hidden? Create your own cryptonym (secret name) book that contains all the prefix and suffix meanings provided in this chapter. Add others of your own.

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Complete this digital doc: Worksheet 2.4: Summing up (doc-19797)

Complete this digital doc: Worksheet 2.5: Looking back (doc-19798)

assessON
Link to assessON for questions to test your readiness **FOR** learning, your progress **AS** you learn and your levels **OF** achievement.
www.assesson.com.au

TOPIC 3
Classification

3.1 Overview



Our planet contains an amazing variety of living things. Scientists classify these living things into groups on the basis of their similarities and differences.

This seahorse is called a sea dragon. Is it like a horse or can it be classified as something else?

3.1.1 Think about Classification assessON

- How can you use a key to unlock the door to classification?
- Why bother classifying living things?
- Which animals have their skeletons on the outside?
- I have scales and lungs and live on land. What am I?
- In terms of biological classification, which class do you belong to?
- What did prehistoric pelycosaurs use their sail-like fins for?
- Which herb helps relieve constipation?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

3.1.2 Your quest

Sorting out dragons

Harry Potter met a dragon, as did Shrek and Bilbo Baggins. In fact, dragons feature in almost every culture from around the world — but did they really exist? If they did, were they somehow related to snakes, lizards or birds?

Think

What sorts of features do the dragons on these pages have in common? How are they different? What criteria could you use to divide the dragons up into groups?

Dragon impostors?

The names of some plants and animals include the word 'dragon'. Look at the sea dragon on the previous page and the 'dragon' examples on this page and suggest why this is. The use of these common names can lead to misunderstandings about the similarities and differences of these organisms. One reason scientists use a classification or naming system is so that we have a shared understanding of what is meant and can communicate with each other more effectively.

Komodo dragon





Dragonfly





Snapdragon







INVESTIGATION 3.1

Dragon mapping

AIM: To find similarities between dragons

Form a group of four and allocate the roles of scribe, captain/organiser, timekeeper and encourager.

1. Brainstorm all that your group knows about dragons. Each person then uses that information to construct a bubble map of different dragons and their features (see section 5.10 for more information about bubble maps).
2. Compare your bubble map with those of others in your group. On a new piece of paper, the group scribe should collate all of the group's ideas into a group bubble map, adding any extra points that arise during your group sharing.
3. On your group bubble map, use one colour to highlight the features that are common to all dragons.
4. Can any of the dragons shown above be grouped using the features left uncoloured in your bubble map? If so, highlight each group in a different colour.
5. Organise your group's bubble map into a cluster map to show how your dragon information can be grouped or clustered (see section 2.9 available in your learnON title at www.jacplus.com.au, for more information about cluster maps).
6. Use the internet to find out more about one area in your group's cluster map.
7. Report back to your group and produce a group summary that you can present to the class.

3.2 Patterns, order and organisation

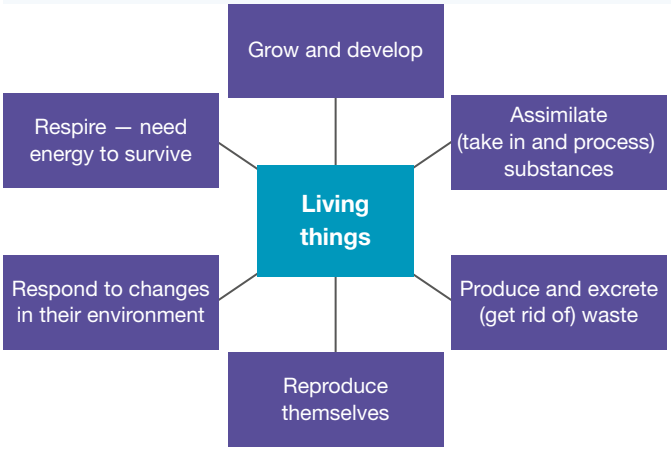
3.2.1 Why classify?

Is it alive? What is it? Is it friendly or dangerous? Can I eat it? Our brain is very good at recognising patterns and grouping similar patterns together. By organising information into patterns, it is easier to remember. Sometimes your survival can depend on recognising important patterns in the world around you.

We classify things into groups to make them easier to identify, remember and describe. Classifying is a way of organising and bringing order. Classification of living things (also known as organisms) enables scientists to put some order on the natural world. In this way, scientists can communicate with each other and know whether they are talking about the same or different kinds of organisms.

Classification is useful, for example, when dealing with diseases, disease-carrying organisms and disease control. There are thousands of different types of mosquitoes, but only a small number of these transmit the parasite that causes malaria. Instead of spraying all mosquito populations, scientists can identify those that may result in malaria and then take steps to control them.

Features common to all living things



3.2.2 Is it alive?

Prior to classifying living things, a shared understanding of the features of living things (organisms) is required. All living things **respond** to

HOW ABOUT THAT!

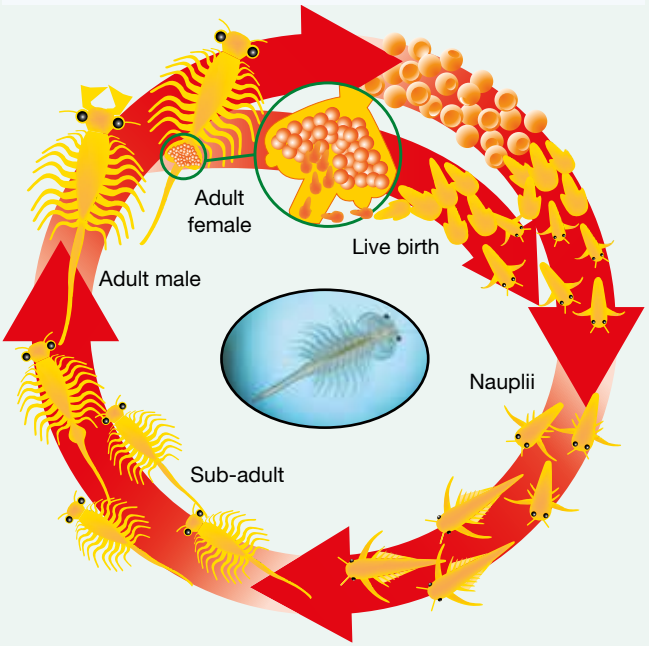
Instant life?

Just add water and, 'hey presto', you've brought sea monkeys to instant life! Are they really alive? Are they really monkeys? Can you create them just by mixing up sachets of powdered ingredients and adding water?

Sea monkeys are not really monkeys … but they are alive! They are made up of cells that require nutrients and produce wastes. They belong to the animal kingdom and are classified as members of the Arthropoda phylum and Crustacea class. They are actually a type of brine shrimp belonging to the species *Artemia salina*. As they can tolerate very salty water they are naturally found in salt lakes. Their gills help them to cope with high levels of salt by absorbing and excreting ions and producing very concentrated urine from their maxillary glands.

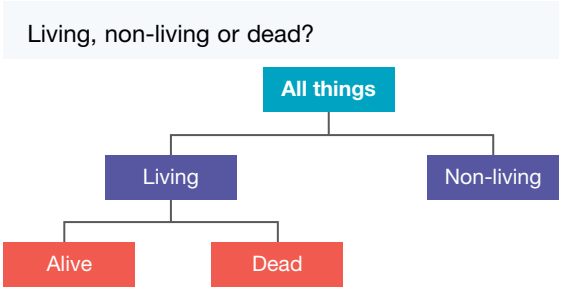
The 'magic' behind the sea monkeys appearing to become instantly alive is the process of **cryptobiosis**. This is a type of 'suspended animation' of the egg. One of the powders in the sachets sold in the sea monkey package contains *Artemia salina* eggs in their cryptobiotic stage. When these eggs come into contact with water, this phase ends and they begin their next stage of development and grow into 'sea monkeys', which swim around in their watery environment.

The life cycle of the sea monkey (*Artemia salina*)



changes in their environment, **need energy** to survive, **assimilate** (take in and process) substances, produce and **excrete** wastes, **grow** and **reproduce**.

If a living thing stops living, then it is **dead**. If something is **non-living**, then it has never had all of the characteristics of living things. For example, a squashed snail and roast chicken are dead, whereas a rock, a car and a computer are non-living.



INVESTIGATION 3.2

Living, non-living or dead?

AIM: To classify things as living, non-living or dead

Method and results

1. Copy and complete the table below.

Characteristics	Robo-bilby (electronic toy) 	Bilby 	Bilby fossil 
Independent movement			
Requires oxygen			
Requires water			
Requires nutrients			
Produces and excretes wastes			
Grows as it gets older			
Responds to changes its environment			
Reproduces itself			

2. Construct another table the same as the one above but replace the bilbies with:
   (a) paper
   (b) fire
   (c) a tree.
3. Complete the table.

Discuss and explain

4. Identify which of the three bilbies is non-living. List the characteristics it has.
5. Identify which of the three bilbies is living. List the characteristics it has.
6. Of the paper, fire and tree, which is non-living?
7. Does the living thing have all of the characteristics listed?
8. Which characteristics does the living thing have that the non-living thing does not?

3.2.3 Made up of cells

Cells are the building blocks that make up all living things. Organisms may be made up of one cell (**unicellular**) or many cells (**multicellular**). These cells contain small structures called organelles that have particular jobs within the cell and function together to keep the organism alive.

Cells can be divided on the basis of the presence and absence of particular organelles and other structural differences. Organisms can be classified by the different types of cells they are made up of.

WHAT DOES IT MEAN?

The prefix *uni-* comes from the Latin term meaning 'one'. The prefix *multi-* comes from the Latin term meaning 'many'.

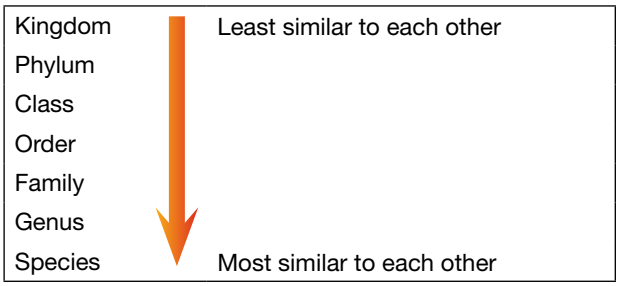
Cell or cell-less?

Protoctistan cells and **prokaryotic** cells are both very small and are living things. The types of cells that make them up are different. If you were to view the cellular details of protoctistans such as *Amoeba, Euglena* and *Paramecium* under a microscope, you would notice that they were more complex in their structure than prokaryotic cells.

There are other small things on Earth that show some features of living things but not others. These are not made of cells. **Viruses**, **viroids** and **prions** are three groups that are not made up of cells, but appear to show some features of living things when they have infected the cells of living organisms.

A painting of Carolus Linnaeus as a young man





3.2.4 Classification — grouping to order and organise

Taxonomy is the formal classification of living things. A taxonomist is a biologist who specialises in classification. The Swedish naturalist Carolus Linnaeus (1707–1778) is considered to be the 'father of taxonomy' because his classification system formed the basis of our current system.

Linnaeus sorted organisms into groups based on their physical similarities. He called the largest grouping **kingdoms** and the smallest grouping **species**. Organisms classified into the same kingdom are more similar to each other than are organisms classified into different kingdoms. For organisms within a kingdom, however, as you move down the hierarchy of groupings (see figure above), the more alike its members are.

Classification systems can change

New technologies have provided us with more information about organisms. This new knowledge can change the classification of a particular organism and may even result in the proposal of new classification systems or categories.

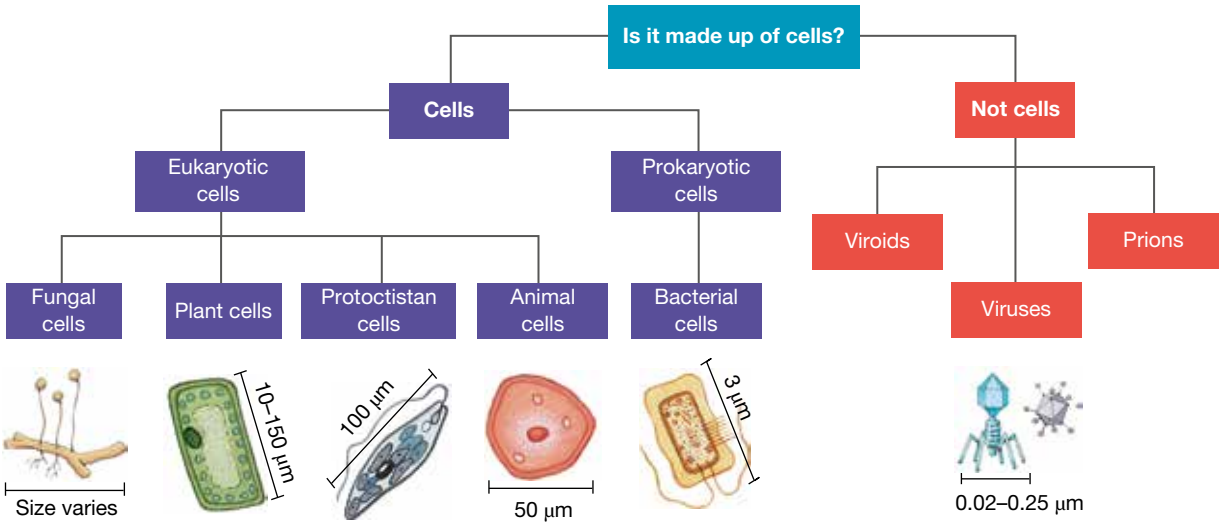
In the 1700s, Linnaeus proposed that living things could be grouped into three kingdoms. However, the invention of the microscope led to the discovery that all living things were made up of cells, but it also revealed that some organisms did not fit into the three proposed kingdoms.

3.2.5 Five kingdoms?

In the 1960s, a five-kingdom system of classification was proposed by ecologist, Robert Whittaker. This divided all living things up into the Animalia, Plantae, Fungi, Protista (or Protoctista) and Monera (or Prokaryotae) kingdoms. A key characteristic used to classify organisms into the five different kingdoms was the structure of their cells.

Scientists have discovered that viruses, viroids and prions show some features of living things but other features of non-living things. As they are not made up of cells, they are not considered in the five-kingdom classification system.

A key characteristic used to classify organisms into kingdoms is the structure of their cells.



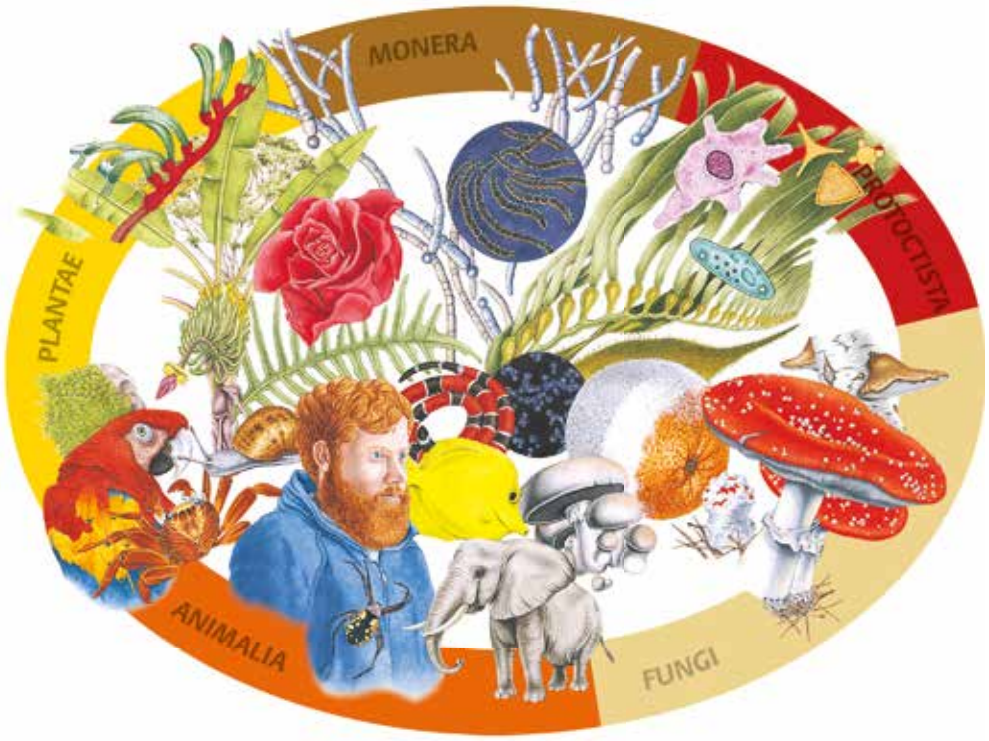
Other key features that can be used to divide organisms into the five kingdoms are shown in the table below.

Kingdom	Animalia	Plantae	Fungi	Protista	Monera
Unicellular or multicellular?	Multicellular	Multicellular	Most multicellular; some unicellular	Unicellular	Unicellular
Cell wall	No cell wall	Cellulose cell wall	Predominantly chitin	Many have no cell wall; some have a cell wall	Cell wall present; composition varies
True nucleus	Present	Present	Present	Present	Absent
Mode of nutrition	Eat or absorb other organisms	Photosynthesise to produce sugars	Produce chemicals that break down the material on which they grow and absorb the nutrients released	Some photosynthesise; some ingest food	Some absorb nutrients from surroundings; some photosynthesise; some use other chemical processes

(*continued*)

Kingdom	Animalia	Plantae	Fungi	Protista	Monera
Chloroplasts	Absent	Present	Absent	Present in those that photosynthesise	Absent (those that photosynthesise have chlorophyll but no chloroplasts)
Examples	Pigeon, earthworm, ant, camel, human, starfish	Eucalyptus tree, grass, wheat, rose bush	Baker's yeast, mushrooms, bread mould	Amoeba, Euglena, Paramecium	*Escherichia coli, Staphylococcus aureus*

The five kingdoms into which organisms are classified

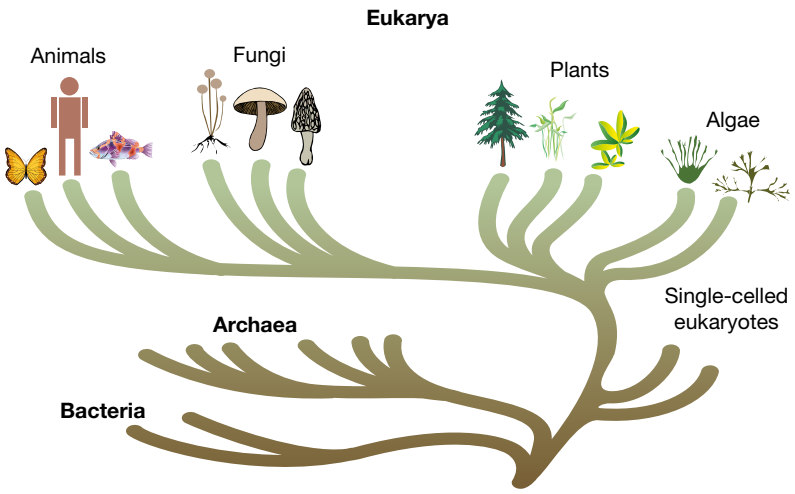


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Try out this interactivity: Choose the kingdom to which each species belongs. (int-0204)

3.2.6 Classification systems still changing?

This five-kingdom system is still often used. However, with new technologies and discoveries, other classification systems have been (and are being) proposed that are based on genetic rather than physical characteristics to group organisms. One of these is based on research findings by Carl Woese. Instead of five kingdoms, he suggested that there should be three domains: Archaea, Bacteria



(true bacteria) and Eukarya (living things made up of one or more cells with a nucleus). Eukarya is then divided up into kingdoms.

Although classification systems are not fixed and can change when new information is discovered, they are very useful in the organisation of organisms into groups. Classification systems help us to see patterns and order in the natural world.

3.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Match the 'heads' and 'tails' in the table below.

Head	Tail
Cells …	describes something that has never been alive (e.g. a clock).
Dead …	is the smallest grouping of living things used by Linnaeus.
Kingdom …	are the building blocks that make up all living things.
Non-living …	describes something that was once alive but is not now.
Plant …	describes an organism made up of only one cell.
Species …	is the largest grouping of living things used by Linnaeus.
Taxonomy …	is the use of a formal system for classifying living things.
Unicellular …	is a multicellular organism containing chloroplasts and a cellulose cell wall.

2. Provide two examples of each of the following.
   (a) Non-living thing
   (b) Plant
   (c) Fungus
   (d) Protist
3. Distinguish between each of the following.
   (a) A living thing and a non-living thing
   (b) A dead thing and a non-living thing
   (c) Kingdom and species
   (d) Plant cells and animal cells
4. Use a flowchart to order the following in terms of their complexity, from simplest to most complex.
   kingdom, species, family, phylum, class, genus, order
5. Outline the relationship between:
   (a) living things, non-living things and dead things
   (b) fungal cells, plant cells and animal cells
   (c) Linnaeus, Whittaker and Woese.
6. (a) State the scientific name for sea monkeys.
   (b) State the phylum that sea monkeys belong to.
7. Suggest how sea monkeys can tolerate living in very salty water.
8. Define the term 'cryptobiosis'.
9. Are sea monkeys living or non-living? Give reasons for your response.
10. Suggest why scientific definitions of classification systems sometimes change over time.
11. Identify whether the following statements are true or false. If a statement is identified as false, justify your response.
    (a) Living things are also referred to as organisms.
    (b) All types of mosquitoes can transmit the malarial parasite.
    (c) Sea monkeys are non-living monkeys.
    (d) All living things need energy to survive.
    (e) If a living thing stops living, it is referred to as non-living.
    (f) Stromatolites are living rocks.
    (g) Organisms made up of many cells are called unicellular.
    (h) Organelles are small structures inside cells that have particular jobs.

(i) Cells can be classified on the basis of the presence or absence of particular organelles or structures.
(j) Protoctistan cells are structurally more complex than prokaryotic cells.
(k) Viruses are made up of cells.
(l) Taxonomy is the formal classification of living things.
(m) Carl Linnaeus sorted organisms into groups based on physical similarities.
(n) Members of the same species have less in common than members of the same kingdom.
(o) The five-kingdom classification system includes viruses.
(p) Fungal cells, plant cells, animal cells and protoctistan cells are all examples of prokaryotic cells.
(q) Bacterial cells are larger than animal cells.
(r) Animal cells do not possess chloroplasts.
(s) Plant cells possess a cellulose cell wall.
(t) Mushrooms consist of fungal cells.
(u) *Amoeba*, *Euglena* and *Paramecium* are all protists (protoctistans).
(v) Bacterial cells possess a true nucleus.
(w) *Staphylococcus aureus* is an example of a bacterium.
(x) *Eucalyptus* trees are made up of eukaryotic cells.
(y) Earthworms are made up of prokaryotic cells.
(z) Classification systems are fixed and do not change.

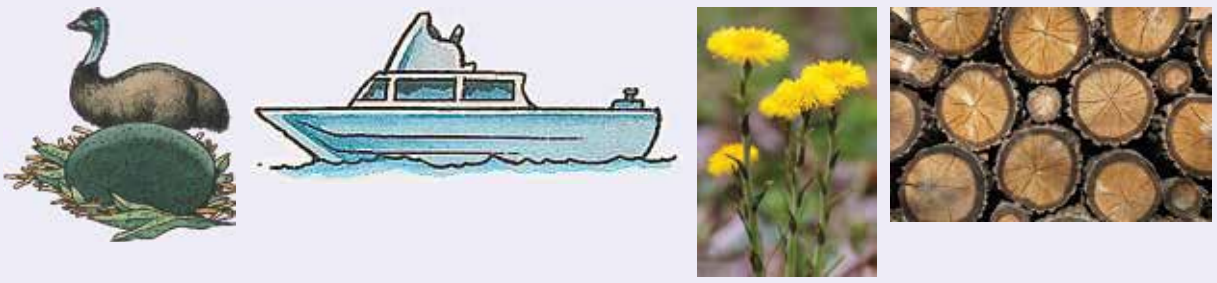
Think and discuss

12. Carefully observe the items below.
    (a) Construct a table to show your classification of each of the items in the drawing as either living, non-living or dead.
    (b) Which of the things were difficult to classify? Why?
    (c) Which characteristics of living things did the non-living or dead classified items *not* display?

Living, non-living or dead?



13. Carefully observe the items below and opposite. These items can be divided into a number of different groups by using different classification criteria. Using criteria other than living, non-living and dead:
    (a) divide the items into four groups
    (b) give each group a name and list the features that you used as criteria
    (c) compare your classification groups with those of others in the class
    (d) comment on similarities, differences or patterns in how the items were classified.








Investigate, think and discuss

14. Find out more about the history, advertising strategies and commercial success of sea monkeys. Who 'discovered' them and developed a commercial business around them? How effective was the advertising? How accurate are their claims? Construct a PMI chart, and then present your information as a poster, PowerPoint presentation or newspaper article.
15. In 1972, a US patent was granted for 'hatching brine shrimp or similar crustaceans in tap water to give the appearance of instantaneous hatching'. What is a patent? What do you think about the idea of patenting living organisms? Research this patent and then share and discuss your opinions with others.
16. When conditions are not suitable, seeds from some plants may remain dormant rather than germinate. For example, lotus seeds can germinate after being dormant for more than a century.
    (a) In their dormant state, are the seeds living, non-living or dead?
    (b) Use Venn diagrams to show how the seeds are:
        (i) similar to viruses
        (ii) different from viruses.
17. Suggest why the ability to classify organisms is important in the following situations.
    (a) You have been bitten by a spider.
    (b) You are very hungry and find a bush with berries in the forest.
18. Search the internet to find more information (including pictures) about each of the five kingdoms. Use this information to construct, on a sheet of A3 paper, your own 'kingdom wheel' similar to that on page 50.

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- **Complete this digital doc:** Worksheet 3.1: Animal features (doc-19799)
- **Complete this digital doc:** Worksheet 3.2: The great debate (doc-19800)
- **Complete this digital doc:** Worksheet 3.3: Is it alive? (doc-19801)
- **Complete this digital doc:** Worksheet 3.4: Five-kingdom classification (doc-19802)
- **Complete this digital doc:** Worksheet 3.5: Creatures from a parallel universe (doc-19803)
- **Complete this digital doc:** Worksheet 3.6: Responding (doc-19804)

3.3 Unlocking meaning—patterns in scientific language

3.3.1 Historic keys?

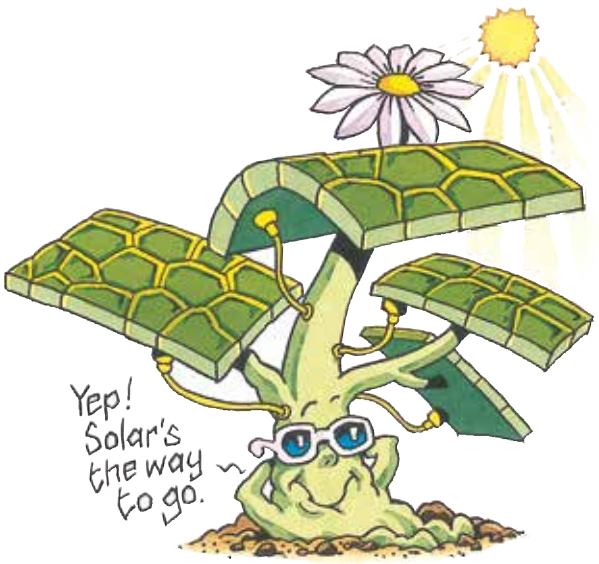
Etymology is the term used to describe the study of words, their origin and grammar. Words are often made up of a prefix at the beginning of the word and a suffix at the end. Some examples of prefixes and suffixes that you might come across in science are shown in the table on page 56. Being aware of this pattern will help you to unlock the meaning of many new scientific words that you come across.

Name me a dino …

Tyrannosaurus, *Pterosaurus*, *Stegosaurus* … Did you ever wonder why the dinosaurs had such big names? Do you know what they mean? The term 'dinosaur' was actually decided on by the British anatomist and palaeontologist, Sir Richard Owen in 1842. *Dino* means 'terrifying' and *saur* means 'lizard'. Some dinosaurs were named for their unusual head or body features, others for their teeth or feet, or after a person or place.



3.3.2 Unlocking patterns



Many scientific terms, like others in our language, begin with a particular prefix and end with a specific suffix. These can give you hints about what the words mean. For example, the terms 'chlorophyll' and 'chloroplast' both begin with *chloro*, which comes from the Greek word *chloros*, meaning 'green'. Chlorophyll is the green pigment found in the chloroplasts of plant cells. This green pigment captures light energy so that plants can made their own food using the process of photosynthesis (*photo* = light and *synthesis* = to make). The presence of chlorophyll in the chloroplasts is the reason that they (and plants) appear to be green.

Leucoplasts (*leuco* = 'white') and chromoplasts (*chromo* = 'colour'), like chloroplasts, are plastids found in plant cells. Leucoplasts are not coloured as they do not contain coloured pigments. Chromoplasts are coloured and contain pigments other than chlorophyll. They are responsible for pigment synthesis and storage and are found in the coloured parts of plants, such as fruit and petals, giving them their characteristic colours. These pigments can be extracted and used as plant dyes.

Chemicals such as those in foods that you eat also have clues in their names that help you to work out what they are made of. You may have heard of glucose, sucrose and starch. Gluc*ose* and sucr*ose* are both sugars. Glucose is a *mono*saccharide (*mono* = 'one' and *saccharide* = 'sweet'). Sucrose is a *di*saccharide and made up of two monosaccharides. Starch is a *poly*saccharide and is made up of many monosaccharides.

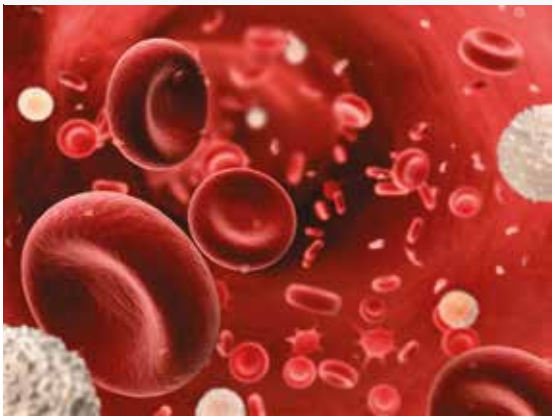
There are other prefixes that provide you with clues about size and number. Microscope (*micro* = 'small' + *'scope'* = view) and megafauna (*mega* = 'large' + *fauna* = 'animal') are examples of terms that indicate size in their names. Can you deduce which numbers are indicated in the following words: *uni*cellular, *bi*nary, *di*chotomous, *tri*pod, *quad*rant, *deci*mal, *centi*grade, *milli*pede?

'Cell speak'

Later, when you study different types of blood cells, you will come across terms containing the suffix or prefix *cyte*. This is a variation of *cyto*, which means 'cell'. Examples of terms that you may come across include:

- monocyte
- phagocyte
- leucocyte
- lymphocyte
- erythrocyte
- cytosol
- cytoplasm
- cytology
- cytoskeleton
- cytotoxic
- phagocytosis
- endocytosis
- exocytosis

Erythrocytes (red blood cells) and leucocytes (white blood cells)



Inside or within

In science, you will learn about endoskeletons, endocytosis, endoplasmic reticulum, the endocrine system and endoparasites. The prefix *endo* in these words tells you that they all have something to do with 'inside' or 'within'. Even without knowing their full definitions, you can begin to see patterns and get an idea about what they may refer to.

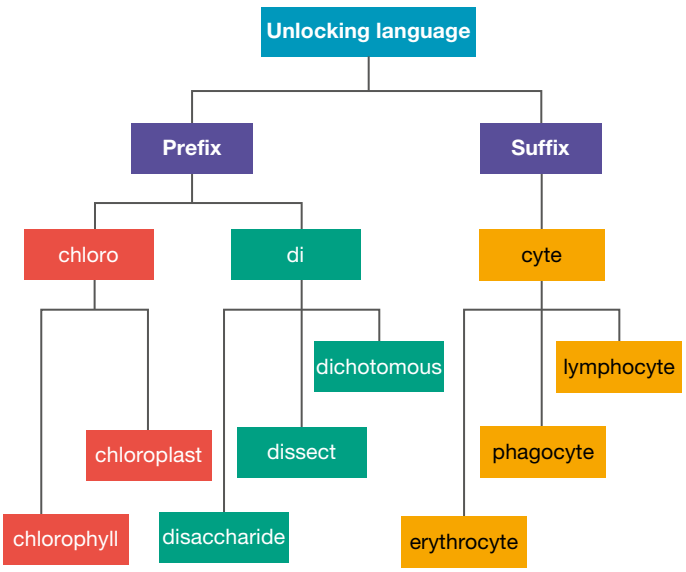
Numbers or words?

In science you also need to know the difference between two different ways of describing your data. One of these is *qual*itative and the other is *quant*itative. Qualitative data describe your observations in words (describing the 'qualities' of the data), whereas quantitative data are numbers (or 'quantities').

Hookworms are endoparasites and live inside their hosts. You can see the hooks that it uses to attach itself to its host.



The prefixes and suffixes of scientific terms often give you hints about what they mean.



INVESTIGATION 3.3

Cryptonym game

AIM: To increase familiarity with scientific prefixes and suffixes

Method

- In teams, begin by writing each of the scientific terms in the table below on a card.
- One player should shuffle the cards and then observe which term is on the top card without letting others in the team see.
- Place the card face down and 'act out' its meaning.
- The first team member to identify the term gets to shuffle the cards and act out the next term.

Discussion

1. A *crypto*graph refers to secret writing and a *crypto*nym is a secret name. Suggest the meaning of *crypto*.
2. Identify the types of questions that were most helpful in predicting the correct name on the card.

Conclusion

3. Suggest how you could transfer what you have learned in this activity to predicting the meanings of scientific terms.

Latin/Greek prefix or suffix	Meaning	Scientific term
bio + ology	life + study	Biology
etymon + ology	true + study	Etymology
heteros + trophe	different, other + to feed or eat	Heterotroph
echinus + dermis	spiny + skin	Echinodermata (e.g. sea urchin)
anthros + zoion	flower + animal	Anthrozoa (e.g. sea anemone)
epi + dermis	outside + skin	Epidermis
arthron + pous	joint + foot	Arthropod (e.g. insect)
gastro + pous	stomach + foot	Gastropod (e.g. snail)
poly + dactylus	many + finger or toe	*Polydactylus*
kroko + deilos	pebble + worm	*Crocodylus*
photo + synthesis	light + make, build	Photosynthesis
exo + skeleton	outer, external + skeleton	Exoskeleton

3.3 Exercises: Understanding and Inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

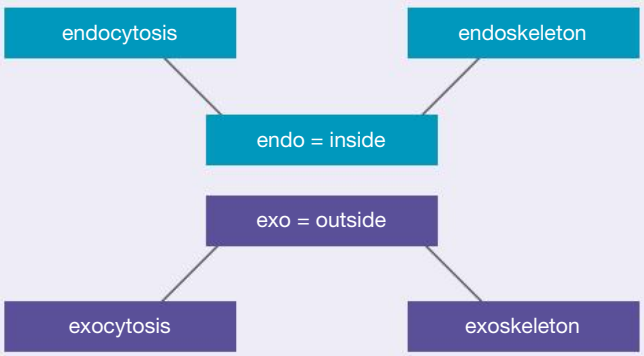
1. Suggest what type of animal may have *saur* in its name.
2. Outline the difference between the terms 'prefix' and 'suffix'.
3. Identify the shared meaning between the terms:
   (a) chlorophyll and chloroplast
   (b) monocytes, leucocytes and erythrocytes.
4. (a) Where are you likely to find leucoplasts, chromoplasts and chloroplasts?
   (b) Describe how they differ.
5. Outline the difference between qualitative and quantitative data.
6. Suggest the suffix that sugars may share in their names.
7. Distinguish between monosaccharides, disaccharides and polysaccharides.
8. If you came across two words and one began with *micro* and the other with *mega*, predict what the difference between them would be.

Think, investigate and discuss

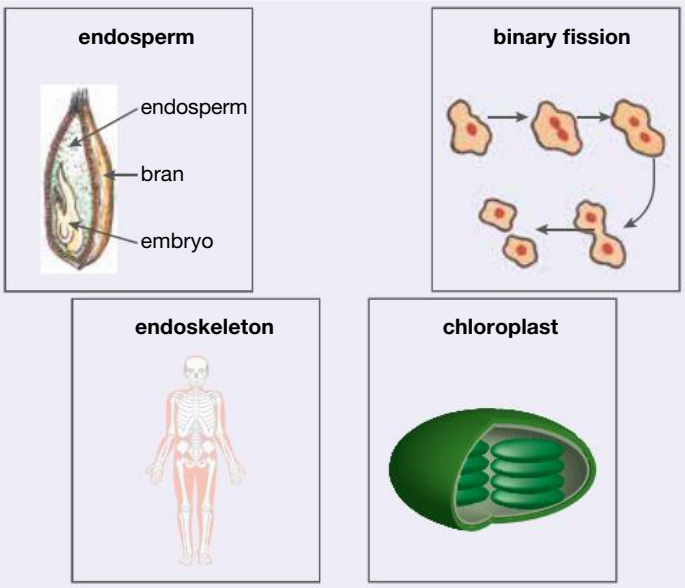
9. (a) Carefully examine the dinosaur names below and discuss with your partner any clues that may help you predict their meanings.
   Triceratops, *Spinosaurus*, *Ceratosaurus*, *Heterodontosaurus*, *Pentaceratops*, *Microdontosaurus*, *Microceratops*

(b) Find out the meanings behind the dinosaur names above.
(c) Based on your findings, comment on any patterns and suggest groups you could divide them into.

10. Find out about the life and scientific contributions of Sir Richard Owen in 1842. Report your findings in a timeline.
11. Research examples of Australian megafauna. Report on clues within their names that help describe what they may have looked like.
12. Find out what palaeontologists do, investigate their distinct ways of working and representing their specialised knowledge, and give an example of a contribution an Australian palaeontologist has made to our understanding of ancient life in Australia.
13. Find out prefixes for one, two, three, four, ten and hundred that have originated from Latin or Greek words. State an example of a scientific term that uses each prefix.
14. Find out the meanings of and similarities and differences between the following:
    (a) microscope, telescope, periscope
    (b) millimetre, centimetre, nanometre, kilometre
    (c) binary fission, dichotomous key, binocular
    (d) *Tyrannosaurus, Pterosaurus, Stegosaurus*
    (e) anatomist, scientist, palaeontologist
    (f) cardiac, renal, pulmonary
    (g) dehydrated, deoxygenated, denatured
15. Throughout history, coloured pigments from plants and animals have been used by humans. Find out about two plant and two animal examples. Identify the scientific names of the pigments and what they mean.
16. Chlorine is an element. Suggest what colour it may be.
17. Find out the history behind the names of the elements in the chemistry periodic table. Present your findings as a picture book.
18. Find out the definition and two key points for each of the *endo* and *exo* words shown in the diagram on the right.
19. (a) Find at least five examples of scientific terms that begin with the following prefixes: *endo*, *bio*, *anti*, *chloro*, *thermo*, *bi*, *hetero*.
    (b) Create your own set of scientific terminology cards, using a particular colour for each prefix and adding a diagram or image for each that provides a hint about its meaning. The illustration at right shows what your cards may look like.
    (c) Design a game that uses the cards to teach students about scientific terminology. Include an instruction brochure or rule book with your game.
    (d) Play your game and those of others.
    (e) Construct a PMI chart for each game that you play.



An example of what your cards may look like



Think and create

20. Research the meanings of the words below and then construct a Venn diagram to show similarities and differences between them:
    (a) chlorophyll and chloroplast
    (b) leucocyte and erythrocyte
    (c) prefix and suffix
    (d) endoparasite and ectoparasite
    (e) cilia and flagella
    (f) plant cells and animal cells
    (g) vertebrates and invertebrates.
21. (a) Carefully observe the information in the boxes on the right, and then construct Venn diagrams to compare the different types of dinosaurs.
        (i) *Microceratops* and *Triceratops*
        (ii) *Triceratops* and *Pentaceratops*
        (iii) *Microdontosaurus* and *Heterodontosaurus*
        (iv) *Microdontosaurus* and *Microceratops*
    (b) Suggest the meanings of the prefixes *micro*, *tri*, *penta*, *micro* and *hetero*.
    (c) What do you think the prefix *donto* might refer to? Justify your response.

Microceratops
- Name means 'small-horned face'
- Only 76 cm long
- Lived about 83–65 million years ago

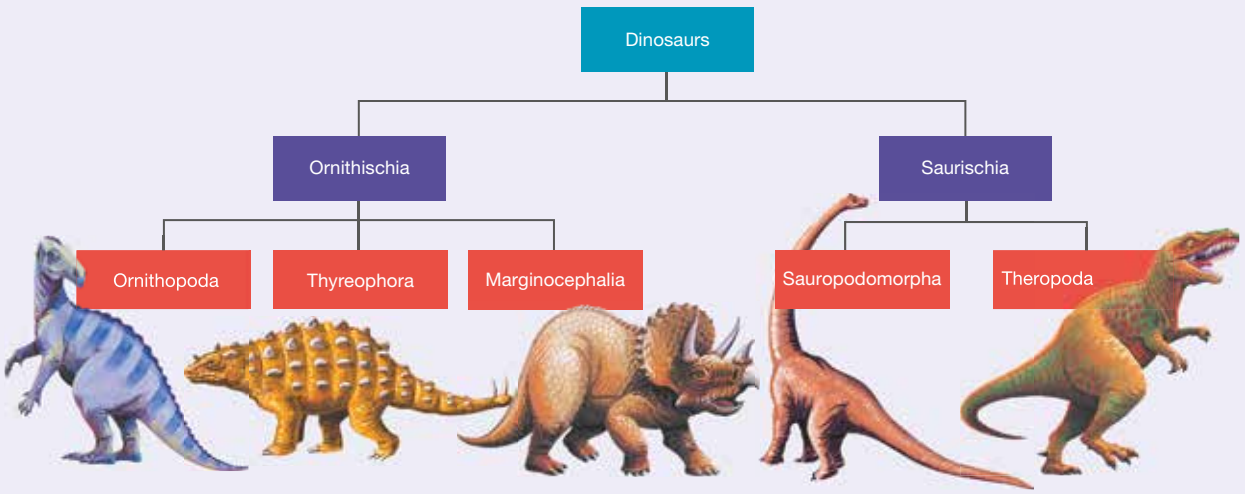
Heterodontosaurus
- Name means 'different-toothed lizard'
- Had three types of teeth
- 2.2 m long
- Lived about 208–200 million years ago

Pentaceratops
- Name means 'five-horned face'
- Had three horns on its head
- 8 m long
- Lived about 75–65 million years ago

Triceratops
- Name means 'three-horned face'
- 'Frilled' dinosaur
- Had three horns on its head
- 8 m long
- Lived about 75–65 million years ago

Microdontosaurus
- Name means 'tiny-toothed lizard'
- 8 m long
- Lived about 75–65 million years ago

22. Use the information in the diagram below to construct the following Venn diagrams.
    (a) Dinosaurs under 10 metres long and dinosaurs over 10 metres long
    (b) Dinosaurs with horns and spikes and dinosaurs without horns and spikes
    (c) Dinosaurs that weighed less than 8000 kilograms and dinosaurs that weighed more than 8000 kilograms



Example:
Iguanodon
Weight: 5000 kg
Length: over 9 m, up to 5 m tall

Example:
Ankylosaurus
Weight: up to 4000 kg
Length: over 10 m

Example: *Triceratops*
Weight: up to 11 000 kg
Length: over 9 m

Example:
Brachiosaurus
Length: up to 24 m, up to 12 m tall

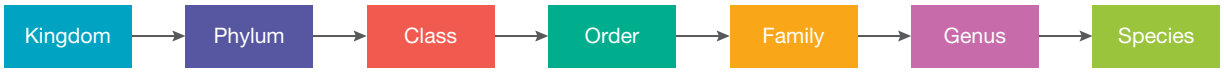
Example: *Tyrannosaurus rex*
Weight: up to 8000 kg
Height: over 6 m

3.4 Unlocking patterns in scientific names

3.4.1 Levels of classification

Now that you are more aware of the patterns in scientific language, you can apply what you know to the classification of living things.

You may recall that living things can be grouped into five kingdoms and that these kingdoms contain a number of sub-groups. As you move from kingdoms to species, the members of the group have increasingly more in common. Organisms of the same **species** resemble each other and can interbreed to produce fertile offspring.



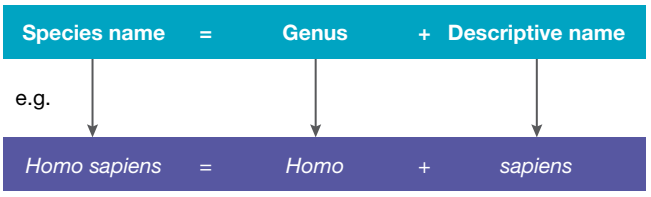
WHAT DOES IT MEAN?

The word *binomial* comes from the Latin terms *bi*-, meaning 'two', and *nomen*, meaning 'name'.

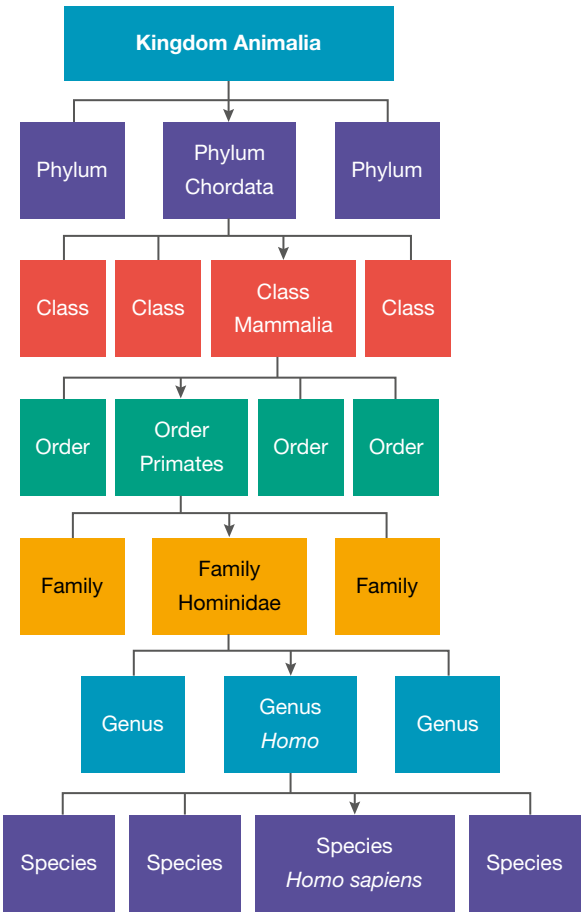
3.4.2 Binomial nomenclature

Carl Linnaeus (1707–1778), a Swedish botanist, zoologist and physician, developed a naming system called **binomial nomenclature** in which each species has a name made up of two words. The scientific names given to organisms were often Latinised. In this system, the species name is made up of the genus name as the first word and the descriptive or specific name as the second word. The genus name begins with a capital letter and lower case is used for the descriptive name. If handwritten, the species name should be underlined; if typed, it should be in *italics*.

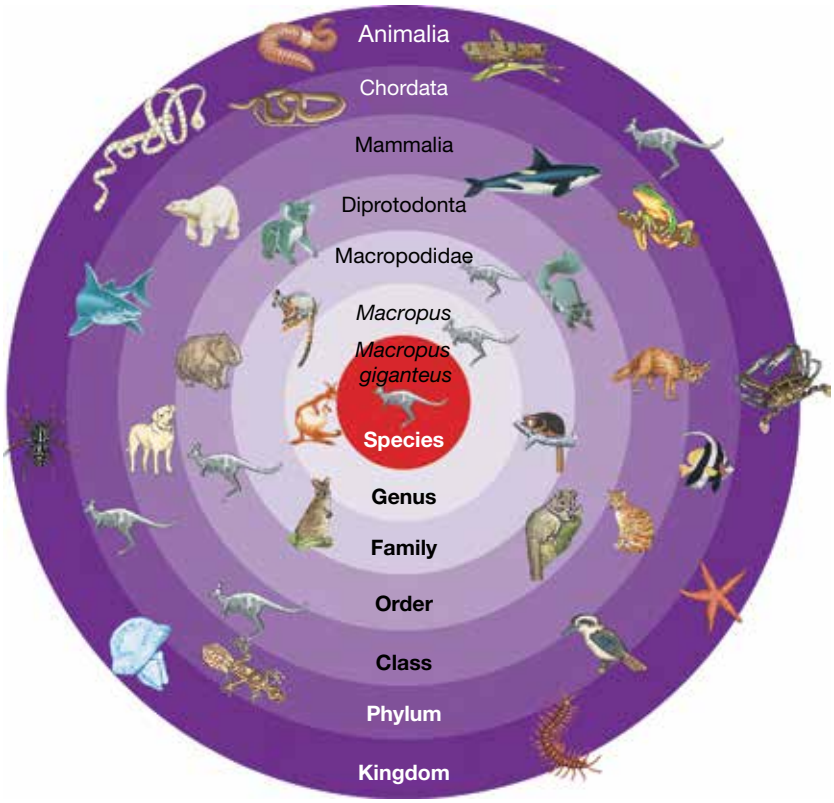
The chart on the right shows the various groups that you belong to. You are a member of the *Homo sapiens* species, in the *Homo* genus, in the Hominidae family, in the Primate order, in the Mammalia class, in the Chordata phylum, in the Animalia kingdom.



This target map shows the classification groupings of eastern grey kangaroos or *Macropus giganteus* species. Which levels of classifications do these kangaroos share with your species?



The scientific name for the Eastern grey kangaroo is *Macropus giganteus*. *Macropus* is the genus name and *giganteus* is the descriptive name.



3.4.3 Unlocking names

Many of the words used in our classification system tell a story about history and language.

Common name: Major Mitchell's cockatoo
Species name: *Cacatua leadbeateri*



What's the story?

- *Cacatua* — derived from the Greek terms meaning 'dawn' and 'crest', referring to a crest like the rising dawn
- *leadbeateri* — named after British naturalist Benjamin Leadbeater
- cockatoo — this word originates from the Malay name for the bird, *kakaktua*, from *kakak* meaning 'sister' and *tua* meaning 'old'.

Common name: Freshwater crocodile
Species name: *Crocodylus johnstoni*



What's the story?

- *Crocodylus* — derived from the Greek terms *kroko*, meaning 'pebble', and *deilos*, meaning 'worm'
- *johnstoni* — named after Johnson, the first European to discover and report it. Note that his name was actually Johnson and has been misspelt!

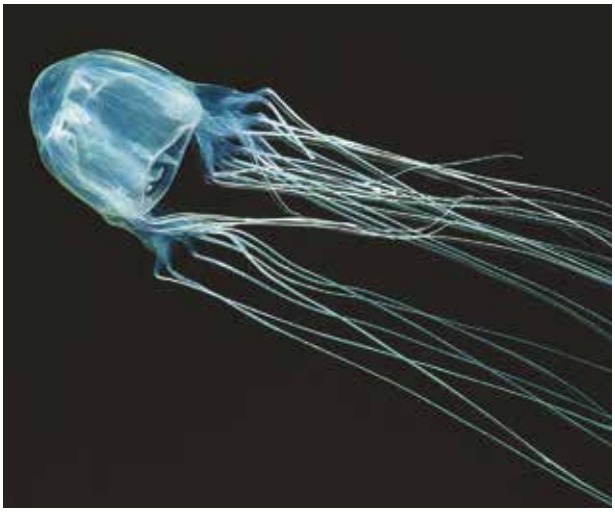
Common name: Crown-of-thorns starfish
Species name: *Acanthaster planci*



What's the story?

- *Acanthaster* — derived from the Greek terms *acantha*, meaning 'spiny' or 'thorny', and *aster*, meaning 'star'
- *planci* — possibly named after Max Planck, a German physicist

Common name: Box jellyfish
Species name: *Chironex fleckeri*



What's the story?

- *Chironex* — derived from the Greek and Latin terms *cheiro*, meaning 'hand', and *nex*, meaning 'murder' or 'violent death'
- *fleckeri* — named after Dr Hugo Fleck, a radiologist in Cairns, Qld, for his contribution to science

Following are some of drought-tolerant Australian plants.

Common name: Native wisteria, 'Happy Wanderer'
Species name: *Hardenbergia violacea*



What's the story?

- Genus was named after Countess von Hardenberg.
- Wisterias are named after the American anatomist Caspar Wistar by the English botanist Thomas Nuttall.

Common name: Snow gum
Species name: *Eucalyptus pauciflora*



What's the story?

- Genus name comes from the Greek terms *eu*, meaning 'good' or 'well', and *calyptos* or *kalyptos*, meaning 'veiled' or 'covered'.
- Species name comes from the Latin terms *pauci*, meaning 'few', and *florus*, meaning 'flowered'.

Common name: Kangaroo paw
Species name: *Anigozanthos flavidus*



What's the story?

- Species name comes from the Greek terms *anis*, meaning 'unequal', *anthos*, meaning 'flower', and *flavidus*, meaning 'yellow'.
- Common name is due to its similar appearance to a kangaroo's paw.

Common name: Golden wattle
Species name: *Acacia pycnantha*



What's the story?

- Genus name comes from the Greek term *akakia*, meaning 'thorny Egyptian tree' (after the first thorny species discovered).
- Species name comes from the Greek terms *pyknos*, meaning 'dense', and *anthos*, meaning 'flower'.
- In 1988 the golden wattle was proclaimed Australia's national floral emblem.

3.4 Exercises: Understanding and inquiring

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Remember

1. Name the person who is recognised as having developed the naming system for all living things.
2. Use a flowchart to show the names of the groupings in the hierarchical classification system, from largest to smallest.
3. In each of the following pairs, identify which group contains members that have more in common.
   (a) Kingdom and species (b) Genus and family
   (c) Order and phylum (d) Class and order
4. Describe the binomial system of nomenclature and give an example.
5. State the common name of each of the following.
   (a) *Crocodylus johnstoni* (b) *Cacatua leadbeateri*
   (c) *Chironex fleckeri* (d) *Acacia pycnantha*.
6. True or false? When writing a species name, the genus should begin with a capital letter and the descriptive name should begin with a lower-case letter.

Think and discuss

7. Use the information in the table to answer the following questions.
   (a) Identify the species name of a lion.
   (b) State the common name of the organism that belongs to the species *Felis domestica*.
   (c) State the name of the genus to which a crayfish belongs.
   (d) Suggest why it might be useful to know whether a crocodile was of the species *Crocodylus porosus* or *Crocodylus johnstoni*.

Species name	Common name
Cherax destructor	Crayfish
Rhyothemis phyllis	Dragonfly
Crocodylus johnstoni	Freshwater crocodile
Felis domestica	House cat
Felis leo	Lion
Crocodylus porosus	Saltwater crocodile
Antirrhinum australe	Snapdragon

8. Construct a Venn diagram to show the similarities and differences between the classifications of saltwater and freshwater crocodiles.

Investigate

9. Research and report on how the box jellyfish *Chironex fleckeri* got its scientific name. Research the various types of jellyfish that can be found in Australian waters.
   Suggest why it is important to know the name of the type of jellyfish. Which features are used to classify them?
10. Research and report on the one of the following.
    - British naturalist Benjamin Leadbeater and the various species named after him
    - The naming of *Crocodylus johnstoni* and other crocodiles
    - The scientist Max Planck, the Max Planck Institute and *Acanthaster planci*
    - The significance of the naming of *Cherax destructor*
    - Radiologists in Australia — what do they do?
    - Careers associated with identifying, classifying and naming organisms
11. (a) Research features, classification and the life cycle of a crown-of-thorns starfish. How is it different from other types of starfish found in Australian waters? Outline research on its impact on the Great Barrier Reef.
    (b) In a team of four, imagine that you are investigating the impact of this starfish on the Great Barrier Reef. In your team, formulate questions that you would need to consider in your research.
12. Research Carl Linnaeus and the binomial system of nomenclature. Document his contributions to the taxonomy of plants and animals.
13. (a) Which group contains more living things, the Animalia kingdom or the Primate order?
    (b) Dogs belong to the Animalia kingdom, Chordata phylum and Mammalia class. Use the table below to list some characteristics that dogs and humans have in common.
14. Outline features that crayfish, yabbies and lobsters have in common. How does the classification system deal with them?

Create

15. Create a cartoon to show how to write the scientific name of an organism.
16. In pairs or groups, create a song or poem to help you to remember the following and then present your finished product to the class.
    (a) The order of the groupings kingdom, phylum, class, order, family, genus and species
    (b) Rules for writing scientific names
    (c) Which groups you belong to
17. Construct a target map to show the classification groups that you belong to in a scientific context and then do the same for another animal that does not belong to the same kingdom as you.
18. The full classification for humans is shown below.
    (a) Which group contains more living things, the kingdom 'animal' or the order 'primate'?
    (b) Dogs belong to the animal kingdom; they are vertebrates and they are also mammals. Use the table below to list some characteristics that dogs and humans have in common.
    (c) Chimpanzees and humans are closely related. Which of the groups listed in the table below do chimps belong to?

Category	Group	What all the living things in the group have in common
Kingdom	Animalia	Made up of more than one cell; eats food
Phylum	Chordata	Backbone
Class	Mammalia	Hair or fur; feeds its young milk
Order	Primate	Opposable thumb; nails instead of claws; binocular vision
Family	Hominidae	Arms shorter than legs; nails flattened; upright stance
Genus	*Homo*	Walks upright on feet only; cares for young for a long time
Species	*Homo sapiens*	Large brain; can talk and think abstractly; complex social structures

3.5 Keys to unlock identity

3.5.1 Giants in a lost world

In 2009, scientists discovered creatures trapped within a 'lost world' in an extinct volcano (Mount Bosavi) in Papua New Guinea. One of the creatures discovered was a gigantic silvery-grey rat with thick woolly fur. It was about 82 centimetres long and weighed around 1.5 kilograms — the size of a domestic cat. Along with the discovery of this new species of rat (*Mallomys* spp.) were 16 species of frogs, 1 species of gecko, 3 species of fish and at least 20 species of insects and spiders.

Giant 'animal-eating' plants

In 2007, scientists on an expedition to catalogue the different species of pitcher plant found in an area in the Philippines discovered giant 'rat-eating' carnivorous pitcher plants. The pitchers of these plants were open and completely filled with fluid containing digestive enzymes that broke down the bodies of the large insects (and possibly rats by misadventure) that were trapped in them.

That's one big rat! The volcano's crater was 2.5 miles wide and rimmed with walls nearly half a mile high.



Giant 'rat-eating' plant *Nepenthes attenboroughii,* named after the science documentary broadcaster and naturalist Sir David Attenborough



3.5.2 Why classify?

Scientific curiosity has resulted in the discovery of an increasing number of living things. This has led to the increased need to classify living things into groups. Classifying things into groups makes them easier to remember, describe and identify.

When scientists such as those in the above expeditions find an unknown organism, they make observations about its features and behaviour. Various technologies can also be used to obtain information about its chemistry and genetic make-up. This information is used to sort the organisms into groups on the basis of similarities and differences. Classification of organisms into groups enables more effective communication and understanding.

3.5.3 Keys for ID

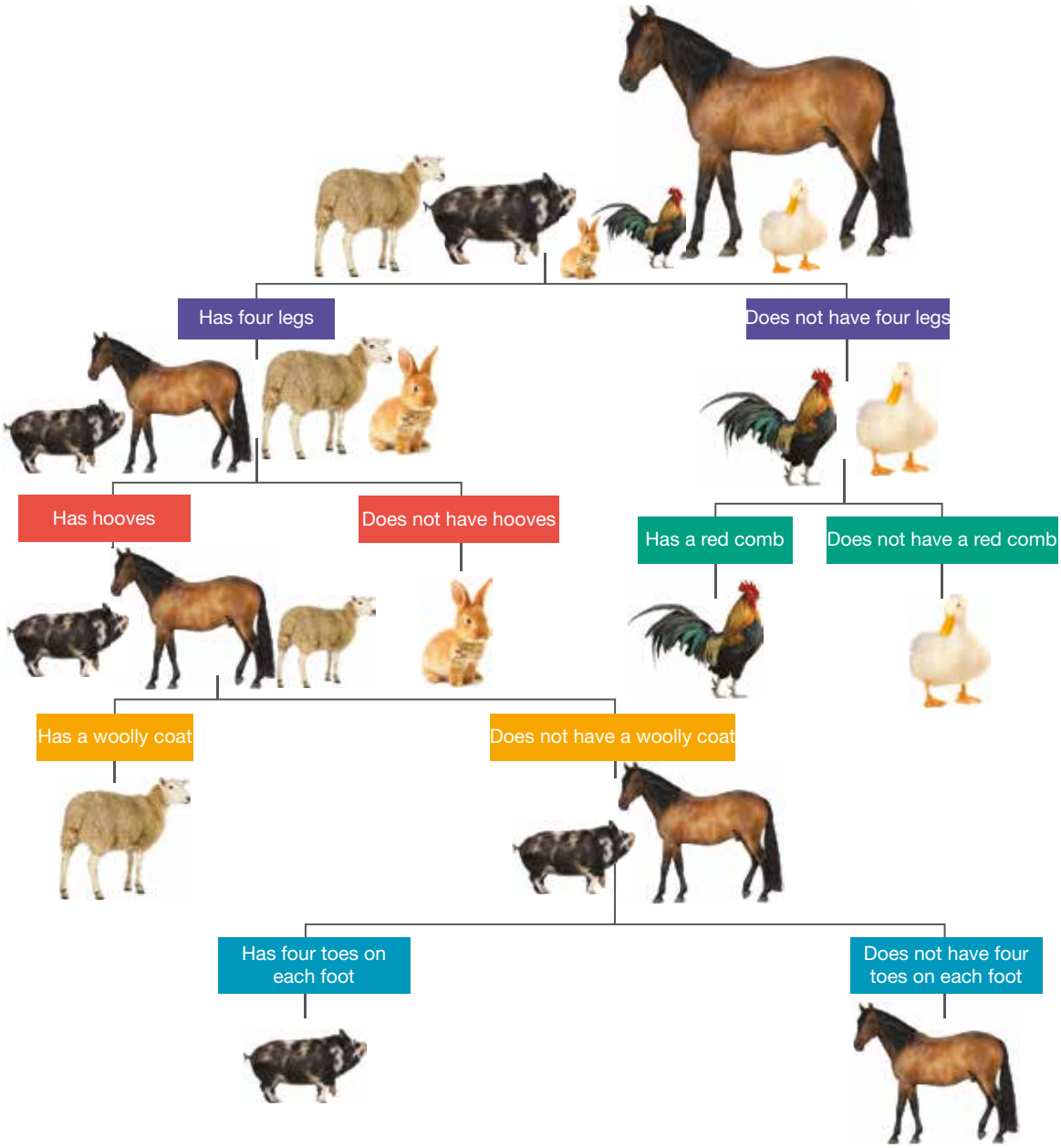
Keys and field guides can be used to identify organisms. A variety of criteria are used to classify the unknown organism into smaller groups on the basis of whether it has a particular feature.

Dichotomous keys

Dichotomous keys provide choices at each branch (*dichotomous* = 'cutting in two'). Features such as size, colour, behaviour and habitat are not good for classification because they can change throughout the life of the organism. It is better to use the presence or absence of structural features or differences in these features.

Dichotomous keys can be presented as branching keys or tabular keys. Examples of each of these keys can be seen below and on the next page. To convert information from a branching key to a tabular key, each fork of the branching key is given a number, which becomes the step number in the tabular key. Tabular keys are often used because more information can fit into a smaller space.

In a dichotomous key, you always select from two choices. In this key, you decide whether an organism has a particular feature.

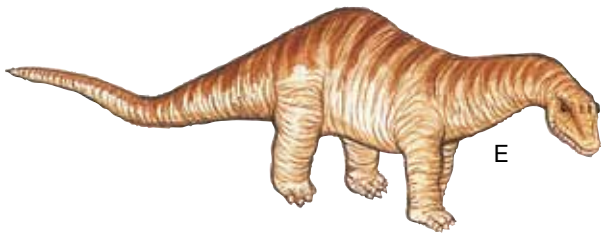








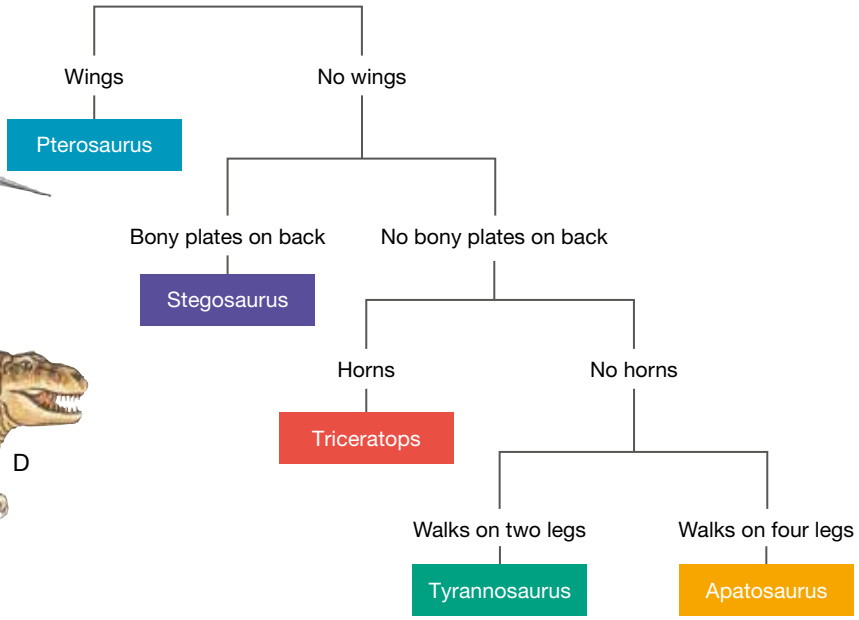




A tabular key

1. Wings.....*Pterosaurus*
   No wings.....Go to 2
2. Bony plates on back.....*Stegosaurus*
   No bony plates on back.....Go to 3
3. Horns.....*Triceratops*
   No horns.....Go to 4
4. Walks on two legs.....*Tyrannosaurus*
   Walks on four legs.....*Apatosaurus*

A branching key

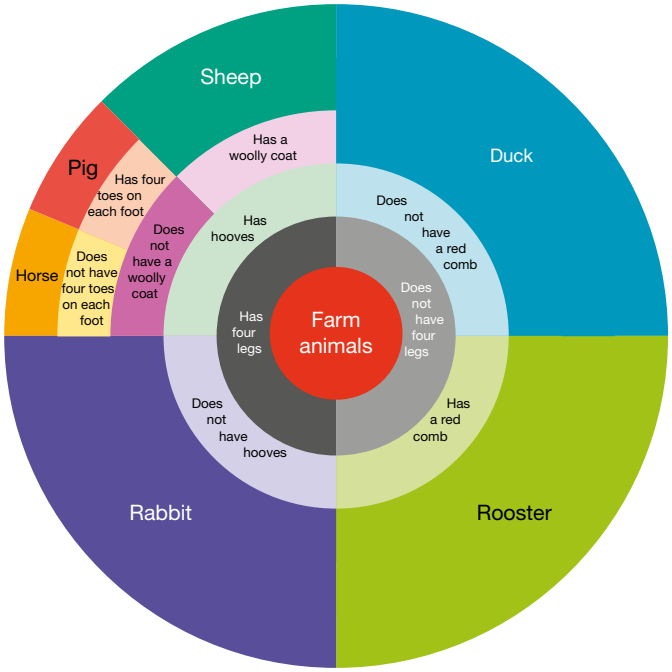


Circular keys

Circular keys can also be used to unlock identity. To read this type of key you start in the middle and work outwards, choosing one of the options in each layer. The final layer provides you with the organism's identity.

Carefully observe the dinosaurs A–E shown above and consider features that could be used to separate them into groups. Consider how you could use these features in the design of a circular key that would enable each individual to be identified.

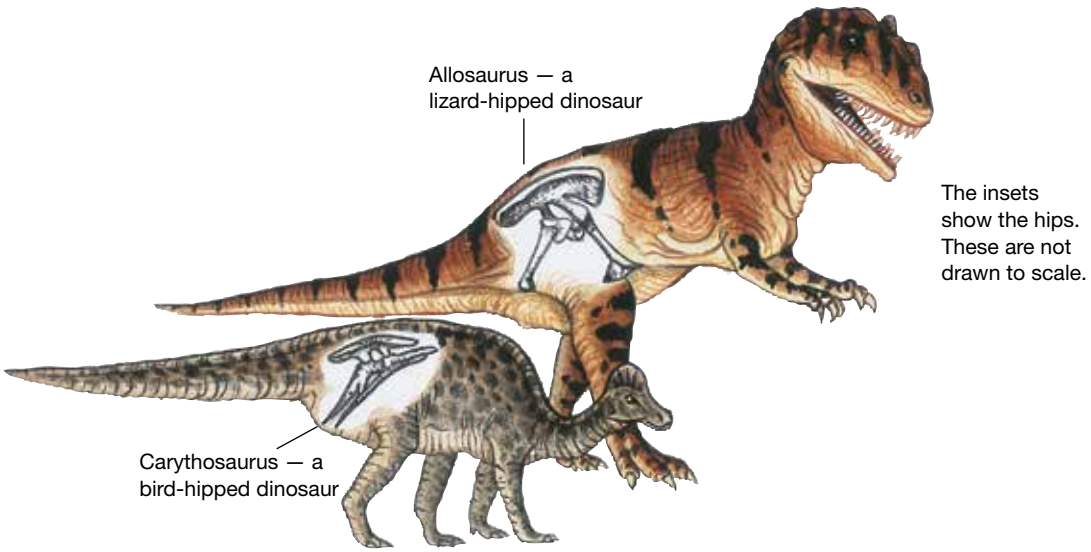
Keys to unlock farm animal identity



3.5.4 Field guides

Field guides are a commonly used type of reference book to help people identify organisms. These guides are specially designed to assist you in 'on-the-spot' identification. They often contain brief written descriptions and pictures, and are small enough to take outside when you are observing wildlife. There are also a number of electronic 'field guide' databases available.

Dinosaurs can be classified on the basis of the position of their hipbones. The 'lizard-hipped' dinosaurs belong to the meat-eating saurischian group and the 'bird-hipped' dinosaurs belong to the plant-eating ornithischian group.



INVESTIGATION 3.4

Making a class key

AIM: To use appropriate classification criteria in the construction of a class key

Materials:
tape measures or string and rulers

Method and results

1. Measure, observe and record at least 10 different characteristics for each member of the class. You may like to include some of the following.
   - wrist size (cm)
   - distance from elbow to shoulder (cm)
   - foot length (cm)
   - height (cm)
   - eye colour
   - hair colour
   - wears watch
   - pierced ears
- Have each member of the class select a secret code name.
2. Use some of these recorded class characteristics to construct a key (tree map or dichotomous key) that will separate as many individuals (using their code names) as possible.
   (*Hint:* You may find it best to describe measurements as 'greater than' or 'less than' a particular measurement.)
- Have someone from outside the class use the key to find the identity of one of the class members.

Discuss and explain

3. How successful was your key?
4. If you were to do the activity again, what would you do differently to improve its success?
5. Were some characteristics of more use than others? Explain.

INVESTIGATION 3.5

Making a class field guide

AIM: To use appropriate classification criteria in the construction of a class field guide

Materials:
paper, pencils
photocopies of photographs of each student (e.g. the school class photograph copied), or students can sketch each class member themselves

Method and results

- Work in pairs. If there is an odd number of students in your class, your teacher might agree to participate.
1. Observe your partner and record data such as height, hair colour, eye colour etc.
2. Interview your partner to find out some other details such as favourite music, movie, sport, colour, food etc.
3. Allowing about half an A4 page for each class member, present the information and photograph/sketch.
4. Make the pages into a book or poster.
- Use the class field guide to see how easy it is to identify each student.
- Try making a field guide for the teachers in your school.

Discuss and explain

5. What are the benefits of a field guide?
6. Which features do you think would be most useful to include in a field guide to assist in identifying a class member? Why?
7. Which features would be most useful to include in a field guide for:
   (a) plants
   (b) birds
   (c) insects?
8. Describe any problems that you encountered when you were constructing the field guide.

3.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

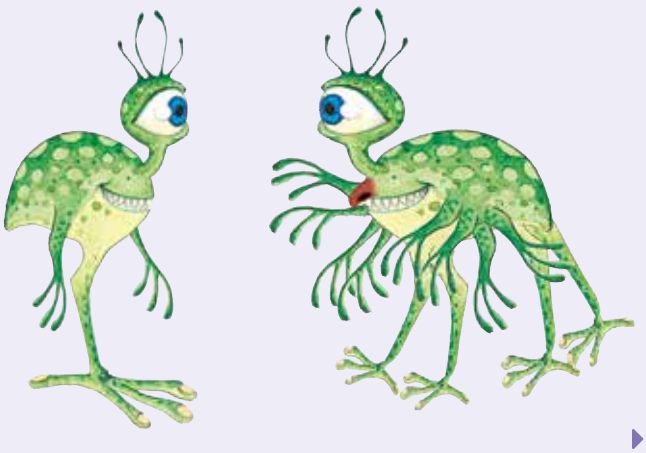
Remember

1. Suggest why scientists classify living things.
2. Some types of features are not very useful as classification criteria. Explain why this is the case, including examples.
3. Identify three features that would be useful as classification criteria.
4. State the name of the Swedish biologist that our current classification system is based on.
5. Suggest reasons why the current classification system may change.
6. What is a dichotomous key? Give an example of such a key.
7. Suggest why tabular keys are sometimes used instead of branching keys.
8. Outline the differences between field guides, branching keys, circular keys and tabular keys.
9. State the name of the genus to which the giant rat discovered in the extinct volcano in Papua New Guinea in 2009 belongs.
10. Identify who the giant 'rat-eating' carnivorous pitcher plant discovered in 2007 in the Philippines was named after.

Think and discuss

11. Use the dinosaur keys on page 67 to identify the dinosaurs illustrated on that page.
12. Imagine that you have landed on another planet and seen the two creatures on the right. Use the circular key to identify them.
13. Explain how supermarkets provide an excellent example of the effectiveness of a classification system. Include the types of criteria that are used. Construct a dichotomous key that would enable ten different supermarket items to be identified.





Investigate

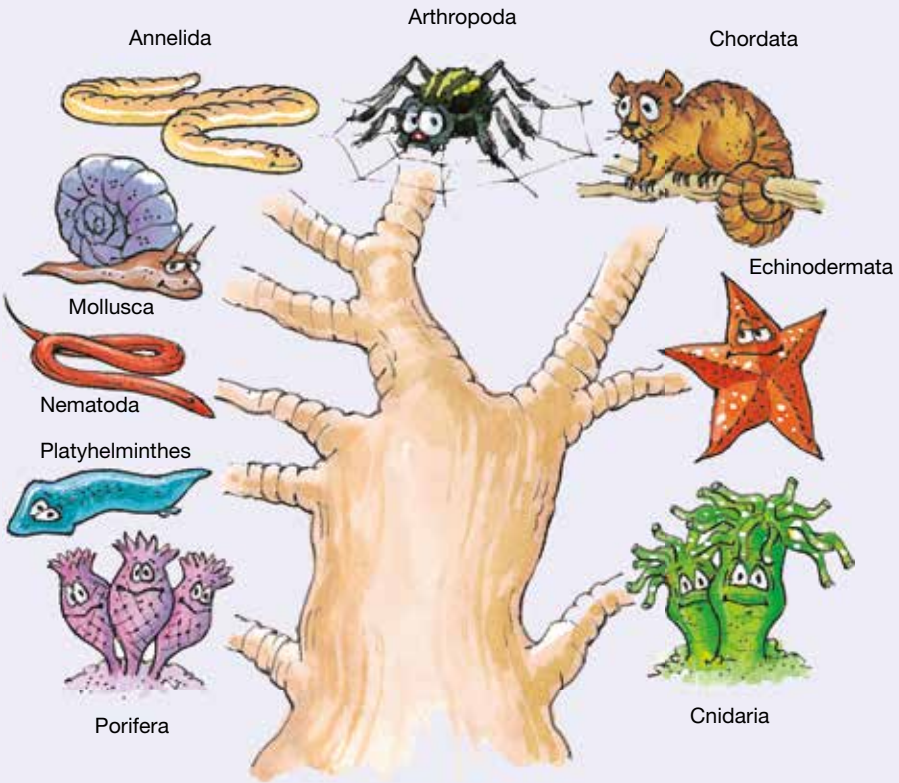
14. Cave people were often interested in only two groups of living things — those that were useful to them and those that were dangerous. Research and report on examples of bush and native foods and their parts that can be eaten and those that are poisonous. Display your findings in a format that includes dividing them into groups using relevant criteria.
15. Research and report on the various types of pitcher plants and how they are classified.
16. Research and report on one of the discoveries below and report your findings as a newspaper article, poster, PowerPoint presentation or journal entry. Include the types of information that were used to classify and identify it in your presentation.
    - *Homo floresiensis* (possible human ancestor)
    - *Fruitadens haagarorum* (tiny dinosaur)
    - *Mycena luxaeterna* (glowing fungus)

17. Observe the types of grass or insects in your local environment and construct a simple key to classify them.
18. Find and use two different online classification databases for either plants or animals. Comment on features that you find most useful in the database.
19. If you could meet and talk to a dinosaur, which one would it be and what questions would you ask? Find out the answers to your questions and use them to write an article for a class newspaper about dinosaurs.

Think and create

20. Carefully observe the features of animals in the animal kingdom evolutionary tree below.
    (a) Construct a mind map to record as many features for each animal as you can.
    (b) Compare your mind map with those of others in the class.
    (c) Discuss similarities and differences in your mind map observations.
    (d) If you wish, modify your mind map to include new ideas from your discussions.
    (e) Based on the features recorded in your mind map, construct a tree map or a dichotomous key that would enable the identification of each animal group.

The animal kingdom evolutionary tree, based on genetic and structural information

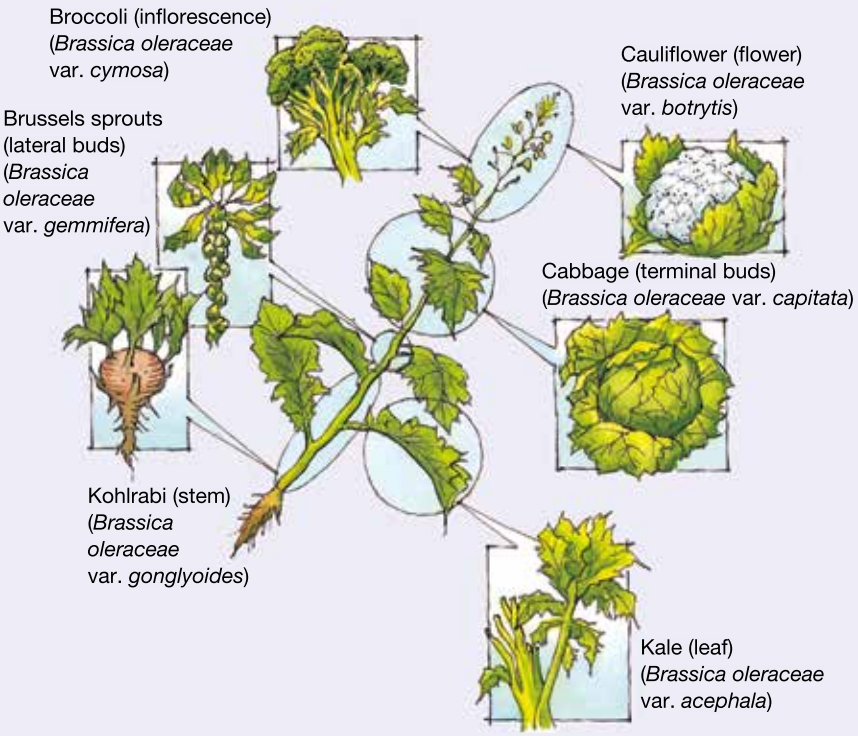


21. Carefully observe the features of vegetables in the figure on the next page.
    (a) State the species names for the following vegetables.
        (i) Cauliflower
        (ii) Cabbage
        (iii) Broccoli
        (iv) Brussels sprout
    (b) State the genus to which all of these vegetables belong.
    (c) Discuss with your partner your observations on the features of these vegetables.
    (d) Construct a mind map to record as many features for each vegetable as you can.
    (e) Compare your mind map with those of others in the class.
    (f) Based on the features recorded in your mind map, construct a tree map or a dichotomous key that would enable the identification of each vegetable species.

(g) These vegetables were produced by artificial selection and share a common ancestor. Find out what artificial selection is and then research and report on the history of these vegetables.

22. The table below provides information about some poisonous plants.
    (a) Construct a dichotomous key that allows identification of each plant.
    (b) Considering two plants at a time, use the information in the table to construct four different Venn diagrams.

All of these vegetables were produced by artificial selection and share a common ancestor. Could this have happened by natural selection also?



Common name	Botanical name	Poisonous parts	Symptoms	Degree of toxicity	Type of plant
Bird of paradise 	*Caesalpinia gilliesii*	Pods, seeds	Gastroenteritis	Mild *	Shrub
White cedar 	*Melia azedarach*	Fruit (6–8 can kill small child)	Nausea, spasms	High ***	Tree
Daphne 	*Daphne odora*	All parts, especially berries	Burning sensation in mouth/stomach, vomiting, collapse	High ***	Shrub

(continued)

Common name	Botanical name	Poisonous parts	Symptoms	Degree of toxicity	Type of plant
Oleander 	*Nerium oleander*	All parts, and smoke from burning wood	Vomiting, dizziness, irregular pulse, collapse	High ***	Shrub
Poinsettia 	*Euphorbia pulcherrima*	Leaves, sap, seeds	Delirium, gastroenteritis; sap injurious to eyes and mouth	Moderate **	Shrub
Wisteria 	*Wisteria sinensis*	Seeds, pods	Gastric pain, vomiting	Mild *	Climber

* Mild symptoms may occur if a large quantity of the poisonous parts are eaten.
** Causes discomfort and irritation but is not lethal.
*** Can cause serious illness or death.

Create

23. Collect a leaf from each of eight different plants in the school grounds.
    (a) On an A3 sheet of paper, create a branching dichotomous key to classify the leaves.
    (b) Construct the key in your exercise book as a tabular key.

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- **Complete this digital doc:** Worksheet 3.7: My own zoo (doc-19805)
- **Complete this digital doc:** Worksheet 3.8: A catalogue of cats (doc-19806)
- **Complete this digital doc:** Worksheet 3.9: Branching keys (doc-19807)
- **Complete this digital doc:** Worksheet 3.10: Tabular keys (doc-19808)

3.6 Which animal?

3.6.1 Classified by structural features

Animals can be classified into eight phyla (plural for phylum) on the basis of their structural features. Two commonly used features are their type of skeleton and their symmetry.

Have you got a backbone?

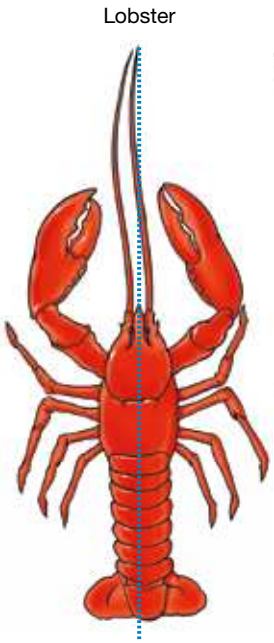
It may seem a strange question to ask, but this is one of the key criteria used to classify animals into groups. Animals that have internal skeletons or backbones are called **vertebrates**, whereas animals with external or no skeletons are referred to as invertebrates. Most of the animals on our planet are **invertebrates**.

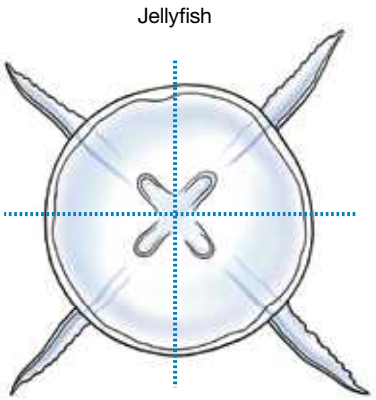
3.6.2 Endoskeletons and exoskeletons

Did you know that 75 per cent of all animals in the world have a skeleton on the outside of the body? These external skeletons are called **exoskeletons**. They may be thick and hard like those of crabs and lobsters or as thin and tough as those of ants and centipedes. As these animals grow, they sometimes moult or discard their old exoskeleton before growing a bigger one.

Although exoskeletons are good for jumping and swimming, they do not allow flexibility for the twisting and turning actions that are possible for animals with an inside skeleton (**endoskeleton**). In an animal with an exoskeleton, the muscles are attached inside the skeleton, whereas the muscles in an animal with an endoskeleton are connected to the outside of the skeleton. The human endoskeleton is an internal skeleton which is made of bone and cartilage and clothed in muscle and skin.







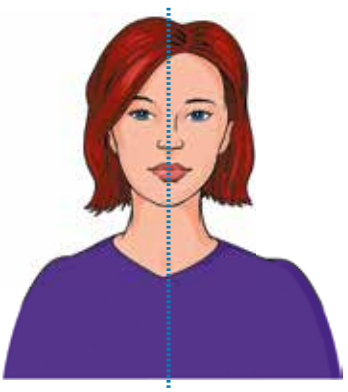
3.6.3 No skeleton at all

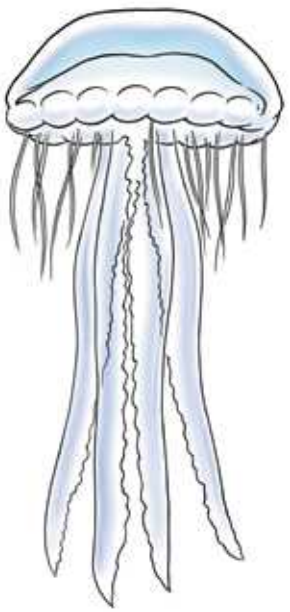
Some animals, such as worms and jellyfish, have no skeleton at all. The body is supported by the pressure of fluid within it. What do you think would happen if a lot of fluid was lost? How can animals without skeletons move?

Earthworms expand and contract their bodies to burrow through the soil. They use two sets of muscles to do this. One set of muscles wraps around the body. When these contract, the body becomes long and thin, enabling the worm to poke into crevices in the soil. The second set of muscles runs along the length of the body. When these contract, the worm becomes short and fat. This helps to anchor the worm in place, pushing the soil apart to form a burrow. By shortening the rest of its body, the worm pulls itself up and moves through the soil.

3.6.4 What's your symmetry?

The type of symmetry that describes an animal's body design can also be used as a structural feature to help classify it. Some animals such as jellyfish and sea stars have **radial symmetry** whereas humans, lobsters and earthworms have **bilateral symmetry**.





INVESTIGATION 3.6

Classifying animals into phyla

AIM: To investigate characteristics used to classify animals

Materials:

preserved specimens or photos of animals from a range of phyla
hand lens

Method and results

- Observe each specimen carefully. Use a hand lens if necessary.

CAUTION

Some specimens are preserved in a liquid called formaldehyde, which is toxic and possibly carcinogenic. If you are provided with specimens in jars that contain liquid, do not open the jars. Look at the specimen through the sealed jar.

- Use the key on the previous page to decide which phylum each animal belongs to.

1. Draw up a results table with the following column headings:
   - Name of animal
   - Phylum
   - Characteristics used to classify.

Disscussion

2. Were there any characteristics in the key that were difficult to identify in the specimens?
3. Which phyla were most difficult to distinguish? Why?

3.6 Exercises: Understanding and inquiring

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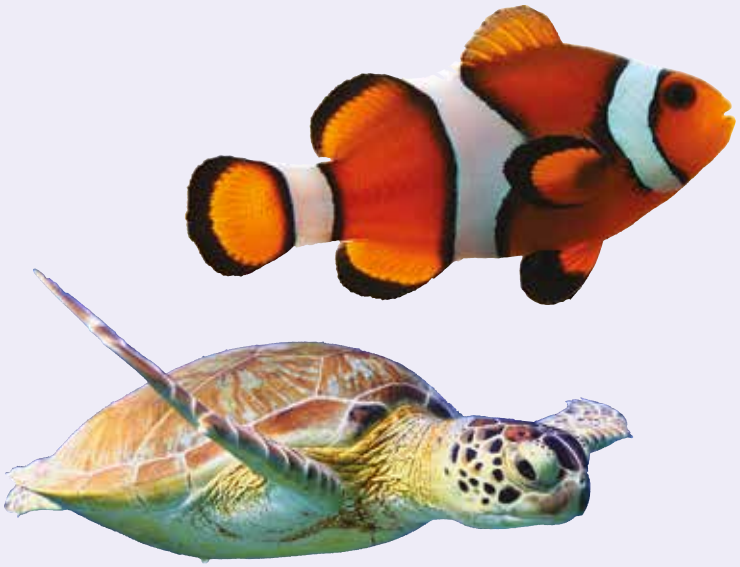
Remember

1. Construct Venn diagrams to show the similarities and differences between:
   (a) vertebrates and invertebrates
   (b) endoskeleton and exoskeletons.
2. Identify which group, vertebrates or invertebrates, is more abundant on Earth.
3. List two criteria that can be used to divide invertebrates into groups.
4. Describe the difference between the way in which muscles are attached in animals with endoskeletons and those with exoskeletons.
5. Worms have no skeleton and no legs. Describe how they are able to move.

Think, discuss and design

6. The Great Barrier Reef is home to a diversity of living things. There are links between many of them, without which not only they but also other organisms may not survive. Find out more about the animals living on the Great Barrier Reef. Research and report on:
   (a) one invertebrate and one vertebrate
   (b) links between four different organisms
   (c) the issue of the crown-of-thorns starfish
   (d) the issue of tourism and the sustainability of the Great Barrier Reef
   (e) identify current research questions being investigated.
   Present your findings as a PowerPoint presentation, poster, picture book, podcast or newspaper article or in a multimedia format.
7. Carefully observe the pictures of the marine animals on the next page.
   (a) Label features that you consider may be useful as criteria to classify and identify the organisms.
   (b) Design a dichotomous key that would enable each of these organisms to be identified.

(c) Compare your key with those of others in the class.
(d) Convert your dichotomous key into either a tabular or circular key.
(e) Use your key to try to classify two animals not shown below. Suggest any modifications that would enable them to be identified using your key.









3.7 Got a backbone!

3.7.1 Similar, but different?

What do you have in common with a jawless fish like a lamprey, you may ask? The answer is that you both have a backbone. Lampreys represent one of the earliest vertebrates.

Although there are many different groups of vertebrates, they all share some common features because they have shared common ancestors at some point in their evolution. Some scientists study these structural similarities to determine how recently they may have shared common ancestors. One example is the study of bones that are similar in shape.

Did you know that the lamprey was one of the earliest vertebrates?



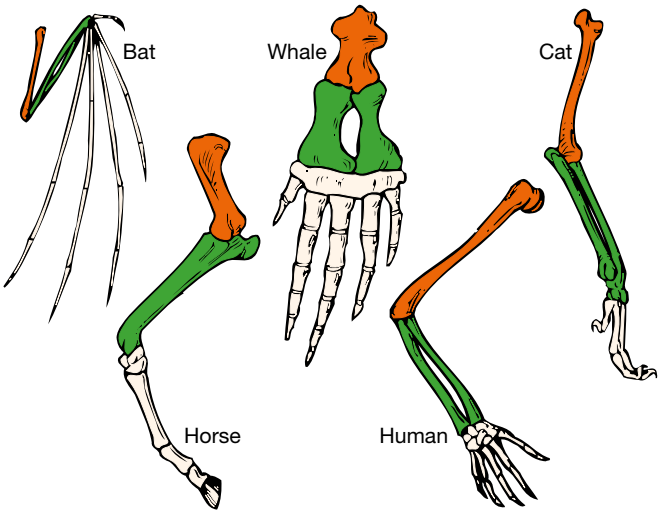
3.7.2 Linking features?

You can also see similarities between the skeleton and backbone of a modern day chicken and that of an extinct animal called *Archaeopteryx*, which some scientists suggest is the link between dinosaurs and birds.

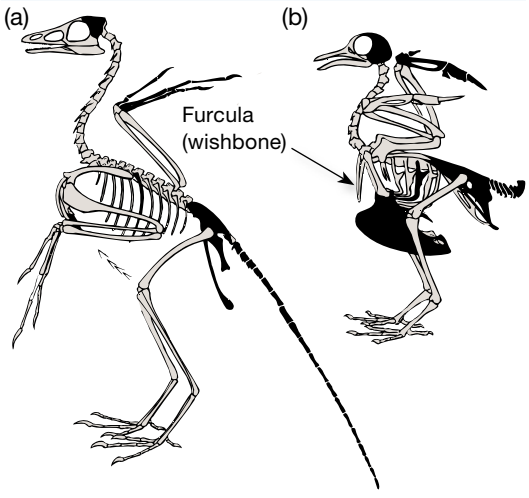
3.7.3 Not just one bone, but many

The word 'vertebrate' is derived from the Latin word *vertebra,* which means 'joint'. Your backbone is not a single bone. It is made up of many small bones called **vertebrae**, which are stacked on top of one another to form your **vertebral column**.

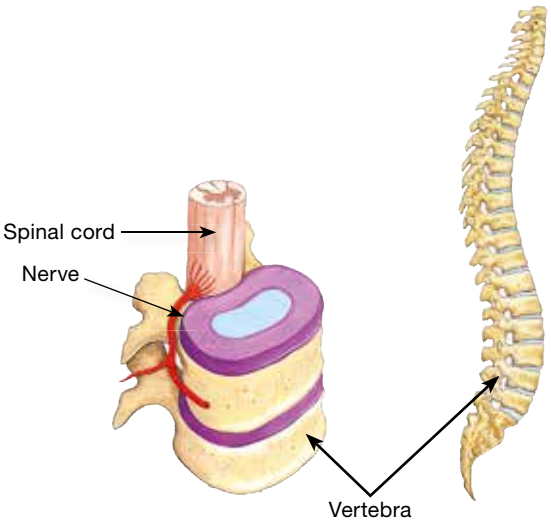
The structures shown have the same basic arrangement since they are all derived from a vertebrate forelimb. Do they have identical functions?



Skeleton of (a) *Archaeopteryx* and (b) a modern flying bird. The black regions on the skeletons show distinctive reptilian features (at left) and bird features (at right).



Your backbone is made up of many bones called vertebrae.

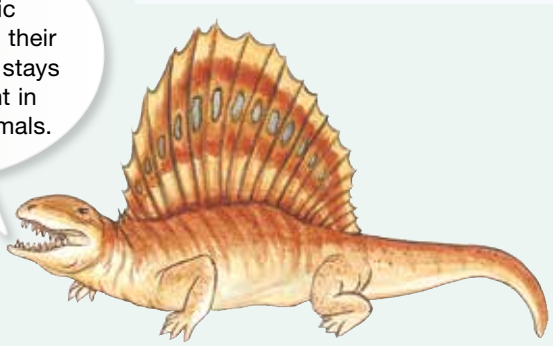


HOW ABOUT THAT!

Dimetrodon was a meat-eating pelycosaur. The pelycosaurs were the most successful reptiles of the Permian period. They looked like big lizards with huge sail-like fins on their backs. The pelycosaurs used this 'sail' to regulate their body temperature. They could stand in the early morning sun with the sail arranged towards the sun to warm them up. They could turn it into the wind to cool off. It is thought that this fin arrangement was an early stage in the development of temperature regulation of mammals.

The body temperature of poikilothermic animals varies with their environment, but it stays relatively constant in homeothermic animals.

Dimetrodon — a mammal-like reptile



Vertebrates are animals that have a backbone made of bones called vertebrae. The five main groups of vertebrates are fish, amphibians, reptiles, birds and mammals.



Mammals

Examples
Wallaby, possum, echidna, dog, human, dolphin, whale

Characteristics
- Skin with hair or fur
- Females with mammary glands that secrete milk
- Constant body temperature



Birds

Examples
Kookaburra, emu, penguin, cockatoo, galah, parrot, seagull

Characteristics
Skin with feathers
- Eggs with hard shell
- Beak for feeding
- Constant body temperature

Reptiles

Characteristics
- Skin with scales
- Eggs with membranous or leathery shells laid on land
- Lungs for breathing
- Changing body temperature

Examples
Snake, lizard, tortoise, crocodile



Vertebrates

Fish

Examples
Goldfish, barramundi, shark, bream, stingray



Characteristics
- Found only in water
- Changing body temperature
- Gills for breathing
- Most have eggs without a shell.
- Skin with scales

Amphibians

Characteristics
- Soft, moist skin without scales
- Eggs without a shell usually laid in water
- Larvae usually live in water.
- Adults usually live on land and have lungs.
- Changing body temperature

Examples
Frog, toad, salamander



INVESTIGATION 3.7

Flash 'n' mind

AIM: To learn the characteristics of the vertebrate groups

- You can make a set of *Flash 'n' mind* cards for yourself or for your team. Each card is about one-eighth of an A4 page in size, and made of coloured cardboard. You will need about 50 flash cards.

1. Type or write creatively the following terms on five separate cards: vertebrates, mammals, birds, reptiles, amphibians, fish.
2. On 21 separate cards, write each dot point from the characteristics sections on page 78.
3. Using the internet, clipart, magazines or other sources, find as many photographs or pictures as you can of the animals listed on page 78. Paste these images onto separate flash cards.
4. Shuffle your cards and, without looking at the figure on page 78, try to arrange them into a similar mind map. As you are laying each card down, say aloud why you are putting it in that place. If you are doing this as a team, discuss any differences of opinion. Once completed, check page 78 to see how you did.
5. As a team, use your *Flash 'n' mind* cards to design and play as many games as you can to help you learn the characteristics and examples of each vertebrate group.

3.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Identify the feature that jawless fish such as lampreys have in common with humans.
2. Suggest why vertebrates all share some common features.
3. What does the Latin word *vertebra* mean?
4. Describe the relationship between vertebrae and your backbone.
5. Construct Venn diagrams to show the similarities and differences between:
   (a) mammals and birds
   (b) reptiles and amphibians
   (c) fish and mammals.
6. Identify the group to which each of the following vertebrates belongs.
   (a) Snake
   (b) Cane toad
   (c) Goldfish
   (d) Whale
   (e) Emu
   (f) Shark
   (g) Lamprey
7. Suggest the function of the huge sail-like fins on the backs of pelycosaurs.
8. (a) Copy and complete the table below.
   (b) Are the answers to the questions in the table the same throughout the life cycle of the organism? Discuss your response with others in your class.

Feature	Mammals	Birds	Reptiles	Amphibians	Fish
Is body temperature constant or does it change?					
What type of body covering does it have?					
Does it lay eggs? If so, what type of shell do they have?					
Does it have lungs or gills?					
Does it feed its young milk?					
Give two examples.					

Think

9. Identify the group to which each of the following animals belongs.
   (a) I have lungs but no legs. My offspring are found in membranous-shelled eggs and use lungs to breathe.
   (b) I have moist skin but no scales, and two pairs of legs. Although I have lungs and live on land, my young usually live in water and use gills to breathe.
   (c) I have a constant body temperature, have feathers, and lay eggs with a hard shell.
   (d) I have a changing body temperature, gills and fins.
10. Suggest why it is thought that the pelycosaurs were a link between reptiles and mammals.
11. Using the table from question 8 and the translations in the table below, in which scientific classification groups would you place the vertebrates shown in the pictures below?

Latin or Greek word	English translation	Scientific classification
Amphis + bios	Double, both sides + life	Amphibia
Chondros + icthyes	Cartilage + fish	Chondrichytes
Marsypos	Pouch	Marsupialia
Osteon + icthyes	Bone + fish	Osteichtyes
Repere	To creep	Reptilia
Rodere	To gnaw	Rodentia
Siren	A kind of mermaid	Sirenia

Hamster



Stingray



Quokka



Eel



Dugong



Newt



Investigate

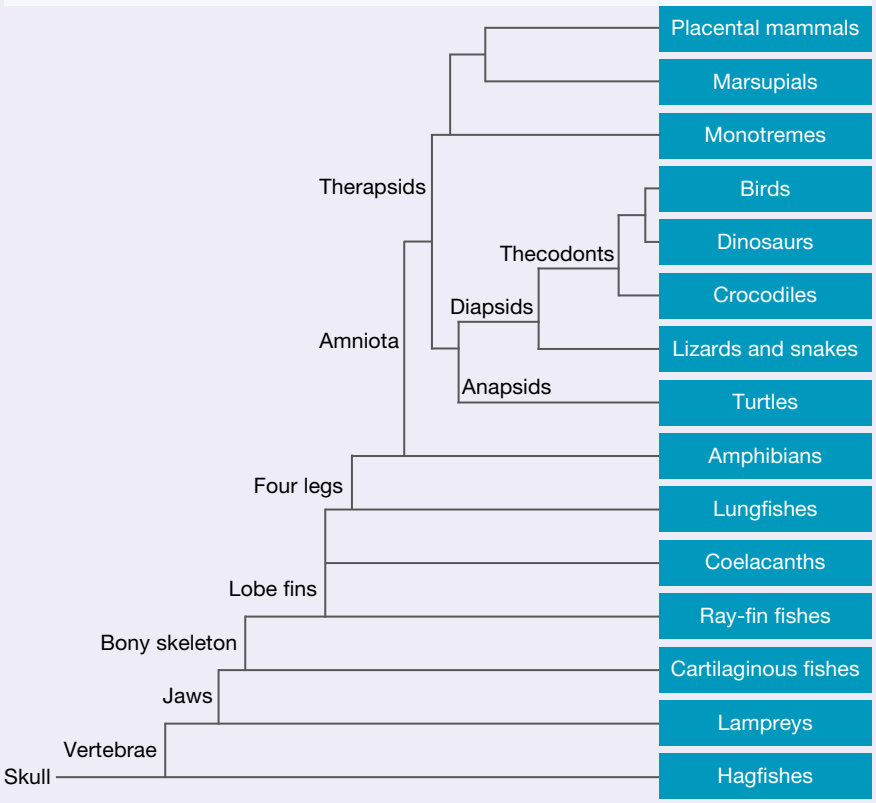
12. Goldfish and sharks are fish. Apart from their size, how are they different from each other? Construct a Venn diagram to summarise your findings of the structural and behavioural similarities and differences.
13. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions), but create new cards using scientific terms or animal groups that appear in this section.
14. Research and report on the issues and implications of tourism and overhunting on populations of the Australian freshwater crocodile, *Crocodylus johnstoni*, and share your findings with others.

Use data, investigate and create

Use the evolution figure on the right to answer questions 16, 17 and 18.

15. Find out about the evolutionary history of lampreys and present your findings to the class as an annotated timeline.
16. Which of the following pairs would you suggest shared the most recent common ancestor?
    (a) Birds and dinosaurs or turtles and lampreys?
    (b) Marsupials and monotremes or placentals and marsupials?
17. Select two of the vertebrates in the figure on the right and create a PowerPoint presentation or web page to show how they are similar and how they are different.
18. Find out about the features and 'lives' of two types of vertebrates in the figure, construct puppets of each and present a story or play about their lives.

The branches of this evolution tree diagram show how recently various groups shared common ancestors.



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Complete this digital doc: Worksheet 3.11: Classifying vertebrates (doc-19809)

3.8 Mammals

3.8.1 Placenta, pouch or egg?

Do you possess skin with hair or fur and have a constant body temperature? If you do, you could be one of the three types of mammals! The key criterion used to divide mammals is the way in which they give birth to their young.

You are classified as a **placental mammal** because you grew inside your mother, receiving your needs via a placenta, and were born at a well-developed stage. **Marsupials**, however, are born at a very early stage of development and then grow inside their mother's pouch. **Monotremes** are laid in leathery-shelled eggs.

3.8.2 Unique for its mammals

Australia is unique in terms of the diversity of mammals that live here. Two-thirds of the world's marsupials live in Australia and monotremes are found naturally only in Australia and the nearby islands. Particularly in the spotlight is our platypus. Because of its uniqueness, research is currently being performed in a variety of different scientific fields.

Australia's native mammals are particularly well adapted to their harsh environments.

Mammals:
- have skin with hair and fur and have a constant body temperature
- have females with mammary glands that can secrete milk
- can be divided into three groups based on the way they give birth to their young.

Placental mammals



- Young grow inside the body of their mother and are attached by a cord to the placenta, which supplies their food.
- Young are well developed when they are born.
- Most mammals are placental mammals. Examples include horses, mice, humans, cats, cows and pigs.

Marsupials



- Although blind and naked, newborn marsupials crawl from their mother's birth canal to her pouch and attach themselves to the nipple to feed.
- Young are born at a very early stage of development.
- Two-thirds of the world's marsupials live in Australia. Examples include kangaroos, wombats, possums and koalas.

Monotremes



- Young are laid in leathery-shelled eggs.
- Monotremes are found only in Australia and some nearby islands. There are only two types of monotremes: the platypus and the echidna.

3.8.3 What kind of creature is this?

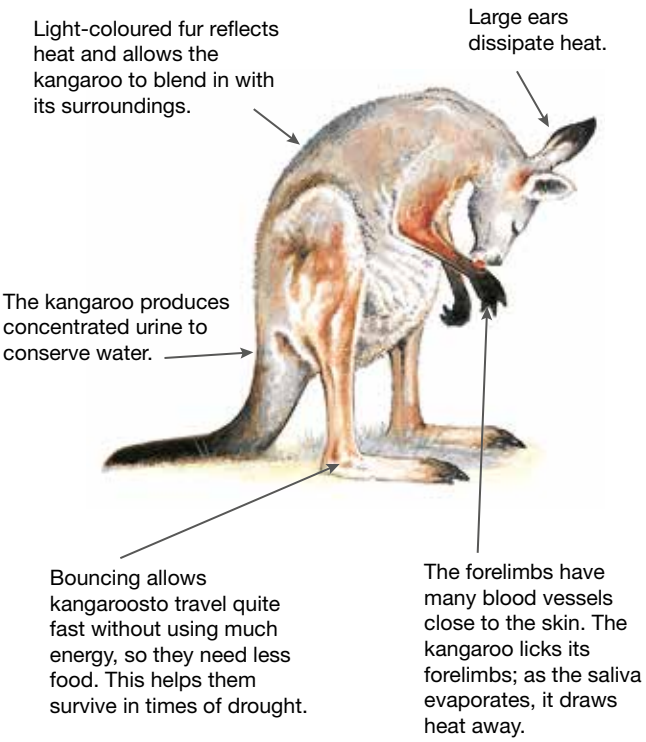
When European explorers returned from Australia with stories of 'strange' animals such as kangaroos, wallabies, koalas and wombats, people were surprised. Australian animals seemed so different from those common in Europe and other countries.

Imagine their disbelief when the platypus was first described to them. This strange animal had webbed feet and a bill like a duck, but it had no feathers. It laid leathery eggs like lizards and crocodiles, but it did not have scales on its skin. It also had fur and a large tail like that of an otter but, like a reptile, it had only one opening for ejecting faeces and urine.

In London in 1799, an Australian sailor presented a platypus specimen to Dr George Shaw, a prominent biologist of the time. It was so different that Shaw considered it a hoax and tried to cut off the duck-bill with scissors. The scissor-marks are still visible on the preserved platypus skin in the British Museum (Natural History) in London.

It is thought that the reason for the existence of Australia's unique animals like the platypus is Australia's isolation from the other continents after they separated millions of years ago. The animals evolved over time to be well suited to the unique Australian environment.

An **adaptation** is a feature that helps an organism to survive and reproduce in its environment. This figure identifies adaptations that help a kangaroo survive in the hot, dry Australian environment.



3.8.4 New evidence — changing ideas

The platypus was the first Australian animal to be included in the Human Genome Project. The platypus (*Ornithorhynchus anatinus*) genome (genetic information) was published in 2008 and has brought new insights into mammalian evolution.

XXXXX-rated sex

Platypus sex is X-rated … in a big way! Sex is determined in most mammals by the X and the Y chromosomes — XX (two X chromosomes) will result in a female and XY (one X and one Y chromosome) will result in a male. In platypuses, however, it gets really interesting! Instead of having a single pair of sex chromosomes, platypuses have a set of ten chromosomes to determine sex. So a female has XXXXXXXXXX and a male has XYXYXYXYXY!

It's got webbed feet, a bill, fur and lays leathery eggs — is it real?



Monotreme milk

Teams of Australian scientists at the University of Melbourne, Deakin University and the Australian National University have been studying the milk produced by various mammals. Their research suggests that the milk from monotremes is very different from the milk of other mammals. This supports the theory that placental and marsupial mammals are more closely related to each other than they are to monotremes.

Venom

Platypus venom contains a cocktail of more than 50 different substances. Studies have suggested that some of these substances may be useful in the future as new painkillers. It will be exciting to see what new medicines may result from these findings.

3.8.5 A long, long time ago …

If you could travel back in time, you would be amazed by the types of megafauna (giant animals) that roamed our Australian continent. Imagine 'wombats' the size of cars (*Diprotodon optatum*), giant

flightless birds (*Genyornis*) and lizards 7 metres long (*Megalania*). You might face fearsome lion-like marsupials (*Thylacoleo*) and wolf-like *Thylacinus*, not to mention having giant kangaroos (*Ptovspyofons*) bounding past.

Marsupial mammals have existed in Australia for about 35 million years and due to our 'isolation' many different types have evolved. The story of the history of our mammals is told in our fossil records.

WHAT DOES IT MEAN?

The word *megafauna* comes from the Greek word *megas*, meaning 'great' or 'large', and the Latin word *fauna*, meaning 'animals'. The Latin term *flora* means 'plants'.

3.8.6 Questions of the past in the future

Archaeologists and other scientists in a variety of fields are working together to answer questions such as 'Why did the megafauna become extinct?' and 'Why do platypuses have so many sex chromosomes?'.

Theories that have been suggested as to why the megafauna became extinct include the following.

- Aboriginal people may have hunted them as a food source.
- Aboriginal people may have brought diseases with them that infected and killed the animals.
- Fires lit by Aborigines may have led to a change in the types of vegetation.
- The climate became drier and vegetation changed so that food sources became scarce.

A timeline of some marsupial fossil finds and major mammal events

Some marsupial fossil finds and events	Epoch (millions of years ago)		Major mammal events
Present	HOLOCENE 0.01–present	Quaternary period	Humans investigate Earth's history.
Most of the large Pleistocene marsupials became extinct about 15 000–30 000 years ago.	PLEISTOCENE 1.64–0.01 mya	Quaternary period	Aborigines arrived in Australia about 55 000 years ago.
Many giant browsing marsupials became extinct; there were grazing kangaroos and lots of diprotodons.	PLIOCENE 5.2–1.64 mya	Tertiary period	*Homo habilis,* the earliest known human, appeared in East Africa.
Primitive marsupial 'mice' and 'tapirs' were found at Lake Eyre, South Australia, and diprotodons at Bullock Creek, Northern Territory.	MIOCENE 23.5–5.2 mya	Tertiary period	Lots of marsupial mammals were living in Australia and South America.
First Australian marsupials occurred about 23 million years ago. Diprotodons and a relative of pygmy possum fossils were found in Tasmania.	OLIGOCENE 35.5–23.5 mya	Tertiary period	First marsupials appeared in Australia. First primates appeared.
Lots of marsupial fossils of this age were found in South and North America.	EOCENE 56.5–35.5 mya	Tertiary period	Swimming and flying mammals appeared.
Dinosaurs became extinct about 65 million years ago.	PALAEOCENE 65–56.5 mya	Tertiary period	More mammals appeared after dinosaurs became extinct.

Cenozoic era

In May 2013, an international team of experts published research findings stating that, of 90 megafauna, only 8–14 still existed when humans arrived. It concluded that climate change was the real culprit. Debate continues!

Giant kangaroo

The extinct giant kangaroo, *Procoptodon*, was heavily built and stood about 2.5 metres high. Procoptodons may have weighed about four times as much as the largest kangaroos of today. They had a short face and deep skull with huge molar teeth. Their molars may have helped them to eat tough plant foods. Procoptodons may have used their very long forelimbs to pull down the branches of trees and shrubs.

Diprotodons

The members of this group are all extinct. They were the largest of all the marsupials. *Diprotodon optatum*, often referred to as the diprotodon, was the largest known marsupial to have ever lived. The skeleton of the diprotodon suggests that the animal was about the size of a rhinoceros, being about three metres long and possibly weighing about two tonnes.

This illustration shows some of the animals that inhabited Australia in the Tertiary period. Others included marsupial lions, koalas, possums, wallabies, kangaroos, goannas and long-beaked echidnas (*Zaglossus*).



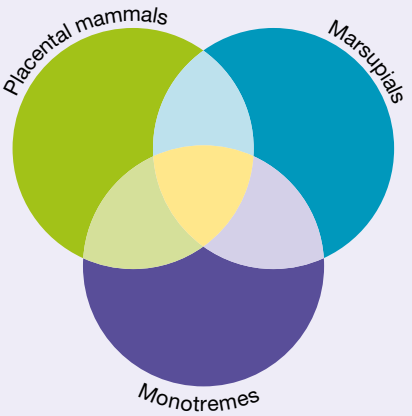
3.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember and think

1. Construct a three-column table and use it to summarise the main characteristics of each of the three groups of mammals.
2. Outline how marsupials are different from all other animals.
3. Suggest how placental mammals got their name.
4. Identify which group of mammals the following animals belong to.
   (a) Echidna (b) Possum (c) Cat
5. How many chromosomes decide the sex of a platypus? Suggest how this is different from the situation in other mammals.
6. Suggest how we know that marsupials have existed in Australia for millions of years.
7. List features of each of the following and suggest which living animal it is most similar to today.
   (a) *Procoptodon*
   (b) *Diprotodon optatum*
8. Outline the importance of the findings related to the genome of the platypus.
9. Suggest why Australian mammals are so different from those found in other countries.
10. List theories as to why Australia's megafauna became extinct. Which of these theories is currently supported by research?

Think and discuss



11. Construct a triple Venn diagram to show the similarities, differences and examples of the three mammal groups.
    Look at the illustration of prehistoric animals on the previous page.
12. Which animals alive today are they most similar to? Give reasons for your answers.
13. How are present-day wombats different from their ancient ancestors?

Analyse and evaluate

14. Use the timeline on page 84 to answer the following questions.
    (a) List the seven epochs in the table on page 84 in order of most recent to least recent.
    (b) In which epoch did marsupials appear in Australia? How do we know this?
    (c) Earth's greatest ice age was in the Pliocene epoch. When was this? What other events occurred then?
    (d) Look up other sources to find out what other important events occurred, and add these to your timeline.

Investigate

15. Find out more about one placental mammal, marsupial or monotreme and present your information in a poster or PowerPoint presentation.
16. Did you know that adult hedgehogs have 5000 spines? So that the birth canal is not damaged when the mother is giving birth, the initial spines of a newborn are covered with a layer of skin. The spines pop through hours after birth. Although hedgehogs are mammals and they look a little like echidnas because of their spines, they are not classified as monotremes.
    (a) Find out whether hedgehogs are placental mammals or marsupials.
    (b) How do hedgehogs differ from echidnas?
    (c) A porcupine also has spines. What type of mammal is a porcupine?
    (d) How are porcupines different from hedgehogs and echidnas?
17. Find out more about Australia's prehistoric marsupials, and present your information as a poster, poem, story or PowerPoint presentation.
18. Find out about the different climates, environments and organisms for one of the epochs in the Cenozoic era, and then write a story about an imaginary journey back in time.
19. Besides the Cenozoic, what are the other four eras used to describe the history of the Earth? Draw a timeline showing all five eras, including their periods, times in millions of years and any other information you can locate.
20. What do taxonomists in museums do? Why is their work important?
21. Research and report on one of the following topics of research in Australia.
    - Platypus genome
    - Platypus milk and lactation
    - Platypus venom
    - Platypus sex chromosomes and mating
    - Koala diet
    - Koala diseases
    - Koala reproduction
    - Tamar wallabies
    - Bilbies

    Present your findings as a poster, PowerPoint presentation, web page, picture book or journal article.
22. Find out the names and features of some Australian mammals and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.
23. Imagine you are an Australian palaeontologist with a time machine. Document a week in your journal. Share your journal with two others and find out about their adventures. Present the three journal entries to the class.

learnON RESOURCES — ONLINE ONLY

Complete this digital doc: Worksheet 3.12: Looks can be deceiving (doc-19810)

3.9 No backbone!

3.9.1 Invertebrates

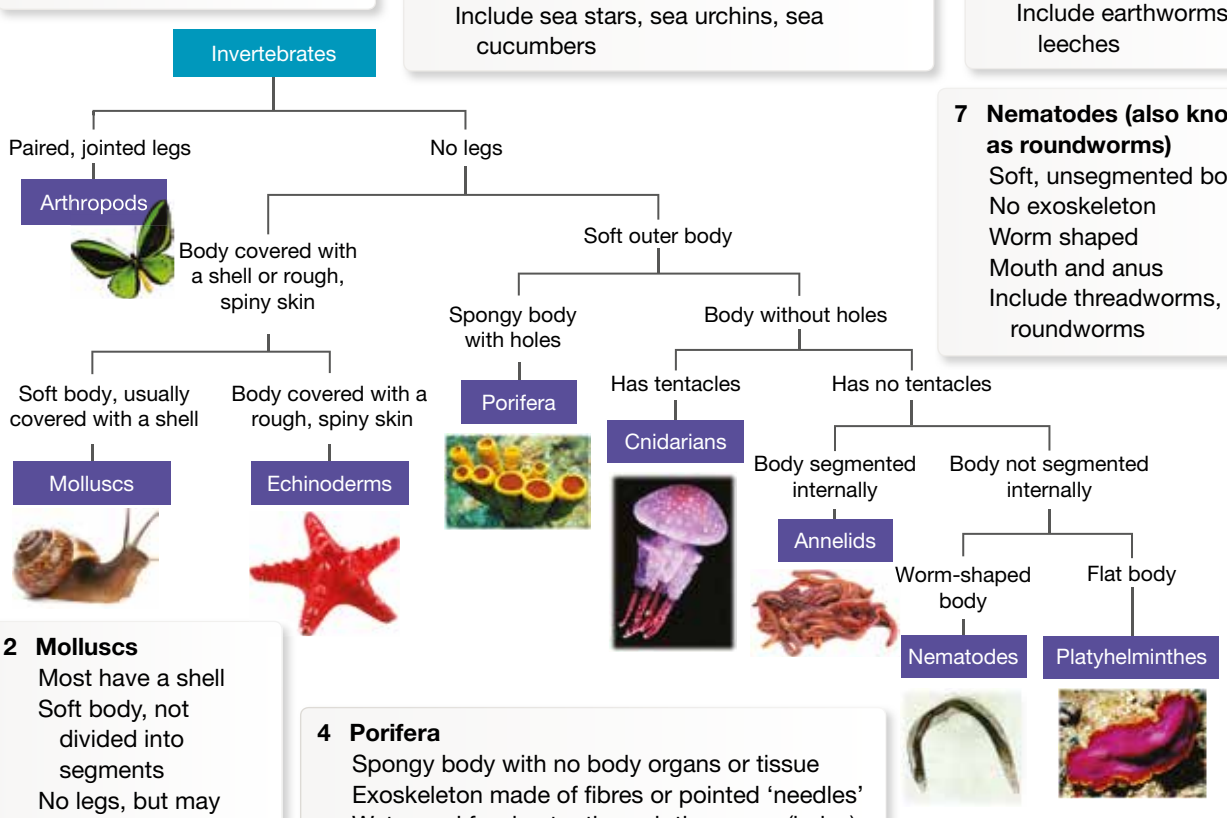
Feel a little itchy? Did you feed something in your sleep — or were you awake? Was it a flea, an insect, a worm or a louse? Did it burrow its way inside you to feed or did it get its food while crawling on your skin? Chances are it might have been an invertebrate — a creature with no backbone.

1 Arthropods
- Body divided into segments
- Exoskeleton
- Paired, jointed legs
- Most have antennae
- Include centipedes, spiders, crabs, ants, grasshoppers, moths

3 Echinoderms (pronounced ee-KAI-no-derms)
- Most have a soft body over an internal skeleton
- Rough, often spine-covered 'skin'
- Body has a five-part pattern
- Move through water by taking water in and pushing it out of tubes in their bodies
- Include sea stars, sea urchins, sea cucumbers

6 Annelids (also known as segmented worms)
- Internal segments with some repeated organs
- Soft bodies with an obvious head
- No exoskeleton
- Mouth and anus
- Include earthworms, leeches

7 Nematodes (also known as roundworms)
- Soft, unsegmented bodies
- No exoskeleton
- Worm shaped
- Mouth and anus
- Include threadworms, roundworms



2 Molluscs
- Most have a shell
- Soft body, not divided into segments
- No legs, but may have tentacles
- Have a strong 'foot' muscle to help them move
- Include oysters, octopuses, scallops, slugs, snails

4 Porifera
- Spongy body with no body organs or tissue
- Exoskeleton made of fibres or pointed 'needles'
- Water and food enter through tiny pores (holes) in body
- Wastes pass out through one big opening
- Include barrel sponges, glass sponges, tube sponges

5 Cnidarians (pronounced ny-DAIR-ee-ins — the 'C' is silent)
- Hollow, soft body
- No body organs
- Take in food and pass out waste through one opening
- Have tentacles containing stinging cells, which fire shots of toxin
- Include box jellyfish, sea anemone, Portuguese man-of-war, coral

8 Platyhelminthes (pronounced plat-ee-hel-MIN-theez; also known as flatworms)
- Soft, flat, usually unsegmented bodies
- No exoskeleton
- Mouth but no anus
- Include tapeworm, fluke

3.9.2 Invertebrates beware!

Some organisms obtain their nutrients by feeding on other living organisms. These are called **parasites**. **Endoparasites**, such as tapeworms, live inside their hosts, whereas **ectoparasites**, such as head lice, live on the outside. Some of these organisms also act as carriers or **vectors**, transporting disease-causing organisms from one animal to another.

No backbone

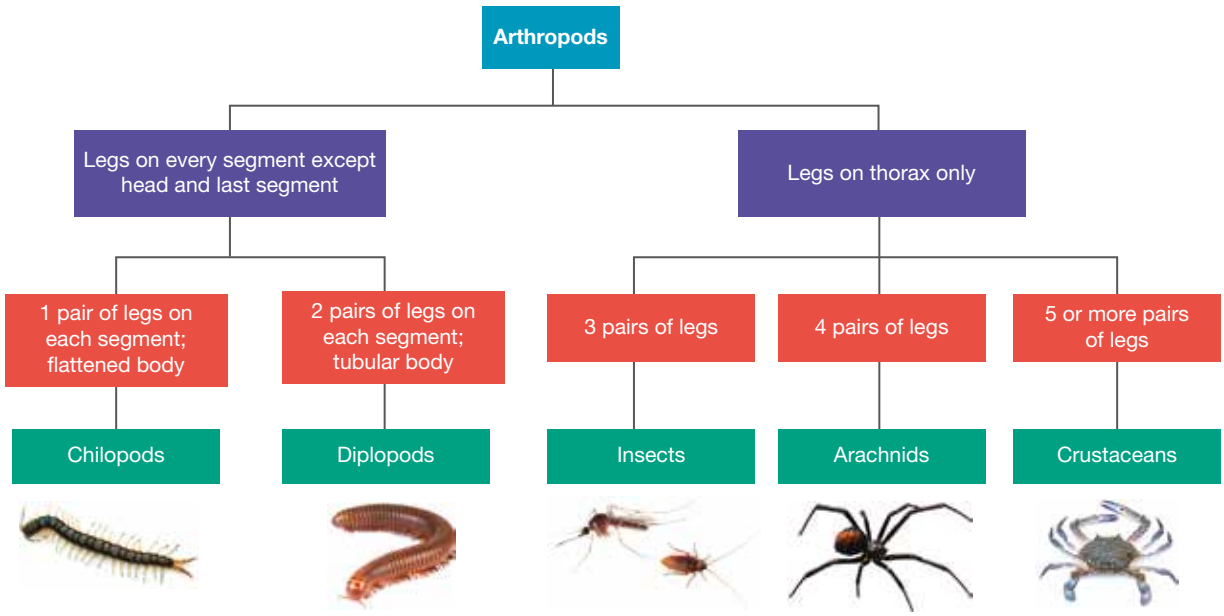
No backbone? Animals without backbones are called invertebrates. Many invertebrates have an exoskeleton (skeleton on the outside) and some have no skeleton at all. About 95 per cent of animals are invertebrates. Have a look at the invertebrate dichotomous key on the previous page to see how many of the features, groups and examples you recognise.

A number of the invertebrate groups contain organisms that may find you quite tasty. There are some well-known human parasites in the following groups of invertebrates:

- arthropods (for example, head lice, mosquitoes, fleas, ticks and mites)
- nematodes (for example, threadworms, hookworms and pinworms)
- platyhelminthes (for example, liver flukes and tapeworms)
- annelids (for example, leeches).

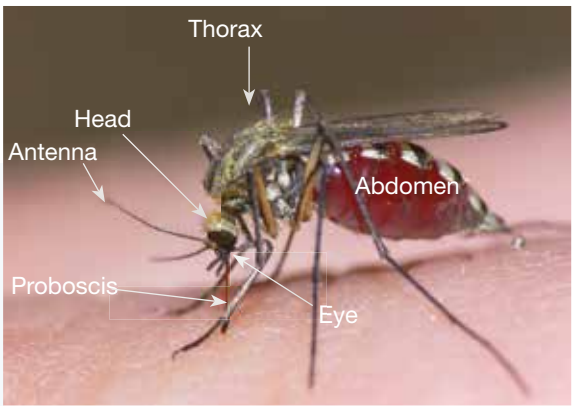
3.9.3 Arthropods

About 80 per cent of invertebrates are **arthropods**. Arthropods can be classified on the basis of the organisation and number of their legs.



3.9.4 Insects

The figure on the right shows the head, thorax and abdomen of a mosquito. As there are three pairs of legs attached to the thorax, it is classified as an insect.



Insects' bodies are divided into three parts — the head, thorax (chest) and abdomen (stomach) — and have three pairs of legs attached. Most have either one or two pairs of wings, a characteristic that separates them from any other invertebrate animal. The proboscis of a female mosquito has sharp needles that poke out when a blood vessel in its victim is pierced.

3.9.5 Functional features

All insects have the same basic mouthparts, but over millions of years, depending on their particular diet, they have developed in different ways. Most insects either bite off pieces of food and chew them or suck up liquids such as nectar or blood.

Sap and sweet suckers

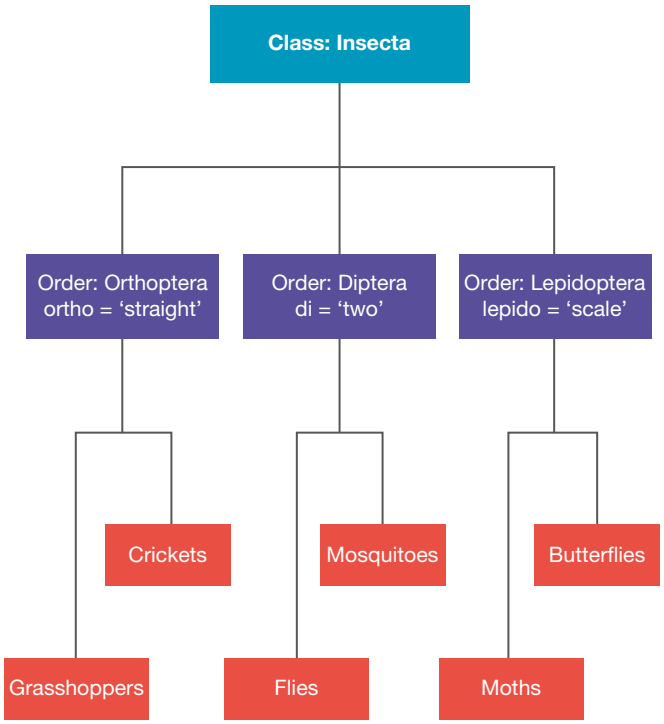
Some insects may obtain their food by sucking sap from plants. The shape of an insect's head can often suggest the sort of food it eats. A sap-sucking insect usually has a tiny head with a long, pointed tube extending from its mouth, which it uses to suck up sap.

Moths and butterflies have a long tubular **proboscis** that unrolls to reach the nectar within a flower. Dragonflies also have extendable mouthparts for hunting.

WHAT DOES IT MEAN?

The term *platys* comes from the Greek term meaning 'flat'; *helminth* comes from the Greek word for 'worm'; *nema* comes from the Greek term for 'thread'; and *mollusc* comes from the Latin term *mollis*, meaning 'soft'.

Using the knowledge that *pteron* is Greek for 'wing' and the prefix translations below, can you suggest a feature that these insects all share, and one that can be used to separate them?



Although adult mosquitoes feed on the sugar in plants, the females in some species must have one or more blood meals to produce eggs. In most species of mosquito, the female has a sharp, tubular proboscis well suited to piercing and sucking. Male mosquitoes never suck blood. Female mosquitoes may pass on malaria, yellow fever, elephantiasis and filariasis while obtaining blood, because they inject infected saliva into their hosts.

A hawk moth has an unusually long proboscis — it is often longer than its body. Moths and butterflies don't blow up their proboscis; they use muscles that act like an elastic rod, coiling it up again so that it may be kept coiled under the head.

Bee fly proboscis



Dragonfly mouth



Hawk moth proboscis



Butterfly proboscis



Bite and chew

Some insects have feeding structures that are designed for biting and chewing. They usually eat plants and have a large head to support the strong muscles and jaws that are needed to get through the tough plant tissue.

HOW ABOUT THAT!

Bedbugs (*Cimex lectularius*) come out at night and feed on the blood of mammals and birds. Their mouthparts are well suited to piercing their host's skin. They have barbed structures for piercing and sawing. The bugs have a pair of tubes, one of which inject saliva containing a substance that stops the blood from clotting, while the other sucks up the blood and saliva mixture. They usually feed just before dawn if the temperature is above 13 °C and may take five minutes or more to extract their meal before scurrying off to digest it and rest.



3.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

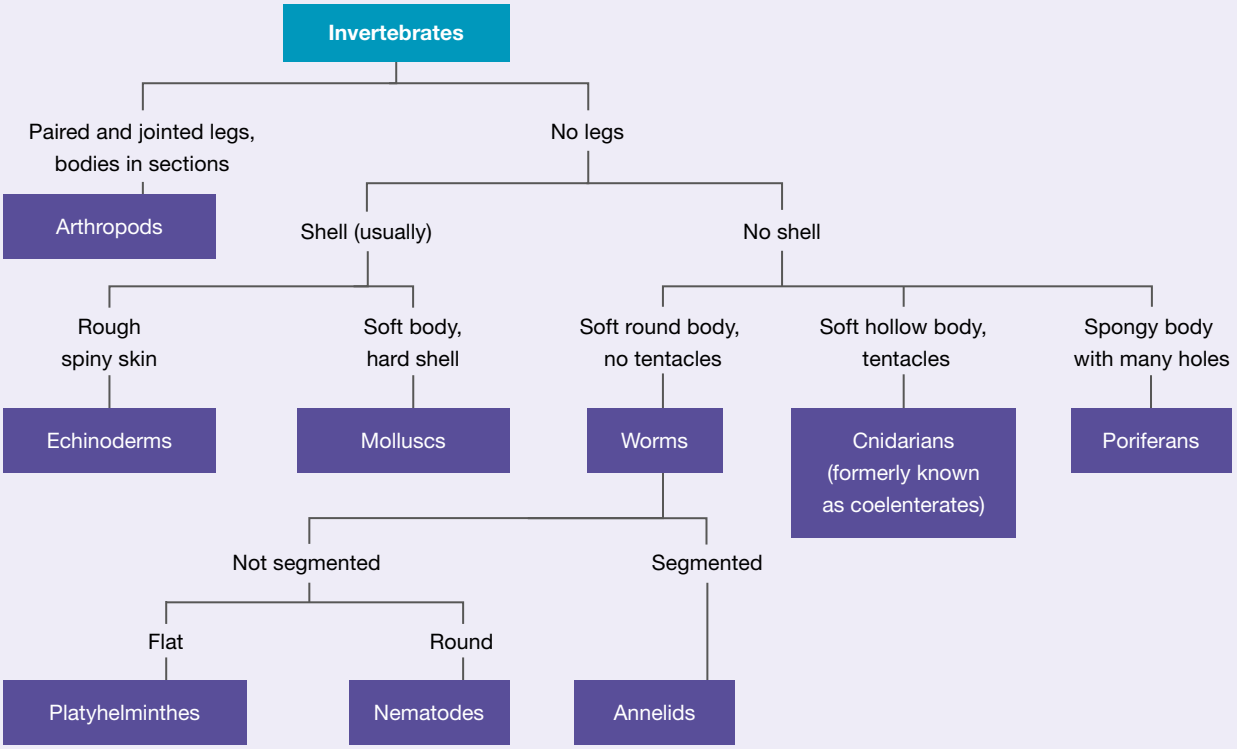
1. Define the term 'parasite'.
2. Outline the difference between endoparasites and ectoparasites.
3. What do all invertebrates have in common?
4. Identify the name of the invertebrate group to which each of the following organisms belongs.
   (a) Threadworm
   (b) Earthworm
   (c) Jellyfish
   (d) Tapeworm
   (e) Tube sponge
   (f) Sea urchin
   (g) Slug
   (h) Grasshopper

   Use the invertebrate dichotomous key on page 87 to answer questions 5 and 6.
5. State which of the following pairs have (a) most in common and (b) least in common.
   (A) Nematodes and platyhelminthes
   (B) Molluscs and annelids
   (C) Arthropods and cnidarians
   (D) Arthropods and annelids
6. For the pairs that you have identified in question 5, list the features that each pair has in common.
7. Construct a table to show examples of arthropods, nematodes, platyhelminthes and annelids that can be human parasites.
8. Suggest features that can be used to divide arthropods into groups.
9. Describe what a proboscis is used for.
10. Describe the features of the mouthparts of a bedbug that enable it to feed on humans.
11. Outline how the types of heads and mouthparts of insects can tell you about the way that they live and feed.

Using data, think and discuss

12. Who am I? Use the dichotomous key on the opposite page to find the identities of the following invertebrates.
    (a) I do not have legs but I have a soft outer body and tentacles.
    (b) I have a rough spiny body covering, a five-part body pattern and no legs.
13. Use the dichotomous key on the opposite page to classify an octopus.
    (a) To which group does it appear to belong?
    (b) Check the lists of characteristics to see if the answer you gave in part (a) was correct. If you find that you were incorrect, suggest why.
    (c) Classification is not always straightforward. Use the lists of characteristics to design a dichotomous key of your own that will make it easier to classify an octopus.
    (d) Test your key by using it to classify a snail, a starfish and an earthworm. Does your key seem to work?

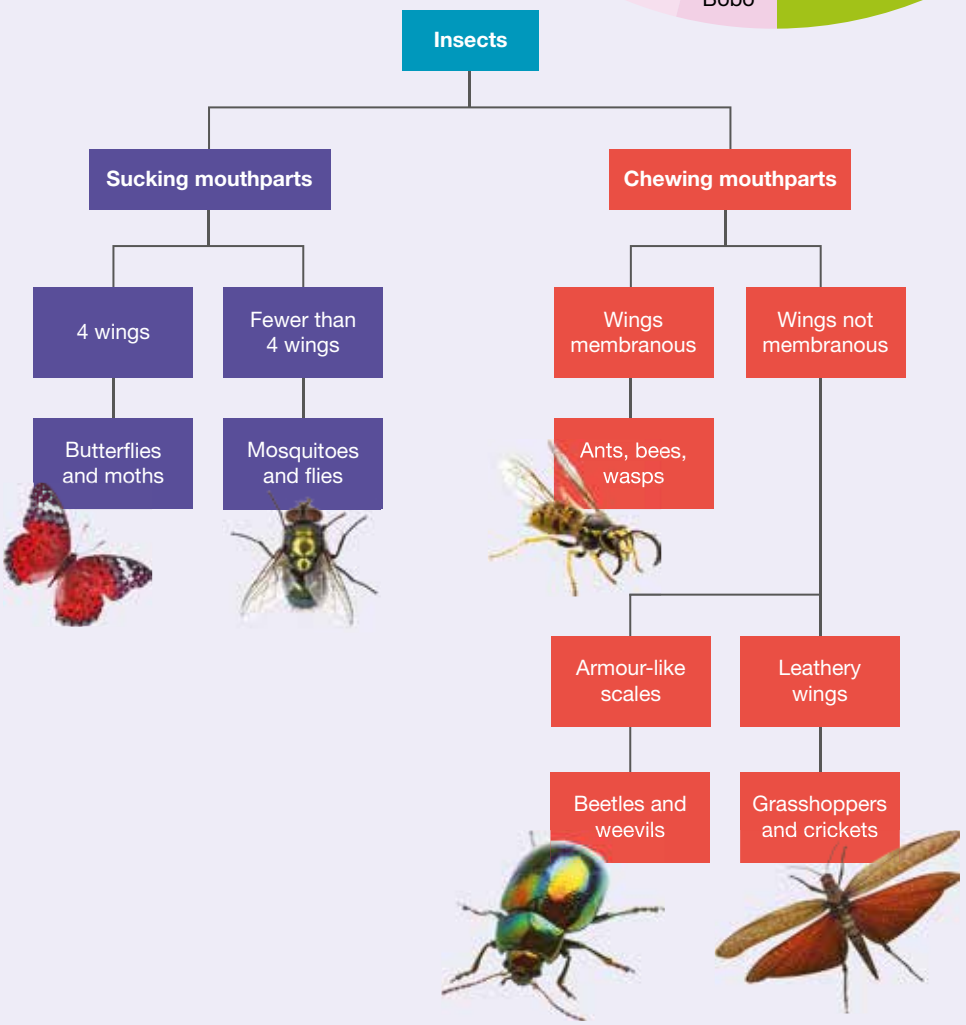
14. Use the lists of features of the invertebrate groups to state which group (or groups):
    (a) has jointed and paired legs
    (b) usually has a hard shell
    (c) can have tentacles
    (d) has a body with many holes.
15. Use the dichotomous key below to classify each of the following invertebrates. As you work down from the top of the key, list the characteristics of the animal that enabled you to classify it (for example: snail — no legs; shell (usually); soft body, hard shell).
    (a) Earthworm
    (b) Crab
    (c) Oyster
    (d) Spider



16. (a) In a table, list the features of slugs, earthworms and snails.
    (b) Highlight or circle features that they all have in common.
    (c) Which two appear to have most in common?
    (d) Use the invertebrate key to see if your data are supported by their classification group.
    (e) Discuss your findings.
17. Find out why cnidarians are no longer classified as coelenterates.
18. (a) Use the circular key on the next page to identify the 'insect' creatures from another planet.
    (b) Describe the characteristics of a trisee, a peeler and a bitpart.
    (c) Make a sketch of a gazer and a bozo.
    (d) Which of the following are most similar: a bisharp, a noner and a peeler?
19. (a) Use the insect key on the next page to classify a variety of insects into their groups.
    (b) Did you have any difficulties using the key? Suggest any changes that you could make to improve it.
20. (a) Using the information on page 87 and images from the internet, clipart and magazines, create a set of Flash 'n' mind cards for invertebrates (see Investigation 3.7).
    (b) Design as many different games as you can that use the cards to help you learn the characteristics and examples of each invertebrate group.
    (c) Play some of your card games with your team and also with other teams.
    (d) Combine your invertebrate cards with your vertebrate cards from Investigation 3.7 to create a floor mind map to share with others what you have learned.
21. Design and make masks to model the feeding parts of several different insects.
22. Use a magnifying glass or stereo microscope to observe and sketch the heads of a range of insects. Pay special attention to the parts that may be involved in feeding. Suggest what types of food each of the insects might eat and how they might obtain these.

23. (a) Find out the similarities and differences between locusts and grasshoppers and present your results in a Venn diagram.
    (b) Research the functions of the Australian Plague Locust Committee (APLC).
    (c) Identify, research and report on a question or problem related to locust plagues.
24. Find out the names and features of invertebrates that can be found in Australia and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.





3.10 Zooming in … human endeavours into classification

Science as a human endeavour

3.10.1 A world of wonder

Science is full of wonder, just waiting to be explored. More than in any other career, the scientist can be both an adventurer and an explorer. The opportunities to discover new things are almost endless, with the journey of discovery full of many twists and turns along the way.

The life of scientist Denis Crawford is one such adventure. He asks questions, makes observations and experiences new challenges as he tries to make sense of the world around him.

3.10.2 Chemical colours

Educated in West Essendon, Victoria, Denis studied a mix of humanities and sciences. After completing Year 12, he spent 18 months at Dookie Agricultural College. From there he moved to the Organic Chemical Research Section of ICI, experimenting with 'colourful chemistry'. His job was to discover new colours of pigments, paints and inks, and then think up names to describe them.

3.10.3 Caring for 'crawlies'

In 1977, the 'call of the wild' beckoned Denis. For the next 10 years he was involved in **entomological** research with the Department of Agriculture. He immersed himself in the world of insects. During the day he collected caterpillars and maintained breeding colonies in his laboratory. Here he could study not only the insect's reproductive cycle but also the best way to control insect populations. Over two billion dollars worth of pesticide is used annually in Australia to rid crops of agricultural pests; Denis's caterpillars were responsible for half of this use. During this time he was often referred to as 'the caterpillar chef'. He found that the best food for the caterpillars was a blend of baked beans and agar, which he set into blocks and cut up into insect 'bite size' pieces.

Denis Crawford photographing the Sorsdal Glacier



3.10.4 Snappy travels

Denis became more and more interested in the challenges involved in 'capturing' the wonders of the world around him. At the end of his time at the Department of Agriculture, he travelled overseas, taking photographs of the natural world around him. On his return to Australia, over 500 of his photographs were placed in a photographic library. This library acted like an agent and sold Denis's photographs to magazines, journals and other parties.

One of Denis's creeping, crawling specimens, an emperor gum moth larva (*Opodiphthera eucalypti*)



3.10.5 Getting a closer look

Denis's dual interests in natural science and photography led him to enrol in the RMIT's Applied Science (Photography) degree course in 1991. His third-year project was on close-up insect photomicrography, that is,

taking photographs using a scanning electron microscope. His aim was to produce a series of photographs in which dead insects were made to look alive. Denis successfully met the challenge he set himself, and at the end of 1993 his work on the project earned him the Chris Hales Imaging Award.

3.10.6 Strange looking …

Denis was increasingly seen to be 'staring at bushes, waiting for insects to move into the right spot'. He remembers the reactions of other people when they saw him lying 'fully stretched out on the footpath photographing harlequin bugs going about their daily business'. As Denis recalls, 'People stared at me, gave me strange looks and then crossed the street to avoid me. To "shoot" a bug properly you have to get down to their level … I had no choice!'

3.10.7 Living in a freezer

The wilds of Antarctica had always held a fascination for Denis. Since he was young, he had loved to hear about Antarctic adventurers like Sir Ernest Shackleton, Captain Scott and Sir Douglas Mawson.

In 1994, he approached the Antarctic Division to offer his services as a photographer. Two years later, in January, he was on a ship travelling through rough seas and pack ice. His mission was to photograph small fossils in the Vestfold hills, in eastern Antarctica. Fifteen of the 70 expeditioners disembarked with Denis at Davis Station. They included a palaeontologist, a meteorologist, an astrophysical engineer, a space plasma physicist and a zoologist.

Denis's first impressions of Davis Station were interesting: '… a Legoland on Mars … a colourful blockscape of buildings … all colour coded'. The Antarctic environment is, in fact, so unusual that NASA has used one of the ice-free regions as a training ground for astronauts in extraterrestrial living.

Finding frozen fossils

Denis was very excited about what he found, 'Fossils were sitting on the surface of what

Denis's *Backyard Insects* book cover photograph of a honey bee



One of Denis's insect images of a robber fly



used to be a seabed four million years ago. After the last major glaciation, about 12 000 years ago, a glacier receded and exposed this seabed. Although most of the fossils were of shells, there were also fossils of ancient dolphins and whales. They were extraordinary!

'As you walk across the Marine Plain, you disturb very fine dust. This dust is the remains of four-million-year-old diatoms (phytoplankton), and from time to time you have to stop to wipe the diatoms out of your eyes.

'Sitting on the surface of this flat plain are many unique rocks which have been moved from other areas and deposited here by the glacier. There is a two-metre high "turtle skull" rock which has strange holes in it caused by the eroding winds.'

An Antarctic fossil



Life at the bottom of the world

Wind is an ever-present and important feature of Antarctica. The winds come off the great Antarctic plateau from the South Pole and fall downwards towards the sea. They are known as katabatic winds. When the wind hits the coast, it can be travelling at a speed of 200 kilometres per hour.

Denis's challenge was to photograph fossils in the field. 'It was so windy it was difficult to set up the tripod, and the camera kept shaking. As it was so cold, I had to wear thick gloves. This made it hard to operate the camera. I ended up photographing the fossils in the station lab.'

Sleeping arrangements on field excursions were also curious. 'Once I was outside in the field for five days. During this time, the research team stayed in round fibreglass huts. These huts were named on the basis of their shape and size. I slept in a "melon" but there were also "apples" and "Smarties". The "melons" slept two people, whereas the "apple" slept only one. Although we had torches, we didn't really need them, as in summer there were 20 hours of full sunlight. The rest of the time was like a "weird dusk". We had no television but we didn't miss it because there was so much to learn and so many adventures to live …'

Fire and ice

The Sorsdal Glacier lies at the end of Marine Plain. Denis was among a group of scientists who climbed it, starting at twilight and reaching the top at midnight. 'When we reached the top, we celebrated by eating a packet of TimTams and drinking Tang. It was the most stupendous sight. I'll never forget the colours … the sky was on fire and the ice was purple.

'Wow! … to capture the colour and feeling of the moment. Hand me my camera quickly!'

And now? Denis's latest passion involves his company Graphic Science. What adventures await him once he's finished that journey?

3.10 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Draw a flowchart of Denis Crawford's life. Include years where possible.
2. What is photomicrography?
3. What was Denis's job while he was in Antarctica?
4. How old were the fossils that Denis photographed in Antarctica?
5. What are diatoms and why did they get in Denis's eyes?
6. Why didn't Denis need to pack a torch for his Antarctic travels?

Investigate, think and discuss

7. Find out more about types of collaborative transnational Antarctic science research by researching projects associated with the Scientific Committee on Antarctic Research (SCAR), European Project for Ice Coring (EPIC) or Interpolar Transnational Art Science Constellation (I-TASC).
8. What do palaeontologists, meteorologists, astrophysical engineers, space plasma physicists and zoologists do? What might they be doing in Antarctica?
9. Find out more about the lives and expeditions of Sir Ernest Shackleton, Captain Scott and Sir Douglas Mawson.
10. What is an entomologist?
11. Investigate some of the caterpillars that destroy Australian crops. How can farmers control them?
12. Investigate glaciers. How are they able to move rocks from one place to another? Where are the nearest glaciers to Australia?
13. Find out about the lives and features of organisms that inhabit Antarctica. How are they suited to their environment?

Imagine

14. Imagine you are going on an expedition to Antarctica. Suggest a scientific reason for your expedition. Carefully plan your trip including what types of scientists you would take. What two personal items would you take? Write an imaginary journal detailing your expedition.
15. Photograph some insects and use the photos to construct a class field guide to local insects. You will need to use reference books to find out about each insect.
16. Write a story about your future adventures. Include dates and key events. Your final story may take the form of a journal, biography, tape recording or video.

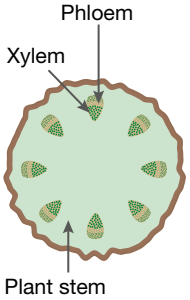
3.11 Which plant?

3.11.1 Patterns can be used to classify plants

More than 23 centuries ago, a Greek philosopher named Aristotle developed one of the first widely used classification schemes. He divided plants into groups on the basis of their type of stem. Although this is still a useful system, like most classification systems it has limitations.

Biologists often use the presence, absence or patterns in structural features or reproductive structures to group, classify and identify different types of plants. Plants that contain vascular tissue belong to a group called **tracheophyta** (= 'windpipe' + 'plant'). Ferns, conifers and flowering plants all contain **vascular tissue**. Mosses and liverworts do not. Vascular tissue consists of cells that make up tube-like structures that conduct (or transport) materials along the stem of a plant. **Xylem** and **phloem** are two types of conducting tissues. Xylem transports water and minerals from the roots up to the leaves, whereas phloem carries mainly sugars throughout the plant. The dichotomous key on the opposite page shows one way these and other features may be used to group different types of plants.

Classification of plants



Plants

Contain vascular tissue (e.g. xylem and phloem)

Do not contain vascular tissue

Produce seeds

Do not produce seeds

Produce flowers with seeds

Do not produce flowers; seeds in woody cones

Angiosperms (flowering plants)



Mainly found on land; have true roots, leaves, stems.
Examples: fruit trees, daffodil, wattle

Gymnosperms (conifers)



Found on land; have true roots; most have fine, needle-like leaves.
Examples: cypress, pine, cedar

Pteridophytes (ferns)



Found in moist, cool and shaded areas; have true roots and stems and produce spores on underside of leaf-like fronds.
Examples: maidenhair fern, tree fern, bracken

Bryophytes (mosses and liverworts)





Found in moist, cool and shaded areas; lack true roots, stems and leaves.
Examples: mosses and liverworts

INVESTIGATION 3.8

Getting to know plants

AIM: To investigate features of some plant groups

Materials:

two pine cones
fern frond (with sporangia)
some moss
flowering weed pulled out of the ground (with roots attached)
camera (such as digital camera, webcam or mobile phone camera)

Method and results

1. Create a table with the following column headings: ‘Group’, ‘Photo’.
2. Take a photo of each plant or plant part. Insert the photos in the table you created and write down the group name for each photo.

3. Add labels to the photos. Label the following.
   – Scales on the pine cone
   – Sorus on the underside of the fern frond (The sori are the brown dots. Each sorus is a cluster of sporangia. The sporangia contain spores.)
   – One single moss plant
   – Roots, stem, flower and a leaf of the weed
- Leave one pine cone in a warm dry area overnight and place the other pine cone in water for one hour (or overnight).
4. Look closely at the pine cone that was left in the dry environment. Can you see any seeds between the scales? Can you get any of the seeds to fall out?
5. Observe the pine cone that was left in water. In what way is it different from the dry cone? What causes pine cones to open and close?
- Place the fern frond on a white piece of paper (with the sori on the bottom). Leave for an hour (or overnight).
6. Observe the white paper on which the fern was left. What has fallen on it?

Discuss and explain

7. On the basis of your observations, compare the pine cones and seeds with the fern sori and spores in terms of their structures and how they could be dispersed (spread out) from the plant.
8. Mosses are tiny plants that grow in moist environments. Suggest why they (a) grow in these locations and (b) are such tiny plants.
9. On the basis of your observations, suggest the benefits of weeds producing flowers and being made up of stems, leaves and roots.
10. For each plant observed, identify a structure with a function that helps the plant survive in the environment in which it lives.

3.11.2 The language of plants

Plants can be described using different words, depending on a person's purpose. For example, in describing a bottlebrush tree:

- a scientist would refer to its correct botanical name as *Callistemon citrinus* and say it belonged to the angiosperm or flowering plant group
- a gardener might say 'I planted a new tree called a bottlebrush'
- a horticulturalist would tend to use both scientific and common names.

Words used to describe groups of plants

Scientific term	Common name
Bryophytes	Mosses and liverworts
Pteridophytes	Ferns
Angiosperms	Flowering plants
Gymnosperms	Conifers
Tracheophytes	Plants with stems

Gardeners use words like 'tree', 'shrub', 'herb' and 'grass' to describe groups of plants. To a scientist, a tree could belong to the angiosperm or gymnosperm group. A scientist would carefully examine the characteristics of the plant to find out whether it had flowers,

A bottlebrush flower



seeds and fruit, or cones containing seeds. The scientific names for individual plants and groups of plants are more specific than the common names.

WHAT DOES IT MEAN?

The prefix *gymno* comes from the Greek word *gymnos*, meaning 'naked'; *angio* comes from the word *angios*, meaning 'vessel'; *phyton* comes from the word *phyton*, meaning 'plant'; and *pterido* comes from the word *pteron*, meaning 'feather'.

3.11.3 Evergreen quest

Have you ever grown a herb garden — your own 'evergreen quest'? Many believe that the use of herbal remedies to treat simple ailments is as old as the human race itself. From early hunting and gathering times, humans have had a close relationship with plants as sources of both food and medicine. Ancient civilisations of Egyptians, Chinese, Persian, Greeks and Romans all practised herbalism.

The herbs (and spices) in your kitchen could have medicinal properties — do you know what effects they might have on you?

Grow your own

Try growing these common herbs in your own garden or planter box.



- Thyme is used to make tea for treating stomach cramps, indigestion, colic and gas retention.



- Lemon thyme smells and tastes like lemon. A few sprigs of lemon thyme in boiling water can make refreshing herbal tea. It is also useful for treating asthma and coughing, and is considered great for boosting your immune system.



- Sweet basil (such as Greek basil) has tiny leaves with a spicy fragrance. Basil is best eaten fresh, rather than dried, and goes well with tomato-based dishes. It also helps digestion and relieves constipation.



- Dill is valued for its leaves in spring and its seed in autumn. Its flowers are pale yellow and stems grey-green. Dill is added to soups and fish dishes to enhance their flavour. It has also been used as a hair restorer, and as a tea for digestive ailments and to help relieve flatulence.



- Lemon balm is fabulous in salads and refreshing in iced tea. Its healing properties include promoting the relief of tension and restlessness. It also soothes toothache and headaches and relieves stomach-aches, indigestion and heartburn. Freshly crushed leaves have been used to soothe and cleanse wounds.



- Rosemary can be added to roast potatoes and garlic for a tasty feast. Oil extracted from the leaves and flowers is also used for stomach complaints, gas retention and cramping muscles and limbs — and for aromatic baths.



- Parsley (such as Italian parsley) is rich in vitamins A and C. A brew made from the roots is recommended in all ailments of the digestive and urinary tracts. Freshly crushed leaves are also used as a compress for insect bites. Although parsley is often used as a garnish, tabouli is an example of a food made mainly from parsley.

3.11.4 Plants beware

History is full of myths and stories about the 'magical' — and sometimes supernatural — properties and uses of plants, and about plants that carry out unusual 'unplant-like' activities. Some of these stories contain elements of truth.

HOW ABOUT THAT!

Don't get edible parsley mixed up with fool's parsley, which may look similar but can be poisonous. It can be distinguished from parsley by crushing its leaves, which give an offensive, nauseating odour resembling the stench of mouse droppings!



Witchcraft, superstition and customs

For hundreds of years, some plants have been associated with witchcraft and superstition. For example, the four-leaved form of clover (*Trifolium repens*) that is occasionally found has been considered to be a token bringing good luck. Another type of clover, *Trifolium pratense*, was thought to guard against witchcraft. In some cultures, people once used garlic (*Allium sativum*) to protect them against witchcraft and sorcery; some even added it to animal foods to protect them against evil.



3.11.5 Plants that get on our nerves

Inhabitants of tropical forests used some plants to make arrow poison. In Asia and South America, some species of the genus *Strychnos* were used to obtain arrow poison from their roots and bark. The poison used on the arrows was curare. Although a person hit with a poisoned arrow could still think and sense things for quite some time, organs involved in movement would gradually fail to function. In the end, the person's ability to speak would disappear, followed by the lack of movement in other areas (such as the face) and, finally, death.

Another type of plant with a sting is the giant stinging tree (*Dendrocnide excelsa*), which has large heart-shaped leaves covered with fine stinging hairs. It is commonly found in the rainforests of Queensland and New South Wales. Merely brushing against its leaves can result in a severe burning sensation that may persist for several months. Some people suggest that the juice of cunjevoi lilies (*Alocasia macrorrhizos*), squeezed over the stings, will relieve the stinging.

Stinging hairs covering the leaves of a giant stinging tree



3.11.6 Plants of prey

Some plants found in nitrogen-deficient soil 'eat' insects to supplement their nitrogen. Attracted by

the smell of food and a safe landing place, insects can be lured into plants that are not what they seem. The Venus flytrap (*Dionaea muscipula*), for example, has a special trap with a hinged lid. As soon as an insect touches the trigger bristles on the trap's upper surface, the trap springs shut. The insect is then trapped in a cage-like prison. Acids and special substances called enzymes are secreted from the plant. These slowly break down the soft parts of the insect's body. It may take the Venus flytrap two weeks to fully digest a damselfly. When the trap reopens, the insect's hard exoskeleton, including its wings, is blown away by the wind.

Sundews (*Drosera* spp.) are another group of insect-eating plants, of which there are more than 50 different species in Australia. The upper part of the leaf is covered with thin red tentacles that are covered in a sticky substance. If an insect touches the tentacles, they bend inwards and trap it. The body of the trapped insect is then digested.

A Venus flytrap



A sundew is covered in a sticky substance.



3.11 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Make a table to summarise the characteristics of bryophytes, pteridophytes, angiosperms and gymnosperms. Include the headings shown below.

Name of group	Where found	Type of stem	Flowers or no flowers	Seeds or spores	Other information	Examples
Bryophytes						

2. Use a table to summarise the information provided in this section. Use the headings 'Plant' and 'Interesting feature, characteristic or myth'.
3. Describe the advantages to plants of being able to catch and digest animals as well as to photosynthesise.
4. Match the scientific names to the common names:

(a) *Dendrocnide excelsa*	Garlic
(b) *Allium sativum*	Clover
(c) *Dionaea muscipula*	Four-leaved clover
(d) *Trifolium repens*	Venus flytrap
(e) *Trifolium pratense*	Stinging tree

Think

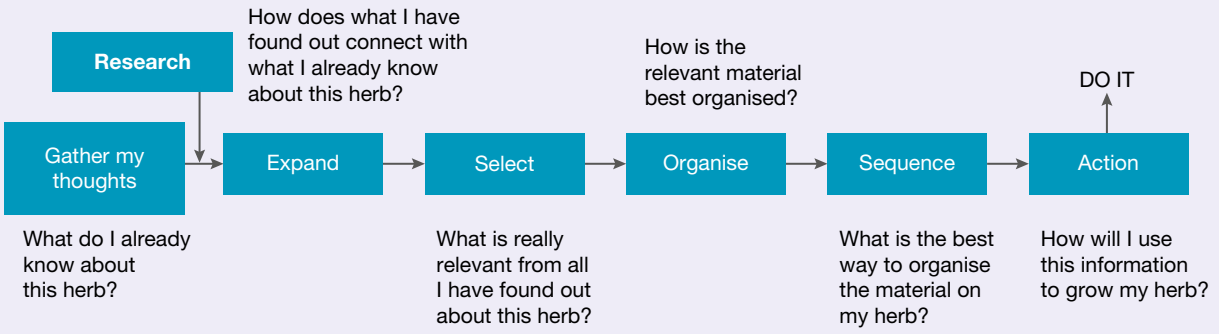
5. Design a key that uses the following features, in the order given below, to separate ferns, mosses and liverworts, conifers and flowering plants.
   - Seeds or no seeds
   - Seeds in cones or seeds in flowers
   - Stem or no stem
6. Make a list of 10 plants you already know. To which plant group does each belong?
7. Suggest what advantage it gives to plants to sting.
8. Construct a crossword using the information in this section.
9. Suggest why the inner surface of the leaves of a Venus flytrap has both nectar-producing glands and digestive glands.

Investigate

10. Design a key to help a gardener tell the difference between trees, shrubs, herbs and grasses. Ask at least five people to test your key.
11. (a) Find three examples each of a tree, shrub, herb and grass. Observe and record five characteristics for each of these plants.
    (b) Using your observations, decide which scientific plant group each example belongs to.
    (c) Use field guides or keys to identify the plants you observed.
12. What does a taxonomist in a herbarium do? Why is this job important?
13. (a) In pairs, walk around your school grounds and select ten plants.
    (b) Draw a sketch of each and add as many details as you can next to your diagram.
    (c) Construct a key to organise these plants into groups.
    (d) Use field guides and the internet to find out the identity of these plants.
    (e) Combine your data with that of other groups in your class and use it to construct a plant field guide and key for your school grounds.
14. Brainstorm with your team all the different plant names that you know. Select one of these and find out five interesting features to share with your team.
15. Find out the names and features of members of each of the plant groups that can be found in Australia and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.
16. Australia has about a thousand species of plants that are considered to be toxic to humans and our livestock. Of these, 60 per cent are natives. Investigate and report on an example of a toxic plant within each of these Australian plant families:
    (a) legumes (Fabaceae, Mimosaceae)
    (b) nightshades and tobaccos (Solanaceae)
    (c) buttercups (Ranunuclaceae)
    (d) cycads (Cycadaceae, Zamiaceae).
17. Find out the meaning of ‘toxicology’ and then find examples of Australian plant toxicology research.

Investigate, create and share

18. (a) Use the below figure to organise and record your research on a herb of your choice.
    (b) In the ‘action’ phase, use your information to set up an experiment to grow your herb.
    (c) Take photographs throughout your experiment and keep a journal to record all of your observations.



(d) Throughout your experiment, share and discuss your results with others growing the same herb and also with others growing different herbs.
(e) As a class or in groups, organise your observations into a summary that can be shared with another class.
(f) Find examples of four recipes (for food or herbal value) that use your herb.
(g) Select a recipe to use some of the herb that you have grown to demonstrate the importance and value of your herb.

Investigate, design and share

19. (a) In your workbook, or using a computer, construct a table with the following headings.
- Herb
- Genus or species
- Description of useful plant part
- Beneficial effects
- Other details

(b) Complete the table with details on the following herbs, using the information in this section and your own research. In the 'Description' column, you could insert a photo or drawing of the herb.
(i) Peppermint (*Mentha piperita*)
(ii) Sweet basil (*Ocimum basilicum*)
(iii) Borage (*Borago officinalis*)
(iv) Thyme (*Thymus serpyllum*)
(v) Rosemary (*Rosmarinus officinalis*)
(vi) Parsley (*Petroselinum sativum*)
(c) Reformat your table into a visual map and share it with others in your group.
(d) Add relevant information from others in your group to your map.
(e) Select one of your herbs and find a recipe that uses it. When at home, make the food with the herb, take photographs and record your experience. Share your photographs and comments with other students.

Think and create

20. Summarise the information on the herbs described in this section into a mind map.
21. All blackberry plants should be destroyed. Is there a scientific basis for this claim? To help you evaluate this claim, construct a PMI chart on research relating to blackberry plants.

learnON RESOURCES — ONLINE ONLY

Watch this eLesson: Growing plants in Australia (eles-0055)

3.12 Gumnut babies

Science as a human endeavour

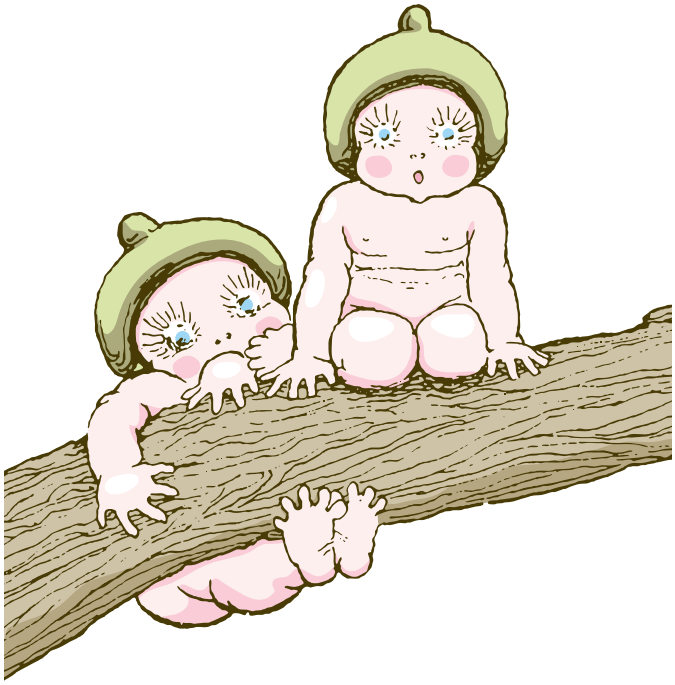
3.12.1 Snugglepot and Cuddlepie

When you were young, did you read about the adventures of the Gumnut Babies, Snugglepot and Cuddlepie? They lived in the Australian bush and were constantly bothered by the Big Bad Banksia Man. Did you know they are based on real Australian plants?

May Gibbs was the creator of Snugglepot and Cuddlepie. She was inspired by our Australian bush.



The Gumnut Babies Snugglepot and Cuddlepie



3.12.2 Eucalyptus

The genus *Eucalyptus* includes gums, stringybarks, peppermints, boxes, mallees, ironbarks and ashes. Of the 800 species, all but 13 are endemic to Australia. Snugglepot and Cuddlepie, the Gumnut Babies, were inspired by the flowers of this group of plants.

The Banksia Man is based on the *Banksia* follicle, which is a woody, cone-like structure that develops after a *Banksia* flowers.



The flowers of a eucalypt



A *Banksia* flower



An example of the flower structure of a *Grevillea*. There are more than 360 species of *Grevillea*.



A *Hakea*



3.12.3 Proteaceae

Not all flowers have soft bright ribbon-like petals. You may not even recognise the flowers of many of our native Australian plants.

The early landmass Gondwana was the centre of the origin of the family Proteaceae and it is in Australia that this family has the greatest diversity. This group includes banksias, grevilleas, hakeas, macadamias and waratahs. Many of these have roots that are very efficient at absorbing water and nutrients and they are often able to grow in soil that may be deficient in nitrogen and phosphorus.

Macadamia flowers and nuts



3.12.4 Inspiration for *Banksia*

The genus *Banksia* was named in honour of Sir Joseph Banks (1743–1820), the first European to collect *Banksia* specimens. Of the 76 species of *Banksia*, all but one is native to Australia. All members of this genus have distinctive flower clusters or spikes. Each of these spikes is made up of hundreds (sometimes thousands) of tiny individual flowers with long, stiff projecting styles. Once fertilised, the outer parts of the flower die off and the fruit body develops into a hard, woody cone-like structure called a follicle. The seeds within these fruits are protected from foraging animals and fire. In many species, the seeds are not released until they are completely dried out or burnt.

There are only five species of *Telopea*, commonly known as waratah.



3.12 Exercises: Understanding and inquiring

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Remember

1. List four Australian members of the Proteaceae family.
2. Recall who the *Banksia* genus is named after.
3. Describe the fruit and flowers of the *Banksia*.
4. List four Australian examples of the *Eucalyptus* genus.
5. State which type of plant Snugglepot and Cuddlepie, from May Gibbs's stories, were inspired by.

Investigate

6. Each Australian state and territory has its own floral emblem. Research:
   (a) the key features of each plant
   (b) why these plants were selected
   (c) any scientific research or interesting information.

   Present your findings in a visual, colourful and entertaining format to advertise each state or territory.

Floral emblems of Australia



State Australian Capital Territory
Common name Royal bluebell
Scientific name *Wahlenbergia gloriosa*



State New South Wales
Common name Waratah
Scientific name *Telopea speciosissima*



State Victoria
Common name Common heath
Scientific name *Epacris impressa*



State Queensland
Common name Cooktown orchid
Scientific name *Dendrobium phalaenopsis*



State Northern Territory
Common name Sturt's desert rose
Scientific name *Gossypium sturtianum*



State Tasmania
Common name Tasmanian blue gum
Scientific name *Eucalyptus globulus*



State South Australia
Common name Sturt's desert pea
Scientific name *Swainsona formosa*



State Western Australia
Common name Red and green kangaroo paw
Scientific name *Anigozanthos manglesii*

7. Find out who each of these Australian plants were named after and why they received these names.
   (a) Waratah
   (b) Proteus
   (c) Grevillea
   (d) Hakea
   (e) Banksia
8. On your own or in a team, write your own story, poem or play about our native flora.
9. Select two examples of Australian plants. Research and report on the history and importance of these plants.
10. Who was May Gibbs? Why did she include Australian plants in her stories?
11. Research a variety of Australian plants and create your own picture-book story. Have a book launch and invite friends, family and students from other year levels.
12. Investigate and report on Australian research into Australian plants.

3.13 Plants no more!

3.13.1 Changing classification

Algae, fungi and lichen were once considered the most primitive plants on Earth. These organisms do not produce flowers or seeds, nor do they have roots, stems or leaves. On the basis of current information, many biologists no longer consider them plants.

While most of these organisms are harmless to humans and other animals, some are not. For example, some fungi can cause disease and blue-green algae can poison water supplies.

Giant kelp (seaweed) is an alga.



3.13.2 Algae

Characteristics:
- All live in water
- Often unicellular
- No true roots, stems, leaves or flowers
- No special tissue for transporting food or water
- Divided into groups depending on their colour
- Make their own food using photosynthesis

  Examples: diatom, *Euglena*, Neptune's necklace, sea lettuce

Not all mushrooms are safe to eat! Some mushrooms and toadstools can be poisonous.



3.13.3 Fungi

Characteristics:
- No true roots, stems, leaves or flowers
- Usually multicellular; some unicellular
- No chlorophyll and unable to make their own food
- Usually obtain their food from other living or dead organisms
- Produce enzymes that break down food outside their cells
- Broken-down food is absorbed through their cell walls

  Examples: yeast, mould, mushroom, toadstool

Several types of lichen may grow together.



3.13.4 Lichens

Characteristics:
- Found on bare rocks, bark of trees, in cold polar regions and on mountain tops
- No true roots, stems, leaves or flowers

- Made up of two different organisms: an alga and a fungus
- Algal cells live among tiny fungal threads
- Algal cells photosynthesise and supply the fungus with food
- Fungus provides protection and anchorage for the algal cells
- Grow very slowly and are extremely long-lived
- Often responsible for breaking down rocks, allowing other organisms to grow

The key below can be used to separate algae, fungi and lichens from plants.

1a	No roots, stems, leaves or flowers	Algae, fungi and lichens
1b	Distinct leaves: with or without roots or flowers	Go to 2
2a	No true roots or flowers	Bryophytes
2b	True roots: with or without flowers	Go to 3
3a	No flowers or seeds, reproduce by spores	Pteridophytes
3b	Seed-bearing plants	Go to 4
4a	Seeds in cones	Gymnosperms
4b	Seeds produced in an ovary/flower	Angiosperms

Better dry between your toes or you may get the fungal infection athlete's foot (*Tinea pedis*).



Mushrooms are fungi we eat; and yeasts are very important in making bread and wine.



3.13 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Construct a table that summarises the characteristics of lichens, algae and fungi.

Think

2. Construct a key to divide lichens, algae and fungi into separate groups.
3. Use your coloured thinking hats (see page 42) to describe your thinking on whether lichens, algae and fungi should be classified as plants.
4. Suggest reasons why lichens, algae and fungi were once classified as plants.
5. Which, if any, of these organisms do you think are most like plants? How?
6. If you were a biologist, would you classify any of these as plants? Why?
7. Within a group, prepare and then present a debate to the class on whether lichens, algae and fungi should be included in the plant kingdom.

Investigate

8. Look up lichens, algae and fungi in at least three different biology books and record whether they are classified as belonging to the plant kingdom or to a different group. Try to find at least one biology book published before 1980. Why have ideas about the classification of lichens, algae and fungi changed? Use your data to complete the table below.
9. Find out which features are used to classify fungi.
10. What are slime moulds? Describe their characteristics. Into which kingdom would you classify them?
11. Design an investigation, using slices of bread, to find out which conditions are best suited to growing moulds.
12. Find out more about the discovery of penicillin and the influence it has had on medicine and disease. Present your findings as a newspaper report, PowerPoint presentation, cartoon, poem or song.
13. What are the symptoms of tinea? How do you get it and how can it be prevented and treated? Present your findings in a concept map.
14. Find out the names and features of members of each of the groups algae, fungi and lichen that can be found in Australia and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.

Reference title	Date published	Lichen grouping	Fungi grouping	Algae grouping
e.g. Text A	1983	Plant kingdom	Plant kingdom	Plant kingdom
e.g. Text B	1990	Fungi kingdom	Fungi kingdom	Protoctista kingdom

3.14 Tree maps, mind maps and Venn diagrams

3.14.1 Tree maps, mind maps and Venn diagrams

To show the hierarchy of ideas within a topic

why use?

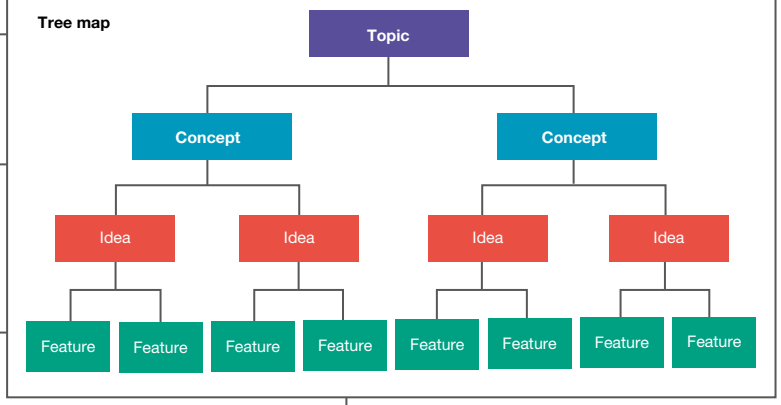
1. On small pieces of paper, write down all of the important ideas related to your topic.
2. Arrange your pieces of paper in groups related to the main ideas within the topic.
3. Within each group, arrange the ideas into their order of importance.
4. Now draw your tree map with the main ideas at the top and others below it.

how to ...?

How do parts or ideas relate to each other?

question

Tree map



Branching diagram dichotomous tree

also called

Similarity

Main concepts are identified and used to divide into groups.

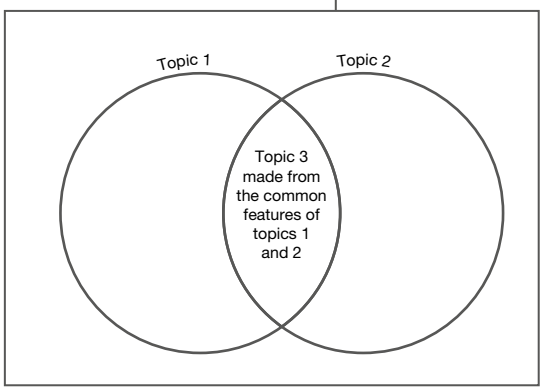
Difference

Venn diagrams explicitly show similarities and differences rather than showing a hierarchical division.

comparison

Venn diagram

example



comparison

Similarity

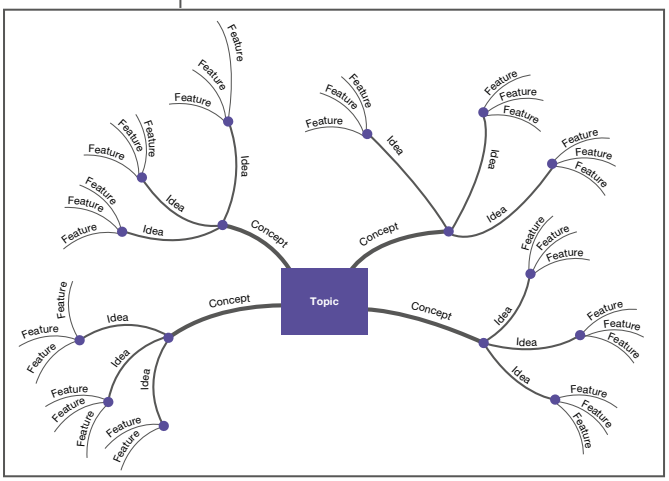
Main concepts are identified and broken down into groups.

Differences

Mind maps radiate out from centre and use 'free' lines; not all ideas are organised horizontally.

Mind map

example



learnon

3.15 Project: Snakes alive!

Scenario



Every year in Australia, an average of around 4000 people are bitten by snakes. Some of these snakes are non-venomous and their bite results in little more than a nasty wound, but many are venomous with a bite that is deadly unless medical intervention can be reached in time — in fact, Australia has more venomous snake species than any other country in the world! You can encounter a snake just about anywhere — on bushwalking trails, in your back garden, in a shed, even swimming in the ocean — so it is really important that you know what kind of snake you are looking at.

Your task



Your group has been approached by State Parks and Wildlife to create a Snake Safety brochure, copies of which will be sent out to all bushwalking clubs and National Park centres in your state for distribution to bushwalkers, campers and nature lovers. The main part of the brochure will be an easy-to-follow identification key that allows the reader to quickly and easily determine the species of snake they have encountered and so learn whether it is venomous or non-venomous. The brochure will also contain a diagram indicating on a state map where different venomous species are usually found, as well as advice on what to do if you encounter a snake and what first aid you should render if someone is bitten by a venomous or non-venomous snake. You may also like to include some interesting snake statistics, or a Snake Fact or Fiction section.

3.16 Review

3.16.1 Study checklist

Diversity of living things: classification

- state the difference between 'unicellular' and 'multicellular'
- explain why biologists classify living things
- describe the hierarchy of biological classification
- distinguish between the five kingdoms
- use hierarchical systems to classify organisms into groups
- define the term 'taxonomy'
- describe the binomial system of nomenclature
- use scientific conventions for naming species
- explain how structural features can be used to classify organisms into groups
- use simple taxonomic dichotomous keys to identify, sort and name organisms
- interpret and design dichotomous keys to classify organisms
- classify vertebrates based on their characteristics
- classify invertebrates into groups using a dichotomous key
- distinguish between the following groups of organisms: vertebrates and invertebrates; placental, monotreme and marsupial mammals; different classes of arthropods; different types of insects; different plant phyla; prokaryotes and protoctistans; fungi, algae and lichens; prions, viroids and viruses
- provide examples of Australia's unique flora and fauna
- suggest why biological classifications have changed over time

Current issues, research and development

- describe the patterns and history of naming organisms
- describe research and discoveries by Australian scientists in the field of taxonomy
- describe examples of collaborative transnational Antarctic scientific research
- outline issues relevant to the patenting of living organisms

Individual pathways

ACTIVITY 3.1
Classification
doc-6051

ACTIVITY 3.2
Further classification
doc-6052

ACTIVITY 3.3
Developing biological classification
doc-6053

learnON ONLINE ONLY

3.16 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. The figure on the opposite page shows examples of some Australian animals.
   (a) Carefully observe and record the features of each organism. Discuss your observations with your partner and add any missing from your list. Record your observations in mind maps, tables or annotated diagrams.
   (b) Identify each of the organisms in the figure as a vertebrate or an invertebrate. Justify your responses.
   (c) Did you find any of the specimens difficult to identify? If so, suggest questions or details that would assist you in making a decision.

(d) On your own or with a partner, construct a dichotomous key that would enable you to identify each specimen.
(e) Use the details that you have recorded to suggest the following levels of classifications (and more if you can) for each animal.
  (i) Kingdom
  (ii) Phylum
  (iii) Class
(f) List the types of questions that were most useful in your research for part (e).
(g) Select one of the animals and research:
  (i) other features that could be used to identify it
  (ii) the name of a particular species that belongs to this group
  (iii) the effects of the toxin that it produces.
  Prepare a poster, brochure, PowerPoint presentation or animation that enables you to present your findings to the class.
(h) Investigate and report on an example of research in which the Australian Venom Research Unit (AVRU) is involved.
(i) Imagine that you are a scientist on an expedition to discover new organisms. Create a diary (including annotated diagrams of your findings). Prepare newspaper and journal articles to communicate your discoveries to the world.

Some Australian animals produce toxins that can interfere with our nervous systems.

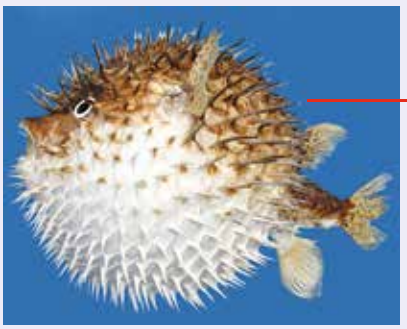


Funnel-web spider



Red-back spider

Toxins cause wastage of acetylcholine.



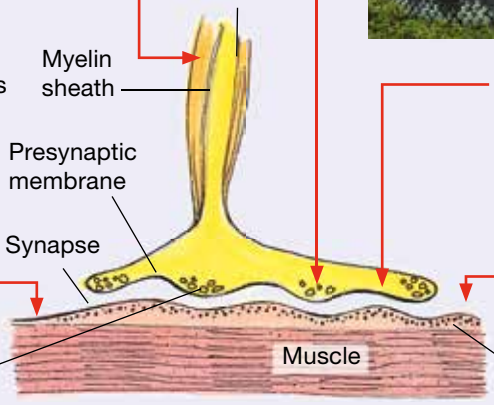
Toxins prevent electrical impulses from passing along nerve.

Porcupine fish



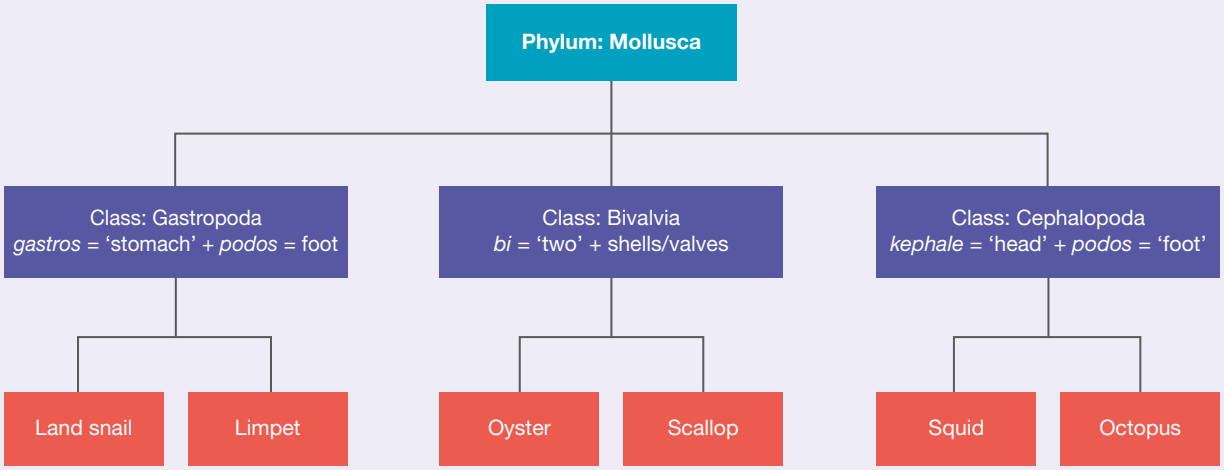


Australian paralysis tick toxins act on postsynaptic membrane.



Snake venom contains many toxins. Both presynaptic and postsynaptic membranes can be affected.

2. Using your own knowledge and the information provided in the diagram below, construct Venn diagrams about:
   (a) a land snail and an octopus
   (b) an oyster and a squid
   (c) a limpet and an oyster.



3. (a) Suggest which two of the organisms shown below and on the opposite page are most closely related.
   (b) Give a reason for your suggestion.
   (c) The common names for these plants are: borage, pincushion flower, fennel, spearmint, primrose, coltsfoot and peppermint. With your partner, try to match the common names of these plants with their scientific names.
   (d) Find out more about these plants and how they are classified into their groups.

Borago officinalis



Mentha piperita



Mentha spicata



Primula officinalis



Tussilago farfara



Scabiosa columbaria



Foeniculum officinale



WARNING ON JELLY INVASION

Holly Lloyd-McDonald
Herald Sun

JELLYFISH have invaded bayside beaches, with 22 children stung yesterday.

And with a hot Labour Day long weekend ahead, emergency services and the Melbourne Aquarium have warned swimmers to be on the lookout.

Seventy-six students from Chelsea Heights Primary School were at Chelsea Beach for the end of a week-long beach awareness program when students started to complain of itching and stinging.

As the Grade 6 students were ferried back to the Wells Rd campus, 22 of them fell ill with nausea and lethargy.

Principal Danny Mulqueen said paramedics were called and the school's first aid plan was implemented, with critical and non-critical patients separated.

'Young kids were stung and sore, and others get distressed too when they see them,' Mr Mulqueen said.

Metropolitan Ambulance Service group manager Andrew Watson said three ambulances were sent but there were no serious injuries.

Melbourne aquarium aquarist David Donnelly said the culprits were blue blubber jellyfish. The jellyfish has a pale blue tinge, short stumpy tendrils and a big head, or bell.

Mr Donnelly said a 'smack' — the collective noun for jellyfish — of the species, which he numbered in their thousands, had been pushed into the bay in recent weeks by currents and huge krill production in northern Bass Strait.

A concerned bayside resident who walks his dog on Melbourne's southeastern beaches also contacted Melbourne Aquarium yesterday to report foreshores studded with dead blubbers.

'If people leave them alone they won't get stung — but it's a mild tingle and uncomfortable, and it subsides quickly,' Mr Donnelly said.

'The best thing to do is to wear stockings, although I'm not sure how men would feel about that!'

Up to six different species of stinging jellies can reside in the bay at any time, with blue blubbers likely to stay from three days to three weeks.

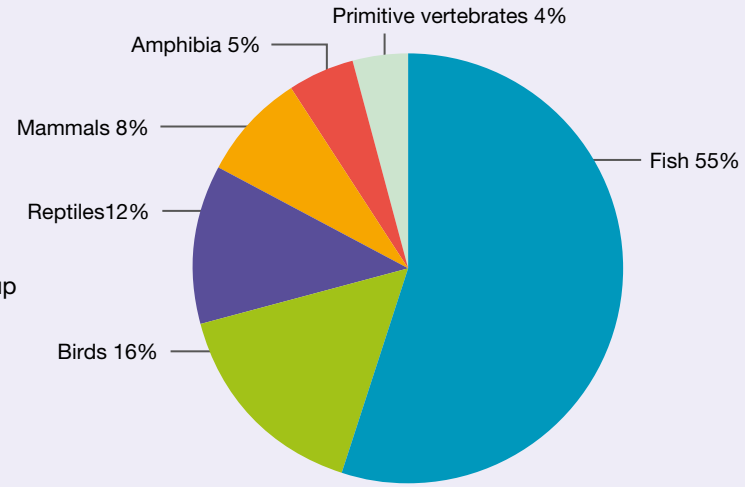
Mr Donnelly warned beachgoers not to touch any dead stingers because their tentacles could still pack a punch.

'My opinion is the blubber sting is low-risk with no serious adverse reactions.'

The marine expert recommended Stingose to ease the impact of the tingles, and paramedic Mr Watson recommended washing affected areas with clean water.

'Just keep an eye out and consult a doctor if the symptoms persist,' he added.

4. Read the article 'Warning on jelly invasion' on the previous page and answer the following questions.
   (a) List some of the symptoms that the students swimming in bayside beaches complained of.
   (b) Name the type of jellyfish that stung the students.
   (c) What does the jellyfish look like?
   (d) What is the collective noun for a group of jellyfish?
   (e) How many jellyfish had been pushed into the bay?
   (f) What does the article suggest as the reason for increased numbers of jellyfish?
   (g) How many different species of jellyfish may be found in the bay at any one time?
   (h) Describe ways to prevent getting stung and how stings could be treated.



5. The pie chart on the right shows some of the different kinds of vertebrates.
   (a) State which are in greatest abundance.
   (b) Recall the name of:
      (i) a primitive vertebrate
      (ii) a fish
      (iii) an amphibian
      (iv) a reptile
      (v) a bird
      (vi) a mammal.
   (c) Construct a mind, concept or tree map to show how these vertebrates are different.

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Complete this digital doc: Worksheet 3.13: Summing up (doc-19811)

Complete this digital doc: Worksheet 3.14: Crossword (doc-19812)

assessON
Link to assessON for questions to test your readiness **FOR** learning, your progress **AS** you learn and your levels **OF** achievement.
www.assesson.com.au



TOPIC 4
Ecosystems: Interactions and relationships

4.1 Overview

Ecosystems are made up of living and non-living things that interact with each other. Interactions between organisms can be described in terms of the feeding relationships. Various types of human activity can affect these interactions.



4.1.1 Think about ecosystems

assessON

- Why is your ecological footprint a different size from other people's?
- What have chains and webs got to do with food?
- What's all this fuss about cane toads?
- Who's on your NOT WANTED ecoposter?
- Why are greenhouse gases a 'hot' environmental issue?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

4.1.2 Your quest

Connected threads



Biologist Professor James Lovelock developed the Gaia theory. He named his theory after Gaia, the mythical Greek goddess of Mother Earth. His theory states that Earth is a 'super-organism' made up of both the physical environment and living organisms. In this theory, the forests are like skin, sweating to keep us cool. Rivers and oceans are like blood transporting supplies to where they are needed and washing away wastes. Just like the linked threads within a spider's web, in the Gaia theory interactions in one part may have implications in another part. Hurting one part may hurt all; likewise, helping one part may help all.

Our planet contains a variety of different **ecosystems**. These ecosystems are made up of living and non-living things that interact with each other. The non-living things (such as temperature, water, soil and light) can determine which types of living things can survive in a particular area. These living things can affect both non-living and other living things within their ecosystem. In a similar way, interactions in one part of an ecosystem may have implications not only for one ecosystem, but also for others on our planet.

INVESTIGATION 4.1

Modelling interactions

AIM: To use a model to demonstrate interactions between living and non-living things within an ecosystem

Materials:

one large label per student
ball of string

Method and results

- Select a part of the environment for each student. Examples you could use are the sun, temperature, wind, soil, water, light, a bee, a worm, a bird, a plant or a human. Attach a large label to each person to show what they are representing.
- Organise yourselves into a circle.
- Decide who is to go first. This person holds on to one end of the string and passes the ball of string to another student in the circle, while explaining their relationship to what that student represents. For example, a 'plant' may pass the string to 'light' and say, 'I need light in order to photosynthesise'.
- Repeat the last step until you can't think of any more relationships.

1. Have a scribe record your string pattern on paper or the board.

Discuss

2. What do you think might happen if one part of your 'circle environment' is removed? Try this and discuss what happens.
3. While standing in the circle, discuss which parts of the environment you would not let go of. Include reasons for suggestions given.
4. In your circle, get all of those parts that are non-living (abiotic) to sit down. Discuss your observations.



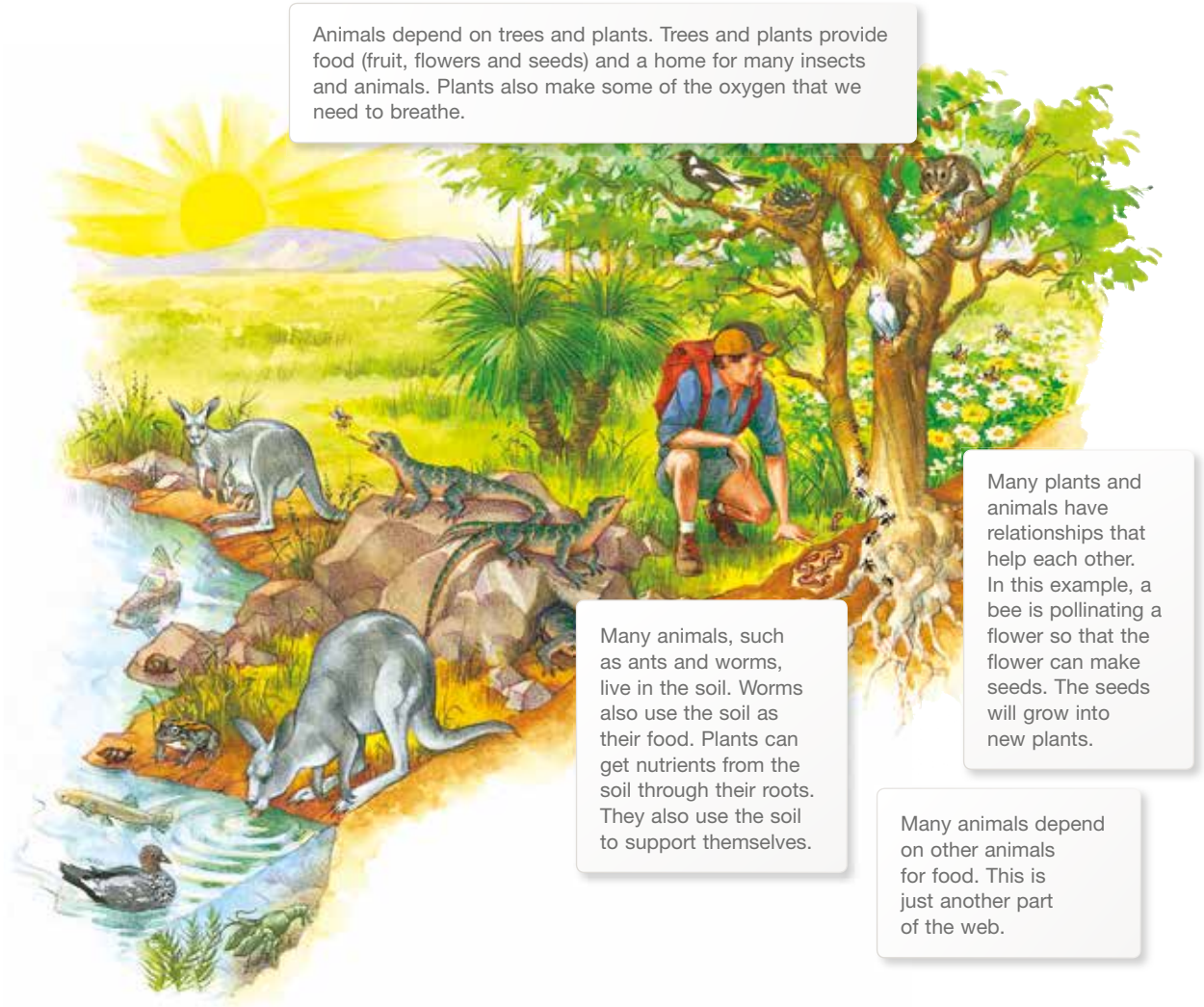
Summarise and explain

5. Comment on the string pattern.
6. Comment on what happened when one part of the circle was removed.
7. Which parts were considered living? What reasons were given for these? Do you agree? What is your opinion?
8. What happened when all of the non-living parts sat down? What do you think would happen in a real ecosystem?
9. Apply what you have observed and discussed to a real ecosystem.

4.2 Systems: Ecosystems

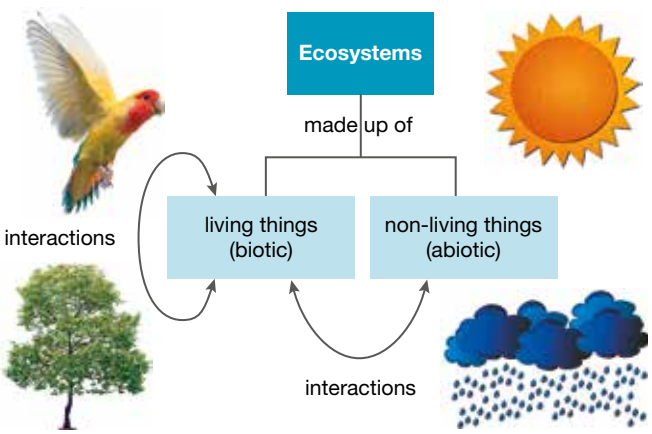
4.2.1 All together

The world around you is filled with amazing diversity. Next time you go to the zoo, the beach or an aquarium, or walk outside, have a look at how many different living things there are around you. Differences between these organisms provide clues about how they survive in the environments in which they live. Whatever the differences, they are all similar in that they depend on each other and their environment for their survival. **Ecology** is the study of how living things interact with their environments.



4.2.2 Ecosystems

Ecosystems are made up of living things (**biotic factors**) and non-living things (**abiotic factors**) that interact with each other. Organisms such as bacteria, worms, birds, plants and snakes are examples of biotic factors. Examples of abiotic factors include water, temperature, pH, salinity and light intensity. Within an ecosystem, there are interactions between the biotic factors and between the biotic and abiotic factors.



4.2.3 Habitat is home

An ecosystem may contain many habitats. A **habitat** is the place or location within the ecosystem where an organism lives. For example, the habitat of a frog may be a pond, for a scorpion it may be the desert and for a fish it may be the ocean. An organism's habitat provides it with appropriate environmental conditions (such as light intensity and temperature) and essential resources, such as food, water, oxygen and shelter.







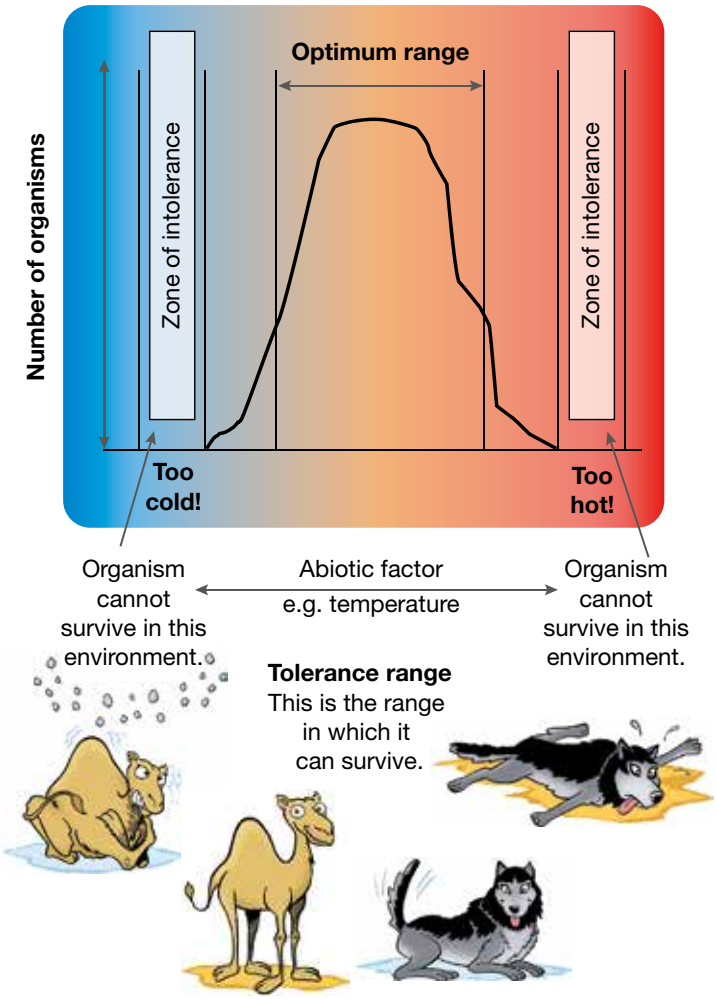
4.2.4 Abiotic factors — within your range?

Abiotic factors can determine the conditions in a particular environment. These environmental conditions can affect which types of organisms can survive in that environment. Each species has a tolerance range for a particular abiotic factor. Within this range, the optimum range is the range in which the organism functions best.

Abiotic factors within habitats can influence not only the types of organisms located in them, but also where they are found within the habitat and how many there are. The term 'distribution' describes where organisms are found and 'density' is the number of a particular organism in that area.

Determining the distribution and density of particular types of organisms within habwitats can be very useful. Information about the distribution and density of endangered species or unwanted introduced species within habitats may be used to plan appropriate protective or reduction strategies.

Abiotic factors can affect the survival of an organism within an ecosystem.

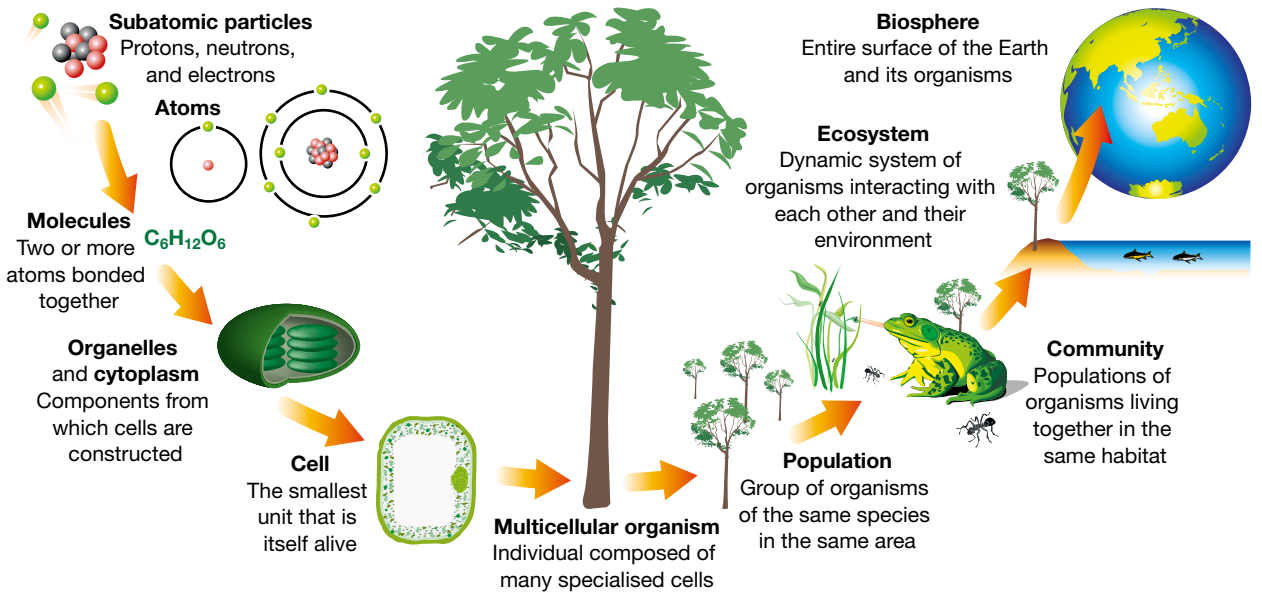


4.2.5 Patterns, order and organisation of biotic factors

The biotic factors within an ecosystem can be grouped in a number of different ways. One way is in terms of their complexity. An organism may be made up of one or more cells. Organisms that can interbreed with each other and produce fertile offspring belong to the same species. A group of organisms of a particular species living in the same place at the same time is called a

population. All of the different populations living in the same place at the same time are called a community. The biotic component of ecosystems contains all of these communities of organisms.

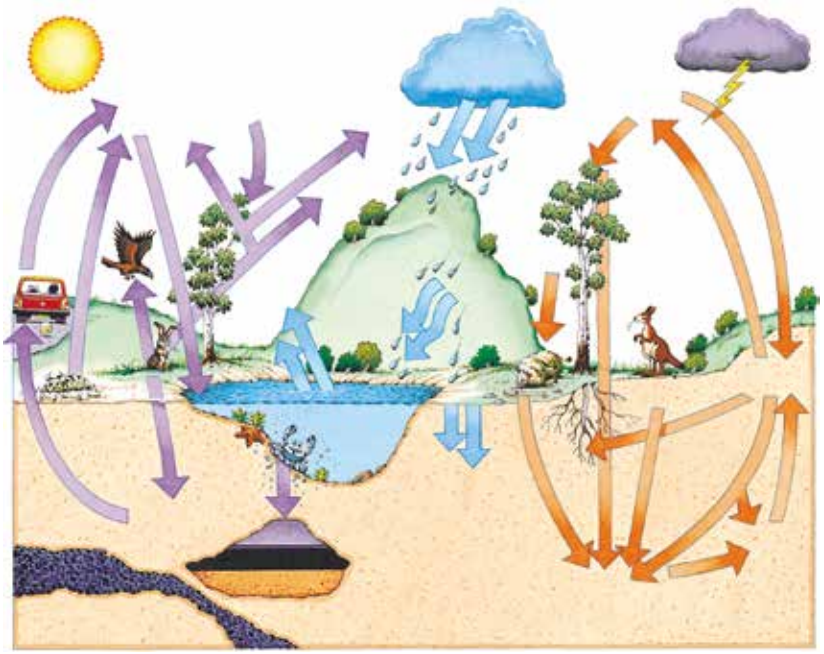
Levels of biological organisation



4.2.6 Interacting atoms?

Cells are made up of components that, in turn, are made up of molecules. These molecules are made up of atoms. Many of these atoms cycle through living and non-living parts of ecosystems. In the carbon cycle, for example, carbon atoms may be taken in by plants in the form of a carbon dioxide molecule to use in the process of photosynthesis. When animals eat the plants, these atoms can then be used or incorporated into animal tissue. When organisms use a process called cellular respiration, carbon-containing glucose molecules are converted into a form of energy that their cells can use. Carbon dioxide is a waste product of this process and is released back into the surroundings.

Cycles of nature in an ecosystem allow the matter to be recycled. The water, nitrogen and carbon cycles work together to sustain a healthy ecosystem.



INVESTIGATION 4.2

Ecosystem in a bottle

AIM: To create your own ecosystem

Materials:
1 L clear plastic bottle
scissors or knife
masking tape
soil or potting mix
small plants or seedlings
grass clippings or ground mulch (including small organisms). If there are few organisms in the grass clippings or mulch, you may want to add ants or slaters.

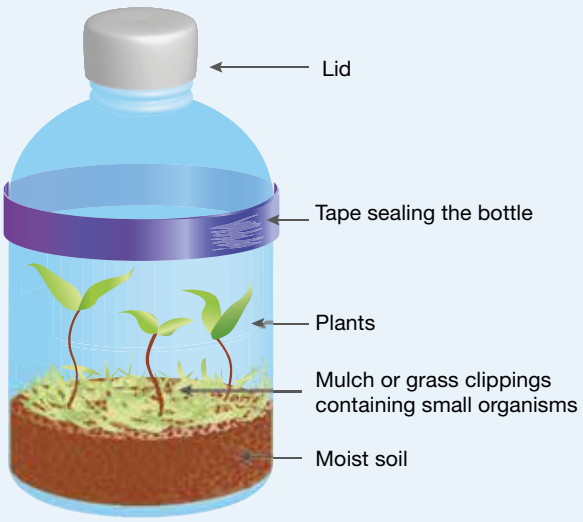
Method and results

- Cut the top off the bottle.
- Pour the soil or potting mix into the bottom of the bottle.
- Plant the seedlings into the potting mix.
- Place the ground mulch or grass clippings over the potting mix and around the seedlings.
- Add sufficient water to moisten the soil.
- Put the top back on the bottle and seal it with masking tape. The bottle should be completely sealed so that no air, nutrients, animals or plants can be added or removed from the mini ecosystem for the duration of the experiment.

1. Record your observations for your mini ecosystem each lesson for the duration of the topic.

Discuss and explain

2. Comment on something that you found interesting or learned throughout your observations.
3. The living things in your mini ecosystem need oxygen to survive. Suggest why.
4. If the bottle was sealed, where did the organisms in your ecosystem get the oxygen from?
5. If you didn't add food to your bottle ecosystem throughout the investigation, where did the organisms get energy from?
6. If the ecosystem inside your bottle is balanced, the organisms within it could continue to survive for a long time without the need for you to add extra water and food.
   (a) Suggest possible reasons for this.
   (b) What is meant by the term 'balanced ecosystem'?
   (c) Suggest events that could unbalance your ecosystem.
7. List three strengths in the design of this investigation.
8. Suggest how this investigation could be improved.
9. (a) Suggest a hypothesis that you could investigate using this equipment (with possible modifications).
   (b) Outline the procedure that you would use to investigate your hypothesis.
10. Summarise conclusions that you can make from your bottle ecosystem investigation.



INVESTIGATION 4.3

Measuring abiotic factors that can affect biotic factors

AIM: To measure abiotic factors that may influence the survival of organisms within habitats

Materials:

water samples A, B and C (provided by your teacher)
thermometer
dropper bottle of silver nitrate solution (0.1 mol/L)
dropper bottle of universal indicator solution and universal indicator colour chart, or universal pH indicator paper

Method and results

1. Construct a table with the following headings and use it to record your observations.

Abiotic factor	Sample A	Sample B	Sample C
Water temperature (°C)			
Water pH			
Water salinity			

- Temperature: Use the thermometer to measure the temperature of each sample.
- pH: Use either of the following methods.
  - Pour 5 mL of water sample A into a test tube. Add 3 drops of universal indicator. Compare the colour of the water with the colour chart and record the pH of the water sample. Repeat for the other samples.
  - Dip a small piece of universal pH indicator paper into water sample A. Use the colour chart to match the pH of the water sample. Record the pH in your table. Repeat for the other samples.
- Salinity: Pour 5 mL of water sample A into a test tube. Add 3 drops of silver nitrate solution. Observe the changes and use these to determine the salinity by using the table on the right. Repeat for the other samples.

Description	Salinity
Clear	Nil
Slightly cloudy	Low
Completely white/grey	High

Discuss, investigate and explain

2. Of the abiotic factors measured, which factor varied between the samples (a) the most and (b) the least?
3. Within aquatic (water) ecosystems, temperature is very important because it can influence dissolved oxygen levels and the rate at which plants capture light energy to convert it into chemical energy that they and others can use.
   (a) If you had measured the temperatures of your water samples in their original environments, do you think that they would be the same? Explain.
   (b) Which of your water samples had the highest temperature and which had the lowest temperature?
   (c) Suggest the impact of increasing water temperature on organisms living in aquatic habitats.
4. A pH less than 7 is considered acidic. The lower the pH, the more acidic the sample is.
   (a) Which of your samples was the most acidic?
   (b) Find out which organisms could survive in a water habitat in your sample identified in (a).
   (c) Suggest reasons for the differences in pH between your samples.
5. While salt is a natural component of our Australian landscape, a number of our freshwater ecosystems are becoming increasingly threatened by increasing salinity.
   (a) Which of your water samples had the highest salinity and which had the lowest salinity?
   (b) Suggest reasons for the differences in salinity between your samples.
6. Answer the following questions about your investigation.
   (a) Identify which of the tests were qualitative and which were quantitative.
   (b) Which variables were controlled in the salinity test?
   (c) List two experimental design strengths.
   (d) Suggest two ways in which the experiment investigation could be improved.
7. A variety of human activities can lead to an increase in temperature in aquatic environments. These include thermal pollution (such as introducing warm water to aquatic ecosystems), cutting down trees and removing vegetation.
   (a) Investigate and report on examples of human activities that can lead to increased temperature in aquatic environments.
   (b) Find out more about the effects of increasing water temperature on organisms living in aqueous environments. Summarise your findings.

8. Human activity can result in changes to the abiotic factors in habitats, which can affect the survival of other organisms. For example, burning wood and fossil fuels (such as coal) releases oxides of sulfur and nitrogen that can react with water in the atmosphere, forming sulfuric and nitric acid, which can then fall back to Earth's surface as acid precipitation, such as **acid rain**. Acid rain can decrease the pH of aquatic ecosystems and affect organisms living within it.
   (a) Investigate and report on acid rain and its impact on aquatic ecosystems.
   (b) Report on research or strategies to reduce the production or impact of acid rain.
9. Although some Australian organisms have adapted to relatively high salinity habitats, this is not the case for those living in freshwater ecosystems. A variety of both natural and human activities, however, are resulting in increasing salinity in some Australian freshwater ecosystems. Investigate and report on adaptations that some organisms use to survive in high salinity habitats, such as oceans.
10. Suggest a question related to your local habitats or ecosystems that you could research using what you have learned in this investigation.
    (a) List the materials and outline the method for your investigation.
    (b) Submit your proposal to your teacher for approval.
    (c) Perform your investigation, collecting your data in appropriate formats.
    (d) Discuss and explain your results, relating them back to your research question.

HOW ABOUT THAT!

The white plague

Did you know that a number of Australia's rivers and landscapes are under threat due to increased salinity? Not only does this put almost 450 species of plants, insects and birds under threat, but it is also affecting some of our most productive agricultural land. Australian scientists are exploring a variety of engineering- and plant-based possible solutions. What can we do to help?



4.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Match each term with its meaning.

Term	Meaning
Ecology	Living things
Ecosystem	Non-living things
Biotic factors	Populations of organisms living together in the same habitat
Abiotic factors	Groups of organisms of the same species in the same area
Population	The study of how living things interact with their environment
Habitat	Organisation made up of living things and non-living things that interact with each other
Community	Place where an organism lives

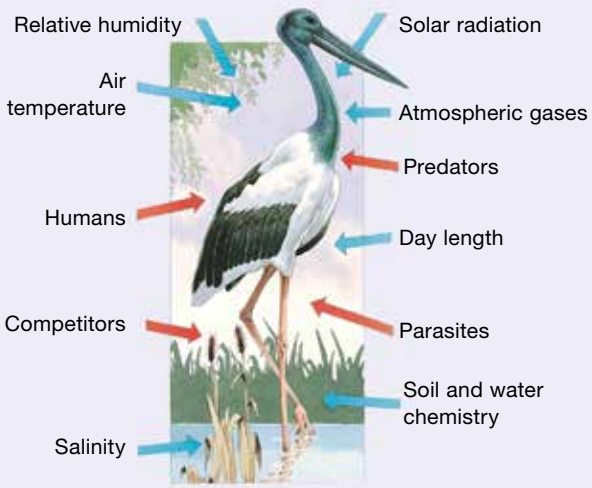
2. Provide two examples of each of the following.
   (a) Abiotic factor (b) Biotic factor (c) Habitat
3. Distinguish between the following.
   (a) Biotic and abiotic factors
   (b) Density and distribution

(c) Optimum range, tolerance range and range of intolerance
(d) Habitat and ecosystem

4. Order the following in terms of their complexity, from simplest to most complex.
   organism, ecosystem, population, species, cell, atom, community
5. Outline the relationship between ecosystems, abiotic factors and biotic factors.
6. List key terms associated with each of the following.
   (a) Carbon cycle
   (b) Nitrogen cycle
   (c) Water cycle

Investigate, think and discuss

7. (a) List five biotic factors that are part of the ecosystem in which you live.
   (i) Select one of these biotic or abiotic factors and research the possible consequences if it changed.
   (ii) Suggest how any negative consequences might be minimised.
8. Find out more about the effects of rising salinity on our ecosystems and then suggest why rising salinity has been described as a 'white plague'.
9. Human activity can result in changes in abiotic factors that may have an impact on the survival of organisms within ecosystems.
   (a) Find out why rising salinity is an issue in Australia.
   (b) Investigate examples of research that Australian scientists are undertaking in their search for possible solutions to the threat of rising salinity within many of our ecosystems.
   (c) Outline two examples of salinity research from (b).
   (d) Compare and contrast these two research responses to the salinity problem.
   (e) Which research from (c) do you think has greater potential to reduce the salinity threats? Justify your response.
10. Select an abiotic factor from the list below and find out more about how it affects the survival of a particular organism.
    - Acidity
    - Salinity
    - Temperature
11. Research the carbon cycle, nitrogen cycle or water cycle and find out how human activities have affected it. Suggest possible consequences of this effect.
12. Find a photograph or image of an animal and use two different-coloured arrows, one for abiotic and one for biotic factors (similar to the figure on the right), to add examples of factors that can affect its survival.
13. (a) Find out more about two types of research into water management in Australia.
    (b) Summarise your findings so that they can be communicated to others.
    (c) Put forward an argument that justifies the research from:
    (i) a scientific perspective
    (ii) an ethical perspective
    (iii) a financial perspective.



learnon RESOURCES — ONLINE ONLY

Complete this digital doc: Worksheet 4.1: Biotic and abiotic factors (doc-19813)

4.3 Ecosystems need relationships

4.3.1 Interacting through feeding relationships

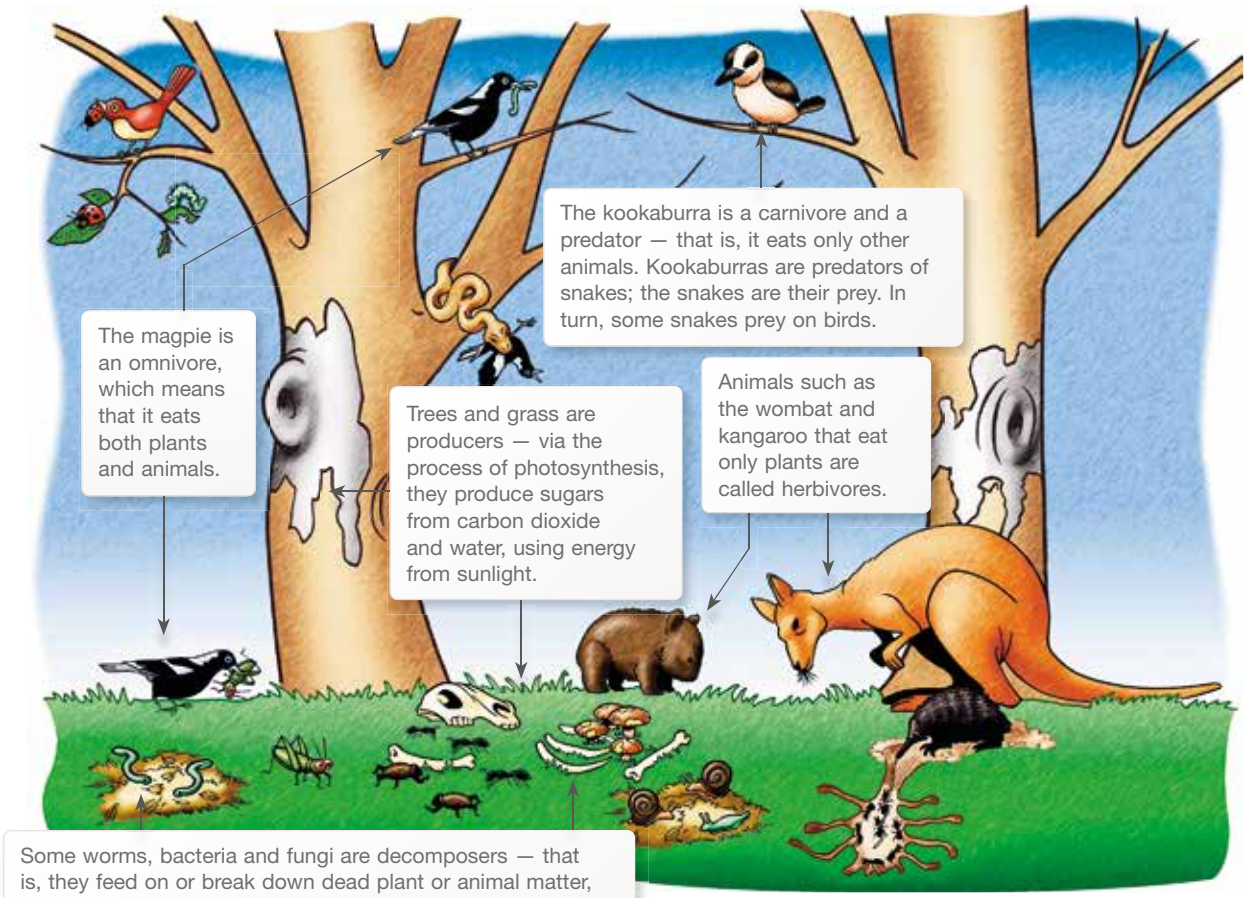
If you want to get into the 'zone' to effectively think and learn about ecosystems, you need to focus on relationships and interactions. To get started, carefully observe the figure below. How many different types of interactions can you see occurring?

Ecosystems are made up of living (biotic) and non-living (abiotic) things that interact with each other. For example, plants use energy from the sun, some animals eat the plants, and some animals eat other animals. It is through feeding relationships that energy flows through ecosystems and a variety of atoms that make up matter can be recycled.

4.3.2 Living levels of organisation within ecosystems

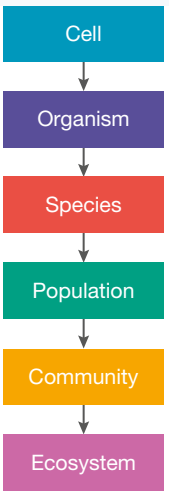
In order to explore these feeding relationships, you need to be able to distinguish between the terms 'organism', 'species', 'population' and 'community'. An **organism** is the simplest form of life. It may be made up of a single cell (unicellular) or many cells (multicellular). Organisms that can interbreed and produce fertile offspring are members of the same **species**. Organisms of the same species living in the same place at the same time are called **populations**. A group of populations that live and interact with each other in the same area is called a **community**. Basically, an **ecosystem** is made up of a community and its physical environment.

Within an ecosystem, organisms interact with each other and with their non-living environment.



Do you make it or take it? Within ecosystems, the members of a community can be identified as being either **producers** (autotrophs) or **consumers** (heterotrophs). The feeding relationships between these groups can be shown in flowcharts called **food chains** and diagrams showing interacting food chains, which are called **food webs**.

An ecosystem is a complex level of organisation.



4.3.3 Producers

Producers are organisms that can make their own food from their non-living environment. They achieve this by using a process called **photosynthesis**. This process is summarised below.

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll (or other light-capturing pigment)}]{\text{visible light energy}} \text{glucose} + \text{oxygen} + \text{water}$$

Did you know that life on Earth is solar powered? The source of energy in all ecosystems on Earth is sunlight. Producers, such as plants, are responsible for capturing light energy using the green pigment **chlorophyll** (or other light-capturing pigments). Plants then use this energy to convert inorganic materials (carbon dioxide and water) into organic matter (glucose). Oxygen is also produced as a waste product of photosynthesis. This molecule is essential for **cellular respiration** — a process that is essential to the survival of most organisms on our planet.



Plants can convert glucose produced by photosynthesis into other essential organic substances. This means that they do not need to feed on other organisms. It is for this reason that they are often referred to as **autotrophs** ('self-feeders').

4.3.4 Consumers

Consumers are organisms that eat other organisms or their products. They cannot make their own food, so they need to eat other organisms to provide their energy and chemical building blocks. This is why they are referred to as being **heterotrophs** ('other-feeders').

Lions are carnivores, whereas koalas are herbivores because they eat only plants.





Within ecosystems, consumers can be grouped on the basis of the type of food they eat. Animals that eat only plants are called **herbivores** (such as cows and koalas), those that eat only other animals are called **carnivores** (such as snakes, dogs and lions), and those that eat both plants and animals are called **omnivores** (such as humans and crows).

Detritivores (such as dung beetles, crabs and earthworms) and **decomposers** (such as bacteria and fungi) are two other groups of consumers. These two consumers differ from one another in that detritivores ingest (take in) their food, then digest it (break it down) and absorb the products; however, decomposers first release enzymes to digest food externally and then absorb the products.

Detritivores feed on decomposing organic matter, such as decaying animal remains, rotting leaves and dung. The name given to this type of 'food' is detritus, and that is how they get their name.

Detrivores, such as dung beetles, and decomposers, such as fungi and bacteria, play an important role in ecosystems.





Decomposers convert organic matter into inorganic matter. This is the reverse of what producers do. Decomposers obtain their energy and nutrients from dead organic material. This includes dead organisms and their wastes (such as faeces and skin flakes). As they feed, they break down the organic matter chemically into simple inorganic forms or mineral nutrients. Their wastes are then returned to the environment to be recycled by producer organisms. This recycling of matter from one form to another within ecosystems is key to their sustainability.



4.3.5 Interactions between species

A species exists in an ecosystem within a specific **ecological niche**. The **niche** of a species includes its **habitat** (where it lives within the ecosystem), its **nutrition** (how it obtains its food) and its **relationships** (interactions with other species within the ecosystem).

Competition, predator–prey and symbiotic relationships are all examples of different types of interactions between organisms.

Interactions between organisms within an ecosystem may be between members of the same species or between members of different species.

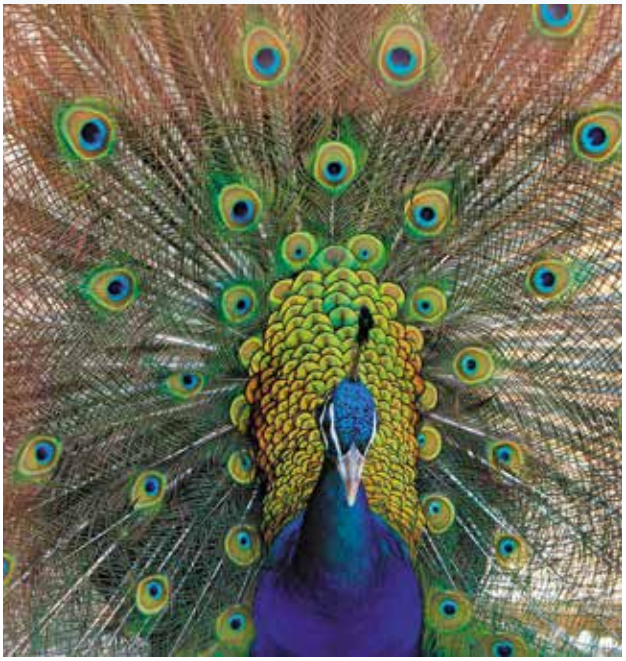


4.3.6 Competition

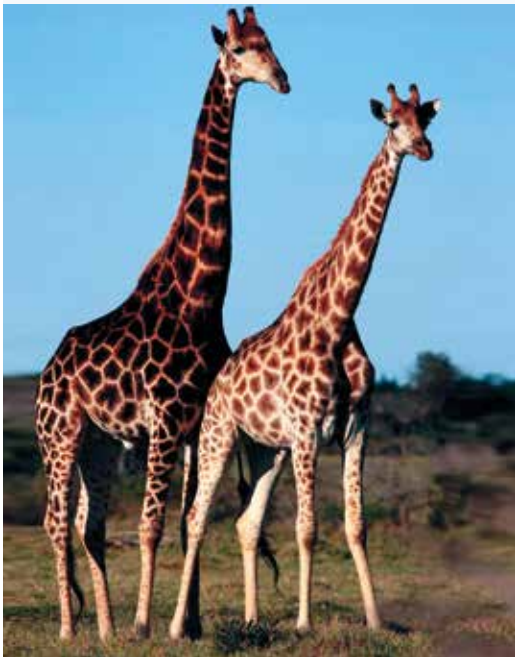
Organisms in a similar niche within an ecosystem compete when their needs overlap. Competition between members of different species for the same

resource (such as food, mates or shelter) is called **interspecific competition**. Competition for resources between members of the same species is called **intraspecific competition**.

Why so colourful? Male peacocks and lyrebirds compete for mates with other males of their species.



My neck's longer than yours! I can reach the higher branches and get more food!



Seals compete for mating territory in a crowded colony.



Plants in a rainforest compete for space and to get enough sunlight for photosynthesis.



4.3.7 Predator–prey relationships

In a predator–prey relationship, one species kills and eats another species. The predator does the killing and eating, and the prey is the food source. Examples of predator–prey relationships include those between eagles and rabbits, between fish and coral polyps, between spiders and flies, and between snakes and mice.

Domestic cats can interfere with the food chains of other species as they prey on birds, mice and many other small animals.







4.3.8 Symbiotic relationships

Some organisms of different species can have a very close relationship, with at least one of them benefiting; sometimes, their survival depends on it. This type of relationship is called **symbiosis**. The different types of symbiotic relationships are grouped on the basis of whether one of the species is harmed (**parasitism**), both species benefit by the association (**mutualism**), or one species benefits and the other is neither harmed nor benefits (**commensalism**).

Interaction	Species 1	Species 2
Parasitism	✓ (Parasite)	X (Host)
Mutualism	✓	✓
Commensalism	✓	0

✓ = benefits by the association; X = harmed by the association; 0 = no harm or benefit

Parasitism

In a parasitic relationship, one species is the **host** and the other is the **parasite**. Humans can be hosts for parasites such as tapeworms, leeches and fleas. The parasite lives on or in the host and usually obtains its food from it. Sometimes the host is unaffected, but at other times it may cause harm or even death.

Parasites such as this tapeworm harm their hosts.



Mutualism

A relationship in which both species benefit is called **mutualism**. In a lichen, algae and fungi grow together. While the fungi provide water and protection for the algae, the algae provide food for the fungi.



Commensalism

Commensalism is a relationship in which one organism benefits and the other is unaffected. Clownfish, for example, get food and protection from the sea anemone.



INVESTIGATION 4.4

Do all leaves contain the same pigments?

AIM: To extract and compare pigments, such as chlorophyll, from different types of plant leaves

Materials:

large beaker
hotplate
at least three different types of leaves. Geranium, hydrangea, lettuce, spinach and silverbeet cuttings are excellent.
metal tongs
large test tube or small beaker
methylated spirits
test-tube holder
stirring rod
clear plastic wrap
medium-sized beaker
filter or chromatography paper
coloured pencils
digital camera, iPad or smartphone
ruler

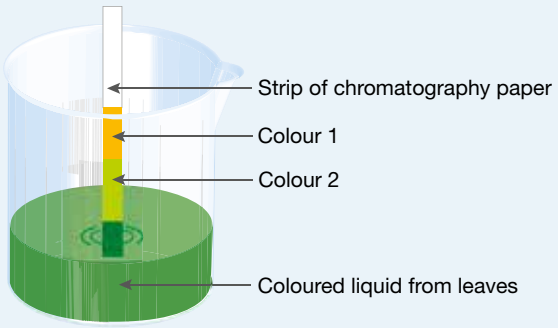
CAUTION

Methylated spirits is toxic and extremely flammable.

Method and results

- Half-fill the large beaker with water and bring to a gentle boil on the hotplate. This large beaker will serve as a water bath.
- Soften two or three leaves by dipping them with tongs into the hot water for 10 seconds.
- Place the leaves into a test tube or small beaker and cover them with 30–40 mL of methylated spirits. Use a test-tube holder to hold the test tube or small beaker upright in the water bath, so that its contents do not spill into the water.
- When the leaves turn pale and the methylated spirits deepens in colour, remove the test tube or small beaker from the water bath.
- Decant the coloured methylated spirits into the medium-sized beaker. Allow the liquid to cool for 10 minutes.

- Suspend a long narrow strip of chromatography paper or filter paper in the beaker so that just 2–5 mm sits in the liquid, as shown in the diagram on the right. Fold the paper over the side of the beaker to hold it in place.
- Remove the strip of paper from the methylated spirits before the colours reach the top of the paper.



1. Decide how you are going to record your detailed observations of the chromatography strip for each leaf. Prepare appropriate headings, keys, templates and other materials to support this format.
2. Construct a table with the following headings and use it to summarise your detailed observations.

Chromatography strip observations	Leaf A	Leaf B	Leaf C
Colours observed and distance each colour moved up strip			
Number of colours observed			

3. For each leaf, observe the colours produced and measure their distances along the strip. Record these detailed observations and summarise them in your table.
4. Identify which observations can be graphed and construct a graph to display a summary of your results.

Discuss, investigate and explain

5. Use specific examples from your observations to answer the following questions.
   (a) How many different colours did you identify? Which were they?
   (b) Which colour was the most dominant? Did all leaves contain it?
   (c) Was there any pattern between the distance that a colour moved on the strip and its colour? If so, what was it?
   (d) Did all of the leaves contain the same coloured pigments? If so, which colours? If not, which leaves contained which pigments?
6. Answer the following questions about your leaf pigment investigation.
   (a) Identify the independent variable of the investigation.
   (b) Identify which variables were controlled (kept constant or the same) for all leaf samples.
   (c) List two strengths of the experimental design.
   (d) Suggest two ways in which the experiment investigation could be improved.
7. (a) Suggest a hypothesis or research question that you could use this equipment (with possible modifications) to investigate.
   (b) Outline the procedure you would use to investigate your hypothesis.
8. Find out possible names for the pigments that you have separated, and at least one interesting piece of information about each of them.

HOW ABOUT THAT!

Bacteria in your deodorant

Our skin is covered in bacteria that use us for food. They do not really harm us. In fact, they may even help to keep our skin healthy. These bacteria also give us a distinct body odour or B.O. The bacteria that grow under our arms and on our skin when we get sweaty make chemicals that smell bad! *Phew!* Normally we would just cover up the smell with a deodorant. But there may be a better way. Genetic engineers are trying to make bacteria to produce nice smelling chemicals instead of bad ones. You then simply roll on bacteria using your deodorant. When you get hot and sweaty, the bacteria on your skin would smell nice. The hotter you get, the better you smell. Perhaps like roses!



4.3 Exercises: Understanding and inquiring

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Remember

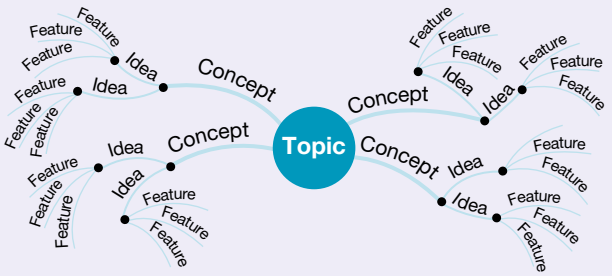
1. Match the heads and tails in the table below.

Head	Tail
Producers …	are organisms that break down dead organisms.
Omnivores …	are animals that eat only plants.
Herbivores …	are consumers that eat both plants and animals.
Carnivores …	are organisms that can produce their own food.
Decomposers …	are animals that eat other animals.

2. Identify:
   (a) the source of all energy in ecosystems
   (b) the name of the green pigment that captures light energy
   (c) which organisms trap the energy from sunlight.
3. Provide two examples of each of the following.
   (a) Herbivores (b) Carnivores (c) Decomposers
4. Distinguish between the following.
   (a) Autotroph and heterotroph
   (b) Predator and prey
   (c) Interspecific competition and intraspecific competition
   (d) Producer and decomposer
   (e) Parasitism, mutualism and commensalism
5. Construct a sentence that uses each of the following lists of terms.
   (a) Producer, light energy, chlorophyll, carbon dioxide, water, glucose, oxygen, plant
   (b) Organism, species, population, community, ecosystem, physical environment
6. Outline or describe the relationship between each of the following pairs.
   (a) Consumers and heterotrophs
   (b) Producers and consumers
   (c) Herbivores, carnivores and omnivores
   (d) Predator and prey

Think and create

7. Construct a double bubble map to show some of the similarities and differences between carnivores and herbivores.
8. Construct a mind map to show the links between and key points about the following: producers, consumers, carnivores, herbivores, omnivores, decomposers, predators, prey.
9. Use a Venn diagram to compare producers and consumers.



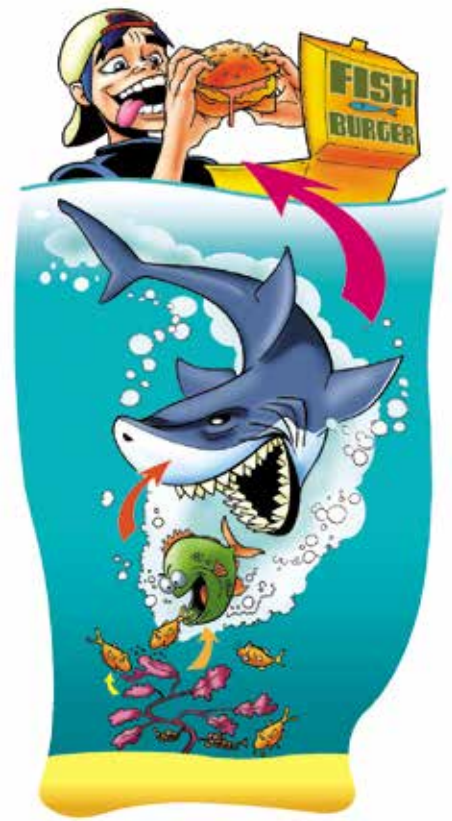
Investigate, think and discuss

10. Identify each of the following relationships as
    (a) competition, (b) predator–prey, (c) mutualism, (d) parasite–host or (e) commensalism.
    - Cats hunt and eat mice.
    - Aphids suck the sap from a rose bush.
    - Male kangaroos fight each other for the attention of females.
    - Termites contain a fungus in their stomach that digests the wood they eat. The fungus cannot live anywhere else. Without the fungus, the termites would not survive.
    - Lampreys are fish that attach themselves to sharks. They feed on scraps of the shark's food and the shark is unaffected.

11. (a) List three examples of predators and then match them to their prey.
    (b) Suggest structural, physiological and behaviour features that may assist:
        (i) predators in obtaining food (e.g. webs, teeth, senses, behaviour)
        (ii) prey in avoiding being eaten (e.g. camouflage, mimicry, behaviour, chemicals).
12. In the interaction between a clownfish and a sea anemone, which is the commensal?
13. Some clovers (*Trifolium*) produce cyanide. Find out how this may protect them against being eaten.
14. Find examples of ways that Australian plants try and protect themselves from being eaten by herbivores.
15. Use internet research to identify three problems that can be investigated about interactions between organisms.

4.4 Food chains and food webs

The food chain that links you and a shark: algae → small fish → large fish → shark → human



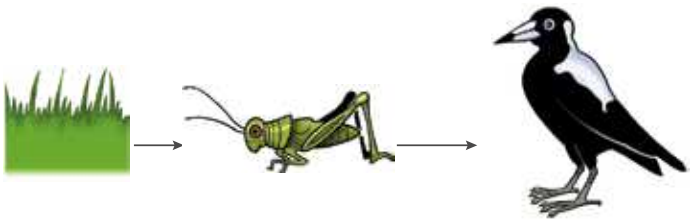
4.4.1 Feeding relationships

Feeding relationships between organisms within an ecosystem can be described in **food chains** and **food webs**.

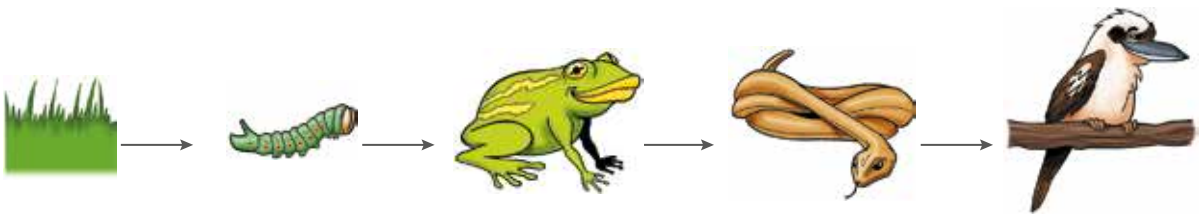
4.4.2 Food chains

Food chains describe the feeding relationships between organisms. To describe a food chain, the names of these organisms are linked by arrows. The arrow in a food chain indicates 'is eaten by' and describes the direction of the flow of energy.

Consider the feeding relationships between the organisms in the food web on page 135. How many different food chains can you see between the organisms in this ecosystem? Two examples of food chains are shown below.



Grass → Grasshopper → Magpie

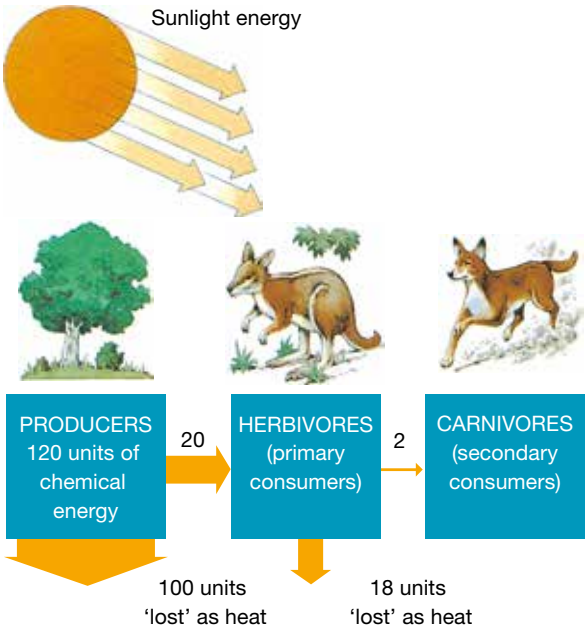


Grass → Caterpillar → Frog → Snake → Kookaburra

4.4.3 Energy flows

Our sun is the initial source of energy for our ecosystems. Producers, such as plants, capture some of this light energy and convert it into chemical energy using the process of photosynthesis. When consumers eat producers, some of this energy is passed along the food chain.

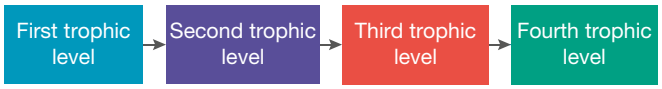
Energy flow in an ecosystem. The values of units of energy flowing through the food chain are averages.



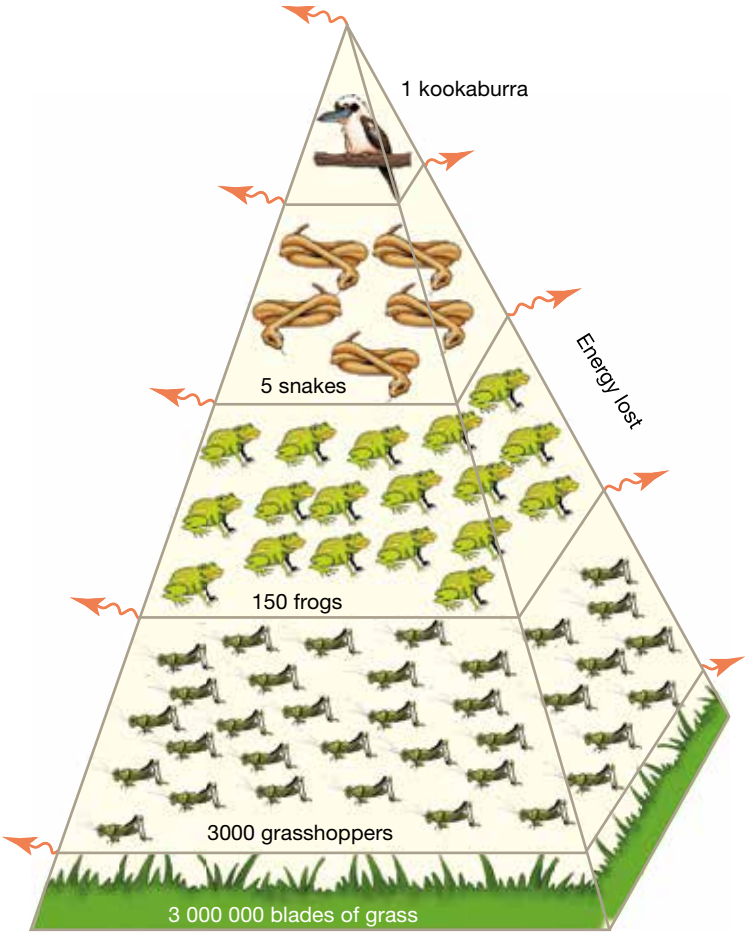
Within a food chain, each feeding level is called a **trophic level**. Food chains can be defined as a pathway along which food is transferred from producers to one trophic level and then to the next.

For example, **primary producers** make up the **first trophic level** and the consumers (herbivores) that eat them make up the **second trophic level**. Consumers eating these herbivores make up the **third trophic level** and consumers eating these consumers make up the **fourth trophic level**.

Energy is not recycled, nor can it be created or destroyed. Energy is transformed from one form to another. At each level in the food chain, some energy is also released to the environment in other forms (such as heat, kinetic and sound energy). As only about 10 per cent of the chemical energy is passed from one trophic level to the next, most food chains do not usually contain more than four trophic levels. There is also a limit to the number of organisms that can exist at each level.



Pyramid showing numbers of organisms in a food web



4.4.4 Order in chains

In the food chain on the previous page, grass is the **primary producer**.

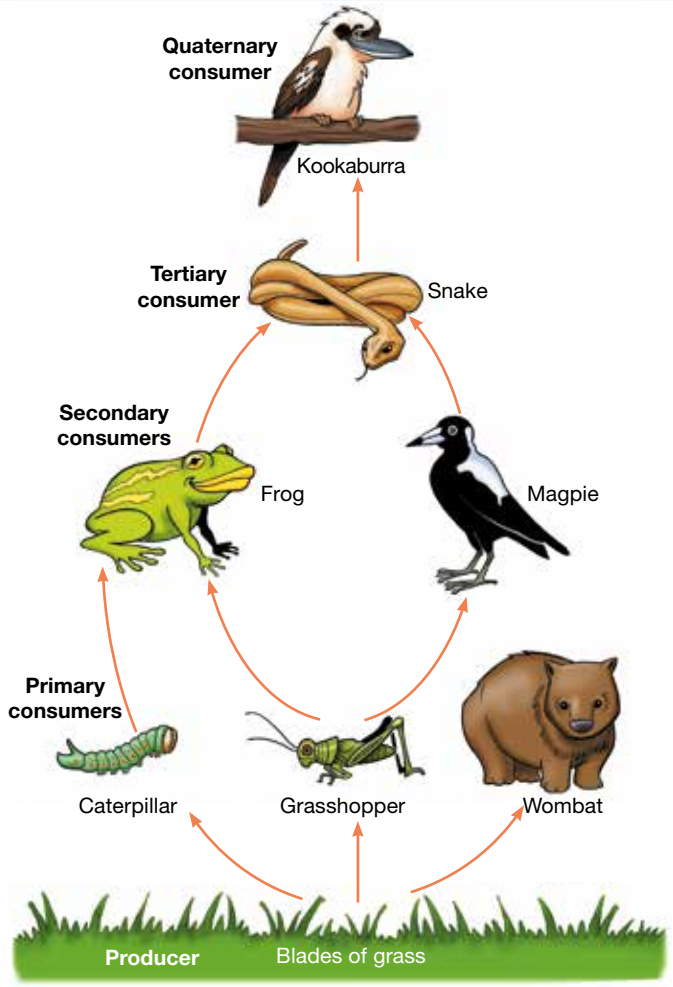


The consumer that eats the producer is called a **primary** (or **first-order**) **consumer** (for example, the grasshopper). The consumer that eats a primary consumer is called a **secondary** (or **second-order**) **consumer** (for example, the frog). The consumer that eats the secondary consumer is a **tertiary** (or **third-order**) **consumer** (for example, the snake). Can you suggest the name given to describe the kookaburra in this food chain?

4.4.5 Food webs

Interconnecting or linked food chains make up food webs. In the food web shown below, the caterpillar, grasshopper and wombat are all primary (first-order) consumers, and the frog and magpie are secondary (second-order) consumers. The snake is a tertiary (third-order) consumer, and the kookaburra is a quaternary (fourth-order) consumer. Depending on the feeding relationships within a food web, organisms can hold more than one position. For example, if the kookaburra ate the caterpillar, it could also be considered as a secondary consumer.

Each of the steps in a food chain is described as a trophic level. Multiple food chains result in a food web.



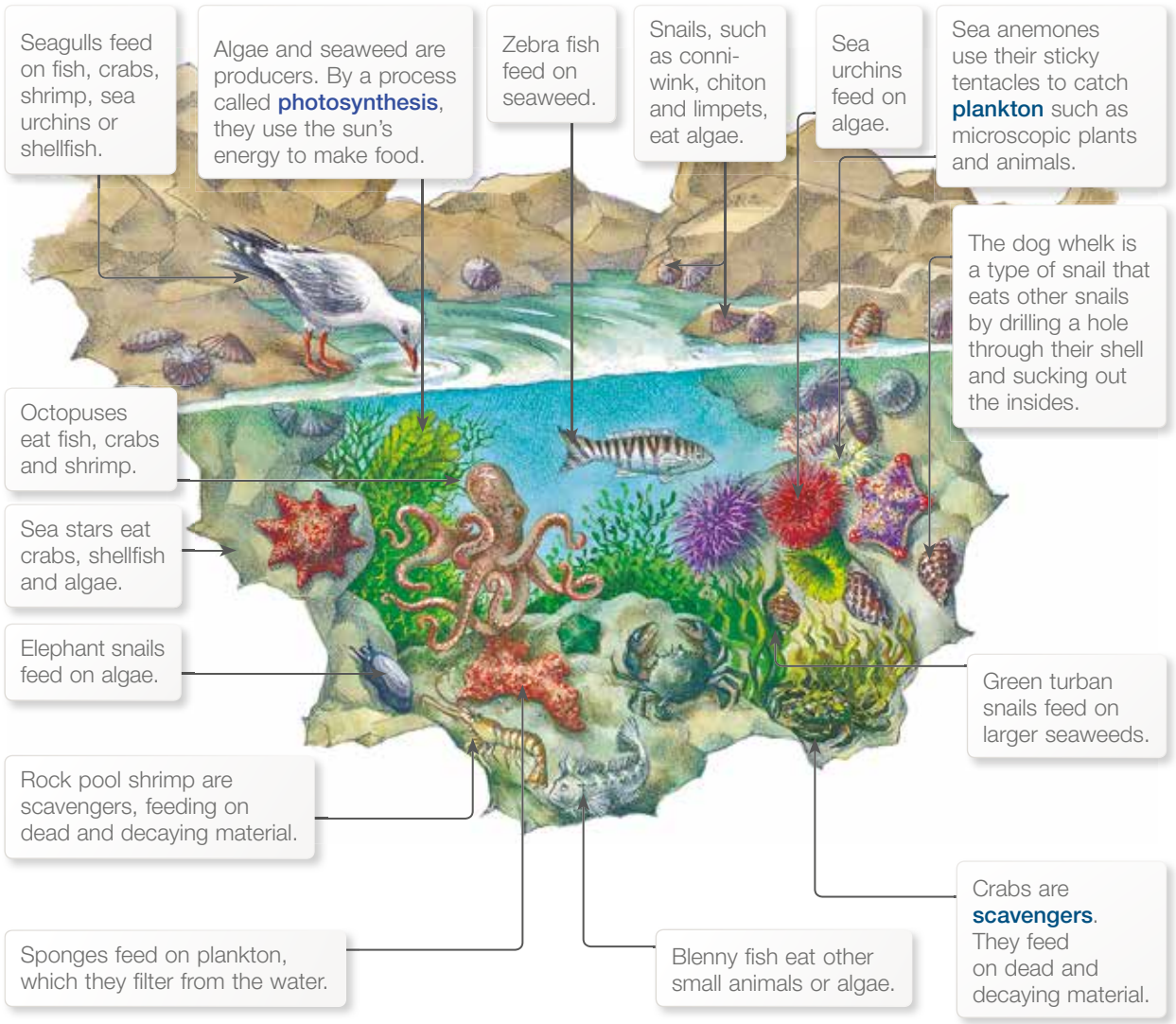
If one of the organisms in a food web is removed, or a new organism is introduced, other organisms in the food web may be affected. For example, what do you think the effect might be if the grasshoppers were removed from this ecosystem? What if all of the kookaburras died? What do you think may happen to the numbers of snakes? What implications might this have on the other organisms in this food web?

4.4.6 Visiting a rock pool

Carefully study the rock pool picture below. There are many different feeding relationships within this ecosystem. Two examples of food chains are shown below. How many other food chains can you suggest?

algae → sea urchin → seagull
producer **primary consumer** **secondary consumer**

seaweed → green turban snail → dogwhelk snail → seagull
producer **primary consumer** **secondary consumer** **tertiary consumer**



INVESTIGATION 4.5

Make a food web

AIM: To model your own food web

- Construct a food web using students connected by pieces of string. You can use one of the food webs described here or make up one of your own by discussing it in a group and planning it out on a large piece of paper.
- Pull on one string and see how it affects other organisms. If you feel a tug on a string you are holding, then pull on all the other strings you are holding.

1. Which ‘organisms’ in the food web felt the tug on the string?
2. Which ‘organisms’ did not feel anything?

Discuss and explain

3. List two strengths in the design of this investigation.
4. Suggest a way in which this investigation could be improved to better model or simulate food web interactions.
5. Try out your suggestion to see how it works, making more modifications if required.

4.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

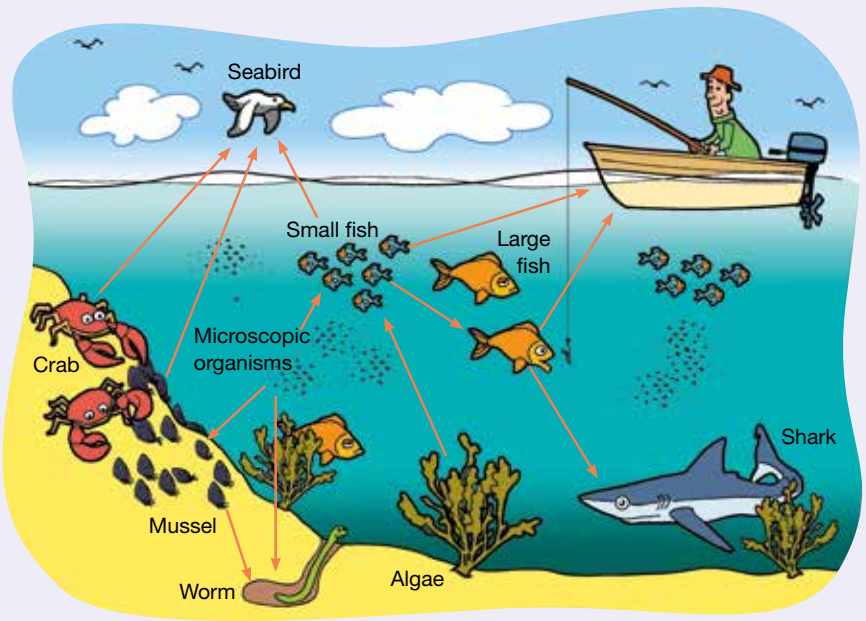
Remember

1. Match the ‘heads’ and ‘tails’ in the table below.

Head	Tail
Food chain …	is a herbivore (eats plants or algae) in an ecosystem.
Food web …	is a carnivore that eats herbivores in an ecosystem.
Primary producer …	shows the interconnected feeding relationships within an ecosystem.
Primary consumer …	is an autotroph (such as plants or algae), which collectively make up the first trophic level in an ecosystem.
Secondary consumer …	is a pathway along which food is transferred from producers to the next trophic level, and so on.

2. State the alternative term used for:
   (a) primary consumer
   (b) secondary consumer
   (c) tertiary consumer.
3. Provide an example of each of the following.
   (a) Food chain
   (b) Food web
   (c) Primary producer
4. Distinguish between each of the following pairs.
   (a) Primary producer and primary consumer
   (b) Food chain and food web
   (c) First trophic level and third trophic level
5. Construct a sentence that contains each of the following lists of terms.
   (a) Feeding relationship, food chain, organism, ecosystem, food web
   (b) Primary producer, primary consumer, trophic level, energy, plant, caterpillar

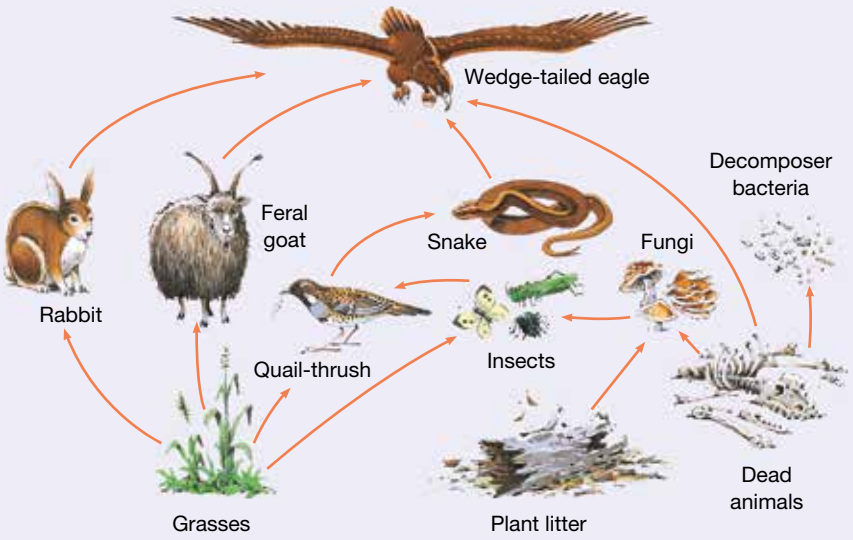
Food web 1



Using data

6. Use information in the picture of the rock pool ecosystem on page 136 to:
   (a) identify a primary producer
   (b) identify two secondary consumers
   (c) identify two tertiary consumers
   (d) identify a detritivore or scavenger
   (e) construct two food chains
   (f) construct a food web.
7. For each of food webs 1 and 2:
   (a) construct three different food chains
   (b) identify a producer
   (c) identify a first-order consumer
   (d) identify a second-order consumer
   (e) identify a third-order consumer
   (f) identify a decomposer.

Food web 2



Using data

8. Genevieve and Callum made some observations over a period of a week about the feeding habits of a number of organisms in a small pond. Their results are listed below.
   - Snails eat water plants and algae.
   - Tadpoles eat algae.
   - Small fish eat snails, algae and water plants.
   - Larger fish eat snails, small fish and tadpoles.

   Construct a food web using the information above. Start with the producers at the bottom and work upwards. Make sure your arrows face the right way.
   (a) Which organisms are the producers?
   (b) Which organisms are first-order consumers?
   (c) Which organisms are both second- and third-order consumers?
   (d) Which organism is an omnivore?
   (e) Which organisms are predators of the snail?
   (f) Which organisms are competitors of the tadpoles?
   (g) What would happen to the water plants and the larger fish if the snails increased in number?
   (h) What would happen to the snails and the larger fish if the small fish disappeared?

Think, discuss and investigate

9. In a team, think about and discuss the following 'what if' statements.
   (a) The sun stopped shining.
   (b) All plants died.
   (c) There were no decomposers.
   (d) There were no carnivores.
   (e) There were no herbivores.
10. Write down a food chain in which you are:
    (a) a first-order consumer
    (b) a second-order consumer
    (c) a third-order consumer.

11. Give an example of each of the following.
    (a) Competition between two carnivores
    (b) Competition between two herbivores
    (c) A predator and its prey
12. Try to draw a food chain that contains a fifth-order consumer.
13. Why do food chains rarely contain more than three levels of consumer?
14. Describe a situation in which an organism can be both a second-order consumer and a third-order consumer in a food web.
15. Draw a pyramid showing the numbers in a food chain in a parasite–host feeding relationship. How is it different from the predator–prey pyramid on page 134.
16. A number of years ago the insecticide DDT was used on farms to kill insect pests. Find out:
    (a) why DDT causes a problem for consumers higher up the food web
    (b) how DDT got into aquatic environments such as lakes and the ocean.

Think and create

17. Use a relations diagram or cycle map to show the role of decomposers in a food web.
18. Use a mind map, flowchart or another visual tool to describe how energy flows through an ecosystem. Add lots of colour and diagrams to your map. Compare your map with others in the class, and then make any changes or modifications you wish.
19. Construct a mind map to show the links between and key points about the following: producers, consumers, carnivores, herbivores, omnivores, decomposers, predators, prey.
20. Use a Venn diagram to compare producers and consumers.
21. (a) Draw a food web for a community of organisms in one of the following: your own garden, a forest, a desert, a river, a marina.
    (b) Convert your food web into a mobile, model, rug or blanket.
22. Write a play about the flow of energy in ecosystems. Create puppets to represent various characters or features in your play and then act it out for the class.
23. (a) On your own or in a team, create a list of key terms and important information from this section.
    (b) Use your list to construct a set of *Flowing on* flash cards. Add diagrams, symbols, colour or other details to your cards.
    (c) Create a game that uses these cards to help other students learn about the flow of energy within ecosystems.
    (d) Construct a rule book and other items essential for your game.
24. Write a play about a food web in an ecosystem and create puppets to act it out to the class.

learnon RESOURCES — ONLINE ONLY

Complete this digital doc: Worksheet 4.2: Food webs (doc-19814)

Complete this digital doc: Worksheet 4.3: Ocean explorations (doc-19815)

Complete this digital doc: Worksheet 4.4: Nature pyramids (doc-19816)

Complete this digital doc: Worksheet 4.5: Food chains and food webs (doc-19817)

Complete this digital doc: Worksheet 4.6: Cycles in nature (doc-19818)

4.5 Angiosperm interactions

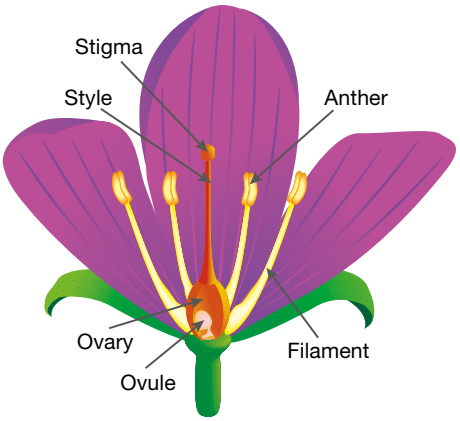
4.5.1 Interactions

The reproduction, development and growth of plants can involve a variety of interactions not only with other organisms, but also with abiotic factors within the environments in which they live.

4.5.2 Flowers by design

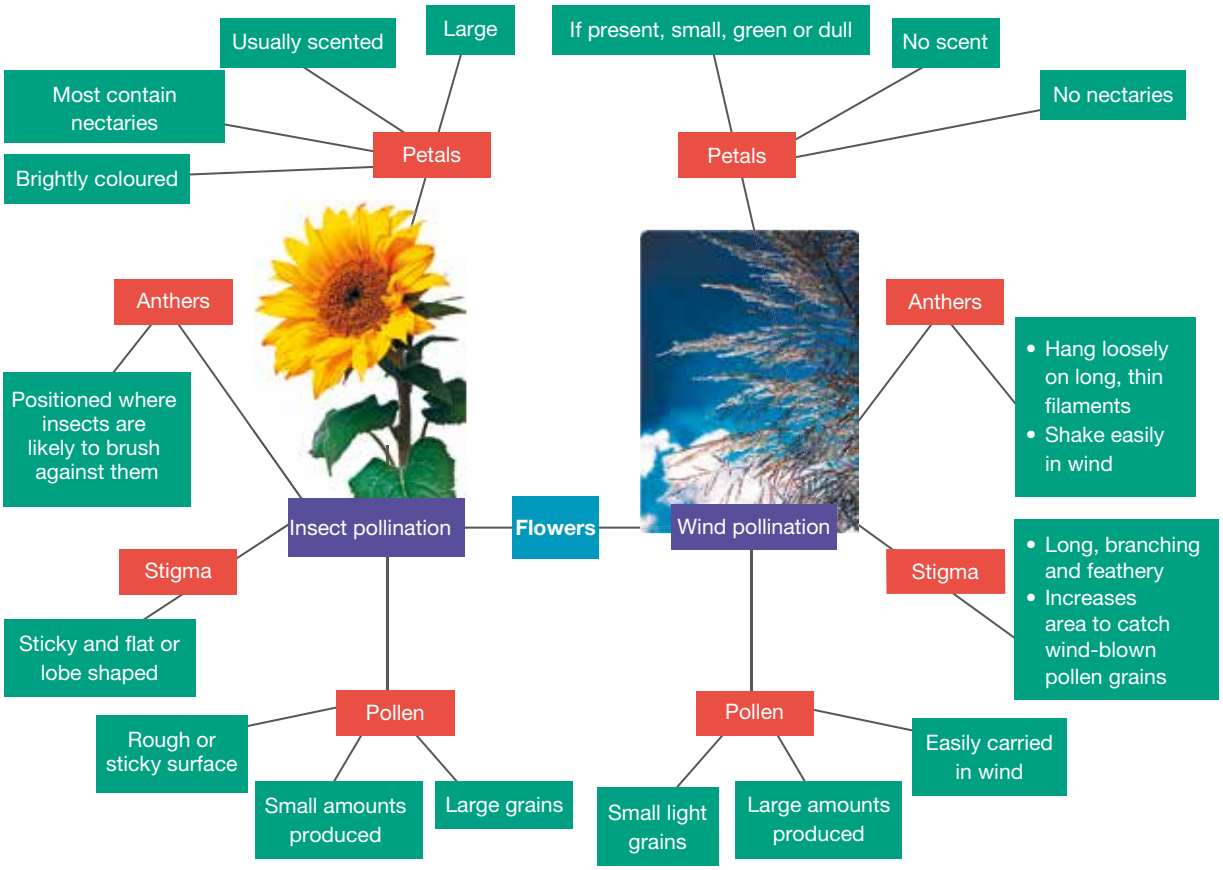
Plants that produce flowers are called angiosperms. These flowering plants have their male and female reproductive structures located in their flowers. **Pollen** is produced in the **anthers**. **Ovules** are produced in

the **ovaries**. When pollen grains attach to the **stigma**, **pollination** has occurred. A pollen tube then forms and grows down the **style**, carrying the male sex cells to the ovary. If a male sex cell fertilises an ovule (female sex cell) in the ovaries, a **seed** is produced.



4.5.3 Pollination — biotic and abiotic interactions

Both biotic and abiotic factors can contribute to successful pollination. While some plants may be able to pollinate themselves, many plants rely on either animals (such as bees, butterflies and birds) or the wind to transport their pollen from one plant to the stigma of another. The structure of these flowers is often well suited to the biotic or abiotic factor assisting them.



Flowers — feeding relationships

Organisms that assist plants in pollination are called **pollinators**. They are very useful in plant reproduction because it supplies them with food! Birds and insects such as honey bees and butterflies feed on the nectar of flowers and, in the process, they become covered with pollen. This pollen can then be transferred to other plants when they go to feed on them.

Flowering plants are also primary producers. They are positioned at the first trophic level in their food chains. As well as parts of these plants supplying a food source to many different animals, they also provide the raw materials for bees to make honey, which other animals can eat.

Three examples of feeding relationships between animals and plants



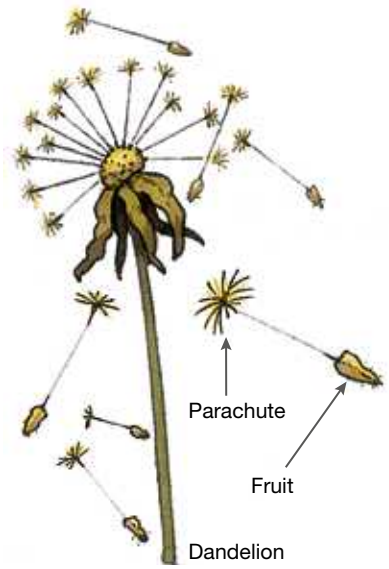


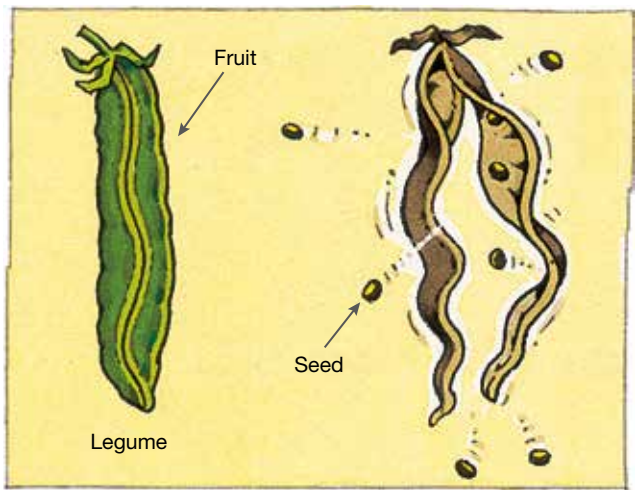
4.5.4 Dispersal — biotic and abiotic interactions

The fruits of plants contain the seeds. These are actually the swollen ovaries of the plant. One of the main jobs of fruits is to help with dispersal or spreading of the seeds. A variety of biotic or abiotic factors may also be involved in dispersal of the seeds.

Some Australian plants, such as *Banksia* and mountain ash (*Eucalyptus regnans*), require high temperatures to burst their fruit so that the seeds may be released. This adaptation gives these plants an excellent chance of survival in regions prone to bushfires.

Dispersal may involve animals eating them (such as tomatoes, grapes and apples), water (such as coconuts) or wind (such as grasses and dandelions). Some plants, including some legumes, split open when ripe, throwing their seeds out long distances, dispersing their seeds themselves.





Fruits and seeds — feeding relationships

Fruits that attract animals are often brightly coloured. When a fruit is eaten by an animal, usually only the soft parts of the fruit are digested. The seeds that are not broken down inside the animal are passed out in its faeces. So, by eating the fruit, animals assist in the dispersal of the seeds.



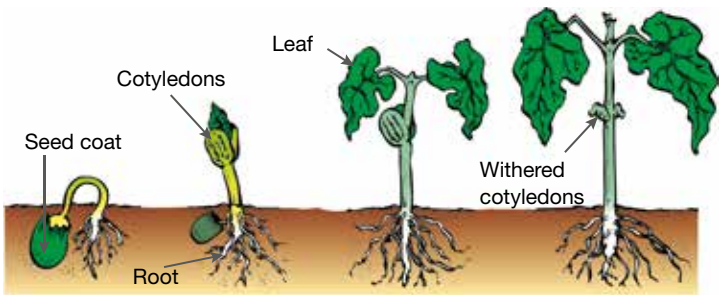
4.5.5 Germination — biotic and abiotic interactions

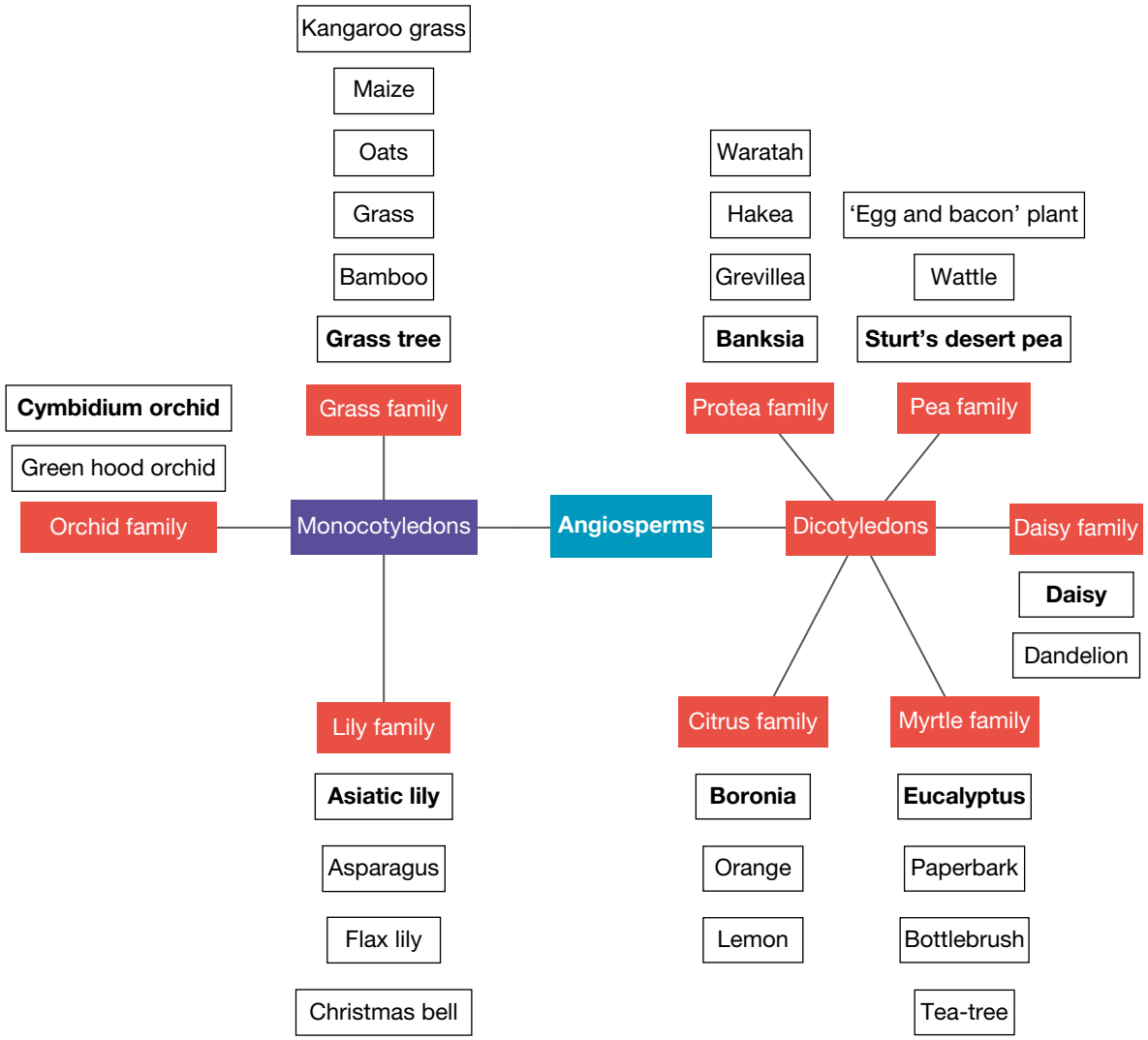
Inside the seed of a flowering plant is an embryo plant, which has one or two seed leaves called cotyledons. Plants with one cotyledon are called monocotyledons (monocots) and those with two cotyledons are called dicotyledons (dicots).

Germination is a process in which the seed bursts open and the embryo plant becomes a young plant called a seedling. Germination depends on three key abiotic factors: water, oxygen and an optimum temperature. Water is necessary for the seed to swell and burst open and then to transport food to the growing embryo. Oxygen is required for cellular respiration and the conversion of energy into a form that the plant cells can use, so that the plant can grow and develop. The optimum temperature for germination depends on the particular type of plant.

Although light is not necessary for germination of most seeds, it is needed once the young shoot breaks through the soil surface. Plants use light energy and carbon dioxide and water from their environment to make their own food using a process called photosynthesis.

Germination of a broad bean





HOW ABOUT THAT!

Using flowers to tell the time

You may have noticed that most flowers open in the morning and remain so throughout the day. Some plants, however, have flowers that open at particular times. Carl von Linné (1707–1778), a well known Swedish naturalist, was one of the first to study the opening and closing of flowers. He even arranged a flower clock that showed some typical opening times of flowers. Some opening times are shown in the table on the right.

Which abiotic factors do you suggest may be responsible for the different opening times? How might these flower opening times affect animals that feed off their nectar?

Time of flower opening	Common name
4 am	Tall morning glory
5 am	Corn poppy
	Pumpkin
6 am	Fireweed
	Chicory
7 am	Coltsfoot
8 am	Marsh marigold
6 pm	Evening primrose
7 pm	Catchfly

INVESTIGATION 4.6

Practising botanists

AIM: To observe, record, investigate and classify five different types of flowering plants

SOME WORDS OF WARNING

- Be responsible in your fieldwork and handle the plant parts very gently and carefully.
- Do not pick, break, tread, trample or climb the plants.
- Remember that you are dealing with living things

Materials:

5 different types of flowering plants in their natural habitats
A4 paper
pencil
ruler
magnifying glass
digital camera, iPad or smartphone to record extra information (optional)

Method and results

- Find five plants, each with different types of flower.
- Use a separate page for each plant.

1. At the top of the page
   - record your name and the date
   - record the plant's name, or, if unknown, record it as specimen A, B, C etc.
   - give a general description of the location in which the plant is found.
2. Divide the rest of your A4 sheet into three sections:
   (a) half-page sketch of a flower
   – Try to show the parts in the diagram on page 140 and label them.
   – Count or estimate how many stamens, stigma, petals and sepals are present.
   (b) quarter-page sketch of a leaf — include any veins that you see
   (c) quarter-page sketch of the plant's overall appearance.
3. Record the colour, scent (also give a mark out of 10 for its strength), and the texture and shape of the flowers, leaves and stems next to your diagrams.

Discuss, investigate and explain

4. Suggest which of the plants are likely to be pollinated by insects or the wind, or by other means. List this information in a table. Give reasons for your suggestions.
5. For those plants that you suggested were insect-pollinated, suggest a type of insect that may pollinate them. Give reasons for your suggestions.
6. Suggest which plants are monocots and which are dicots and give reasons for your suggestions.
7. Use published field guides or keys to identify the scientific names of the flowering plants observed.
8. Research your identified plants and take note of how they are pollinated and any other interactions that they have with other organisms.

9. Construct five possible food chains, each including one of your flowering plants.
10. Comment on how effectively your previous suggestions (in questions 4–6) matched your research.
11. What difficulties did you encounter when doing this activity? Suggest how they might be overcome (or any improvements) if you were to do it again.
12. Design a field guide, cluster map, classification key or multimedia summary that could be used to separate and describe the plants you observed.

4.5 Exercises: Understanding and inquiring

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Remember

1. Match the heads and tails in the table below.

Head	Tail
Angiosperms …	is the fusion (joining together) of a male and female sex cells.
Pollen …	are produced in ovaries of a flowering plant.
Ovules …	occurs when pollen grains attach to the stigma.
Pollination …	are swollen ovaries of the plant containing seeds.
Seed dispersal …	is produced in the anthers of a flowering plant.
Fertilisation …	is the process in which the seed bursts open and the embryo plant becomes a seedling.
Germination …	are plants that produce flowers.
Fruit …	is the spreading of seeds.

2. Identify whether a plant with the following features is more likely to be insect or wind pollinated.
   (a) Flowers with large, scented, brightly coloured petals and nectaries
   (b) Flowers with very small, green and unscented petals
   (c) Flowers with anthers hanging loosely on long, thin filaments and shaken easy in the wind
   (d) Flowers that produce small amounts of large, sticky pollen
3. Provide two examples of members of each of the following angiosperm families.
   (a) Myrtle family (b) Pea family (c) Grass family (d) Citrus family
4. Distinguish between each of the following pairs.
   (a) Pollination and germination
   (b) Fertilisation and dispersal
   (c) Monocotyledons and dicotyledons
   (d) Fruits and seeds
5. Construct a sentence that includes each of the following lists of terms.
   (a) Germination, seed, embryo plant, seedling, abiotic factors, water, oxygen, temperature
   (b) Pollination, nectar, honey, bee, flower, food, plant, pollen, stigma, anther
6. Outline or describe the relationships between:
   (a) flowers of flowering plants and bees
   (b) fruits of flowering plants and animals.
7. If an animal, such as a bird, eats the seeds of fruit, how can the seeds be dispersed?
8. Identify which conditions are necessary for germination. Explain why they are needed.
9. Explain why light is usually necessary only after a plant has germinated.

Investigate and design

10. Design an experiment to see whether water affects the germination of a variety of different types of seeds.
11. Find out more about the seed dispersal of five different types of plants and report your findings in a visual map.
12. Find out more about each of the different families of plants listed in the diagram on page 142. Present your information in a poster.

13. Find out other differences between monocotyledons and dicotyledons and communicate your findings in a matrix table.
14. Not all plants are welcome in Australia. Some plants have been identified as Australian 'weeds of national significance'. Features shared by these plants relate to their invasiveness, their potential to spread and their effect on primary production and the environment.
    (a) Find out the names of five plants on the Australian government's list of twenty 'weeds of national significance'.
    (b) Select any plant on this list and complete the following in a brochure or electronic format.
        (i) State the common and scientific names of the plant.
        (ii) Describe the plant (include size, shape, structures and colour).
        (iii) Describe the distribution of this plant in Australia.
        (iv) Outline some interesting points about this plant.
        (v) Suggest why this plant is considered to be a weed.
        (vi) Suggest ways to control or eliminate this weed in Australia.
        (vii) Use a relations diagram or algorithm to suggest possible consequences of removing this weed from Australian ecosystems.

4.6 Another beanstalk story

4.6.1 Think like a scientist

Bean plants grow quickly. Here is your chance to think like a scientist and design and carry out your own investigation about the growth of bean plants.

4.6.2 Planning your investigation

In planning your investigation, you need to ask yourself some key questions.

1. What is your research question?
   What do you want to find out?
   What 'one thing' do you want to change to see what effect it has on some 'other thing'?
   Answering these questions will help you to answer the next questions concerning which variable you will deliberately change (**independent variable**), which you will measure (**dependent variable**) and which you will keep the same or constant (**controlled variables**).
2. What is the one thing you are going to change?
   In designing your investigation you should change only ONE variable at a time. The variable that you deliberately change is called the independent variable.
3. What thing are you going to measure?
   The variable that you measure is called the dependent variable.
4. What other variables are there to keep the same? How can you keep them the same?
   It is important to keep the variables that you are NOT investigating the same. These are called controlled variables. This increases the chance that it is the variable you are changing that is causing the effect you are measuring, rather than some other variable.
5. How can you make sure that the investigation is fair and not a 'fluke' or mistake?
   A control enables you to see whether the independent variable has an effect on the dependent variable and provides a baseline for comparison. A large sample size and repeating the investigation decreases the

You need at least two groups of plants.



chance that your findings were a fluke or due to a mistake. It also helps to reduce the effects of individual variations that may occur in your data.

6. What is your prediction of the answer to your research question?
   A **hypothesis** is an educated guess or prediction of what the results of an investigation may be. An example is 'that bean growth is faster when watered with tap water rather than salt water' or 'that bean germination decreases with increasing salt concentration'.
7. What materials and equipment do you need for your investigation?
   Once you have decided on the variables in your investigation, you can write a list of what you will need to perform it. Include quantities and specific descriptions so that you remember to keep your controlled variables constant.
8. What are you going to do in your investigation? What steps are you going to follow?
   By having your steps clearly outlined you could repeat the investigation in exactly the same way if you were to do it again. This is your **procedure** or **method**. Others could repeat it as well. If you make any changes to your plan when you are conducting your investigation, make sure you record them. If you are using bean seeds, remember to soak your bean seeds (10 seeds or more) in a dish of water overnight. There are some examples of set-ups for you to consider in the figures below.

Planting your seeds

Step 1



Press a hole about 2 cm deep into the potting mixture with a pencil.

Step 2



If you are planting more than one plant in each container, mark the position of each seed by sticking a toothpick beside it.

Step 3



Label your container with your name and the date and any other vital information, e.g. 'salty water', 'red light'.

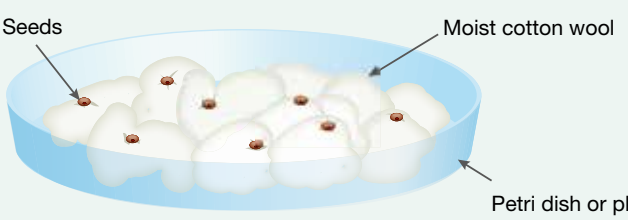
Step 4



Water your seeds, but take care not to overwater! Leave your seeds in a warm and sunny position.

Another way to set up your experiment

Step 1



Put some cottonwool in a Petri dish or plate.
Add enough water to moisten the cottonwool.
Place the pre-soaked seeds on top of the cottonwool.

Step 2



Water the seeds as required to keep the cottonwool moist, but do not overwater as mould will grow on the seeds.

9. What are you going to record and how are you going to record it?
   In your procedure you should have outlined *what you intended to measure* and *how you intended to measure and record it*. The details that you record are your **results** or **data**. You may decide to record your results in a table similar to the one shown on the next page or you may use a journal or diary to record observations as diagrams with descriptive labels and measurements.

Sample table. This table could be used to record the results of an experiment to find out whether watering plants with salt water affects their growth.

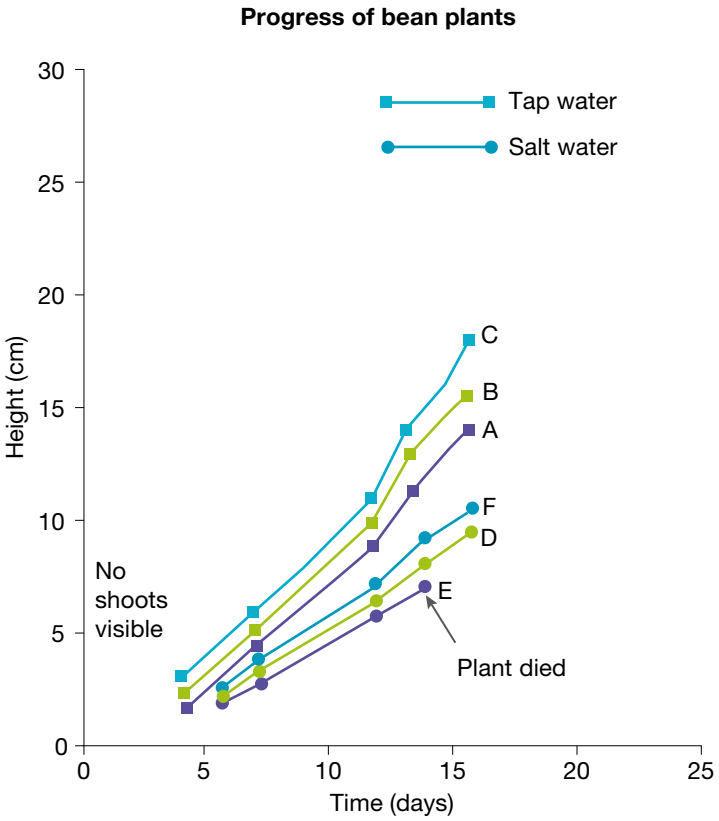
			Height of seedling (mm)												
			Tap water						Salt water						
Date	Day	What I did	A	B	C	D	E	Ave.	A	B	C	D	E	Ave.	Observations and diagrams
5/3	10	Watered all plants at 3 pm; gave each plant 50 mL water	7.1	8.0	8.9	7.5	8.2		5.0	4.4	5.8	4.8	5.2		

4.6.3 Reformatting your data

While your bean plants are growing, you can record their progress on a line graph such as the one at right. This graph shows how the heights of two groups of plants change. If any of your plants die, your investigation is not a failure. You should, however, make a reasonable attempt to suggest why they died.

By changing the format of your data into graphs, it can help you see patterns. It will make it easier for you to make conclusions about your data.

Use a graph to record the progress of your plants. The independent variable is on the *x*-axis; the dependent variable is on the *y*-axis.



4.6.4 Writing your report

In reporting your investigation to others, you should use the headings listed below. You will find a description of what should be included under each heading in topic 1 of this book.

- Purpose or aim (you may include your research question or hypothesis)
- Procedure (materials and method)
- Results (all of the data that you have collected including graphs, diagrams and tables)
- Discussion (comments on patterns, relating your data to theory and what your results suggest)
- Evaluation (of your procedure and results)
- Conclusion (relate your key findings to the purpose of your investigation)

4.6.5 Example of investigation planning

Research question: what is the effect of different concentrations of salt on bean germination?

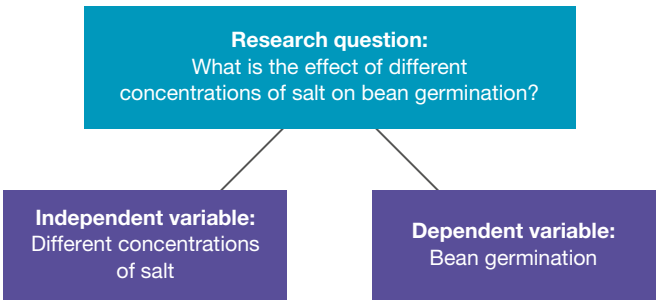
- **Independent variable:** different concentrations of salt
- **Dependent variable:** bean germination
- **Controlled variables:** for example, types, ages and sizes of beans, type of salt, temperature, intensity and colour of light, volume of solution added

- **Control:** set-up that had everything the same, but used water with no salt. This could be used as a baseline for control to see whether the addition of salt had an effect on bean germination.
- **Sample size:** using 10 bean seeds instead of one seed in each set-up and using class results to increase the number of times that the investigation was performed.

Examples of variables that you may choose to investigate in an experiment on bean growth

Dependent variable	Independent variables (vary only one at a time)
Number of seeds germinated in a week	• Salt concentration • Volume of water added each day • Amount of light (e.g. using different types of cloth to cover)
Time taken for seeds to germinate	• Colour of light (e.g. red, green, blue or yellow cellophane covers) • Different substances added to water (e.g. caffeine, sugar, salt or garlic)
Height of shoots each day	• Type of growth medium (e.g. water, sand, soil, gravel or cottonwool)

Scientific design for investigations



4.6 Exercises: Understanding and inquiring

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Remember

1. Match the heads and tails in the table below.

Head	Tail
Independent variable …	is used to see whether the independent variable had an effect on the dependent variable. It provides a baseline for comparison.
Dependent variable …	is an educated guess or prediction of what the results of the investigation may be.
Controlled variables …	is the variable that you measure.
Control …	are variables that you keep the same or constant.
Hypothesis …	is a variable that you keep the same or constant.

2. In a graph, on which axis would you show the:
   (a) independent variable (b) dependent variable?
3. Order the following parts of an investigation report into their correct sequence.
   conclusion, materials, discussion, aim, results, evaluation, method
4. In the research question 'What is the effect of different coloured light on pea germination?', identify the:
   (a) independent variable
   (b) dependent variable.
   Suggest what the following might be.
   (c) Controlled variables
   (d) Control
   (e) Sample size

Think

5. In the table on page 147, five bean plants are watered with each type of water. Explain why this is better than testing just one plant with each type of water.
6. Genevieve is investigating the effect of shadecloth on the growth of bean plants at home. She places three plants under the pergola at the back of her house, which is covered with shadecloth. She places the other three against the wall at the front of the house. All plants are in the same size pots and are given the same amount of water. Describe how Genevieve could improve her experimental design.
7. Cameron is trying to find out whether sand or garden soil is better for growing radishes. He also wants to find out if sugar added to the water that is given to plants makes a difference. Cameron plants three seeds in sand and three seeds in garden soil. The plants growing in sand are watered with tap water. The plants growing in garden soil are given the same amount of a mixture of sugar and water.
   (a) What two questions is Cameron trying to answer with his experiment?
   (b) Identify the major problem with Cameron's experimental design.
   (c) Is it possible for Cameron to design a better experiment to answer both of his questions with only six seeds? Explain how.
8. Summarise what you know about scientific method and reports into a mind map or another visual map.

Investigate

9. Propose how a plant would grow in a container that is upside down. Design and perform an experiment to find out.
10. Propose how a plant would grow in a fully enclosed container with a hole in one side. Design and perform an experiment to find out.
11. Can a plant grow without soil? Design and perform an experiment to find out.
12. Find out what hydroponics is and how it might be useful for the future.

4.7 Bush tucker

4.7.1 Old know-how

Before European settlement over 200 years ago, Aboriginal Australians were able to obtain a balanced diet from the bush.

Whether they lived by the sea, on the banks of a river, high in the mountains or in the desert, they successfully gathered and hunted food. Traditional Aboriginal communities still obtain a balanced diet from 'bush tucker'. The photograph on the next page shows a selection of colourful and nutritious bush tucker.

Aboriginal bush tucker includes a range of plant energy storage organs such as nuts, fruits and roots.



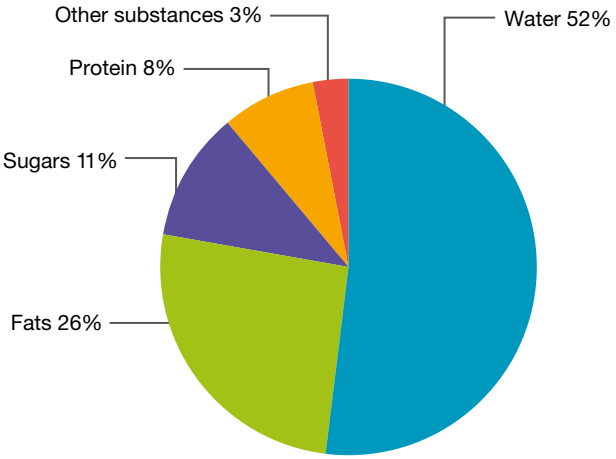
Aboriginal people hunted for almost any available animal. They knew the habits of the animals and kept a close watch on changes in the weather and plant growth. Their knowledge and skill allowed them to hunt very successfully. Aboriginal Australians were also skilled gatherers of food. They obtained shellfish, nuts, berries, fruits, waterlily stems and roots, ants and much more. They knew which foods were poisonous and were able to prepare some of these so that they could be eaten safely.

Some of the early European settlers and explorers learned some of the traditional Aboriginal bush tucker skills, but most didn't bother. The explorers Burke and Wills died of starvation in central Australia on their return journey to Melbourne in 1861, even though seeds, roots and grubs eaten by the local Aborigines were available.

4.7.2 Essential water

Water, of course, is scarce in most areas of Australia. Aboriginal people knew how to obtain water in even the most arid areas. They knew where to dig in dry creek beds and were able to obtain water from tree roots, tree stems, frogs and other animals. Aboriginals cut tree roots into small sections and sealed the ends with clay to store water.

Average body composition of a witjuti grub



Witjuti tucker

Witjuti grubs were regarded as a delicacy in drier areas. They could be obtained from the roots and stems of trees, especially the witjuti bush, after which they are named. Witjuti grubs are the white larvae of beetles and can be up to 13 cm long. They live off the sap of the trees that they live in. Witjuti grubs are very nutritious and are rich in protein, fat and sugars. They are also good sources of iron, calcium and water.

A witjuti grub — regarded as a delicacy in drier areas



4.7.3 Plants — living warehouses

Plants also store material for future use, often in special storage areas that are formed when that part of the plant swells up. The stems, roots or leaves may be involved in storage. The main form of storage in plants is carbohydrate stored as **starch**. Other forms of carbohydrate, protein and fat can also be stored. **Sucrose** is stored in the stems of sugarcane and **glucose** in grapes.

A potato is actually an underground stem swollen with starch; a carrot is a specialised storage root; rhubarb and celery are storage-filled leaf stalks; and an onion is a swollen mass of leaves. Vegetarians make use of the **protein** stores in various seeds, grains and nuts to make up for the protein that would otherwise be provided by meat. Nuts are also known for their storage of fats and oils and are hence a source of concentrated energy.

A considerable number of plant storage organs are found in an Australian bush tucker menu. For example, cycad nuts, bush potatoes and several types of yams and seeds provide a variety of nutritional energy sources when properly prepared.

4.7.4 Dugong gone?

Dugongs are fully marine animals, with a flattened tail and cow-like appearance. They are thought to be the source of myths about mermaids, and they feature in the creation stories of many Indigenous peoples across northern Australia.

Dugongs are now considered endangered. Although they can live for up to 70 years, they have a slow reproductive rate, long gestation period and slow growth rate. Their coastal habitats are being destroyed, and they have been hunted for food and accidentally captured in fishing nets.

For some coastal Australian Aborigines and Torres Strait Islanders, dugongs have been a highly prized source of meat. In the past, white settlers were allowed to hunt them for food, hide and oil. However, it is now legal only for Indigenous peoples to hunt them, and only if they use traditional methods of hunting. Even with these restrictions, dugong populations in some regions are dwindling to dangerous levels.

Helene Marsh

Professor Helene Marsh studies dugongs. A dugong is a type of mammal that lives in the ocean and feeds on seagrass. Her research initially involved studying the carcasses of dugongs that had died in shark nets. She worked out a way of estimating the age of dugongs by studying their tusks. Later, she focused on the reproductive cycle of dugongs. Helene has also been involved with estimating the abundance of dugongs in various areas using aerial photographs. By measuring the abundance of dugongs regularly, it has been possible to identify areas where dugong numbers are falling and suggest strategies to maintain dugong numbers.

Helene Marsh bottle feeding a dugong



4.7.5 Healthy tucker

In 2009, the CSIRO produced a research report on the presence of 'health-enhancing compounds' in a variety of native herbs, spices and fruit samples. They reported that the 'bush foods' sampled were exceptionally rich sources of antioxidants, folate, iron and vitamins C and E.

Some of the findings of a 2009 CSIRO report on Australian native foods

'Bush food'	High in antioxidants	High in vitamin C	High in folate	High in iron
Kakadu plum	✓	✓	✓	
Quandong	✓		✓	✓
Tasmanian pepper leaf	✓		✓	✓
Lemon myrtle	✓		✓	
Australian desert lime		✓	✓✓	

4.7.6 Grow your own?

Interest in 'bush tucker' or Australian native foods is increasing. Some Australians are even taking on the challenge of trying to grow native foods themselves. Matthew Koop is one such pioneer. Matthew believes that he is the sole commercial quandong harvester in Victoria. These tangy-fleshed stone fruits are native to Australia's central deserts and southern arid regions.

Kakadu plum trees may be another native plant that we could see growing in orchards in the future. Dave Boehme, a Darwin farmer, believes that this plant can be grown successfully in remote communities and may be a very successful Indigenous horticultural project. Increased interest in bush foods may see many more of our Australian natives cultivated to become viable economic enterprises.

Darwin farmer David Boehme with one of the 100 native plum trees on his property



Quandongs



Matthew Koop — a quandong pioneer



4.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Outline examples of knowledge and skills that Aboriginal Australians traditionally used to help them achieve a balanced diet.
2. State where witjuti grubs may be found and what they look like, and suggest why they are described as being very nutritious.
3. Describe how Aboriginal Australians living in arid areas find enough water to survive.
4. (a) Describe the distinctive features of dugongs.
   (b) Suggest reasons why dugongs are endangered.
   (c) Which groups of people in Australia are allowed to hunt dugongs and why?
   (d) Which part of the dugong was used to determine its age?
   (e) Explain the purpose of using aerial photographs in dugong research.

Think

5. Construct a matrix table to show the similarities and differences between potatoes, carrots, rhubarb, celery and onion.
6. Bush tucker can provide a balanced diet. Give examples of bush foods that contain:
   (a) protein
   (b) carbohydrate
   (c) fats and oils.
7. Construct a Venn diagram to compare the following.
   (a) Kakadu plums and quandongs
   (b) Lemon myrtle and Tasmanian pepper leaf

Investigate, design and create

8. Find out and report on research into Australian native plants as a source of food or medicine. Display your findings in a brochure, story book or journal article.

CAUTION

Take food allergies into careful consideration when planning your recipes.

Investigate and share

9. Investigate how Indigenous land management practices can help inform sustainable management of the environment.
10. What do you think aboubt hunting dugongs? Who should be allowed to hunt them? How many should be taken, when and why? Research dugong hunting, then share your findings and opinions with your team. Organise a class debate on an aspect of dugong hunting.
11. Dugongs feature in the creation stories of many indigenous peoples across northern Australia. Find out more about one of these stories and present it in a creative way to your team or class.
12. The tears of baby dugongs have been sought as an aphrodisiac. Share your research on dugong tears with your team and collate your team research into a report that uses the six thinking hats.

4.8 Recycle me!

4.8.1 Atoms need to be recycled in ecosystems

Tyrannosaurus rex stalked the Earth over 65 million years ago. We have found the bones, but what happened to the atoms that made up its flesh? What will happen to the atoms in your body when you die?

Borrowing atoms

All living things contain atoms. They make up our body cells, are in the food that we eat, and are involved in essential chemical reactions that keep us alive. The set of all of these chemical reactions is called **metabolism**. Throughout these reactions, atoms are rearranged; some used or retained for a time, and some returned to the environment as wastes.

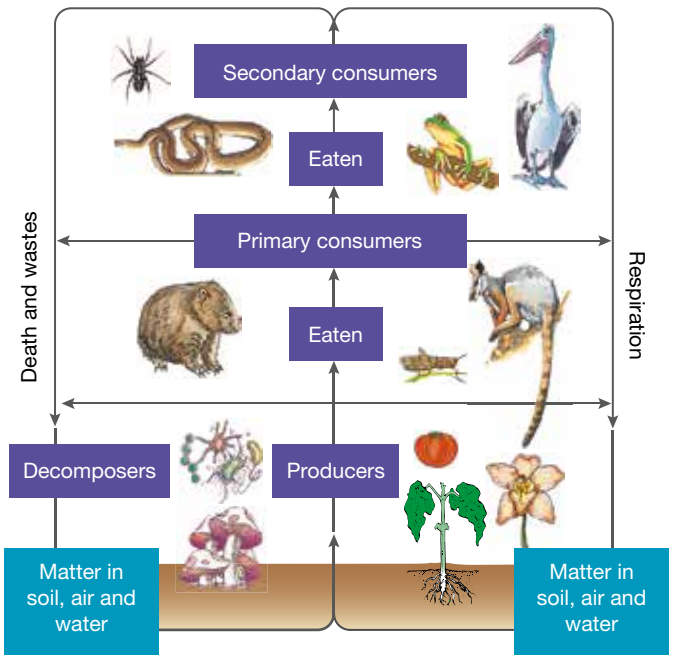
Processes, such as cellular respiration, result in wastes such as carbon dioxide being released into the environment. Other wastes are excreted in perspiration from our skin and others via our excretory systems, such as urine.

The organic molecules that make up our bodies were once parts of the inorganic compounds of soil, air and water. One day, they will become those inorganic compounds again. Life on our planet relies on the recycling of atoms between the biotic and abiotic parts of ecosystems.

Decomposers recycle atoms

Decomposers are heterotrophs that consume the remains of dead organisms and their wastes. The two main groups of decomposer organisms

Atoms in matter recycle through ecosystems.





are bacteria and fungi. These decomposers are also called **saprophytes** because they release enzymes to break down complex organic material into simple inorganic material that they may then absorb.

Other larger organisms, such as earthworms and maggots, are called **detritivores** because they feed on **detritus** (dead and decaying material). By breaking it down into smaller pieces, they increase its surface area, which increases the efficiency of further breakdown by bacteria and fungi.

Flies lay their eggs on dead and decaying animals. The eggs hatch into larvae that are called maggots. The maggots can quickly eat away large parts of a dead animal. The maggots grow up to become flies, which lay eggs somewhere else, or become food for other animals. This recycles the nutrients from the dead animal back into the ecosystem.



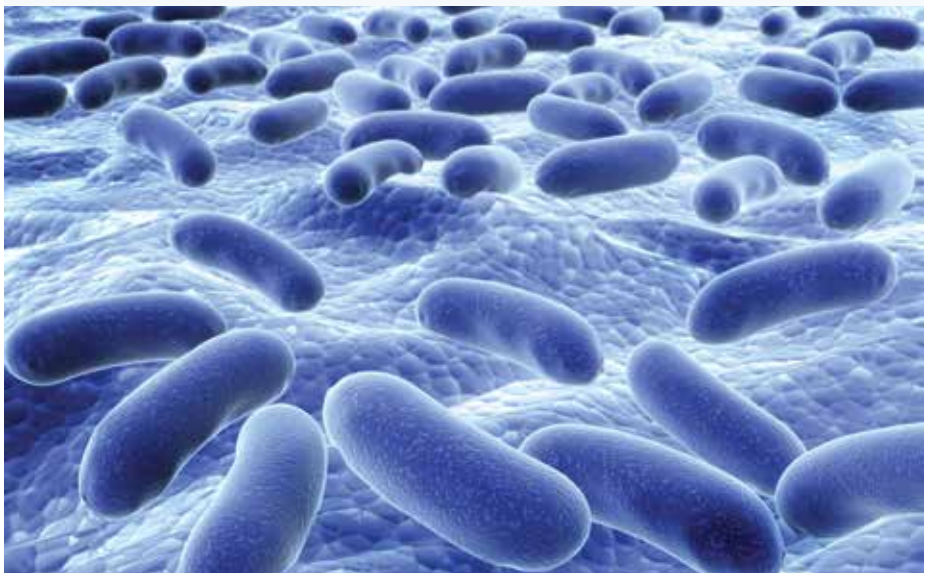
The products of decomposition can then be used by other organisms. For example, plants can use these inorganic molecules in reactions such as photosynthesis to produce organic molecules. These organic molecules are then eaten by other organisms (such as consumers) and passed along food chains. If it were not for decomposers, carbon, nitrogen, phosphorus and other elements essential to life would be locked in the organic molecules of dead organisms and their wastes. Decomposers play a key role in recycling of atoms within ecosystems.

4.8.2 Stinky forensics

Dr Rachel Parkinson is investigating the bacterial species that decompose bodies and researching whether the types of different bacteria can provide information about when a person died. Instead of using human bodies in her research, she uses the decomposing bodies of pigs. She is getting used to the smell and the maggots, but still holds her breath a lot. Her research has shown that the same combination of bacteria breaks down the bodies of both humans and pigs. She has also found that the types of bacteria involved in the decomposition change over time, providing some information about possible times of death. Dr Parkinson suggested that this was because, once one type of bacteria has used its specific food source, it dies off and is replaced by another.



Bacteria grow and reproduce very quickly. Some bacteria feed on decaying material, breaking it down into nutrients that can be recycled within ecosystems.



INVESTIGATION 4.7

Looking at decomposers

AIM: To observe decomposers

Materials:

safety glasses
6 nutrient agar plates
fresh grass
grass that has recently died
decomposing grass
3 paper bags
forceps
oven
Bunsen burner, heatproof mat and matches
stapler and marking pen
tape incubator
stereo microscope
or hand lens

Method and results

- Sterilise the forceps by holding them in a Bunsen burner flame for one minute.
- Using the forceps, place a sample of the fresh grass in a paper bag. Fold the edge over several times and staple the fold securely closed. Label the bag 'fresh'.
- Resterilise the forceps and repeat the procedure above for the other two samples of grass. Label them 'dead' and 'decomposing' respectively.
- Place all three bags in a hot oven for 15 minutes.
- While the bagged samples are sterilising in the oven, use sterile forceps to gently wipe a sample of fresh grass over the surface of an agar plate, taking care to use the correct technique. (See the figure below.) Label this plate 'fresh U'. (U means unsterilised.)
- Resterilise the forceps and repeat the procedure for the other two samples of grass, labelling them 'dead U' and 'decomposing U' respectively.
- Using the correct technique (see previous instructions and figure opposite), gently wipe a sample of each of the three types of sterilised grass over an agar plate. Use a new plate for each sample. Label the three samples 'fresh S', 'dead S' and 'decomposing S'. (S means sterilised.)
- Incubate all six plates for 24 hours at about 37 °C.
- Use a stereo microscope or hand lens to observe any growth of micro-organisms.

1. Record your observations.

Make sure that the lid of the agar plate is only slightly lifted as you rub the grass over the agar.



Discuss and explain

2. Which plate had the greatest amount of microbe growth?
3. Why were samples of each of the grasses sterilised?
4. Which type of microbe was more prevalent on the plates, bacteria or fungi? (Bacteria make smooth, shiny and usually round colonies, whereas fungi make fuzzy, irregularly shaped growths.)
5. What do your findings suggest?

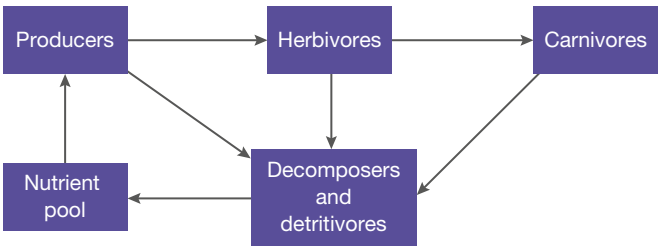
4.8.3 Are you biodegradable?

If something can be broken down by decomposers then it is said to be **biodegradable**. This is very useful as it means that some decomposers can also break down not just dead and decaying organisms, but also some of the rubbish that humans produce. If the material cannot be broken down, it is described as **nonbiodegradable**. Paper and food scraps are examples of biodegradable materials, whereas plastic and foam are examples of nonbiodegradable materials.

4.8.4 Cycles in nature

If an organism is burned after it dies, gases are released into the atmosphere, leaving only ash. If a dead organism is simply left on the surface of its normal habitat, then its remains are consumed by other organisms. Scavengers, such as birds, fish, crustaceans and large insects, may break off parts of the organism for food. The dead organism may also be used as a food source by decomposers. While some of the products of digestion may be used for their life processes and growth, most is returned to the soil as nutrients that can be used by other organisms. This cycling of nutrients (such as carbon, nitrogen and phosphorus) is essential for the ecosystem to be sustainable.

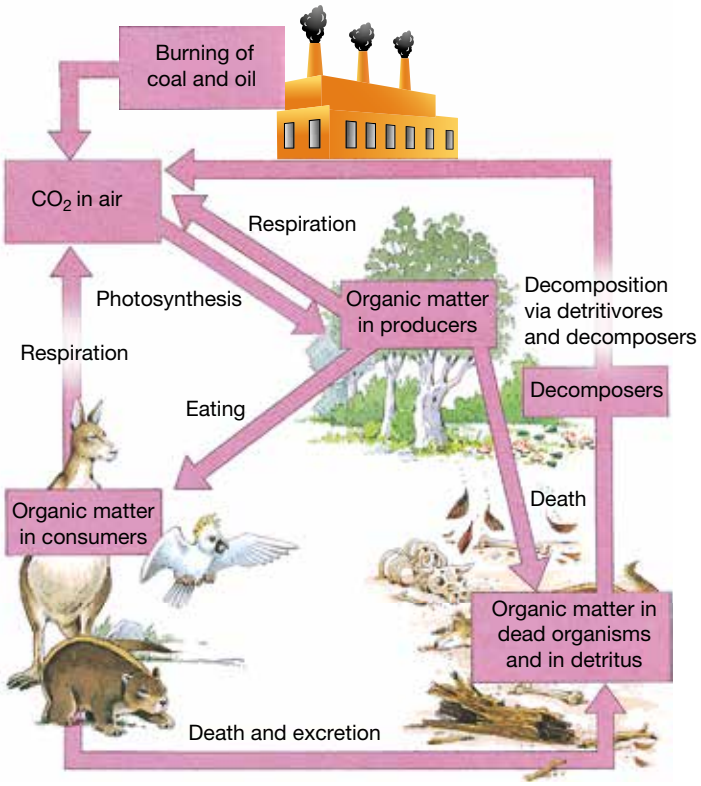
A simplified view of how matter is cycled within an ecosystem



4.8.5 The carbon cycle

Carbon atoms exist in the atmosphere as carbon dioxide gas. Carbon dioxide is captured by plants and used in the process of photosynthesis to make glucose molecules. After more chemical reactions, the carbon is stored in complex molecules in the plant body. When an organism consumes a plant it uses the plant's carbon atoms, which then become part of the organism's body. The carbon is found in the compounds that make up carbohydrates, fats and proteins. When organisms respire, the carbon atoms combine with oxygen atoms to form carbon dioxide, which is then released to the atmosphere. If plants or the **fossil fuels** that form from plants are burned, carbon atoms again combine with oxygen atoms to form carbon dioxide, which is released into the atmosphere. Carbon dioxide also dissolves in the sea. Here it is absorbed by sea plants and other sea organisms that photosynthesise. These producers are consumed by fish and other sea creatures, which are, in their turn, consumed by other organisms. Some of the carbon becomes part of coral reefs and shells, which, over millions of years, form limestone. Limestone is mined and, when heated in factories, releases carbon dioxide to the air, where it can again be absorbed by plants.

Carbon atoms cycle within an ecosystem. Identify one movement of carbon atoms from the inorganic to the organic pool.



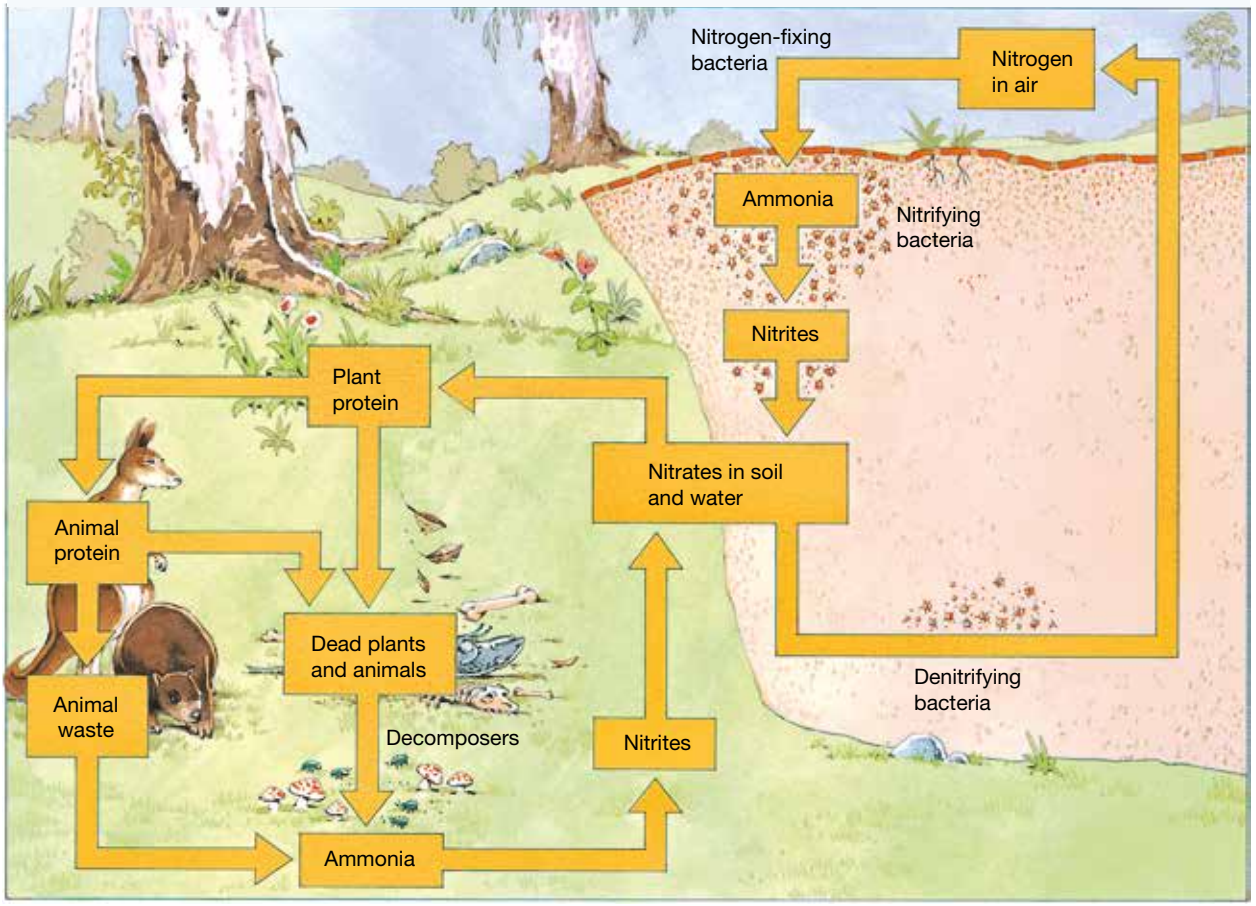
4.8.6 The nitrogen cycle

Nitrogen is an element that is essential for the production of organic molecules called proteins. Although almost 80 per cent of the air is nitogen gas, most organisms cannot access it in this form. There are only a very few organisms that can make use of nitrogen gas in the air.

Nitrogen-fixing bacteria can convert nitrogen in the air into ammonia. Some plants (such as peas, beans and clover) have nodules on their roots that contain nitrogen-fixing bacteria. **Nitrifying bacteria** can convert

ammonia into nitrites and nitrates, which may be released into the soil and water. These nitrates can be absorbed from the soil water by plant roots and be used again to make proteins. Other consumers (such as animals) can then eat the plants, passing the nitrogen along food chains and supplying it to other organisms to make proteins. When an organism dies, its proteins can be broken down by **decomposer bacteria** into ammonia. The ammonia can be converted by **nitrifying bacteria** into nitrites and nitrates, which **denitrifying bacteria** can convert into nitrogen to be released back into the air. And so the cycle continues …

Bacteria involved in nitrogen cycling



HOW ABOUT THAT!

An entomologist is a scientist who studies insects. Sometimes entomologists are asked to provide information to help solve crimes. After a person or animal dies, insects are attracted to the corpse and feed on it. They lay their eggs in the corpse, and larvae eventually emerge from the eggs and develop into adult insects.

Over time, different types of insects colonise the body. By looking at the types of insects and what stage of their life cycle they are at, it is often possible to work out the time of death. It is sometimes also possible to find out other information about the crime from the types of insects that have colonised the body. If a body spent some time in a dry cool area before being buried in dry sandy soil, the insects living on it would be different from those that would be present if it had been buried in dry sandy soil straight after death.

Professor Jerry Butler is an entomologist. He is shown here examining hairy maggot blowfly larvae retrieved from a murder victim.



INVESTIGATION 4.8

Investigating decomposition

AIM: To investigate how different materials decompose

Materials:

samples of different types of plant matter, such as grass clippings, leaves, vegetable peels, cuttings from a shrub or hedge, straw
250 mL beakers
cling wrap
temperature probes and a data logger

Method and results

- Half-fill each beaker with a different type of plant matter.
- Cover each beaker with cling wrap.
- Connect the temperature probes to the data logger (one probe for each beaker) and set up the data logger to collect a temperature reading every 10 minutes for 24 hours.
- Push each temperature probe into a different type of plant matter (you will need to pierce a hole in the cling wrap) and start the data logger.

1. After 24 hours (or during your next Science lesson), collect the results from the data logger and observe the plant matter in each beaker.

Discussion

2. Study the graph produced by the data logger. Which type of plant matter released the most heat as it decomposed?
3. Describe some improvements that could be made to this experiment to make it a fairer test.
4. What are the advantages of using temperature probes connected to a data logger rather than thermometers for this experiment?
5. Apart from the rise in temperature, what other evidence is there that the plant matter has started to decompose?
6. Microbes decompose the plant matter. Explain why keeping the plant matter moist accelerates its decomposition.

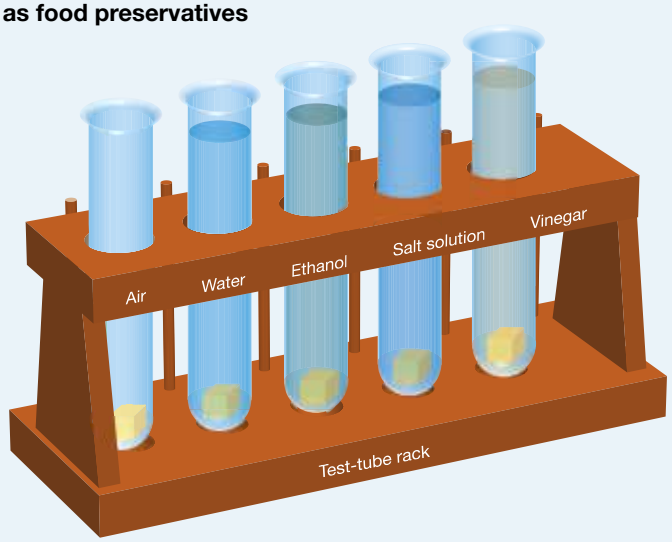
INVESTIGATION 4.9

Preserving apples

AIM: To test substances for their effectiveness as food preservatives

Materials:

small apple cubes (peeled)
test tubes
range of solutions to test for their effectiveness as food preservatives (e.g. water, ethanol, sugar solutions of different concentrations, vinegar, salt solutions of different concentrations)



Method and results

- Place one apple cube in each test tube.
- Do not add anything to test tube 1.
- In each of the other test test tubes, pour one of the solutions you are testing. For example, you could put water in test tube 2 and ethanol in test tube 3.

1. Write an aim for this experiment.
2. Design a table to record your results. You will be recording your observations for each apple cube each lesson for the next two weeks.
3. In each lesson, record whether each piece of apple has changed. Take note of the colour, the presence of mould and any other signs of decay.

Discussion

4. At the end of two weeks, write a conclusion for this experiment.
5. Why do you think certain substances were able to preserve the food (stop the food from decaying)?
6. List some examples of foods that are preserved using:
   (a) salt (b) sugar (c) alcohol (d) vinegar.

4.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Match the heads and tails in the table below.

Head	Tail
Metabolism …	release enzymes to break down complex organic matter into simple inorganic material to be absorbed.
Nitrifying bacteria …	are animals that feed off dead and decaying matter (detritus).
Denitrifying bacteria …	are heterotrophs that consume the remains of dead organisms and their wastes.
Nitrogen-fixing bacteria …	is the set of all of the chemical reactions that keep organisms alive.
Detritivores …	can convert nitrates in soil and water into nitrogen to be released into the air.
Saprophytes …	can convert ammonium salts into nitrites and nitrates.
Decomposers …	can convert nitrogen in the air into ammonia.

2. Identify the term used for:
   (a) organisms that eat only plants
   (b) the process that plants use to convert light energy into chemical energy
   (c) a material that can be broken down by decomposers.
3. Provide two examples of:
   (a) decomposer
   (b) detritivore
   (c) scavenger
   (d) bacteria involved in the nitrogen cycle.
4. Identify three processes that release carbon dioxide into the atmosphere and one process that removes it from the atmosphere.
5. Distinguish between:
   (a) biodegradable and nonbiodegradable
   (b) decomposer and producer
   (c) respiration and photosynthesis
   (d) nitrifying and denitrifying bacteria
   (e) carbon cycle and nitrogen cycle.
6. Construct a sentence that uses each of the following lists of terms.
   (a) Decomposer, heterotroph, consumer, dead organisms, ecosystems, recycle
   (b) Producers, herbivores, carnivores, decomposers, nutrient pool, matter, ecosystem
7. Outline or describe the relationship between:
   (a) photosynthesis and respiration
   (b) death and decomposition
   (c) nitrogen and proteins.
8. An entomologist may be called upon when a body is found. Explain how an entomologist may be able to help the investigation.

Think

9. Explain the difference between nitrogen-fixing bacteria, nitrifying bacteria and denitrifying bacteria.
10. Explain the role played by photosynthesis in the carbon cycle.

Imagine

11. Write a short story that describes what may have happened to the carbon atoms in Leonardo da Vinci's body when he died.
12. Imagine that suddenly all the nitrifying bacteria on the planet were killed by a mystery virus. Write a paragraph describing the effects of this global disaster.

Create

13. Create a poster of the carbon or nitrogen cycle. On your poster, follow the passage of one particular atom, explaining the changes that it experiences.

Investigate and design

14. Find out why some of the bones of the dinosaurs were not decomposed by micro-organisms.
15. Things that can be broken down by decomposers, such as paper and food scraps, are described as biodegradable. Plastic bags and foam packaging are described as nonbiodegradable.
    (a) Find out why nonbiodegradable items are not broken down by decomposers.
    (b) Create an advertisement that may influence people to use fewer nonbiodegradable items.
    (c) Suggest advantages and disadvantages of using paper bags instead of plastic bags.
    (d) Design your own biodegradable carry bag.
16. Research an issue related to Earth cycles, recycling or sustainability, and create a written report, multimedia presentation, web page, poster or drama script to present your findings.
17. Research examples of forensic succession and prepare your findings as a police report.
18. Find out more about the field of forensic entomology. Report your findings as a job advertisement.

4.9 Unbalanced ecosystems

4.9.1 In times gone by

We have come a long way since we lived as hunter–gatherers — but have we gone in the right direction?

Apple orchards like this must be fertilised to promote growth and also sprayed to protect the fruit from pests.



What have we done?



When people lived as hunter–gatherers, they collected food without severely disturbing the environment. They consumed the fruits and roots of plants, leaving the rest of the plant to die and be broken down by decomposers.

In this way, the nutrients in the dead plants were returned to the soil. The soil was not dug over or exposed to the air. In these natural ecosystems, other animals, birds and insects would also feed off the plants and each other in a complex set of feeding relationships.

4.9.2 Increased demand!

While we have prospered as a species, our environment and numerous ecosystems have not! Our populations have dramatically increased in size, with many populations exceeding the available resources within their ecosystems. Yet we continue to strip ecosystems and give very little back in return. What will the consequences be?

4.9.3 Artificial ecosystems

About 5000 years ago when **agriculture** (farming) began, humans learned how to control the growth of other organisms in order to maximise their own food supply. These humans began to create artificial ecosystems.

The purpose of agriculture is to turn as much of the sun's light energy as possible into chemical energy in particular crops or pasture plants for animals. To do this, it is necessary to interfere with the food web of which the selected organism is part. This often also requires the clearing of forests or removal of other organisms that may compete for resources and hence lower the yields. Such activities have led to the destruction of many natural ecosystems. The development of agriculture has led to drastic environmental changes in many ecosystems on our planet.

4.9.4 Monocultures

Farms usually grow very large areas of only one type of plant. For example, in some regions there are thousands of hectares planted only with wheat, while in other regions thousands of hectares are covered with grapes, sugarcane or some other single crop. Such crops are called **monocultures** and can lead to reduced biodiversity.

At the end of each growing season, the crops are harvested, processed and delivered to shops and supermarket shelves for the consumer. There is little natural decomposition of dead material, and the soil may be exposed to the effects of wind and rain for a certain period of the year. These factors combine to remove valuable nutrients from the soil.



4.9.5 Too much of a 'good thing' can cause trouble!

High levels of phosphorus from fertiliser in water can lead to eutrophication.



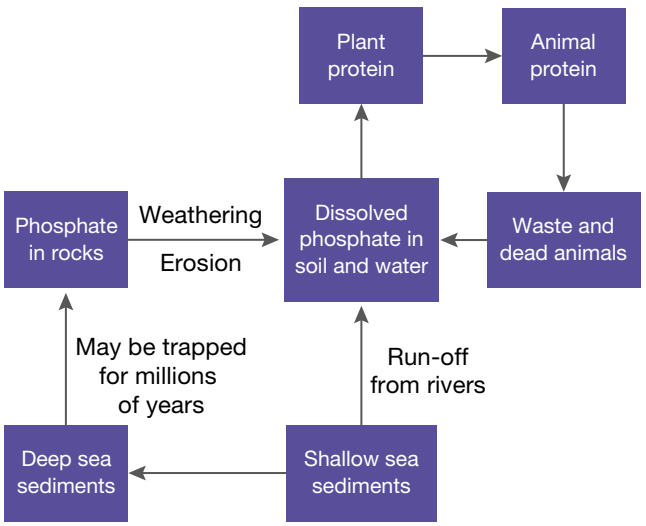
Nitrogen and phosphorus atoms are required by organisms so that they can make proteins. These organic molecules can play many key roles in both the structure and functioning of organisms. A supply of these atoms is essential for an organism's survival.

Harvesting and removal of crops can reduce the amount of organic material available for decomposers to feed on. This results in reduced levels of nutrients (such as nitrogen and phosphorus) on agricultural land. As this would reduce the future production of crops, **fertilisers** are often added to replace these 'lost' nutrients.

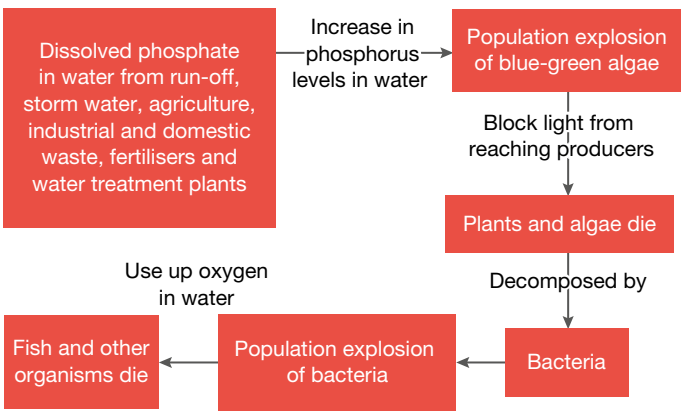
Some of these fertilisers may, however, end up in waterways and result in unnaturally high levels of nitrogen and phosphorus in the water. This can lead to a rapid increase in populations of blue-green algae that block light from reaching producers in the water. Increased death of plants and algae provide increased organic matter for bacteria to decompose. This leads to an increase in the bacterial populations, which then use up more oxygen in the water. This process is called **eutrophication**. Reduced availability of oxygen can kill fish and other organisms.

Carefully observe the two diagrams below. The first diagram on the left shows how phosphorus is normally cycled within ecosystems. The second diagram on the right shows the effect of excess phosphorus on populations of organisms. Eutrophication is like suffocation of a waterway. It can result in the death of organisms and so it unbalances food chains and webs.

A simplified view of how phosphorus is cycled within an ecosystem



Eutrophication is like suffocation of a waterway and can result in the death of organisms within the ecosystem.



Modern agriculture provides large amounts of food, but at a cost to the environment.



4.9.6 Pest control

Organisms that compete for resources or potentially lower the yield of the plant crop being grown are considered to be pests that need to be controlled. Pest control may be carried out through the use of **chemical control** or **biological control**.

4.9.7 Chemical control

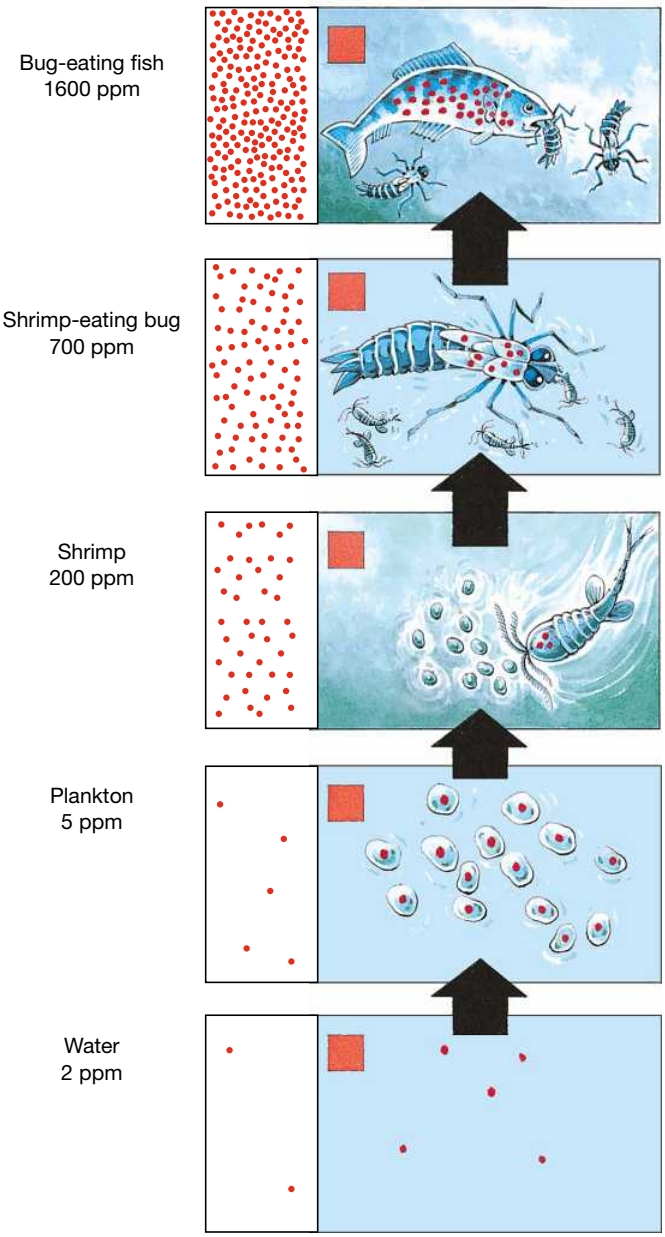
Chemical methods of control include the use of **pesticides** such as insecticides, fungicides, herbicides and fumigants. Herbicides kill plants other than the planted crop so that they do not compete for nutrients and water in the soil, and light from the sun. Insecticides are used to kill organisms that compete with humans for food crops.

Although pesticides are still being used in agriculture, their effectiveness on target pest species often decreases. Other species within the ecosystem and food webs of which they are members may also be affected. In some cases, concentrations of nonbiodegradable pesticides (such as DDT) can be magnified along the food chain by a process described as **bioaccumulation** or **biomagnification**.

4.9.8 Biological control

Biological control of unwanted plants and animals uses other organisms, rather than chemicals (such as insecticides and herbicides), as a method of control. Biological control may use a predator or competitor to kill or reduce numbers of the pest, or somehow disrupt the pest's reproductive cycle. A disease might also be used to

Some chemical pollutants such as pesticides can become more concentrated along the food chain.



kill the unwanted plant or animal without harming other species. Sometimes, however, the method does not work as planned and the supposed cure becomes a problem.

4.9.9 Unwanted guests

An **introduced species** is one that has been released into an ecosystem in which it does not occur naturally. The food webs in ecosystems are very delicate and can be easily unbalanced, especially when new organisms are introduced. These introduced organisms compete with other animals for food, provide predators with a new source of prey, or may act as predators themselves.

NORTHERN PACIFIC SEA STAR

History:



The northern Pacific sea star (*Asterias amurensis*) is a marine pest, accidentally brought to Ausralia on the hulls of boats and ships and in ballast water. This foreign sea star was first discovered in the Derwent estuary near Hobart in 1986. Since then it has spread to Port Phillip Bay, with its population now estimated at around 100 million. The population is likely to continue to increase because it has no natural predators or competitors in our ecosystem, and the female sea star can produce up to 10 million eggs a year.

Ecological impact:

- Potentially causing great harm to our marine ecosystem and to marine industries
- Threatening biodiversity and shellfish aquaculture in south-eastern Tasmania and Port Phillip Bay
- Acting as a voracious predator. Some of our native marine species, such as scallops and abalone, don't recognise it as a predator, so do not try to escape it.

CANE TOADS

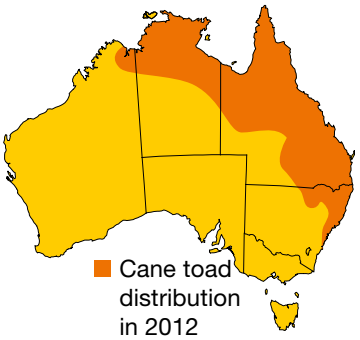
History:



The cane toad (*Bufo marinus*) was introduced into Australia in 1935 to control the sugarcane beetle, which was destroying sugarcane in Queensland. Unfortunately, the cane toad preferred other insects and the cane beetle was not greatly affected. Cane toads are poisonous and kill animals that eat them. They need little water for breeding. In one season, the female toad can lay up to 40 000 eggs, which take only three days to hatch.

Ecological impact:

- Occupying water habitats so that native tadpoles cannot live there
- Killing fish that eat the tadpoles and other animals that eat the adult toads
- Eating our natural wildlife including frogs, small lizards, birds, fish and insects.

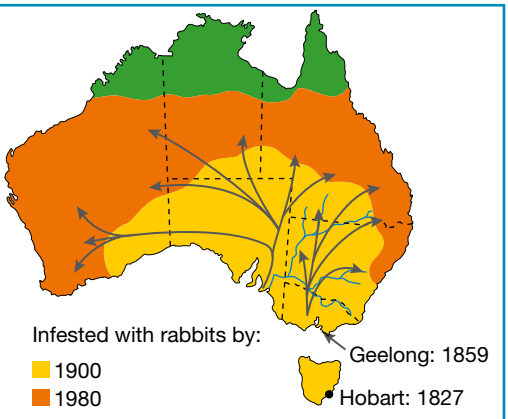


RABBITS

History:



In 1859, 24 rabbits were introduced from Europe and released in Geelong, Victoria. With few predators, they multiplied rapidly and thrived. By 1890, there were 600 million rabbits in NSW alone, all of which had descended from the first 24 rabbits introduced into Victoria.



Ecological impact:

- Competing for food with the native animals such as kangaroos, wallabies, wombats and bandicoots
- Disrupting food webs and unbalancing ecosystems
- Building extensive underground warrens
- Stripping most of the vegetation in their area, causing another problem — erosion. Without plant roots to hold the soil, wind and rain carry the soil into creeks, rivers and lakes, causing further problems for the organisms that live there.

LOCUSTS SET TO INVADE

by Adrian Tame



Swarms of locusts are set to swarm across the Murray River into Victoria.

The destructive swarms, some covering up to 200 sq km, have been massing in southern NSW over the past month.

Northerly winds early this week are expected to drive them into Victoria.

The Goulburn Valley, known as Victoria's fruit bowl, is among areas vulnerable to the voracious pests, capable of causing millions of dollars of damage to crops within hours.

Malcolm Campbell, a principal scientist with the State Department of Primary Industry, said the situation was grave.

One swarm, measuring up to 100 ha across, has already crossed the border and is being monitored in the Picola area, north of Shepparton, centre of the state's prime fruit-growing area.

The locusts cannot be sprayed in this area.

Potentially more serious are swarms north of a stretch of the NSW border extending from Swan Hill to Albury.

Areas facing the most significant threat include regions around Gunbower, Mitiamo, Rochester and Elmore and thousands of hectares south of Echuca.

Mr Campbell said even if the predicted northerlies fail to arrive, and Victoria has the same lucky escape it experienced in December, a further high-risk period is anticipated in late March, early April.

'This could be particularly damaging for cereal crops planted in late Autumn, when they are at their most vulnerable.

'We are expecting another generation of adult locusts in NSW around that time,' he said.

Locusts will eat almost any form of green leaf.

Source: Herald Sun

4.9.10 Agricultural collaboration

Throughout all of this 'doom and gloom' there have been some exciting developments. There is increasing collaboration between governments, communities, scientists and farmers to work together to:

- meet the demand for food for the world's increasing populations
- reduce damage to and preserve natural ecosystems
- reduce the risks of disease to crop plants
- develop strategies to deal with the possible effects of climate change and natural disasters such as droughts, floods and fires.

4.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Match the heads and tails in the table below.

Head	Tail
Monoculture …	is a chemical used to kill plants other than the planted crop so that they don't compete with crop plants for nutrients, water and light.
Fertilisers …	is a chemical used to kill insects that compete with humans for food crops.
Eutrophication …	increases the concentration of pesticides along a food chain.
Insecticide …	results from the addition of very high levels of phosphorus into waterways, which can reduce levels of oxygen available in the water.
Herbicide …	is a crop that contains only one species.
Biomagnification …	is a species that has been released into an ecosystem in which it does not occur naturally.
Introduced species …	are chemicals that are added to the soil to replace nitrogen and phosphorus.

2. Distinguish between chemical pest control and biological pest control.
3. Outline the link between agriculture and artificial ecosystems
4. Describe what is meant by the terms 'introduced species' and 'biological control'.
5. Give examples of:
   (a) three species that have been introduced into Australia
   (b) three ways in which biological control may be used
   (c) three reasons why rabbits, northern Pacific sea stars and cane toads are not wanted in Australia.
6. Why is it important to spend a lot of time and effort testing biological controls before they are used?
7. Suggest projects that governments, communities, scientists and farmers can work collaboratively on.

Think and discuss

8. Is biological control of pests better than using chemicals? Give some reasons for your answer.
9. Select two different thinking keys and use them to unlock your thinking on introduced species.
10. Are all introduced species pests? Explain.
11. Use Venn diagrams to compare the following.
    (a) Herbicide and pesticide
    (b) Chemical control and biological control
    (c) Photosynthesis and cellular respiration
12. Do you think humans have been greedy in terms of their environment? Give reasons for your opinion.
13. Suggest how our lifestyles are different from those of our hunter–gatherer ancestors. Discuss possible consequences of the differences.
14. Construct a SWOT analysis of monocultures.
15. Use your coloured thinking hats to organise your thinking on woodchipping, logging or deforestation. Share your thinking with others in your team.
16. Look at the image of deforestation at the start of this section. Should forests be protected? If so, how many of them? If not, why not? Give reasons for your answers.

Using data

Use the following information to answer questions 17–23.
Population statistics of several animals were collected in two areas over 5 years. One area contained only native animals, while the other area contained native animals with an introduced species — the rabbit.

The feeding habits of the animals were also studied:

- Bandicoots eat roots, seeds, leaves and insects.
- Dingos eat bandicoots, wallabies and rabbits.
- Wallabies eat grasses and leaves.
- Rabbits eat grasses and leaves.
- Insects eat roots, seeds, leaves and grasses.

Area 1: populations of native animals over 5 years

Year	1	2	3	4	5
Bandicoot	310	488	505	505	505
Dingo	5	11	11	12	10
Wallaby	90	197	281	293	290

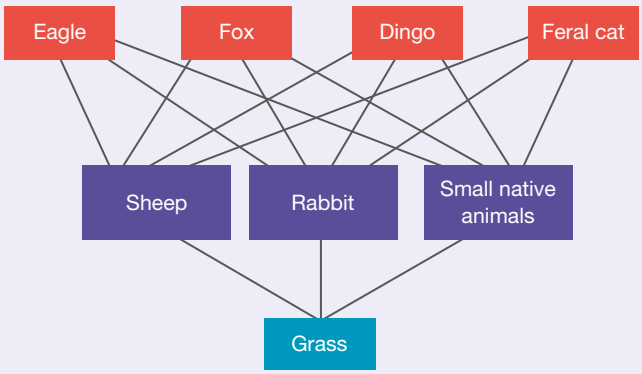
Area 2: populations of native animals over 5 years

Year	1	2	3	4	5
Bandicoot	310	475	495	500	505
Dingo	5	11	11	12	10
Wallaby	90	199	72	72	73
Rabbit	6	412	5122	5114	5120

17. Draw two separate food webs: one of the native animals only, and the other one including the introduced species.
18. Plot two population graphs from the two tables, using a different colour for each animal. Join the points with straight lines.
19. (a) Which native animal was most affected by the introduction of the rabbit into the second area?
    (b) Which animals were least affected?
20. (a) What happened to the number of rabbits in the first two years?
    (b) What happened to the number of rabbits after the first two years?
    (c) Can you explain why this happened?
21. (a) What effect did the introduction of the rabbits have on the wallaby population?
    (b) Why do you think the rabbits had this effect?
22. Did the rabbits have any effect on the dingo and bandicoot populations? Explain.
23. In your own words, describe any differences in the food webs of the two areas and how the populations of each of the native animals changed.

Imagine

The food web at right shows a northern Australian sheep station ecosystem. Imagine that a successful method of biological control was found to totally wipe out the rabbit population in Australia. Use this food web to help you answer the following questions about what might happen.



24. Which animals would benefit immediately from the disappearance of the rabbit? Explain why.
25. How would the diets of the eagles, foxes, dingos and feral cats change?
26. What do you think might happen to the populations of the small native animals over a longer period of time?

Create

27. Assign the roles of rabbit, kangaroo, sheep, farmer, rabbit hunter, eagle and fox to different members of your group. Interview each character about their thoughts on the introduction of rabbits to Australia, and what they hope will happen in the future.
28. Create a poster comparing the food web of a forest with the food web of a large apple orchard farmed using pesticides and fertilisers.
29. Create a poster, PowerPoint presentation or web page that warns of the consequences of changing the balance within one of nature's cycles. Choose an ecosystem close to your school.
30. Imagine that you are involved in each of the following situations. Prepare a brochure for both to promote your profession (or viewpoints), activities and any effects on the environment.
    (a) Woodchipping, deforestation or land clearing
    (b) An environmental protection group, such as Greenpeace

Investigate, discuss and report

31. It has been recorded that Aboriginal people used fire to promote new plant growth, attract animals and increase the ease with which they hunted and gathered food. Investigate how they recognised relationships in ecosystems.
32. Find out more about the impact of one of the following introduced plants and animals: horse, camel, cat, fox, goat, hare, sparrow, mallard duck, pig, rat, garden snail, starling, water buffalo, deer, ferret, housefly, European wasp, thistle, blackberry, serrated tussock, Paterson's curse, ragwort, pasture grasses.
33. Find out more about the successes and failures of using myxomatosis and calicivirus to kill rabbits. Report your findings in a priority grid.
34. Find out why cane toads were unsuccessful as a biological control for the sugarcane beetle. Report your findings as a newspaper article, storyboard, puppet play, web page or PowerPoint presentation.
35. Read the article 'Locusts set to invade'. Find out why locusts are unwelcome visitors. Display your findings in your own NOT WANTED poster.

36. One of the most successful examples of biological control in Australia is the control of prickly pear cactus. The moth *Cactoblastis cactorum* was imported from South America to eat the flesh and flowers of the cactus. Find out more about this and other successful examples of biological control.
37. Investigate and report on the effect of agriculture or deforestation on an Australian ecosystem.
38. Investigate how land management practices of Aboriginal and Torres Strait Islander peoples can contribute to future sustainable management of the environment.
39. Research information about woodchipping, deforestation and land clearing. Organise a debate in which some members argue for and others against one of these human activities.
40. Research and report on different scientific responses to rabbit plagues in Australian agricultural areas.
41. Research and report on the use of fire by traditional Aboriginal peoples.
42. Research and report on the effects of palm oil harvesting in Sumatra and Borneo.
43. Construct a PMI chart to show how human activity in the community has had both positive and negative effects on the sustainability of ecosystems.
44. Identify and report on food chains (or food webs) that are relevant to either natural or artificial Australian ecosystems.

learnON RESOURCES — ONLINE ONLY

Complete this digital doc: Worksheet 4.7: Population overload (doc-19819)

Complete this digital doc: Worksheet 4.8: Spot the pest (doc-19820)

4.10 Living in a greenhouse

Science as a human endeavour

4.10.1 Cycles in ecosystems

Have you heard the 'heated' discussions about global warming and the greenhouse effect? What's it all about? How does this relate to ecosystems and how matter cycles through systems?

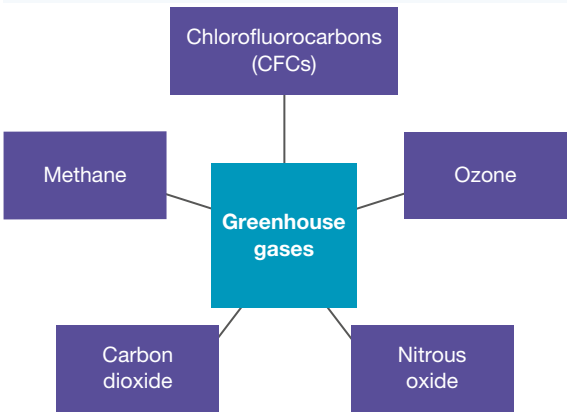
Some wonderful recycling systems have evolved on our planet. The recycling of carbon, water and nitrogen are examples of how effectively atoms can be cycled through our ecosystems. But what happens when human activities disrupt this cycling?

4.10.2 Global warming — a hot environmental issue

The Earth is surrounded by a layer of gases that trap the sun's heat, maintaining an appropriate temperature for life on our planet. The maintenance of Earth's temperature in this way is called the **greenhouse effect**.

Human activity can result in an increase in **greenhouse gases** (such as carbon dioxide), which trap heat in our atmosphere. This increase is called the **enhanced greenhouse effect**. It has been proposed that this may contribute to the rising temperature of the Earth, which is known as **global warming**.

Examples of greenhouse gases



learnON RESOURCES — ONLINE ONLY

Watch this eLesson: Global warming in Australia (eles-0057)

4.10.3 What's carbon got to do with global warming?

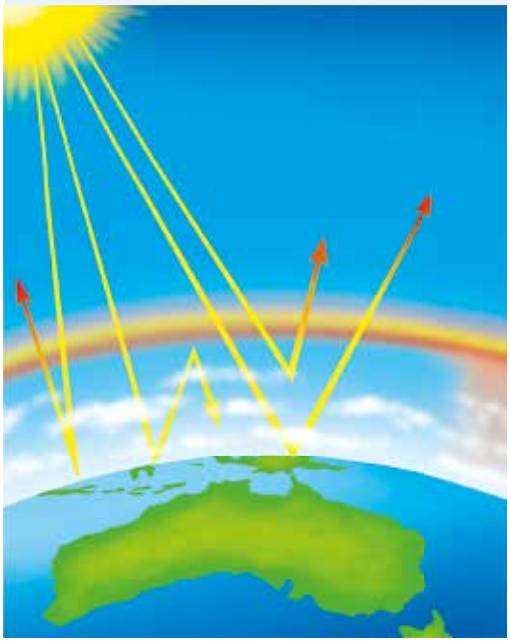
Producers capture light energy and use this energy plus carbon dioxide and water to make glucose (a type of sugar) and oxygen during the process of photosynthesis. The overall chemical word equation for photosynthesis is:

$$\text{carbon dioxide + water} \xrightarrow[\text{chlorophyll}]{\text{visible light energy}} \text{glucose + oxygen + water}$$

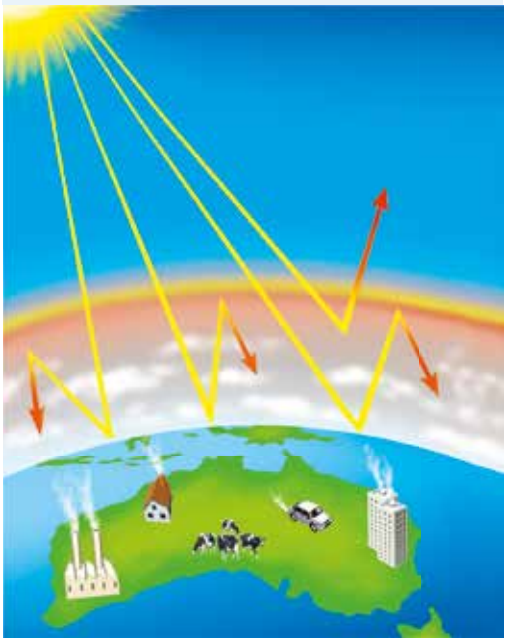
Producers and consumers use **cellular respiration** to break down glucose into a form that their cells can use for the many activities required to keep them alive. The overall chemical word equation for cellular respiration is:

$$\text{glucose + oxygen} \longrightarrow \text{carbon dioxide + water + energy.}$$

The Earth is covered by a blanket of gases that trap enough heat to keep the temperature stable. Most heat escapes back into space.

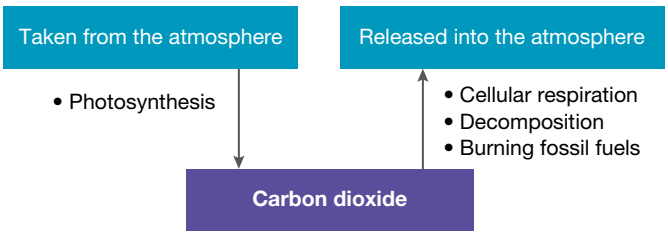


More carbon dioxide and other greenhouse gases in the air will trap more heat from the Sun. The Earth's temperature will rise.



So, in terms of the carbon cycle, carbon dioxide is taken from the atmosphere during photosynthesis and released back into the atmosphere during cellular respiration. This suggests that, if producers are reduced in number or removed from ecosystems, less carbon dioxide will be removed from the atmosphere, resulting in an overall increase in this gas. This explains why cutting down trees and replacing them with buildings or crops with lower photosynthetic rates can contribute to the enhanced greenhouse effect.

Deforestation and removing trees can result in more carbon dioxide in the atmosphere as less is absorbed for use in photosynthesis.



Not only living organisms release carbon dioxide into the atmosphere. Carbon dioxide is also released when dead organisms decompose and when fossil fuels (such as coal, petrol and gas) are burned. It has been argued that human activities have led to a rise in the release of carbon dioxide into our atmosphere and thus has contributed to global warming. Australian scientists are asking questions about the cause and possible consequences of global warming and what we can do to protect our ecosystems and species, and to reduce its negative effects in the future.

In 2010, our federal government reported that climate change (such as global warming) will affect Australia's economy, society and environment and that 'adapting to climate change will involve all levels of government, business and the community'. This is where the challenge for us really begins. How will you be involved? What will you contribute?

INVESTIGATION 4.10

The greenhouse effect on a small scale

AIM: To construct a small-scale greenhouse to demonstrate the greenhouse effect

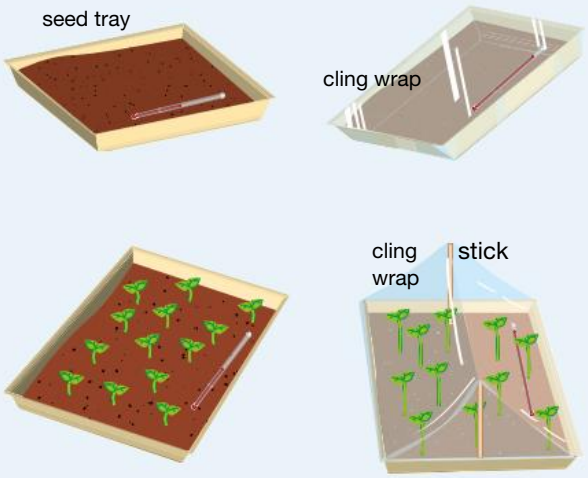
Materials:

several kinds of flower seed
2 seed trays
moist soil
plastic cling wrap
2 thermometers
2 sticks

Method and results

- Place the soil in two seed trays.
- Plant the flower seeds.
- Place a thermometer in each tray.
- Cover one of the trays with plastic cling wrap.
- Place the trays in an area exposed to the sun but protected from the rain.
- When the plants begin to grow, insert sticks in the covered tray to raise the cling wrap.

1. Record the temperature in each tray every second day.
2. Plot your temperature results on a graph using two different pencil colours, one for each tray.



Discuss and explain

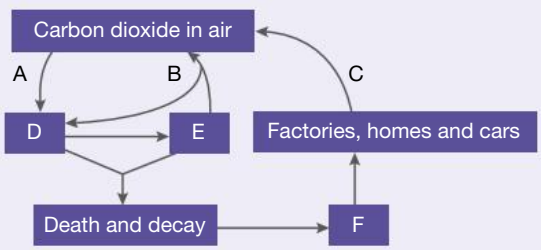
3. Compare the temperature changes between the two different trays.
4. Suggest why one tray had a plastic covering and the other didn't.
5. Which tray represents the greenhouse effect? Why?

4.10 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

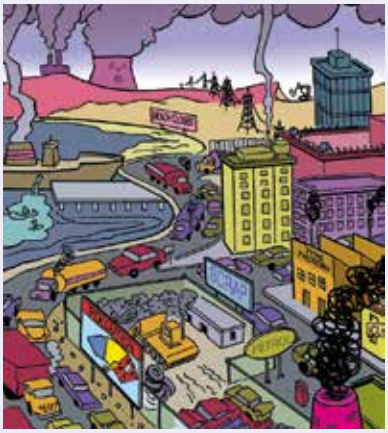
1. List key terms associated with the carbon cycle.
2. Complete the missing labels (A–F) in the carbon cycle at right.
3. List five examples of greenhouse gases.
4. Suggest a possible link between deforestation (removal of trees) and global warming.
5. Outline the link between carbon and global warming.



Think and create

6. (a) Observe the figures at right and identify activities that may increase levels of greenhouse gases in the atmosphere.
   (b) Create your own cartoon or diagram that includes examples of human activities that may contribute to the enhanced greenhouse effect.



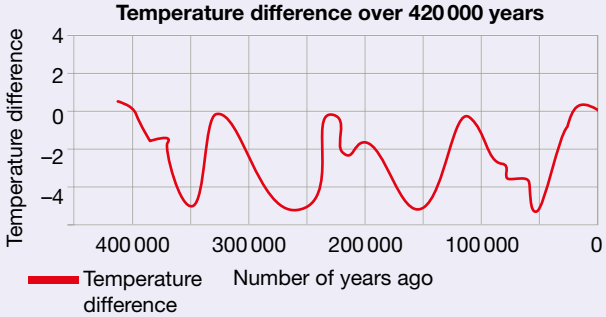


Investigate, discuss and report

7. Research the carbon cycle, nitrogen cycle or water cycle and find out how human activities have had an effect on it. Suggest possible consequences of this effect.
8. Scientists have drilled into ice on Antarctica and collected samples at very deep levels. Ice cores can provide information about the Earth and its atmosphere over hundreds of thousands of years.
   The Earth's temperature and the levels of carbon dioxide in the air can be tracked using these ice cores. Carefully study the graphs at below.
   (a) Describe the pattern shown for temperature differences over 420 000 years.
   (b) Describe the pattern shown for carbon dioxide levels over 420 000 years.
   (c) Do these graphs support the theory that global warming is due to increased levels of carbon dioxide in the air? Explain.

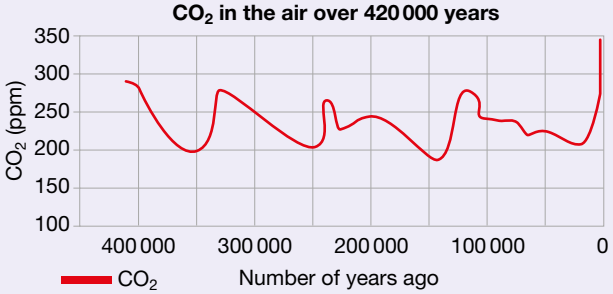
Zero on the temperature scale represents the Earth's average temperature now. Greater than zero is warmer than now, and below zero is cooler. On the temperature line, the peaks represent warmer periods of time. In between the peaks, the average air temperature was up to 6 °C lower than now. These colder times are called the **ice ages**.

Temperature difference over 420 000 years



The line on the graph for carbon dioxide resembles the temperature line. When the temperature was higher, there was more carbon dioxide in the air. When the temperature dropped, so did the amount of carbon dioxide. (The abbreviation **ppm** means parts per million.)

CO_2 in the air over 420 000 years



4.11 Ecological footprints

Science as a human endeavour

4.11.1 What is an ecological footprint?

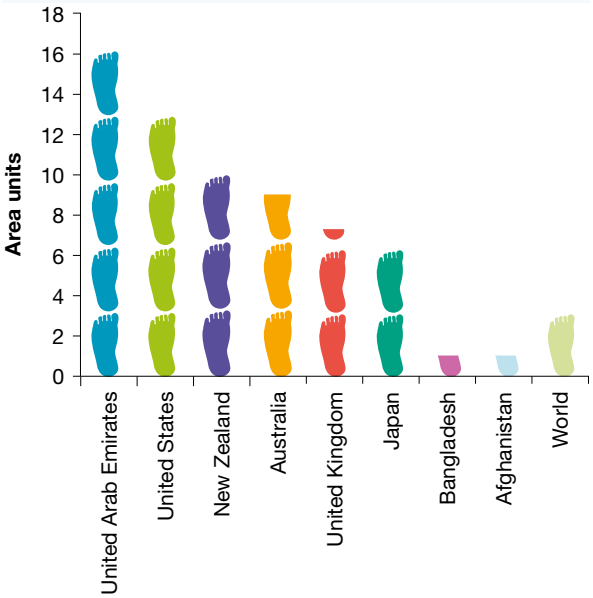
How much of our planet's resources do you take each year? Do you take more than your fair share? Who is doing without so that you can get all that you want, when you want it and how you want it?

Different lifestyles can have very different impacts on our environment. Scientists have developed a scale of the impact that our lifestyles may have on our planet's resources. This has been called an **ecological footprint**. It is a measurement of how much biologically productive land our activities require. It helps us see the impact that we have on our planet.

How big is your ecological footprint?



Comparison of ecological footprints of people in different countries



Dear Bree

Thank you for your letter. We miss you but are glad that you have finally settled into your new country. Your current science project is very interesting. I have never heard about ecological footprints before.

Your comment that an average North American has the same impact on the planet as 50 Sri Lankans or 290 Ethiopians was an eye-opener. I had no idea that, on average, a citizen of the so-called developed countries uses as much of the world's resources in two days as an Ethiopian uses in one year.

Having reflected on your research, I guess we in Australia leave larger ecological footprints than many other citizens around this globe. I found out that, on average, every person in Australia needs about 7 hectares of space — that's the size of 112 Olympic-sized pools! Some studies suggest that we are a greedy nation and are among the top eight users of Earth's resources.

Your letter inspired me to do some research of my own. It seems that the use of energy and other resources is distributed unevenly around the world. Sadly, some countries (and the people in them) are making huge efforts to get an even larger share of the resources. This greed is not only unfair, but also unsustainable.

Can you make any suggestions about how I could help out — any suggestions for reducing the size of my ecological footprint would be much appreciated!

Hope to hear from you again soon.

Yours sincerely
Cameron

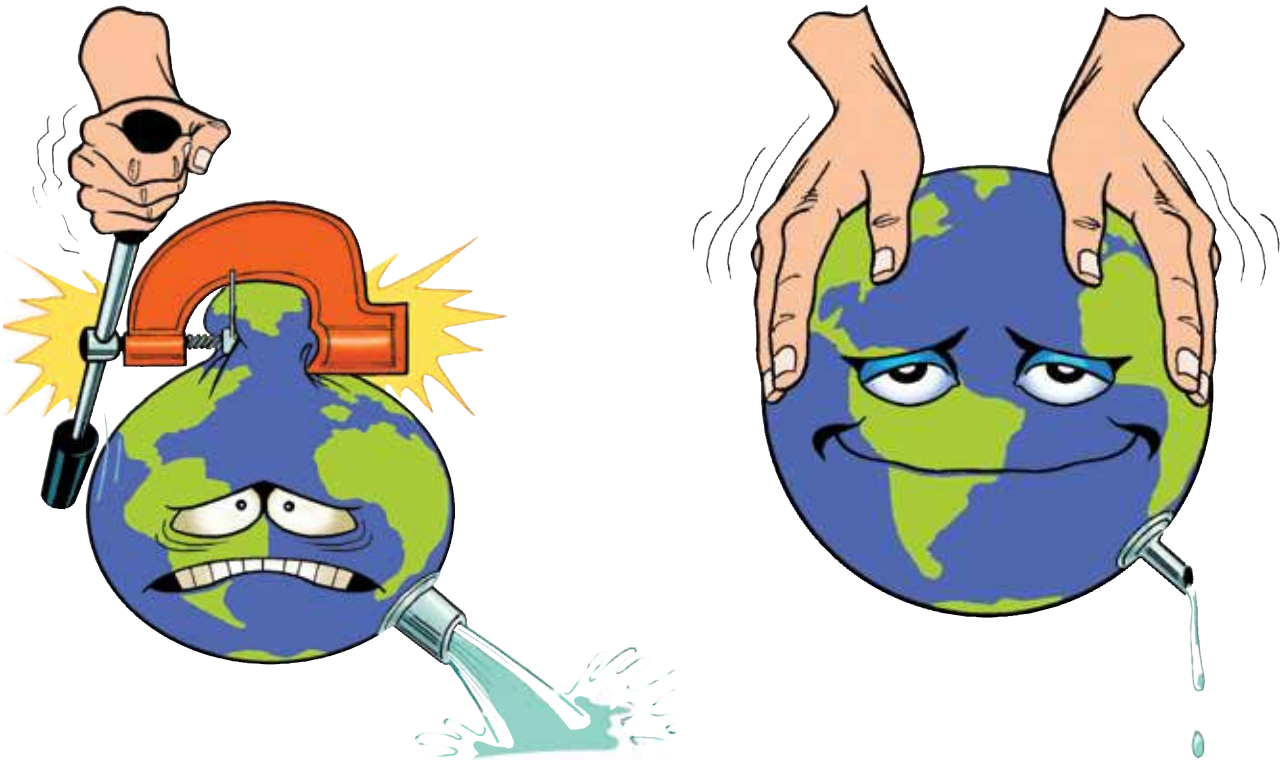
4.11.2 Using more than the Earth can give

In order to live, we need to consume resources available on our planet. But what happens when we use more than is available to us? For example, what if humanity's ecological footprint is 20 per cent larger than what our planet has to offer (or can regenerate)? This would mean that it would take one year and two and a half months for the Earth to supply what we use in a single year. How could we pay back the debt each year?

Sustainability is based on the recognition that, if resources are consumed faster than they are produced or renewed, they can be depleted or used up. This may result in resources becoming costly or unavailable, resource conflicts and increasingly barren habitats. Many of our resources are finite and, once used, cannot be replaced.

By understanding the ideas behind ecological footprints, we can empower people to take their own personal and collective actions to support a sustainable lifestyle on our planet.

Do you take more than your share?



4.11 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Describe what is meant by the term 'ecological footprint'.
2. List the following countries in order of the size of their ecological footprints, from biggest to smallest: United Arab Emirates, Bangladesh, United Kingdom, Australia, United States.
3. Suggest how understanding ecological footprints can be useful.

Think

4. If everyone on Earth had the ecological footprint described in the table at right, we would need 2.7 planets to meet our needs.
   (a) Suggest questions that might be asked about each category.
   (b) Suggest answers that may be the most sustainable for the environment.
5. Under each of the following categories is a lifestyle activity statement — a suggested way of minimising our impact on the environment. In your team, brainstorm at least two other lifestyle activity statements for each category.
   (a) Food consumption and packaging
   - I take my own bags when I go shopping.

   (b) Household energy and supplies
   - I turn off the lights when rooms are not being used.

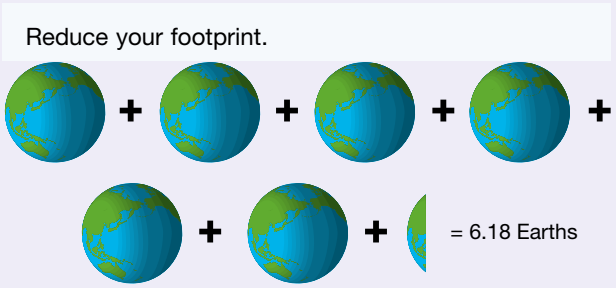
   (c) Transport
   - I often walk or ride to school.

   (d) Recycling and reusing
   - I use a reusable lunch box rather than plastic bags.

   (e) Water
   - I turn the tap off while brushing my teeth.

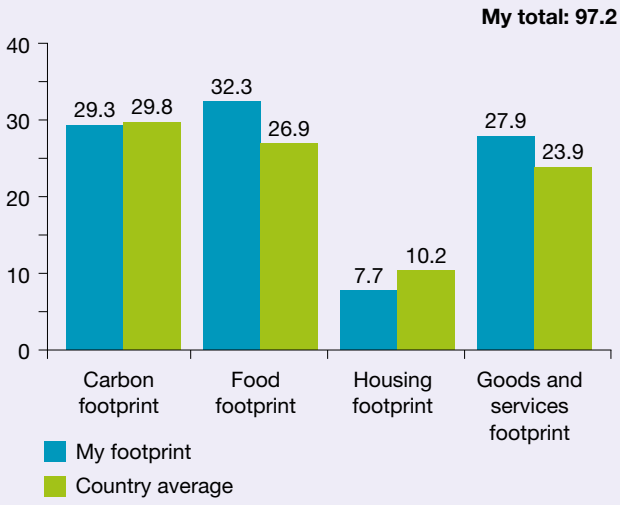
   (f) The environment
   - I treat my environment with respect.

Category	Global hectares
Food	1.5
Mobility	0.3
Shelter	1.1
Goods/services	1.9
Total footprint	4.8



Investigate

6. Charlotte completed an ecological footprint quiz. Her results are shown at right.
   (a) Explain the statement 'if everyone on the planet lived my lifestyle, we would need 6.18 Earths'.
   (b) Overall, is Charlotte's footprint bigger or smaller than that of the average Australian?
   (c) Suggest some ways in which Charlotte could reduce her food and goods and services footprints.
   (d) People living in wealthy countries such as Australia and the US have, on average, a much bigger ecological footprint than people living in poorer countries. Explain why.



7. Professor Tim Flannery was named Australian of the Year in 2007. Professor Flannery began his scientific career studying the evolution of Australasian mammals and has helped Australians become more aware of environmental issues. Find out about and report on:
   (a) Tim Flannery the research scientist
   (b) scientific research that Professor Flannery has been involved in
   (c) the evolution of Australasian mammals
   (d) Professor Flannery's book *The Future Eaters*, which describes the damage humans have caused the Australian environment
   (e) Professor Flannery's book *The Weather Makers*, which focuses on global warming and controversial ways of addressing the issue.

Think and discuss

8. Suggest ways in which you could measure your water footprint.
9. (a) Suggest a link between energy, sustainable lifestyles and ecological footprints.
   (b) In your team, discuss what may be meant by the term 'sustainable lifestyle'.
   (c) Brainstorm some examples of sustainable lifestyles.
   (d) Share your definition of 'sustainable lifestyle' and your examples with other teams.
   (e) Select three of these examples to focus on yourself over the next week.
   (f) Report your experiences to your team after a week.
   (g) Suggest ways in which you could encourage others to have a more sustainable lifestyle.
   (h) Create a web page, PowerPoint presentation, song, advertisement or poster that encourages a sustainable lifestyle.

4.12 What a load of rubbish!

4.12.1 Rubbish!

Every Australian creates one tonne of rubbish each year, making the nation the second largest waste creator after the United States.

Most of the household rubbish we produce is packaging — the cartons, plastic wrapping and cans in which food and other products are sold. The packaging of clothing and some other goods is often excessive. Before choosing a brand of food or clothing, perhaps you should think about whether or not all of the packaging is needed.

4.12.2 At the tip

Your local city council collects rubbish and dumps it into big holes in the ground. Over many years, the rubbish settles and the hole is filled. A layer of soil is bulldozed over it and trees are planted. These areas are often used as parkland or reserves.

Biodegradable organic substances are broken down into simpler chemicals by bacteria and fungi, producing methane gas. Methane and other gases contribute to the smell around these landfills. The rubbish under the ground continues to decompose, although some materials such as plastic and glass will last for hundreds or thousands of years. That is why it is better to recycle them.



Landfill sites cause many problems. Pests such as rats, which can spread disease, breed in the rotting garbage. If industrial waste is dumped in this manner, toxic substances could leak into other areas and contaminate groundwater.

4.12.3 Into the sea



Imagine how much space will be required if people keep dumping rubbish at this rate. Have you ever wondered what happens to the litter you see in the schoolyard? Quite a lot of it is blown and washed into street gutters. After heavy rain, litter flows into creeks, rivers, lakes and, eventually, into the sea.

The litter that ends up in the sea contains a large amount of plastics, metal and glass, which are **nonbiodegradable**; that is, they are not broken down into simpler chemicals by bacteria and fungi. The litter may float on the surface or sink to the bottom, where it stays for many years. Litter can also cause injuries to many organisms in the ocean.

4.12.4 Composting



Food scraps can of course be recycled by setting up a **compost** heap. Compost is decaying plant matter. Composting encourages the breakdown of food scraps, leaves and other vegetable matter by bacteria, fungi, earthworms and insects. It produces a number of nutrients that help plants grow better. When compost is mixed with garden soil, it returns these nutrients to the soil and reduces the need for fertilisers.

Some people add manure or lime to compost heaps to speed up the composting process. Adding animal manure provides a balance of nutrients and helps provide the right conditions for decomposers to live. The addition of worms speeds up the process and produces a very rich compost from the products of digestion of vegetable matter by the worms. Decomposers need moisture and oxygen, so compost heaps, especially the bin type, must be turned to aerate them and occasionally even watered during hot, dry spells.

4.12.5 Are you a polluter?

A **pollutant** is anything added to the environment that harms living things. Examples of pollutants include car exhaust fumes, household waste, pesticides and industrial waste such as smoke, poisonous fumes and liquids. What if some things that you use were produced by processes that are destructive to your environment? Are you a polluter?



HOW ABOUT THAT!

Did you know that, in 2004, Australians used about 5.6 billion single-use plastic bags? That is equivalent to one bag a day for every person in Australia throughout the year! After their first use, many became litter within our environment. Because most plastic bags are made up of non-renewable natural resources and can take up to 1000 years to break down naturally, these are likely to be still littering our environment today. While biodegradable plastic bags are being developed and are sometimes used, these also have a variety of problems associated with them. As well as their claimed ability to break down naturally being questioned, it is currently not known whether harmful products are left over once biodegradation has taken place.

INVESTIGATION 4.11

Anti-litter video

AIM: To make a two-minute video that discourages littering.

Your video should include:

- the concept of ecological footprints
- the extent of the litter problem
- future consequences
- possible solutions.

1. Write and record an audio commentary and use appropriate titles and transitions. Try to incorporate a suitable music track into your video.

INVESTIGATION 4.12

Sustainable cyberhunt

AIM: To investigate the meaning of 'sustainability'

One of the simplest and best definitions of sustainability is 'to meet our needs in the present without compromising the ability of future generations to meet their needs'.

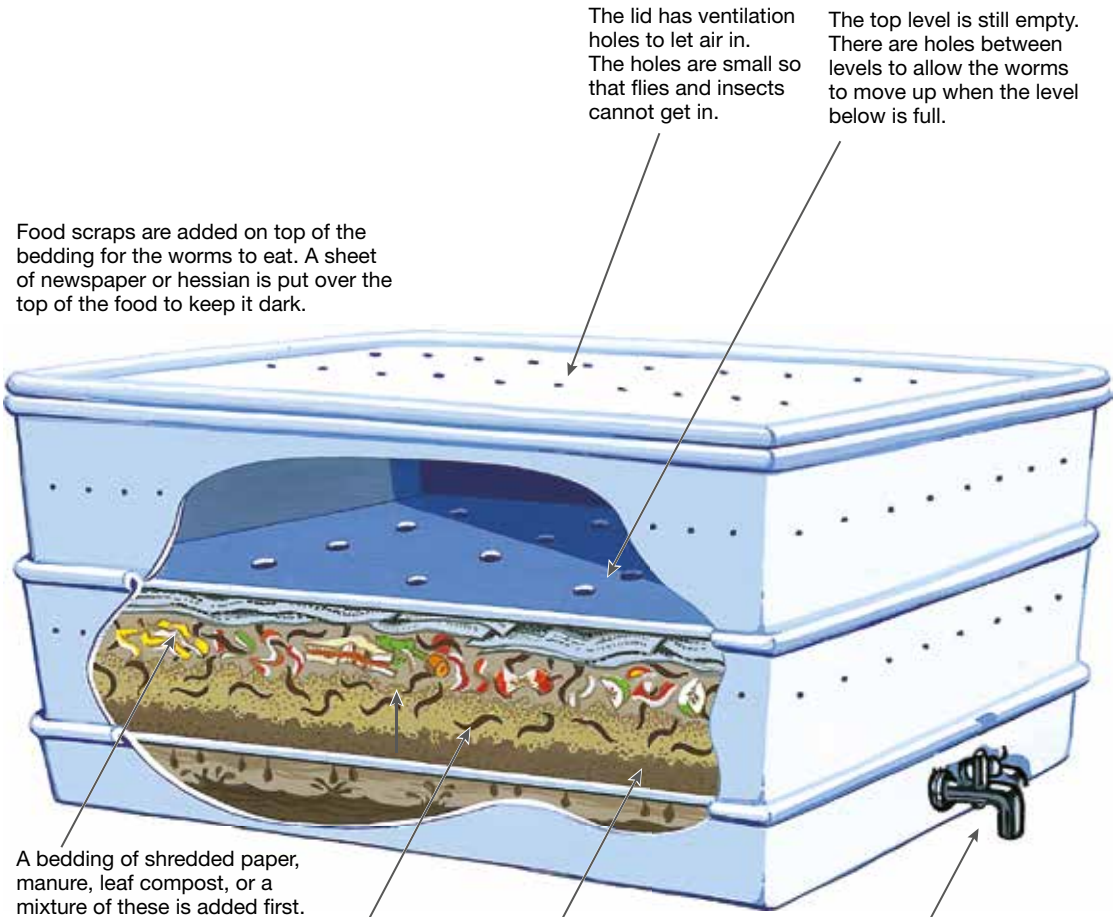
Choose a science cartoon from the internet that will illustrate an issue related to sustainability.

- Choose a search engine such as Yahoo! or Google.
- In the search box, type ‘science + cartoons’ or ‘science + environment’ or ‘science + sustainability’ or ‘cartoons + recycle’.
- Select ‘images’, and then search.
- Choose a cartoon that you think makes an important point.

1. Write a paragraph explaining what message the selected cartoon gets across and why it is funny.

4.12.6 The amazing worm farm

About 60 per cent of our household rubbish can be used as worm food. Worms eat just about anything that was once living, including kitchen scraps, garden waste and manure. They love pizza and will even eat the box it comes in! Worms can eat about half their body weight in food each day. We can use a worm farm to feed our once-living rubbish to worms. This is how a worm farm works.



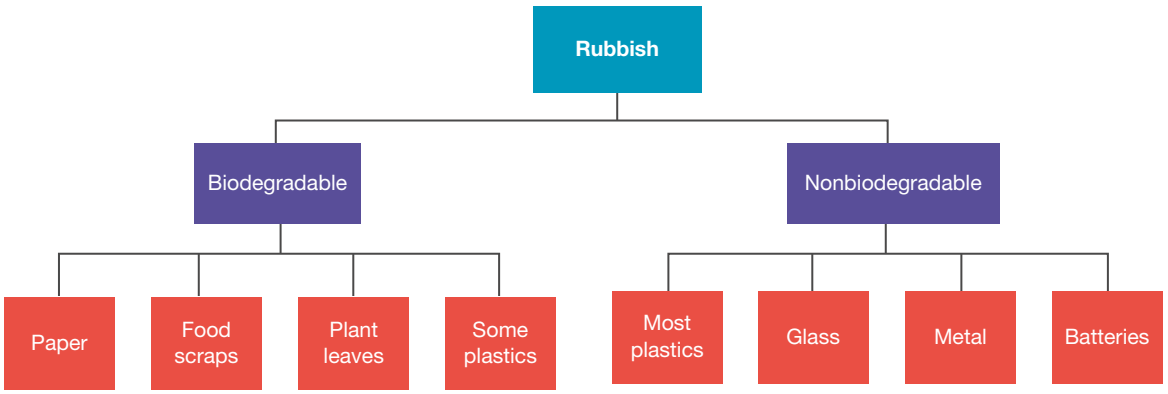
HOW ABOUT THAT!

Is it a boy? A girl?

Earthworms — like many flowering plants, snails and coral — are hermaphrodites. This means they have both male and female reproductive organs and so can produce both eggs and sperm. But earthworms still need mates to reproduce.

First, the earthworms swap each other's sperm, depositing it in special openings in the body. Then a swollen area near each worm's head, called a clitellum, produces a mucus that slides down over the head of the worm like a tiny tube. The worm lays a few eggs in it and adds a few of the sperm cells deposited by the other earthworm. Then the tube is tied off to form a little cocoon. If soil conditions and temperature are right, the embryos hatch in about three weeks.

Examples of biodegradable and nonbiodegradable materials



4.12 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is a pollutant? Give three examples of pollutants.
2. Give examples of what makes up most of household rubbish.
3. List three ways in which you can reduce your household rubbish.
4. Name a gas that contributes to the smell around rubbish tips.
5. List three problems associated with rubbish tips and landfills.
6. Describe the difference between biodegradable and nonbiodegradable.
7. Suggest three advantages to composting.
8. State two conditions necessary for decomposition to take place in a compost bin.

Think

9. Do you think loud noise is a pollutant? Explain your answer.
10. Christmas wrapping paper produces a lot of waste. List some creative ways of reducing the problem.
11. Ingestion of discarded plastic by our marine life is an increasing problem. Find out more about the effects of plastic on marine ecosystems. In a team, brainstorm ways to prevent this problem. Report your findings to the class.
12. Brainstorm ideas on the benefits of composting.
13. Use two thinking keys of your choice to unlock your thinking on litter.

Create

14. Set up a compost bin or heap in an appropriate area of the school. Find out in detail what you need to start one, how you are going to get food scraps and what you will do with the finished product — the compost.
15. Produce some posters that discourage littering. Display them around your school. Use a slogan or a simple diagram to get your message across.
16. (a) Create a mind map of relevant ideas, issues and information on the topic of rubbish.
    (b) Write a *What a load of rubbish* picture story book that tells the tale from the perspective of (i) the rubbish, an organism being affected and (iii) the environment.

Investigate

17. Visit at least three local service stations and find out what happens to the used oil after they change oil in cars during a service. Present your findings to the class.
18. Visit a supermarket, clothing store or hardware store and make a list of at least 10 packaged products. For each product, state:
    (a) why the packaging is used
    (b) any disadvantages of the packaging
    (c) your opinion about whether the package is necessary or excessive.
    Before you start, design a table in which you can record the products and your comments.
19. Find out more about composting toilets and how they work. Search your neighbourhood, picnic areas and campgrounds to find out where composting toilets have been installed and why.
20. (a) Some types of worms are better recyclers than others. Design an experiment to test how good different worms are at recycling food scraps.
    (b) Investigate the structure and systems of worms and their requirements for life.
    (c) Investigate worm farm designs.
    (d) Design and construct a worm farm for your class. Use lunch scraps to feed your worms.
    (e) Decide on questions that you could research with your worm farm.
    (f) Construct a PMI chart about worm farms.

4.13 Water aware?

4.13.1 Precious water

Feeling thirsty? What if there was no water to drink? What if you received only one cup of water a day — not just to drink, but to wash in as well? Australia is the driest habitable continent in the world! Fresh water is probably our most valuable **renewable resource**. Its quality is vital to human health, wildlife and agriculture.

learnon RESOURCES — ONLINE ONLY

Watch this eLesson: A world of water (eles-1616)

4.13.2 The water cycle

Water, warmed by energy from the sun, evaporates from lakes, rivers, oceans and the soil surface to form water vapour in the atmosphere. When the water vapour condenses into large droplets, rain falls on both land and water bodies. When rain soaks into the soil it becomes soil water. This water is found between the grains of soil and is taken up by plants. As it passes through plants, some of the water molecules are involved in the process of photosynthesis. The rest of the water molecules pass through the plant body

and out through the stomata, to become water vapour in the atmosphere again. This process is called **transpiration**. Transpiration occurs because the sun causes water to evaporate from the leaves of plants. If it did not, water would not move up the inside of the plant.



4.13.3 Waterwatch

Waterwatch is a program that brings together schools, community groups, landcare groups, land owners, councils and water authorities in an effort to maintain and improve water quality. Together, these groups monitor the quality of streams and other freshwater sources throughout most parts of Australia. The water monitoring groups:

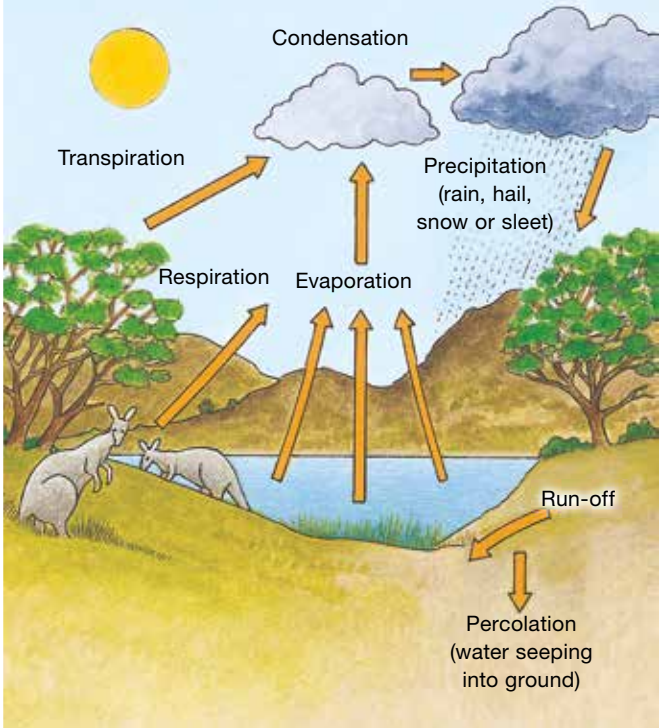
- survey streams and water sources to assess their present condition
- identify areas where water quality is poor
- identify the causes of poor water quality
- provide data that water authorities can use to analyse trends in water quality.

Waterwatch surveys

Most of the groups conduct **biological surveys** and monitor the physical and chemical properties of the water. Biological surveys involve observing, describing and counting organisms that live in fresh water. They are photographed and, in some cases, samples are taken.

The physical properties that are monitored include temperature, turbidity and rate of flow. **Turbidity** is a measure of how 'murky' or 'cloudy' the water is. Chemical monitoring involves testing for dissolved oxygen, pH, pesticides and nutrients such as phosphorus and nitrogen.

The water cycle



Farm'n'water

As part of the Waterwatch program, a group of students from Yea High School, Victoria, worked with their local dairy farmer David Mold to improve the quality of the water leaving his farm and entering the Goulburn River. After investigating several methods of treating dairy waste, David undertook his own waste treatment project. The students monitored the water at each of three sites. The types of chemical and physical factors that they monitored are shown in the table below. The students visited regularly to build up a seasonal picture of life in each of the habitats.

Yea High School student Kathleen Oliver working with farmer David Mold to collect macro-invertebrates. Macro-invertebrates are those animals without backbones that can be seen without the aid of a microscope. They include worms, snails, yabbies and insects.



Chemical and physical monitoring, 19 February 1997, 2 to 3 pm

Test	Site A (settling dam)	Site B (fenced wetland)	Site C (unfenced wetland)
Water temperature (°C)	32.2	24.5	24.5
Air temperature in sunlight (°C)	38.0	38.5	38.5
Dissolved oxygen (%)	Too murky to test	55	70
Nitrate level (mg/L)	1.144	0.189	0.484
Soluble phosphate level (mg/L)	0.429	0.106	0.191
pH	9.7	7.8	8.1
Conductivity (EC)	1540	860	1610
Turbidity (NTU)	180	55	41

David's waste treatment project

I first removed the solid waste dropped by the farm's 70 cows during milking (it is used as fertiliser on other parts of the farm). The run-off from the dairy includes mud, urine, milk and other liquid waste.

Site A — Settling dam

The run-off drains into a concrete pit and then drains into a settling dam (site A). This settling dam is about 100 metres from the dairy. Water running down from roadside and hillside drains adds to the dam, and it sometimes overflows in wet months.

Site B — Fenced natural wetland

From the settling dam, the water drains along a natural creek to a strip of natural wetland (site B). This wetland has been fenced to keep the cattle out. It is partially shaded by river red gums and has a cover of reeds, rushes and other wetland plants.

I have released 250 Murray cod fingerlings (about the length of a finger) into site B. They will help to recycle nutrients and compete with the European carp (an introduced species) that inhabit the creek. I'm hoping that the European carp will eventually be eradicated from the natural wetland.

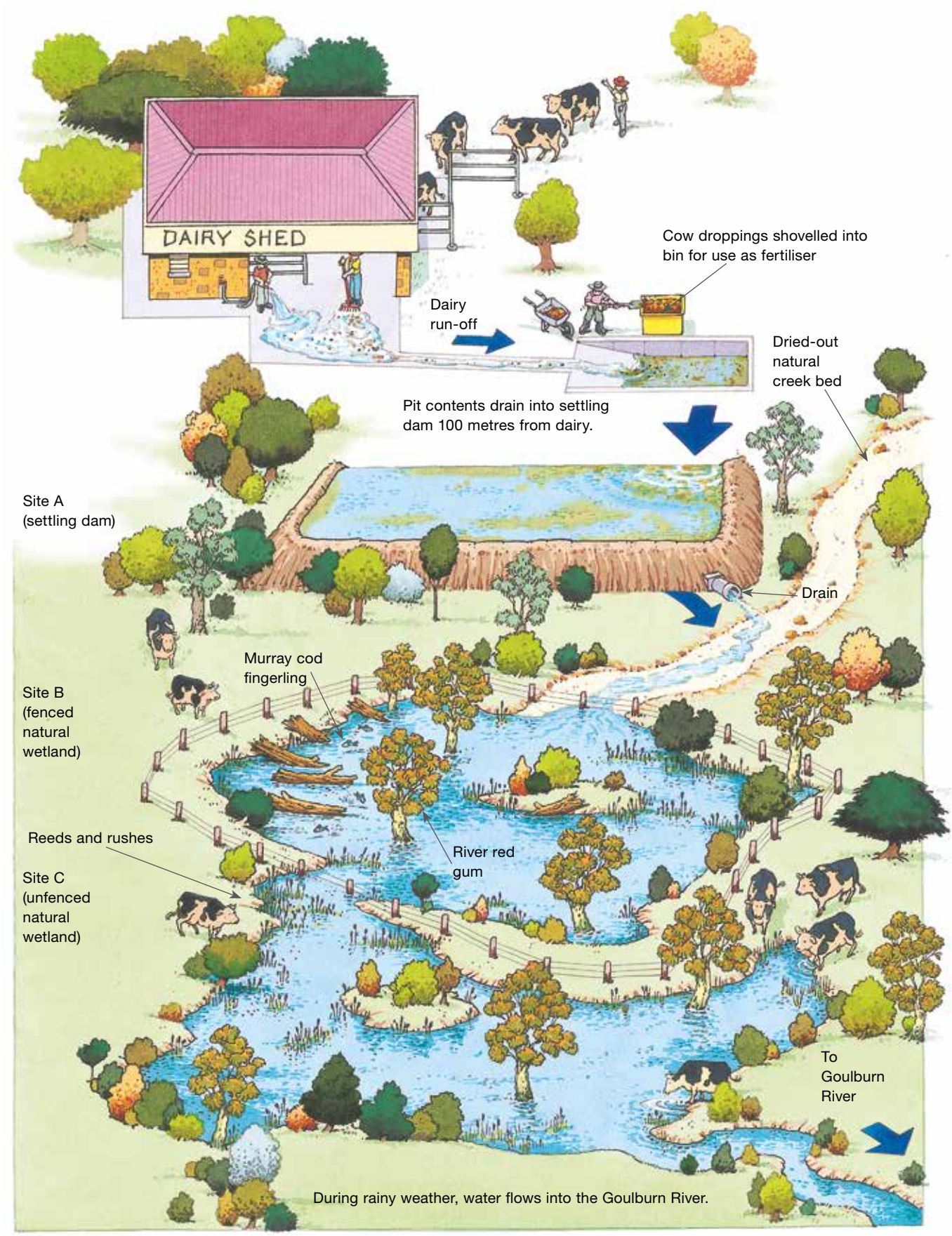
I have also moved some old logs to this site, and plan to plant more native trees to provide a natural habitat for native plants and animals.

Site C — Unfenced natural wetland

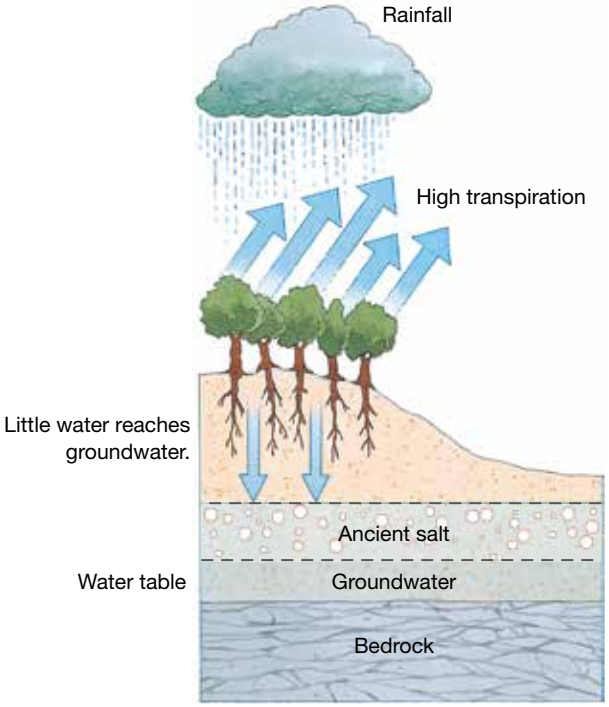
Site C is located alongside the fenced wetland. It is similar to site B. However, as it is not fenced, the cattle have access to it. When it rains, water flows from site C along a two-kilometre route into the Goulburn River.

I am confident that the habitats I have created will be self-sustaining, and will provide a natural way of recycling the nutrients in the farm's dairy waste.

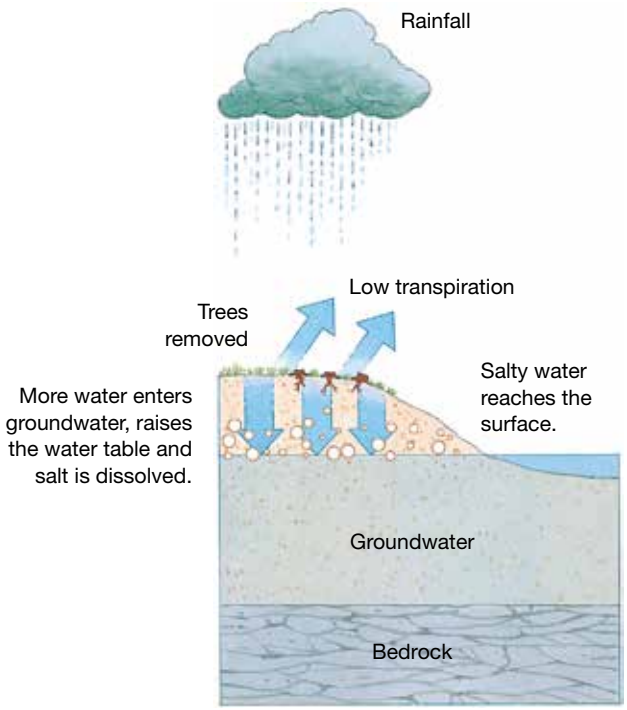
David Mold's dairy waste treatment project



Deep-rooted trees take up water and maintain the water table at depth below the soil surface.



Removal of trees results in more water entering the groundwater, so that salty water comes close to or reaches the surface.



INVESTIGATION 4.13

Measuring water quality

AIM: To investigate some methods for testing water quality

Materials:

samples of water from various locations
turbidity tube
data logger with the following probes: pH, temperature, dissolved oxygen, conductivity.
(Note: If your school does not have data loggers or you do not have some of the probes listed you could use a thermometer, pH meter and conductivity meter instead.)

Method and results

1. Copy the table below into your book and record your results.

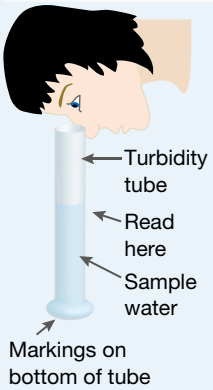
Measurement	Site X	Site Y	Site Z
pH			
Temperature (°C)			
Dissolved oxygen (ppm)			
Conductivity (S/m)			
Turbidity (mL)			

- Use the data logger and probes to measure pH, temperature, dissolved oxygen and conductivity.
- Place the turbidity tube on the floor and look down the tube. You should be able to see a mark on the bottom of the tube.
- Fill the tube using one of the samples until the mark can no longer be seen through the water. Read the turbidity reading off the side of the tube (see diagram on the next page).
- Repeat the previous steps using the other water samples collected.

Discuss and explain

2. Turbid water is not clear. You cannot see through it very well. Explain how the turbidity test works.
3. What could cause a high turbidity reading?
4. Why is it important to monitor the amount of oxygen dissolved in water?
5. Explain how sewage pollution might affect the dissolved oxygen level of a body of water. (*Hint:* Sewage contains organic matter that can be broken down by bacteria. Bacteria carry out respiration.)
6. Gases, including oxygen, are less soluble in hot water than in cold water. How might an increase in water temperature affect fish living in the water?
7. What effect would acid rain have on the pH of a stream?
8. When salts are dissolved in water its conductivity increases. Would you expect sea water or fresh water to have a greater conductivity?
9. Did any of the samples you tested appear polluted? Justify your answer.

How to use a turbidity tube



4.13.4 Thirsty for water?

Conditions of drought can reduce the amount of fresh water available for our use. Although Australia is surrounded by sea water, fresh water is in short supply. What are our alternatives? Can we take the salt out of the sea water? Are there other ways in which we can 'make' water that we are able to drink?

Desalination — a salty issue

A desalination plant has been built in Kurnell in Sydney, New South Wales. This plant uses a process called reverse osmosis, which results in a more salty solution on one side of a membrane and 'pure' water on the other side (see section 5.5). There are, however, some environmental concerns associated with this process. One is the huge amount of electricity (produced by the burning of coal or fossil fuels) needed to power the plant and another is the problem of what to do with the salt that is produced.

Recycled water — tasty?

Fancy drinking recycled sewage? In 2006, the three dams in Toowoomba in Queensland had collectively fallen to below 20 per cent capacity. In July 2006, the residents of Toowoomba voted on a proposal that 25 per cent recycled water from the sewage treatment plant be added to the city's rapidly diminishing water supply. The issue divided the city. Despite an extensive educational campaign, the proposal was defeated (61.8 : 38.2 per cent). How would you have voted? Why?

4.13 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly

Using data

Use the data in the table on page 182 to complete the following.

1. Construct bar graphs to compare each of the following chemical or physical properties.
   (a) Dissolved oxygen
   (b) Nitrate level
   (c) Soluble phosphate level
   (d) pH
   (e) Conductivity
   (f) Turbidity
2. Nitrates and soluble phosphates are nutrients that occur naturally in water.
   (a) Suggest why the levels are so high in the settling dam.
   (b) Suggest why the levels are higher in site C than in site B.
   (c) What effects could these high levels of nutrients have on the dam?
3. Which of the three sites appears to be most suitable as a habitat for fish like the Murray cod? Explain why.

Think and discuss

4. Why is fresh water described as a renewable resource?
5. Why do you think that David decided to kill the European carp that inhabited the creek?
6. Explain how David's project will help provide habitats for native wildlife.
7. David has invested a lot of time and money on his project. Is the investment worthwhile? Explain your answer.

Investigate

8. Find out what equipment you need to monitor some of the physical or chemical properties of a local stream or lake and design a monitoring program.
9. Find out the differences between the following alternative water supplies: groundwater, rainwater, grey water, stormwater, recycled water.
10. Suggest possible water-saving ideas for your school and/or home. Design a poster to display them.
11. List the types of chemicals that you pour down your kitchen sink over a week. Select two different chemicals and research what happens to them once they enter your drains. Select one of the chemicals you have researched and write a story about its experience.

learnon RESOURCES — ONLINE ONLY

Try out this interactivity: Ways forward (int-3082)

4.14 Going, going, gone!

4.14.1 In danger of extinction?

The intimate interactions that link us all together can also sometimes break us apart.

During the 200 years since the European settlement of Australia, over 125 different species of Australian native plants and animals have become extinct. Many more species are in danger of extinction.

4.14.2 Why worry?

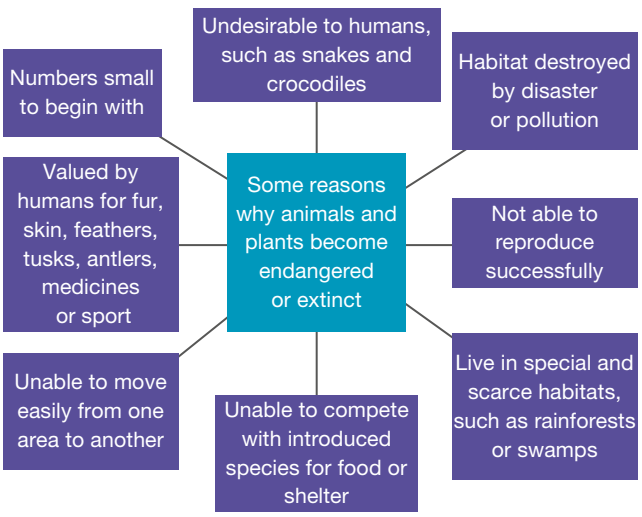
Why should we be so concerned about endangered species? After all, there are many plants and animals on Earth and it may become overcrowded in future.

Some of the reasons to be concerned about endangered species are that:

- their disappearance affects all other species in the food web
- all species have a right to live and share the Earth
- they may be useful in the future for food, medicines etc.
- future generations should have the same chance to see a diverse world.

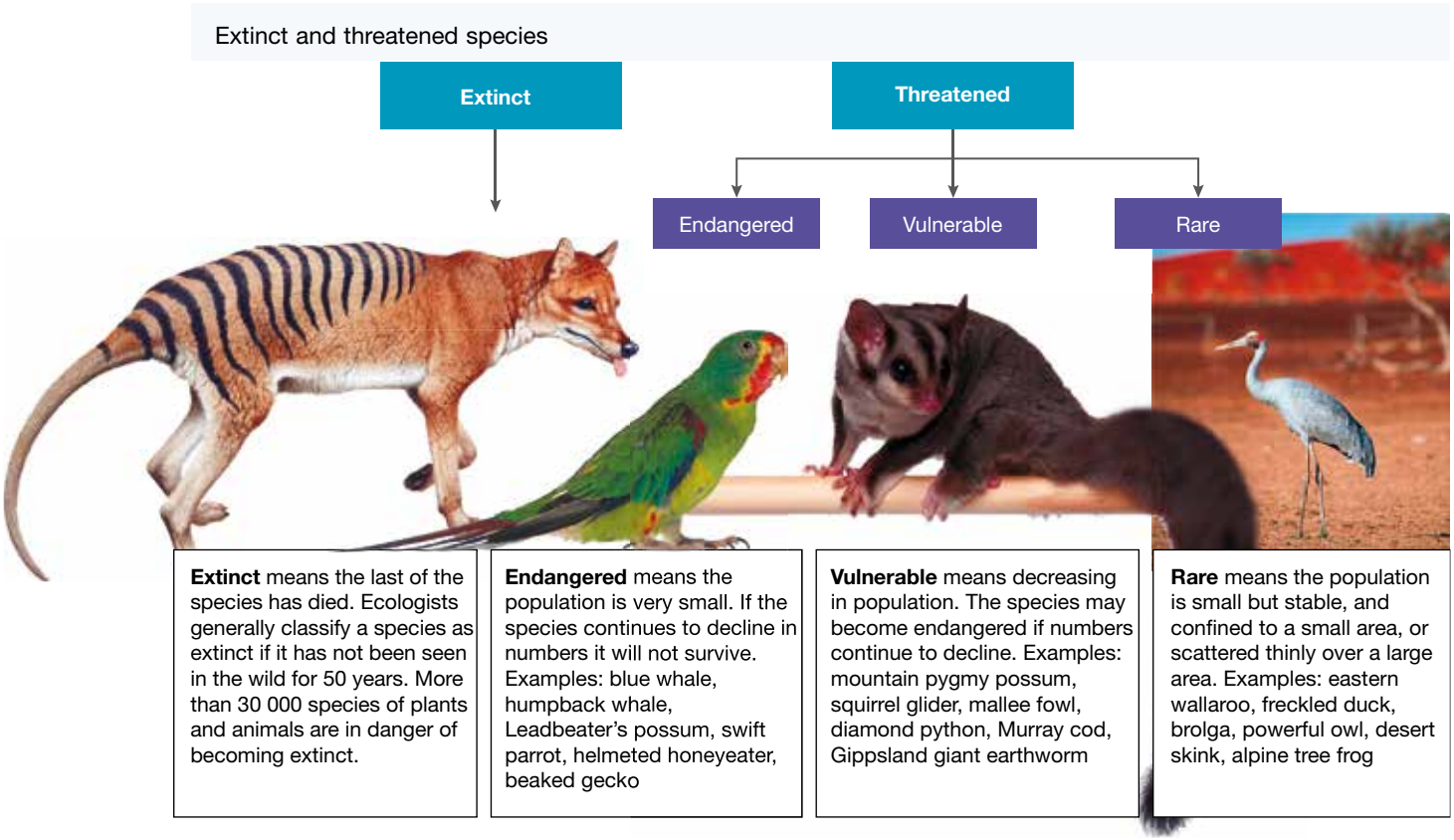
Some of the solutions put into practice to reduce the threat to endangered species include:

- declaring areas as national parks where plants and animals are protected
- setting up fauna and flora reserves, wetlands and other specialised habitats
- placing quotas (limits) on hunting and exports



- culling (reducing numbers) of overpopulated species, such as western grey kangaroos in some national parks, to allow native plants to survive.

Australia is not the only place where organisms are in danger! All around the world, humans are threatening the survival of other inhabitants of our planet.



4.14.3 Behind bars

For thousands of years, humans have kept animals in captivity; animals have been kept as pets and they have been put on display in zoos, circuses and 'water worlds'. Many people believe that animals should not be held in captivity. What do you think?

4.14.4 Arguments against keeping animals in captivity

- The animals in zoos and circuses are kept in cages with little room to move and are out of their natural habitats. They don't feed naturally; for example, lions do not hunt for their food, and seals do not catch their own fish. Polar bears usually have to put up with temperatures at the zoo that are much higher than they are used to in their Arctic environment.
- Most animals in captivity are isolated from others of their own kind and cannot live in their natural social groupings.
- The living conditions and isolation of animals in captivity causes stress. This has an effect on feeding and reproduction; most animals do not reproduce well in captivity.
- Family pets are sometimes unwanted after a short period of time and are abandoned to roam the streets or escape into the bush. Some pets, such as cats, dogs and even horses, escape into the bush



and become feral or wild, causing damage to the environment and killing or competing with native species.

Thousands of birds and small native animals are killed by cats every year, especially in national parks and reserves such as Sherbrooke Forest in the Dandenong Ranges, Victoria. Many of the cats are feral but many are also pets that are allowed to roam outside at night.

INVESTIGATION 4.14

Animals should not be kept in captivity

AIM: To investigate the issues involved in keeping animals in captivity

1. Use the information and images in this section and in other resources to construct a written response to the statement: 'Animals should not be kept in captivity'.

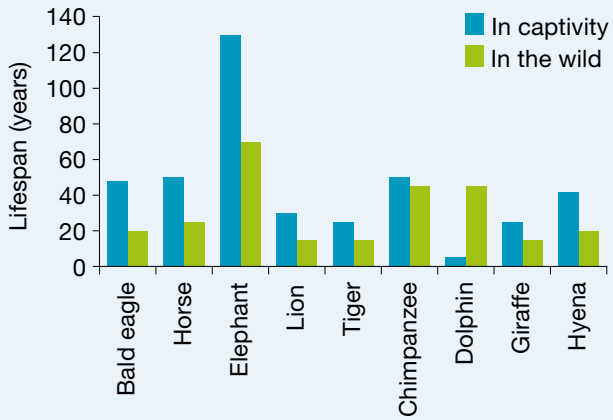
Average distance travelled per day when living in the wild

Animal	Distance travelled (km)
Feral horse	65–80
Asian elephant	25
Red fox	10–250

An animal's lifespan is different in captivity.







4.14.5 Arguments in favour of keeping animals in captivity

- Zoos provide us with a very valuable educational resource, not only by enabling school children to study animals, but also by making the general public more aware of animals and their value in our world.
- There are many hundreds of species of endangered animals in the world today because of the destruction of their habitats by humans, pollution, overhunting and many other reasons. Zoos provide a breeding program for these animals so that the species can reproduce and have a better chance of survival in the future. For example, research has been carried out into freezing sperm and eggs from some animals, such as the clouded leopard, that are very aggressive towards each other and are unlikely ever to mate in captivity.



- Animal enclosures have improved greatly from the concrete-floored, barred, small 'box'. Today, most zoos have quite large, specially designed enclosures that imitate the natural habitats of the animals as closely as possible. At Melbourne Zoo, a gorilla rainforest has been created where people can observe the gorillas in a very natural environment. This type of enclosure is very different from the small cages of the past.
- Research is carried out at zoos into the needs and behaviour of animals, and this gives us a better understanding of the animals in their natural environments.
- Zoos are very good tourist attractions, and this benefits not only the zoo but also the city, the state and the country. They are great places to visit, especially if you live and work in the city and don't have much contact with nature.
- The benefits of household pets are too many to list here. They are great companions, especially for the elderly and sick. It has been shown that people recover more quickly from illness when they have a pet with them. Pets are also very good for children to play with and learn responsibility by looking after them.

4.14 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly

Remember

1. State the meaning of the term 'extinct'.
2. What is the difference between an endangered species and a vulnerable species?
3. How is a rare species different from endangered and vulnerable species?
4. List five of the factors that have contributed to the extinction of some species of animals.
5. Give two good reasons why endangered species should be saved.
6. What is being done to save endangered species?
7. Animals in zoos do not feed naturally. Give an example to explain this statement.
8. Give one reason why family pets can be a problem.
9. (a) What does the word 'feral' mean?
   (b) Why are feral animals a problem?
10. How have animal enclosures in zoos changed over the years?
11. Why don't animals reproduce well in captivity?
12. How does the technique of freezing sperm and eggs help breeding programs in zoos?

Think

13. How does logging of forests affect native plants and animals? Give some examples.
14. The extinction of one species affects several other species. Explain this statement and give some examples.

Think and discuss

15. Select three of the following thinking-key questions to unlock your thinking:
    (a) 'combination' key — list the attributes of a whale and a flower, and then combine them
    (b) 'alphabet' key — list examples of parts of animals that are used by humans
    (c) 'inventions' key — design a protective device for baby seals.
16. Keep an issue learning journal to track your personal learning. An issue learning journal is like a scrapbook diary that includes all of the issues that you find interesting, relevant or thought provoking. You could cut

and paste articles, photographs, diagrams, notes, thoughts, clippings and summaries of your reading. You may decide to add comments on issues including:

- what the issue is about
- what you already know about the issue
- a PMI chart on the issue
- your opinion of the issue
- opinions of others in your class or family about the issue
- any biases in information about the issue
- how an author or presenter was effective in communicating the issue to others
- solutions or advice that might help resolve the issue
- other things you would like to find out about the issue.

17. In a team, brainstorm other arguments for and against keeping animals in captivity. Organise a class or team debate.

Using data

18. (a) Copy and complete the table below, calculating the totals and entering them in the table.

Year	1930	1940	1950	1960	1965	1970
Blue whales killed	25 000	15 000	7000	3000	2000	0
Fin whales killed	14 000	14 000	23 000	32 000	20 000	5000
Sei whales killed	1000	1000	3000	8000	25 000	15 000
Sperm whales killed	1000	5000	12 000	20 000	30 000	23 000
Totals						

The data above have been adapted from P. R. & A. H. Ehrlich, *Population, Resources, Environment* (W. H. Freeman, San Francisco, 1972).

(b) Plot the data for all four whales, and the totals, on a graph, using the same set of axes for all of them. Put the years on the horizontal axis (scale of 1 cm = 5 years, starting at 1930) and the numbers of whales killed on the vertical axis (scale of 1 cm = 5000). Use different colours for the different whales and the total numbers, and make a legend to show which colour represents which whale.
(c) Which whale was killed less and less over the whole period?
(d) When was the total number of whales killed the greatest?
(e) What can you say about the rate of killing of the whales after 1965? Why do you think this happened?
(f) Why do you think there were fewer whales killed in total in 1940 than in 1930?

Investigate

19. Use the library or internet to find out more about one of Australia's most threatened vertebrate species. Write a short report, or design a poster, and include the following information:
(a) a description of the animal and its habitat
(b) a list of the animal's requirements (e.g. food, shelter)
(c) reasons why the animal is threatened with extinction
(d) what, if anything, is being done to save the species.
(e) Choose your vertebrate from the species listed below.
    - Mountain pygmy possum
    - Leadbeater's possum
    - Spotted-tailed quoll
    - Dugong
    - Southern right whale
    - Humpback whale
    - Western black-striped snake
    - Western swamp turtle
    - Platypus frog
    - Trout cod
    - Bar bar frog
    - Mallee fowl
    - Helmeted honeyeater
    - Golden-shouldered parrot
    - Yellow-bellied parrot
20. Investigate some other ways in which humans have had an impact on the survival of other organisms. Present your findings in a storyboard, concept map, mind map or puppet play.
21. Contact your local zoo or wildlife reserve and obtain information about which endangered animals are in their breeding programs.

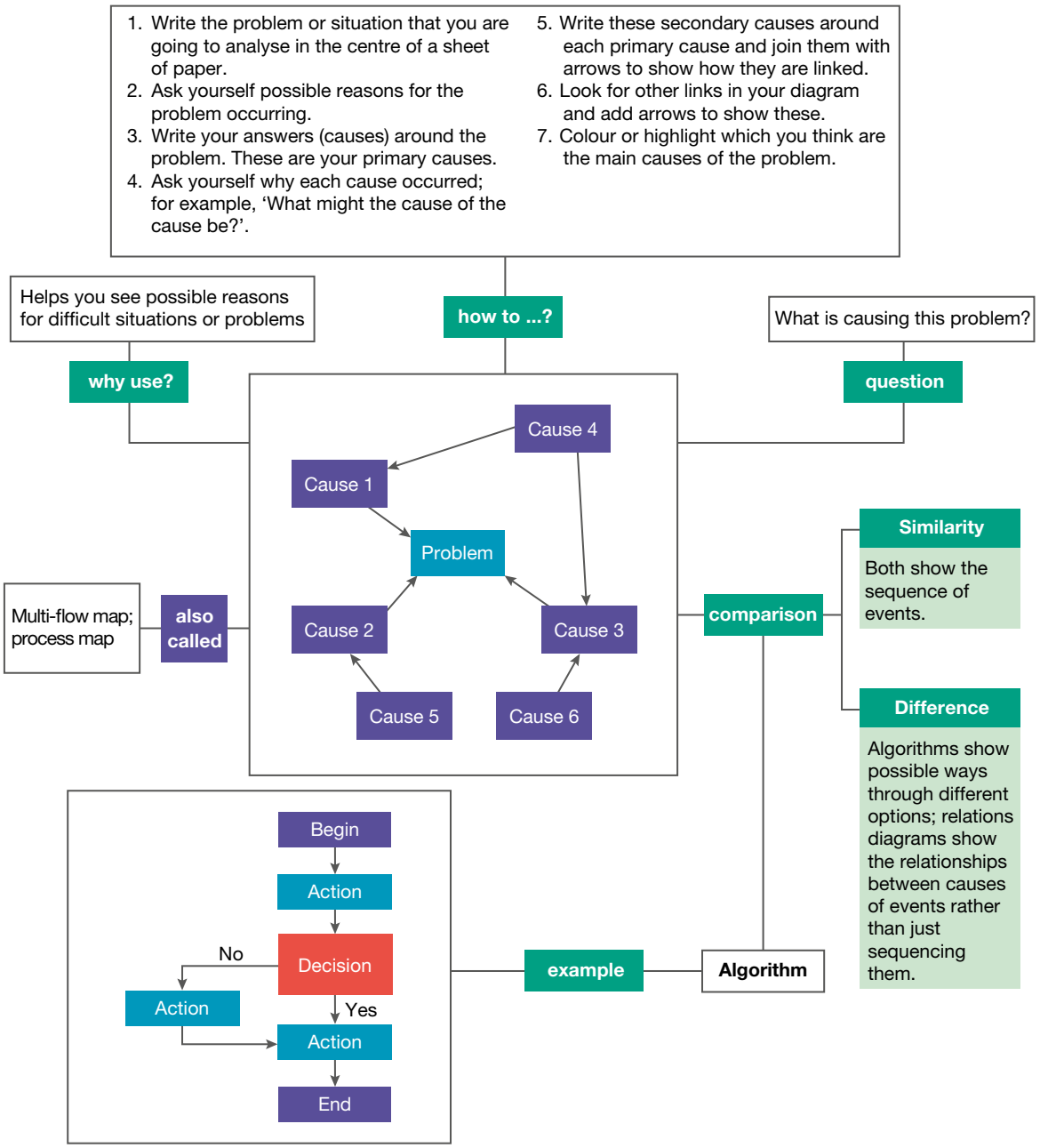
Imagine

22. Imagine that you are an explorer in the ever-shrinking Amazon jungle. After many years of searching, you come across a small animal that has not been seen for many decades, and is spoken about only in stories told by the local people.
    (a) Describe your discovery of the animal, what it looks like and how it lives.
    (b) Think about the choices of what to do about your discovery.
    - Do you tell others?
    - Do you capture it and take it back with you?
    - Do you leave it alone despite the fact that it is probably endangered and will soon become extinct?

    (c) Put your thoughts down in your explorer's journal.

4.15 Relations, diagrams and algorithms

4.15.1 Relations, diagrams and algorithms



learnon

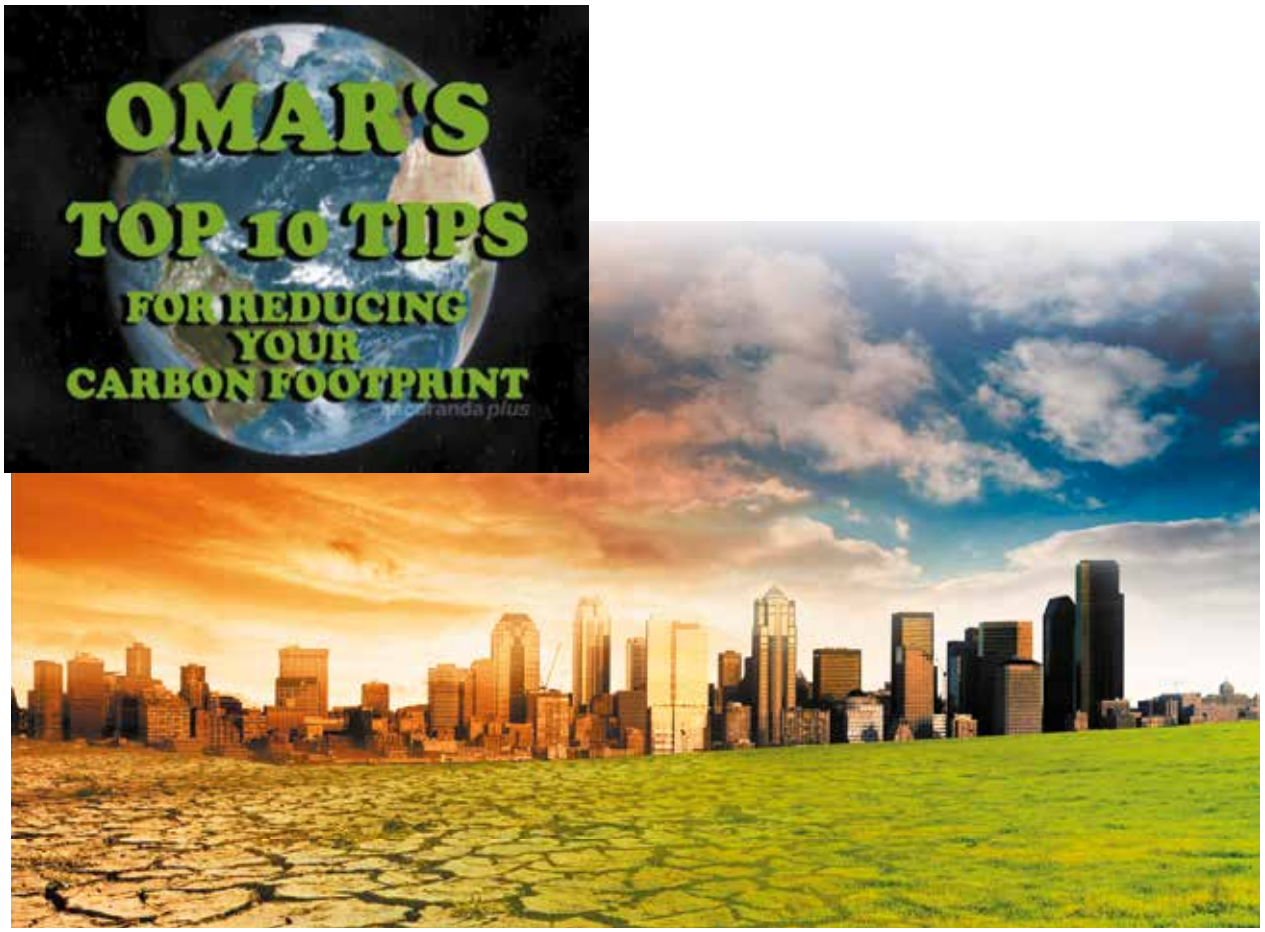
4.16 Project: Small acts, big changes

Scenario

As a member of generation Y, climate change is an issue that is very important to you. Nearly every day you hear frightening statistics about what the world will be like by 2050 unless we all make dramatic changes to our lifestyles. You are also getting frustrated by how slowly change is being initiated. Therefore, you have decided to take action yourself and create a persuasive video that will inform households and local communities of actions they can take personally to help stop the consequences of climate change.

Your task

Your task is to create a three-minute internet video to be distributed online. You're aim is for this video to 'viral' — for it to be good enough that people want to pass it on to their friends. Your video should provide the viewer with practical advice on reducing their carbon footprint, but it should also be entertaining enough to appeal to a wide range of people who use the internet. Remember, the consequences of climate change have already begun, so you video should not only create a sense of urgency about the seriousness of the problem but also be persuasive enough to encourage its viewers to take immediate action. Therefore, you need to provide convincing and accurate facts while appealing to the emotional and intellectual capacities of your audiences.



4.17 Review

4.17.1 Study checklist

Interactions in ecosystems

- identify biotic and abiotic factors in ecosystems
- investigate the effect of an abiotic factor on a biotic factor
- distinguish between producers and consumers
- distinguish between predator and prey
- construct food chains and food webs
- use food chains to show feeding relationships within a habitat
- interpret food chains and food webs
- classify organisms according to their positions in a food chain
- describe the role of decomposers in ecosystems
- describe the roles of photosynthesis and cellular respiration in ecosystems
- outline how carbon, water and nitrogen are recycled in ecosystems
- describe how energy flows through ecosystems

Human impact on ecosystems

- describe how living things can cause changes to their environment and impact other living things
- define the terms 'greenhouse effect' and 'enhanced greenhouse effect'
- suggest strategies to address global warming
- distinguish between biodegradable and nonbiodegradable substances
- suggest ways to reduce your weekly household rubbish
- define the term 'introduced species' and provide an example
- provide examples of the impact of introduced species to Australia
- define the term 'endangered species' and provide an example
- investigate the effects of the following types of human activity on Australian habitats: deforestation, agriculture, introduction of new species
- investigate ways to control the spread of introduced species (e.g. cane toads)
- research specific examples of human activity that have had an impact on Australian ecosystems

Science as a human endeavour

- identify contributions of Australian scientists to the study of human impact on environments and to local environmental management projects
- investigate research and issues related to water use and management in Australia
- investigate how Indigenous land management practices can help inform sustainable management of the environment
- consider effects of human activity in the community on the sustainability of ecosystems

Individual pathways

ACTIVITY 4.1
Investigating ecosystems
doc-6054

ACTIVITY 4.2
Analysing ecosystems
doc-6055

ACTIVITY 4.3
Investigating ecosystems further
doc-6056

learnon ONLINE ONLY

4.17 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **fully worked solutions** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. Eco-MI toolbox — Select and complete four activities from the table below. Make sure that you have at least four rows represented in your selection.

Type of multiple intelligence (MI)	Activity 1	Activity 2
Verbal/linguistic 	Write a fable or legend to explain food webs or the nitrogen cycle.	Write a letter to a school newsletter or local newspaper to express your concerns about an issue related to your local ecosystem. Include suggestions.
Musical/rhythmic 	Write a story about a prey animal trying to convince its predator not to eat it. Put your story to music and turn it into a video or puppet play.	Think of at least ten keywords in this chapter. Write a song that includes examples and definitions.
Logical/mathematical 	Use a graph to summarise data on different temperatures across a range of habitats in a local ecosystem.	Construct a PMI chart on the issue of global warming.
Visual/spatial 	Create a set of illustrated flashcards on key terms used throughout this chapter. Create a mind map of these to show your understanding of the concepts.	Create a PowerPoint presentation to show a primary-school child the arguments for and against a particular ecosystem issue.
Bodily/kinaesthetic 	Using costumes and dialogue in a team of at least four, model a food web with at least three food chains.	Construct a mobile or wall hanging of a food chain in two of the following ecosystems: a. inner city b. Murray River c. outback Australia d. Great Barrier Reef.
Naturalist 	Having just crash-landed on another planet, describe what you need to find out about your new environment in order to survive.	Deforestation can have a big impact on ecosystems. State possible effects and problems that may be caused by this type of human activity and suggest how you could help to reduce the environmental damage or contribute to a solution.
Intrapersonal 	Think about what your ideal environment would look like, smell like and feel like. Create a Y chart about it.	Construct a single bubble map or cluster map to show ten things that you could do to protect your local ecosystem.
Interpersonal 	Research a local ecosystem issue, dilemma or problem. In a team of four, brainstorm how you could help address two of these issues. Construct a letter or proposal to relevant authorities with your suggestions and/or ways you could help out.	In a team of at least two, design a questionnaire to find information about a school or local ecological issue. Distribute your questionnaire to at least 20 people and summarise your findings in a school newsletter or local newspaper article.

2. Redraw the table below to correctly match the heads and tails.

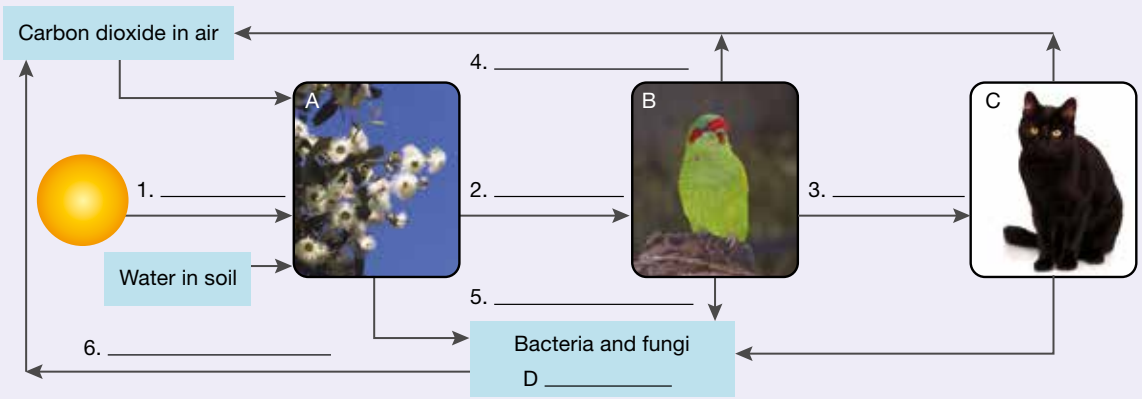
Head	Tail
Herbivores are …	organisms that produce their own food.
Producers are …	animals that eat plants.
Consumers are …	organisms that live in or on other organisms and obtain their food from them.
Parasites are …	organisms that break down dead plants and animals.
Decomposers are …	animals that eat other organisms.

3. Unjumble the words below to reveal some of the important terms in this chapter. Write down what each term means and give an example.
   (a) bttaiha (b) typstoossehinh (c) cibaoti
   (d) dofo incah (e) ytsseemco
4. Copy the puzzle below into your workbook, then use the clues to complete it.

(a) _ _ _ _ E _ _ _ _ _ _
(b) _ _ _ _ N _ _ _ _ _
(c) _ _ _ _ _ V _ _ _ _
(d) _ _ _ I _ _ _
(e) _ _ R _ _ _ _ _ _
(f) _ _ O _ _ _ _ _ _
(g) _ _ _ _ N _ _
(h) _ _ _ _ M _ _ _ _ _ _
(i) _ _ _ _ _ E _
(j) _ _ N _ _ _ _
(k) _ _ T _ _ _ _ _ _

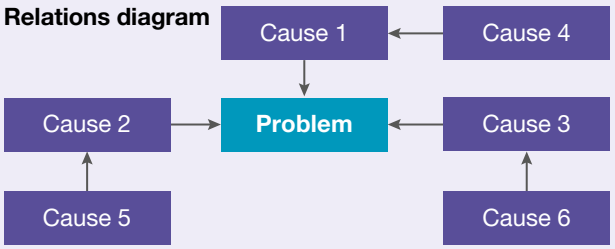
Clues
(a) Animals that eat the same sort of food, and live in the same area
(b) Animals that are close to extinction
(c) Meat-eating animals
(d) A place where an organism lives
(e) Plant-eating animal
(f) A stable system made up of living and non-living things
(g) Describes plants or animals that no longer exist
(h) Organisms such as bacteria and fungi that break down plant and animal remains
(i) A diagram that shows the feeding relationships of organisms in an ecosystem
(j) Information about closeness of organisms determined by sampling
(k) The interaction between members of two species that benefits both species

5. Copy and complete the diagram below by filling in:
   (a) the types of organisms labelled with the letters A, B, C and D
   (b) the processes labelled with the numbers 1–6. You may use words more than once.



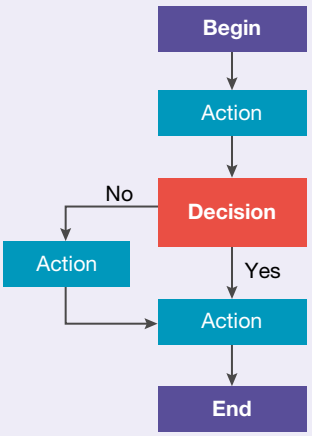
6. Think carefully about the following questions and write a paragraph to answer each one.
   (a) What is the difference between energy flow and matter recycling in an ecosystem?
   (b) There is a connection between the food you put into your stomach and the air you breathe into your lungs. Explain the connection.
7. (a) Identify the key source of energy in ecosystems.
   (b) Describe how energy moves through ecosystems.
8. Construct a pyramid that represents the transfer or transformation of materials and energy in food chains and webs.
9. Construct a food web that includes organisms in a local ecosystem.
10. The hunting and fate of whales is of great concern to many Australians. Find out more about the issues associated with the hunting of whales.
    (a) Construct a relations diagram to show the reasons for the hunting of whales.

Relations diagram

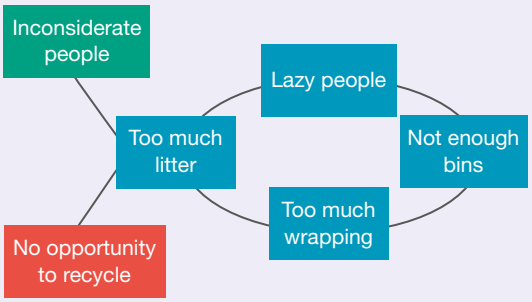


    (b) Construct an algorithm to show possible relationships between the reasons.

Algorithm



11. Use a relations diagram to capture your team's brainstorm of possible causes of, or reasons for:
    (a) Australians having large 'ecological footprints'
    (b) rubbish/litter on our beaches
    (c) the ecological impact of introduced species
    (d) species becoming endangered.
12. Use an algorithm to suggest possible actions to address the following ecological problems:
    (a) Australians 'ecological footprints'
    (b) too much rubbish/litter on our beaches
    (c) the ecological impact of cane toads
    (d) species becoming endangered (e.g. blue whale, swift parrot, beaked gecko, helmeted honeyeater).
13. (a) In teams, brainstorm possible causes of litter in your school. Summarise your discussion into a relations diagram.
    (b) Compare your relations diagram with that shown on the right. Comment on any similarities or differences.
    (c) Construct an algorithm that could be used to discourage littering in your school.
    (d) Share and discuss your algorithm with those of your teammates.



INVESTIGATION 4.15

Mind ‘n’ flash

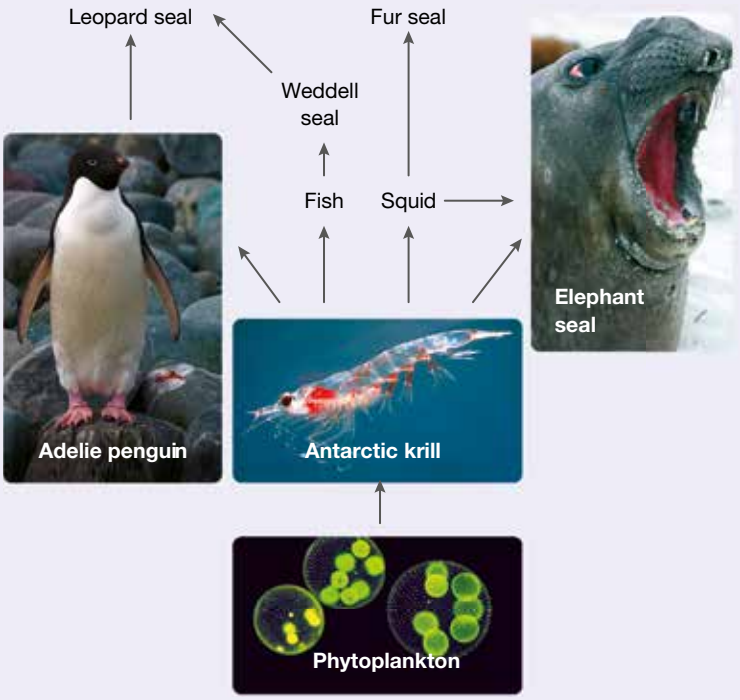
AIM: To use flash cards to review this chapter

1. Make up flash cards in the colours indicated, using the following terms.
   Green cards (use green card or green writing): photosynthesis, autotroph, producer, light energy, chlorophyll, chemical energy
   Orange cards (use orange card or orange writing): consumer, heterotroph, primary consumer, secondary consumer, trophic levels, food chain, food web, decomposer, predator, prey, competitor
   Red cards (use red card or red writing): cellular respiration, pollination, germination, decomposition, chemical energy, heat energy
   Yellow cards (use yellow card or yellow writing): oxygen, carbon dioxide, water, chemical energy, glucose, sucrose, starch, protein, amino acid, nitrogen, carbon, hydrogen, nitrates, nitrites, ammonia, fossil fuels
   Blue cards (use blue card or blue writing): plants, animals, bacteria, fungi, nitrogen-fixing bacteria, nitrifying bacteria, denitrifying bacteria
   White cards (use white card): greenhouse effect, enhanced greenhouse effect, global warming, introduced species, endangered species, deforestation, pollution, biodegradable, nonbiodegradable, renewable resource, biological control, ecological footprint, nitrogen cycle, water cycle, carbon cycle
2. Browse through this chapter and:
   (a) add any symbols or pictures on the fronts of the cards that will help you to remember their meanings or importance
   (b) add on the backs of the cards any summaries, key points or definitions.
3. Clear a playing area with space to arrange your cards in various mind maps, equations, cycles or flowcharts.
4. (a) Taking turns, each person in your team is to place a card in the playing area.
   (b) When it is your turn, try to use a card that links in some way to one of the cards already in place. As you place it near its connecting card, tell your teammates what the connection is.
   (c) Continue this until no-one in your team can think of any other connections.
   (d) Elect two team members to stay with your mind map to explain it to ‘visiting scavengers’ and send the others out to scavenge ideas from other groups.
   (e) Make any adjustments suggested by your teammates when they return.
5. (a) On A3 paper, write out your own version of your team ‘flash card mind map’.
   (b) Convert your mind map into a concept map by adding your own notes to describe connecting lines between the terms.
   (c) Compare your map with those of others, adding any of their notes that help you make sense of why the terms are linked by these lines.
6. Reflect on what you have learned together.

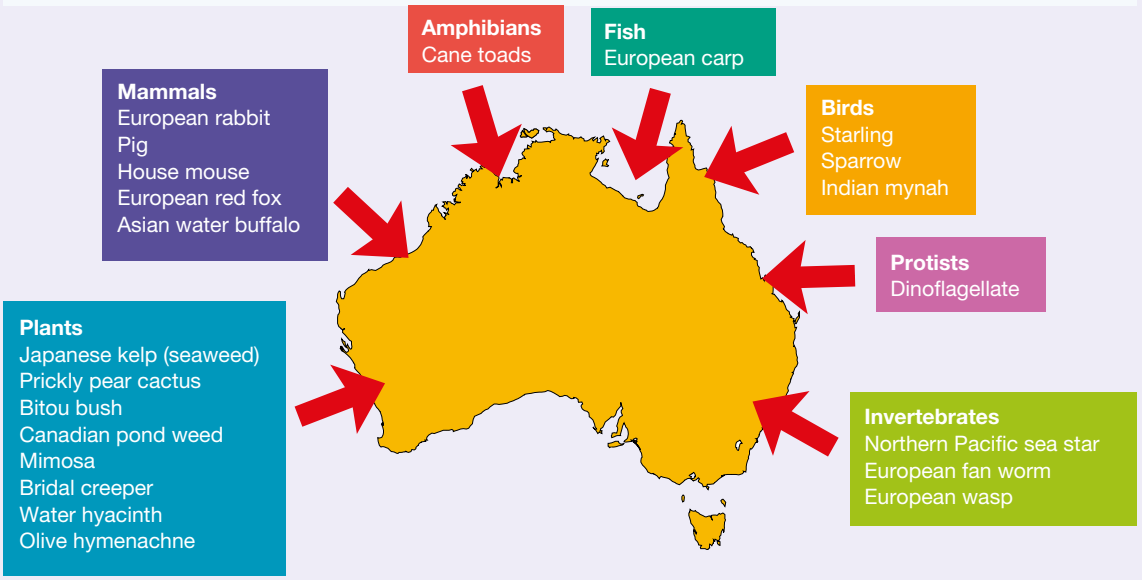
14. It’s another lovely warm night with a slight breeze and a whiff of blossom in the air … but what’s that dreadful noise? It’s the cicadas’ mating call! They may look scary with their strange-shaped heads, but they won’t sting or bite you, and they are not poisonous.
    (a) Find out more about the life cycle of cicadas, where they live, what they eat and who eats them.
    (b) Use a relations diagram to show possible causes of a decrease or increase in their population.



15. Construct three food chains from the food web at right.
    (a) In the food web, identify the:
        (i) producer
        (ii) primary consumer
        (iii) secondary consumer
        (iv) tertiary consumer.
    (b) In the food web, identify which organism is both:
        (i) a secondary and a tertiary consumer
        (ii) a tertiary and a quaternary consumer.
    (c) Suggest the effect of reduced numbers of Antarctic krill on the ecosystem.
16. Select one of the introduced organisms shown in the figure below. Find out and report on:
    (a) where they came from and how they arrived in Australia
    (b) the effects that they have had on Australian ecosystems



Some of the exotic species introduced to Australia since the late 1700s (the arrows *do not represent* the point of introduction)



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Complete this digital doc: Worksheet 4.10: Ecosystems: Summary (doc-19822)

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TOPIC 5
Separating mixtures

5.1 Overview

Any substance that is not a mixture is a pure substance. When coloured watercolours are applied to paper, sometimes the colours in the inks separate. This means that each ink is made up of separate colours. This technique is called chromatography. What other techniques can be used to separate mixtures?



5.1.1 Think about Mixtures

assessON

- What makes a fizzy drink fizz?
- How does the Red Cross separate the red and white blood cells from the blood of donors?
- How can you get fresh water from sea water?
- What do a vacuum cleaner and tea strainer have in common?
- What happens to your waste after you flush the toilet?
- Where is the cream in homogenised milk?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

5.1.2 Your quest

A world of mixtures

The ground that you stand on, the air that you breathe and the oceans of the Earth are all mixtures. For example, air is a mixture of many gases, including nitrogen, oxygen and carbon dioxide. Ocean water is a mixture of pure water, salt and many other substances. Even the fresh water in lakes and rivers is not pure and always contains small amounts of other substances.

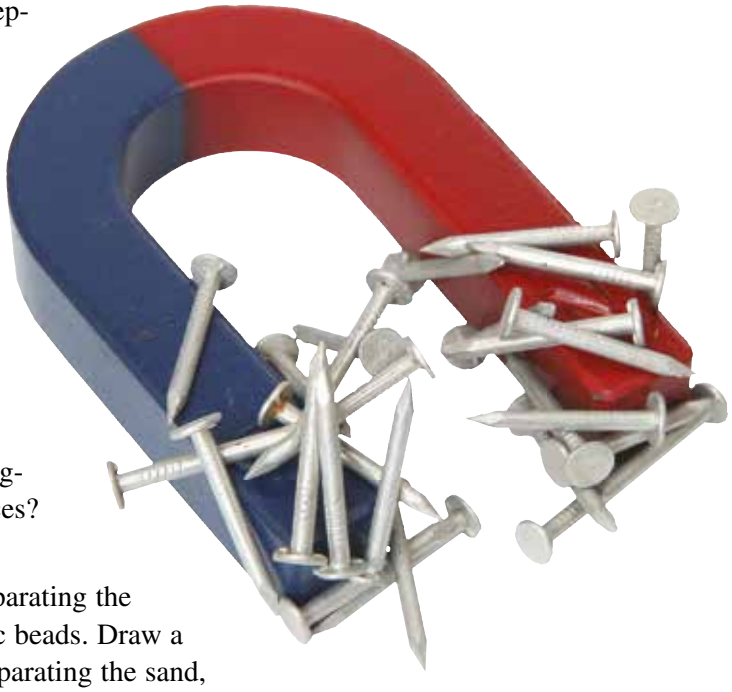
Think

1. Are the rocks and soil on Earth also mixtures that can be separated? How?

Separating mixtures

Unlike pure substances, mixtures are usually easy to separate into their different parts. For example, imagine that a few small iron nails have been dropped into a child's sandpit and have sunk into the sand so that they can't be seen. One way of separating the nails from the sand is to use a magnet. This works because the nails and sand have different **properties**, or features. The nails are made from a substance that is attracted to magnets, but the sand is not attracted to magnets.

But what if plastic beads had been dropped into the sandpit instead of nails? They can't be separated from the sand with a magnet. The key to separating them is recognising the different properties of the plastic beads and the sand. An obvious difference is size. The plastic beads are much bigger than grains of sand. A child's sand sieve would do the trick. Sand grains pass through but the plastic beads don't.

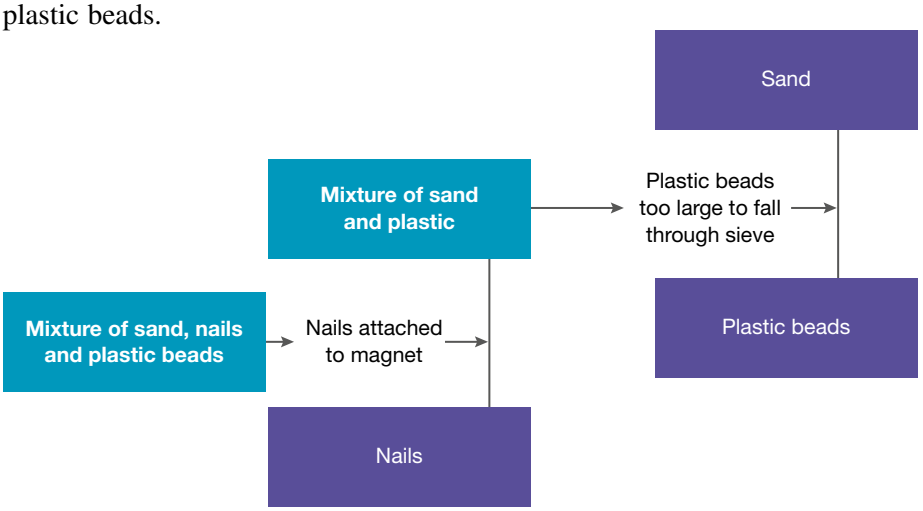


Think

2. Suggest another method of separating the nails from the sand.
3. What difference in properties does your suggested method use to separate the substances?

Think and create

4. The flowchart below shows one way of separating the parts of a mixture of sand, nails and plastic beads. Draw a flowchart to show a different method of separating the sand, nails and plastic beads.



INVESTIGATION 5.1

Design and separate

AIM: To plan and carry out a method of separating the four parts of a mixture

Materials:

sand (about 250 mL)
'dead' matches
small pebbles
steel paperclips
A3 paper
plastic container (about 500 mL)
water as required

Method and results

Your task is to separate the four parts of a mixture of dead matches, pebbles, steel paperclips and sand.

- Mix the matches, pebbles and paperclips evenly in a plastic container of sand.

1. Devise and write a step-by-step plan of a method to separate the four parts. You will need to think about the properties of each part of the mixture that will make separation possible.
2. Make a list of all of the equipment that you will need.
   - Check your plan with your teacher, and then gather the equipment and perform the separation.
3. On A3 paper, draw a flowchart like the one on the previous page to show how each part was separated from the mixture.

5.2 What's in a fizzy drink?

5.2.1 Looking at solutions

The 'fizz' in fizzy drinks is the carbon dioxide gas that is dissolved in the flavoured liquid. Carbon dioxide is pumped into bottles or cans at high **pressure**. The bottles and cans are then sealed to keep the carbon dioxide **dissolved** in the water. When you open the container, the pressure is reduced and the carbon dioxide bubbles out.

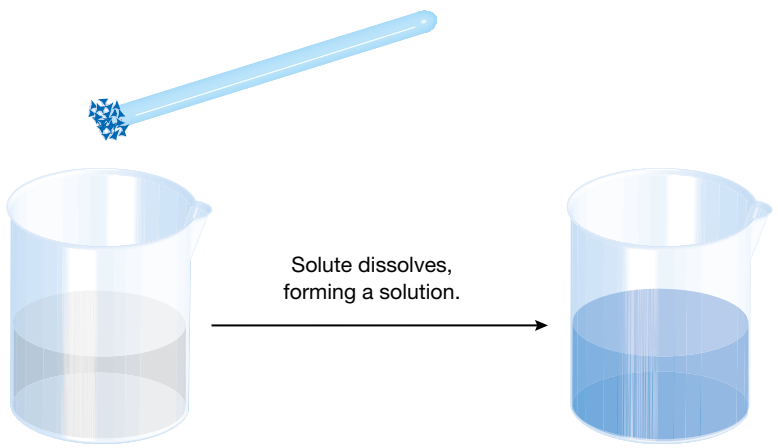
Like most substances, fizzy drinks are mixtures of other substances. If you look at the label on a bottle or can of soft drink, you will see that, as well as carbon dioxide, it also contains sugar, food colouring, flavouring and preservative. Preservatives stop the substances in soft drinks from going off. Flavourings are added to make the drink taste more pleasant and food colouring is added to make the drink look more attractive.

All of these substances are dissolved in water. A mixture of one substance dissolved in another is called a **solution**. The substance that dissolves is called the **solute**. The substance that the solute dissolves in is called the **solvent**. Solutions in which water

When carbon dioxide is dissolved you can't see that it's there. When you open the container, the pressure is reduced. Adding a sugar-coated mint lolly makes all the carbon dioxide bubble out at once.



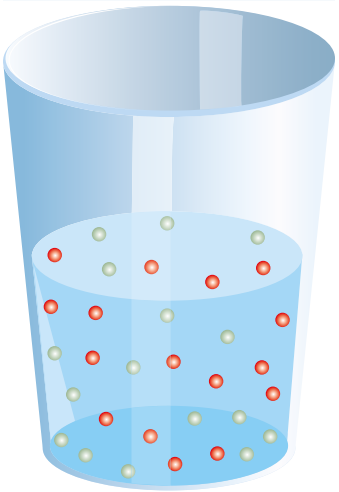
Adding a soluble substance to a liquid



is the solvent are called **aqueous solutions**. Water is a good solvent because many chemicals can dissolve in it. Fizzy soft drinks are aqueous solutions.

Substances that dissolve in a liquid are said to be **soluble**. Those that do not dissolve are said to be **insoluble**.

In a solution, the particles of one substance (the solute) are spread evenly throughout the other (the solvent). The particles of the solute are too small to be seen.



5.2.2 'Do-it-yourself' fizz

You can make carbon dioxide gas using two chemicals found in your kitchen — vinegar and bicarbonate of soda.

When these two chemicals are mixed in Investigation 5.3, a **chemical reaction** takes place. The vinegar and bicarbonate of soda change into new substances. One of these new substances is the gas carbon dioxide, a pure substance and the same gas that is in fizzy drinks. The rough surface of the sultanas allows the carbon dioxide bubbles to collect on the surface. The carbon dioxide bubbles rise, carrying the sultanas with them. When the bubbles reach the surface, they burst and the sultanas sink to the bottom.

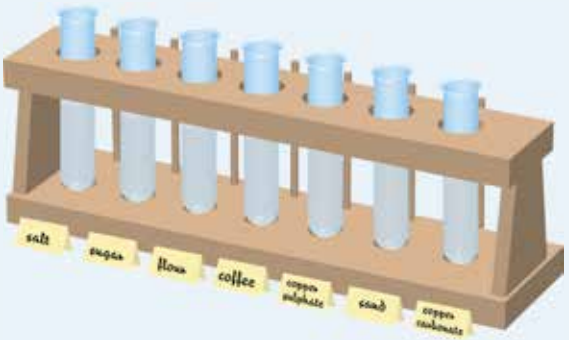
INVESTIGATION 5.2

Soluble in water?

AIM: To test a range of substances for solubility

Materials:

safety glasses and laboratory coat
heatproof mat
7 test tubes in a test-tube rack
spatula
samples of salt, sugar, flour, coffee, sand, copper sulfate and copper carbonate



Method and results

- Half-fill each of the test tubes with cold water.
- Label the test tubes: salt, sugar, flour and so on.
- Use a spatula to add a very small amount of each substance to its labelled test tube. Do not use more than a quarter of a spatula full.

1. Draw up a table of your results like this incomplete one:

Substance mixed with water	Clear or cloudy?	Soluble or insoluble?
Salt		
Sugar		
Flour		

- Hold each test tube up to the light. Decide whether the mixture is clear or cloudy. Record your results in the table.

2. Decide whether each mixture is soluble or insoluble. Record this in the table.
3. Which of the substances dissolved in water?

Discuss and explain

4. How can you tell if a substance has dissolved?
5. How can you tell that a substance has not dissolved?

INVESTIGATION 5.3

Froth and bubble

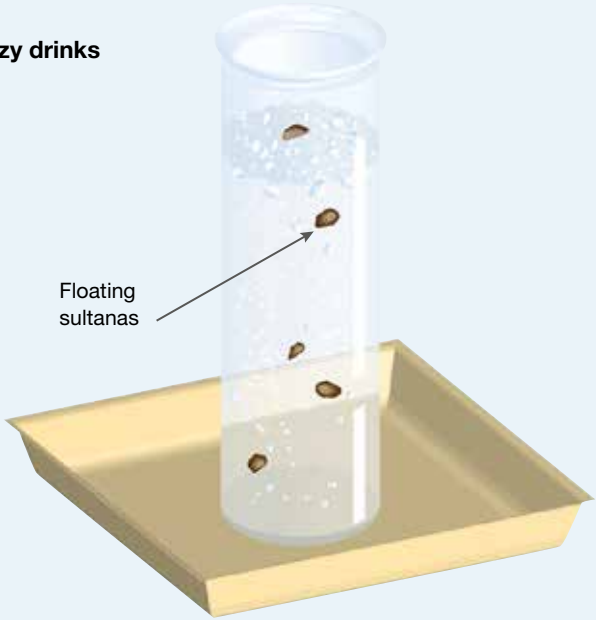
AIM: To model the separation of carbon dioxide from fizzy drinks

Materials:

vinegar
bicarbonate of soda
spatula
plastic tray
stirring rod
gas jar
sultanas

Method and results

- Stand the gas jar on a plastic tray and pour the vinegar into the gas jar until it is 2 cm from the top.
- Add a spatula of bicarbonate of soda and several sultanas.
- Stir the vinegar and remove the stirring rod.
- Watch the sultanas as they rise and fall in the gas jar.



Discuss and explain

1. Explain how the sultanas rise to the surface.
2. When the sultanas get to the surface why do they drop back to the bottom?
3. Try other things in the gas jar to see whether they can be carried to the surface.

5.2.3 A matter of concentration

When more solute is dissolved in a solvent, the solution is said to be more **concentrated**. For example, by adding more and more sugar to a cup of hot water, you are making the solution more and more concentrated. Eventually the solution gets so concentrated that no more sugar will dissolve in it. When no more solute can be dissolved in a solvent, the solution is **saturated**.

You could make a solution of sugar and water less concentrated by adding more water. This process, where more solvent is added, is called **dilution**. When you add water to bottled cordial you are diluting it.

The cordial in these glasses is a coloured solution. Can you tell which has the greatest concentration of cordial syrup?



5.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Is fizzy soft drink a solution, solvent or solute?
2. List the solutes likely to be found in a bottle or can of fizzy soft drink.
3. What leaves a fizzy drink to cause it to go flat?
4. What substance is added to cordial to make it more dilute?
5. Describe how an aqueous solution is different from other solutions.

Think

6. Copy and complete this table by filling in the 'Solvent' and 'Solutes' columns.

Solution	Solvent	Solutes
Soft drink		
Sea water		
Swimming pool water		
Jelly		
Cup of coffee		

7. A bottle of soft drink left lying in the sun may burst open. Explain why.
8. What is the difference between a concentrated solution and a saturated solution?
9. What substance should you add to salt water to make it:
   (a) more concentrated
   (b) less concentrated?

Investigate

10. It is claimed by manufacturers that some washing powders work just as well in cold water as in hot water. Investigate washing powders to find out whether they dissolve as well in cold water as they do in hot water.
11. Conduct a survey of food and drink products. Use the list of ingredients to determine what is in them. What are the most common chemicals added to food and drink products?
12. Design your own experiment to test whether a fizzy drink will go flat faster when it's cold or when it's warm. Remember to use a **fair test**. You must keep everything the same except the one thing that you want to test.
13. Place an unopened can of soft drink and an unopened can of diet soft drink of the same type in a sink of water.
    (a) Which can floats?
    (b) Which can sinks?
    (c) What does this tell you about the sugar in soft drinks and diet soft drinks?
14. Find out how much sugar can be dissolved in 200 mL of water at room temperature and what difference an increase in temperature of 10 °C makes.

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Complete this digital doc: Worksheets 5.1: Soluble or insoluble? (doc-19823)

Complete this digital doc: Worksheet 5.2: Mail room mayhem (doc-19824)

5.3 Kept in suspension

5.3.1 Kept in suspension

There are many ways of separating mixtures in a laboratory. Some methods are simple and quick and others need expensive equipment and take some time.

No matter how hard you try, you can't dissolve sand in water; sand is insoluble. If you shake up the sand and water in a sealed jar, the sand spreads through the water, forming a cloudy **suspension**. When you stop shaking the jar, the particles of sand are suspended in the water briefly, but they soon settle to the bottom, forming a **sediment**. Muddy water is also a suspension, but most of the particles in mud are smaller than sand particles so it takes much longer for them to settle to the bottom. Some insoluble substances don't form suspensions but float on top of the liquid.

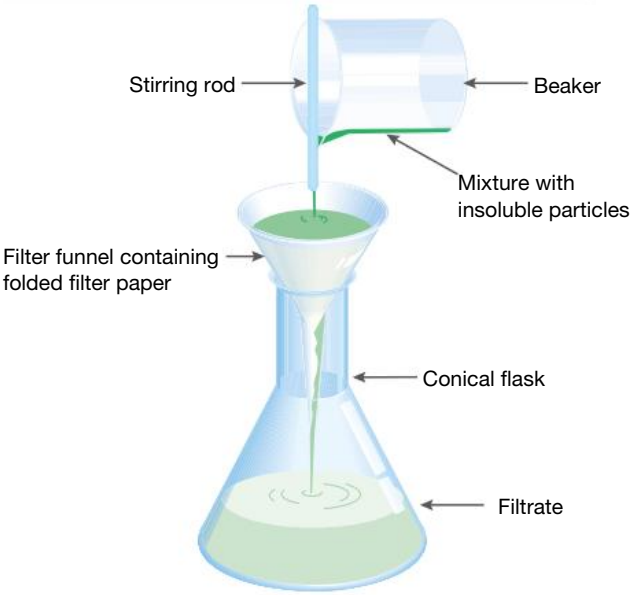
What do a vacuum cleaner, tea strainer and protective face mask have in common? They are all devices for separating particles from suspensions by **filtration**. In the laboratory, filtration is carried out using

filter paper, but there are many other useful methods of filtration that are used in the home and in industry. In filtration, solutions, solvents or gases pass through the filter but particles that cannot fit through the filter are trapped by it. Insoluble particles can be separated from a mixture using filter paper in a funnel as shown below.

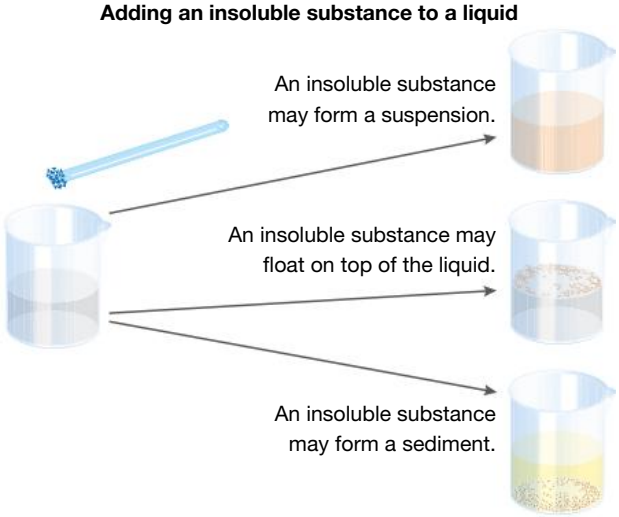
5.3.2 Sift and separate

The particles of solutes dissolved in a solution are so small that they can't be seen, and they can't be separated from a solution by filtration.

Equipment used to filter a mixture that contains insoluble particles



Adding an insoluble substance to a liquid



WHAT DOES IT MEAN?

The word *residue* comes from the Latin word *residium*, meaning 'left over'.
The word *aqueous* comes from the Latin word *aqua*, meaning 'water'.

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Try out this interactivity: Filtration (int-0223)

5.3.3 More mixtures

Some mixtures are neither solutions nor suspensions. A mixture that contains suspended particles too small to settle or be removed by filtering is called a **colloid**. Unlike solutions, which are clear, colloids are cloudy. Colloids can be formed by solids, liquids or gases. Examples of colloids include mist, cappuccino froth, whipped cream and paint. An **emulsion** is a colloid in which one liquid is spread evenly through another and the liquids don't settle out into layers. Homogenised milk and mayonnaise are examples of emulsions.

Unhomogenised milk has a layer of insoluble cream floating on the milk; homogenised milk is an emulsion.



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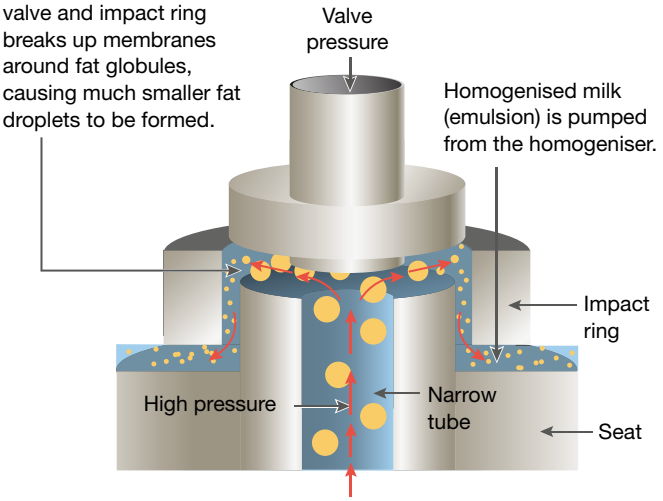
Try out this interactivity: Mixtures (int-0224)

5.3.4 Settling down

There are a number of ways of separating mixtures that are not solutions. The simplest method of separating a mixture of a liquid and an undissolved solid is **decanting**. The solid is allowed to settle to the bottom of the container, forming a sediment. The liquid is then carefully poured off the top. Decanting can be used to separate most of the mud from muddy water. After the mud has settled, the water can be poured off. If the water is still cloudy, it can be filtered to remove the remaining undissolved particles.

Aboriginal Australians combine **sieving** (a type of filtration) and decanting to prepare native yams, which contain a poison. The yams are boiled and placed into a dilly bag. The bag is squashed and the softer parts of the yam are strained through the bag into a can of water. The bag acts as a sieve, allowing some substances to pass through but not others. The skins and harder parts of the yam that are left in the bag are thrown away. The water is decanted from the can, and repeated washing with water removes more poison. The yam is then placed into another dilly bag and hung up overnight before being ready to eat.

The homogenisation process



INVESTIGATION 5.4

Filtration in the laboratory

AIM: To use filtration to separate substances in a mixture

Materials:

100 mL beaker *funnel* *filter paper*
glass stirring rod *conical flask*
insoluble substance, such as soil, chalk dust or charcoal

Method and results

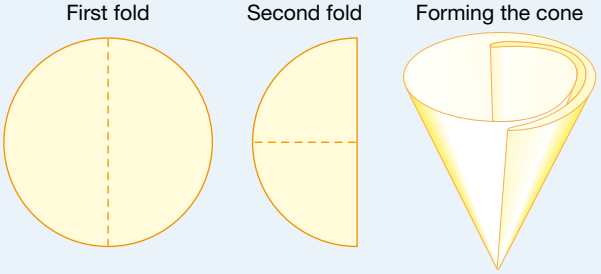
- Half-fill your 100 mL beaker with water.
- Add your insoluble substance to the water and stir with the stirring rod.
- Set up the equipment for filtering as shown in the diagram on the previous page.
- Fold the filter paper as shown in the diagram below.
- Place the filter paper in the funnel and moisten with clean water to hold the filter paper in place.
- Pour your mixture into the filter paper.

1. Describe the appearance of your mixture in the beaker before filtration. Did it form a suspension or sediment, or float on top?
2. The liquid passing through the filter into the conical flask is called the **filtrate**. Describe your filtrate.
3. Examine your filter paper. The material trapped by the filter paper is called the **residue**. Describe your residue.

Discuss and explain

4. Filter paper is like a sieve with small holes in it. Explain how the filter paper worked like a sieve in this experiment.

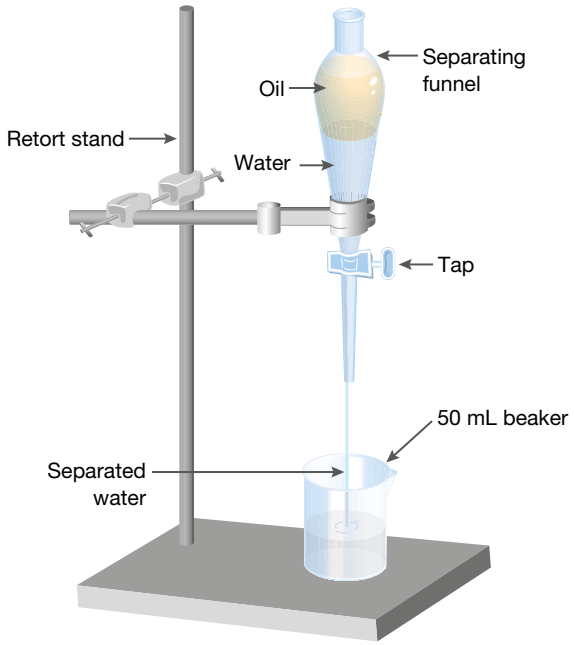
Origami cone: Folding filter paper



5.3.5 The separating funnel

When one liquid does not mix with another but floats on top of it, a **separating funnel** can be used to separate the two liquids. Oil floats on water. This mixture can be separated using a separating funnel as shown on the right.

Using a separating funnel to separate oil from water



5.3.6 Centrifuging

A mixture can be separated by spinning it very quickly. This method is called **centrifuging**. The spin-dry cycle of a washing machine acts as a centrifuge and a filter. As it spins at high speed, the clothes are forced to the sides of the tub and the water passes out through the holes in the tub. The clothes cannot fit through the holes and so much of the water is removed from them.

In the laboratory, centrifuging is used to separate solid or liquid substances from liquids. The mixture is placed in special test tubes that are spun in a circle at high speeds. The heavier substances are forced to the bottom of the tube and the lighter substances are left near the top.

WHAT DOES IT MEAN?

The word *centrifuge* comes from the Latin words *centrum*, meaning 'centre', and *fugere*, meaning 'flee from'.

5.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Replace each of the following expressions with a single word.
   (a) Liquid in which a substance dissolves
   (b) Insoluble particles dispersed in a liquid
   (c) Liquid passing through filter paper

(d) Substance that dissolves in a liquid
(e) What is formed when a solute dissolves in a solvent
(f) Material deposited on a filter
(g) An insoluble substance that sinks to the bottom

2. Describe what happens to a suspension if it is left to stand.
3. How can you distinguish a colloid from:
   (a) a suspension
   (b) a solution?
4. Which types of substances mix with each other to form emulsions?

Think

5. Think of some filters used in the home. Construct a four-column table like the one below to describe the filters.

Filter	Mixture	Residue	Filtrate
Vacuum cleaner	Air and dust	Dust	Air
Food strainer	Chips and hot oil	Chips	Oil

6. The air filter and oil filter in a car engine have to be replaced occasionally. Why do you think this is done?
7. List some examples of separating mixtures in the kitchen using:
   (a) filtration
   (b) decanting.

Imagine

8. You are out in the bush and the only water available to drink is in a muddy waterhole. You have an empty bottle and a cup. How would you remove the dirt from the muddy water so that you could drink the water?

Investigate

9. The kidneys act as filters to remove wastes from our blood. Find out more about how the kidneys filter wastes from the blood.
10. What types of paper can be used to filter a suspension? Carry out an investigation that tests a variety of different papers (such as newsprint, tissue paper, brown paper, kitchen towel and so on) for their suitability as filter paper. Write a report on your findings.
11. An oil spill at sea can ruin the local environment and kill wildlife. Find out when and where the worst oil spill disasters have occurred and how the oil was separated from the water.

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Watch this eLesson: Centrifuging (eles-0061)

Complete this digital doc: Worksheet 5.3: The pool shop (doc-19825)

5.4 Separating blood

Science as a human endeavour

5.4.1 Separating blood

About one million donations of blood are made in Australia each year. Some of the donations are given to people who have lost blood during surgery, accidents or disasters. Blood is also given to people during the treatment of many diseases, including cancer. These people need to be given a regular supply of blood.



Red cross blood donor

Plasma donation

Some donors give only the plasma from their blood. As the blood is taken out of the donor, it passes through a machine that separates the plasma from the rest of the blood. The blood cells are pumped back into the donor.

Standard whole blood donation

Blood cells are suspended in the plasma. Like other suspensions, blood donations can be separated into parts by spinning. Red and white blood cells are heavier than plasma and platelets, so they are forced to the outside edges of the containers in the centrifuge.

Centrifuge

Plasma and platelets

Centrifuge

Further centrifuging separates the plasma solution from the platelets. Plasma is used to treat many diseases.

Platelets

Plasma

Red and white blood cells

Filtration

The mixture of red and white blood cells can be separated by a special kind of filtration. Red cells are used to treat people who have lost blood in an accident or surgery.

White blood cells not used

Red blood cells

5.4.2 The blood mixture

Blood is a life-giving mixture. It can be separated into four parts: **plasma**, a clear, yellowish liquid; **red blood cells**, which carry oxygen; **white blood cells**, which fight disease; and **platelets**, which clot blood.

Because each part of the blood has a special job to do in our bodies, different problems can be treated with different parts of the blood. In Australia, blood is collected and separated by the Australian Red Cross Blood Service. Separation allows doctors to treat a larger number of patients and save many lives. The blood cells and platelets are separated from blood donations by spinning in a refrigerated centrifuge. Further centrifuging separates the platelets and different types of blood cells.

Once blood is separated, each part has to be stored differently.

- Red blood cells can be stored for 42 days at 2–6 °C.
- Plasma can be frozen for 12 months at –40 °C.
- Platelets are stored for 5 days at 20–24 °C. During this time they have to be moved at least every 12 hours, to stop them clumping together. (Platelets seal wounds in our bodies by sticking together.)

Blood type	Percentage of population	Most useful donations	Main uses
AB	3%	Plasma	AB plasma can be given to any blood type.
A	38%	Whole blood, plasma or platelets	Common blood type so high demand for these products
B	10%	Plasma	Particularly useful for people with blood diseases, severe burns or trauma
O–	9%	Whole blood or platelets	All products can be given to any blood type.
O+	40%	Whole blood, plasma or platelets	Most common blood type; high demand for these products

HOW ABOUT THAT!

The average human body contains between 5 and 7 litres of blood. During exercise, each drop of blood passes through the heart about 8 times every minute. The blood travels through blood vessels. The total length of a person's blood vessels is about 800 000 km! Compare this with the **circumference** of the Earth, which is about 40 000 km. How amazing is that!

5.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. List the four components that the blood from donors is separated into.
2. Explain why blood is separated into different parts.
3. Which technique is used to separate the different parts of blood?

Think

4. Explain why blood is separated in a centrifuge rather than left to settle by itself.
5. Identify the property of plasma and platelets that allows them to be separated with a centrifuge.

Create

6. Create an advertisement to encourage people to donate blood. The advertisement could be in the form of a poster, a song, a set of digital photos or part of a multimedia presentation.

Research and report

7. In an average week, the Australian Red Cross Blood Service needs about 21 000 blood donations to meet the need for blood and blood products. Research and report on the following questions.
   (a) How old do you need to be to donate blood?
   (b) What is the minimum body weight required of blood donors?
   (c) Why are you not allowed to donate blood if you have recently had a tattoo?

5.5 Separating solutions

5.5.1 What's the solution?

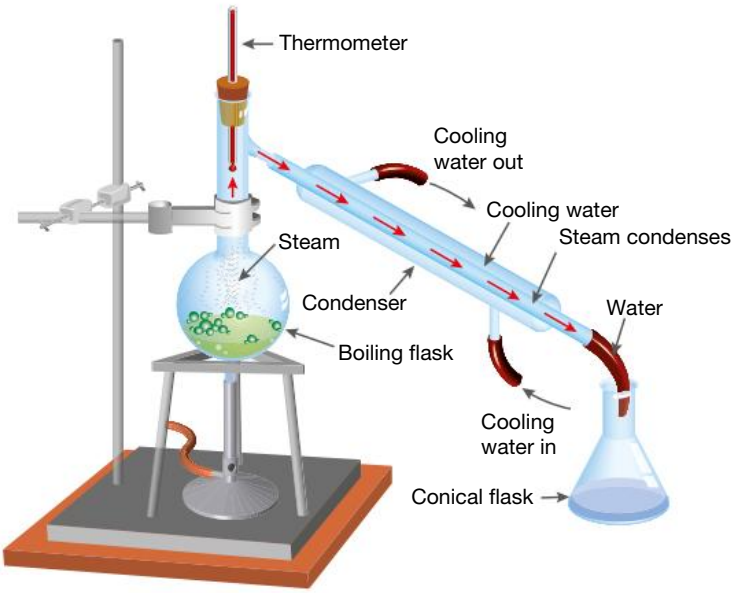
Imagine being stranded on a small, sandy island with no fresh water to drink. You are surrounded by the sea. But you can't drink the sea water; it would dehydrate you even further. You have to find a way of separating the water from the salt dissolved in it. What can you do?

Sea water is a solution. Separating the solute from the solvent in a solution is usually much more difficult than separating undissolved substances from a liquid. Filtration won't work — the dissolved particles are too small. Neither will decanting or centrifuging. You can't even see the dissolved particles. The answer lies in the fact that the solvent and solute have different properties. In the case of salt water, when heated to 100 °C the water evaporates and boils away, leaving the salt behind as solid crystals.

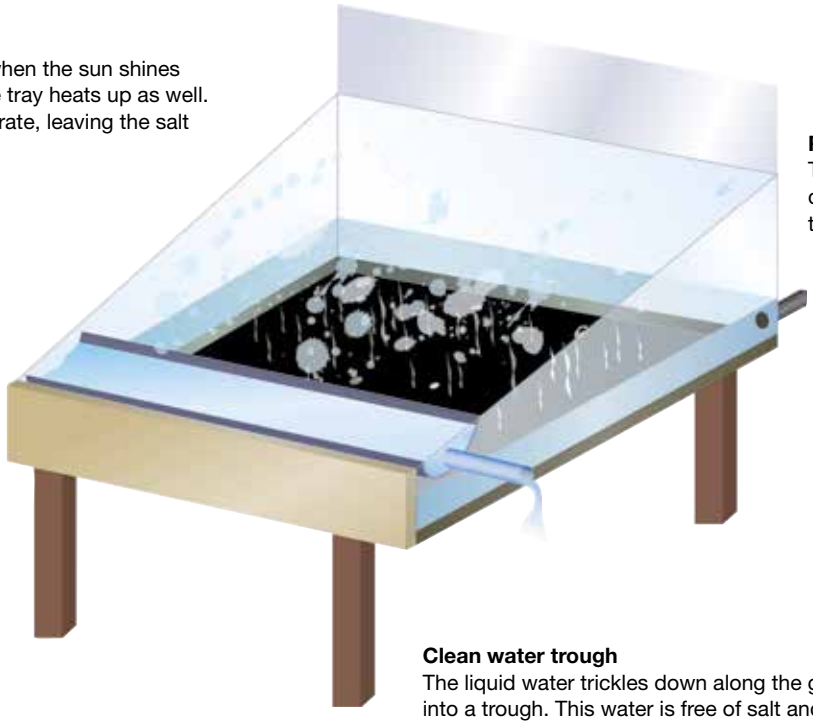
5.5.2 Distillation

In the laboratory, pure water is produced by a process called **distillation**. Tap water is poured into the boiling flask (see the diagram below) and heated to the boiling temperature for water, 100 °C. The water boils, **evaporates** and becomes steam. The steam travels along the **water condenser**. The steam inside the condenser is cooled to below 100 °C and **condenses** to form liquid water. The condenser is kept cool by running cold water through its outer jacket.

Equipment used for distillation in the laboratory



Solar distillation. The sun's energy can be used to distill sea water.



Black tray
The black tray warms up when the sun shines on it. The salty water in the tray heats up as well. The water begins to evaporate, leaving the salt behind.

Reflector
The reflector helps to direct sunlight onto the tray.

Glass cover
The glass cover stops the evaporated water from escaping. When the **water vapour** reaches the glass, it begins to cool down. The vapour turns back into liquid water.

Clean water trough
The liquid water trickles down along the glass cover and falls into a trough. This water is free of salt and other impurities. The salt remains in the black tray, where it can be collected and used for other purposes.

The pure water collected in the conical flask is called the **distillate** and can be rightly labelled **distilled water**. The impurities in the water are left behind in the boiling flask.

Distillation can be used to separate pure water from sea water. It can also be used to separate a mixture of two liquids as long as they boil at different temperatures.

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Watch this eLesson: Distillation (eles-0060)

5.5.3 Evaporation

Pure water can be separated from salty water without boiling it. The salt and other impurities are left behind. The process takes longer, but the energy of the sun can be used to evaporate the water. The solar still shown above could be used to produce small amounts of pure water from salt water.

When evaporation is used to separate pure water from salty water, the salt is left behind as crystals. If it is more important to collect the solute than the solvent, this process of separation is called **crystallisation**. Table salt is produced by the process of crystallisation, using energy from the sun to evaporate sea water or water from salt lakes.

5.5.4 The desert island solution

In places where fresh water is scarce, a simple water still like the one on the next page could be used to evaporate and collect pure water. If the water is muddy or not clear, it should be filtered first to separate the undissolved particles. On a desert island a handkerchief could be used as a filter.

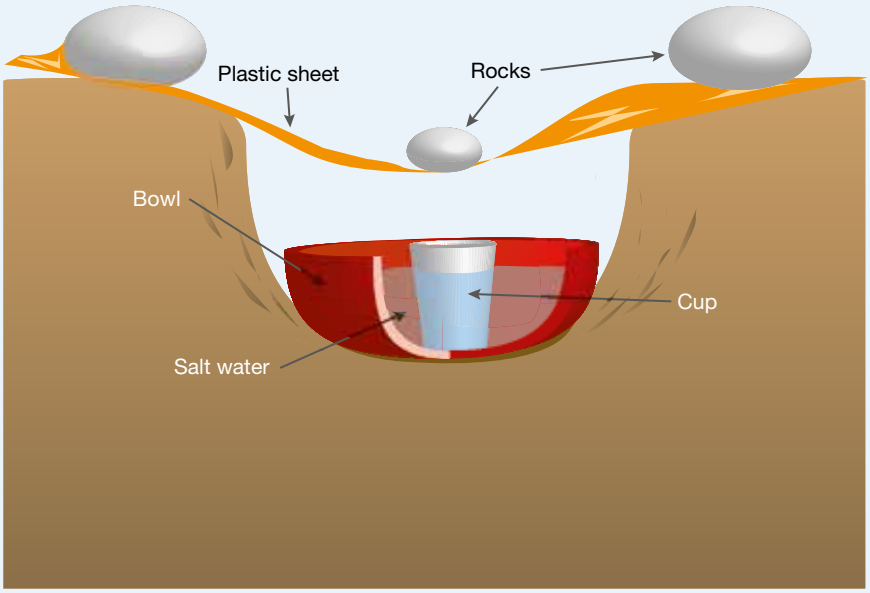
INVESTIGATION 5.5

Making a simple water still

AIM: To use a simple still to separate salt from salt water

Materials:

trowel
bowl
scissors
some small rocks
cup
saltwater solution
plastic bag



Method and results

- Dig a shallow hole in the ground outside. The hole should be a few centimetres deeper than the height of the cup and should be in a spot that gets a lot of sun.
- Put the bowl in the bottom of the hole and put the cup in the middle of the bowl.
- Pour the salt water into the bowl. Don't allow any salt water to get into the cup.
- Cut the side seams of the plastic bag and open it up so that it forms a flat sheet of plastic. Place the plastic over the hole, using small rocks to anchor it in place. Make sure that the hole is completely covered.
- Place a small rock in the middle of the plastic sheet, just above the mouth of the cup.
- Leave undisturbed for a couple of hours then examine the contents of the bowl and the cup.

Discuss and explain

1. How has the water level in the bowl changed?
2. Is there any residue on the walls of the bowl? What do you expect this is made of?
3. How is the water in the cup different from the water in the bowl? You may need to taste it to tell the difference — check with your teacher first!

5.5.5 Large-scale separation

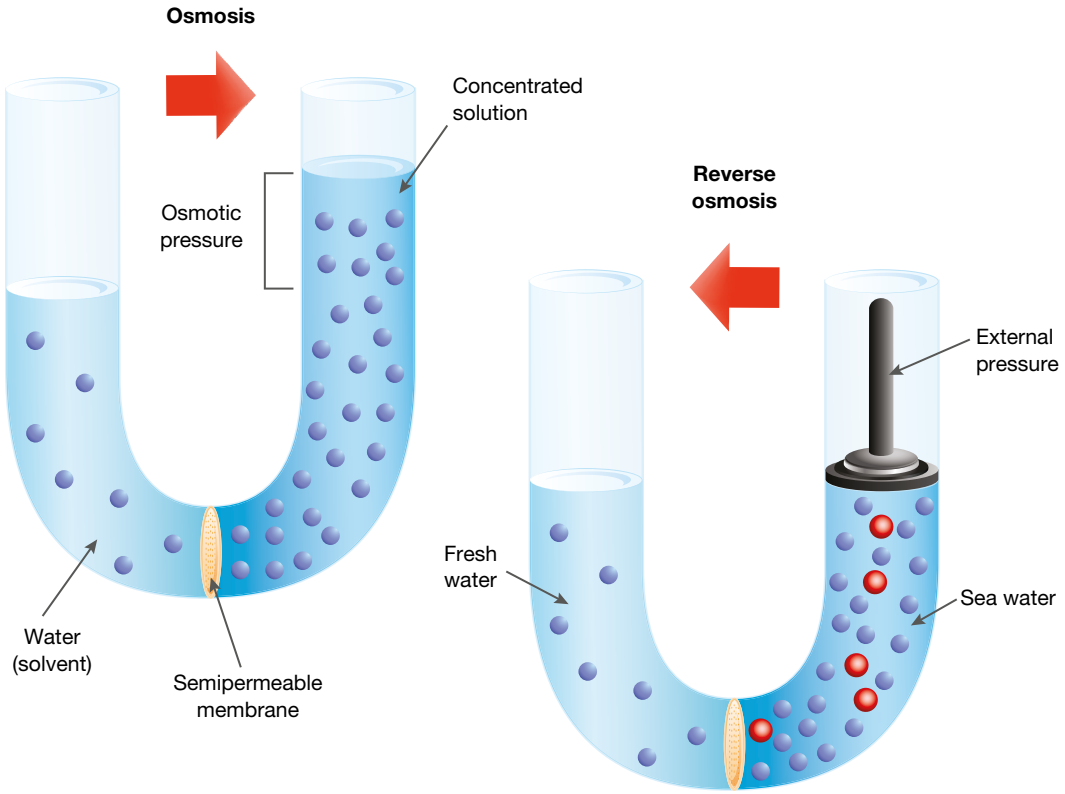
The processes of distillation and evaporation are not suitable for purifying sea water on a scale large enough to supply drinking water to large communities. In New South Wales, Victoria, Western Australia and South Australia, desalination plants have been built. In all of these plants, a process called **reverse osmosis** is used to separate salt from large quantities of sea water.

In the process of **osmosis**, water moves through a very thin membrane from an area of low salt concentration to an area of high salt concentration. This continues until the concentration of salt is the same on both sides of the membrane. The membrane has tiny holes that allow water to pass through without the salt. In reverse osmosis, the water is forced under very high pressure to flow through the membrane in the opposite direction.

In desalination plants, sea water is pumped under high pressure through thin membranes in coils. The pure water that has passed through is directed to drinking water supply tanks. The very salty water left behind is pumped back into the sea.

The use of desalination plants is controversial. Two major concerns are:

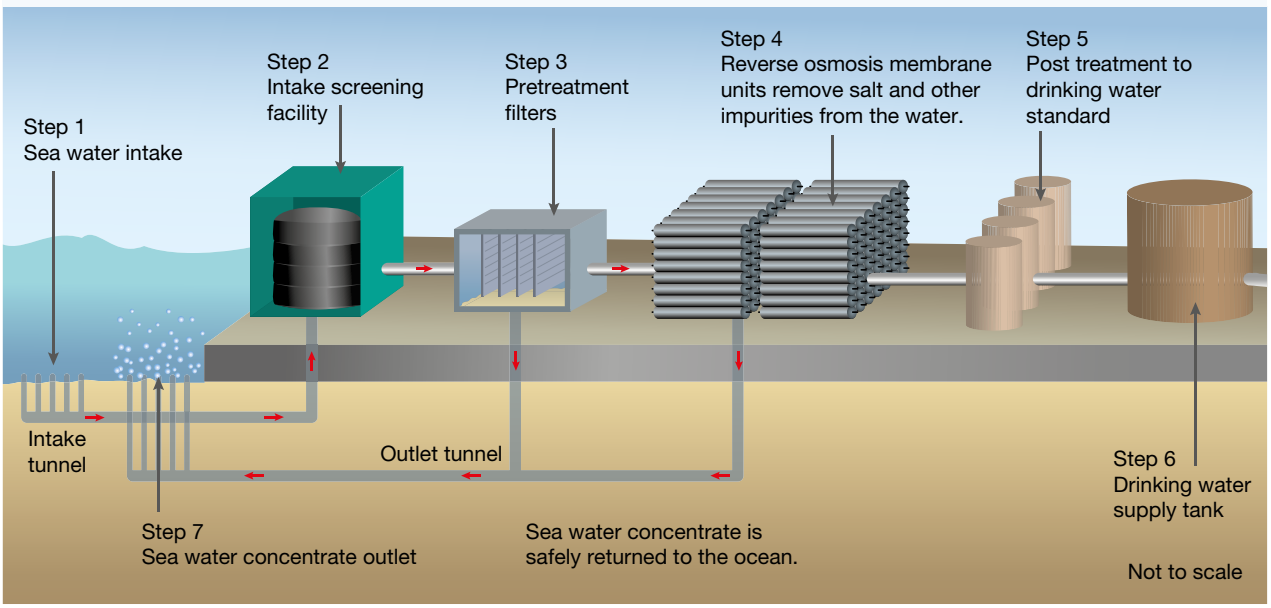
- they use a lot of energy, which is usually supplied by coal-fired power plants. Apart from the pollution caused by these plants, there are many who feel that they are not **sustainable**. That is, they cannot



continue to operate without putting the environment and our future at risk. In some cases, the large amounts of energy used are offset by constructing wind farms or by supporting other renewable sources of energy.

- the water flowing back to the sea contains much more salt than sea water. It is also warmer. This poses a threat to marine animals and plants that live near the desalination plant. The threat can be reduced by choosing suitable locations for the salty water outlet. This requires scientific studies by marine biologists and other scientists. In the case of the Wonthaggi plant in Victoria, the outlet is around 1 kilometre offshore.

Example of a desalination plant



5.5.6 Chromatography

Paints, inks, dyes and food colourings are often mixtures of substances that have different colours. You can separate a mixture of different colours using **paper chromatography**.

In paper chromatography a liquid soaks through the paper carrying the mixture with it. Some substances in the mixture are carried through the paper faster than others. In this way the substances in the mixture are separated along the paper.

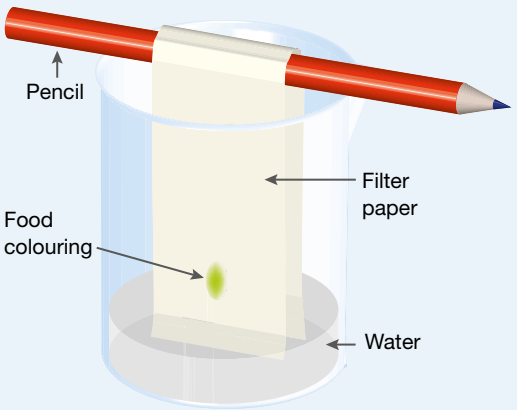
INVESTIGATION 5.6

Separating colours

AIM: To use paper chromatography to separate substances in food colouring

Materials:

food colouring
toothpick
filter paper
scissors
250 mL beaker
pencil
ruler



Method and results

- Cut a piece of filter paper approximately 10 cm by 3 cm.
- Rule a pencil line 2 cm from the end of the paper.
- Use the flat end of a toothpick to place a small dot of food colouring in the centre of the pencil line on the filter paper.
- Pour tap water into the beaker to a depth of 1 cm.
- Stand the filter paper so that the end just dips into the water. Make sure that you keep the dot of food colouring out of the water.
- Fix the filter paper to a pencil to hold it in the beaker.
- Leave the filter paper to stand until the water has risen almost to the top.
- Repeat the experiment with different food colourings.

1. What colours were in the first food colouring tested?
2. List the different food colourings that you tested. For each one, write down the colours that made up the food colouring.

Discuss and explain

3. How do you think the colours are actually separated using this method?

HOW PAPER CHROMATOGRAPHY WORKS

Sample of coloured solution

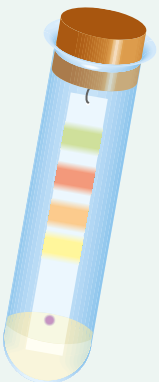
A small amount of the solution is placed on a strip of filter paper 2 cm from its end.

Solvent

The filter paper is hung so that the sample is just above the level of the solvent.

Separated colours

The colours dissolve as the solvent soaks up the paper strip. The more soluble colours move more quickly and travel further up the strip than the less soluble colours.



INVESTIGATION 5.7

Crystallisation

AIM: To observe separation by crystallisation

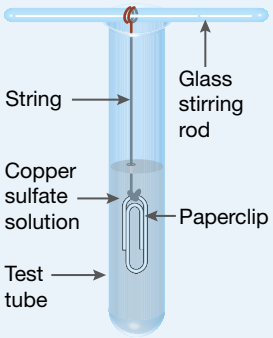
This activity must be done in class with your teacher.

Materials:

test tube
solid copper sulfate (or alum)
a balance
150 mL beaker
glass stirring rod
hot water
string
test-tube rack
piece of filter paper
filter funnel
conical flask or beaker
paperclip

Method and results

- Weigh 28 g of the copper sulfate in the beaker.
- Prepare a hot concentrated solution of the copper sulfate by pouring 20 mL of hot water into the beaker. Stir the solution until no more solid will dissolve.
- Pour the blue copper sulfate solution through the filter paper into the conical flask or beaker. The undissolved copper sulfate will remain on the paper.
- Quickly pour the solution into a test tube.
- Tie the string to the glass rod. Attach the paperclip to the end of the string and arrange it as shown at right.
- Leave to cool overnight in the test-tube rack.



1. Describe the changes that have taken place in the test tube.

Discuss and explain

2. Identify the solid substance that has formed.
3. What do you think was the purpose of the paperclip?

5.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Distillation can be used to separate a mixture of two liquids. What difference in properties between the two liquids allows this to be done?
2. What is the purpose of the glass cover on the solar still illustrated?
3. Explain how evaporation and crystallisation are different from each other.
4. Identify the colours found in this ink, from:
   (a) the fastest moving to the slowest moving
   (b) the most soluble to the least soluble.
5. What process is used to separate salt from sea water in Australian desalination plants?
6. The building of desalination plants is controversial. List two reasons for this.



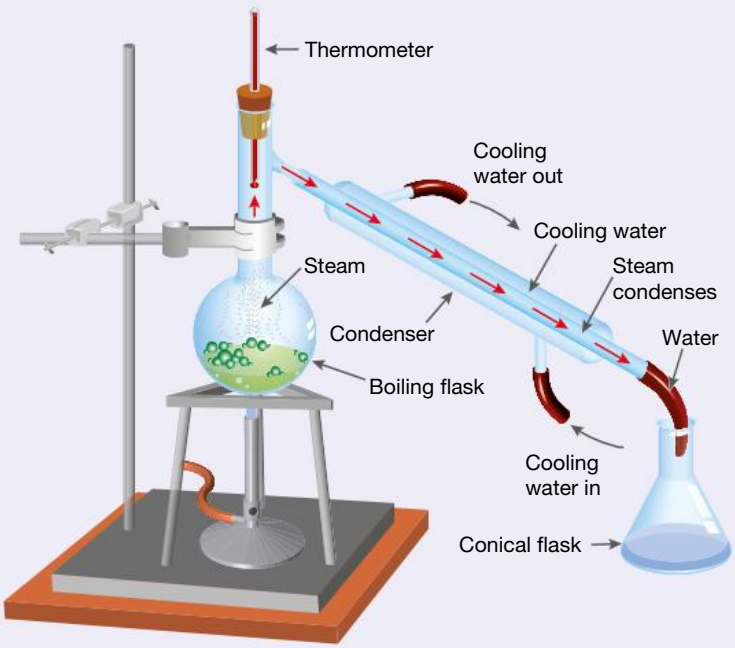
Design and create

7. Design and build a separating machine that will separate a mixture of three substances. Create a brochure to advertise your separating machine that includes:
   (a) the name of your separating machine
   (b) a diagram of the machine

(c) information on what mixture your machine will separate
(d) instructions for how to use it
(e) an explanation of why it works
(f) the advantages that your machine has for its particular use.

Think

8. Explain why cool, running water is passed through the distillation equipment shown below.



9. Explain why crystallisation is not suitable to purify water.
10. Explain why the mixture is placed above the level of the solvent rather than in the solvent in a chromatography experiment.
11. Zoe performs a paper chromatography experiment on waterproof markers using water as a solvent. Will her experiment work? Explain your answer.
12. Describe all the properties you can think of for:
    (a) salt
    (b) sand
    (c) water.
13. Explain how you would separate the parts of a mixture of salt, sand and water. Use the properties that you considered in question 12.

Investigate

14. An oil spill at sea can ruin the local environment and kill wildlife. Research and report on each of the following.
    (a) Find out how environmental and other authorities clean up oil spills at sea. List the properties of oil that allow each method to succeed.
    (b) When and where did the worst oil spill disaster occur and how was the oil separated from the sea water?
15. Investigate how to distill perfume.

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Complete this digital doc: Worksheet 5.4: Heating and distillation (doc-19826)

Complete this digital doc: Worksheet 5.5: Crystallisation and distillation (doc-19827)

5.6 Systems: Down the S-bend

5.6.1 Waste water treatment

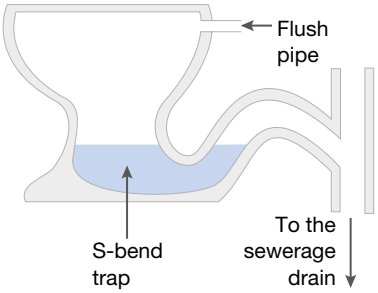
Every time you flush the toilet, have a shower, wash the dishes or your clothes or even clean your teeth, the waste water travels into an underground **sewerage** system.

The waste water is a mixture of human body waste flushed down the toilet, detergent, dirt, toothpaste, food scraps and other materials washed down the drains. The mixture, which is mostly water, is called **sewage**.

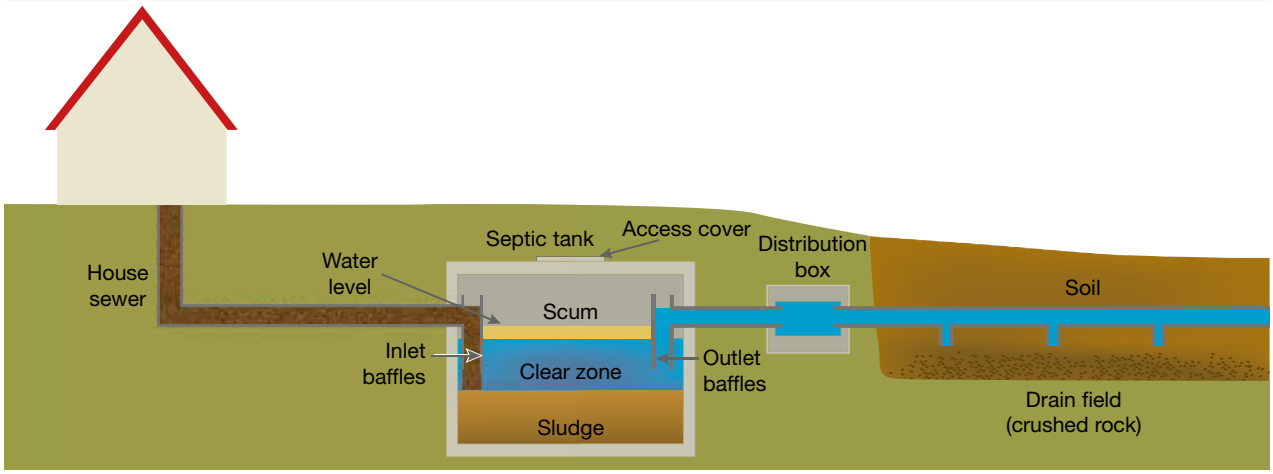
If you live in a major city, the sewage in the drain under your house flows into a larger drain under your street and travels through the sewerage system to a treatment plant. The waste water needs to be treated before it can be returned to the **environment**.

The design of treatment plants normally involves consultation between your state or territory government, engineers, scientists including biologists and environmental scientists, and local community groups. In country centres, treatment plants are usually located on the edge of the town. If there is no local treatment plant, the waste water flows into a personal sewage treatment system — a **septic tank** buried in the backyard.

The S-bend trap in the toilet fills with clean water to prevent smelly gases from the sewer travelling back into the house.



A typical septic tank system



A septic tank contains **bacteria** that break down the sewage. A thick, smelly sludge is formed. The sludge sinks to the bottom of the tank and clear water flows out into the surrounding area. The sludge needs to be removed from time to time.

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Watch this eLesson: Treating sewage (eles-0059)

5.6.2 The separation process

Waste water contains **suspended** solids such as bacteria, grit and dirt as well as some large items like rags and sticks. It also contains many dissolved substances.

When the waste water arrives at the sewage treatment plant for primary treatment, it passes through a screen (a wire mesh **filter**) that removes the larger items. The sewage then flows into settling tanks where it is kept for about two hours. In the settling tanks, suspended solids settle to form a sediment, and **floatables** such as oil and plastic collect on top of the sewage and are removed.

The watery part of the sewage flows from the settling tank into secondary treatment. This waste water still contains dissolved substances and bacteria. Secondary treatment takes place by filtering the water though soil and grass or by storing it in a series of one-metre-deep lagoons for two to four months. In the secondary treatment, the bacteria in the waste water break down the dissolved substances to purify the water further. In the lagoons, sedimentation also takes place. The treated water looks clear but it is still not safe to drink.

This advanced lagoon sewage treatment system is part of Melbourne Water's Western Treatment Plant in Werribee and covers 11 000 hectares in area. Some of this treated water is recycled and used for agriculture, horticulture and other applications.



5.6.3 Think first!

There are many materials that should not be tipped down kitchen, bathroom, laundry or school laboratory sinks. The treated water is eventually released into the sea, but there are many substances that the sewerage system is not designed to treat. Such substances include:

- chemicals such as oven cleaners and insect sprays that are poisonous
- substances like fat and oil that don't dissolve in water.

These substances can eventually find their way to the sea, polluting it and killing or harming animals, plants and other living things (such as algae) that live there. Substances like these should be saved for collection by local councils.

Small objects such as cotton buds and tampons should not be flushed down the toilet because they can block the filters at treatment plants. These objects can be put out with other household garbage.

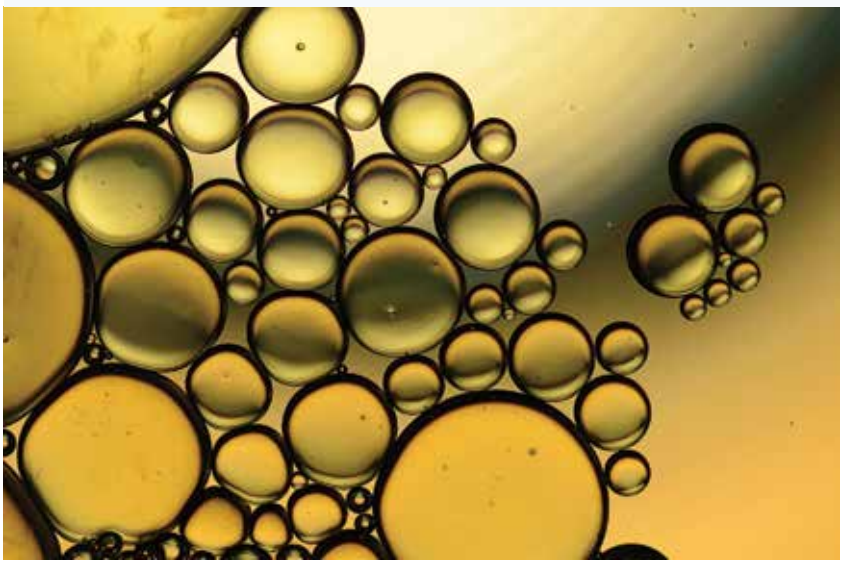
5.6.4 Play it safe

The best policy at home is to avoid putting down the sink anything solid or oily, or that you suspect may be poisonous or harmful to living things. Some things that can go down the sink at home in small amounts are:

- drain cleaners
- window cleaners
- kitchen and bathroom cleaners
- disinfectants (unless you have a septic tank).

At school, you should not tip anything down the sink except water, unless your teacher instructs you to.

Fat and oil don't dissolve in water.



5.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. List five examples of substances other than human body waste that can be found in waste water.
2. How does a septic system work?
3. Describe two methods of separation used during the primary treatment of sewage.
4. What separation process takes place in lagoons during the secondary treatment of sewage?
5. Suggest why disinfectants that kill bacteria should not be poured down a septic system.

Think

6. A certain type of shower provides water at a rate of 11 L per minute.
   (a) If you have a five-minute shower, how much water do you use?
   (b) How much water would you use showering in a year?
   (c) How much water would your family use showering in a year?
7. Make a list of substances that should not be tipped down the kitchen sink.
8. Suggest what the role of each of engineers, biologists and environmental scientists would be in the development of a sewage treatment plant.

Investigate

9. Find out the kind of treatment (primary or secondary) that is used for the sewage treatment system in the capital city of your state or territory. Where does the treated water go? How suitable do you think this system is for a large city?
10. Find out who is responsible in your area for the collection of waste that cannot be tipped down the kitchen, bathroom or laundry sinks, and how often it is collected.

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Complete this digital doc: Worksheet 5.6: What do you know? (doc-19828)

5.7 Fit to drink?

Science as a human endeavour

5.7.1 Unwanted substances

Water used for drinking and washing needs to be clean and free of harmful substances. Water supplies can be **contaminated** by dissolved substances or substances suspended in the water. Besides clay, there are a number of other contaminants:

- Human and other animal body wastes contain disease-causing micro-organisms.
- Algal blooms can release poisonous substances into the water. They can also affect the taste and cause odour problems.
- Pesticides or detergents can be washed into rivers and contaminate water supplies.
- Poisonous chemicals may also be washed into rivers.
- Salt dissolved in water can make it unfit for drinking.

- Iron dissolved in water can contaminate it. This is common in bore water.
- High levels of calcium and magnesium salts can cause water to be 'hard', making it difficult to lather. This causes problems in laundries, bathrooms and kitchens.

5.7.2 Keeping water safe

The water supplies of most of Australia's biggest cities comes from very large protected catchment areas. In the catchment areas surrounding dams and reservoirs, human habitation is not allowed and public access to these areas is strictly controlled. This reduces contamination of the water as it flows through and over the ground and into the dam or reservoir. The water is stored for up to five years in the major reservoirs. During this time it is purified by settling and other natural processes.

Some chemicals are commonly added to major city water supplies to make drinking water safe and healthy.

- Chlorine is added in very small amounts to kill harmful micro-organisms, which might cause diseases. It keeps the water safe to drink up to the moment it reaches your tap.
- Fluoride is added to protect your teeth from decay.
- Lime is also added to balance the acidity of the water caused by adding chlorine and fluoride.

5.7.3 Would you drink this water?

Would you like your water to come out of the tap looking like what is in the glass at right? Would you bathe or shower in it? Imagine your clothes after washing them!

The cloudiness of the muddy water is caused by tiny clay particles. Muddy water is an example of a colloid. Recall that a colloid is a cloudy mixture that contains suspended particles too small to be removed by filtering.

Would you drink it?



5.7.4 Country water supplies

If you live in a country town, your water probably comes from a nearby river or lake. It is quite likely you would not want to drink that water unless it had been purified. Many country towns have their own water treatment plants. Water is pumped from the river or lake into the treatment plant. The cloudy water contains mud and other substances in suspension, which can be settled out of the water by a process called **flocculation**.

The suspended particles would take a long time to settle if the water were just left standing, and so the chemical **alum** (aluminium potassium sulfate) is added to the cloudy water to make the small particles clump together. These clumps are called **floc**. The floc is heavy enough to settle to the bottom of the tank and form a sediment. The water above the sediment is clear and flows off to the filtering stage.

After flocculation, the clear water is filtered through sand and gravel to remove any leftover suspended substances in the water. Chlorine is added to kill harmful bacteria. The purified water is pumped to the local water tower, which then supplies the town with drinking water.

INVESTIGATION 5.8

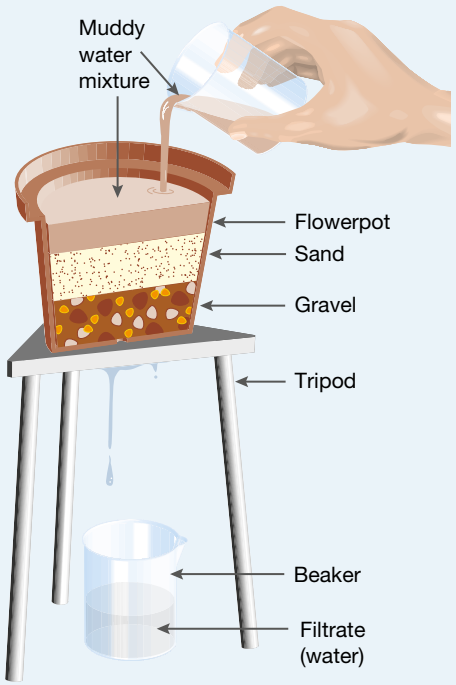
Treating your own dirty water

AIM: To separate clean water from dirty water

Materials:

muddy water (muddy water made with clay is best)
alum (aluminium potassium sulfate)
flowerpot and tripod
limewater
2 × 250 mL beakers
bleach
stirring rod
sand
gravel

A flowerpot water filter



Method and results

- Pour 150 mL muddy water into the beaker.
- Add half a teaspoon of alum and 10 drops of limewater.
- Stir the water to mix the chemicals and allow the floc to form.
- Once you can see the floc forming, allow the water to stand and the floc to settle to the bottom.
- Decant the water from the beaker into your water filter. Collect the filtrate in a clean beaker.
- Add two drops of bleach (which contains chlorine) to your filtrate.

1. Use a table like the one below to describe your water at each stage of the process. Include the appearance and odour of the water.

Treating dirty water

Treatment stage	Description of water
Untreated water	
Water after flocculation	
Water after filtering	
Water after chlorination	

Discuss and explain

2. Which separation techniques did you use to purify the water?
3. Prepare a series of picture diagrams to explain the steps you have taken to purify the water.

5.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. List five substances that can contaminate drinking water.
2. What chemicals are added to most city water supplies?
3. Explain why chlorine is added to drinking water.
4. Why is alum added to country water supplies?

Think

5. If you live in a country town that does not fluoridate the water, how could you obtain your fluoride?
6. What natural method of separating mixtures takes place in reservoirs over a long period of time?
7. Among the swimming pool products that are claimed to clarify pools or make them 'crystal clear' are super-floc, power floc and supa-floc.
   (a) Use the names to deduce the name of the process used by these products to assist in the separation of unwanted particles from the pool water.
   (b) Which process of separation takes place after the product has done its job?

Investigate

8. Home swimming pools are vacuumed using a pool vacuum cleaner. Find out how this type of vacuum cleaner works.
9. Seal pools at Melbourne Zoo and Taronga Zoo are kept free from contamination by a combination of filtration, chemical treatment with ozone, and a process called foam fractionation. Foam fractionation is used to remove solid seal waste, food waste, algae and other small particles from the pool without the use of a flocculant. Find out how a foam fractionator works.
10. List some examples of emulsions used in the home and explain what each example is used for.

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Complete this digital doc: Worksheet 5.7: Clean and clear? (doc-19829)

5.8 Essential separation

Science as a human endeavour

5.8.1 Separation in industry

Separating the useful material from a mixture is often a problem in industry. In mining, the mineral ores that are needed are mixed with useless rock called gangue. In the dairy industry, the cream has to be separated from the milk before it can be put into containers for sale.

5.8.2 Separating mixtures in mining

Copper

The metal copper is used in hot water pipes, electrical wiring and even in the coins we use. Copper is found in rocks in the Earth's crust in the form of mineral ores. Before the copper can be purified, the copper ore has to be separated from the gangue.

The mixture of gangue and copper ore that is dug out of the ground is in solid lumps. These lumps have to be crushed to a fine powder before the copper ore and gangue can be separated. Crushing takes place in a ball mill. This is a long barrel containing lots of heavy steel balls. As the barrel is rotated, the steel balls crush the lumps into a fine powder.

Once the copper ore and gangue are crushed, the copper ore is separated from the gangue by a process called **froth flotation**. The crushed mixture is mixed with water and some special chemicals, and stirred. Bubbles of air are blown into the bottom of the container and the copper ore is carried to the surface by the bubbles. The gangue sinks to the bottom of the tank and the copper ore is skimmed off the top of the liquid. The copper ore is then treated to extract the pure copper, which can then be used to manufacture the many copper products we use.

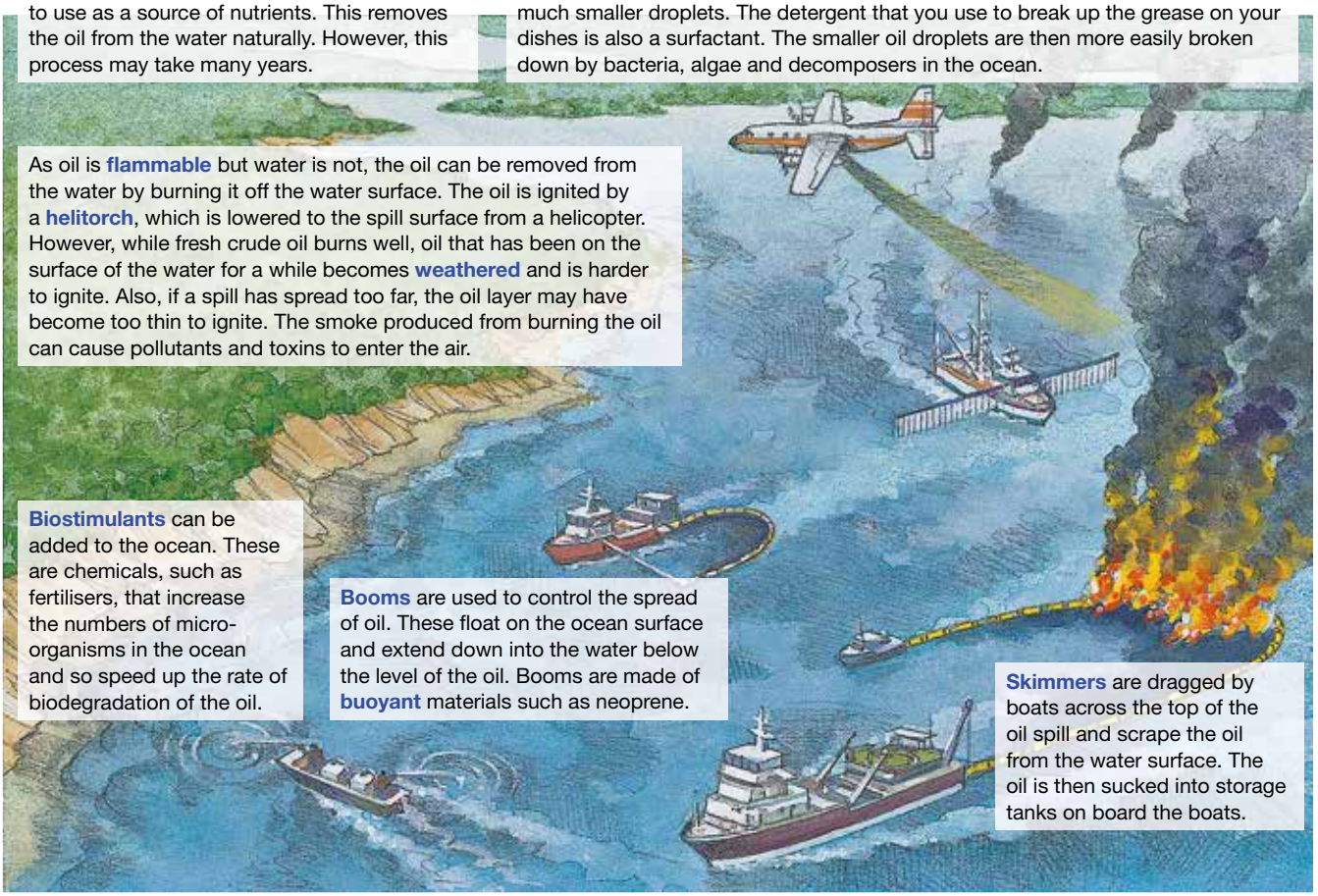
How are oil spills cleaned up?

On 20 April 2010, an explosion on the BP Deepwater Horizon drilling rig caused a massive oil spill into the waters of the Gulf of Mexico. The slick covered thousands of square kilometres of ocean. Such a slick can be cleaned up by considering some of the different properties of oil and sea water.

How to clean up an oil spill!

Biodegradation of the oil occurs when micro-organisms in the ocean break the oil down to use as a source of nutrients. This removes the oil from the water naturally. However, this process may take many years.

Oil spill dispersants can be sprayed onto the oil by helicopters, planes or boats. Dispersants contain substances called **surfactants** that can break up the oil into much smaller droplets. The detergent that you use to break up the grease on your dishes is also a surfactant. The smaller oil droplets are then more easily broken down by bacteria, algae and decomposers in the ocean.



As oil is **flammable** but water is not, the oil can be removed from the water by burning it off the water surface. The oil is ignited by a **helitorch**, which is lowered to the spill surface from a helicopter. However, while fresh crude oil burns well, oil that has been on the surface of the water for a while becomes **weathered** and is harder to ignite. Also, if a spill has spread too far, the oil layer may have become too thin to ignite. The smoke produced from burning the oil can cause pollutants and toxins to enter the air.

Biostimulants can be added to the ocean. These are chemicals, such as fertilisers, that increase the numbers of micro-organisms in the ocean and so speed up the rate of biodegradation of the oil.

Booms are used to control the spread of oil. These float on the ocean surface and extend down into the water below the level of the oil. Booms are made of **buoyant** materials such as neoprene.

Skimmers are dragged by boats across the top of the oil spill and scrape the oil from the water surface. The oil is then sucked into storage tanks on board the boats.

Gold

Gold obtained from the ground is also mixed with unwanted rock. After grinding in a ball mill, the mixture of crushed rock and gold is mixed with water. The gold can be separated from the mixture using **gravity separation** because the gold is heavier than the rock. The mixture is spun and the gold sinks to the bottom.

In the same way, panning for gold by swirling the pan allows the heavier gold to settle in the pan while the lighter gravel and sand swirl out of the pan with the water.

Gold separated from unwanted rock



INVESTIGATION 5.9

Separation by flotation

AIM: To model the separation of the gangue from mineral ore

Materials:

jar and lid *sawdust*
sand *teaspoon*

Method and results

- Half-fill the jar with water.
- Add a teaspoon of sand and a teaspoon of sawdust.
- Place the lid on the jar firmly and shake vigorously.
- Allow the jar to stand.
- Use a spoon to remove the sawdust.

Discuss and explain

1. In this experiment, which substance represented the gangue?
2. Which substance represented the mineral ore?
3. How is the method of separation in this experiment different from the froth flotation method used to separate copper ore from the gangue?

5.8.3 Separation in the dairy industry

Cows' milk is a mixture of watery milk and fatty cream. If fresh milk straight from the cow is left to stand, the cream floats to the top of the milk. The milk that you buy as homogenised full-cream milk contains both the milk part and the cream mixed together. Very fine droplets of cream are dispersed evenly throughout the watery milk.

Skim milk is the watery milk part without the cream. Milk is separated from the cream at the dairy using a centrifuge. The cows' milk is fed continuously into the centrifuge at one end; as the milk is spun in the centrifuge, the lighter cream separates from the heavier skim milk and each part is continuously collected at the other end.

Skim milk powder is made by evaporating about half of the water from the skim milk. A fine mist of this skim milk is then sprayed into a current of hot air, so that more water evaporates. The powdery dry milk is collected from the bottom of the chamber.

5.8.4 Separation in the wine industry

Winemakers use a variety of separation techniques in the production of wine. Presses are used to separate the juice from the grapes. A large plate is lowered onto grapes in a container, pressing until the juice is forced out of the grape skins. Some winemakers still use the ancient method of pressing using a large wooden basket. A plate is lowered onto the grapes and the juice flows out through the openings in the basket.

Filtration is used to remove solid impurities in wine, but the microscopic particles in wine that make it cloudy are separated by a process similar to flocculation. Winemakers call this process 'fining'. They add agents such as eggwhite, gelatin (an animal protein) and casein (a protein found in milk) that bond with the particles, making them larger so that they sink to the bottom of the tank or barrel. The remaining wine is clear.

Fortified wines such as apera (originally called sherry) and muscat are made by distilling wine to separate and remove water from alcohol and other dissolved substances that give the wine its flavour. The remaining mixture is called spirit, which is added to other wines to fortify, or strengthen, them and make them sweeter.

5.8.5 Chromatography in industry

Chromatography is used in the food industry to detect more than just food colours. Food scientists can tell us what other ingredients have been added to food.

Chromatography can also identify pesticides and harmful chemicals that have entered our food from the water in creeks and dams, or from soil **pollution**.

Forensic scientists use gas chromatography to detect a range of substances, including traces of illegal drugs. They can also use chromatography to compare mixtures found at crime scenes with those found on suspects. Many mixtures contain a unique combination of substances. For example, ink from different pens is slightly different, even if the colours look the same.

The separating technique of chromatography is used to detect substances in blood and urine. In medical laboratories, samples of blood or urine are tested for drugs and alcohol. Abnormal levels of vitamins and hormones in a person's blood can also be detected using chromatography.

A chromatograph automatically separates mixtures by chromatography.



5.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Describe how copper ore is separated from unwanted rock.
2. Describe how copper ore is carried to the surface during froth flotation.
3. How is gold separated from unwanted rock?
4. How are skim milk and skim milk powder separated from whole milk?
5. List three uses of chromatography in industry.

Think

6. What type of separation is used when panning for gold?
7. Does homogenised milk contain cream? Where is it?
8. Which pure substance is present in milk and unfortified wine?

Investigate

9. Smoke stacks are used in many production plants and power stations to release waste gases and hot particles into the atmosphere. In some of these smoke stacks, an electrostatic precipitator is used to separate smoke, dust and other small particles and droplets from the waste gases before they are released into the atmosphere. Research and report on how electrostatic precipitators work.
10. Crude oil is a mixture of many different chemicals. Find out how crude oil is separated into the many different chemicals it contains.
11. Investigate the processes used to separate olive oil from the other liquids and solids in olives.

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Complete this digital doc: Worksheet 5.8: Separation techniques (doc-19830)

5.9 Essential recycling

Science as a human endeavour

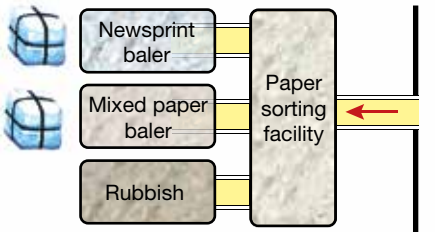
5.9.1 Essential recycling

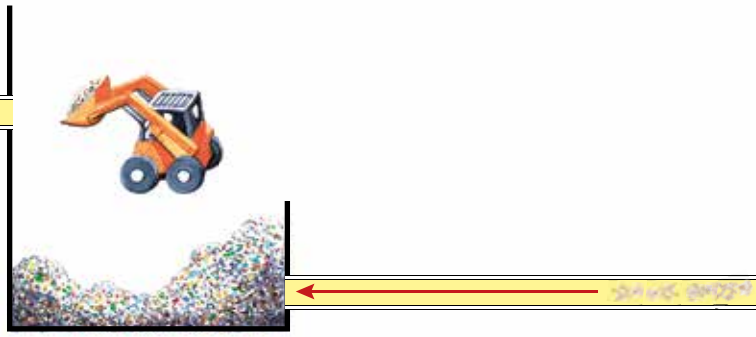
To preserve resources for future generations the **recycling** of materials is essential. Items such as paper, all plastic bottles and containers, glass, aluminium and steel can be recycled and made into new products. Recycling reduces the amount of waste that goes to **landfill** and saves precious natural resources such as trees and bushland. Many **manufacturing processes** pollute the environment. Recycling and reusing materials reduces the need to manufacture from **raw materials**. Fortunately, most local councils have a recycling program.

5.9.2 Separating by sight

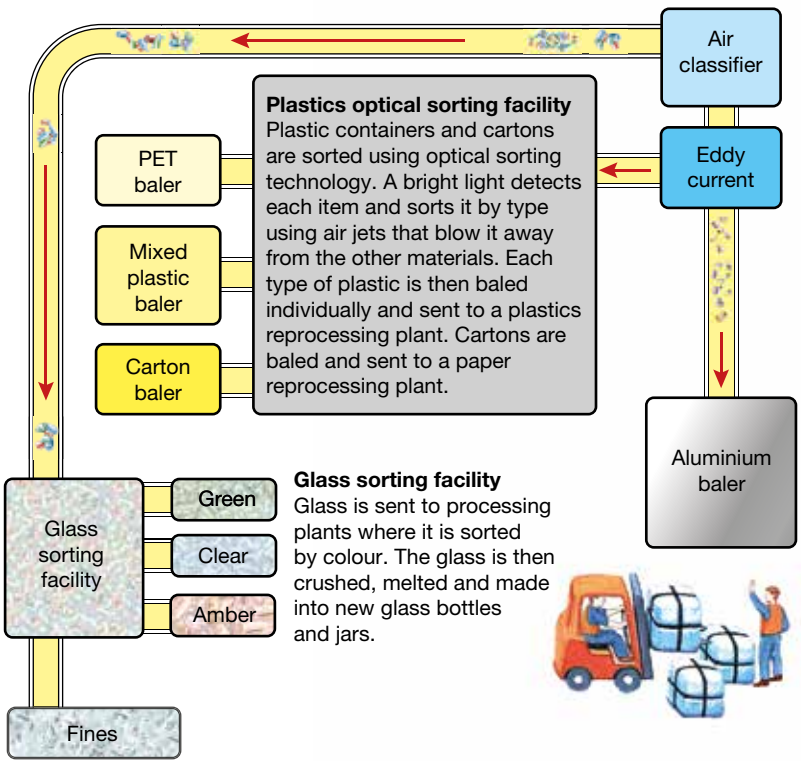
Household rubbish is usually a mixture of food scraps, recyclable materials and other waste. The first step in recycling is to separate the recyclable items from other household rubbish. This is most easily done by hand — that is, separating by sight. We can see the differences between the types of rubbish, and we know which items can be recycled.

Paper sorting facility
All paper and cardboard is manually sorted to ensure that there are no plastic bags or other non-paper items in the mixture. Paper and cardboard is baled and sent to paper mills for reprocessing. At the mill, paper is shredded and mixed with water (pulped) to make new paper products such as cardboard boxes.



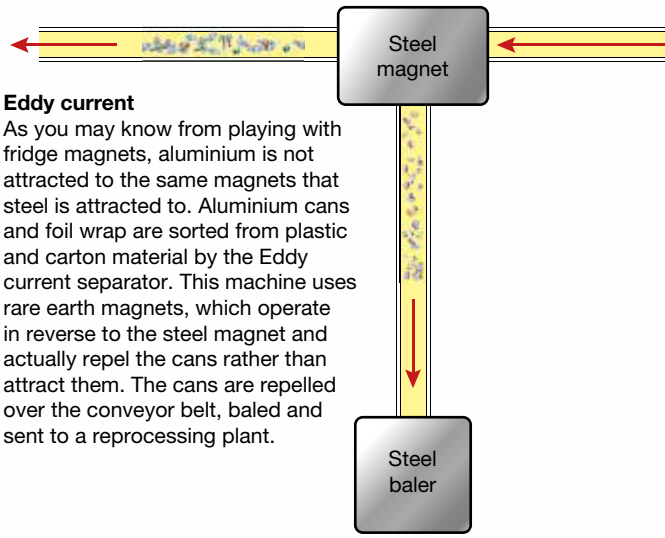


Air classifier
Plastic, aluminium and paper cartons are lighter than glass. A blast of air blows these lighter materials to a separate conveyor belt.



Plastics optical sorting facility
Plastic containers and cartons are sorted using optical sorting technology. A bright light detects each item and sorts it by type using air jets that blow it away from the other materials. Each type of plastic is then baled individually and sent to a plastics reprocessing plant. Cartons are baled and sent to a paper reprocessing plant.

Glass sorting facility
Glass is sent to processing plants where it is sorted by colour. The glass is then crushed, melted and made into new glass bottles and jars.

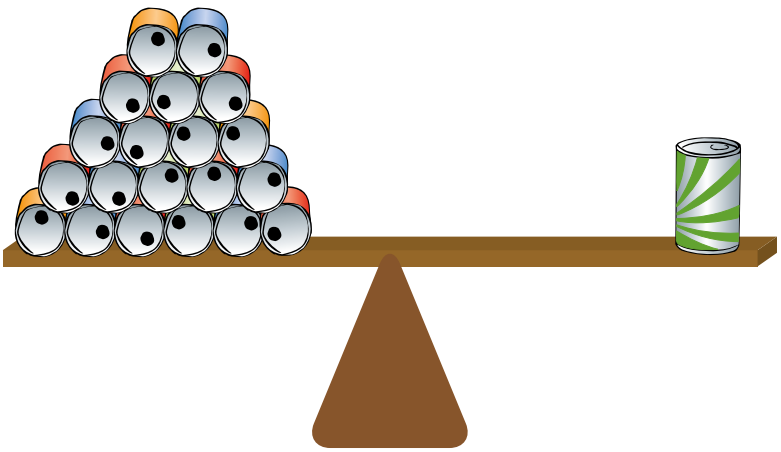


Eddy current
As you may know from playing with fridge magnets, aluminium is not attracted to the same magnets that steel is attracted to. Aluminium cans and foil wrap are sorted from plastic and carton material by the Eddy current separator. This machine uses rare earth magnets, which operate in reverse to the steel magnet and actually repel the cans rather than attract them. The cans are repelled over the conveyor belt, baled and sent to a reprocessing plant.

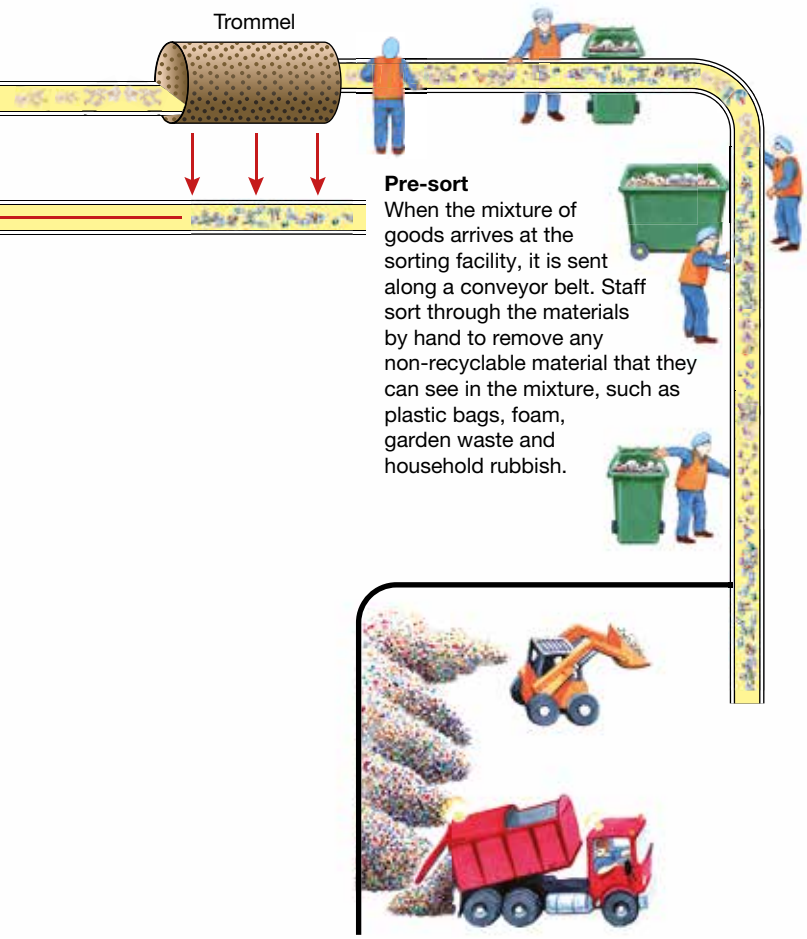
Magnet
Steel cans are separated from other containers using a magnet. The steel is collected in a separate container, ready to be sent to steel manufacturers. Material that is not attracted to a magnet continues along the conveyor belt.



It takes the same amount of energy to make 20 cans from recycled aluminium as it does to make just one new can from raw materials.



Trommel
The trommel is a large rotating cylinder with holes along its sides, similar to the inside of a washing machine. Heavy recyclables, such as plastic, glass, cartons, steel and aluminium, fall through the holes in the trommel, while lightweight material, such as paper and cardboard, continue along the conveyor to be sorted separately.



Pre-sort
When the mixture of goods arrives at the sorting facility, it is sent along a conveyor belt. Staff sort through the materials by hand to remove any non-recyclable material that they can see in the mixture, such as plastic bags, foam, garden waste and household rubbish.

HOW ABOUT THAT!

How does the recycling of cans and bottles save oil, coal and gas? It takes energy from fossil fuels to run the equipment that mines and processes the materials that make new cans and bottles. Recycling also reduces the amount of raw materials that need to be taken from the ground and processed.

5.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. List at least two reasons why recycling is good for the environment.
2. Describe how paper and cardboard are separated from other recyclable materials.
3. What happens to recycled glass after it is separated from other materials in a recycling plant?

Think

4. Construct a table like the one below to show the following information about separating recyclable rubbish.
   (a) The methods used to separate different types of material in a recycling plant
   (b) For each method, the material removed from the flow of rubbish
   (c) The properties of the recycled material that allow it to be separated from the mixture

Method	What is removed?	Properties

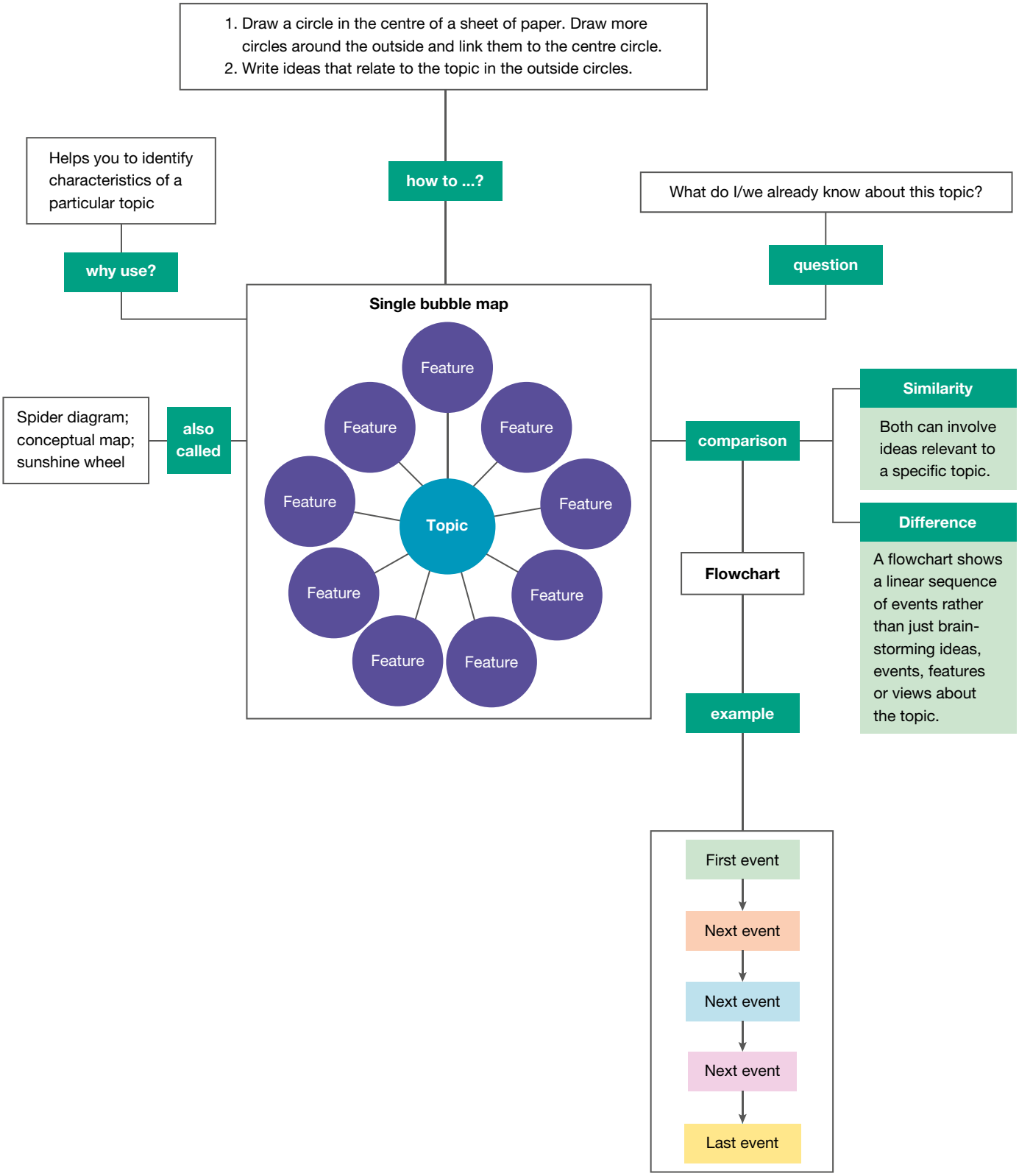
5. Explain why the same type of magnet is not used for separating both aluminium and steel cans.
6. Why do people, rather than machines, manually separate some of the recycling mixture?

Create

7. Design and construct a poster or brochure that explains which plastics can be recycled. Check with your local council for its recycling guidelines. Compare the properties of plastics that can be recycled with those that can't.

5.10 Single bubble maps and flowcharts

5.10.1 Single bubble maps and flowcharts

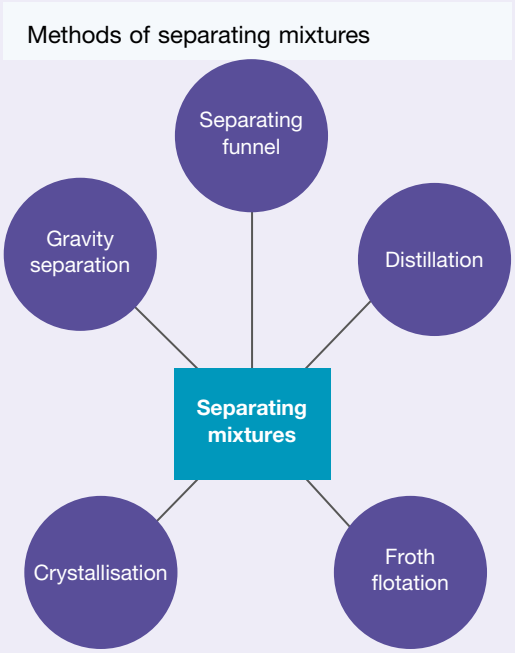


5.10 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think and create

1. The single bubble map below identifies some of the methods used to separate mixtures. Draw your own single bubble map, adding as many additional bubbles as you can. You are doing very well if you can fill ten bubbles.



2. Draw a single bubble map that identifies substances and objects that should not be tipped down the kitchen sink.



3. Draw flowcharts to show the steps involved in separating:
   (a) salt from a mixture of sand, salt and water in a beaker
   (b) copper ore from the rocks dug out of a copper mine (see section 5.8).
4. Copy and complete the following flowchart to show how salt can be recovered from a mixture of salt and sand.

Step 1:	Add water to mixture and stir.
	↓
Step 2:	
	↓
Step 3:	Pour salty water into evaporating dish.

5. Arrange the following steps in the correct order and construct a flowchart to show how country water supplies are purified.

Alum added to water

Floc settles to bottom to form a sediment

Water pumped to local water tower

Water pumped from river or lake

Water filtered through sand and gravel

6. An unfortunate bush camper has accidentally mixed water with the kerosene that he needs to fuel his camp stove. Help him out by drawing a flowchart showing how to separate the water from the kerosene. (*Hint:* Kerosene does not dissolve in water.)
7. (a) Design a mixture that can be separated using as many as possible of the methods you have seen in this chapter. List the components of the mixture and challenge another student to find a step-by-step method of separation.
   (b) Design a mixture that cannot be separated.

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Complete this digital doc: Worksheet 5.9: Single bubble maps and flowcharts (doc-19831)

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5.11 Project: The diamond flush

Scenario

Having only just been toilet-trained, your little brother seems fixated on dropping stuff into the toilet and flushing it away. He has flushed away all sorts of things — Lego blocks, shopping lists, dog biscuits and even the occasional goldfish get put down the U-bend. It all seemed very funny until one day when he flushed away some really valuable things including a diamond ring, a pair of tiny diamond stud earrings, a wallet and a cultured pearl necklace. Your mum is absolutely frantic; but, maybe, if you can track down where in the sewerage system they went, you have a chance of getting some things back for her!



Your task

Choose one of these valuable items and determine the most likely place that the missing object would be found. To do this, you will need to research the pathway taken by the sewage after it leaves your house and the different processes that the sewage (and the object) would be subjected to as it undergoes treatment. You will then put together a PowerPoint presentation that explains the pathway along which the object would have travelled once it left the house, the sewage treatment separation systems it would have passed through and where in the treatment system it is most likely to be found.

5.12 Review

5.12.1 Study checklist

Mixtures

- distinguish between pure substances and mixtures and give examples of each
- recall that a mixture can be separated according to specific properties of its components
- identify some common mixtures

Solutions and suspensions

- identify the solute and solvent in common solutions
- appreciate that water is a common solvent in solutions
- distinguish between solutions and suspensions
- define the terms ‘colloid’ and ‘emulsion’

Separating mixtures

- describe the processes of filtering, sieving, decanting, distillation, evaporation, crystallisation, chromatography and using a separating funnel compare the uses, effectiveness and limitations of separation processes in the home and in industry
- recall how filtering and centrifuging are used in the isolation of blood products
- explain how distillation and evaporation may be used to purify water

Science as a human endeavour

- explain how salt is separated from sea water in desalination plants and why the process is controversial
- describe the processes by which sewage is treated
- evaluate the appropriateness of current sewage treatment systems
- appreciate that water often needs treating before it is drinkable
- recall common contaminants found in water
- identify chemicals that are often added to water supplies and their purpose
- describe the process of flocculation in the treatment of water
- describe examples of the separation of mixtures in industry by froth flotation, gravity separation, centrifuging, distillation and chromatography
- describe the processes used to separate materials in recycling plants

Individual pathways

ACTIVITY 5.1
Investigating separation
doc-2858

ACTIVITY 5.2
Analysing separations
doc-2859

ACTIVITY 5.3
Designing separations
doc-2860

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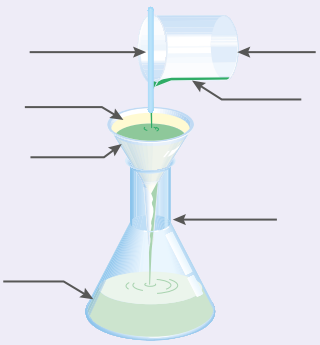
5.12 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. Construct a table with two columns with the headings 'Pure substance' and 'Mixture'. List the following substances under the appropriate heading: freshly made apple juice, tap water, soft drink, cake batter, sterling silver, distilled water, gold nugget, glass, cornflakes.
   You may have to research some of these substances to find out which column they belong to.
2. Black instant coffee is a mixture of coffee powder and hot water. Which substance is:
   (a) the solute
   (b) the solvent
   (c) the solution?
3. How can you tell, just by looking, whether a mixture in water is a solution or a suspension?
4. Copy and complete the table below to summarise what you know about separation techniques.

Method of separation	Description of how it works	An example of how it is used in the home or in industry
Filtration		
Distillation		
Crystallisation		
Flocculation		
Decanting		
Separating funnel		
Centrifuging		
Chromatography		

5. During an experiment, a teacher accidentally drops some steel drawing pins into a bowl of sugar. Suggest two methods that could be used to remove the drawing pins from the sugar. Briefly explain each method.
6. How would you separate the sand from a mixture of sand and sawdust? Construct a flowchart to show the steps you would use.
7. Imagine you dropped nails in the sawdust in woodwork class. Propose two reliable ways of separating the nails from the sawdust.
8. You have been asked to analyse some salt-contaminated soil and to propose a method for separating the salt from the soil.
   (a) Outline the method that you would use to obtain pure dry salt and pure dry soil.
   (b) Draw a labelled diagram showing how your equipment would be set up for each stage of your separation.
9. The diagram on the right shows a mixture being filtered.
   (a) Copy the diagram and add the missing labels.
   (b) What is the purpose of the stirring rod?



10. Pasta is cooked by boiling it in water. It sinks to the bottom of the saucepan when it is left to stand.
    (a) Which type of mixture is the pasta and water?
    (b) Describe two different methods that could be used to separate the pasta.
    (c) Which of the two techniques is better for separating the pasta and water? Explain your answer.



11. Identify which of the following substances is a mixture.
    (a) Silver
    (b) Distilled water
    (c) Smoke
    (d) Nitrogen gas
12. A water sample taken from a river that shows a brown colour is most likely to be:
    (a) a solution.
    (b) a colloid.
    (c) a suspension.
    (d) an emulsion.
13. A separating funnel works when two substances have different:
    (a) melting points.
    (b) colours.
    (c) densities.
    (d) solubilities.
14. Identify the properties that allow the following substances to be separated from a mixture.
    (a) Peas from a mixture of peas and water
    (b) Oil from a mixture of oil and water
    (c) Gold particles from a mixture of sand and creek water
    (d) Cream from cows' milk
15. Use a labelled diagram to illustrate the differences between the processes of osmosis and reverse osmosis used in desalination plants.
16. Oil floats on water. When detergent is added, the oil forms droplets in the water that do not settle. What type of mixture has been formed? Justify your answer.
17. Blue-green algae has grown in a lake. It forms a fine, green suspension in the water. The local council wants to make the water clear again so that fish and other living organisms can safely inhabit the lake. Propose a method that you would use to solve the local council's problem. Remember that your method should not harm the fish already in the lake.
18. Muddy water is an example of a colloid. How is a colloid different from other suspensions?
19. Mayonnaise is an example of an emulsion, which is a type of colloid. How is an emulsion different from other colloids?
20. How does flocculation make the particles in a suspension settle out?
21. Explain why blood collected by the Red Cross Blood Service needs to be separated before it is used.
22. What is the purpose of the S-bend in the toilet?
23. Describe the two separating processes in a recycling plant that are done by sight.
24. State one good reason why each of the following objects or substances should not be tipped down the sink or flushed in a toilet.
    (a) Fat or oil
    (b) Cotton buds
    (c) Oven cleaner
25. Explain why chlorine is added in small amounts to the water supplies of many cities.
26. Read the story on the next page and use the information to answer the following questions.
    (a) Write down what you think Marco would have said to his son. Explain the two methods clearly.
    (b) Propose three questions that Flavius would have asked in return.
    (c) Extension — Construct a flowchart that shows the steps involved in each salt harvest process using appropriate scientific terminology to describe changes of state and separation techniques.
    (d) Spend some time researching ancient methods of salt separation before creating your flowchart. If using the internet, use search words such as 'ancient salt production', 'Roman times salt' and 'salt evaporation'.

An ocean of salt

Salt has been used by civilisations for centuries to preserve meats, cure hides, make cheese and other foods, and as flavouring in cooking. Salt was essential for life. Some communities even used salt instead of money as a form of payment. A community grew wealthy from its ability to produce salt.

Salt was mined from the ground, in the form of rock salt, or collected from sea water. The sea water, sometimes called brine, was evaporated and the salt collected. The brine was either heated over a wood fire or collected in shallow pools and left to heat in the sun.



'There's a whole ocean out there — full of salt — we just need to get it out of the water!', Marco remembered his grandfather saying. Marco lived during ancient Roman times. He lived in a town off the coast of the Mediterranean Sea. Marco himself now worked in the business his grandfather had started. He, too, marvelled at how he used the sun and winds to separate salt from sea water.



This day was special; it marked the day his son, Flavius, would first work at the salt business. As they reached the hill, they smelled smoke from the wood fires and looked out over the flat natural basin where salty water collected in shallow pools. Flavius saw that the smoke was from fires burning under large rectangular lead pans. Marco turned to his son and explained the two ways they separated salt from sea water.

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- **Complete this digital doc:** Worksheet 5.10: Summing up (doc-19832)
- **Complete this digital doc:** Worksheet 5.11: Looking back: Separating mixtures (doc-19833)
- **Complete this digital doc:** Worksheet 5.12: Science literacy (doc-19834)

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TOPIC 6
The Earth in space

6.1 Overview

Earth is just a tiny speck in a vast universe. It's one of eight planets in the solar system, and the sun is one of more than a billion, billion stars in the universe. But life on Earth is very much controlled by events in our own 'neighbourhood'. The seasons, day and night, the tides and the phases of the moon are the results of Earth's orbit around the sun, the rotation of the Earth and the orbit of the moon around the Earth.



6.1.1 Think about the Earth

assessON

- What causes the seasons?
- Why is there more daylight in summer than winter?
- Why does the same side of the moon always face the Earth?
- Which step was 'one giant leap for mankind'?
- What causes the phases of the moon?
- Why do coastal communities experience high and low tides?
- Why are total solar eclipses so rare?
- Which famous scientist was imprisoned for arguing that the planets revolved around the sun?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

6.1.2 Your quest

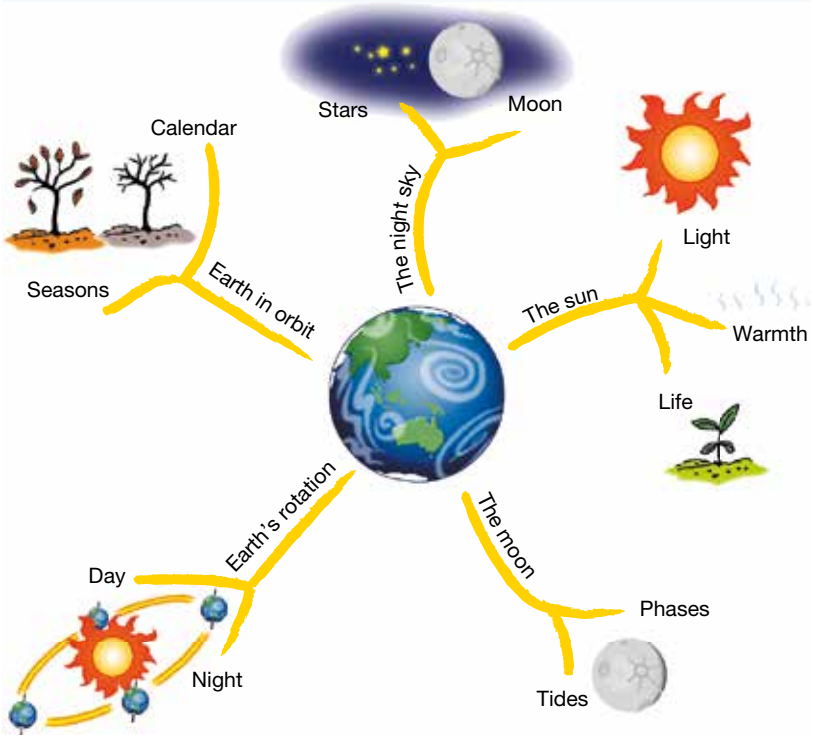
Earth from space

Imagine

In a group of two to four, brainstorm what you know about planet Earth and then draw a mind map to summarise the ideas and information you have collected.

To start your mind map, draw the Earth in the centre of a large sheet of paper. Then use words, pictures and colour to add your own ideas.

An example of a mind map



INVESTIGATION 6.1

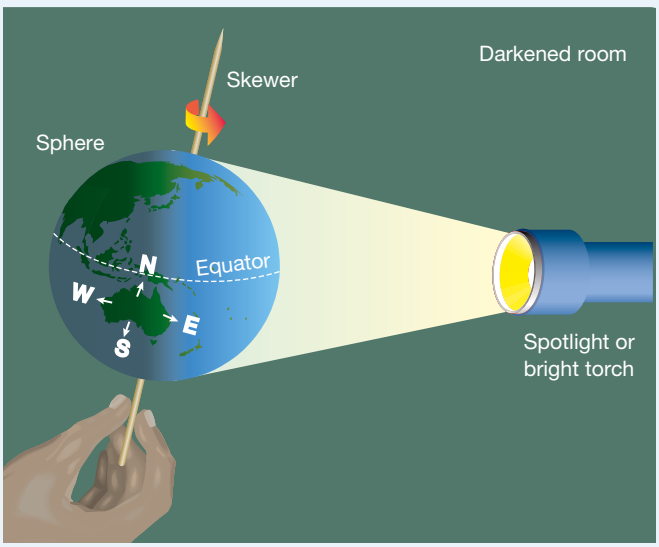
Day and night

AIM: To model the cycle of day and night

Materials:

polystyrene (or similar) sphere
spotlight or bright torch
skewer

Method and results



- Your sphere represents the Earth. Draw a line around the centre to represent the equator. Label the Northern and Southern Hemispheres and mark in the North and South Poles.
- Draw an outline of Australia and Africa on your sphere. Use an atlas to check the positions and approximate shape of each continent. Also note the position of north.
- Mark the four compass directions — north, south, east and west — around the outlines of each continent.
- Gently push a skewer through the centre of your sphere from bottom to top through the 'polar regions'. This represents the Earth's imaginary axis.
- Turn on the spotlight in a darkened room. Its light represents the sun's light. Hold the skewer so it leans a little away from the vertical. This represents the Earth's tilt.
- Turn your sphere very slowly in the light, making sure you keep the skewer slightly tilted all the time. Turn it in an anticlockwise direction (as seen from above). Watch what happens from side on.

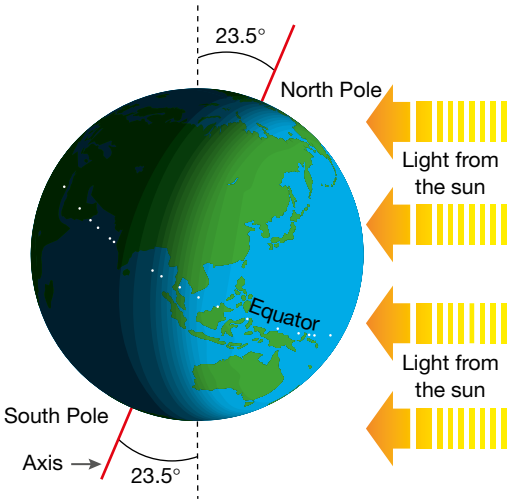
Discuss and explain

1. In which direction is the 'Earth' rotating — from east to west or west to east? Check the compass directions you marked on your sphere.
2. In which direction does the 'sun's' light seem to move around the 'Earth'? How does this explain the apparent movement of the sun across the sky?
3. Where is Africa when Australia is lit up? Where is Australia when Africa is lit up? Explain why these continents experience daylight at different times.
4. How does this model help to explain why night falls in Perth about two hours later than in Sydney and Melbourne?

6.2 Sunrise, sunset

6.2.1 Night and day

Only one half of the Earth can face the sun at any one time. This diagram shows Australia in daylight.



Each day, the sun rises in the east, moves across the sky and sets in the west. The ancient Egyptians believed that the sun god Re sailed a boat across the sky each day. The ancient Greeks explained the movement of the sun as the daily journey of the sun god Helios across the sky in a chariot. It is not surprising that early astronomers explained day and night by suggesting that the sun moved around the Earth.

In fact, the sun doesn't move across the sky at all. It is the rotation of the Earth that makes it look like the sun is moving. The Earth rotates on its own axis, as do all the other planets.

The Earth's axis is an imaginary straight line between the South Pole and the North Pole. The axis is tilted at an angle of 23.5° from the vertical, as shown at right. It takes 24 hours to complete each **rotation**. As the Earth rotates from west to east, the sun appears to move from east to west. At night the moon and planets also appear to move in this direction, seeming to travel from east to west.

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Try out this interactivity: Day, night and time zones (int-0006)

6.2.2 The sun and the seasons

The Earth takes 365¼ days to complete one **revolution** around the sun. This period is called a calendar year. To make the calendar simpler, we make each year 365 days with every fourth year being a leap year, 366 days. Over four years that averages out at 365¼ days.

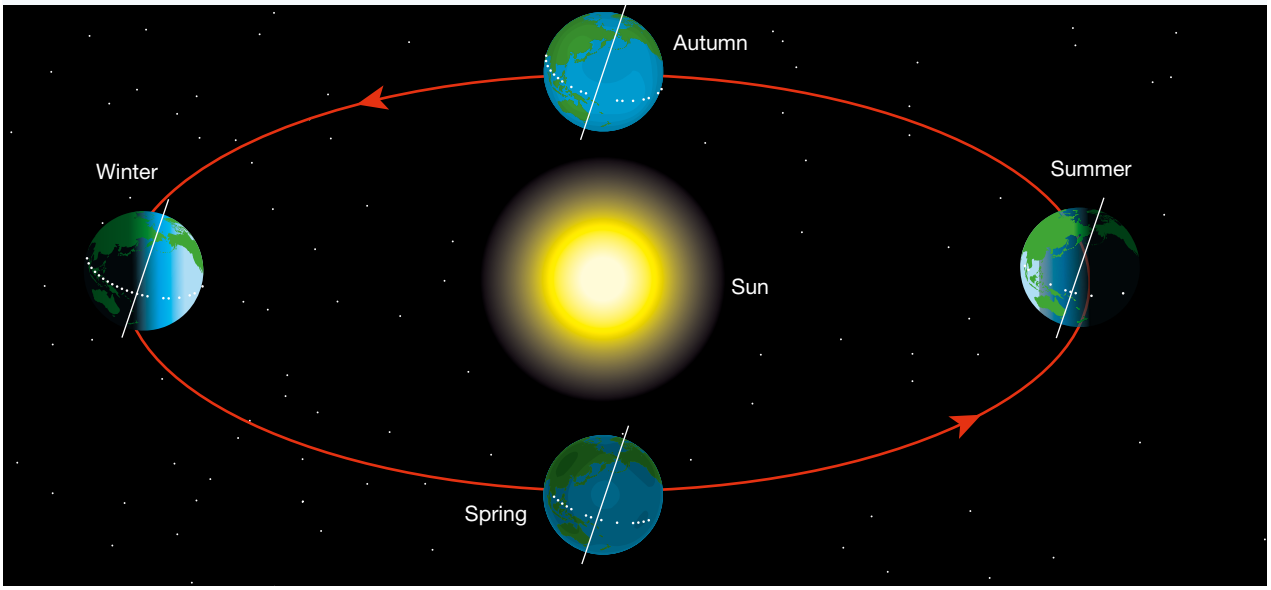
As the Earth orbits the sun, the tilt of its axis remains the same. The diagram on the next page shows that, for one part of Earth's **orbit**, the Southern Hemisphere is tilted towards the sun. For the other part of the orbit, the Southern Hemisphere is tilted away from the sun. The opposite is true for the Northern Hemisphere.

The Southern Hemisphere experiences summer when it is tilted towards the sun. During summer, the South Pole is in constant daylight. At the same time the Northern Hemisphere experiences winter because it is tilted away from the sun. The North Pole is in constant darkness. The Southern Hemisphere experiences

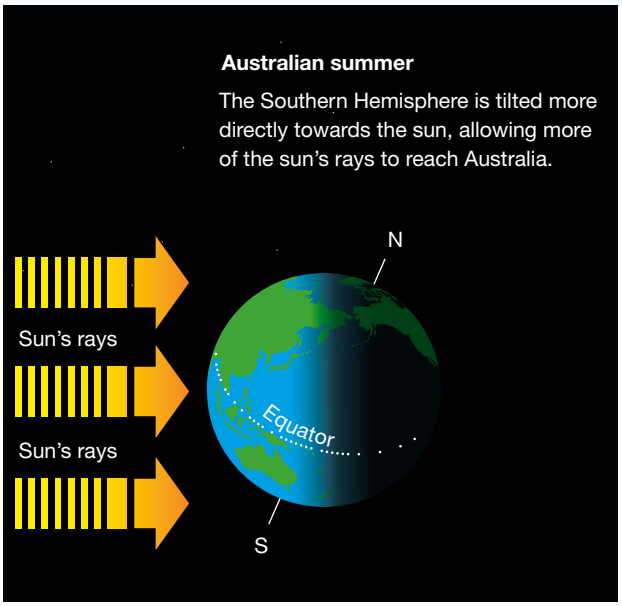
winter when it is tilted away from the sun. It's cooler than summer because the sun's energy is spread out over a larger area.

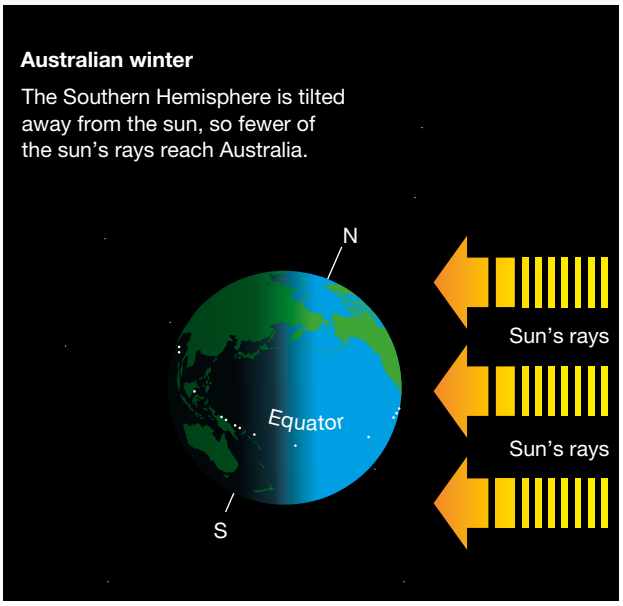
While it's winter in the Southern Hemisphere it's summer in the Northern Hemisphere. Between summer and winter, neither hemisphere is tilted towards the sun. This happens during autumn and spring.

As the Earth orbits the sun, the seasons change. This diagram shows the seasons as they are in the Southern Hemisphere.



The tilt of the Earth's axis and its path around the sun help explain the seasons.





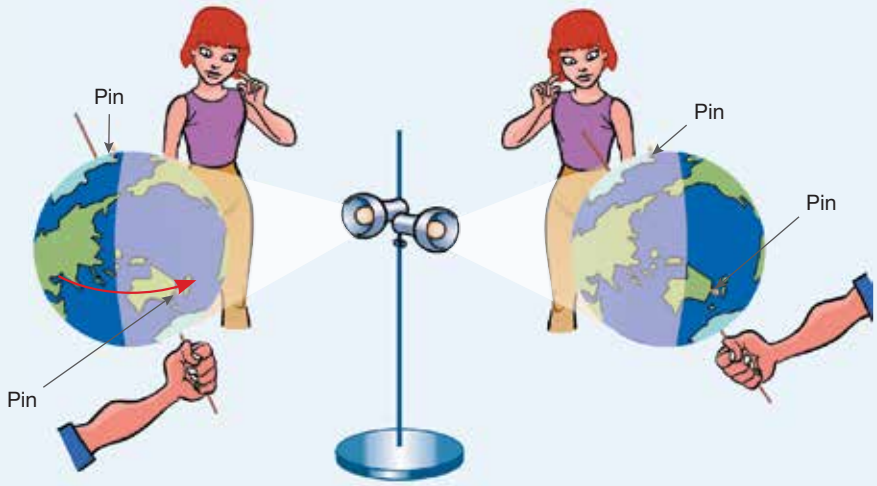
INVESTIGATION 6.2

Long days, short days

AIM: To model the cycle of the seasons and explain the variation in daylight hours

Materials:

the equipment used for Investigation 6.1
2 pins with coloured heads



Method and results

- Hold the skewer vertically. Push two pins into your sphere — one about where Sydney is and the other directly above it at the top of the sphere, near the skewer.
- Set the spotlight up in a central place (such as on a table you can move around). Darken the room.
- Stand to the left of the spotlight. Hold the skewer so it leans to the left from the vertical. The southern half of your sphere should be leaning more towards the light.
- Slowly turn your sphere in the light, making sure you keep the skewer slightly tilted. Turn it in an anticlockwise direction. Watch what happens from side on. Watch the side of the sphere you can see as you turn it. A partner should watch the other side.
- Now stand to the right of the spotlight holding your skewer tilted to the left as before. This time the northern half of your sphere should be leaning more towards the light. Repeat what you did in the previous step.
- Repeat the whole procedure above two more times. The first time, look at what happens at each of the poles. The second time, look at what happens at the equator.

Discuss and explain

1. Which pin comes into the light first when the southern half of the sphere leans towards the light? Ask your partner which pin moves out of the light first.
2. What does this tell you about the number of daylight hours in each hemisphere when the Southern Hemisphere tilts towards the sun?
3. Which pin comes into the light first when the northern half of the sphere leans towards the light? Ask your partner which pin moves out of the light first.
4. What does this tell you about the number of daylight hours in each hemisphere when the Northern Hemisphere tilts towards the sun?
5. What is the approximate length of day and night at the equator in each season?
6. Suggest why the sun never sets at certain times of year at the North and South Poles. What season is the Southern Hemisphere experiencing when the South Pole has several months of darkness?

6.2.3 The longest day of the year

The longest day of the year is called the summer solstice and occurs in late December in Australia. Some people mistakenly think that it occurs because the Earth is closer to the sun; however, that is not true. The seasons are determined not by the distance of the Earth from the sun but by the angle at which the sun's rays strike the Earth. In summer the sun is high in the sky. In winter the sun is low in the sky and rises late in the morning then sets early in the afternoon. Your shadow is at its longest on the shortest day of the year, the winter solstice, at midday. This happens in June.

WHAT DOES IT MEAN?

The word *solstice* comes from the Latin words *sol*, meaning 'sun', and *sistere*, meaning 'to stand still'.

HOW ABOUT THAT!

A day on Jupiter is less than 10 hours. This means it takes under 10 hours to complete one rotation. But this giant planet, made mostly of gas, is about 13 000 times bigger than Earth. So when it rotates, its outermost clouds move at close to 45 000 kilometres every hour!



6.2 Exercises: Understanding and inquiring

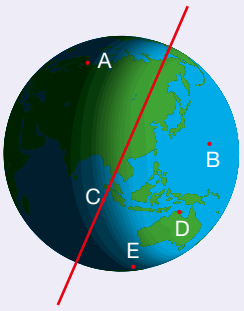
To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Explain the difference between the revolution and rotation of the Earth.
2. How long does it take the Earth to complete one:
   (a) rotation
   (b) revolution?
3. Explain why we experience day and night.
4. Why does the sun rise in the east and set in the west?
5. During which season does Australia tilt towards the sun?
6. Explain why it is usually warmer on a summer's day than on a winter's day.
7. Explain why there are 365 days in most years but 366 days in every fourth year.

Think

8. Explain, with the aid of a diagram, why the South Pole is in darkness during the Southern Hemisphere's winter.
9. Use the diagram at right to answer the following questions.
   (a) Which of the locations A, B, C, D and E:
      (i) are in daylight
      (ii) are experiencing summer
      (iii) are experiencing the longest day
      (iv) are experiencing the shortest day?
   (b) In which of the locations that are in daylight will the sun set first?
10. Explain why both the time and position of sunrise and sunset are not the same every day.



Brainstorm

11. In a small group, brainstorm to compile a list of occupations in which day-to-day work is affected by seasonal changes. Provide a brief description of how each occupation is affected.

Investigate and think

12. Observe the position of the shadow of a tree trunk or vertical pole from time to time on a sunny day.
    (a) Explain how the shadow moves during the day from sunrise to sunset.
    (b) How do you think prehistoric people have explained the movement of the shadow?
    (c) What does the shadow tell you about the sun and the Earth?
    (d) How would you expect the length of the shadow to change from summer to winter?
    (e) In ancient times a vertical stick was used as a daylight clock. It was called a sundial. Describe the disadvantages of sundials.

Investigate

13. Use the internet or other resources to find out when and where the astronomer Al-Battani lived and worked, and what contribution he made to an understanding of the seasons.

6.3 The moon

Science as a human endeavour

6.3.1 A face in space

From Earth, the moon is, by far, the brightest object in the night sky. Its presence and changing appearance have raised questions, inspired myths and legends, shaped our calendar and even determined the dates of some religious holidays.

The moon takes the same time to complete one full turn about its own axis as it takes to orbit the Earth. For this reason only one face of the moon can be seen from the Earth. The face seen from Earth is much less mountainous and rugged than the other side. Because the moon wobbles a little during its orbit around Earth, we sometimes get a view of the edges of the far side. However, 41 per cent of the moon's surface is never visible from the Earth.

Unlike the Earth, the moon has no atmosphere. There is no air. There is no sign of water on the surface. There is no wind and no rain. This means that there is no erosion.

6.3.2 Getting to know the moon

From the time of the invention of the first telescope in 1608, it was possible to see some detail in the features of the moon's surface. In 1609, Galileo Galilei used his homemade telescope to study the moon, planets and stars.

While observing the moon's surface, Galileo observed:

- large, dark and flat areas that he called maria (Latin for seas)
- dark shadows that appeared to be made by mountains up to 6 kilometres high
- numerous craters.

Each of these features can be seen in the photograph at right.



Until 1959, when the first television pictures were transmitted from space, our knowledge of the moon depended on what could be seen through telescopes from Earth. The table below lists some of the important events that have occurred in the quest for knowledge about the moon.

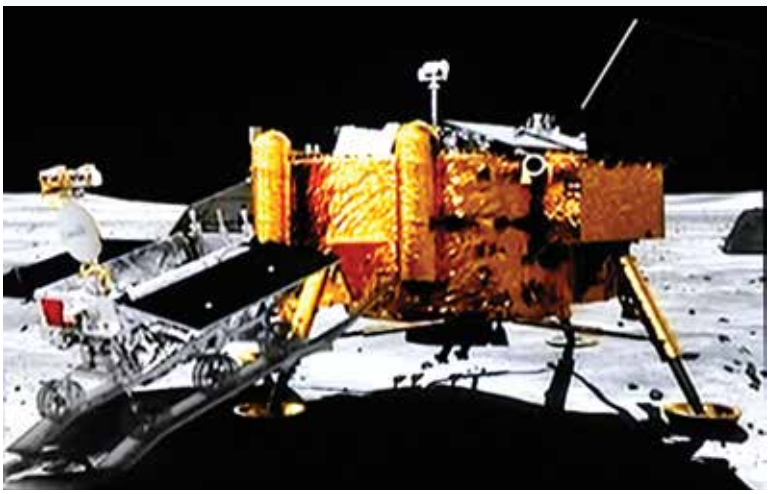
The most significant event since Galileo's use of a telescope in 1610 to observe the moon occurred on 20 July 1969. On that day, astronaut Neil Armstrong stepped down from the lunar landing craft *Eagle*, and as his foot touched the lunar soil he uttered the words: 'That's one small step for a man, one giant leap for mankind'.

Indian, Russian, Chinese and USA space agencies are all planning further missions to explore the moon during the next decade. There are also some private companies planning missions.

PROFILE OF THE MOON

- Natural satellite of the Earth
- Distance from Earth: 385 000 km (three days by spacecraft)
- Diameter at equator: 3475 km (Earth's diameter is 12 750 km)
- Period of orbit around Earth: about 29½ days
- Period of rotation about its own axis: about 29½ days
- Surface gravity: about one-sixth that of Earth
- Surface temperature: ranges from –175 °C in darkness to 125 °C in sunlight

The lunar rover *Yutu* (also known as Jade Rabbit) exploring the moon's surface in December 2013



INVESTIGATION 6.3

Observing the moon's surface from Earth

AIM: To observe the moon's surface using a telescope or binoculars

Materials:

binoculars or small telescope

Method and results

- Observe the moon with a pair of binoculars or a small telescope. The best time to observe the moon is when about half of it is visible. Craters and mountains are difficult to see when there is a full moon because they do not cast shadows.
- Try to identify the seas (dark, smooth areas), mountainous areas and craters.

1. Sketch and label what you see.

Discuss and explain

2. Which features were easiest to locate?
3. How do you think the craters were formed?

Probing the moon: some important events

Year	Event
1609	Galileo Galilei used a telescope to observe the moon.
1850s	Astronomers took the first photographs of features of the moon.
1959	*Luna 2* (USSR) became the first space probe to reach the moon when it crashed into the surface.
1964	Space probe *Ranger 7* (USA) took the first close-up pictures of the moon.

(*continued*)

Year	Event
1966	*Luna 9* (USSR) became the first space probe to make a soft landing on the moon and take pictures from the surface.
1969	*Apollo 11* (USA) carried three astronauts to and from the moon. Astronauts Neil Armstrong and Buzz Aldrin became the first humans to walk on the moon. They spent three hours collecting soil and rocks, performing experiments and setting up equipment for further experiments.
1969–1972	Apollo missions 12 and 14–17 (USA) successfully reached the moon, enabling more experiments to be completed. *Apollo 13* failed, stranding the three astronauts in space. The movie *Apollo 13* shows how the astronauts were able to return safely to Earth by using the fuel and oxygen stored in their lunar lander.
2008	*Chandrayaan-1* (India) discovered evidence of water and a large cave beneath the surface that could provide a location for human settlement on the moon.
2013	*Chang'e 3* (China) landed with a six-wheeled lunar rover, called *Yutu,* with a mission to explore 3 square kilometres of the lunar surface. It used cameras and scientific instruments to send data back to Earth.

6.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Why does the same side of the moon always face the Earth?
2. Why is there no erosion on the moon?
3. What are the large, dark, flat areas on the moon that are visible from Earth?

Think

4. How would you expect the mountains on the moon to be different from those on Earth?
5. As Neil Armstrong stepped down from the lunar landing craft onto the lunar soil, his now-famous words were heard by the millions of people watching the event live on television. Why do you think that this step was such a 'giant leap for mankind'?

Imagine

6. It is likely that, in the not-too-distant future, people will be living and working on the moon for long periods. Before that happens, a lot of scientific investigations need to be carried out. The lack of gravity, fresh food, water and oxygen are just a few problems that need to be solved. Make a list of the types of scientist that need to be involved and what they would need to investigate to ensure that people could maintain healthy lives.

6.4 Systems: Phases of the moon

6.4.1 Phases of the moon

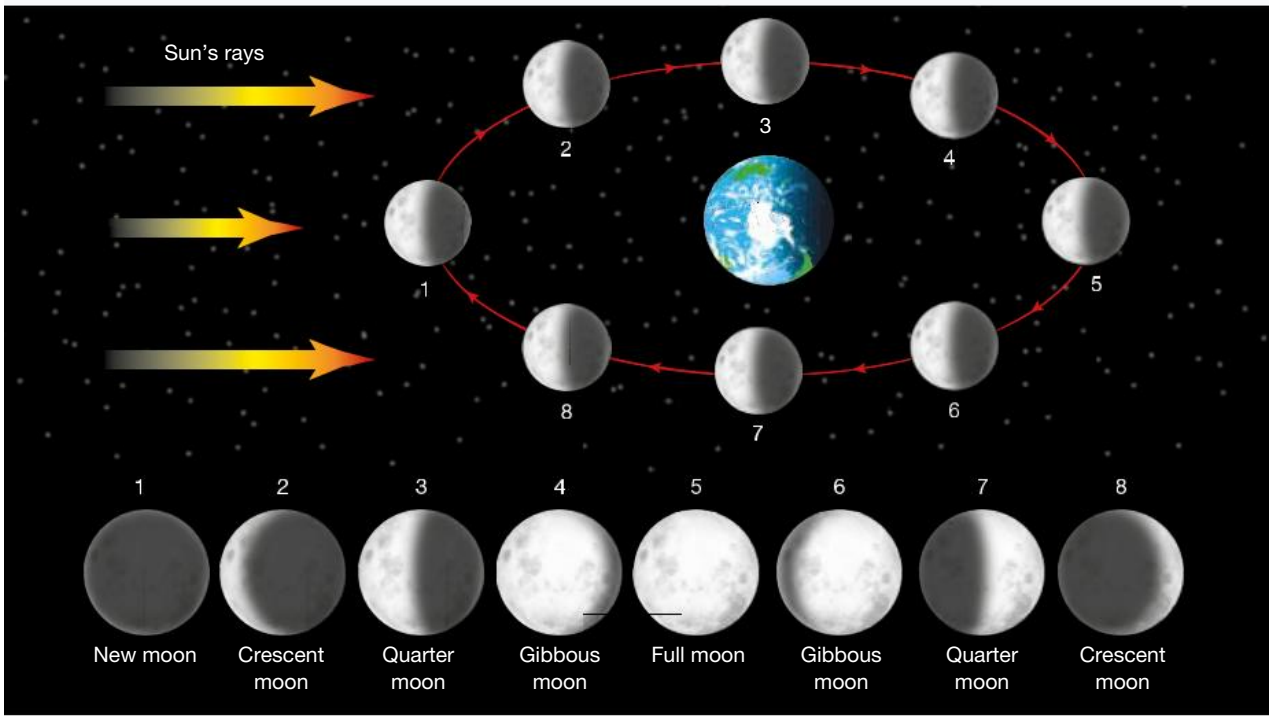
The moon is visible from Earth only because it reflects light from the sun.

As the moon orbits the Earth, it turns so that the same side of the moon always faces the Earth. At night, when you are in darkness, this side of the moon is sometimes completely bathed in sunlight. You then see a **full moon**. When the moon is between the sun and the Earth, its near side is facing away from the sun and in complete darkness. You are then unable to see the moon. When the near side of the moon is partially bathed in sunlight and partially in shadow, you see only the part that is in sunlight. The different shapes of the moon that you see from Earth are called **phases**. The diagram on the next page shows how the phases change during the 29½-day period between one new moon and the next. The view of the moon from Australia at each of the numbered positions is shown at the bottom of the diagram. The actual

appearance of the moon varies a little depending on where exactly in Australia you are. The closer you are to the equator, the more the phases will be like the ones in the diagrams.

During the period between a new moon and a full moon, the moon is said to be **waxing**. As the phases change between the full moon and the new moon, it is said to be **waning**.

The phases of the moon



INVESTIGATION 6.4

The changing moon

AIM: To observe and explain the phases of the moon

Method and results

- Copy the start of the table below into your workbook.
- Observe the moon every third or fourth evening over a period of at least two weeks. Observations over one whole month would be best. Try to make your observations as close to sunset as possible so that you know where the sun is.

1. Record the date, the time and the shape of the sunlit part of the moon in your table.

Discuss and explain

2. Each time you make an observation, make a comment about the position of the sun and suggest why the moon has the shape that you have observed.

Observing the phases of the moon

Date	Time	Shape of moon	Comment about the position of the sun and the shape of the moon

INVESTIGATION 6.5



Modelling the phases of the moon

AIM: To model the phases of the moon

Materials:
projector
large, light-coloured ball

Method and results

- Select one student to act as the Earth and another to hold the ball representing the moon.
- Darken the room and aim the projector (the sun) at the ball (the moon). The student holding it walks around the 'Earth' slowly in an anticlockwise direction, holding the same side towards the 'Earth'.
- Try to identify each of the eight phases of the moon, as they are seen by the person representing the Earth. Stop rotating briefly when each of the phases is identified so that the positions of the 'sun', 'Earth' and 'moon' can be recorded.

1. Draw a diagram to show the positions of the 'sun', 'Earth' and 'moon' that result in:
   (a) a full moon (b) a gibbous moon (c) a quarter moon
   (d) a crescent moon (e) a new moon.
2. Describe the positions of the sun, Earth and moon when there is:
   (a) a full moon (b) a new moon.

WHAT DOES IT MEAN?

The word *month* comes from the Old English word *mona*, meaning 'moon'. In early calendars, a month was the length of time between full moons. This period is called a lunar month. The modern calendar was not worked out until the sixteenth century by Pope Gregory XIII. The Islamic, Hebrew and Chinese calendars are still based on the lunar month.

6.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. During which phase of the moon is it:
   (a) between the sun and the Earth
   (b) on the opposite side of the Earth from the sun?
2. What is a lunar month?

Think

3. Explain, with the aid of a diagram, how a quarter moon occurs.
4. Why is the phase in which half the moon is visible called a quarter moon?
5. Sometimes the moon is visible during the day.
   (a) What phases of the moon would you be most likely to see during the day?
   (b) Would it be possible to see a full moon during daylight hours? Explain your answer.

Create

6. Draw a large poster to show how the phases of the moon occur.

Investigate

7. What is a harvest moon?
8. The moon has been the subject of many poems and songs. As a class, see how many songs you can list with the word 'moon' in the title. Many of them are quite old, so you might need to ask music-minded adults for some help.

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Complete this digital doc: Worksheet 6.1: The moon (doc-19835)

6.5 A lunar attraction

6.5.1 Changing tides

If you have lived near or visited coastal areas, you will know that the level of the water rises and falls. These changes in the water level are called **tides**.

Because the Earth rotates on its axis, the oceans bulge near the equator. This bulge is shown in the diagram below. This effect is just like that in the spin-dryer of a washing machine. As it spins, the water is flung towards the outside.

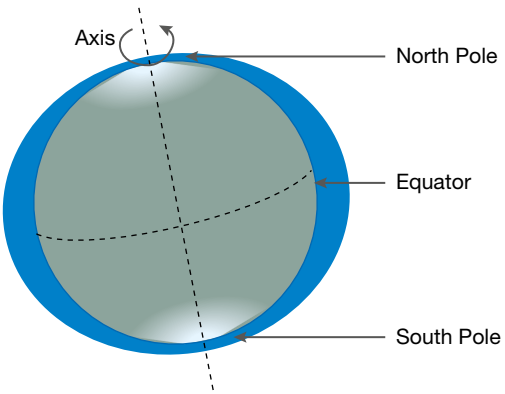
The oceans are not flung completely off the Earth because they are pulled back by the Earth's gravity. The size of the bulge would always be the same if it were not for the sun and the moon.

High and low tides at Lorne, Victoria. Between these two tides the water level rose vertically by 2.6 m, but stretched horizontally much further along the beach.



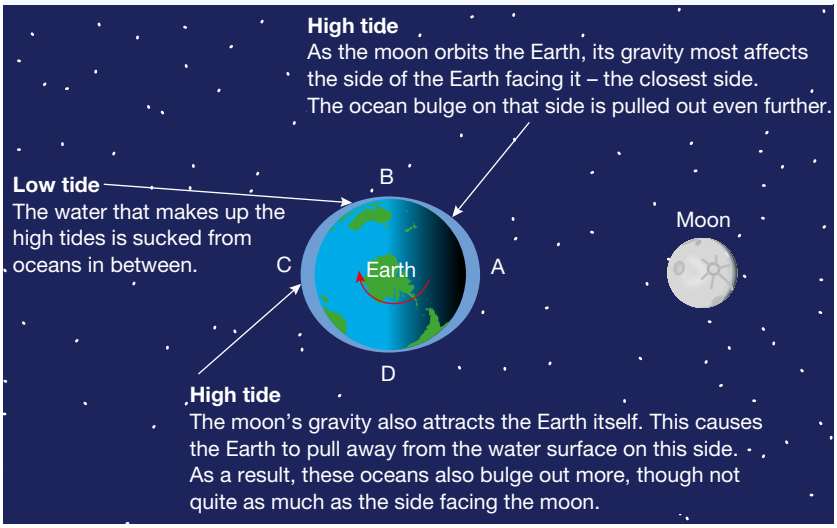


The rotation of the Earth would cause a permanent bulge all the way around the equator if it were not for the sun and the moon.



6.5.2 Tides and the moon

Looking down on Earth from above the South Pole. As the Earth rotates once, each place on Earth experiences two high tides and two low tides.



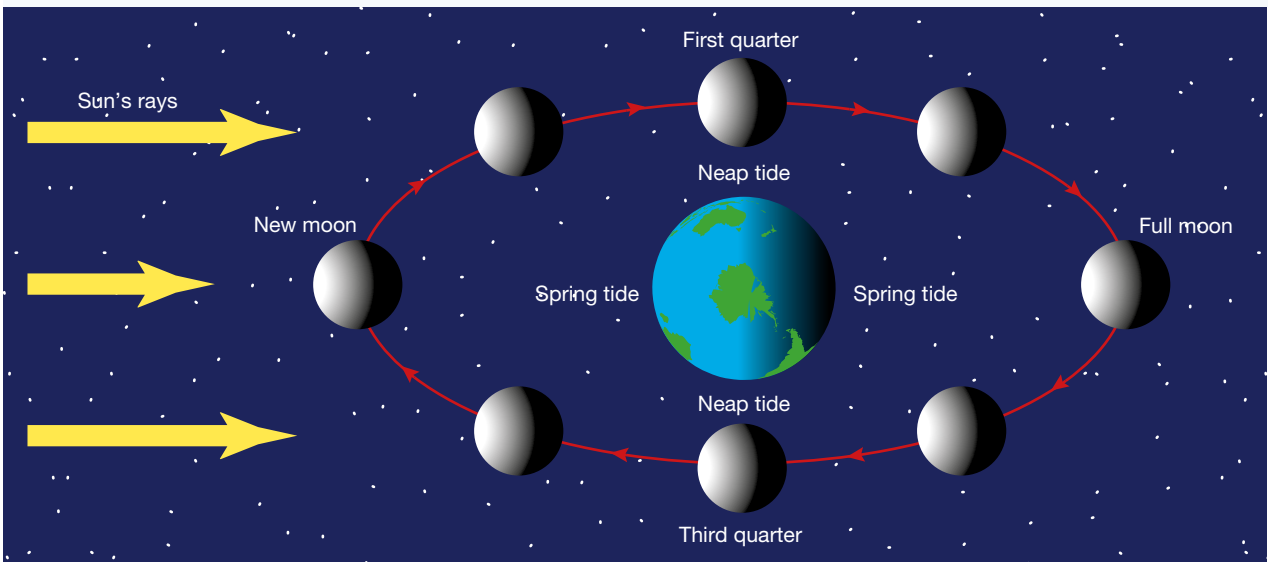
Tides are mostly caused by the gravitational pull of the moon. The diagram at right shows a view of the Earth from above the South Pole. The arrow shows the direction of the Earth's rotation. The oceans at A, closest to the moon, are pulled more strongly towards it, taking water away from B and D. The oceans at C, furthest from the moon, are pulled less strongly than the rest of the Earth. The result is that A and C are regions of high tide while B and D are regions of low tide. As the Earth rotates, different places on Earth experience high and low tides. During one day, each place on the Earth experiences two high tides and two low tides.

6.5.3 The effect of the sun

The sun also influences the tides. However, because it is further away, its gravity has much less effect than the moon's. Even though the mass of the moon is 27 million times less than that of the sun, its gravitational pull on the Earth is greater because it is so much closer to Earth. When the sun is on the same side of the Earth as the moon, or on the opposite side, higher tides than normal are experienced. These tides are called **spring tides**. They occur when there is a full moon or a new moon.

About seven days after a spring tide, the sun and the moon are no longer in the same line as the Earth. The gravitational pull of the sun is at right angles to the gravitational pull of the moon. The pull on the oceans of the sun and the moon are working against each other. The high tides are not as high as usual. The low tides are not as low as usual. These 'weaker' tides are called **neap tides**.

During each orbit of the moon around the Earth (29 days), there are two spring tides and two neap tides.



6.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is the major cause of tides on Earth?
2. Why are there two high tides and two low tides in a day?
3. Even though the sun is much larger than the moon, it has much less effect on the tides. Why?

Think

4. Explain why the highest tides occur during a new moon or a full moon.
5. If the moon did not exist, would there still be tides? If so, how would they be different?
6. How would the tides be different if the Earth did not rotate? Explain your answer with diagrams showing the Earth, sun and moon.
7. On any given day, one high tide is higher than the other one. Suggest a reason for this.

Draw

8. Draw a diagram that shows one arrangement of the sun, moon and Earth that would cause a neap tide on the side of the Earth closest to the sun.

Create

9. Design and act out a role-play that shows how the orbits of the Earth around the sun and the moon around the Earth cause tides. The role-play should involve at least four people, including a narrator to provide a commentary.

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Try out this interactivity: Tides (int-0225)

Complete this digital doc: Worksheet 6.2: Surf's up (doc-19836)

6.6 Lunar and solar eclipses

6.6.1 Lunar eclipses

A **lunar eclipse** occurs when the moon passes into the Earth's shadow. This can happen only during a full moon, when the Earth lies between the sun and the moon.

Lunar eclipses occur more often than solar eclipses. However, the moon's orbit around the Earth is tilted, so it does not pass through the Earth's shadow every time there is a full moon.

6.6.2 Solar eclipses

Any object that you cannot see through casts a shadow when the sun shines on it. The Earth and moon both cast shadows into space. Sometimes, when the moon passes between the Earth and the sun, the moon's shadow falls on the Earth. If this happens during the day, the part of the Earth in the shadow experiences a **solar eclipse**.

The shadow cast by the moon during an eclipse is not sharp. Most of the shadow is only partially dark. Only the centre of the shadow is in total darkness. Even though the moon passes between the sun and the

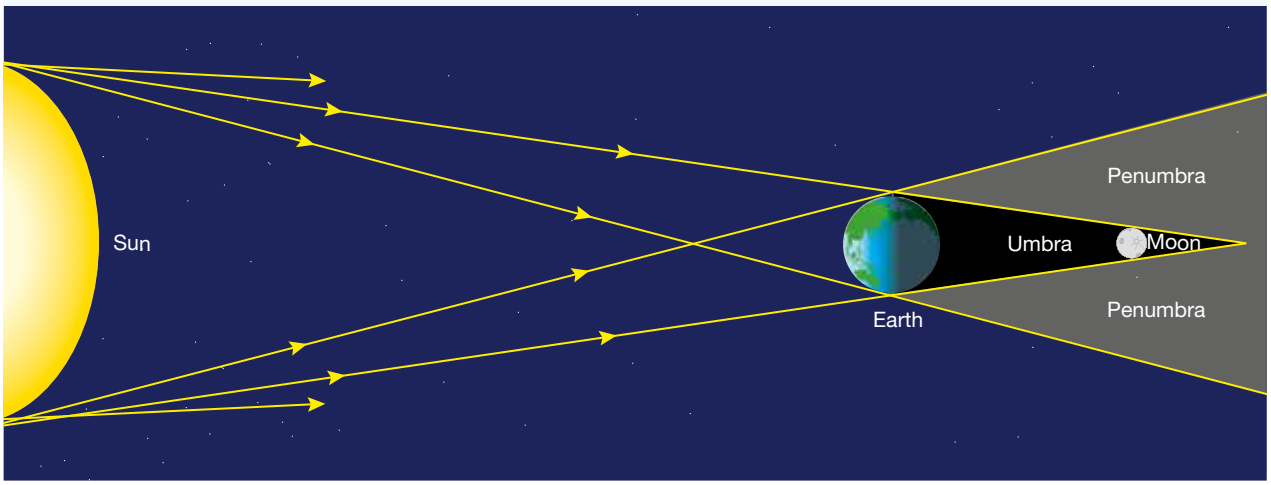
Earth every 29½ days, eclipses do not occur very often. Usually the whole shadow passes above or below the Earth. If the dark centre of the shadow falls on the Earth, a **total solar eclipse** is experienced.

During a total solar eclipse, the area in the dark centre of the shadow becomes completely dark, as if it were night-time. The sun is completely blocked out. The last total solar eclipse to affect Australia passed across a narrow band of tropical northern Australia in November 2012. It plunged the Cairns area into complete darkness for about two minutes. The next total solar eclipse to affect Australia will touch the coast at Exmouth in Western Australia in April 2023. A further total solar eclipse in July 2028 will cross a narrow band from the Kimberley in Western Australia all the way to Sydney.

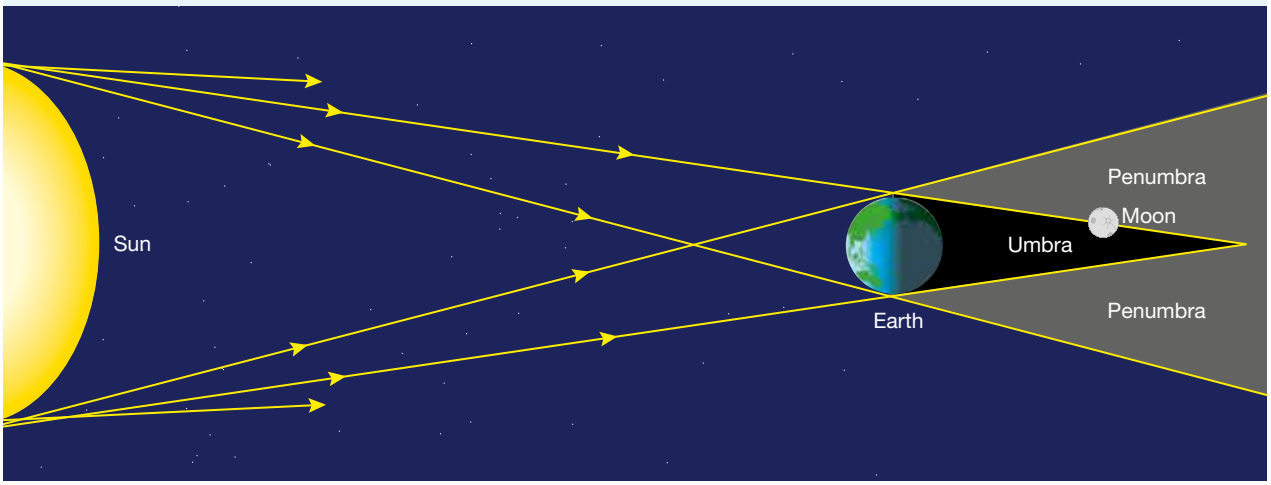
Partial solar eclipses and **annular solar eclipses** are much more common than total solar eclipses. A partial solar eclipse is experienced by areas in the partially dark part of the shadow. Not enough of the sun is blocked out to cause darkness. An annular eclipse occurs when the moon blocks out the central part of the sun, leaving a ring (called an annulus) of light from the outer part of the sun, which is visible from Earth.

Solar eclipses are extremely useful to astronomers because the outer part of the sun, known as the corona, can be seen. The corona is normally not visible because of the brightness of the rest of the sun. However, during a total solar eclipse the rest of the sun's light is blocked out by the moon. The corona can then be successfully photographed and studied.

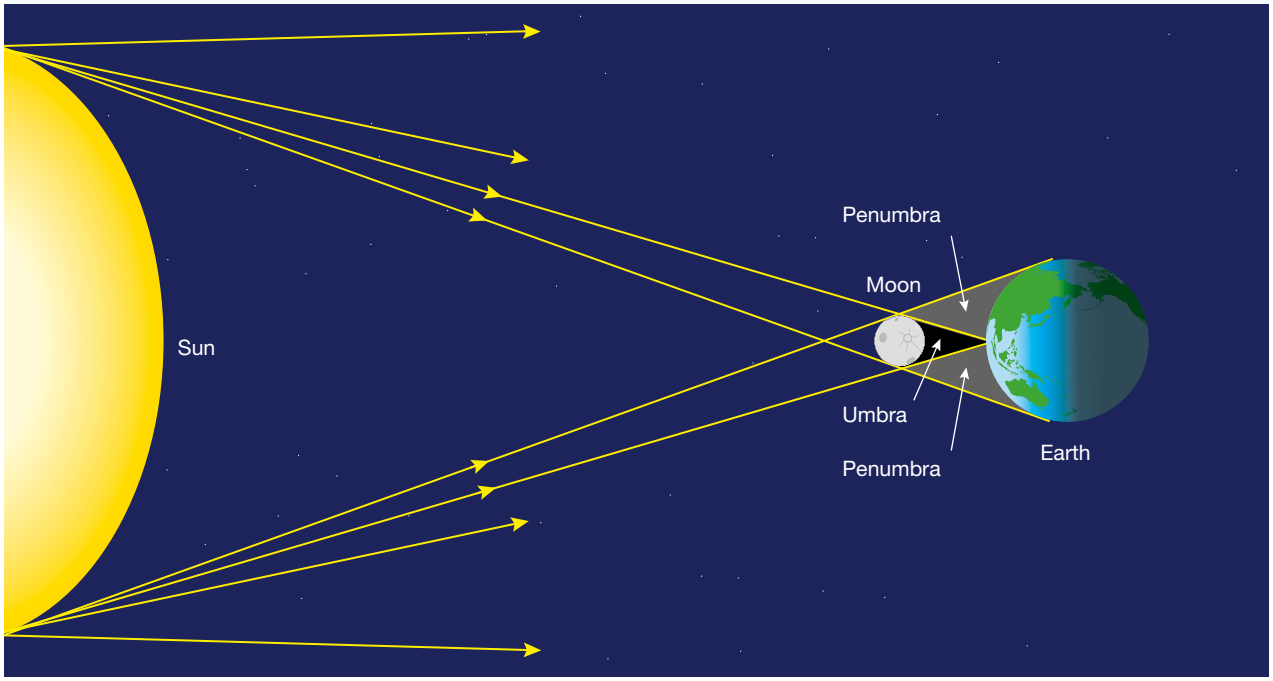
Total lunar eclipse



Partial lunar eclipse



Total and partial solar eclipses



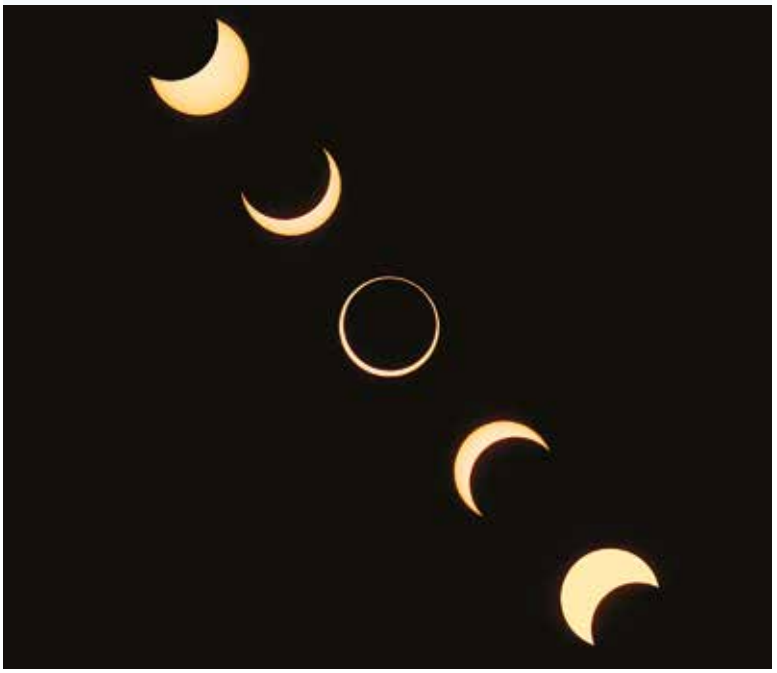
CAUTION

You must NEVER look directly at an eclipse of the sun — even a partial eclipse. You could permanently damage your eyes. Sunglasses will not protect you.

The Earth's shadow makes the moon appear to change phases during a total lunar eclipse. Note the red tinge of the moon at the height of the eclipse.



A total solar eclipse — the sun's light is blocked as the moon passes in front of it.



HOW ABOUT THAT!

The ancient Chinese believed that solar eclipses occurred when a giant dragon ate the sun. They thought that if they made enough noise they could frighten the dragon. The frightened dragon would then spit the sun out, bringing daylight back.



INVESTIGATION 6.6

Modelling solar and lunar eclipses

AIM: To model solar and lunar eclipses

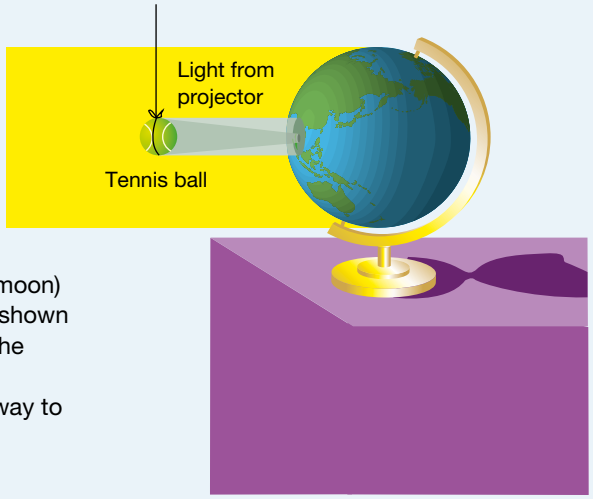
Materials:

projector
globe
tennis ball attached to string

Method and results

- Darken the room and aim a beam of light at the globe.
- To simulate a solar eclipse, suspend the tennis ball (moon) between the projector (sun) and the globe (Earth) as shown at right. Ensure that you keep your own shadow off the globe.
- Rotate the globe a little (think carefully about which way to turn it) and note what happens to the shadow.

Modelling a solar eclipse



- To simulate a lunar eclipse, move the tennis ball to the opposite side of the globe from the projector. Suspend it so that it is partly in the shadow of the globe.

1. Draw a diagram to show the initial positions of Earth, moon and sun in your model of a solar eclipse.
2. During which phase of the moon does a solar eclipse occur?
3. When you rotate the globe, does the shadow move from east to west or from west to east?
4. Draw a diagram showing the positions of the Earth, moon and sun in your lunar eclipse model.
5. During which phase of the moon does a lunar eclipse occur?

INVESTIGATION 6.7

Fuzzy shadows

AIM: To investigate the creation of sharp and fuzzy shadows

Materials:

torch
white card or a bare wall to act as a screen
coin

Method and results

- Use a torch to cast light on a white card or bare wall. Observe the shadow of a coin as you move it between the light source and screen.
- Create sharp shadows and fuzzy shadows.
- Create a shadow that is dark in the centre and partially dark on the outside. This is the type of shadow cast on the Earth by the moon.

1. Where does the coin need to be to create a sharp shadow?
2. Where does the coin need to be to create a fuzzy shadow?
3. Draw a diagram of this fuzzy shadow.

6.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Outline the difference between a solar eclipse and a lunar eclipse.
2. Explain why you must never look directly at a solar eclipse.

Think

3. Explain why total solar eclipses are much less frequent than partial solar eclipses.
4. Explain why a total lunar eclipse occurs only when there is a full moon, and why a solar eclipse occurs only when there is a new moon.

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Try out this interactivity: Eclipses (int-0207)

Complete this digital doc: Worksheet 6.3: Eclipses (doc-19837)

6.7 Explaining the night sky

Science as a human endeavour

6.7.1 The earliest astronomers

Astronomers have been recording observations of the night sky for at least 4000 years. For just as long they have been trying to explain their observations. The quest for knowledge and understanding of the universe is not over. Astronomers are still making new discoveries, often leading to more questions than answers.

Almost all ancient cultures had stories about how the universe was created, what it was like and how the Earth, sun, moon, planets and stars got here. Thousands of years ago, Indigenous Australians told stories that explained the stars, the sun and the moon. They identified the shapes of groups of stars in the night sky and told stories about them that were passed on from generation to generation. The shapes described and the stories about them varied from tribe to tribe.

The emu in the sky

Rock engravings carved by the Guringai people of the northern outskirts of Sydney show an emu in the sky that stretches from its head in a dark patch of the Southern Cross through the cloud-like band of stars that we call the Milky Way. Their story explains that when the real emu in the sky is directly above the engravings, it is the emu egg-laying season. It signals that it is time to gather the eggs. Another explanation from Papunya in the Northern Territory tells the story of an old blind man who speared the emu and sent it to the Milky Way after it killed his wife while protecting its eggs.

Chopped to bits

The Yolngu people of Arnhem Land explain the phases of the moon with the story of Ngalindi and his wives. At the time of the full moon, Ngalindi is a fat, lazy man. His wives punish him by attacking him with an axe, and he is seen as a waning moon as parts of him are chopped off. Unable to escape his wives, Ngalindi dies of his wounds, and this is the time of the new moon. He rises from the dead after three days and is seen as the waxing moon as he again grows round and fat. Two weeks later, his wives punish him again, and the cycle repeats.

6.7.2 The lunar chariot of Rome

The ancient Romans thought that the moon was a goddess. Named Luna, she drove across the sky at night in a chariot. When the moon did not appear, Luna had driven her chariot down to Earth to visit her mortal lover, a shepherd named Endymion.

6.7.3 Ancient Greek astronomy

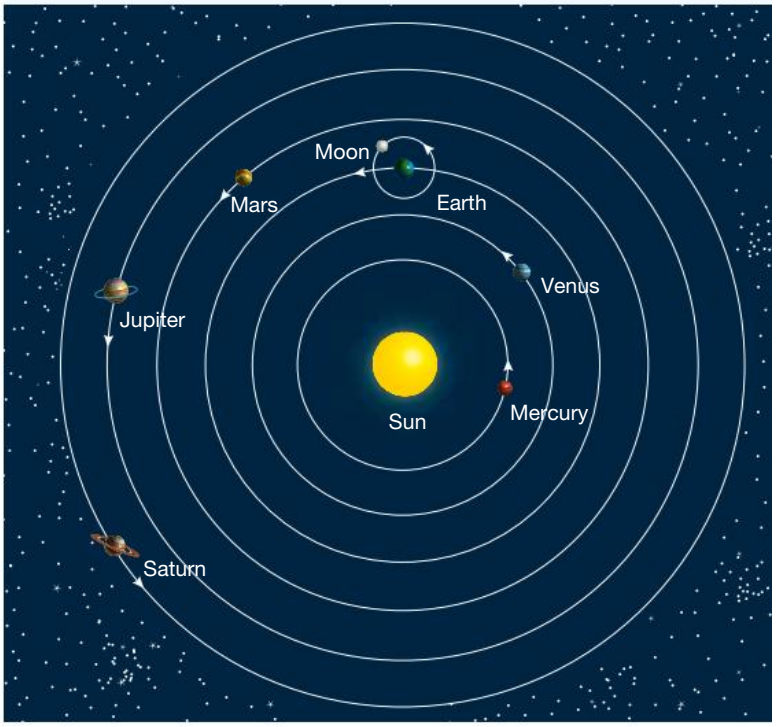
The ancient Greeks provided many of the early ideas from which modern astronomy was developed. Their ideas were widely accepted throughout Europe for hundreds of years.

The Greeks discovered that the Earth was spherical; the Greek philosopher Eratosthenes calculated the circumference of the Earth to within about 300 kilometres of the true value. In the fourth century BC, Aristotle was one of the most influential philosophers in Greece. He believed that the sun and moon revolved around the Earth, which was the centre of the universe. Aristotle's model was easily accepted at the time because people who studied the night sky saw celestial bodies passing over the Earth.

Ahead of his time

In the following century, Aristarchus developed a model of the universe in which the sun was fixed and all the planets, including Earth, orbited it along circular paths. He also noted that, once a day, the moon revolved around the Earth and the Earth rotated on its axis. Aristarchus's model did not gain wide acceptance. This sun-centred theory would have defied common sense at the time because we do not feel the Earth spinning or moving through space.

Aristarchus's heliocentric model



6.7.4 The Incas of Peru

For about 300 years, from the 1200s until the Spanish conquistadors invaded in the 1500s, much of South America around Peru was ruled by the Incan empire.

The Incas had a deep knowledge of the stars and constellations, which they observed and named. They named the Milky Way *mayu*, meaning 'river'. This celestial river was said to join up with the Urubamba River in the waters of a great cosmic sea that encircled the Earth. The Incans believed that the celestial river, the Milky Way, was the source of rain on Earth as it passed through the night sky.

At Cusco, the astronomical centre of their empire, the Incas constructed a series of stone towers to mark the points of sunrise and sunset on important days. These included the summer solstice (the longest day

Most historians agree that the Incans had a calendar based on observations of the sun and the moon and their relationship to the stars. Names of 12 lunar months are recorded.



of the year) and the winter solstice (the shortest day of the year). The Incas created an accurate annual calendar based on the positions at which the moon rose and set on the horizon, as well as observations of the phases of the moon.

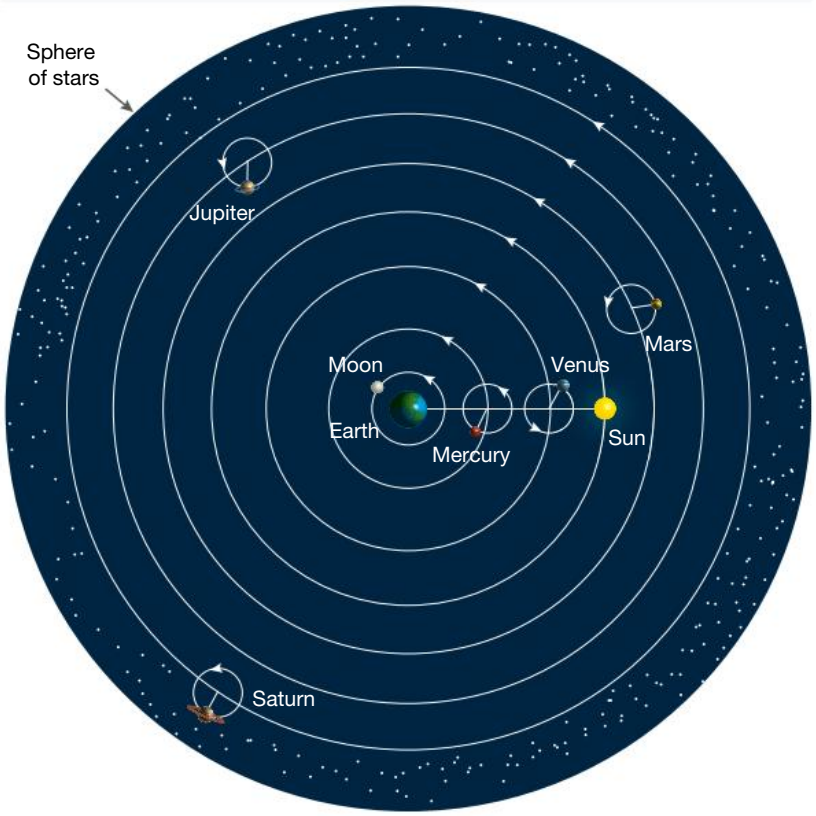
6.7.5 The Earth-centred model returns

The early Greek astronomer Ptolemy, in about AD 150, used his own observations and the ideas of other Greek astronomers to develop a model of the **universe**. The universe is the whole of space and everything in it. In Ptolemy's model, the Earth was the centre of the universe. The universe was surrounded by a sphere called the celestial sphere to which all of the stars were attached. The moon, sun and planets orbited the Earth, which did not move at all. Ptolemy's model was generally accepted as correct for almost 1500 years.

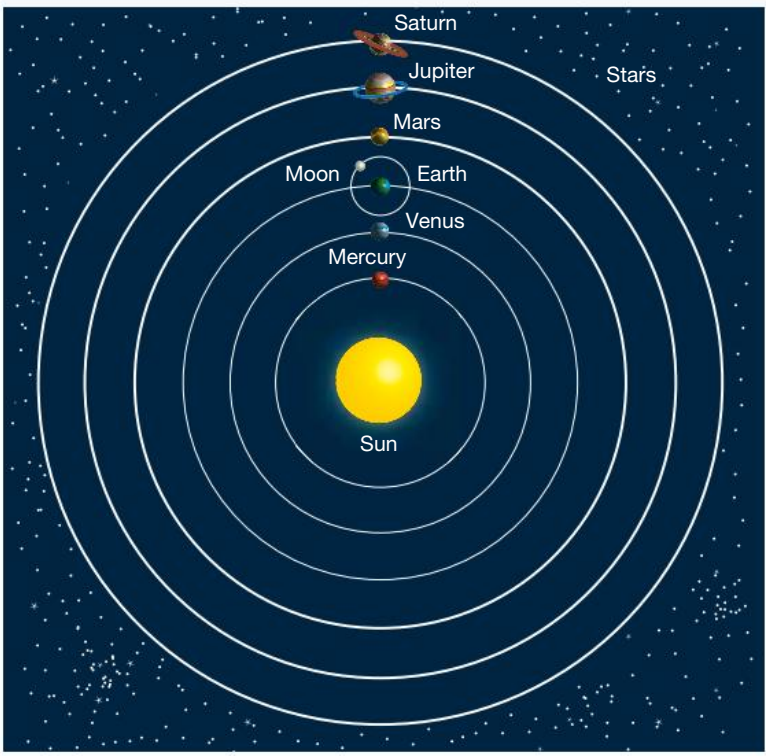
6.7.6 The sun at the centre?

Nicolaus Copernicus, born in Poland in 1473, was a mathematician with a keen interest in astronomy. He was unhappy with Ptolemy's model. Although it explained the circular movement of the stars, it did not fully explain the movement of the planets across the sky. Copernicus was convinced that the planets revolved around the sun. The movement of the stars could be explained if the Earth spun on its own axis once a day. Copernicus wrote a book in which he used

Ptolemy's model of planetary motion



Copernicus's heliocentric model



mathematics to explain his ideas. He died in 1543 on the day that his book, *On the Revolutions of Heavenly Spheres*, was published. The book was then banned because it disputed the teachings of the Church and was considered to be morally wrong. According to the Church at that time, the Earth had to be at the centre of the universe.

6.7.7 He was right after all!

Galileo Galilei (1564–1642) was the first astronomer to use a telescope to observe the night sky. His discovery in 1610 of four moons orbiting the planet Jupiter showed that not all heavenly bodies revolve around the Earth. Galileo, despite strong opposition from the Church, actively supported the ideas of Copernicus. In 1616 he was ordered by the Roman Catholic Church not to defend the Copernican model. However, he defied the order and in 1632 published a book in which he showed that the ideas of Copernicus were far more sensible than the Earth-centred model of Ptolemy. The following year Galileo was forced, under threat of torture, to deny his beliefs in public. His book was banned and he was sentenced to life imprisonment. Old, sick and losing his sight, Galileo was allowed to serve his sentence locked in his own home. He was totally blind during the last four years of his life.

It was not long after Galileo's death that the observations of other astronomers, and the theories of English scientist Sir Isaac Newton, confirmed that the sun was at the centre of the solar system. Newton died in 1727 knowing that he had finally convinced most astronomers that the Earth was not the centre of the solar system or the universe.

6.7.8 The quest continues

Astronomers continue to observe the night sky using telescopes. New technology has allowed observations to be made during the day. Observations can be made even from space — above the gases in the Earth's atmosphere that blur the detail. Sometimes, new observations help astronomers answer questions. The discovery of a new star might, for example, provide some clues about how big the universe is.

One advance in exploring and explaining the universe is the Hubble Space Telescope. It orbits the Earth at a distance of about 600 kilometres above the surface. The images are much clearer than could be obtained by similar telescopes on the Earth's surface. The Hubble Space Telescope was lifted into orbit in 1990 by a space shuttle.

Since the accidental discovery in 1931 that stars emit radio waves as well as light, a new generation of telescopes has emerged. Radio telescopes are huge dishes that collect radio waves from distant stars and galaxies. CSIRO's Australia Telescope Compact Array near Narrabri, NSW, built in 1988, consists of radio telescopes that can be moved along railway tracks to make a more complete picture of the sky. (Photograph courtesy of CSIRO)



6.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. How does the position of the emu in the sky influence the Guringai people of New South Wales?
2. Besides Dreamtime stories that still survive today, what other evidence is there that Aboriginal peoples studied the night sky?
3. The Incan calendar, like our own, is based on astronomy. Outline the information used to help create such a calendar.
4. Explain why an Earth-centred model of the solar system made much more sense to early astronomers than a sun-centred one.
5. Why were the ideas of Copernicus rejected for so long?
6. Which new technology enabled Galileo to make observations that supported the idea of a sun-centred solar system?

Think

7. Describe the limitations that ancient cultures had on their study of the night sky.
8. How did Copernicus explain the circular motion of the stars, if the Earth was not at the centre of the universe?
9. What evidence would you use if you had to argue that the Earth was at the centre of the universe?
10. During the lifetimes of Copernicus and Galileo, new theories about our solar system developed rapidly and previous ones were rejected. In science, why are existing theories replaced by new ones?

Create

11. Use resources from the library or home to find out more about how explanations of the night sky have changed since ancient times. Include in your timeline the technology, such as telescopes and space probes, that has made new explanations possible. You might need to use separate timelines to show some of the detail from AD 1400 to AD 1700 and from AD 1950 to the present time.

Investigate

12. Research and write a report of approximately 200 words about the life and times of Omar Khayyam and the contributions he made to astronomy.

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Complete this digital doc: Worksheet 6.4: Astronomical history (doc-19838)

6.8 Mind maps and tree maps

6.8.1 Mind maps and tree maps

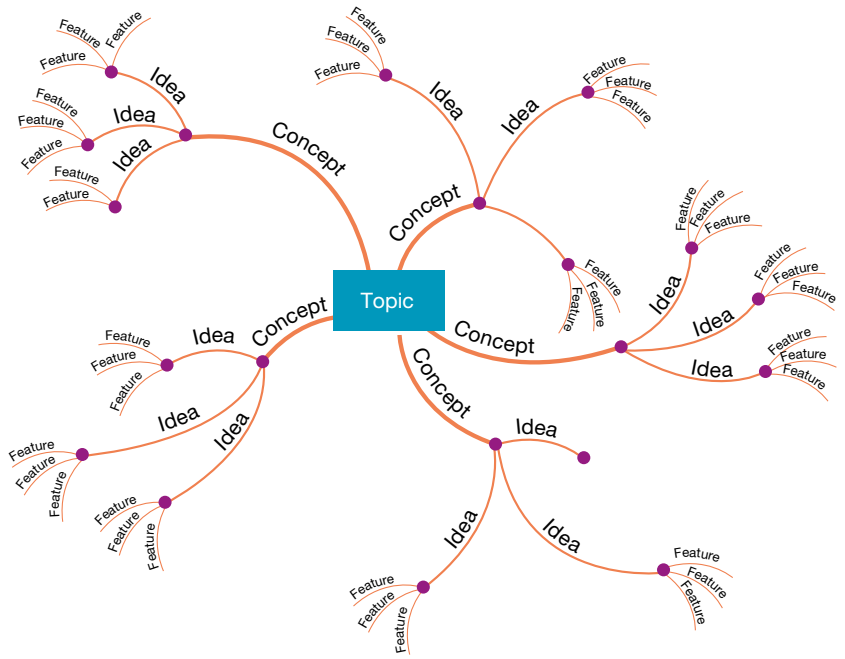
1. Write your topic in the middle of a sheet of paper and draw a number of lines branching out from it.
2. Think of some main ideas related to the topic and write one on each branch.
3. Draw a number of lines branching from each of your main ideas.
4. Think of words or terms related to one of your main ideas and write one on each branch.
5. Continue adding branches until you run out of ideas.
6. Decorate your map with colour, clip art, drawings, photos etc. to make the ideas and links clearer.

how to ...?

To show the hierarchy of ideas within a topic

why use?

Mind map



question

How can I summarise this?

comparison

Similarity

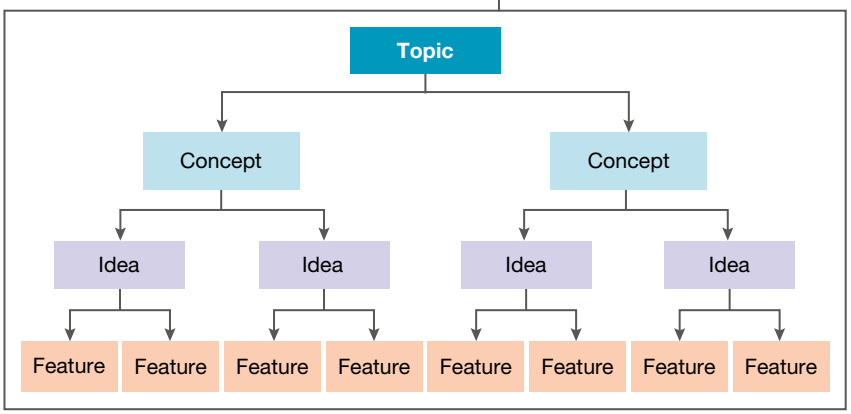
Main concepts are identified and broken down into sections or groups.

Tree map

Difference

Mind maps radiate from the centre. Ideas in tree maps are organised horizontally.

example



also called

Model map; memory map; brain map; learning map

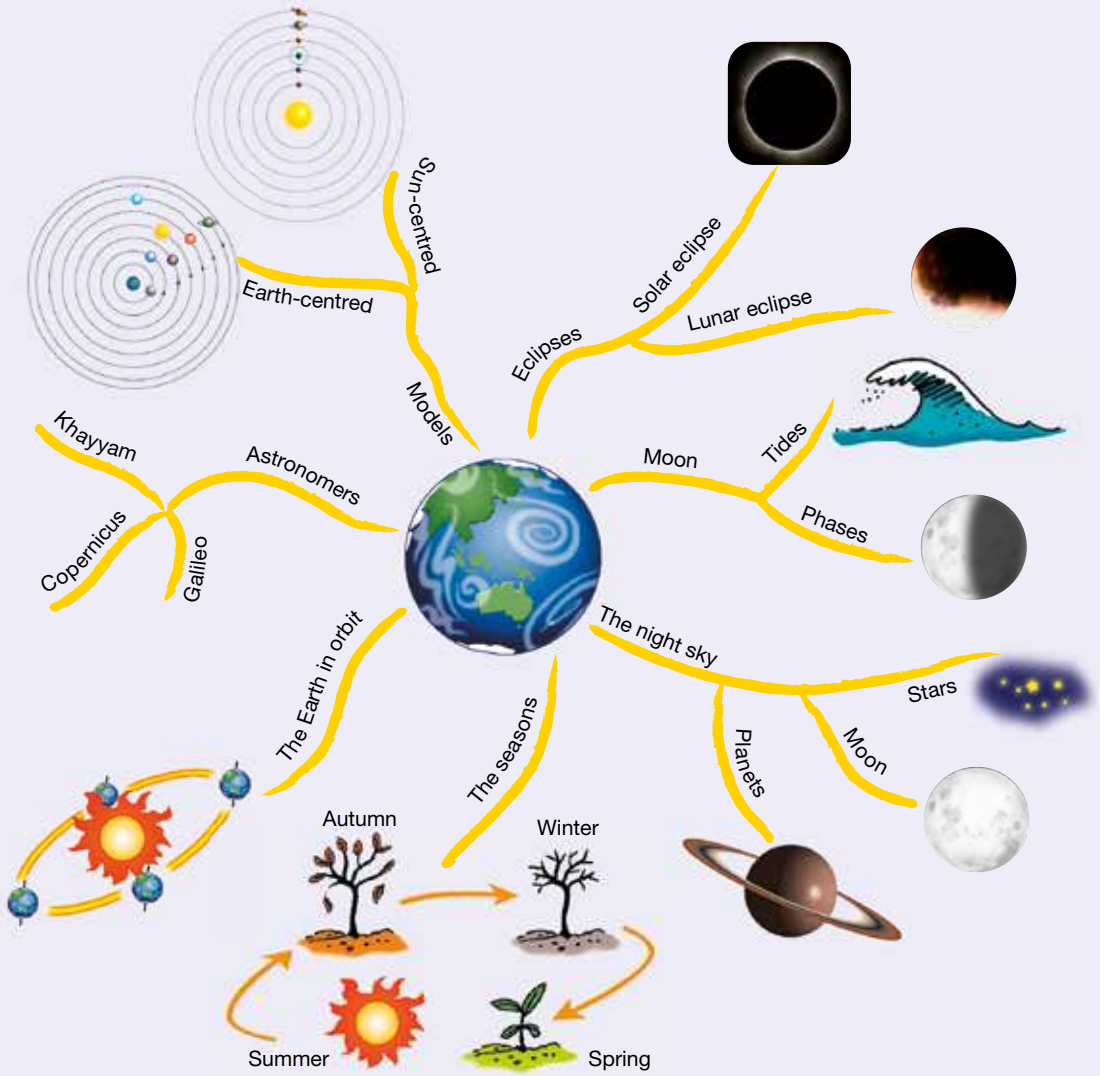
6.8 Exercises: Understanding and inquiring

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Think and create

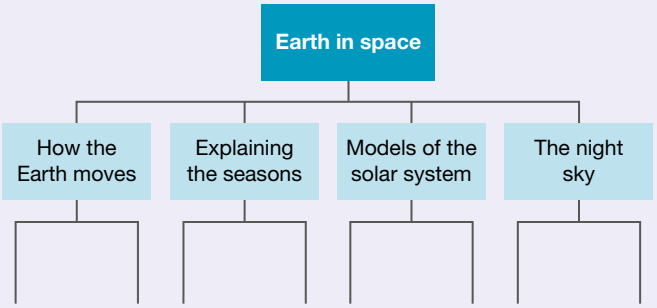
1. Draw a mind map to summarise what you have learned about the Earth in space. Your mind map should consist of branches of words and pictures flowing from a picture of the Earth in the centre. You can use the mind map below to help you get started. Just add more branches.

Use this mind map as a starting point.



2. (a) Convert your mind map of Earth in space into a tree diagram using only the following four main ideas.
   - How the Earth moves
   - Explaining the seasons
   - Models of the solar system
   - The night sky

Use this to start your own tree map showing what you have learned about the Earth in space.



(b) Use your tree map to explain how each of these pairs of 'main ideas' are closely related to each other:
  (i) the seasons and the tilt of the Earth
  (ii) the apparent movement of the stars during the night and the Earth in orbit
  (iii) the change of the positions of stars in the night sky from month to month and the seasons.

(c) Add another branch or layer to your tree map to identify technology that has been used to make observations of the moon, other objects visible in the night sky and the Earth. The technology should include a range of examples such as telescopes, satellites and space probes.

3. (a) Research the seasonal calendars of an Aboriginal or Torres Strait Islander people. Identify the regularly occurring features of the local environment and weather.

(b) Compare your Indigenous seasonal calendar with the western model of seasons (that is, spring, summer, autumn and winter).

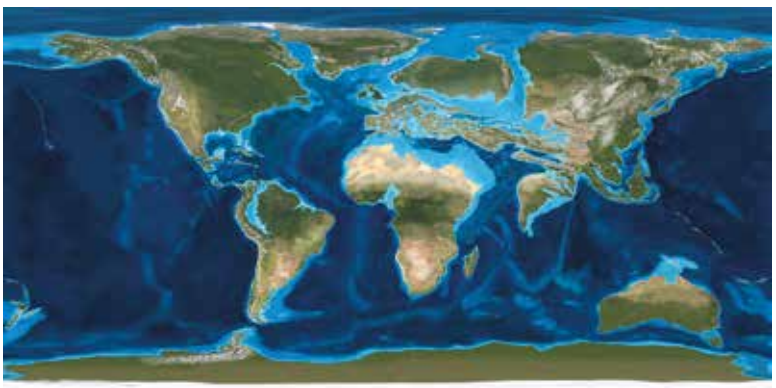
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6.9 Project: Australia 50 million years BC

Scenario

For much of its 4.5 billion year history, the Earth's surface has undergone enormous changes. Based on scientific evidence, our present theories about how and why these changes occur indicate that the Earth of 100, or even 50, million years ago would be vastly different from the one we know today. At various times, according to the theories, the oceans have risen and fallen, Antarctica has been green and forested, continents have collided and separated, the climate has altered and volcanoes have been born and died.

Now, with the development of a time machine by Australian research company Chronoscience P/L, scientists have a unique opportunity to see for themselves just how well their theories match up with reality. After years of testing on watermelons, white rats and labradors, the company is finally ready to start human trials. Their intention is to send a team of four explorers (or 'chrononauts', as the company likes to call them) back to Australia as it was 50 million years ago to make scientific observations that they will bring back with them when they are retrieved to the present era a week later.



The company needs to know a lot more about what our continent was like at that time so that they can prepare their expeditionary team properly — particularly because they aren't exactly sure where on the continent the team will end up.

Your task

As key team members of Chronoscience's Time Taskforce, you are required to prepare a report that will be used to brief, train and equip the expeditionary team. The report will need to describe:

- where the Australian continent was located 50 million years ago relative to its current position
- the seasons that the team will experience, and how they differ from the seasons of today
- the geography of the continent — for example, the shape of the coastline, the main mountain ranges, locations of large lakes or inland seas if present
- what many of Australia's famous natural features, such as Uluru, Wave Rock and the Twelve Apostles, would have looked like at that time
- the conditions of climate and terrain that the team are likely to encounter
- the most likely dangers (including possible predators) that the team may encounter and where on the continent they would be most likely to find them.

Note: In each case, the team will need to describe what scientific evidence exists to justify their findings.

The report will also include

- a map of Australia at that time, with key features such as lakes, seas, volcanic regions, deserts, mountain ranges, jungle, glaciers and forests noted if appropriate
- a bibliography.



6.10 Review

6.10.1 Study checklist

The seasons, day and night

- explain the seasons in terms of the tilt of the Earth's axis and the orbit of the Earth around the sun
- state the time taken for a complete orbit of the Earth around the sun
- explain day and night in terms of the rotation of the Earth about its axis
- state the time taken for a complete rotation of the Earth about its axis
- explain why the amount of daylight varies from season to season and distance from the equator
- use a model to demonstrate how the movement of the sun and Earth causes day and night and the seasons

The moon

- describe the surface of the moon
- state the time taken for a complete orbit of the moon around the Earth
- identify the different phases of the moon

Earth, moon and sun

- explain the phases of the moon in terms of the orbit of the moon around the Earth and the Earth around the sun
- use a model to demonstrate how the phases of the moon occur
- explain how the gravitational pull of the sun and the moon, together with relative movements of the Earth, moon and sun, causes tides
- explain solar and lunar eclipses in terms of shadows and the relative movement of the Earth, moon and sun
- use a model to demonstrate how solar and lunar eclipses occur

Science as a human endeavour

- describe the way in which different cultures have explained night and day, the seasons, phases of the moon and eclipses
- describe the developments of models of the universe and solar system put forward by astronomers including Ptolemy, Copernicus and Galileo
- explain how telescopes, space probes and other advances in technology have affected space exploration

Individual pathways

ACTIVITY 6.1
Investigating Earth science
doc-6090

ACTIVITY 6.2
Earth science analysis
doc-6091

ACTIVITY 6.3
Investigating Earth science further
doc-6092

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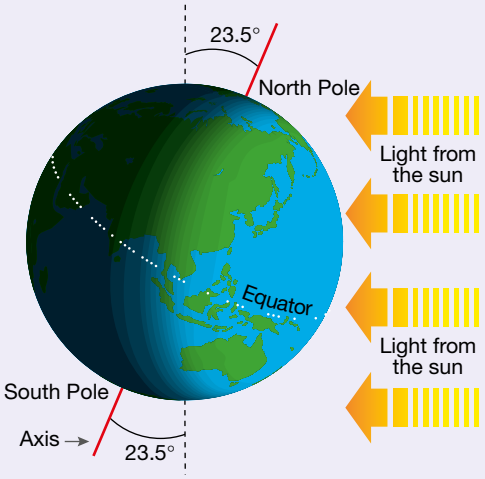
6.10 Review 1: Looking back

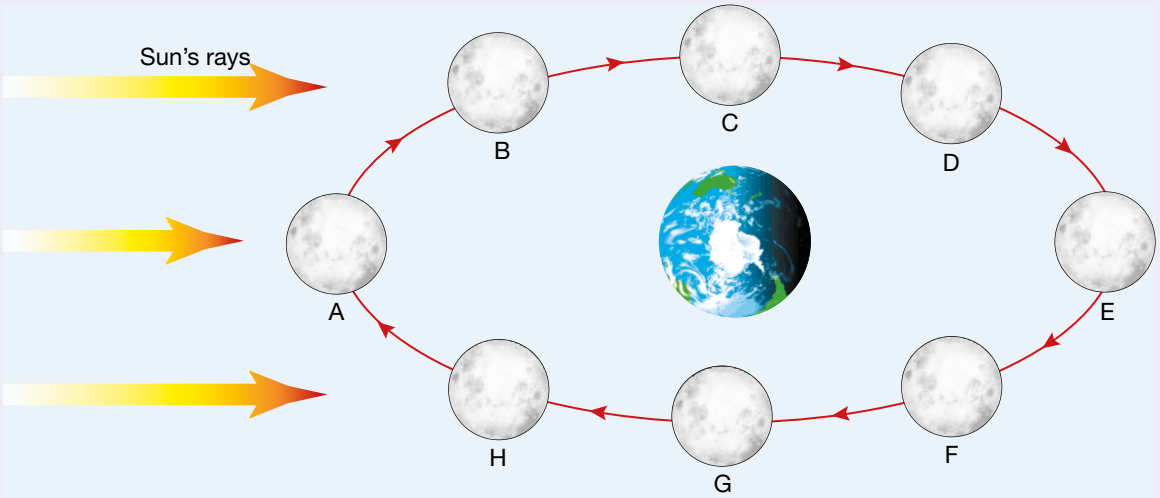
To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Imagine that you are given the task of describing your planet to an alien from a distant galaxy. You are, however, limited to a maximum of 200 words. Write your description. You are not able to use diagrams and must write more than 100 words.

2. The diagram at right shows half the Earth in sunlight while the other half is in darkness. Which Australian season is represented in this diagram? Explain how you know.
3. Explain why the position of the sun in the sky at midday changes from day to day.
4. The diagram below shows the moon in eight different positions during an orbit around the Earth.
   (a) Copy the diagram and shade the parts of the Earth and moon that are in darkness.
   (b) How long does it take the moon to complete a single orbit?
   (c) Why is it not possible to see a new moon during the day?
   (d) Which one or more positions of the moon would result in a quarter moon? Why?
   (e) Which one or more positions of the moon would result in a gibbous moon?
   (f) Which one or more positions of the moon would result in a full moon?
   (g) How many times does the moon rotate about its own axis while completing a single orbit of the Earth?



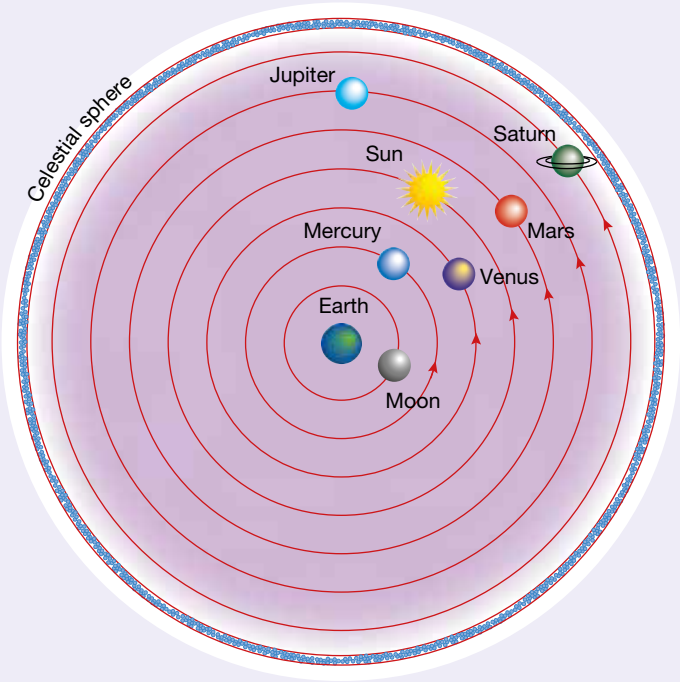


5. The length of a day on the planet Venus is 243 Earth days. The length of a year on Venus is only 225 Earth days. Explain how it is possible for a day to be longer than a year.
6. The photograph at right shows the Earth as it is seen from the moon.
   (a) Why is the Earth visible even though it does not emit its own light?
   (b) Would you expect the Earth to always be visible from the part of the moon that faces it? Explain your answer.
   (c) Does the Earth have the same phases as the moon? Draw some diagrams showing the positions of the sun, Earth and moon to explain your answer.
   (d) If you were on the moon, how long would you expect to have to wait between Earthrise and Earthset?
7. Astronauts have already visited the moon and may soon land on Mars. Is it likely that astronauts will one day visit a planet outside our solar system? Explain your answer.
8. Which type of tide is experienced when a full moon is overhead? Explain your answer.
9. What causes a partial solar eclipse? How is it different from a total solar eclipse?

Photographs like this composite image of the Earth were taken from the *Apollo 8* spacecraft in 1968 as it orbited the moon.

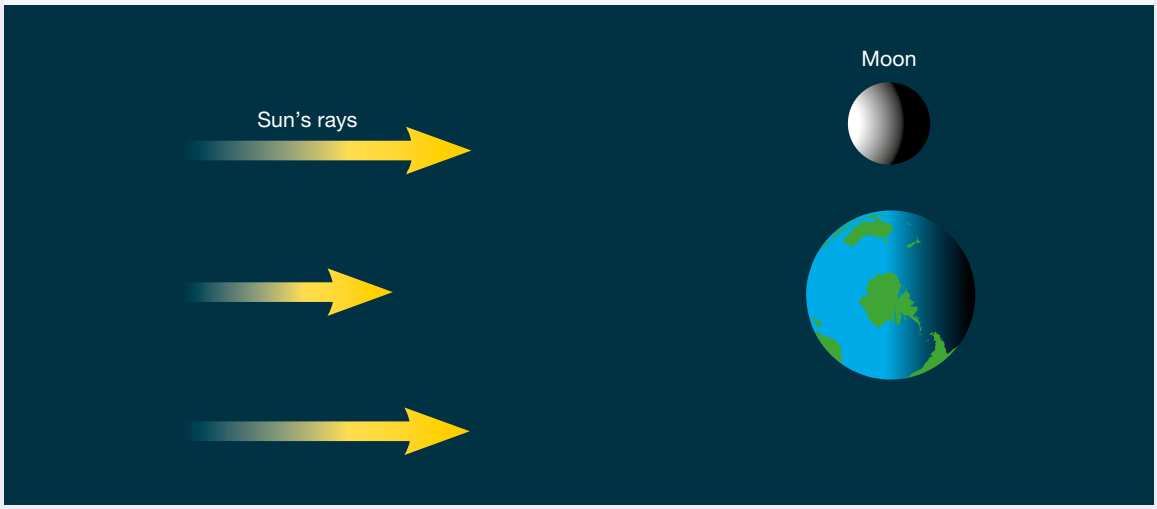


10. (a) Which astronomer developed the model of the universe shown in the diagram below?
    (b) Where are the stars on this model?
    (c) Why do you think that this model of the universe was so well accepted for almost 1500 years?
    (d) Name three well-known scientists or mathematicians who put an end to the popularity of this model.



11. The diagram below shows the view of the Earth from above the South Pole. While the moon is in the position shown, which type of tide is being experienced on the east coast of Australia — high tide, low tide or neap tide?

The moon's orbit around the Earth as seen from above Antarctica



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TOPIC 7
Precious resources

7.1 Overview



When people describe Australia as being rich in resources, they are talking about coal, natural gas, oil, iron, copper, uranium and a host of precious minerals. But when it comes to the most precious resource of all — water — Australia is sadly lacking. Apart from Antarctica, Australia is the driest continent on Earth. All of our resources, whether they are fuels, precious minerals or water, must be used wisely to ensure that our future is sustainable — that is, a future in which we and generations to come can live in a healthy environment.

7.1.1 Think about resources

assessON

- How do geologists know where to mine for precious minerals?
- From a damp green swamp to a lump of coal — how does that happen?
- What makes underground coal mining so dangerous?
- How many homes can be powered by a single wind turbine?
- What causes warm and cold ocean currents?
- Where is most of the world's fresh water?
- How does global warming affect the water cycle?
- What makes soil such a precious resource?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the concepts covered in this topic.

7.1.2 Your quest

Renewable and non-renewable resources

Renewable resources are those that replace themselves in a short time. For example, solar energy is a renewable resource that can be used for heating water or generating electricity. It is never 'used up' and is constantly replaced by the sun. Oil is a **non-renewable resource** that takes millions of years to be replaced.

Think, discuss and collaborate

1. Working in a group, decide whether each of the following natural resources is renewable or non-renewable.
   - Coal
   - Diamonds
   - Hydro-electricity
   - Natural gas
   - Water
   - Wind energy
   - Wood

   After making your decisions, copy and complete the table below.

Natural resource	Renewable or non-renewable?	Reason for your decision
Coal		
Diamonds		
Hydro-electricity		
Natural gas		
Water		
Wind energy		
Wood		

2. Working in a group, discuss the materials listed in the table below. All of the materials in the table are made from natural resources. Copy and complete the table as your discussion proceeds. Fill any gaps by using the internet or books in the library.

Material	Natural resource from which it is made	Renewable or non-renewable resource?	Why it is useful?
Plastic			
Steel			
Aluminium			
Nylon			
Wool			
Paper			
Glass			

7.2 The riches below

7.2.1 Natural resources

The Earth provides a vast range of resources that allow us to live healthily and to make things that we take for granted every day. Buildings, furniture, cars, plastics (including nylon and polyester) are all made from natural resources. Most fuels are provided by or made from natural resources such as coal, oil and natural gas.

7.2.2 Metals in the Earth's crust

The outer layer or **crust** of the Earth, which includes all landforms, rocks and soil, is made mostly of solid rock. A bit like a shell, it covers the whole planet. It varies in thickness from about 8 kilometres below the oceans to about 40 kilometres below the continents.

The metals used in buildings, road vehicles, trams and trains, all electronic devices and countless other products are obtained from **minerals** found in the Earth's crust. Minerals are the natural substances that make up rocks, which are mixtures of two or more minerals. A substance that contains minerals of value is called a **mineral ore**.

Minerals are non-renewable resources, because when they are mined and used they don't replace themselves quickly — in fact, it can take millions of years.

Some mineral ores commonly mined in Australia

Mineral ore	Metal
Bauxite	Aluminium
Galena	Lead
Sphalerite	Zinc
Haematite	Iron
Pentlandite	Nickel
Chalcopyrite	Copper

HOW ABOUT THAT!

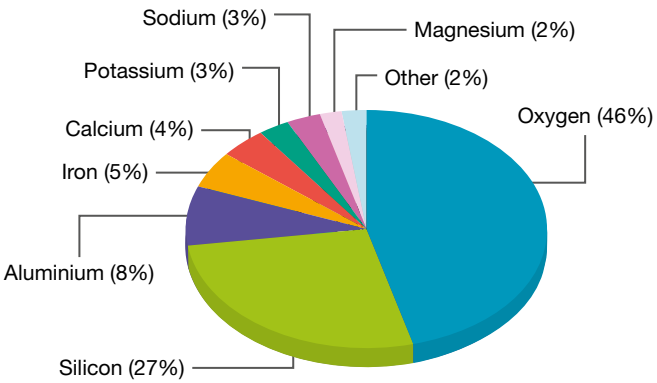
To get an idea of how thin the Earth's crust is, take a medium-sized apple and cut it half. Now imagine that the apple is the Earth — the crust by comparison is as thin as the apple skin!



7.2.3 Needle in a haystack

Locating mineral ores is a bit like finding a needle in a haystack. The amount of any mineral in the Earth's crust varies immensely from place to place. There is no point disturbing the environment and spending huge amounts of money by digging or drilling without knowing where a resource is.

The task of locating mineral sources usually begins with satellites high above the Earth. The satellites are equipped with cameras, radar and other sensors to look for features on the surface that provide clues about what lies below. Geologists on board planes and helicopters look for further clues about the minerals below before exploration begins on the ground. Some minerals, such as those that contain iron, nickel and cobalt, can be detected because of their magnetic properties.



The pie chart on the right shows that, out of the 92 naturally occurring elements, 98 per cent of the Earth's crust is made up of only 8 of them.

7.2.4 Mining the mineral ore

The process of removing the mineral ore from the ground is called **mining**. The method used for mining depends on several factors, including:

- how close the mineral ore is to the surface
- how much rock lies above the mineral ore
- what type of rock lies above the mineral ore.

Open-cut mining is a method of mining mineral ores that are close to the surface. A large hole is made to expose the rocks containing the mineral ores. Explosives are used to break up the rock and huge trucks are used to transport the soil and rocks out of the mine.

An open-cut mine



If the mineral ores are deep below the surface, **underground mining** is undertaken. Shafts and tunnels are dug deep into the ground to reach the mineral ore. Underground mining is more dangerous and expensive than open-cut mining. Shafts can be as deep as 4 kilometres. Temperatures in underground mines are high and there may be some danger from flooding, gas leaks or tunnels caving in.

7.2.5 Extracting the metal

After the rock containing a mineral ore is removed from the ground, the valuable part of it, the metal, is extracted. The method of extraction (or separation) varies from metal to metal. Most methods involve three separate stages.

Hot liquid iron being poured from a melting pot



1. **Concentration** *of the mineral ore*. The useful rock taken from the ground is a mixture of the useful mineral ore and unwanted sand, soil and other minerals. The unwanted substances are called **gangue**. The separation of copper rock from gangue is described in section 5.8.
2. **Reduction** *of the mineral ore to the metal*. This involves a number of chemical reactions because the mineral ore is a pure substance, not a mixture. The reduction process often involves **smelting**, in which the mineral ore is melted. The reduction of aluminium ore requires additional and expensive processes, which is one of the reasons why recycling aluminium cans is so important.
3. **Purification** *of the metal*. Most metals obtained from the reduction process still contain impurities. These are removed using various chemical processes to produce the pure metal.

7.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Why are minerals in the Earth's crust classified as non-renewable resources?
2. Which minerals can be detected because of their magnetic properties?

3. What is a mineral ore?
4. Explain why underground mining is more dangerous than open-cut mining.
5. Construct a two-column table.
   (a) In the first column, list the three stages involved in extracting a metal from its mineral ore.
   (b) In the second column, describe the purpose of each stage.

Think

6. Why is exploration for mining sites for extracting mineral resources like 'finding a needle in a haystack'?
7. List the advantages and disadvantages of open-cut mining.
8. Suggest how open-cut mining got its name.
9. Suggest why the temperature in underground mining tunnels would be greater than the temperature on the ground surface.

Investigate

10. Find out where in Australia the minerals in the table on page 269 are mined.
11. Long before the big mining companies began exploring for and extracting minerals, Aboriginal and Torres Strait Islander peoples were extracting a type of mineral called ochre from the ground. Investigate and report on:
    (a) which chemical substance is found in all ochre
    (b) how ochre was used by Aboriginal and Torres Strait Islander peoples
    (c) how ochre was mined.

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Watch this eLesson: Mining and Australia's environment (eles-0128)

7.3 Fossil fuels

7.3.1 Dead and buried

Among the natural resources below the Earth's surface is a reserve of energy in the form of **fossil fuels**. The energy stored in fossil fuels comes from the remains of ancient plants and animals, buried under layers of the Earth's crust that have built up over tens or hundreds of millions of years. When we burn fossil fuels — coal, oil and natural gas — the stored energy is converted to other forms of energy, including heat, movement and light.

Coal is formed from the remains of ancient plants. Millions of years ago, much of the land on Earth was covered with warm, humid forests and swamps. When trees and plants died, they were buried by layers of other dead plants before they could rot. As the layers of rotting material built up in the forests and swamps, they were compressed under the weight of other plants and water. Over millions of years, the weight and high temperatures drove moisture out of the plant remains. The plant matter left behind is known as **peat**.

Brown and black

As areas were flooded by swollen rivers or changes in sea level, **sediments** of gravel, sand, mud or silt covered the rotting vegetation. Over time, as they were buried under other layers, these sediments changed into rocks known as **sedimentary rocks**. If the swampy conditions returned, more layers of rotting plants and peat formed and were covered. Over millions of years, the peat was compressed by the weight of the layers above and became warmer. Much of the remaining moisture was driven out, forming **brown coal** (lignite). As the compression continued and more moisture was driven out, the harder and drier **black coal** (anthracite) was formed.

HOW ABOUT THAT!

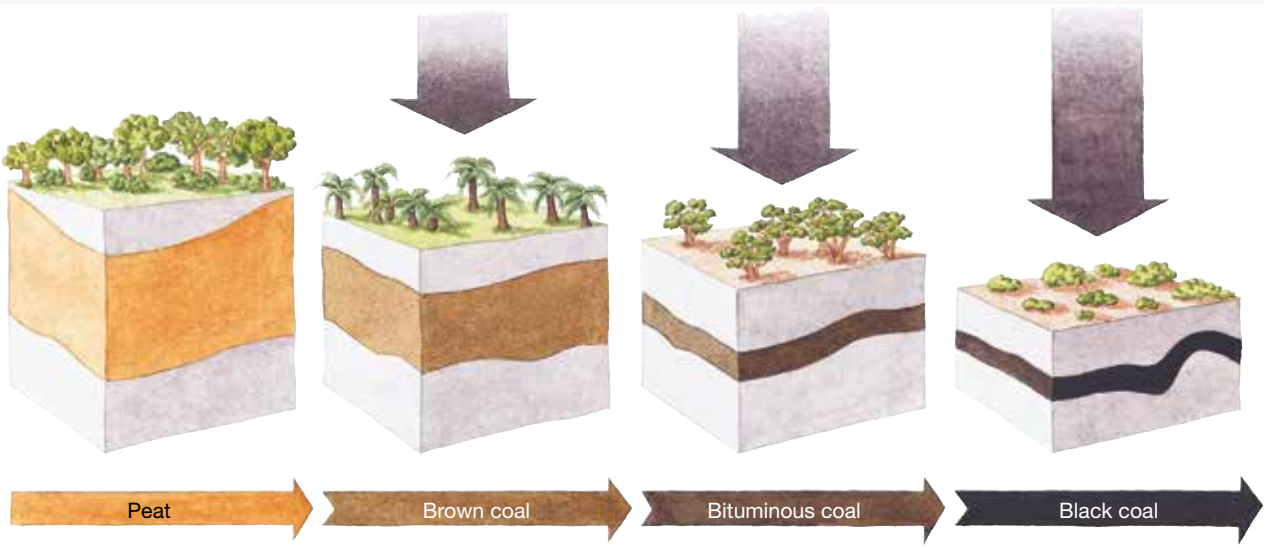
Almost one-quarter of the crust that makes up the Australian continent contains coal of one type or another. Australia has approximately 5 per cent of the world's known reserves of black coal and approximately 23 per cent of the world's recoverable reserves of brown coal.

Coal as a fuel

More than three-quarters of the black coal mined in Australia is exported. Most of the remainder is used to generate electricity in power stations. Some of the black coal is used in the production of steel and as briquettes for heating. The majority of Australia's brown coal mines are in Victoria, where most of the coal is used to generate electricity.

Black coal provides more energy than the same amount of brown coal, mainly because it contains less water. In some countries peat is used as a fuel. However, it has to be dried first. In Ireland, where there is very little coal or oil, peat is used to generate electricity.

How coal forms



At the coal face

In Victoria, the major reserves of brown coal are found in the Latrobe Valley, where more than 75 per cent of Victoria's electricity is generated. Because the coal is close to the surface, the open-cut method is used to mine it. Rock, soil and vegetation (the **overburden**) are first removed by bucket wheel excavators to expose the coal. Bucket-shaped excavators load the coal onto conveyors, which transport it to the power-station boilers.

When the coal is deeper, it must be mined underground. Underground mining is more costly than open-cut mining. Underground mining is also quite dangerous. As well as the threat of cave-ins and flooding, layers of coal contain poisonous methane gas. Another poisonous gas, carbon monoxide, is also often produced when explosives are used underground. The dust produced by the coal not only damages miners' lungs, but also forms an explosive mixture with methane gas. Proper ventilation systems in underground mines are needed to minimise these dangers.

Location of Australian brown and black coal mines



A bucket-wheel excavator at Yallourn in Victoria can remove 2300 tonnes of brown coal in one hour.

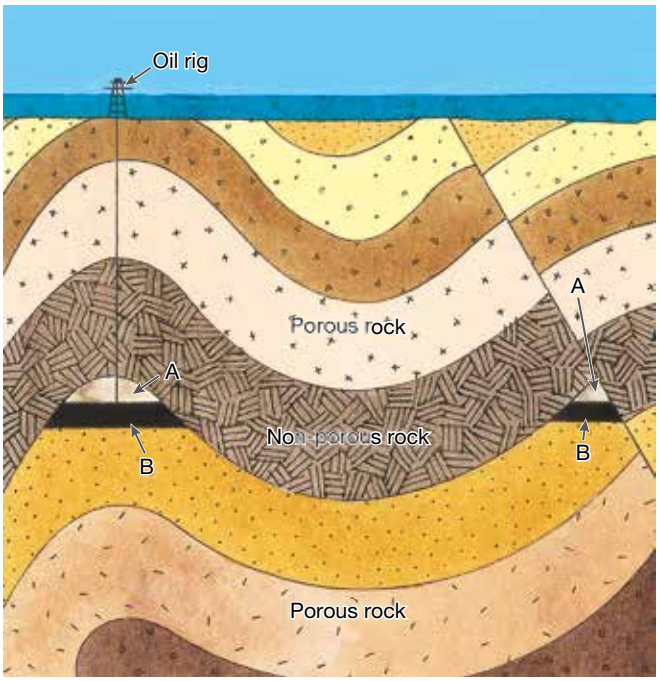


7.3.2 The good oil

Oil and **natural gas** are believed to have formed from the remains of tiny sea animals and plants. These organisms were buried in sediments at the bottom of the oceans millions of years ago. As these plant and animal remains slowly decomposed, they were compressed by water and the layers of sediment that formed above them. Chemical reactions gradually changed them into oil and natural gas, which then seeped upwards through some layers of sedimentary rocks. Such rocks are described as **porous**. The oil and gas were eventually trapped by rock layers that would not allow them to seep through (non-porous rock).

The oil taken from beneath the Earth's surface is converted in oil refineries into a number of different fuels, including diesel fuel, petrol and kerosene products. Natural gas is mainly used for heating and for cooking. Australia's biggest oil and natural gas reserves lie under the seabed in Bass Strait off the coast of Victoria and on the North West Shelf off Western Australia.

The trapping of oil and natural gas by layers of non-porous rock usually occurs as a result of the bending, cracking and movement of rocks beneath the surface.



The layers are folded by rocks beneath the surface pushing against each other. Sometimes the forces are great enough to crack rocks so that layers slide up or down.

7.3.3 Warning, warning!

Fossil fuels are non-renewable resources. To say that they are being used up more quickly than they are replaced is an understatement. Until the Industrial Revolution began a little more than 200 years ago, the use of fossil fuels was rare; since then, it has increased steadily. It wasn't until the 1970s that the prediction was made that, if this rate of increase continued, all known fossil fuel supplies could be used up by early in the twenty-first century. Since then, most developed nations, including Australia, have encouraged the use of renewable resources such as solar, wind and tidal energy.

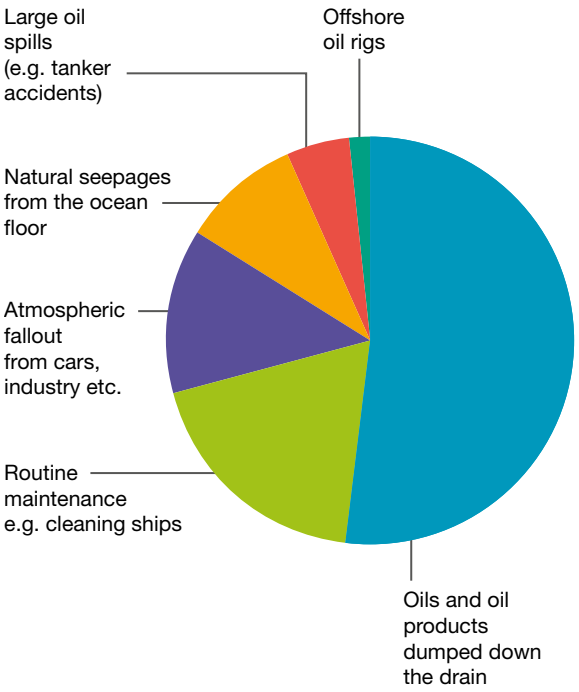
Australia's oil and gas reserves



Coastal pollution

The pollution of the coastline is often blamed on oil from offshore oil rigs, oil spills and natural seepages. However, most pollution comes from the oil and oil products that are dumped down our drains.

Sources of coastal pollution



An oil rig off the coast of Australia. Oil companies drill down through the layers of rock to tap oil reserves. The large pylons extend down to the ocean floor. The drilling bit and oil pipe are fed down through the tall tower.



7.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. From where does the energy stored in fossil fuels come?
2. What happens to the energy stored in fossil fuels when they are burned?
3. Apart from its colour, how is black coal different from brown coal?
4. Why is peat generally not used as a fuel in most countries of the world?
5. How does oil and natural gas get trapped underground?
6. Where are Australia's biggest oil and natural gas reserves?

Think

7. When we burn fossil fuels — coal, oil and natural gas — the stored energy is converted to other forms of energy, including heat, movement and light. What else is produced?
8. Black coal is sometimes mined underground but brown coal is not, even though there are reserves that could be mined in that way. Suggest why that is the case.
9. Suggest why brown coal is used to generate electricity in Victoria rather than black coal, even though brown coal contains more moisture.
10. Explain why it is correct to describe fossil fuels as 'stored solar energy'.
11. Apart from the threat of the supply running out, describe two other major disadvantages of the use of fossil fuels.

Investigate

12. Find out what coal seam gas is and why it is controversial.

Imagine

13. Imagine a world with no heating in cold weather or cooling in hot weather, no television, no computers and no lighting at night. Make a list of the ten everyday 'necessities' and luxuries that you would miss the most if the world's supply of fossil fuels ran out and you had no renewable energy sources.

7.4 Make mine renewable

Science as a human endeavour

7.4.1 A question of responsibility

About 80 per cent of the world's energy needs are supplied by fossil fuels. In 2010, fossil fuels provided about 94 per cent of Australia's energy. Only 6 per cent is supplied by renewable energy sources. The federal government has set a target of 20 per cent renewable energy by the year 2020.

Most power stations on mainland Australia rely on coal to drive the **turbines** used to generate electricity. The problems caused by using a fossil fuel such as coal, including pollution and global warming, give us no choice but to look for alternative sources of energy. Governments, industry and power companies all have a responsibility to seek renewable alternatives. Even you, as a consumer, have a responsibility to make sensible choices about your energy use. The first step is to be aware of the problems caused by using coal and of other options for generating electricity.

7.4.2 Renewable options

Solar energy

Photovoltaic cells can be used to power domestic hot water systems. Photovoltaic cells transform light energy from the sun into electrical energy that can be used immediately or stored in rechargeable batteries.

Solar thermal power stations use curved mirrors that reflect sunlight onto tubes filled with oil. The hot oil is used to heat water to form steam, which drives the turbines that generate electricity.

WHAT DOES IT MEAN?

The prefix *photo* in 'photovoltaic cell' comes from the Greek word *photos*, meaning 'light'.

Wind energy

Wind 'farms' dotted with wind turbines can be found in many countries throughout the world, including Australia. A single wind turbine can provide enough energy to supply more than 700 average homes with the electricity they need. **Wind energy** is renewable because wind is caused by the uneven heating of the Earth and its oceans by energy from the sun.

Biomass

Biomass is a renewable fuel produced by the remains of living things. Dead and rotting plant and animal tissue produces gases such as methane, methanol and oils that can be used as fuels to drive small turbine electricity generators. Some small biomass electricity generators already exist in rubbish tips.

Ocean waves

The energy of ocean waves has been used to generate electricity on a wave 'farm' in Portugal since 2008. The up and down movement of the waves is used to drive motors that generate electricity. **Ocean wave energy** is renewable because the waves are produced by the effect of the wind on the ocean.

Tidal energy

The energy of rising and falling tides is used in several power stations worldwide. Reversible turbines are placed at the entrance to a bay in areas with extremely high and low tides. Water moving into and out of the bay drives the turbines as the tide changes. Tides are caused by the gravitational pull of the moon and the sun, so **tidal energy** is renewable.

Geothermal energy

In parts of New Zealand and Iceland, energy transferred from rocks just below the Earth's surface is used to turn water into steam and drive turbines in geothermal power stations. Other countries that use **geothermal energy** include the United States and Japan.

WHAT DOES IT MEAN?

The word *geothermal* comes from the Greek terms *geo*, meaning 'of the Earth', and *therme*, meaning 'heat'.

Hydro-electricity

About 15 per cent of Australia's electricity is generated by **hydro-electric** power plants. This is a renewable energy source because it depends on solar energy and water. Heat from the sun evaporates water from the oceans. Clouds are formed and it eventually rains. The turbines in hydro-electric power stations are turned by water falling through pipes from very high and large dams.

In a hydro-electric power station the turbines are driven by water falling through pipes from a high dam.



7.4.3 The nuclear energy option

Nuclear power stations use energy released from the radioactive metals uranium or plutonium to boil water to produce the steam that drives turbines to produce electricity. **Nuclear energy** is a non-renewable energy source. Most of the world's nuclear power stations can be found in the United States, Europe, Japan and Canada.

7.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. How much of Australia's energy will be supplied by renewable energy sources in 2020, according to the target set by the federal government?
2. List two ways of ensuring that the Earth's supply of non-renewable energy resources doesn't run out.
3. Describe two ways in which solar energy can be used to generate electricity.
4. Identify a non-renewable fuel that is not a fossil fuel.

Think

5. The turbines in coal-fired and hydro-electric power stations rotate in only one direction. Why are the turbines in tidal power stations reversible?
6. Which renewable energy options involve the use of heat from the sun? (*Hint:* There is more than one answer.)
7. Nuclear energy is a non-renewable energy source.
   (a) Why is it classified as non-renewable?
   (b) Is nuclear energy a fossil fuel? Give a reason for your answer.
8. Most of the methods of generating electricity involve the use of turbines. Into what form of energy do turbines convert the energy of steam, falling water and other energy resources?
9. Each of the renewable energy options for generating electricity solves some of the problems caused by burning fossil fuels. However, each of them also has disadvantages. Describe the disadvantages of each of the renewable energy options.

Investigate

10. Choose one of the renewable energy options or nuclear energy and research it in more depth. Write a report, using diagrams where necessary, to show how this form of energy is used to generate electricity.

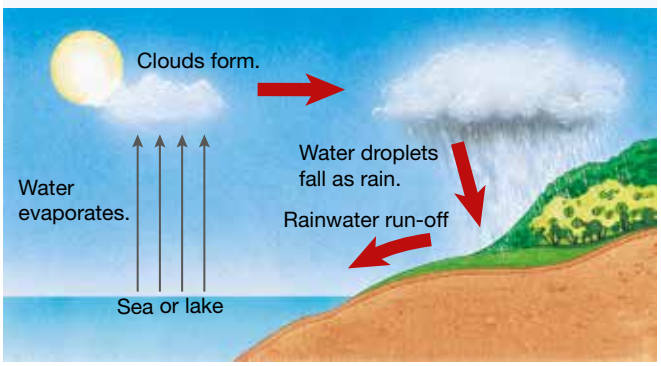
7.5 Stability and change: Water — the liquid of life

7.5.1 The water cycle

Water is essential for life on Earth. It is therefore our most precious resource. There is certainly plenty of water on the planet — almost 70 per cent of the Earth's surface is covered with water. But almost all of it is salt water in the oceans. The rest is in rivers, lakes, glaciers and ice in the polar regions.

Water is constantly moving and changing states. Heat from the sun makes water from the oceans evaporate slowly and form water vapour. The invisible water vapour rises with the warm air. When the water vapour becomes cold enough, it condenses to form **clouds** of tiny water droplets. The clouds are visible and are kept up by the air moving around them. If a cloud is close enough to the ground it is known as **fog**.

The water cycle



At high altitudes the air is very cold. When thick clouds reach this very cold area, the water droplets in them join together to form larger droplets, which are too heavy to be held up by moving air. The large droplets fall to the ground as rain. If the air is cold enough, the water is frozen and falls as snow or hail. Rainwater falls into the sea or runs over the ground into rivers and streams, eventually reaching the sea. This constant movement of water between the various states is called the **water cycle**.

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Watch this eLesson: The water cycle (eles-0062)

Try out this interactivity: Waterworks (int-3077)

7.5.2 Ocean currents

The sea water in the oceans of the world is constantly moving in currents. Ocean currents near the surface of the world's oceans move warm water and cooler water between the tropics and the North and South Poles. The main causes of the currents are the warming of water near the equator and the sinking of colder water near the poles. Other factors, including wind and rate of evaporation, also affect the currents.

INVESTIGATION 7.1

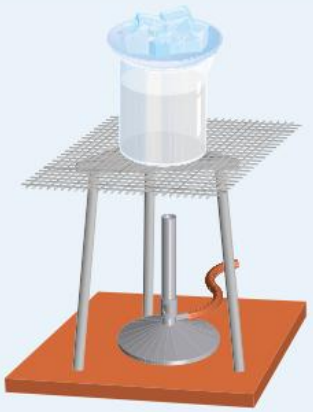
Forming clouds

AIM: To model the formation of clouds

Materials:

250 mL beaker
ice cubes
watchglass
safety glasses
heatproof mat, Bunsen burner and matches
tripod and gauze mat

Forming clouds in a beaker



Method and results

- Half-fill a beaker with water and heat it until the water is boiling.
- Stop heating and cover the beaker carefully with a watchglass. Observe the bottom of the watchglass.
- Remove the watchglass and heat the water again until it boils.
- Stop heating and turn off the gas supply. Quickly but carefully, cover the beaker with a watchglass containing ice cubes.
- Observe the area under the watchglass.

1. Describe what happened to the bottom of the watchglass when you first boiled the water.
2. Describe what happens in the beaker just below the watchglass.
3. What change of state has taken place?

INVESTIGATION 7.2

Observing clouds

AIM: To investigate the links between clouds and rain, hail and snow

Method and results

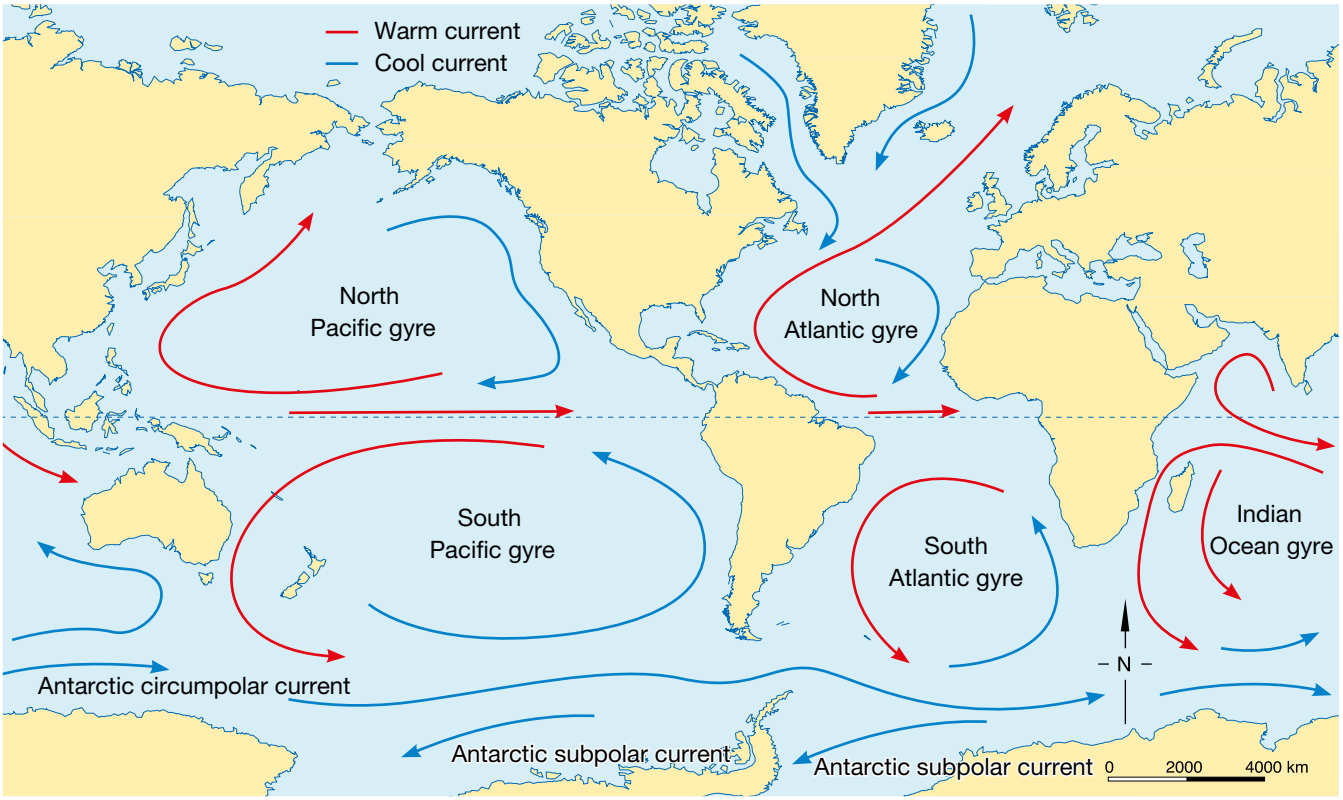
1. Before commencing your observations, design a table in which you can record them; but first read the observations to be made.
2. Record the fraction of the sky covered by cloud for five consecutive days. Make your observations at the same time each day.
3. Record whether there was any drizzle, rain, hail or snow during the hour after your observations were made.
4. If it did drizzle, rain, hail or snow, investigate and record the type of cloud that produced it.
5. Which types of cloud produced drizzle, rain, hail or snow?

Discuss and explain

6. Does the likelihood of drizzle, rain, hail or snow seem to depend more on the amount of cloud or the type of cloud?

Ocean currents have a major influence on the water cycle and weather patterns. Changes in the ocean currents in the southern Pacific Ocean can cause periods of drought or unusually high rainfall in parts of Australia. Some ocean currents are permanent and form circular patterns called **gyres**. The diagram on the next page shows the major ocean currents and gyres.

The world's major currents and gyres



7.5.3 Global warming

During daylight hours, heat from the sun enters the atmosphere and warms up the Earth's surface. At night, heat from the surface escapes through the atmosphere. Some of the gases in the atmosphere, including carbon dioxide, trap some of the heat. This trapping of heat is called the **greenhouse effect**.

Without a natural greenhouse effect, the Earth would be too cold to sustain life as we know it. Together, plants and animals help to keep the gases in the atmosphere in balance. During the day, plants take in carbon dioxide to help them make their own food. In doing so, they produce and release oxygen. Animals do the reverse, breathing in oxygen and breathing out carbon dioxide. For a very long time the amount of carbon dioxide and oxygen in the atmosphere has been fairly constant.

However, over the past 200 years the amount of carbon dioxide and some other heat-trapping gases has increased. As a result, the Earth's temperature is beginning to rise. The rising temperature is known as **global warming**. Two of the main reasons for global warming are:

- *the burning of fossil fuels*. Each year the world's population adds almost 30 billion tonnes of carbon dioxide to the atmosphere by burning fossil fuels — and the amount is growing year by year.
- *the clearing of forests*. Trees absorb carbon dioxide from the air and produce oxygen. As forests are cleared, this means of keeping the gases in the atmosphere in balance is removed. In Australia, two-thirds of all forests that existed 200 years ago have been cleared.

Global warming and the water cycle

The increase in the Earth's temperature is likely to have an impact on the water cycle and therefore the world's climate. There is already evidence that in Antarctica, where 70 per cent of the world's fresh water is stored as ice, the coastal ice shelf and glaciers are melting. The permanent cover of ice in the Arctic Circle is shrinking by an estimated 9 per cent every 10 years. As the polar icecaps shrink, rising sea levels could cause flooding of some islands and coastal cities.

Changes in climate due to global warming and changes in the water cycle may also cause:

- less rain and snow in high mountain regions
- more wild storms, including tropical cyclones
- more heat waves, droughts and bushfires.

The evidence for climate change is gathered by teams of scientists using technology including:

- satellites carrying sensors that collect data about moisture in the atmosphere and on the Earth's surface
- probes and other measuring instruments on and beneath the Earth's surface
- radar to collect data that reveal the properties of clouds.

The data are used in computer modelling to improve our understanding of the water cycle and climate. Computer modelling allows us to predict future changes in the water cycle and make better decisions about the sustainable management of water. It also has allowed us to predict day-to-day weather with more certainty than in the past.

Cyclone Tracy, which devastated Darwin on Christmas Eve in 1974, killed 65 people (16 at sea) and injured 650. Nearly 70 per cent of homes were destroyed. Some 35 000 people had to be evacuated. Global warming could cause an increase in the number of cyclones like Cyclone Tracy.



7.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Where is most of the water on Earth found?
2. What causes sea water to evaporate?
3. What are clouds and how do they form?
4. Describe the two main causes of the world's ocean currents.
5. What are gyres?
6. Describe the greenhouse effect and explain why it is important for life on Earth.
7. List two main reasons for global warming.
8. Explain how global warming is changing the water cycle.
9. Explain how evidence for changes in the water cycle is collected.

Think

10. Explain why some clouds pass overhead without producing rain.
11. Why does the water vapour in clouds condense?
12. Explain why you can see clouds but not see water vapour in the air.
13. Could humans alter the water cycle? In what way might this happen?
14. Is water a renewable or non-renewable resource? Explain your answer.

Investigate

15. Research and report on what El Niño and La Niña are and how they affect Australia's weather patterns.

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Complete this digital doc: Worksheet 7.1: Clouds (doc-19839)

Complete this digital doc: Worksheet 7.2: The water cycle (doc-19840)

7.6 Managing water wisely

7.6.1 A precious liquid

Aside from Antarctica, Australia is the driest continent on Earth. Yet Australians are the third greatest users of water per person — only the USA and Canada use more. This makes fresh water a natural resource that we cannot afford to waste. Wise management of this precious resource is essential.

In Australia's major cities, 59 per cent of the available water is used by households. Most of the rest is used by industry or in other ways including maintaining parks and for firefighting. More than half the water used by households is used for watering gardens and flushing toilets. Until recently, people in major coastal cities have taken the supply of clean water suitable for drinking for granted. There was enough clean water available in dams to use for watering lawns and gardens, washing the car and filling swimming pools. However, in recent years, droughts have been responsible for severe water restrictions in most major cities and many smaller regional towns.

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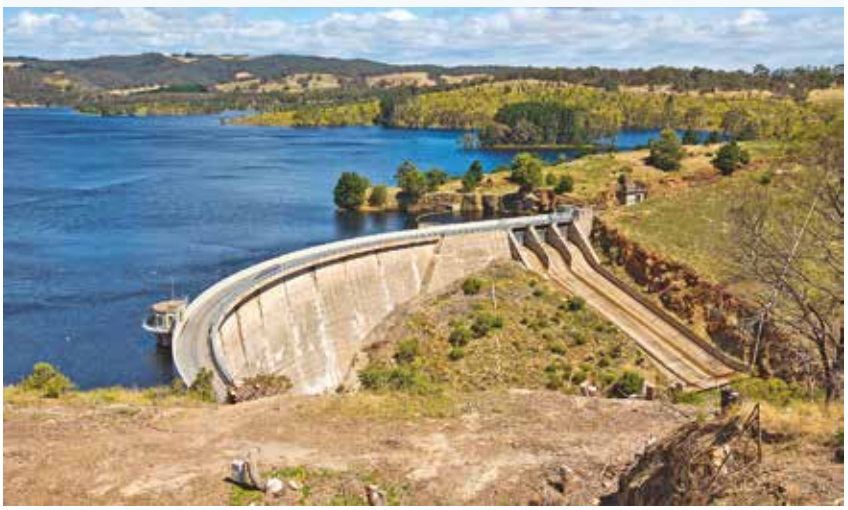
Watch this eLesson: Water — a vital resource (eles-1615)

7.6.2 Dealing with drought

According to a clear majority of scientists, climate change will result in an increase in the number and length of droughts. However, droughts are not new to Australia. There have been twelve major droughts in different parts of Australia since the 1860s, when proper weather record keeping began. Australians have to live with droughts, and as the population grows the demand for water will increase.

Apart from more severe water restrictions, the most obvious solution is to build more dams and reservoirs. However, building more dams and reservoirs is not always the best method of increasing water supplies. Dams on major rivers interfere with the flow of water downstream, causing problems for the environment and for farmers.

Myponga Dam, near Adelaide, South Australia. Building more dams like this is not always the best solution for improving water supplies.



7.6.3 Blackwater and greywater

About 20 per cent of the waste water from an average household comes from the toilet. This waste is known as **blackwater**. The waste water that comes from the kitchen, bathroom and laundry is known as **greywater**. It does not flow into the sewerage system or septic tanks.

Greywater from the laundry can be used on the garden and is commonly used during periods of water restrictions. However, greywater contains chemicals left over from detergents and other laundry products, which could cause damage to plants. The damage can be minimised by choosing detergents that are low in phosphorus and are **biodegradable**. Untreated water from the kitchen should never be used on gardens because it contains oil, grease and other chemicals that could damage plants.

THE TALE OF TOOWOOMBA

Toowoomba is a city in southeast Queensland, well known for its beautiful parks and gardens. In 2006, a prolonged drought had left its dams with only 20 per cent of their full capacity. Toowoomba's economy relies on the influx of tourists visiting the city to see its lush parks and gardens. Desperate measures were required. The Toowoomba City Council proposed that a quarter of the recycled water from its sewage treatment plant be discharged into its three dams.

The proposal divided the city and, after a long and bitter debate, the voters of Toowoomba rejected it. The vote was 38 per cent in favour and 62 per cent against.

As a result of the rejection, Toowoomba was placed on level 5 water restrictions, the strictest in Australia at the time. The use of tap water outdoors was banned.

Toowoomba's economy relies on attracting visitors to its lush, well-watered parks and gardens.



The safest way to use greywater is to install a greywater treatment system, which removes chemicals that can damage plants. In some locations a council permit is required for the installation of a greywater treatment system, so it is important to check first. Untreated blackwater should never be used on a garden.

7.6.4 Recycled water

In some countries, fresh water is so scarce that treated sewage is used as drinking water. This recycled water goes through a number of processes to ensure that it is safe to drink.

Several studies have shown that most Australians are happy to use recycled water for firefighting, watering lawns, flushing toilets and irrigation. However, there is little support for the idea of drinking recycled water.

7.6.5 Is desalination the answer?

In major cities close to the ocean, **desalination** can be used to 'top up' dwindling water supplies. This process of separating fresh water from salty sea water is described in chapter 5. However, like dams, desalination has some negative consequences for the environment.

7.6.6 Monitoring water quality

The quality of the drinking water can be maintained only with constant monitoring to ensure that dangerous levels of pollution are quickly identified and fixed. In Australia, water quality is monitored by state and territory government agencies, water authorities, local councils, landcare groups and community groups. Streams and reservoirs are checked for numerous properties including temperature, flow rate, cloudiness, dissolved oxygen, pH, bacteria and the presence of pesticides and unwanted nutrients.

7.6.7 Lessons in sustainability

Over many thousands of years, Indigenous Australians have successfully located and conserved fresh water in some of the driest parts of the continent. Some of their techniques for locating and conserving water provide valuable lessons for today's scientists and engineers as they meet the challenge of supplying a growing population with this precious resource in a sustainable way. Many Indigenous techniques for locating and collecting water are used in survival training by the Australian Defence Force.

HOW ABOUT THAT!

NASA engineers have collaborated with other scientists and engineers to develop a system that recycles water from air breathed out, sweat and urine into safe drinking water. It was first used by astronauts on the International Space Station. The system is now used in developing countries where water is scarce or heavily contaminated. Volunteers in the northern Iraq village of Kendala help install and test a water purification system that has its origins in the space program.



7.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Explain why fresh water is such a precious resource in Australia.
2. How do Australian households use the majority of their fresh water?
3. Describe two ways in which greywater can be used on gardens without damaging plants.
4. Explain the difference between blackwater and greywater.

Think

5. Describe the problems that could affect the environment and farmers downstream from a newly built dam on a major river.

6. Suggest why the majority of the voters of Toowoomba rejected the use of recycled water from a sewage treatment plant when more water was so desperately needed.
7. Would you be prepared to drink recycled water in the form of properly recycled sewage if it was declared safe by environmental authorities? Give reasons for your answer.

Brainstorm

8. In a small group, make a list of ways in which you can save water around your home.

Investigate

9. Research and report on the location of rivers, dams and reservoirs that supply drinking water to your home.
10. If you have access to recycled water, compare its appearance and odour with those of tap water. Do NOT drink the recycled water as it will not have been treated properly for safe drinking.
11. Use the library and the internet to research and report on the importance of the Aboriginal rain dance.

7.7 Soil — it's worth conserving

Science as a human endeavour

7.7.1 Feeding the world

Good soil contains the nutrients needed for the growth of plants. It is therefore vital in feeding the Earth's growing population. But about 43 per cent of the Earth's dry land is desert or desert-like and useless for growing crops. In Australia the situation is much worse, with 96 per cent of Australian soil unsuitable for growing crops. That's what makes the rest of our soil such a valuable resource.

7.7.2 Weathering and erosion

Rocks on the surface of the Earth are slowly and continuously being changed by natural events. They are broken down into smaller rocks in a process called **weathering**.

The wind wears rock away, especially in dry conditions when it blasts the rock with sand and soil it has picked up.

Water on the ground can react with certain chemicals in rocks, soil and decaying plants, producing other chemicals that make the rocks crack and crumble more easily.

Carried away

Weathered rock is usually moved from one place to another by the wind, running water, the sea or glaciers. This process is called **erosion**. The weathered rock moved by erosion is deposited, and settles on the land, riverbeds and floors of lakes, seas and oceans to form **sediments**.

HOW ABOUT THAT!

About 43 per cent of the Earth's dry land is desert or desert-like. In Australia the situation is much worse. About 96 per cent of Australia's soil is not suitable for growing crops. That's what makes the soil that is left so valuable.

Soil is formed by weathering, erosion and **deposition** of rock. Soil also contains **humus** — decaying plant and animal material that plants can grow in.

Fertile soil is a mixture of minerals, rock particles and humus. It also contains space between the particles where air, water, nutrients and microbes can be stored. The variation in soils from place to place largely depends on the rock and minerals from which it formed.

Forests in Australia and elsewhere are still cleared to supply wood and wood products.



7.7.3 Holding it together

Fertile soil can be blown away by the wind or washed away by rain or streams. The roots of trees and other vegetation help protect fertile soil from erosion. When early European settlers arrived in Australia, they cut down numerous trees to create farmland. As the population grew, more trees were cleared to provide space for industrial areas and housing. Cities have grown larger and the forests have grown smaller. Trees are still being cleared on a large scale for wood and wood products such as paper (see photo above). During the past 200 years, over two-thirds of Australia's natural forests have been cleared. The removal of trees on a large scale is known as **deforestation**.

7.7.4 Coasts under threat

Coastal areas are vulnerable to erosion and can be badly affected. Bare sand is easily washed away by water and blown inland by the wind. Vegetation that binds the sand together has been torn up by recreational vehicles. Vegetation near beaches in tourist areas such as the Gold Coast has been removed and replaced with huge buildings. Barriers such as sea walls, mesh fences and **groynes** are built to hold sand on the beaches.



INVESTIGATION 7.3

Modelling soil erosion

AIM: To use a model to investigate the effect of vegetation on soil erosion

Materials:

stream tray or other metal or wooden tray
sand
wooden block
rubber tubing to fit a water tap
small plastic lid (from an orange juice container)
twigs, matches or cotton buds to act as trees

Method and results

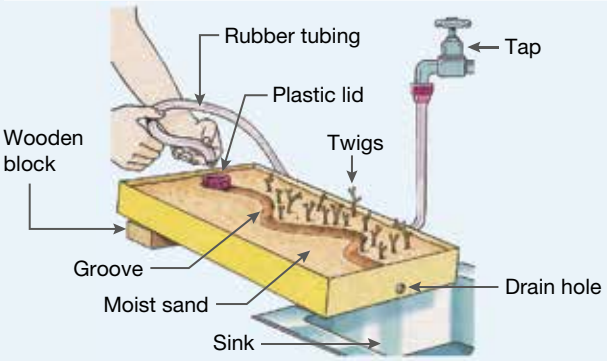
- Pack slightly damp sand into the tray so that it is fairly level.
- Use a small block of wood to raise one end of the tray slightly. Place the other end of the tray on the edge of a sink or over an empty bucket.
- With one finger, make a slightly winding groove in the sand as shown in the diagram below.
- Plant 'trees' along one edge of your model river using twigs, matches or cotton buds.
- Place the plastic lid in the sand at the top of the groove and aim the rubber tubing from the tap over it.
- Turn on the tap so that water flows slowly but steadily into the plastic lid, overflowing into the groove.

1. Describe what happens as the water flows down your model river. Take particular notice of the difference between the two sides of the river.
2. Is there any particular part of the river where erosion is more apparent? Which part?
3. Where is the eroded sand deposited?

Discuss and explain

4. The main aim of this experiment is to examine the effect of plants on the amount of erosion. State your conclusion.

Using a stream tray to model the erosion of soil by a winding river



7.7.5 On the mend

Scientists, conservation groups and government bodies play an important part in improving the environment. The aim is to reduce the impact of human activity and repair past damage. Some methods for reducing erosion and repairing the damage already caused by erosion include:

- farmers ploughing their fields around hills rather than up and down the slope. This reduces the amount of soil washed down hills by rain.
- sealing roads and gutters to direct water into proper drains
- controlling numbers of livestock to prevent overgrazing
- replacing trees that have been removed
- fencing off large sections of beaches and banning recreational vehicles in many coastal areas
- reducing the impact of introduced animals, such as rabbits, on native vegetation.

HOW ABOUT THAT!

Every day many harmful chemicals are pumped into the air. Some are naturally formed chemicals, but many are from cars, factories or from other human activity. The chemicals in the air can dissolve in water, much like salt in hot water. The dissolved chemicals return to the ground in rainwater, snow or fog, and the combination is called **acid rain**.

Acid rain can poison trees, soil and water supplies. It even eats away at rocks, including those used in buildings and statues.



7.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is weathering?
2. What is erosion, and how does it differ from weathering?
3. Identify four natural agents of erosion.
4. When weathered rock is deposited by erosion it forms sediments. What is the difference between soil and sediments?
5. Explain how the cutting down of trees speeds up erosion.
6. Define the term 'deforestation'.
7. Describe at least three actions that farmers can take to reduce erosion.
8. Outline at least four ways in which governments can reduce erosion.

Think

9. Acid rain is a serious problem in industrial areas where there is a lot of air pollution. However, rain reaching the ground after falling through clean air is also slightly acidic. Explain how this could be.
10. Explain how the overgrazing of livestock increases the rate of erosion.
11. Is soil a renewable or non-renewable resource? Explain your answer.

Imagine

12. How much weathering and erosion would take place on the moon? How long would you expect a footprint to remain on its surface? Justify your answers.

Create

13. Some people use coastal sand dunes as a playground. Four-wheel-drive recreational vehicles and sand slides can damage the fragile dune system. Design and produce a leaflet or poster to educate people about the care of coastal sand dunes. Your leaflet or poster should list reasons why they should not walk on or use recreational vehicles in those areas vulnerable to erosion.

learnON RESOURCES — ONLINE ONLY

Try out this interactivity: Break down (int-3101)

Complete this digital doc: Worksheet 7.3: Weathering and erosion (doc-19841)

7.8 Rising salt

Science as a human endeavour

7.8.1 Salinity

While saltiness may be a good thing when you are talking about salted peanuts or fish and chips, it is not a good thing at all when you are looking at salt in the soil.

One of the biggest problems facing Australia's farmers is soil **salinity**. Salinity is a measure of how salty a substance is, but it is commonly used to describe soil that simply contains too much salt for the healthy growth of plants. Soil salinity occurs when salt in the soil layers and rocks deep below the surface is brought up to the surface.

7.8.2 Slow and natural processes

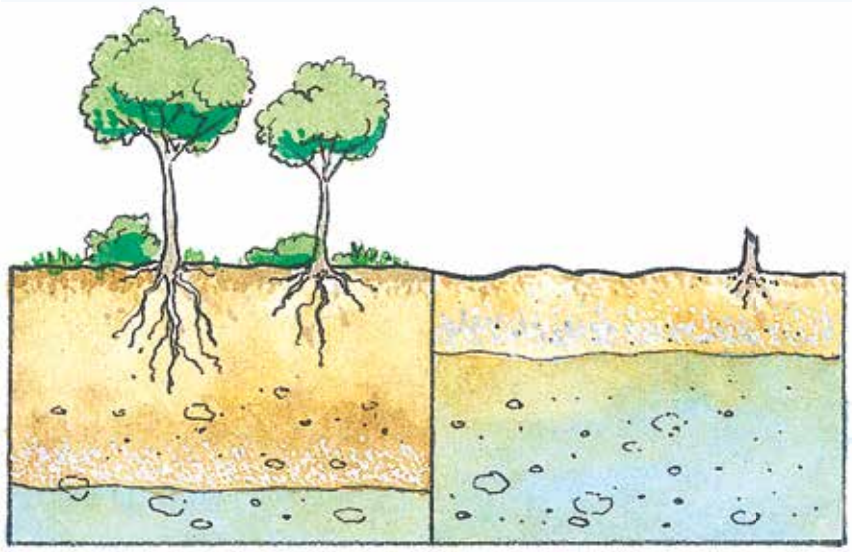
The salt in the lower layers of soil has increased naturally over a very long period for two major reasons.

- Australia has at different times over millions of years either been covered by the ocean or contained a vast inland sea. The sediment that was deposited in these waters later became dry land, and the rocks that formed have retained a lot of salt from the water.
- Because Australia is a relatively flat and dry continent, there are few major rivers large enough to flush salt from the land out to sea. Instead, the salt soaks down deep into the soil. This water that saturates the soil below the surface is called **groundwater**. The top surface of the groundwater (called the **water table**) usually lies far below the roots of the native trees.

7.8.3 The human factor

Natural processes caused the water table to rise slowly over hundreds of thousands of years. However, things changed quickly after 1788 when European settlers started to use the same farming techniques that they had used in Europe. They cleared the native plants and trees from vast areas of land to graze cattle and sheep and to plant crops. Later, they set up irrigation systems to provide water to the crops they had planted.

The removal of deep-rooted trees has caused the water table to rise.



The new crops and pasture grasses have much shallower root systems than the native plants and do not cover anywhere near as much of the soil. So now, when rain falls, much more rainwater enters the groundwater, causing the water table to rise. This rising water table carries with it a lot of the salt that had been locked in the rocks and soil below. The water table rises even faster on irrigated land. After many years of this type of farming, the salt has reached the upper soil layers near the surface.

Salinity affects the land in a number of different ways.

- Where the soil is rich in salt, few plants can survive. This has meant that many crops and many grasses established for herds have died. The native species that originally inhabited the cleared regions cannot tolerate the salt either, so they can't be replanted.
- Where water runs off into waterways it has taken the salt with it, causing increased salinity of waterways. This means that they cannot be used for drinking, and the populations of animals that depend on

these fresh water sources have decreased. The Murray River, one of the major sources of fresh water in this country for humans and animals, has been badly affected by salinity.

- The reduced supply of drinkable water has led to a decrease in biodiversity of plants and wildlife in saline regions.

The soil in cleared regions has also been damaged by heavy erosion. The deep roots of native plants and trees helped keep the soil on the surface in place. When these native plants are cleared, heavy rainfall washes the topsoil into waterways, leaving behind land on which little can grow.

The devastation of the rising water table and salinity threatens much of Australia's farmland.



At present, the problem of salinity is being treated with increased planting of salt-tolerant plants and trees and a massive decrease in land-clearing practices. However, it will be many years before this major problem is solved.

Salinity of water

Description of water	Salinity (g/L)
Distilled water	0.0
Murray River, Albury (NSW)	0.05
Desirable limit for drinking water	0.5
Murray River, Morgan (SA)	0.8
Upper limit for citrus trees	1.0
Upper limit for drinking water	1.5
Upper limit for dairy cows and ewes	6.0
Groundwater, Loddon Plain North (Victoria)	15.0
Pacific Ocean	35.0

The salinity of water is a measure of the amount of salt dissolved in it. It can be expressed as the number of grams of salt per litre (g/L) of water.

7.8.4 Australian research to reduce soil salinity

Evergraze

Scientists and farmers working on the Evergraze trial are studying a range of plants for grazing pastures at a number of experimental sites, including Wagga Wagga in NSW. They aim to reduce soil salinity by reducing the amount of groundwater by 50 per cent. The trial focuses on plants that can thrive over spring, summer and autumn, such as lucerne and chicory. Lucerne plants have roots down to 3 metres below the soil surface. This means that the plants dry the soil to a greater depth so, when it rains, most of the water is used by the plant. This keeps the water table low and therefore helps to reduce soil salinity.

Plants with deep root systems can lower the water table, reducing soil salinity.



Saltbush

Scientists in Western Australia are studying the use of saltbush for sheep grazing. Many species of saltbush are found in arid regions in the world. However, none of these are common in grazing regions in Western Australia. Scientists, including research scientist Dr Hayley Norman, have discovered that saltbush could be a valuable plant in managing soil salinity. Unlike other plants, saltbush has a very high tolerance to salt and retains salt in its leaves. As an unexpected bonus, sheep grazed on saltbush have health benefits; their meat has a lower fat content.

Animals that graze on saltbush often have leaner meat.



7.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Define the term ‘water table’.
2. Explain why the water table has risen throughout much of Australia during the past 200 years.
3. Explain why the rising water table is a threat to farm crops.

Think

4. Describe how soil damage due to salinity could be reduced.

Investigate

5. Design and carry out an experiment to investigate the effect of the salinity of water on the growth of one type of plant.
6. Some plants are more tolerant to salty water than others. Design and carry out an experiment to identify some plants that might be more suited to areas affected by salinity.

7.9 Matrixes and plus, minus, interesting charts

7.9.1 Matrixes and plus, minus, interesting charts

1. Write the topics in the left-hand column of the matrix.
2. Write the characteristics to be compared along the top row of the matrix.
3. If a characteristic applies to a topic, put a tick in the appropriate cell of the matrix.
4. The matrix now shows how the various topics are related.

how to ...?

To show similarities and differences between topics

why use?

In what ways are these topics similar and different?

question

Matrix

Topic	Feature A	Feature B	Feature C	Feature D	Feature E
1	✓		✓	✓	✓
2		✓			✓
3		✓		✓	✓
4			✓	✓	✓

also called

Table; grid; decision chart

comparison

Similarity

Both can be used to examine the key features of a topic and can help you to make a decision on something.

Difference

PMI charts look at positive (plus), negative (minus) and interesting aspects of something. Matrixes can have a broader application.

Plus, minus, interesting

Topic/theme/idea

Plus	Minus	Interesting
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•

example

7.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think and create

1. Copy and complete the matrix on the opposite page. Use ticks to show which energy sources each description in the left-hand column applies to.

Description	Coal	Nuclear energy	Hydro-electricity	Natural gas	Solar energy	Wind energy
Is a renewable resource						
Is a sustainable energy option						
Uses energy from the sun						
Is a fossil fuel						
Can be used to generate electricity						
Contributes to global warming						
Causes chemical pollution						

2. Create your own personal PMI chart to display the positive, negative and interesting aspects of the use of nuclear energy to generate electricity in Australia.
3. Create a PMI chart on each of the following issues.
   (a) Permanent water restrictions to conserve water supplies
   (b) The use of desalination plants to change sea water into fresh water
   (c) Building more dams and reservoirs to increase our water supply
   (d) Adding treated sewage water (guaranteed by the government to be safe for drinking) to our water supply
4. Copy and complete the matrix below to summarise your views about each of the statements in the left-hand column.

Is nuclear power an option for Australia?

Nuclear energy

Plus	Minus	Interesting
• is a clean form of energy • • •	• produces dangerous waste products • •	• is used in the UK, US and Japan • • •



Statement	Yes	No	Unsure
Permanent water restrictions should be introduced in my state or territory to conserve water.			
A desalination plant is the best way to ensure that there is always plenty of water and no water restrictions.			
More dams and reservoirs should be built on Australia's major rivers to guarantee future water supplies.			
We should use treated water from sewage to add to our regular water supply.			

7.10 Review

7.10.1 Study checklist

The earth's resources

- distinguish between renewable and non-renewable resources
- compare the timescales for the extraction of minerals and fossil fuels with the timescales for their formation and regeneration
- explain how useful metals are produced from the mineral ores in rocks
- distinguish between open-cut mining and underground mining

Energy sources

- identify coal, oil and natural gas as fossil fuels
- distinguish between black coal, brown coal and peat in terms of composition and usefulness as a source of energy
- compare renewable and non-renewable energy sources
- describe examples of the use of a range of renewable and non-renewable energy sources

The water cycle

- recognise the importance of water as a natural resource
- describe the water cycle in terms of changes of state of water
- describe the formation of ocean currents and their influence on the water cycle and weather patterns
- explain the impact of global warming on the water cycle and weather patterns
- describe the causes of a rising water table

Soil

- recognise the importance of soil as a natural resource
- describe the processes of weathering and erosion
- identify and describe some examples of reducing erosion and the damage done by erosion
- explain why soil salinity in Australia has increased naturally

Science as a human endeavour

- define sustainability and describe the importance of sustainability in the management of all of the Earth's natural resources
- consider the advantages and disadvantages of open-cut mining and underground mining
- describe and compare methods of maintaining and conserving water supplies
- explain how human management of land and water has contributed to erosion, a rising water table and rapidly increasing soil salinity
- consider how Aborigines and Torres Strait Islanders used and managed natural resources.

Individual pathways

ACTIVITY 7.1
Investigating resources
doc-6093

ACTIVITY 7.2
Analysing resources
doc-6094

ACTIVITY 7.3
Investigating resources further
doc-6095

learnon ONLINE ONLY

7.10 Review 1: Looking back

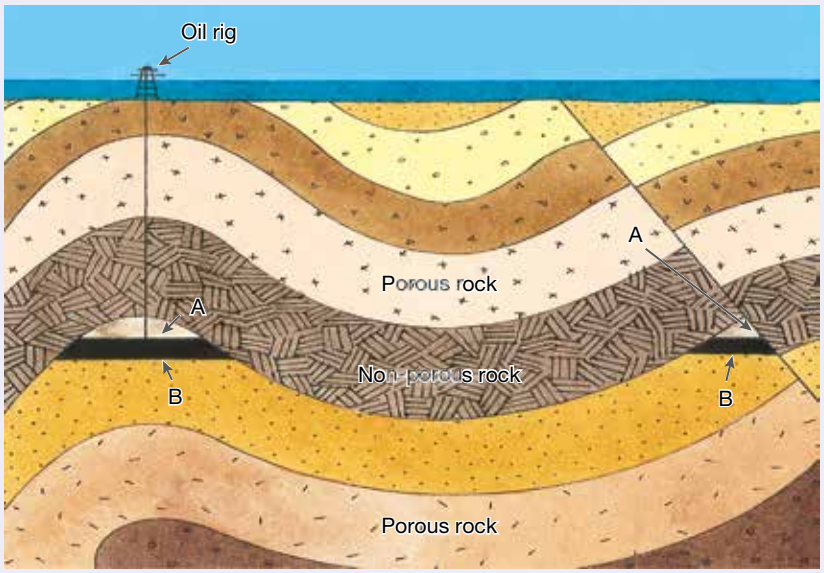
To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Are the precious minerals obtained from mines renewable or non-renewable resources? Explain your answer.
2. What are the solid wastes of metal extraction called?
3. Copy and complete the table below to match the metals with their mineral ores.

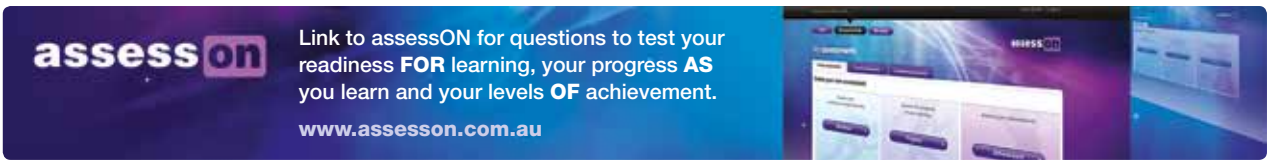
Mineral ore	Metal
Bauxite	
Galena	
Haematite	
Chalcopyrite	

4. List three factors (other than cost) that are used to decide whether a mineral ore is extracted by open-cut mining or underground mining.
5. Describe what happens to the rock taken from the ground during the first stage of extraction of its precious metal.
6. List the three most commonly used fossil fuels.
7. From what are all fossil fuels created?
8. What happens to most of Australia's coal after it is mined?
9. Apart from the colour, what are the differences between brown coal and black coal?
10. The diagram at right shows rocks in the region below an oil rig.
    (a) Identify the two substances labelled A and B.
    (b) What property must the layer of rock directly above A and B have?



11. Draw a flowchart to show how oil and gas are believed to have formed.
12. What is the difference between the way in which coal is formed and the way in which oil and natural gas are formed?
13. Which fossil fuel is the most commonly used in Australia to generate electricity in power stations?
14. Why is it so important for Australia to reduce its dependence on fossil fuels?
15. Our huge dependence on non-renewable energy sources is not sustainable. What is meant by the term 'sustainable'?
16. Explain why the petrol used to fuel cars and the coal used to generate most of Australia's electricity are known as non-renewable energy sources.
17. Solar energy and wind energy are two examples of renewable energy sources. What makes a renewable energy source different from a non-renewable source?
18. Why do you think uranium-fuelled nuclear energy is not used to generate electricity in Australia even though we have more uranium reserves than any other country in the world?
19. Create a circular flowchart to describe the water cycle.
20. Which two regions of the Earth interact in the water cycle?
21. What are the main causes of the world's ocean currents?

22. Write a description of how clouds are formed.
23. Explain how global warming is different from the natural greenhouse effect.
24. What role does carbon dioxide play in global warming?
25. Why does the use of fossil fuels make a difference to the Earth's atmosphere and surface?
26. How does cutting down trees in forests increase the amount of carbon dioxide in the air?
27. Explain how global warming has interfered with the natural water cycle.
28. List three effects of global warming on weather patterns.
29. Explain why building dams is not always the best solution for the problem of maintaining an adequate water supply for growing cities and towns.
30. Identify three alternatives to building more dams to maintain reliable water supplies.
31. Where does greywater come from?
32. How does a greywater treatment system make greywater safe for the watering of plants?
33. Where does blackwater come from?
34. Which groups are involved in monitoring the quality of drinking water in streams and reservoirs?
35. List at least five properties that are monitored to ensure that drinking water is healthy and of good quality.
36. State two reasons why soil is such a precious resource.
37. Explain the difference between:
    (a) weathering and erosion
    (b) erosion and deposition
    (c) sediments and soil.
38. Explain how the planting of trees can reduce erosion.
39. In your opinion, is fertile soil a renewable or non-renewable resource? Explain your answer.
40. What is salinity and how does it affect the usefulness of soil?
41. Explain why the water table in Australia is rising more quickly that it did before European settlement.
42. Why is a rising water table a problem for farmers?



TOPIC 8
Forces in action

8.1 Overview



The way in which objects move depends on what forces are acting on them. A force is a push or a pull. While you are reading this, the muscles in your eyes are pulling the lenses in your eyes into the right shape so that the words are not blurry.

They say that 'what goes up must come down'. But, when a bungee jumper's head is about to reach the water, it's a case of 'what goes down should come up'.

8.1.1 Think about forces

assessON

- Why doesn't gravity make you fall through the floor?
- How does a compass work?
- Why do you sometimes experience a small electric shock when you get out of a car?
- What causes lightning?
- How do crickets make their chirping sound?
- Why is it difficult to walk on ice?
- Why are bicycle helmets necessary?
- What force allows water spiders to walk on the surface of a pond?
- How does a seatbelt protect you in a car accident?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

8.1.2 Your quest

Why don't you fall through the floor?

Stand up and think about the forces that are pushing or pulling on you and answer the following questions.

Think

1. What is the name of the force that is pulling on you now?
2. What force is pushing upwards on your body while you are standing still?
3. What is the size of the upward force compared with the pulling force? How do you know?

What force causes the bungee jumper on the previous page to fall? What makes the jumper slow down before reaching the water? Think about the bungee jumper pictured and answer the following questions.

Think

4. What is the largest force acting on the jumper just before he reaches the water?
5. Just after the bungee jumper leaps and before the rope tightens, there are two forces acting on him. One is much larger than the other. What are the forces and in which direction does each of them act?
6. Work in small groups of three to four and try the following activity.
   (a) Using a large piece of butcher's paper, draw up a table with terms listed in the left-hand column of the table at right.
   (b) Discuss each term and what you all think it might mean.
   (c) In column two of your table, write the possible meaning that your group proposes for each term. If your group finds a term difficult, you can write 'don't know', but don't be afraid to have an educated guess.
   (d) Share your group's responses with the class.

Term	Possible meaning
Force	
Friction	
Magnet	
Magnetic field	
Mass	
Gravity	
Weight	
Lubricant	
Buoyancy	
Surface tension	
Aerodynamic	

INVESTIGATION 8.1

Water drops

AIM: To explore a property of water

Materials:
5-cent coin
small beaker of water
eye dropper
dishwashing detergent



Method and results

- Guess how many drops of water you can get onto a five-cent coin before it starts spilling over the edge.
- With great care, and from a very small height, use an eye dropper to place one drop at a time onto the coin. Keep count of the number of drops.
- Dry the coin thoroughly and try again to see whether you can improve on your first attempt.
- Compare your result with those of others in your class.
- Repeat this challenge using water with a few drops of dishwashing detergent added to it.

1. What is the greatest number of drops that you were able to place on the coin and how does the number compare with your guess?
2. What was the greatest number of drops placed on a five-cent coin in your class?

Discuss and explain

3. What seems to hold the water on the coin?
4. What difference does adding detergent make to your results?
5. Why do you think the detergent has changed the result?

8.2 On the move

8.2.1 Forces everywhere



When a tennis ball is hit with a tennis racquet, it is clear that a **force** is acting on the ball. The ball not only changes its direction of movement, but also, while in contact with the racquet, changes its shape as well.

A force is a push or a pull. Forces are acting around you all the time and they can cause changes to occur. Sometimes the effects are obvious and sometimes they are not. At this moment, forces are acting inside your body to pump blood around. When you write, you use a force to push the pen or pencil.

INVESTIGATION 8.2

What can a force do?

AIM: To observe the effects of forces on different objects

Materials:

rubber band
plasticine
tennis ball
coin
plastic ruler or rod
nylon or wool cloth

Method and results

1. Copy the table below into your workbook and write down your observations.
2. Take note of any changes in the motion or shape of each object and what caused the change in the motion or shape.

Discuss and explain

3. When you squash a lump of plasticine and stretch a rubber band, a change in shape is observed. What is different about the behaviour of these two materials?
4. Does the tennis ball change its shape at all when it hits the ground? What would happen to a falling lump of plasticine when it hits the ground? Would it bounce? Check your prediction.
5. Which two of the forces that you observed were able to change the motion of objects without making contact with them?

	Observations	
What to do	**Changes in motion or shape**	**What caused the change**
Stretch a rubber band.		
Squash a lump of plasticine.		
Push down on the floor with one foot.		
Drop a tennis ball. Observe what happens: (a) at the moment that you drop it (b) as it falls (c) as it hits the ground (d) as it goes up again.		
Flick a coin with one finger so that it slides along the surface of a table. Observe what happens after the coin is flicked.		
Charge a plastic ruler or rod by rubbing it with a nylon or wool cloth. Hold it close to a thin stream of tap water.		

WHAT DOES IT MEAN?

The word *gravity* comes from the Latin word *gravitas*, meaning 'heaviness'.

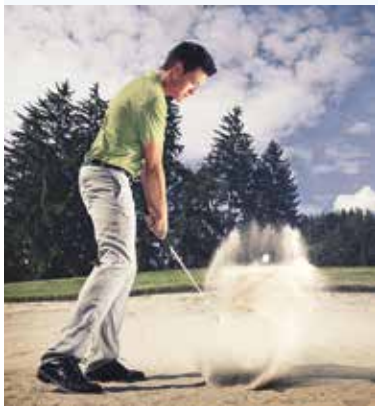
8.2.2 Contact or no contact?

The changes in motion illustrated below are all caused by **contact forces**. One object is in contact with another. The golf club strikes a ball (and the sand), the air pushes against the parachute to slow down the car and the tube of toothpaste is squeezed to change its shape and push out the toothpaste.

But the motion and shape of objects can be changed without touching them with anything.

When you drop a tennis ball, it speeds up as it falls through the air. The force of **gravity** pulls it towards the Earth. Gravity is a **non-contact force**. An object does not have to be touching the Earth to be pulled towards it. Other forces that can work without touching are **magnetic forces** and **electrostatic forces**.

Each of these photos demonstrates the action of at least one contact force and at least one non-contact force. Identify as many of these forces as you can.

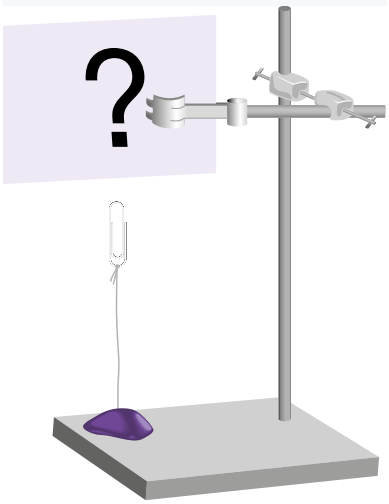






Magnets can attract each other or some metals, such as iron, from a distance. If you rub a pen with a cloth, you can pick up small pieces of paper with an electrostatic force.

What is behind the card? (A force must be holding the paperclip in the air.)



8.2.3 More than one force

Almost never is there only one force acting on an object. You are probably sitting on a chair right now. What forces are acting on you and your chair? There must be at least one! The force of gravity is pulling you towards the centre of the Earth.

There are four major forces acting on the car above: gravity (down), the upward push of the ground, drag provided by the parachutes (to the left) and friction provided by the road on the tyres (to the left if the brakes are applied). The downward and upward forces balance each other out — otherwise the car would rise into the air or sink through the road. There is no force to the right while the driver is braking. The total force is to the left, causing the car to slow down. Without the parachutes it would not slow down quickly enough.

8.2.4 Representing forces

Arrows can be used to represent the sizes and directions of forces. The length of the arrow shows how large the force is compared with another force. The arrows representing forces are usually drawn from the object's centre of gravity. This is where all of the weight of an object would be concentrated if it were in one place. Your body's centre of gravity is at about bellybutton height when you are standing.

The arrows in the photographs below show that the upward and downward forces on the kayaker are the same size but in opposite directions. Gravity pulls the kayaker down and the water pushes the kayak (and the kayaker) up. (The upward push of the water is called buoyancy.) These two forces on the kayaker add up to zero and so there is no change in her upward or downward motion.

The horizontal arrows show that the forward force on the kayaker (provided by using the paddle) is larger than the backward force (provided by the drag of the water). The forward force is larger than the backward force and so the kayaker and kayak speed up. This could not keep happening for long because, as the kayak speeds up, the water drag increases. When the drag reaches the size of the forward force, the total force is zero and the kayak stops speeding up. To speed up again, the kayaker would have to paddle harder or faster.





8.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is a force?
2. List six ways in which a force can affect an object.
3. Which of the following are non-contact forces: friction, electrostatic force, magnetic force, gravity?
4. Name the force that opposes the movement of an object through water.

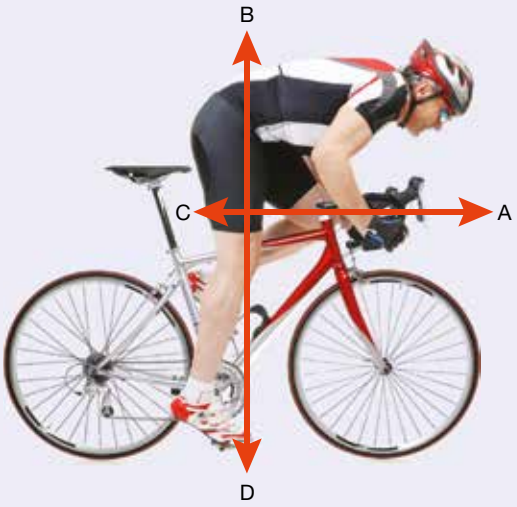
Think

5. Copy the following table into your workbook. Complete it by thinking of two or three everyday examples of each of the effects of forces. You can complete your table with diagrams or words.

Everyday effects of forces

Effect	Examples in everyday life
Starting motion	
Stopping motion	
Speeding up motion	
Slowing down motion	
Changing the direction of motion	
Changing the shape of an object	
Having no visible effect	

6. When you flick a coin so that it slides across a table, it slows down.
   (a) What is the name of the force that slows it down?
   (b) While your finger is still pushing the coin, there are four forces acting on the coin. What are they? Draw a diagram with arrows showing the direction in which each of the four forces pushes or pulls.
   (c) How many forces are acting on the coin after your finger stops pushing?
7. Explain why you don't fall through the floor.
8. Is drag a contact or non-contact force? Explain your answer.
9. Where would you expect to find the centre of gravity of a plastic ruler?
10. There are four forces acting on the person in the diagram on the right.
    (a) Which of the four forces represented is a non-contact force?
    (b) What would happen if forces B and D were not equal?
    (c) Is the cyclist's speed increasing, decreasing or remaining steady?
    (d) Describe what would happen to the cyclist's motion if the size of force C increased to become equal in size to force A?
    (e) What would happen if force C became greater in size than force A?



8.3 A magnetic attraction

8.3.1 A magnetic attraction

Make a list of all the things that you come into contact with every day that use magnets. The pictures below will give you some clues. Share your ideas with others and compile a class list.

Magnets can attract certain materials without actually touching them. Magnetic forces can therefore be referred to as non-contact forces.

Magnets that retain their magnetism when removed from other magnets are called **permanent magnets**. Natural permanent magnets contain one or more of the elements iron, nickel and cobalt. The most common natural permanent magnetic substance is magnetite, also known as lodestone.

Most permanent magnets, however, are **alloys**, or mixtures, of iron, nickel or cobalt with other elements or each other. Items made of steel are attracted to magnets because steel is an alloy of iron, carbon and other substances.

Temporary magnets are those that lose their magnetism when removed from another magnet. The paperclips in Investigation 8.7 are temporary magnets while in contact with the permanent magnet. As soon as they are removed from the electromagnet, they lose their magnetism.

Magnets that might be found at home: fridge magnets, a magnetic knife holder and a magnetic screwdriver



INVESTIGATION 8.3

What does a magnet attract?

AIM: To investigate the attraction to a magnet of a selection of materials

Materials:
magnet
selection of materials to be tested (see the list below)

Method and results

- Place a magnet close to a range of materials to find out which ones are attracted to it.

1. Record your observations in a table like the one at right.
   - Test as many of the following items as possible: pencil, paper straw, plastic straw, coins, iron nail, stainless steel spoon, aluminium foil, paperclip, copper wire.
   - Do some materials 'block' the magnetic force? Design an experiment to find out.
2. Which materials were attracted to the magnet?
3. Are all metals attracted to magnets?

Attracted	Not attracted

Discuss and explain

4. Of the materials that were attracted to the magnet, which one was attracted the most? Why do you think this was so?
5. Were there any forces other than the magnetic force acting on the objects? If so, what were they?
6. Were there any unexpected observations? If so, what were they?

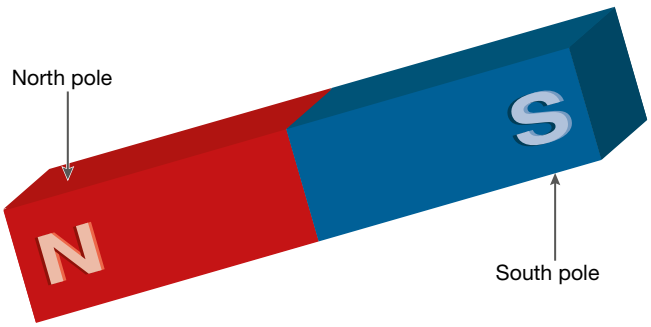
learnon RESOURCES — ONLINE ONLY

Watch this eLesson: Electromagnetism (eles-1778)

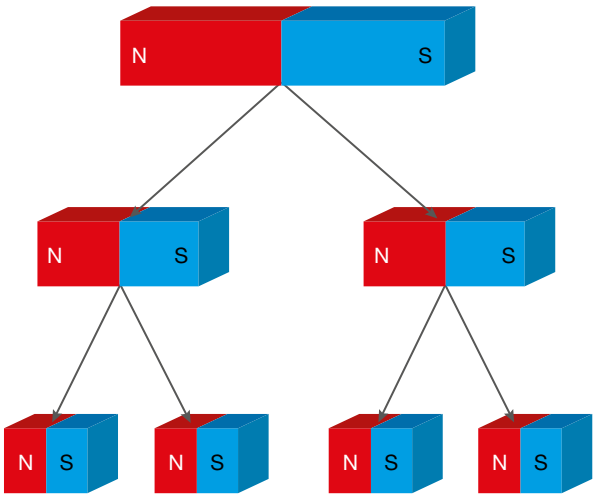
8.3.2 Magnetic poles

All magnets, no matter what their shape, have a **north pole** at one end and a **south pole** at the other.

When a magnet is cut in half, each half still has a north pole and a south pole. If you keep cutting a magnet in half over and over again, each half always has a north pole and a south pole.



Magnets always have a north pole and a south pole, even if broken in half.

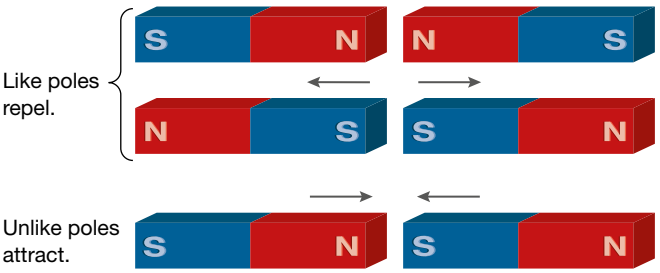


Opposites attract

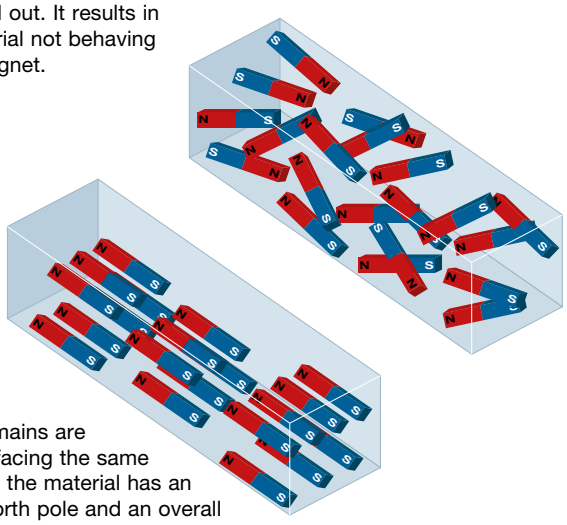
When the north poles of two magnets are brought close together, the magnets push away (or repel) each other. This same **repulsion** force is felt between two south poles.

When the north pole of a magnet comes close to the south pole of another magnet, the opposite happens. They pull on each other, or attract one another.

In one model of magnet materials, they are thought to be made up of small mini-magnets called **domains**.



If the domains inside magnetic materials are facing different directions, the pushes and pulls of the 'mini-magnets' are cancelled out. It results in the material not behaving like a magnet.



If the domains are lined up facing the same direction, the material has an overall north pole and an overall south pole. The material will behave like a magnet.

INVESTIGATION 8.4

Poles apart

AIM: To investigate the forces between the poles of a magnet

Materials:

2 bar magnets

Method and results

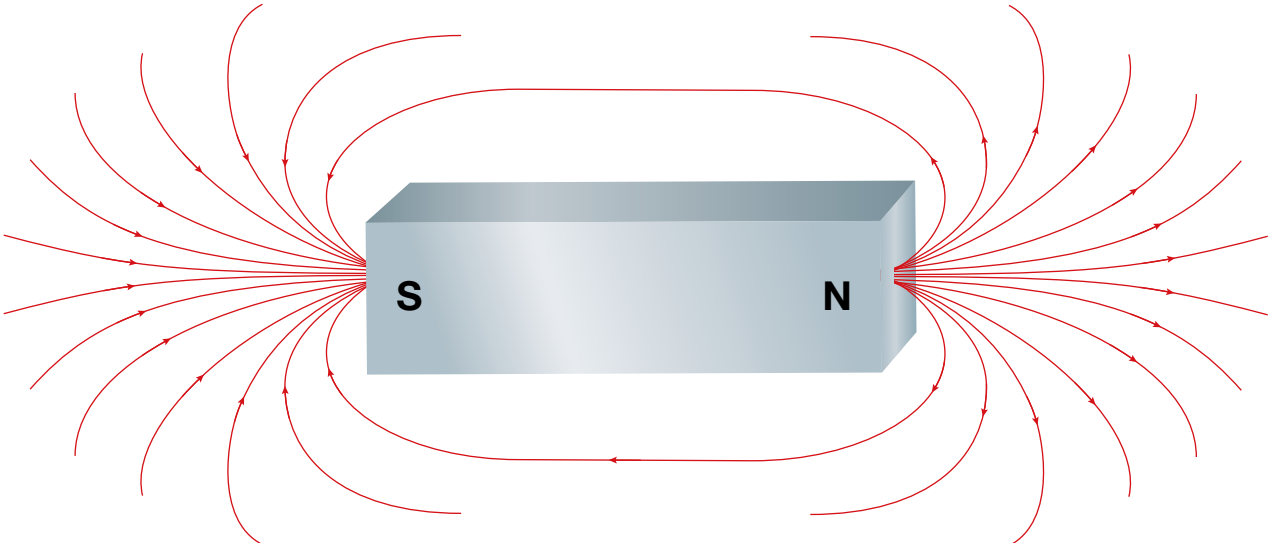
1. Take two bar magnets and identify the north and south pole of each. Position the magnets near each other as shown below. Take note of whether the magnets attract or repel each other in each case.
   (a) N S
   (b) N N
   (c) S S
   (d) S N
   Attraction or repulsion?
2. Complete the sentences to form your conclusion:
   Like poles _____.
   Unlike poles _____.

8.3.3 Magnetic fields

Iron filings line up in the direction of the magnetic force around a magnet. The area where the magnetic force acts is called the **magnetic field**.

The magnetic field can be drawn like a map, as in the diagram below. The lines show the direction of the magnetic force. The lines are closest together where the magnetic force is greatest and furthest apart where the magnetic field is weakest. Notice that the lines of the magnetic field point away from the north pole and towards the south: that is, from north to south. The north pole of a compass points in the direction of a magnet's magnetic field.

Magnetic fields can be drawn as maps.



8.3.4 The Earth's magnetic field

When a bar magnet is suspended by a string at its centre, it always lines up with the North and South Poles of the Earth. The Earth, like the sun and some planets, has its own magnetic field. It is very much like the magnetic field of a bar magnet. Scientists are not sure why the Earth has a magnetic field.

Any magnet free to turn will line itself up along the field lines. The north pole of the magnet is the pole that points towards the North Pole of the Earth. In a similar way, the south pole of a magnet points towards the South Pole of the Earth.

A compass contains a small magnet that aligns with the Earth's magnetic field.

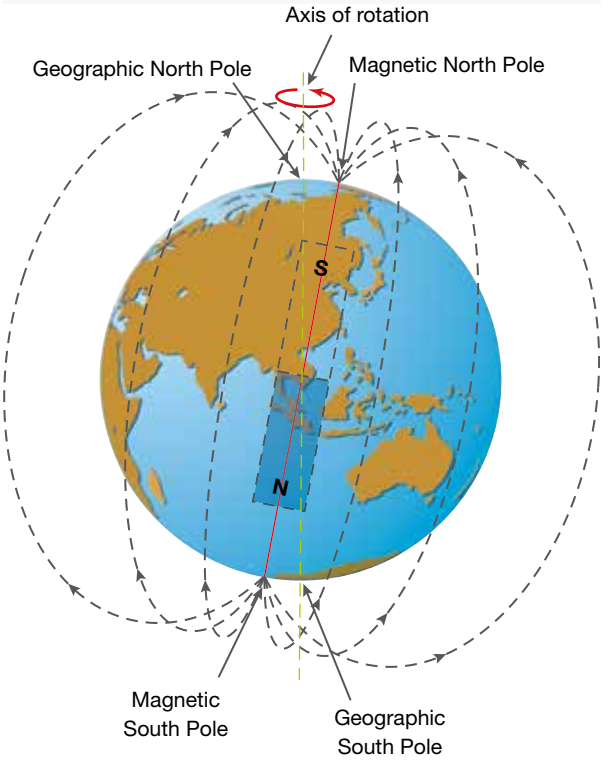


A compass is just a small magnet with its poles tapered to a point. The north pole of a compass is usually coloured; so the coloured end of the compass points towards the North Pole of the Earth. However, if another magnet is brought close to a compass, the north pole of the compass points towards the south pole of the other magnet.

The direction of any magnetic field is the direction in which the north pole of a compass needle points.

Notice that there are two north poles and two south poles shown on the diagram of the Earth below. The Magnetic North Pole is about 1000 km from the Geographic North Pole and the Magnetic South Pole is about 1000 km from the Geographic South Pole. Both magnetic poles move about 40 kilometres every year.

The Earth's magnetic field



INVESTIGATION 8.5

Mapping the magnetic field

AIM: To map the magnetic field around magnets

Materials:

horseshoe magnet in a plastic bag
overhead transparency
2 bar magnets in plastic bags
iron filings
sheet of A4 paper
small compass

Method and results

- Place a bar magnet in the centre of a sheet of white paper. Cover the paper and magnet with an overhead transparency.
- Carefully sprinkle iron filings over the transparency, gently tapping it to spread the filings out. Take care not to let iron filings get under the transparency.

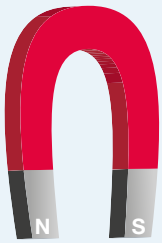
1. Draw a diagram of the pattern made by the iron filings. Label the north pole and south pole of your magnet on the diagram. The pattern in your diagram is a map of the magnetic field around the bar magnet.
   - Use the iron filings to investigate the magnetic fields around a horseshoe magnet and the pairs of magnets shown in the figure on the next page.
2. Place a compass at several positions around the magnet. The direction in which the compass needle points shows the direction of the magnetic field lines. Add arrows to your diagram to show the direction of the magnetic field.
3. Do the magnetic field lines run from north pole to south pole or from south pole to north pole?
4. Draw diagrams of the magnetic fields around the magnets in the figure on the next page. Use your compass to help you decide which way the arrows should go on your diagram.

Discuss and explain

5. Where does the magnetic field appear to be strongest? How do you know this?
6. What happens to the strength of the magnetic field as you get further from the magnet?

Use the iron filings to investigate the magnetic fields around these magnets.

(a)



(b)



(c)



(d)



INVESTIGATION 8.6

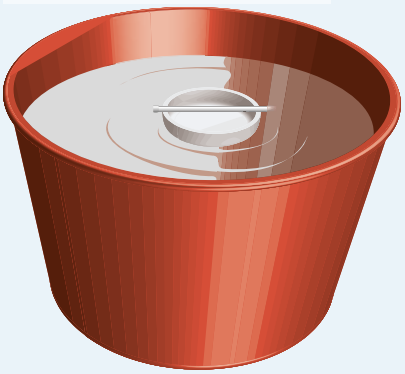
Making your own compass

AIM: To make a compass using an iron nail

Materials:

large iron nail (about 75 mm long)
strong magnet
paperclips or small nails
sewing needle

Make your own compass.



Method and results

- Take a large iron nail and stroke it with a strong permanent magnet. After each stroke, lift the magnet high above the nail before commencing the next one. You need to make sure that each stroke is in the same direction and made with the same end of the magnet.
- After a total of 40 strokes, test your new magnet by trying to attract paperclips or small nails.
- Compare the strength of your magnet with that of others in your class.
- Use your magnet to make a compass like the one shown above. You will need a container of water and a float. The bottom of a styrofoam cup will make a good float.
- Try dropping your 'homemade' magnet on the floor. Test it to see if it works.
- Try to magnetise a sewing needle instead of an iron nail.

Discuss and explain

1. Is your magnet a permanent magnet or a temporary magnet?
2. Which end of your magnet is the north pole? How do you know?
3. Could you magnetise the sewing needle? Explain why or why not.

HOW ABOUT THAT!

The coil of wire that is wrapped around the iron core in an electromagnet is called a solenoid. Even without the iron core inside, a solenoid produces a magnetic field. Solenoids are used in many devices, including cars, to switch things on and off.

8.3.5 Switched on magnets



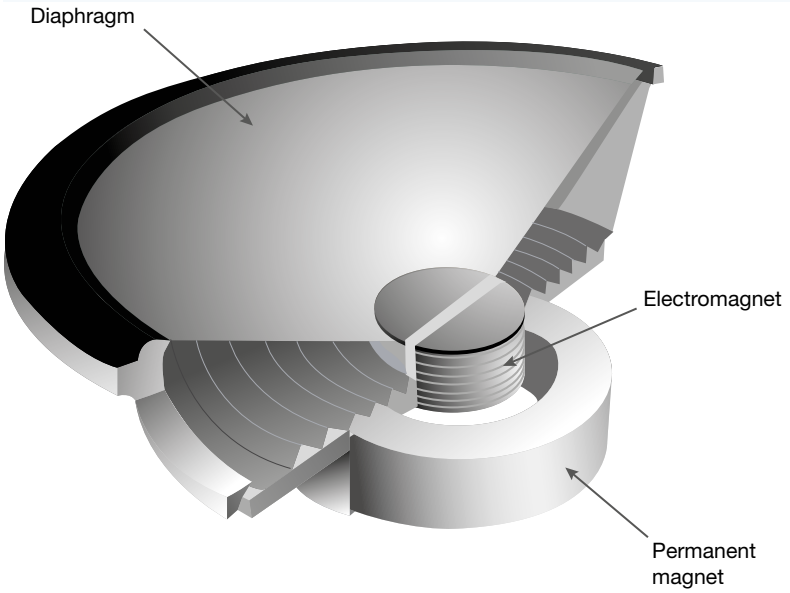
An electromagnet is a coil of wire wrapped around an iron core. When an electric current is passed through the coil, the iron is magnetised. When the current is turned off, the iron is no longer magnetised. Being able to turn a magnet on and off at will can be very useful.

The photograph at right shows one such use. The electromagnet is attached to a giant crane. The electric current is turned off while the electromagnet is lowered onto the load of scrap metal to be lifted. When the current is switched on, the iron or steel in the scrap is attracted to the electromagnet and lifted to a container. The electric current is switched off and the metal falls into the container. However, if the metal was not mostly iron or steel, the electromagnet would be of little or no use.

Electromagnets like the one in the photograph are also useful in separating iron and steel from other scrap metal. The scrap metal is first shredded into small pieces.

Electromagnets are also used in doorbells, metal detectors, speakers, phones, electric motors and generators.

Cross-section through a speaker



8.3.6 Amazing magnets

We use electromagnets and permanent magnets every day. Computer hard drives store information by forming magnetic patterns on disks. Electromagnets are used to store and read the magnetic patterns. Phones have microphones and speakers that rely on both permanent magnets and electromagnets. Electric motors and generators use magnets. Metal detectors and many doorbells also contain electromagnets.

INVESTIGATION 8.7

Making an electromagnet

AIM: To make and investigate an electromagnet

Materials:

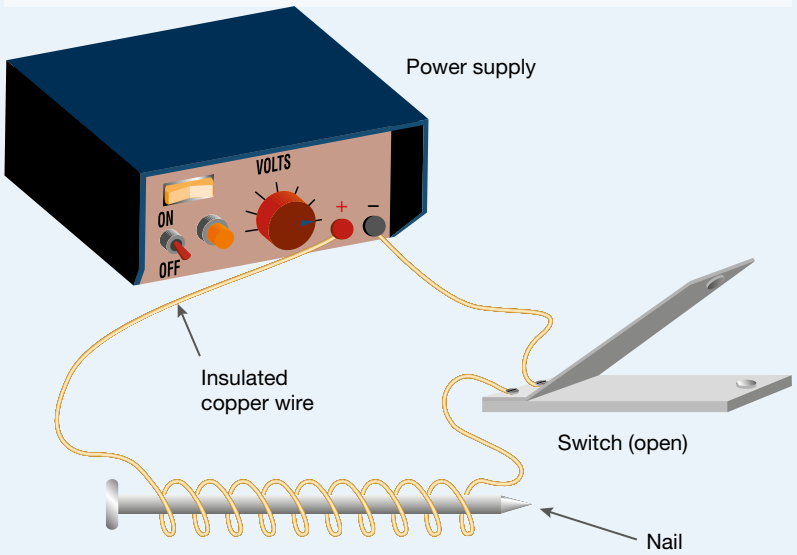
2 insulated wires: one short, the other 1.5 m long
power supply
switch
paperclips (many)

Method and results

- Set up the electric circuit as shown in the diagram below.
- Wind 15 turns of the longer wire around the nail. There will be a lot of wire left over but do not cut it.
- Set the power supply to 2 volts and close the switch.
- Test your electromagnet by opening the switch and seeing how many paperclips it will pick up.

1. Record your results in a table like the one below.
   - Wind five more turns of wire around the nail.

Circuit for an electromagnet



2. Record the number of paperclips picked up by your electromagnet now.
3. Keep winding the wire around the nail. Record the number of paperclips picked up by 25 and 30 turns of wire.
   - Increase the voltage to 4 volts and repeat the previous steps.

Voltage of power supply (V)	Number of turns of wire	Number of paperclips picked up
2	15	
2	20	
2	25	
2	30	
4	15	
4	20	
4	25	
4	30	

Discuss and explain

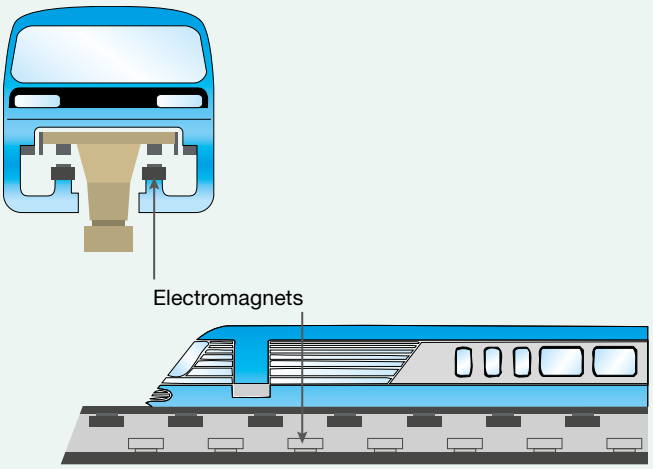
4. What is the effect of increasing the number of turns around the nail?
5. What is the effect of increasing the voltage?
6. Did the iron nail retain its magnetism when the current was switched off? Explain.

HOW ABOUT THAT!

The maglev train gets its name from MAGnetic LEVitation. It carries passengers at speeds of up to 500 km/h and doesn't even need a normal engine to run! It uses pushing forces between electromagnets on the track and on the train to keep them apart.

Electromagnets also propel the train forwards. Magnets ahead of the train pull the train forwards. Magnets behind the train push it forwards.

The maglev train seems to float above the train tracks. The train touches the track only while it is building up speed before moving.



8.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

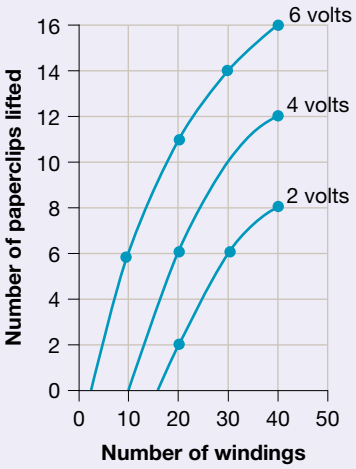
1. Which of the following statements is correct?
   (a) Permanent magnets never lose their magnetism.
   (b) All metals are strongly attracted to magnets.
   (c) Iron, steel and nickel are attracted to magnets.
   (d) Iron is the only substance attracted to magnets.
2. What is the difference between a permanent magnet and a temporary magnet?
3. How should two bar magnets be placed on a table so that they repel each other?
4. What is a magnetic field?
5. How is the direction of a magnetic field determined?
6. Describe what an electromagnet is and explain how it works.
7. List some everyday devices that use electromagnets.

Think

8. Make a list of as many items as you can that are, or contain, permanent magnets.
9. The Magnetic North Pole of the Earth can be considered as one pole of a bar magnet. Is it a south pole or a north pole? Explain your answer.
10. Which way would the coloured end of a compass point if you were in a plane flying directly above the Earth's Magnetic North Pole?
11. What is the advantage of an electromagnet over a permanent magnet? Use an example to illustrate your answer.
12. Explain why people are advised to keep strong magnets away from computer hard drives.
13. Explain how the maglev train is able to travel so fast.

Analyse

14. Arianna made her own electromagnet to find out how the number of windings around a nail affected the number of paperclips that the nail could pick up. She used the circuit shown in Investigation 8.7 with the power supply set to 2 volts. Arianna then repeated her measurements with the power supply set to 4 volts and 6 volts. She recorded her observations in a table, then she constructed a graph (shown at right).



(a) How many paperclips did Arianna lift with 20 windings and the power supply set to 6 volts?
(b) Arianna lifted 12 paperclips when the power supply was set to 4 volts. How many windings were there around the nail?
(c) How many paperclips could Arianna expect to lift with 50 windings around the nail and the power supply set to 2 volts?
(d) Suggest a way in which Arianna would be able to make her results more reliable.

Explore

15. Design and carry out an experiment to measure the strength of different magnets. Record your measurements in a table and display them using a bar or column graph.

Create

16. Build a device that uses an electromagnet to make a noise when you close a switch or push a button.

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Complete this digital doc: Worksheet 8.1: Magnetic words (doc-19842)

8.4 All charged up

8.4.1 What it means to be charged



The girl in the image has her hand on a Van de Graaff generator. It was invented in 1929 and was used to smash **atoms** to find out more about them.

The girl is obviously 'all charged up'. The force pushing her hair up is called an electrostatic force. To understand electrostatic forces, we need to have a look inside the atom.

All matter is made up of atoms. At the centre of each atom is a heavy **nucleus**. Surrounding the nucleus is a lot of empty space and tiny particles called **electrons**. Electrons are constantly moving around the nucleus. Each electron carries a **negative electric charge**.

Inside the nucleus are two different types of particles. The **protons** inside the nucleus are much heavier than electrons. Each proton carries a **positive electric charge**. The **neutrons** inside the nucleus are similar to protons but carry no electric charge. The positive electric charge of a proton exactly balances the negative charge of an electron. Atoms usually contain an equal number of electrons and protons.

Any particle or substance that has more protons than electrons is said to be **positively charged**. Any particle or substance that has more electrons than protons is said to be **negatively charged**. Any particle or substance that has equal amounts of positive and negative charge is said to be **neutral**. The term 'uncharged' is also used to describe neutral particles or substances.

8.4.2 Getting charged

Substances usually become charged by the addition or removal of electrons. This can be done in two ways: by friction or by contact.

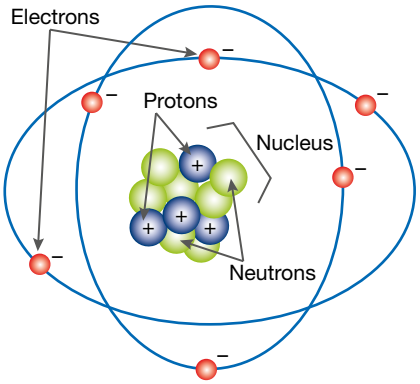
Friction

The rubbing of one neutral substance against another adds or removes electrons. When you rub a plastic ruler with wool, electrons are moved from the neutral wool onto the neutral plastic ruler. The wool, having lost electrons, becomes positively charged. The plastic ruler, having gained electrons, becomes negatively charged.

Contact

If a neutral substance is touched by a charged object, electrons can move to or from the charged object. When the charged object is removed, the previously neutral substance has gained or lost electrons. The girl touching the dome in the photograph on the previous page would become charged by contact, having lost electrons to the dome. Her hair stands on end, repelled from the rest of her positively charged body.

A neutral atom contains an equal number of protons and electrons. (Two of the protons are hidden in this diagram.) This diagram represents a carbon atom. The number of neutrons is not always the same as the number of protons.

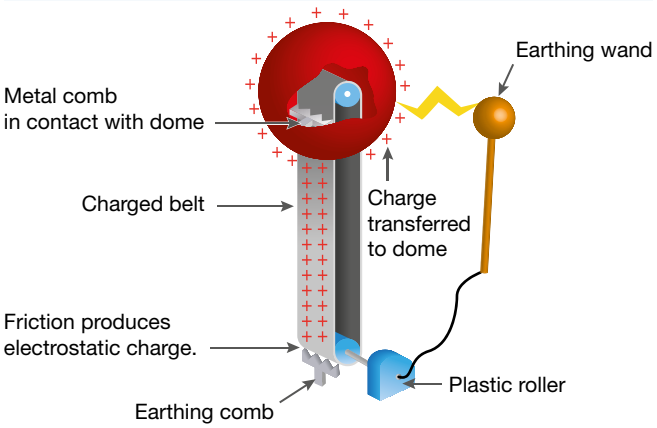


Electrons are the easiest particles to add to or remove from atoms, because they are not held together in the nucleus as protons are.

8.4.3 Standing still

The electricity that builds up on plastic rulers, balloons and the Van de Graaff generator is called **static electricity**. The word 'static' means standing still. The charge on the objects is called electrostatic charge (or static charge). Static charge can leak slowly through substances such as rubber and air. Substances through which electric charge cannot move quickly are called **insulators**. Static charge builds up easily in insulators. Substances through which electric charge flows easily are called **conductors**. Metals are good conductors of electricity. Static charge doesn't build up in conductors.

In a Van de Graaff generator, charge is transferred from the rubber belt to the metal dome. In this Van de Graaff generator, a positive charge builds up on the dome. A spark discharge can be produced if an earthing wand is brought near the metal dome.



Objects with the same static charge repel each other while those with opposite charges attract each other. If sufficient charge builds up in oppositely charged objects, the attraction between the electric charges is so great that they can jump across small air gaps. Lightning is caused by the movement of electric charge between a cloud and the ground. However, the clouds and ground are both neutral! Lightning seems to show that electric charge can move between neutral objects as well as between oppositely charged objects. The explanation for this can be found later in this section.

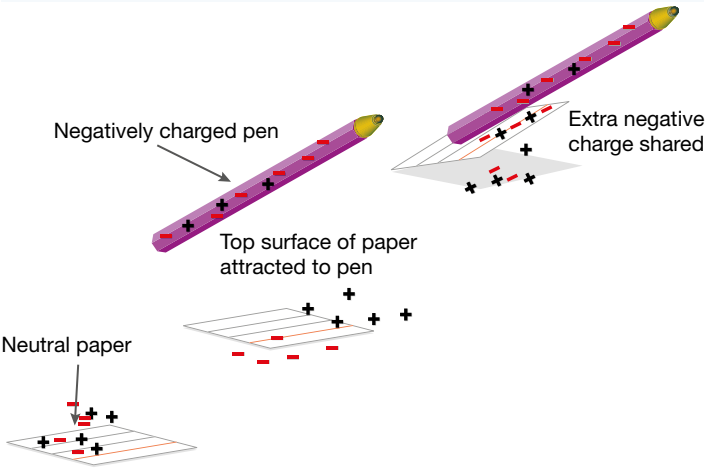
8.4.4 But it wasn't charged!

Charged objects and neutral objects can be attracted to each other. A charged plastic pen attracts a neutral stream of water. A charged balloon sticks to a neutral wall. A charged comb will make dry hair stand up. The illustration on the next page shows how a negatively charged plastic pen is able to pick up a small, neutral piece of paper.

Only a few charges have been labelled in the illustration. In reality there would be millions and millions of them. The labelled charges are there to show whether an object is neutral or charged, and how the charge is arranged in the object.

When the negatively charged pen is close to the paper, electrons are repelled from the pen, leaving the top surface of the paper with a positive charge. Note that the whole piece of paper is still neutral. If there is enough charge and the pen is close enough to the paper, the attraction is great enough to pull the paper up. Once the paper is touching the pen, the charge moves across and arranges itself so that it is evenly spread out.

Charged and neutral objects can be attracted to each other.



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Watch this eLesson: Producing static electricity (eles-0067)

8.4.5 Static charge — what a nuisance!

- When you clean and polish windows and mirrors with a cloth you leave the surface with an electric charge. The light, neutral dust particles nearby are attracted to the surface in the same way that the paper is attracted to the pen. Similarly, TV and computer monitor screens attract dust while they are being used.
- When you walk on carpet, the friction between the surface and your shoes gives your body an electric charge. If the air is dry and you are wearing rubber-soled shoes, the charge does not leak away but builds up. When you touch a metal object such as a door handle, the charge moves very quickly to or from your body, causing a small electric shock.
- A moving car builds up static electric charge as its tyres move along the road and its body rushes through the air. Because its driver and passengers are in contact with the car, they share the electric charge that builds up. Sometimes you will get a small electric shock when you get out of the car and touch the metal body, because the charge moves through your body to the ground.

8.4.6 When lightning strikes

The particles of water and ice inside clouds are constantly moving and colliding with each other. When they collide, electrons are transferred from the smaller particles to the larger particles. This leaves the lighter, smaller particles with a positive charge and the heavier, larger particles with a negative charge. Updrafts take the lighter positively charged particles closer to the top of the cloud. The larger negatively charged particles fall towards the lower part of the cloud.

INVESTIGATION 8.8

The attraction of electricity

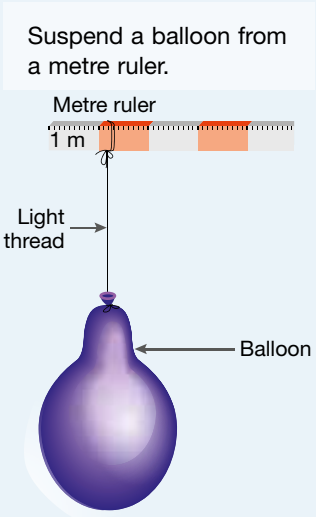
AIM: To investigate static electricity

Materials:

2 balloons
light thread
woollen cloth
metre ruler

Method and results

- Suspend one balloon from the metre ruler with light thread, as shown in the diagram below.
- Rub the balloon with a woollen cloth.
- Remove the woollen cloth and then place it close to, but not touching, the part of the balloon that was rubbed. Observe any movement of the balloon.
- Suspend a second balloon from the metre ruler so that it is close to, but not touching, the first balloon.
- Rub each of the balloons with a woollen cloth — rub on the surfaces that are facing each other.
- Remove the cloth and position the balloons so that they are as close together as they can be without touching each other. Observe any movement of the balloons.



Discuss and explain

1. Describe the movement of the single balloon.
2. Do the balloons have the same charge as the woollen cloth after they are rubbed?
3. Describe the movement of the balloons.
4. After being rubbed with the woollen cloth, do the balloons have like or unlike electric charges?
5. Copy and complete the following sentences by choosing the correct word from the pair of underlined words.
   – Objects with like charges attract/repel each other.
   – Objects with unlike charges attract/repel each other.

INVESTIGATION 8.9

Defying gravity

AIM: To investigate the forces between charged objects and an uncharged substance and object

Materials:

plastic ballpoint or felt-tip pen
woollen, cotton or nylon cloth
balloon

Method and results

- Rub a plastic pen with a piece of cloth, then hold it near a thin stream of water from a tap. Observe the behaviour of the water.
- Rub an inflated balloon with the woollen cloth and place it against a wall.
- If the balloon does *not* stick to the wall, try rubbing it with a different type of cloth.

1. Describe what happened to the water.
2. Did the balloon stick to the wall?

Discuss and explain

3. Explain the behaviour of the water and balloon in your own words.
4. What is the effect of the cloth on the balloon?

The charges keep building up. Eventually there is so much charge built up that huge numbers of electrons move from the lower part of the cloud to either the upper part of a neighbouring cloud or the ground.

If a bolt of lightning strikes a building, it can cause a huge amount of damage. It is known that lightning takes the easiest path to the ground, so **lightning rods** are attached to the tops of tall buildings. It is more likely that lightning will strike the rod, keeping the rest of the building safe.



Although lightning is spectacular to watch, it can also be very dangerous. Make sure you do not talk on a corded telephone during an electrical storm. Lightning can strike the phone line and travel to every phone on the line. Mobile or cordless phones are much safer. It is also unsafe to be outside during an electrical storm. Take shelter inside a building or in a car. Never take shelter under trees, as they are often struck by lightning.

8.4.7 When static electricity is useful

Static electricity is not always a pest. For example, photocopying machines use static electricity to make copies. Electrostatic speakers are used with some stereo equipment. Electrostatic attraction can be used to separate light particles from other substances. In a chimney, smoke particles are charged as they move past a metal grid. They are then attracted to the sides of the chimney and form a layer of soot instead of passing out to pollute the air.

8.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Which two particles of an atom carry electric charge? Which type of electric charge does each of these particles carry?
2. Which particle of an atom carries no electric charge?
3. When you rub a plastic ruler with a woollen cloth, the plastic ruler becomes negatively charged.
   (a) What happens to the atoms in the cloth and ruler to cause this change?
   (b) Complete this sentence.
   As the ruler becomes negatively charged, the cloth becomes _____ charged because it has more_____than electrons.
4. Complete each of the following sentences by using the words ‘attract’ or ‘repel’.
   (a) Two positively charged objects would be expected to _____ each other.
   (b) Two negatively charged objects would be expected to _____ each other.
   (c) A positively charged object would be expected to _____ a negatively charged object.
5. Explain, with the aid of a diagram, how it is possible for a neutral object to be attracted to a charged object.

Think

6. In the diagram of the carbon atom on page 312, some of the protons are not visible. How many are hidden by other protons?
7. Two balloons are hanging on threads next to each other, but not touching. They begin to move away from each other. If one of the balloons is positively charged, what is the charge of the other balloon?
8. Explain why a student who planned to touch the dome of a Van de Graaff generator (shown in the photograph on page 312) might be wearing rubber-soled shoes and standing on a plastic mat.
9. A plastic spoon that has just been dried with a tea towel is placed near some pepper spilt on a kitchen bench. Some of the pepper is attracted to the spoon and sticks to it. Explain why this happens.
10. If you placed a charged pen near a whole A4 sheet of paper, would you expect the paper to rise and stick to the pen? Give a reason for your answer.
11. Draw a labelled diagram to show how a neutral stream of water from a tap is attracted to a charged plastic pen. Use the symbols + and – to represent positive and negative charge.
12. Why are you less likely to get an electric shock after walking on carpet in humid weather than in dry weather?
13. As planes move through the air, they build up large amounts of static electricity. How does this happen? Before refuelling, a wire is used to connect the plane to the ground. Why is this important?

Create

14. Devise a model, using people to represent positive and negative charges, to show how objects become positively and negatively charged. Use your model to demonstrate:
    (a) whether a neutral object contains any electric charge
    (b) what must happen to make an object:
        (i) negatively charged (ii) positively charged.

Investigate

15. Can static electricity be used to separate a mixture of salt and pepper? Try it!
16. Have you ever heard a crackling sound when you removed your clothes at night? What causes it? Which types of clothes are most likely to cause the crackling? Once you find out, try removing them in front of a mirror in total darkness and watch for the sparks.
17. Use the internet to explore the link between lightning and ozone. Does lightning increase or decrease the amount of ozone in the atmosphere?

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Complete this digital doc: Worksheet 8.2: Sticky food (doc-19843)

8.5 Scale and measurement

8.5.1 Gravity is universal

If it weren't for gravity, the moon would fly past us. The gravitational attraction between the Earth and the moon keeps the moon in orbit around the Earth.



What causes a ball to fall to the ground after you throw it? Why don't you get flung from the surface of the Earth as it spins around? What keeps the moon in orbit around the Earth and the planets in orbit around the sun? The answer to all of these is the force of gravity. Without the force of gravity, even the Earth's atmosphere would float off into space.

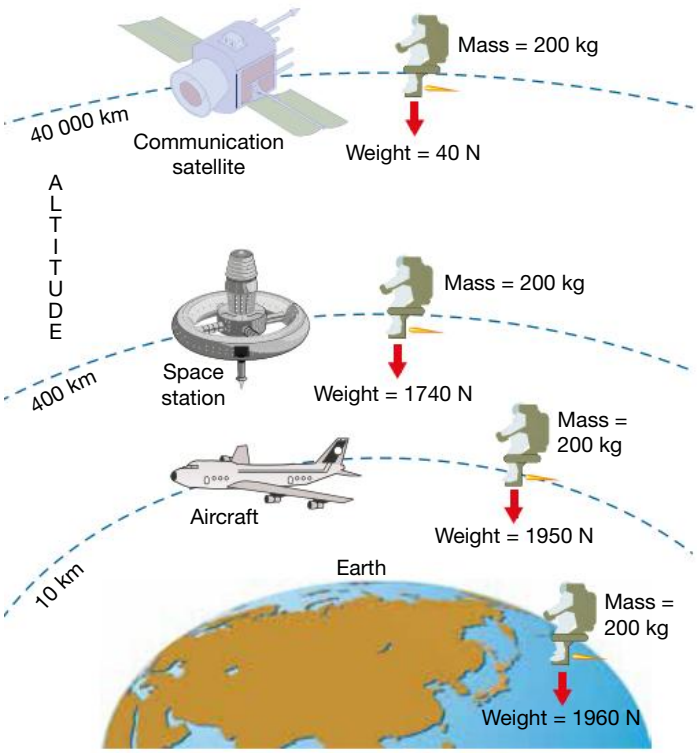
Every object in the universe pulls on other objects with a force of gravity. The force of gravity towards an object depends on its mass. **Mass** is a measure of the amount of material in an object of substance. The mass of an object is the same wherever it is in the universe. The greater the mass of an object, the greater the force of gravity is on it. And gravity is such a tiny force that, unless the object is as large as a star, planet or moon, its pull of gravity is just too small to notice or measure compared with other forces.

Weight and mass

The **weight** of an object or substance is a measure of the force of gravity pulling it down towards the centre of a large object such as a planet, moon or star.

The standard unit of force is the **newton** (N). Because weight is a force, it is measured in newtons. At the Earth's surface, the force of gravity is about 10 newtons for every kilogram of mass. So a 50-kilogram person has a weight of about 500 newtons on Earth. On Mars, however, the force of gravity is only about four newtons for every kilogram. A 50-kilogram person would have a weight of only 200 newtons on Mars.

Weight, the force of gravity on an object, decreases as it gets further from the centre of the Earth. However, the object's mass remains the same wherever it is.



HOW ABOUT THAT!

Isaac Newton (1643–1727) was an English mathematician, physicist, astronomer and philosopher. You might know him as the guy who sat under the apple tree and, after being struck on the head by a falling apple, discovered gravity. But it probably didn't happen that way. Many scientists and historians believe that Newton was looking out of the window when he saw the apple fall.

Whichever way it happened he was struck with a realisation — apples (and everything else) always fall down, not up or sideways. He wondered about the force that caused this to happen. He wondered what would happen if the tree were much taller. In fact, he was able to deduce, after much time and many calculations, that the force that caused the apple to fall was the same force (gravity) that kept the moon in orbit around the Earth. From these ideas, Newton wrote his Law of Universal Gravitation, which describes how gravity acts in all places, not just on Earth.

Newton was able to explain many observations, including falling apples, tides and orbiting planets with a single law of gravity.

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Watch this eLesson: Isaac Newton (eles-1771)

8.5.2 Measuring mass and weight

Mass is measured with a balance. The illustration on the right shows an old-fashioned measuring scale on which the mass being measured is being compared with a known mass. A two-kilogram pile of flour will balance the two standard kilogram masses no matter what the pull of gravity is.

A laboratory beam balance measures mass by balancing the object to be measured on one side with sliding masses on the other side.

Weight can be measured with a spring balance like the one shown in Investigation 8.11. The weight of the object being measured pulls down on the spring and stretches it. The spring stretches evenly and has a pointer attached to it.

The two-kilogram pile of flour will always balance the two standard kilogram weights.



INVESTIGATION 8.10

More than one force?

AIM: To investigate the effect of air resistance on a disc

Materials:
20-cent coin
scissors
paper

Method and results

- Drop a coin from about chest height.

The force of gravity on the coin (its weight) pulls it down. It speeds up until it hits the floor.

- Cut out a disc of paper about the size of a 10-cent coin. Hold the paper disc in one hand and the 20-cent coin in the other, both at chest height.
- Predict what will happen if you drop them at the same time. Test your prediction.

1. Which object landed first? Was your prediction correct?
   - Place the disc of paper on top of the coin and drop them together from waist height.
2. Which landed first when the paper disc was on top of the coin?

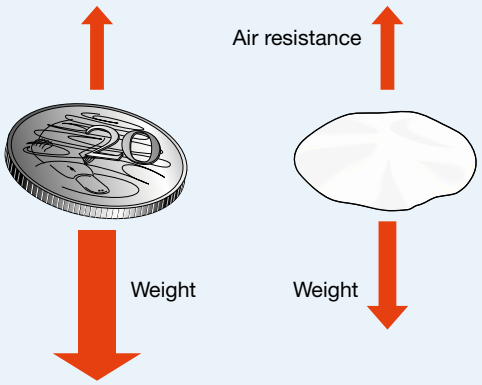
Discuss and explain

3. How many forces were acting on the coin as it fell through the air?
4. What two forces were acting on the paper disc when it was dropped on its own?
5. What was different about the forces acting on the coin?
6. When dropped together with the paper disc on top, how were the forces different from the way they are represented at right?

Drop the paper disc and coin from chest height at the same time.



The forces acting on a coin and a disc of paper as they fall separately



INVESTIGATION 8.11

Measuring weight

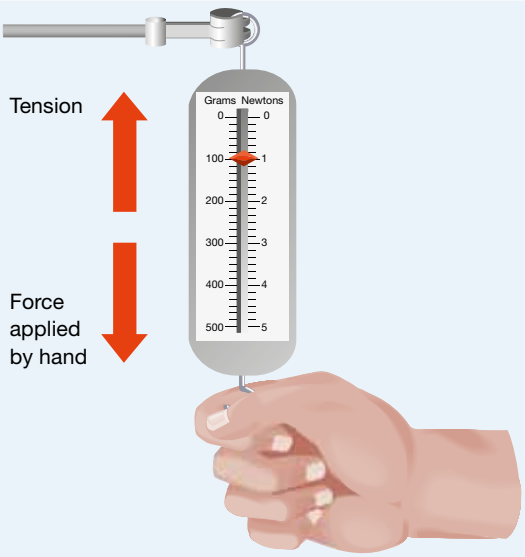
AIM: To investigate the relationship between mass and weight

Materials:
5.0 N spring balance
set of slotted 50 g masses
retort stand, bosshead and clamp

Method and results

- Pull down on the hook of a 5.0 N spring balance until it reads 1.0 N. There are two forces acting on the hook. As long as the hook is not changing its motion, the upward force of tension is the same as the downward pull of your hand.
- Pull the hook down until the spring balance reads 2.0 N. The downward pull has doubled.

A spring balance. There are two forces acting on the hook.



- What is the tension in the spring?
- What has happened to the amount that the spring has stretched?

A spring is a good force measurer because, if the pulling force on it doubles, the amount of stretch doubles. If the pulling force triples, the amount of stretch triples.

- Hang the spring balance from a rod fixed to a retort stand and adjust the pointer so that it reads zero.

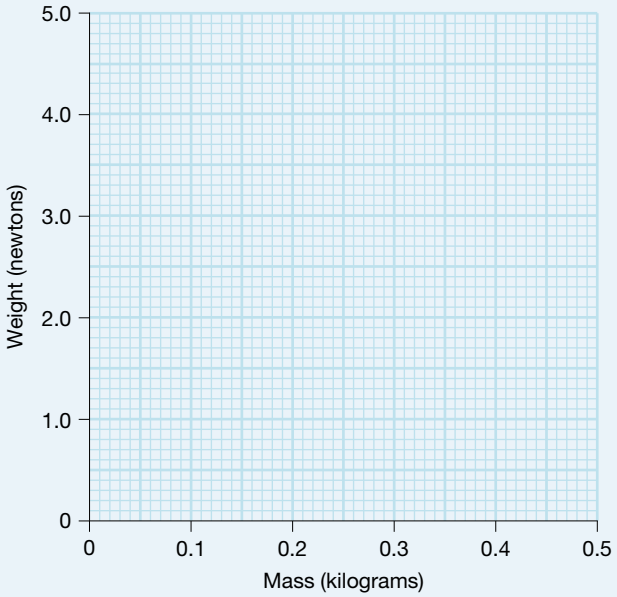
1. Attach a 50 g mass to the hook of the spring balance and record its weight in newtons by copying and completing the table below. Also calculate and record the mass in kilograms by dividing the mass in grams by 1000.
2. Add 50 g masses, one at a time, until you have a total mass of 400 g. Record the mass in kilograms and weight in newtons as you go.

Measuring weight

Mass (g)	Mass (kg)	Weight (N)
50	0.05	
100	0.10	
150	0.15	

3. Use your results to complete a copy of the graph on the right.
4. Draw a line through the points that you have plotted and continue your line to where you think it would be if you measured the weight of a mass of 500 g. This process is called extrapolation.

Graph of weight measured on a spring balance versus mass



Discuss and explain

5. Why is it better to hang the spring balance from a rod rather than hold it in your hand?
6. Does the spring increase its stretch by the same amount each time a 50 g mass is added?
7. How would your results be different if you conducted this activity on Mars?
8. Is your line straight? Should it be straight?
9. What does your graph tell you should be the weight of a 500 g mass? Measure it and see how accurate your prediction is.
10. How could you alter the scale on the spring balance so that you could read the correct mass from it directly?

8.5.3 Falling down

Imagine you are falling through the air with the skydivers on the next page. What would you feel? You would quickly realise that gravity is not the only force acting on falling objects.

The way objects fall depends on the total force acting on them, not just on the pull of gravity. Air in the atmosphere pushes against all falling objects. This push is called **air resistance**. Air resistance is an example of fluid friction.

HOW ABOUT THAT!

Skydivers reach speeds of about 200 km/h before air resistance is great enough to balance their weight. After the parachute has opened, the air resistance is much greater than the skydiver's weight, slowing him or her down to about 20 km/h.

When the paper disc is dropped together with the coin in the second part of Investigation 8.10, the coin shields it from the air that would normally push against it.

Speeding up

The air resistance on a moving object increases as the object moves faster. When cycling or running quickly, you feel the air pushing against your face even if there is no wind. When you slow down, you don't feel the same push of air against you.

There is more than one force acting on this skydiver.



INVESTIGATION 8.12

The landing time of a parachute

AIM: To investigate the effect of a variable on the landing time of a parachute

Materials:

plastic from freezer bags
scissors
large paperclips, or plasticine
stopwatch
cotton or nylon thread
metre ruler

Method and results

Your task is to find out the effect of one of the following factors on the landing time of a parachute.

(a) Mass of the skydiver
(b) Size (area) of the canopy
(c) Shape of the canopy

Use plastic from freezer bags to make the canopy. Cotton or nylon thread can be used to hold a model skydiver, which could be represented by paperclips or plasticine.

Ensure that you do each of the following:

- Keep all things constant except the factor that you are deliberately changing, so that your tests are fair. This is called controlling variables.
- Repeat your measurements of time at least three times and work out an average.

1. Draw up a table in which to record your results. An example is provided below.

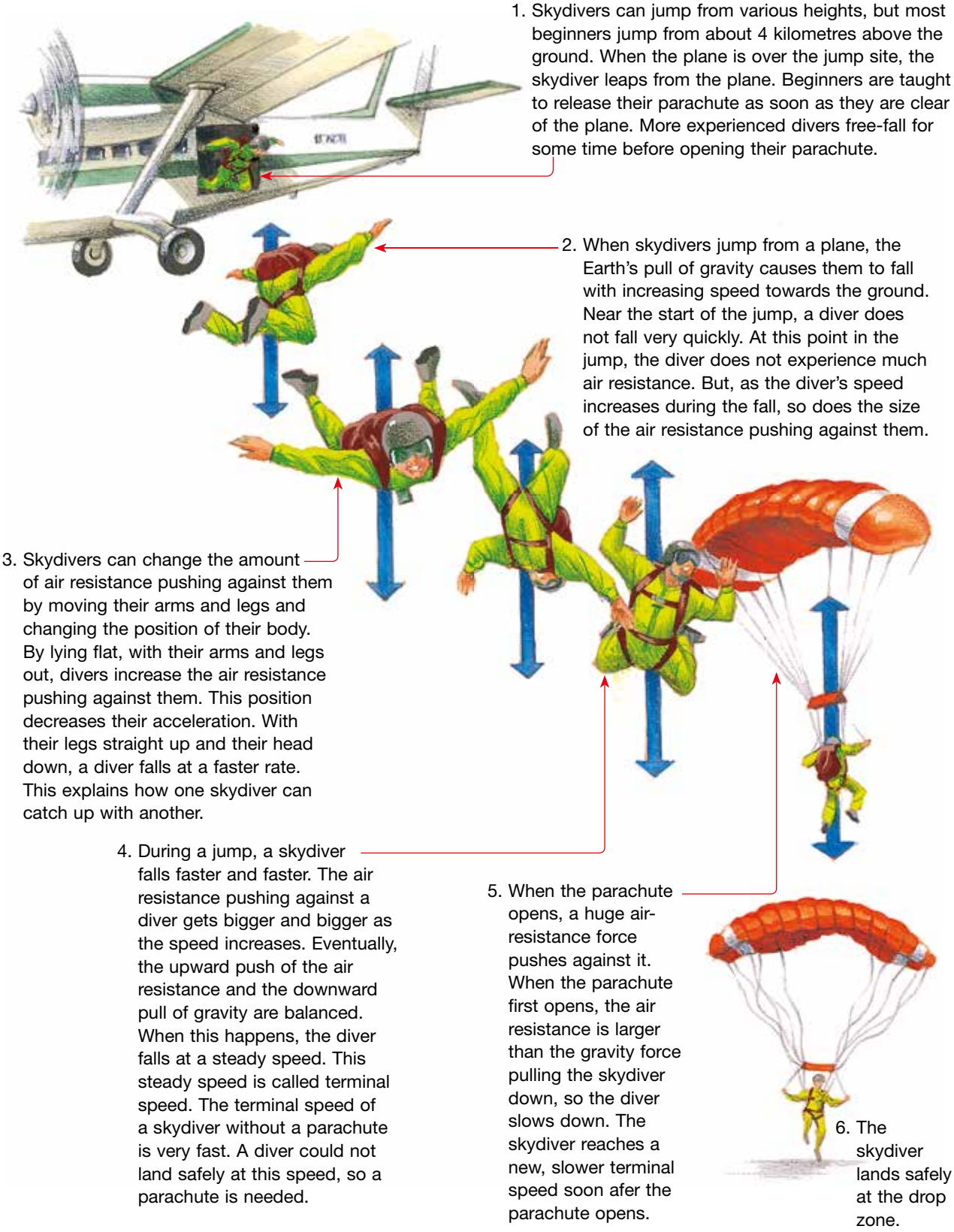
	Time taken to fall (seconds)			
Area of canopy (square centimetres)	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
24 × 24 = 576				
21 × 21 = 441				
18 × 18 = 324				
15 × 15 = 225				
12 × 12 = 144				

Discuss and explain

2. Write a report of your investigation using these headings.
   - Aim
   - Materials
   - Method
   - Results
   - Discussion
   - Conclusion
3. In your discussion, you should evaluate your results and comment on how your design could be improved.
4. As an extra challenge after the investigation has been completed, see who can make the parachute that takes longest to reach the floor with a standard load of five paperclips from a height of two metres.

8.5.4 Forces involved in skydiving

There is something about falling through the air at 190 km/h that really gets the adrenalin pumping! Skydiving is an activity that is enjoyed by thousands of thrill seekers around the world and is an important part of military and rescue services.



1. Skydivers can jump from various heights, but most beginners jump from about 4 kilometres above the ground. When the plane is over the jump site, the skydiver leaps from the plane. Beginners are taught to release their parachute as soon as they are clear of the plane. More experienced divers free-fall for some time before opening their parachute.

2. When skydivers jump from a plane, the Earth's pull of gravity causes them to fall with increasing speed towards the ground. Near the start of the jump, a diver does not fall very quickly. At this point in the jump, the diver does not experience much air resistance. But, as the diver's speed increases during the fall, so does the size of the air resistance pushing against them.

3. Skydivers can change the amount of air resistance pushing against them by moving their arms and legs and changing the position of their body. By lying flat, with their arms and legs out, divers increase the air resistance pushing against them. This position decreases their acceleration. With their legs straight up and their head down, a diver falls at a faster rate. This explains how one skydiver can catch up with another.

4. During a jump, a skydiver falls faster and faster. The air resistance pushing against a diver gets bigger and bigger as the speed increases. Eventually, the upward push of the air resistance and the downward pull of gravity are balanced. When this happens, the diver falls at a steady speed. This steady speed is called terminal speed. The terminal speed of a skydiver without a parachute is very fast. A diver could not land safely at this speed, so a parachute is needed.

5. When the parachute opens, a huge air-resistance force pushes against it. When the parachute first opens, the air resistance is larger than the gravity force pulling the skydiver down, so the diver slows down. The skydiver reaches a new, slower terminal speed soon afer the parachute opens.

6. The skydiver lands safely at the drop zone.

Terminal speed

When an object starts to fall, it moves slowly. There is not much air resistance. As the object speeds up, the air resistance increases. If the object travels fast enough, the air resistance can become as great as the force of gravity on the object. Once the air resistance balances the force of gravity, the object stops speeding up. It has reached its **terminal speed**. It won't fall any faster.

WHAT DOES IT MEAN?

The word *terminal* comes from the Latin word *terminalis*, meaning 'end' or 'limit'.

8.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Explain the difference between mass and weight.
2. What is the standard unit of:
   (a) mass
   (b) weight?
3. The force of gravity is not the same on all objects. On what property of each object does it depend?
4. What is the weight on Earth of a person with a mass of 50 kilograms?
5. What force keeps the moon in orbit around the Earth?
6. If you were to land on Mars, what would change: your mass, your weight or both?
7. What two forces act on all falling objects in the Earth's atmosphere?
8. What happens to the air resistance acting on a falling skydiver if he or she speeds up?
9. Explain the meaning of terminal speed.
10. In what way is the moon's orbit around Earth the same as a falling apple?

Think

11. If every object pulls on other objects with a force of gravity, explain why you don't attract the objects around you.
12. Would you expect your weight to be more on Mars, which has about one-tenth of the mass of the Earth, or the moon, which has about one-hundredth of the mass of the Earth? Explain your answer.
13. On Earth, Belinda has a weight of 450 newtons. What is her mass?
14. If astronauts going to Mars have to take a device to measure out food, would you recommend that they take a beam balance or kitchen scales with a spring inside? Give a reason for your answer.
15. When you drop a nail and a feather from the same height, they reach the ground at different times. Explain, with the aid of a diagram, why this is the case.
16. When riding a roller-coaster on a still day, your hair blows around quite a bit. Why does this happen even though there is no wind?
17. A falling table-tennis ball reaches its terminal speed quite quickly. A falling golf ball takes a long time to reach its terminal speed. Why?
18. Would a table-tennis ball reach a terminal speed on the moon? Explain your answer.
19. What three forces are acting on the bungee jumper on the opening page of this chapter just before reaching the water? Which force (hopefully!) is the largest?

Explore

20. Would a rubber band be as effective as a spring in a force measurer? Design and conduct an experiment to find out. You will need to construct a table and a graph.

Investigate

21. Find out more about the contributions to science made by Sir Isaac Newton. Write a brief report about his achievements other than his Law of Universal Gravitation.

Imagine

22. Imagine that you are working in the first space laboratory on Mars. The pull of gravity is a little more than one-third of what it is on Earth. Write a diary entry for your very first working day in the laboratory. Your diary entry should be an account of your day from 6 am when your alarm rings until 10 pm when you go to bed. Emphasise the effects of less gravity and don't forget that you need to keep physically fit.

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Complete this digital doc: Worksheet 8.3: Moon Olympics (doc-19844)

Complete this digital doc: Worksheet 8.4: Gravity (doc-19845)

8.6 Friction — friend or foe?

Science as a human endeavour

8.6.1 The need for friction

Friction is the force applied to the surface of an object when it moves against the surface of another object.

Friction can slow down an object, stop it from moving or start it moving. The skater in the photograph at right could not start moving without friction. She starts rolling by pushing her foot backwards against the path. Imagine what would happen if the path was covered in smooth ice. There would not be enough friction to get her moving forwards. But if the skater is just peacefully rolling forwards, the friction applied to the wheels by the path will slow her down and eventually stop her.



HOW ABOUT THAT!

Crickets use friction to make their familiar chirping sound. The sound is made by friction as they rub the back of the left forewing against a row of teeth on the right forewing.

8.6.2 Getting a grip on things

You need friction to do many things. Even walking requires friction. If you have ever slipped on a banana peel or wet floor tiles you'll know why.

When you walk, you push your foot backwards against the ground so that the ground pushes you forward. Without friction your foot would slip backwards as it does on a banana peel. This type of friction, used to assist movement, is called **traction**.

Even holding objects in your hand requires friction. Have you ever dropped wet soap in the shower or bath? Wet hands and soap provide little grip.

The force of friction is especially important to cars. On a level road, the friction applied by the road when the wheels turn is needed to start a car moving. This friction is another example of traction. Without this friction, the wheels would spin and the car wouldn't start moving. Without friction, cars would not be able to turn corners or stop. The decrease in friction on wet or icy roads makes it very difficult to steer and stop a car.

Smooth running

Although friction is necessary for movement and control of movement of people and vehicles on a surface, it can also be a nuisance. Pushing objects across rough surfaces can be very difficult. You have to push it with a force larger than the friction force acting on it. And the heavier the object is, the greater the friction force.

Objects can travel faster if they are smooth. Skis and surfboards are waxed and buffed to reduce friction and make them go faster through snow or water.

INVESTIGATION 8.13

Measuring friction

AIM: To investigate the force of friction applied (a) by different surfaces to an object and (b) by one surface on different masses

Materials:

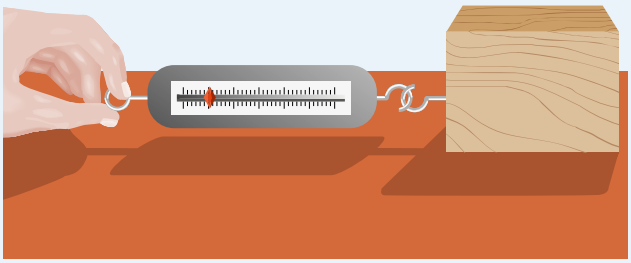
block of wood with hook attached
several identical blocks of wood
spring balance

Method and results

- Copy the table below into your workbook.
- Use a spring balance to pull a block of wood across your desktop. As long as you pull steadily, the reading on the spring balance will be equal to the force of friction on the moving block.

1. Record your reading in the table.
   - Repeat your measurement two more times on the desktop and calculate the average force of friction.
2. Record all data in the table.
   - Repeat this procedure on several other surfaces. Surfaces that you might test are vinyl floor, carpet, doormat, concrete and bitumen.

A spring balance is used to pull a block of wood across a surface.



Friction on different surfaces

Surface	Force of friction (newtons) Trial 1	2	3	Average

3. Summarise your results in a bar or column graph.
4. Design and carry out an experiment to find out the effect of mass on the size of the friction force. Record your results in a table and display them in a line graph.

Discuss and explain

5. List the surfaces in order, from greatest friction force to least.
6. What feature of a surface seems to determine the amount of friction?
7. Why was it a good idea to repeat each measurement three times?
8. Do heavier objects experience more friction?

The smoother the surface on which a vehicle moves, the faster it can go once it gets started. Road surfaces need to be smooth so that vehicles do not waste fuel in overcoming too much friction. However, they need to be rough enough to allow vehicles to turn and brake safely in all types of weather.

A heavy box on a rough surface is very difficult to move.



Olympic bobsled teams spend long hours smoothing and polishing the runners of their sleds.



Trains and trams run on steel tracks because they produce very little friction. That makes them cheaper to run than vehicles that move on rough surfaces. Imagine how powerful a bus would need to be to carry the same load as a long freight train!

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Watch this eLesson: Friction as a driving force (eles-0032)

8.6.3 Just rolling around

Ball-bearings are often used to reduce the friction on wheels as they spin around an axle. The ball-bearings act as wheels, allowing the outside ring to 'roll' around the inside ring without sliding. (Rolling friction is much less than sliding friction. Try rolling and sliding an object.) The ball-bearings enable the wheels to turn faster, and reduce wear and tear as they lessen the amount of contact between the surfaces.

8.6.4 What causes friction?

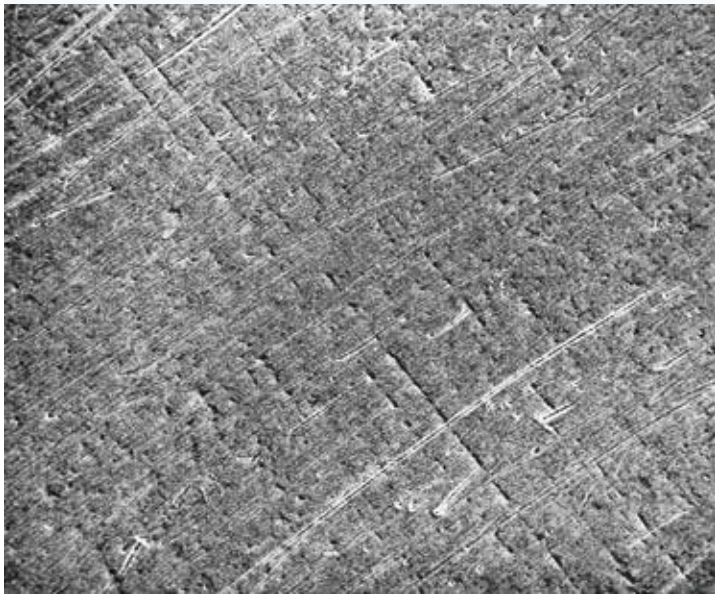
Even very smooth surfaces are rough when you look at them under a very powerful microscope. The photograph on the next page shows a smooth, polished metal surface magnified 300 times. At that magnification, you can see that the surface is actually covered in scratches, making it rough. It is this roughness that causes friction.

8.6.5 Slippery stuff

What makes a door squeak? A squeaky door can be silenced with a few drops of oil. The oil reduces the friction within the hinge. Substances like oil, grease and petroleum are called **lubricants**. They reduce the force of friction produced by the rubbing of solid surfaces. Your joints contain a lubricant called synovial fluid to help stop bones from scraping against each other.

Lubricants are needed in machines where wear and tear, heat and noise result from surfaces rubbing against each other. Oil and grease are used to lubricate wheel bearings on skateboards, rollerblades and bicycles.

This is a close-up of a ‘smooth’, polished surface.



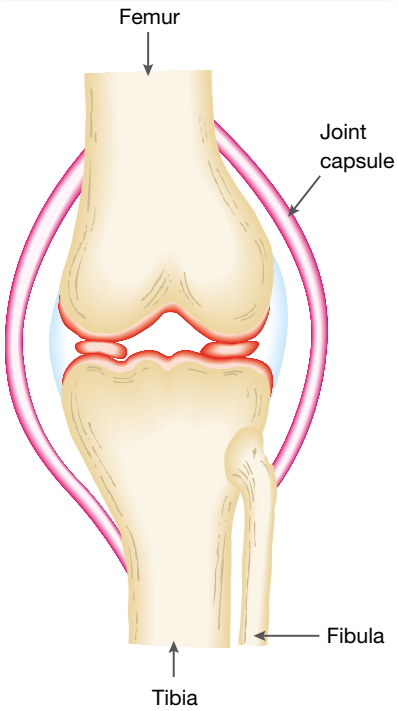
Ball-bearings reduce friction between the axle and wheel hub of a skateboard.



8.6.6 Friction in fluids

Any substance that is able to take up the shape of its container and can flow is called a **fluid**. Air and water are both fluids. Objects travelling through air and water experience fluid friction. Like rolling friction and sliding friction, fluid friction acts against the motion of objects. Fluid friction limits the speed of objects travelling through air and water. It increases the amount of fuel needed by cars, planes, motorised boats and submarines.

Synovial fluid lubricates joints, like this one in the knee, and so reduces friction.



WHAT DOES IT MEAN?

The word *lubricant* comes from the Latin word *lubricus*, meaning ‘slippery’.

A racing cyclist’s helmet, clothing and bicycle are all designed to reduce fluid friction.



Cars, planes, watercraft and bicycles are **streamlined** to reduce fluid friction. The faster a vehicle needs to travel, the more important streamlining becomes. Some athletes even shave their bodies to streamline them.

Sports scientists at the Australian Institute of Sport and universities throughout the world are constantly searching for ways to reduce friction so that swimmers, short-distance runners and cyclists can move faster through fluids. Tight-fitting and smooth materials such as Lycra® reduce fluid friction through water and air. The design of bicycle helmets is always changing as scientists and engineers find new shapes and materials that reduce fluid friction.

8.6.7 Returning to Earth

When astronauts, scientists and other crew members of the International Space Station return to Earth, the greatest danger they face is re-entry into the Earth's atmosphere. Until July 2011, crew members returned on board a NASA space shuttle. Since then they have returned aboard a much smaller and differently shaped Russian *Soyuz* capsule. After travelling through space with almost no friction, both re-entry craft enter the upper atmosphere at speeds above 25 000 km/h. Because they are travelling so fast, the force of fluid friction is huge, causing temperatures on the outside of the craft to reach more than 1500 °C, enough to make them glow red hot.

The surfaces of the NASA space shuttles were covered with thousands of ceramic tiles to protect the crew. The *Soyuz* capsule has a heat shield and a surface covered with ceramic sheets. As the space shuttles slowed down, they zigzagged through the lower atmosphere, cooling down and getting into the correct landing path. It landed like a plane at speeds of about 300 km/h. The *Soyuz* capsules jettison the heat shield on entering the lower atmosphere and are guided down by a system of parachutes. The capsule falls to the ground on the plains of Kazakhstan at about 5 km/h and its crew is assisted out of the capsule by a ground recovery team.

A recovery team locates the *Soyuz* capsule after a safe landing.



HOW ABOUT THAT!

The dangers of the high friction re-entry of spacecraft into the atmosphere were highlighted in 2003 when the space shuttle *Columbia* broke up 16 minutes before it was due to land. All seven crew members were killed. This tragedy is believed to have been caused by minor damage done to some of the ceramic tiles on the shuttle's surface during launch. This left a very small part of the surface unprotected from the high temperatures caused by friction. The resulting fire quickly reached *Columbia*'s fuel tanks, causing a huge explosion.

Damage to *Columbia's* ceramic tiles was believed to have caused it to overheat and explode on re-entry in a tragic incident in 2003.



INVESTIGATION 8.14

Investigating the friction of shoes

AIM: To compare the friction of a variety of shoes on a floor surface

Method and results

- Design an experiment to compare the friction of a variety of shoes and a particular floor surface.
- Collect a variety of shoes to test. Include different types of school shoes and runners.
- Identify the equipment you will need to measure the friction that exists between each shoe and a particular floor surface.
- Collect information about each shoe to be tested, such as length, mass, sole material and tread shape.
- Form testable hypotheses about each variable that you decide to investigate.

1. Write up the method used in your investigation using a scientific report format.
2. Record your results in a suitable table.

Discuss and explain

3. Write a suitable conclusion to your experiment.
4. Identify the variables that you controlled and the variables that you would have liked to control but could not.

8.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is the force of friction?
2. Why is friction important when you walk?
3. Friction can cause objects to slow down. What else can it do?
4. How is traction different from other types of friction?
5. List three ways in which friction can be reduced. Give an example of each method.
6. What is fluid friction? List some examples of fluid friction.
7. What is streamlining?

Think

8. What type of road surface would be safest in wet conditions? Explain your answer.
9. For each of the 'friendly friction' sketches on the right, state:
   (a) how the friction force is being helpful
   (b) what would happen if the friction force was absent.
10. For each of the 'unfriendly friction' sketches on the right, state:
    (a) how the friction force is being a nuisance
    (b) what could be done to reduce the effect of the force of friction.
11. Because trains and trams run on steel tracks, the friction force that opposes their motion is quite small. What major disadvantage does this have?
12. Motorists are advised that they will waste fuel if their tyres are under-inflated. Why is this so?
13. How is friction between the moving parts of a car engine reduced?
14. Olympic swimmers wear smooth, tight-fitting suits, streamlining their bodies to reduce friction. Some of them even shave their heads.
    (a) Do you think that shaving heads or legs could give athletes an advantage? Why?
    (b) In which other sports do athletes shave parts of their bodies or wear clothing that reduces fluid friction?

Friendly friction



Unfriendly friction



Swimmers streamline their bodies to reduce friction.



Imagine

15. Write and present as a play an account of a discussion between seven astronauts aboard the space shuttle as it leaves orbit, re-enters the atmosphere and lands. The re-entry is not as smooth as it should be and the temperature inside becomes dangerously hot. Be creative and dramatic but the play must end with a successful touchdown on Earth.
16. Imagine a world without friction. Form a group of three or four and, together, make a list of things that would be:
    (a) easier to do
    (b) harder to do.

Investigate

17. Research and report on each of the following questions about car tyres.
    (a) Why do tyres have tread?
    (b) Are wider tyres better than narrow ones? Why?
    (c) How does it affect your driving when the tread is worn away and the tyres are 'bald'?
    (d) How does tread make wet weather driving safer?

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Complete this digital doc: Worksheet 8.5: Friction (doc-19846)

8.7 Keeping afloat

8.7.1 Buoyancy

The largest cruise ship in the world, *Allure of the Seas*, has a mass of about 225 million kilograms. The downward pull of gravity on this giant of the sea, its weight, is huge — over 2 billion newtons. Why doesn't it sink?

There must be an upward force equal to its weight. That upward force is provided by the water it is floating on. It's called **buoyancy**.

Buoyancy is the upward push on an object that is floating on top of or submerged in a fluid. It acts in all liquids and gases. It is the force that keeps helium-filled balloons floating in the air. It is also the force that allows submarines to rise to the surface of the ocean.

The force of buoyancy pushes upwards to keep this huge cruise ship afloat.



HOW ABOUT THAT!

The buoyancy force of the water in the Dead Sea is so large you can lie back and read a book. The unusual size of the force is caused by the large amount of salt in the water.



If the buoyancy force is greater than the weight of the balloons, they will rise into the air if the girl lets go. If the buoyancy force is greater than the weight of the girl and the balloons, they will take the girl with them.



8.7.2 Surface tension

In Investigation 8.1, the water appears to be held onto the coin by a skin. There is, in fact, no skin. The water is held in shape by **surface tension**. Surface tension is the pulling of particles in a liquid towards each other. Soaps and detergents reduce the surface tension of water.

Walking on water

The water spider can walk on water. Water spiders are certainly light, but is that the only reason that they do not sink?

Surface tension is what keeps the water spider from sinking and drowning. The small weight of the water spider is well spread out over the surface and is not large enough to push the water particles apart.

The water spider walks on water. Why can't you?



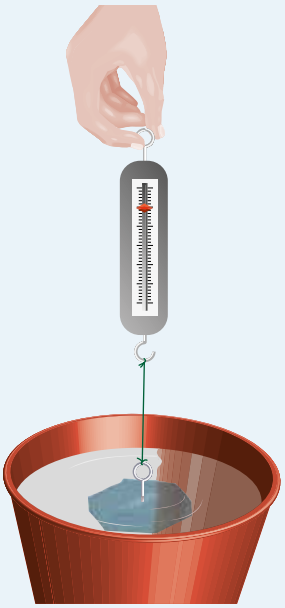
INVESTIGATION 8.15

Are things really lighter in water?

AIM: To measure buoyancy and its effect on the apparent weight of an object

Materials:

stone
length of string
spring balance
bucket
500-gram mass



Method and results

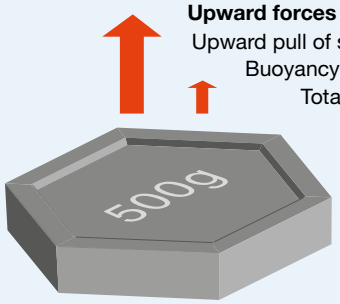
- Tie some string around a large stone. Suspend the stone in a bucket of water without letting it touch the bottom.
- Use a spring balance to find the weight, in newtons, of a 500 g mass and record it. Without removing the mass from the spring balance, carefully lower it into the bucket so that it sits just under the surface of the water.

1. Record the force measured by the spring balance.

Discuss and explain

2. Does the stone feel any lighter when it is in the water? Why?
3. Use the following diagram to work out the size of the buoyancy force on the 500 g mass.
4. Is the 500 g mass really lighter? Explain.

The total force on the mass is zero while it is sitting still under the surface. That means that the total upward force must be equal to the total downward force.



Upward forces

Upward pull of spring balance = _____ N
Buoyancy force of water = _____ N
Total upward force = _____ N

Downward forces

Weight of 500 g mass = _____ N
Total downward force = _____ N

8.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Name two forces acting on you when you float on your back in a swimming pool.
2. What force keeps a water spider on the surface of water?
3. Explain the difference between buoyancy and surface tension.

Think

4. Which fluid produces the greater buoyancy force — air or water? How do you know?
5. Name the three forces acting on a water spider when it is standing on a still pond.
6. What happens to an object when you plunge it into a fluid and let go:
   (a) if the buoyancy force is the same as its weight
   (b) if the buoyancy force is less than its weight?
7. Explain in terms of gravity, buoyancy and surface tension why humans can't walk on water.

Investigate

8. Different fluids produce different buoyancy forces. Drop a corn kernel or pea into a glass of water and another into a glass of soda water. Which liquid applies the larger buoyancy force? Try to explain why.
9. Design and carry out an experiment to compare the buoyancy and surface tension of water, olive oil and vinegar.
10. Find out what capillary action is and how it works.
11. Cut a slit in the end of a match and gently open it up a little. Float the match in a bowl of water. Carefully place a drop of dishwashing detergent in the split end of the match and watch what happens. Try to explain your observations.



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Try out this interactivity: Density (int-0221)

Complete this digital doc: Worksheets 8.6: Buoyancy (doc-19847)

Complete this digital doc: Worksheet 8.7: Deep diving danger (doc-19848)

8.8 Staying safe

Science as a human endeavour

8.8.1 Safer cycling

Every year in Australia, about 1200 people die as a result of road accidents. Many of the deaths and injuries can be avoided.

Bicycle riders account for well over one-third of road accident injuries in the 10–14-year-old age group. The most serious injuries tend to be to the head and face. The wearing of bicycle helmets has greatly decreased the number of head injuries to cyclists.

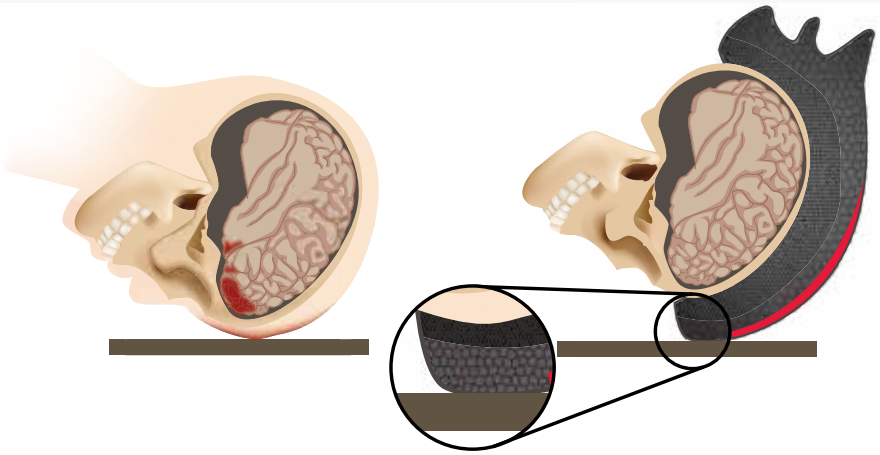
A bicycle helmet has a layer of polystyrene foam at least one centimetre thick inside a shell of hard plastic. A cyclist's head falling to the road hits the ground at speeds of up to 20 kilometres per hour. Without a helmet, the head stops suddenly when it hits the ground. The sudden impact can cause serious head injuries. With a helmet, the head stops more slowly as the plastic shell and polystyrene foam are crushed. The injuries are less severe.

Cycling isn't the only sport where you need a helmet. Other activities in which helmets soften the impact of a fall or collision include motorcycling, horse riding and a wide range of other sporting activities.

A bicycle helmet is required by law.



The plastic shell and polystyrene foam of a helmet soften the impact on the head in an accident.



8.8.2 Safety on four wheels

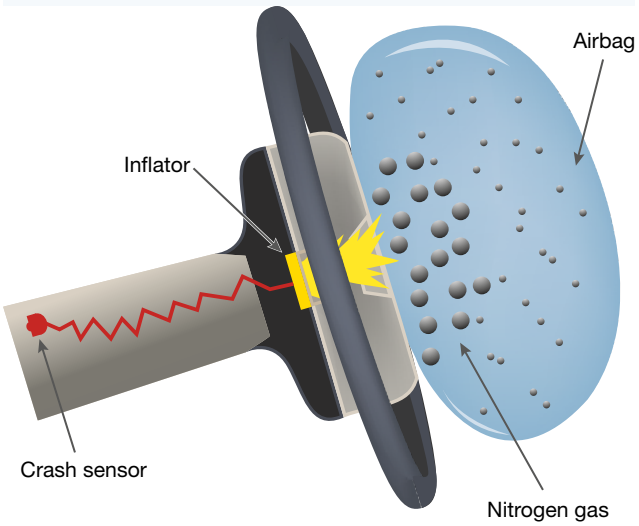
In cars and other motor vehicles, padded dashboards, collapsible steering wheels and airbags reduce injuries by allowing the upper body to slow down more gradually when a car crashes.

Airbags

Airbags inflate when a sensor behind them detects the sudden change in speed or direction that results from a collision.



Deployment of an airbag



8.8.3 Belt up

When a car collides head on with an obstacle or another vehicle, the occupants continue to move forwards after the car stops. In fact, they continue to move forwards with the same speed and direction that the car had before the collision until they are stopped by a force. Without seatbelts the occupants would fly forwards through the windscreen, or their bodies would be stopped suddenly by the steering wheel, dashboard, roof or other parts of the inside of the car. Most deaths and injuries in car accidents are caused by a collision between the occupants and the inside of the car. With properly fitted seatbelts, car occupants stop as the car stops and are less likely to be killed or injured.

Your body is not the only thing that will keep moving once the car stops as a result of a collision. Any loose objects in the car will continue to move after the car stops. You should therefore never leave any loose objects in the car. They are much safer in the boot! In one accident a driver was killed by a paperback novel that was sitting on the shelf behind the back seat. It continued to move after the car and driver (with properly fitted seatbelt) stopped. A corner of the book struck the driver in the back of the head, killing her instantly. Unrestrained pets are also dangerous in a collision.

It's best to bend your knees when landing after a high leap.



8.8.4 Bend your knees

In some sports, like basketball and volleyball, you need to jump high above the ground. But, of course, what goes up, must come down. When you land on the ground, you stop because the surface provides a large upward force. If you land on your feet with your legs straight and rigid, you stop very quickly, even with shoes that cushion. The upward force on your legs is large enough to cause damage. However, if you bend your knees as you land, you stop more slowly and the upward force is less.

INVESTIGATION 8.16

Egghead

AIM: To model a bicycle helmet to observe its effect during a collision

Materials:

hard-boiled egg
selection of packing materials, such as bubble wrap, foam rubber and newspaper
sticky tape
cardboard
wire

Method and results

- Design, build and test a container that will hold a hard-boiled egg. Your aim is to create an egg container that will prevent the shell from cracking when it is dropped from a height of 1.5 metres onto a hard floor.

You are actually creating a model of a bicycle accident. The egg represents the head of a cyclist. Your container represents the helmet.

Discuss and explain

1. Draw a neat, labelled diagram of your egg container.
2. What features of your container were included to protect the shell from cracking?
3. If your 'egg head' was 'injured', suggest how you could improve the effectiveness of your container.

INVESTIGATION 8.17

Crash test dummy

AIM: To model the effect on a crash test dummy

Materials:

pencil sharpener or eraser
toy car
rubber band
block of wood
clamp

Method and results

- Clamp a wooden block to the end of a table.
- Place the pencil sharpener or eraser on the toy car to represent an occupant. Push the toy car towards the wooden block as fast as you can without your 'crash test dummy' falling off. Observe the motion of the crash test dummy after the car collides with the wooden block.
- Modify this experiment to include 'seatbelts' (by using a rubber band).

1. Describe the motion of both the car and the crash test dummy after the collision without the 'seatbelt.'
2. What difference does the rubber band make to the motion of the crash test dummy during and after the collision?

8.8 Exercises: Understanding and Inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. How do bicycle helmets protect the head in an accident?
2. Describe the likely motion of an unrestrained rear seat passenger in a car that collides with a tree at 60 kilometres per hour.
3. Explain how seatbelts decrease the chance of injury or death during a road accident.

Think

4. Bicycle helmets were made compulsory in Victoria on 1 July 1990. Why do you think it was necessary to make a law to force people to wear them?
5. When a stationary car is hit from the rear by another vehicle, it is pushed forwards rapidly. Describe the likely motion of a front seat passenger:
   (a) with a head restraint fitted to the seat
   (b) without a head restraint fitted to the seat.
6. List as many sports as you can in which helmets are worn to protect participants from head injuries.

Create

7. Design a poster with the title 'Don't be an egghead. Wear a helmet'.

Investigate

8. Find out the meaning of the word 'inertia'.
9. Use the internet to research and report on the following questions.
   (a) What evidence is there that the compulsory wearing of bicycle helmets in Australia has saved lives and prevented critical brain injuries?
   (b) Not everybody believes that the wearing of bicycle helmets should be compulsory. Use a two-column table to list the reasons for and against the compulsory wearing of helmets.
10. Find out who Sir Isaac Newton was. What is Newton's First Law of Motion and how is it relevant to seatbelts in cars?

8.9 Cluster maps and single bubble maps

8.9.1 Cluster maps and single bubble maps

1. Think of a topic and write it in the middle of a sheet of paper.
2. Around your topic, write down any ideas that link with it. Draw lines from the ideas to your topic.
3. Write down new ideas that are related to your first ideas, and link them with lines.

How can I develop a particular idea?

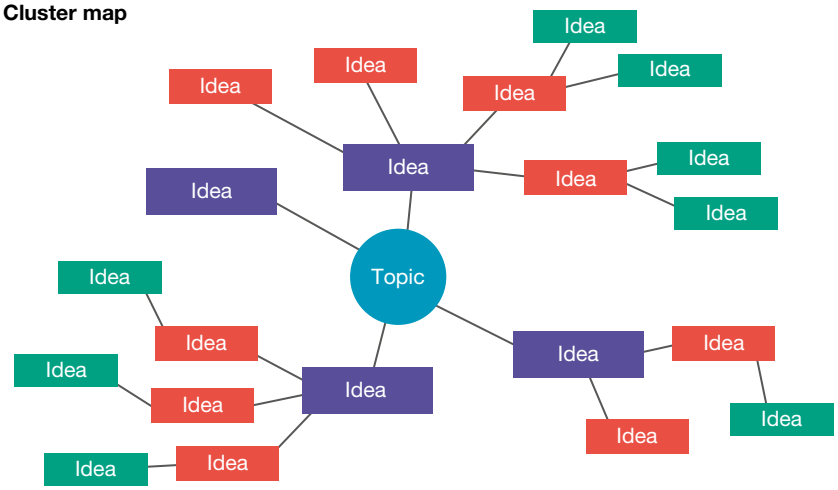
how to ...?

question

To stimulate the generation of new ideas

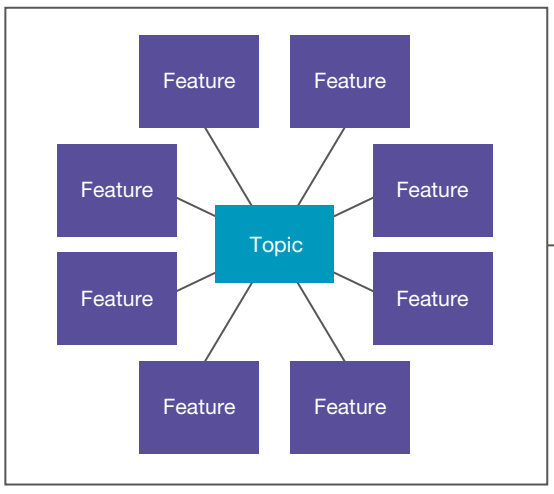
why use?

Cluster map



also called

Mumbles; brainstorm map; spider diagram



comparison

Single bubble map

example

Similarity

Both have links around a central topic.

Difference

Single bubble maps have only one level from the centre while cluster maps can have numerous levels.

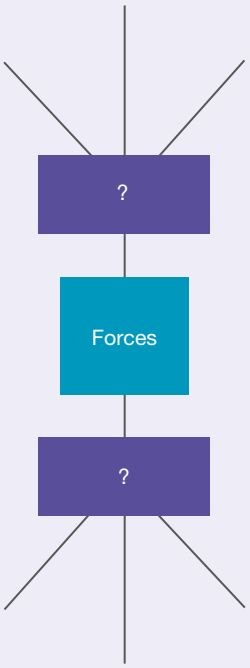
8.9 Exercises: Understanding and inquiring

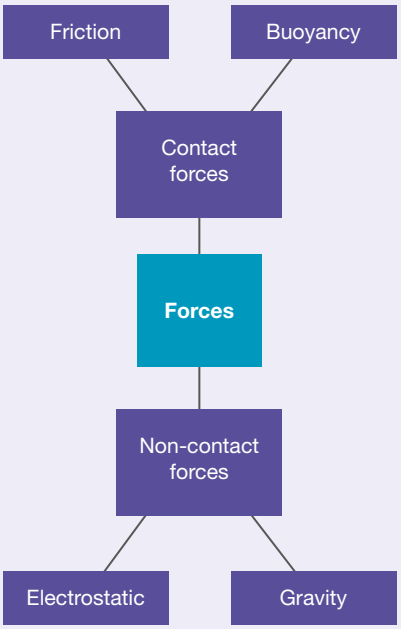
To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Think and create

1. (a) Copy and complete the cluster map on the far right to show the links between the types of forces described in this chapter. Add as many links as you can to the map. Don't forget that you can sometimes make links between the different 'arms' of your cluster map.

   (b) Suggest a different way of dividing the six forces into two groups and draw a new cluster map starting with these two groups branching from the title. Use the cluster map at right as a starting point.





2. A single bubble map like the one below right can be used to make it easier to draw a cluster map. This simple bubble map shows the six types of forces.

   When they are displayed in a bubble map, the links between them are sometimes easier to see. In this case, the bubble map can help you see that the six forces fall into two groups — contact forces and non-contact forces.

   Create a single bubble map for each of the following forces.

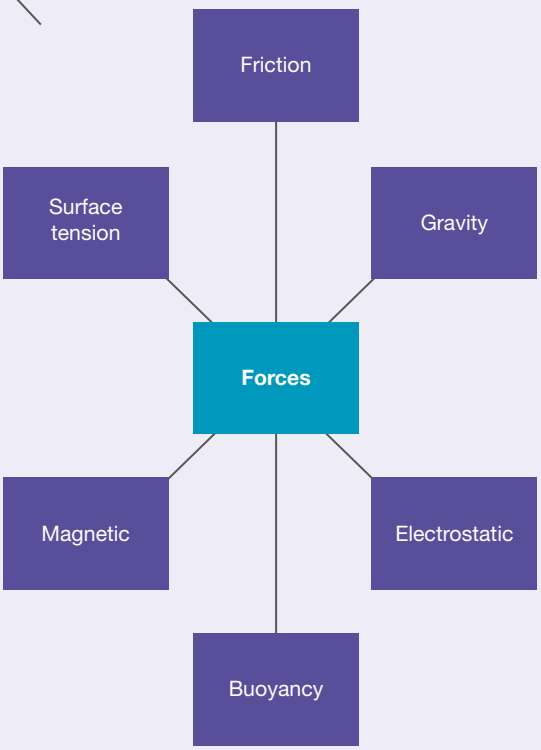
   (a) Gravity
   (b) Magnetism
   (c) Friction

   Before you create each map, brainstorm in a small group to make a list of words associated with the force. For example, your 'gravity' list might include words such as fall, weight, pull, down and non-contact.

3. (a) Draw a single bubble map with the title 'What forces can do'.

   (b) In pairs, compare your bubble maps and draw a new one that combines your ideas.

   (c) Form teams of 4 or 6. Again, compare your bubble maps and draw a single bubble map for the team on a large sheet of paper. Use the detail of the team's single bubble map to construct a cluster map for your team on a large sheet of paper.



8.10 Review

8.10.1 Study checklist

Forces and their effects

- identify and describe the changes in motion caused by forces
- distinguish between contact and non-contact forces
- represent the forces acting on an object in a diagram
- recognise situations in which the forces acting on an object balance each other out

Magnetism

- distinguish between magnetic and non-magnetic substances
- describe the forces between magnets and between magnets and other objects
- represent the magnetic field in the region of magnets and around the Earth
- use a compass to determine the direction of a magnetic field
- explain how an electromagnet works
- identify some of the uses of electromagnets

Electric forces

- explain how objects become charged
- describe the forces between charged objects and between charged and uncharged objects
- relate natural events such as lightning and electrostatic shocks to the build up of electric charge
- outline some uses of static electricity

Gravity

- distinguish between weight and mass
- investigate falling objects and relate their motion to gravity and air resistance

Contact forces

- describe friction as a force that opposes motion
- identify situations in which friction is useful and others in which friction is a nuisance
- distinguish between buoyancy and surface tension

Science as a human endeavour

- describe some of the work done by sports scientists to improve the performance of athletes, swimmers and cyclists by reducing friction
- explain how the effects of friction make the re-entry of spacecraft into the Earth's atmosphere dangerous and how these effects are controlled
- relate the importance of wearing bicycle helmets and seatbelts to the effect of forces on motion

Individual pathways

ACTIVITY 8.1
Investigating forces
doc-6063

ACTIVITY 8.2
Analysing forces
doc-6064

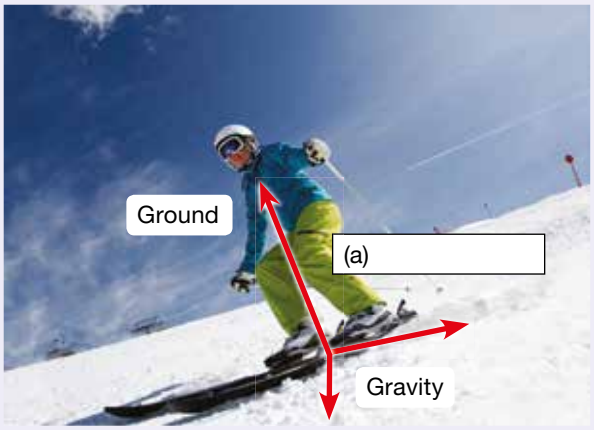
ACTIVITY 8.3
Investigating forces further
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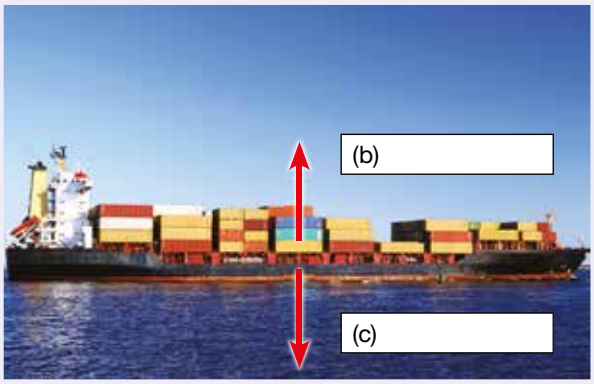
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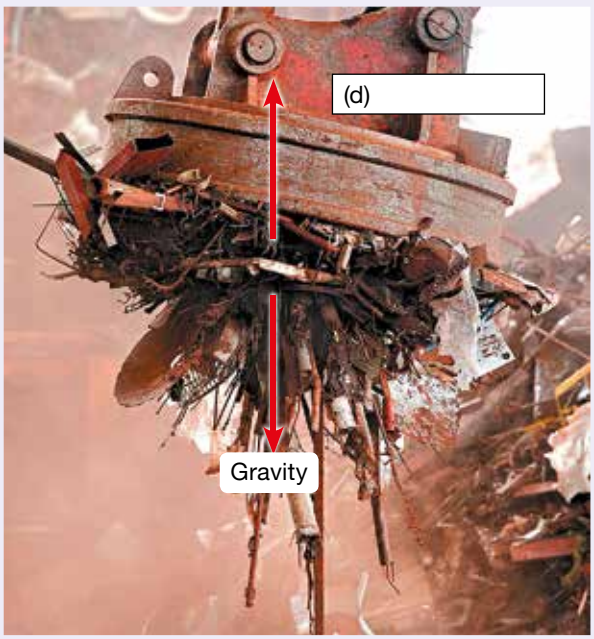
8.10 Review 1: Looking back

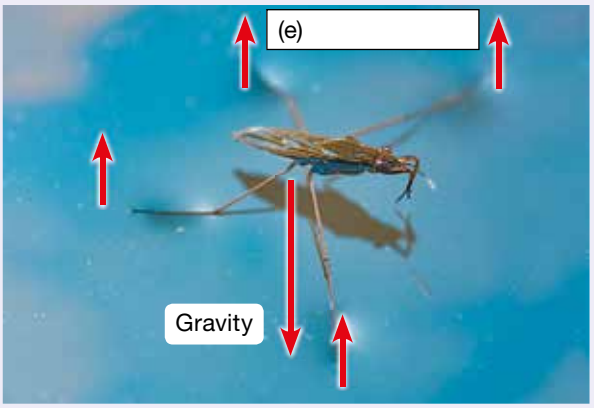
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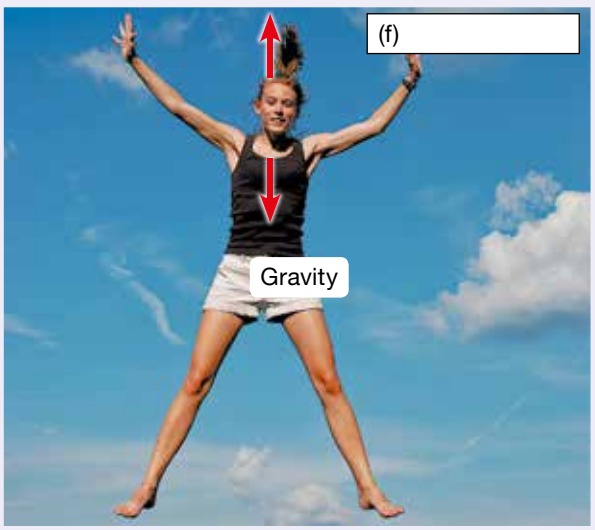
1. Identify the forces missing in each of the diagrams.





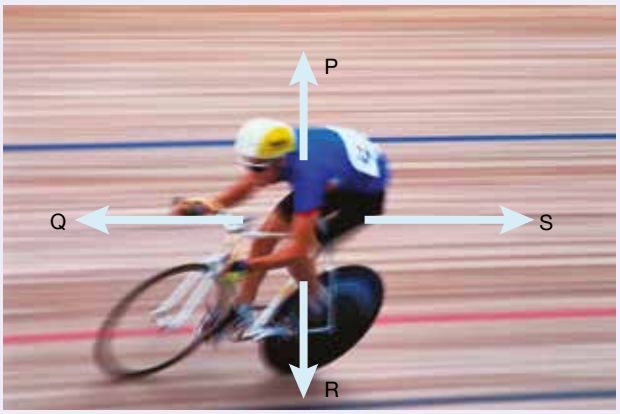






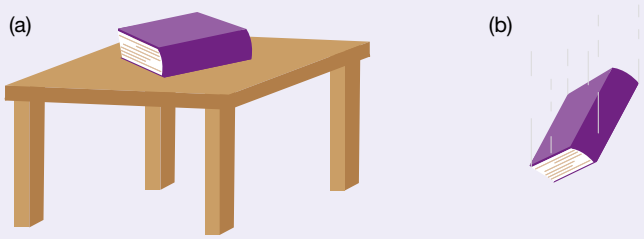


2. The arrows in the diagram below represent four of the forces acting on a cyclist riding on a smooth, flat surface.



(a) Which two forces are equal in size?
(b) Which arrow could represent air resistance?
(c) Is the cyclist speeding up, slowing down or travelling at a steady speed? Explain your answer.

3. Redraw the diagrams below using arrows to represent the forces acting on the book:
(a) while it is at rest on the desk
(b) while it is falling towards the floor.



4. The compass needle is not shown in the diagram below. Redraw the diagram to show the direction in which the needle would point.



5. Explain why a compass always points towards the North Pole of the Earth when it is away from other magnets.
6. Electricians use screwdrivers and long-nosed pliers with handles that are coated with plastic. Suggest a reason for this.
7. When you rub your shoes on some types of carpet, your body becomes negatively charged. Explain what will happen to the extra negative charge on your body if you:
(a) stand still for a few minutes
(b) touch a metal door handle immediately after rubbing your shoes on the carpet
(c) place the palm of your hand near a negatively charged balloon hanging from a thread
(d) place the palm of your hand near a positively charged balloon hanging from a thread.
8. Use a series of labelled diagrams to explain how a positively charged balloon can be attracted to an uncharged plaster wall.
9. Explain why the pull of gravity is less on the moon than it is on Earth.
10. State the units used to measure:
(a) mass
(b) weight
(c) force.
11. When a package of emergency supplies is first dropped from a plane, it gains speed rapidly. Explain why it eventually stops gaining speed before reaching the ground, even without the use of a parachute.

12. Explain how lubricants such as grease and oil reduce the production of heat in the moving parts of car engines and other mechanical devices.
13. Describe at least three ways in which racing cyclists reduce the effect of air resistance on their motion.
14. Scuba divers wear very heavy belts when they are diving.
    (a) Explain why they are necessary.
    (b) What difficulty would be caused if a heavy belt wasn't used?



15. Identify the force that:
    (a) pushes you up when you are swimming underwater
    (b) causes all objects with mass to attract each other
    (c) acts on an object when it moves across the surface of another object
    (d) resists the motion of all objects moving through the air
    (e) pushes up on objects on the surface of water, but not on objects below the surface
    (f) can lift a paperclip from a desktop.
16. Describe some investigations that sports scientists could undertake to improve performance in each of the following sports.
    (a) Tennis
    (b) Golf
    (c) Cricket
17. Describe how your body would move if you were a passenger in a car that stopped very suddenly and you were not wearing a properly fitted seatbelt.
18. Explain how the thick layer of polystyrene foam or similar material inside the outer shell of a helmet reduces the likelihood of severe head injuries in an accident.

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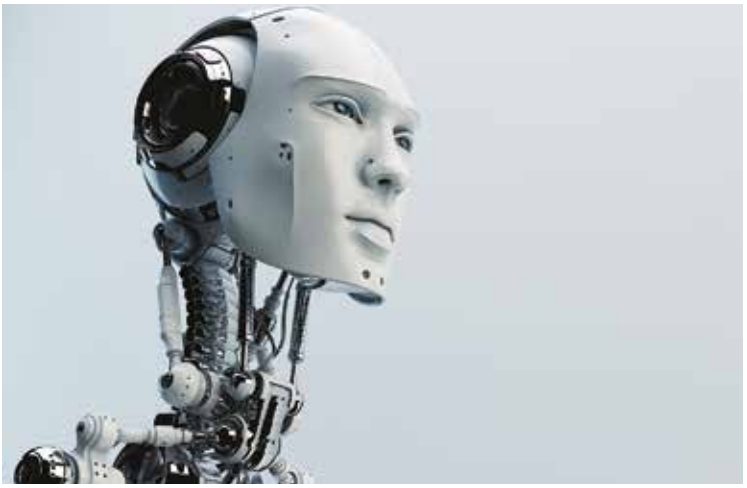
Complete this digital doc: Worksheet 8.9: Crossword (doc-19850)

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TOPIC 9
A world of machines

9.1 Overview



Engineers use scientific knowledge to design and build machines that make life easier, bridges that carry heavy loads, and buildings that don't fall over. Machines transfer energy to or from an object by the action of a force. We all use machines every day to make life easier, sometimes without even noticing. The human body could not move without the many simple machines inside.

9.1.1 Think about machines

assessON

- How does a bathroom tap make life easier?
- Where can you find machines inside the human body?
- Who's the boss — you or your car?
- How could you lift many times your own weight by yourself?
- How did Archimedes try to prove that he could single-handedly move the whole Earth?
- Why do bicycles have gears?
- Why do roads wind around mountains instead of going straight up?

LEARNING SEQUENCE

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Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

9.1.2 Your quest

Exploring simple machines

A **machine** is a device that makes a physical task easier. That means that cars, bikes, cranes, lifts and escalators are machines. But machines like these are actually made up of many smaller machines called simple machines. Simple machines transfer energy from one object to another to make it move or change direction.

INVESTIGATION 9.1

As simple as a spoon

AIM: To explore how a lever can make a task easier

Materials:

Milo can with lid (or similar)
teaspoon



Method and results

- Place the lid firmly on the can.
- Try to remove the lid without using the teaspoon. If you succeed in removing the lid, replace it.
- Use the teaspoon to remove the lid. Replace the lid again.
- Use the teaspoon to remove the lid again, but hold the spoon much closer to the end near the lid.

Discuss and explain

1. How does the teaspoon make it easier to remove the lid?
2. Where should you hold the spoon to lift the lid most easily?

INVESTIGATION 9.2

Hard as nails

AIM: To investigate the use of a lever to remove a nail from wood

Materials:

claw hammer
nail in a block of wood



Method and results

- Try to remove the nail from the block of wood without the hammer. Take care that you don't hurt your hand.
- Now use the hammer to remove the nail.

Discuss and explain

1. Would you have been able to get the nail into the block of wood without the hammer?
2. Does the hammer make it easier to remove the nail?
3. Where should you hold the hammer to make it easier to remove the nail?

9.2 A helping hand

9.2.1 Levers

Can-openers, scissors, tongs, spanners, hammers, brooms, tennis racquets and staplers are **levers**. A lever is a simple machine that uses the turning effect of a force.

The turning point of a lever is called its **fulcrum**. The resistance to motion that a lever works against is called the **load**. The force used to cause movement is called the **effort**.

WHAT DOES IT MEAN?

The word *lever* comes from the Latin word *levare*, meaning 'to make lighter'.

The lever shown in the illustration on the right is a **first-class lever**. The fulcrum lies between the effort and the load. A seesaw is another example of a first-class lever. First-class levers are **force multipliers** because they 'multiply' your effort.

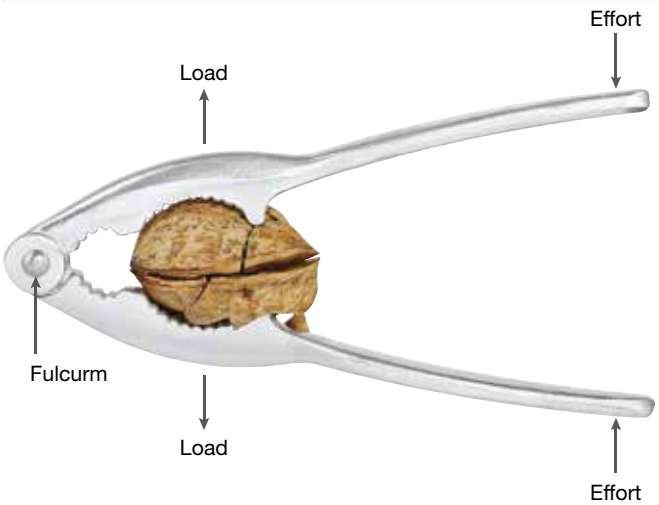
The wheelbarrow and nutcracker shown below are also force-multiplying levers. However, the load is between the fulcrum and the effort. Such levers are called **second-class levers**. A door (not a sliding one!) is another example of a second-class lever.

Spoon being used as a first-class lever





The wheelbarrow and nutcracker are examples of second-class levers. They allow you to move large loads that you would not be able to move without help.



9.2.2 What's the advantage?

The advantage of force-multiplying levers is that they allow you to move a heavy load with a small effort. The **mechanical advantage** of a force-multiplying lever is defined as:

mechanical advantage = load/effort.

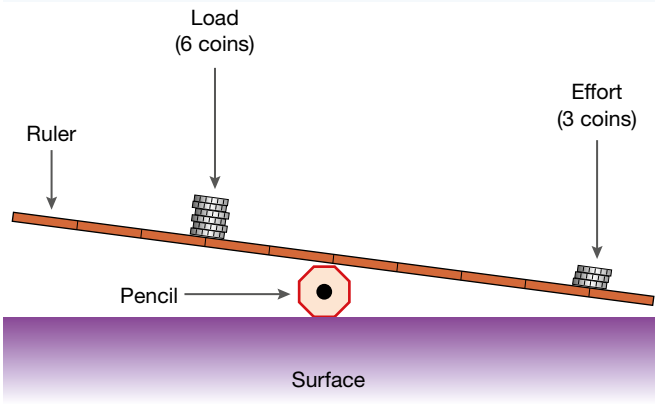
For example, when you use the lever on the next page to raise a load of 6 coins with an effort of only 3 coins, the mechanical advantage is given by:

mechanical advantage = load /effort
= 6 ÷ 3 = 2.

In other words, the lever lifts a load that is two times greater than the effort.

Levers with the effort between the fulcrum and the load are called **third-class levers**. Third-class levers are not force multipliers. They move a load through a larger distance than the effort moves in the same time and are therefore **speed multipliers**. The softball bat shown on the right is a third-class lever. Golf clubs, tennis racquets and brooms are also third-class levers designed to move a small load quickly with a large effort.

The mechanical advantage of this lever is 2.



A softball bat is a third-class lever designed to move a small load quickly.



HOW ABOUT THAT!

Tooth decay was common on the goldfields of Australia in the nineteenth century because of poor diet and dental hygiene. Rotting teeth were usually pulled out by a local doctor. But if a doctor wasn't around, the blacksmith did the job with the same pliers used to pull the nails out of horseshoes. Ouch!



INVESTIGATION 9.3

Pushing your barrow

AIM: To investigate how a wheelbarrow makes lifting a load easier

Materials:

wheelbarrow (or plank if a wheelbarrow is not available)
a few bricks

Method and results

- Place a few bricks in the wheelbarrow and lift it by the ends of the handles.
- Without changing the load, lift the wheelbarrow with your hands as far down the handle as possible.
- While holding the wheelbarrow up, have your partner move the load so that it is closer to the handle.

1. How does the position of the effort affect its ability to raise the load?
2. How does the position of the load affect the amount of effort needed to raise it?

INVESTIGATION 9.4

Get a load of this

AIM: To investigate the relationship between effort and its distance from the fulcrum

Materials:
ruler at least 30 cm long
pencil
6 identical coins or 50-gram weights
plasticine (to hold pencil in place if it rolls)

Method and results

1. Draw up a table like the one below.
   - Use the pencil and ruler to set up a seesaw so that it balances without any weights on it.
   - Place a load of three weights 4 cm to the left of the fulcrum. Place the other three weights (the effort) to the right of the fulcrum so that the effort balances the load.
2. Record the distance from the effort to the fulcrum in your table.
   - Remove two of the weights from the effort and raise the load of three weights with an effort of only one weight.
3. Record the new distance from the effort to the fulcrum in your table.
   - Experiment with your seesaw to see where various efforts need to be placed to raise loads of 5, 4 or 2 weights.
4. Record your observations in your table.
   - Do some more testing, including raising small loads with a small effort.

Discuss and explain

5. Why is this type of lever called a force multiplier?
6. Examine the completed table to see whether any pattern is evident in your data. What is your conclusion?
7. Is there any advantage in using a seesaw-type lever to raise a light load with a large effort?

Raising a load with a first-class lever

Load		Effort	
Number of weights	Distance from fulcrum (cm)	Number of weights	Distance from fulcrum (cm)
3	4.0	3	
3	4.0	1	
5		1	
4		2	
4		1	
2		1	

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Try out this interactivity: Spanner (int-0023)

9.2.3 A word about energy

Although levers can 'multiply' a force or speed, the Law of Conservation of Energy is never broken. The Law of Conservation of Energy states that energy cannot be created or destroyed. It can only be transferred to another object or transformed into a different form. You can never get more energy out of a lever than you put in.

9.2.4 Body levers

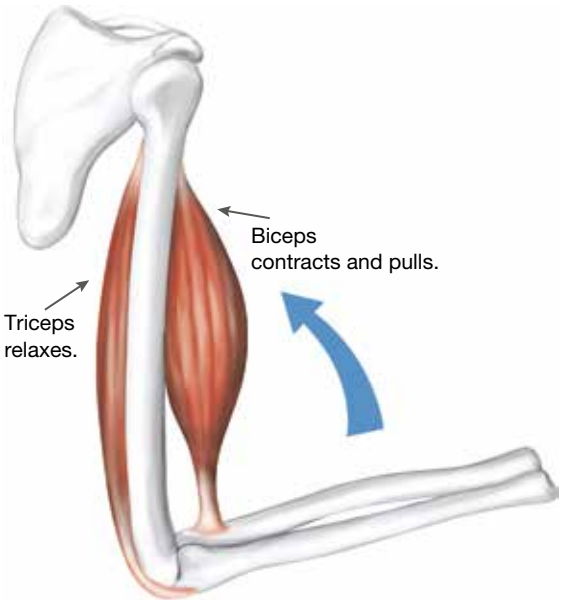
Many of the bones in your own body are levers. The long bones in your arms and legs are the most obvious examples of levers. Joints such as your elbow and knee act as fulcrums. Your muscles pull on part of the bone to provide the effort. The load is the resistance to motion that your bone works against. The load could be the weight of a basketball, a soccer ball, a bucket of water or a heavy weight in the gym.

Levers in your arm

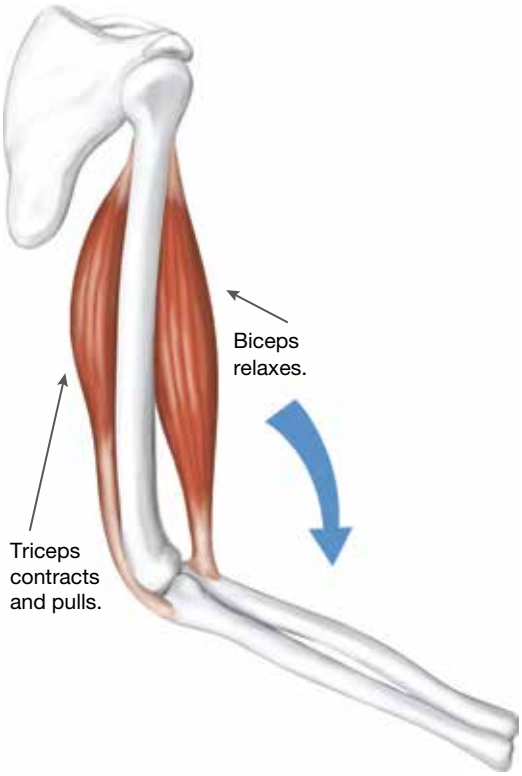
When you bend your arm to lift a weight, the effort is provided by your biceps muscle where it joins a bone called the radius in your forearm, just below the elbow. Your elbow is the fulcrum. It is the turning point of the lever. The load is the weight that you are trying to lift upwards. The effort is between the fulcrum and the load, so your forearm is acting as a third-class lever and a speed multiplier.

When you straighten your arm to push downwards, such as when you do push-ups or push a weight down, your forearm acts as a first-class lever and force multiplier. The fulcrum is your elbow. The effort is provided by your triceps muscle, which is joined to a bone in your forearm called the ulna. The load is the resistance to your downward push. In this case, the fulcrum is between the effort and the load.

When you bend your arm to lift a load, your forearm acts as a third-class lever.



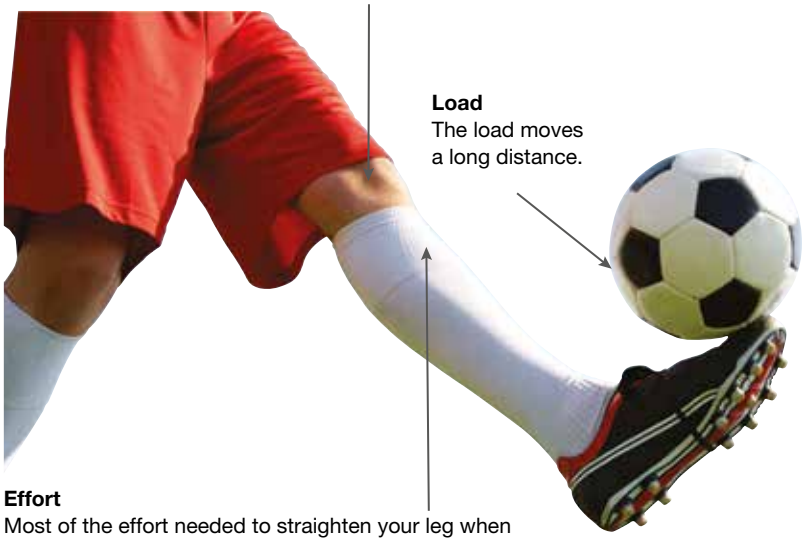
When you straighten your arm to push downwards, your forearm acts as a first-class lever.



Kicking a ball

When a football is kicked, bones in the lower leg act as a third-class lever. The knee is the fulcrum. The effort needed to straighten the leg is provided by muscles attached to the top of the lower leg. The load is the resistance to motion of the football. Although there is little movement where the effort is applied, the foot (where the load is) moves a large distance.

Fulcrum
The lower part of the footballer's leg pivots around the knee. The knee is the fulcrum in this lever.



Load
The load moves a long distance.

Effort
Most of the effort needed to straighten your leg when kicking a ball comes from the muscles in your legs. The effort to kick a ball is applied by muscles that attach to the top of your lower leg.

Anyone for tennis?

In ball games such as tennis, cricket, baseball, golf and hockey, racquets, bats, clubs and sticks are used as third-class levers. The end of the lever that strikes the load (the ball) moves much faster than the end of the lever where the effort is applied.

When a tennis ball is served, the lever consists of your whole arm and the tennis racquet. The fulcrum is your shoulder, the effort is applied by the muscles attached to the bones of your upper arm, and the load is at the centre of the racquet. The larger the distance between the load and the effort, the faster the serve. Professional tennis players can serve tennis balls at speeds of up to 240 km/h. This is many times the speed of the upper arm where the effort is applied.

When a tennis ball is served, the arm and tennis racquet work together as a third-class lever and speed multiplier.



Why warm up?

The muscles that pull on your bones to make them move are made up of tough and elastic fibres. When they are cold, the muscles are less elastic. If you overload muscles without warming up they can easily tear. Even with warming up, if muscles have not been prepared for sport by proper training, they can easily be torn when sudden movements are made.

9.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Which body parts provide the effort when bones act as levers?
2. When you bend your forearm upwards to lift a bucket of water, it acts as a lever.
   (a) Where is the fulcrum?
   (b) Which muscle provides the effort?
   (c) What is the load?
   (d) Which type of lever is your forearm acting as?
3. When you straighten your arm to do push-ups, your forearm acts as a lever.
   (a) Where is the fulcrum?
   (b) Which muscle provides the effort?
   (c) What is the load?
   (d) Which type of lever is your forearm acting as?
4. Why is it important to warm up before playing sport?
5. What is a lever?
6. Explain why first-class and second-class levers are called force multipliers.

Think

7. Why can't you get more energy out of a lever than you put in?
8. In cricket, the arm acts as a lever when the ball is bowled.
   (a) Which class of lever is the arm acting as?
   (b) Is the arm acting as a speed multiplier or a force multiplier? Explain your answer.
   (c) Which part of the body acts as the fulcrum?

In cricket, the bowling arm is used as a lever.

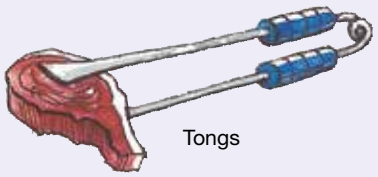


9. Is height an advantage to tennis players and cricket bowlers? Explain your answer.

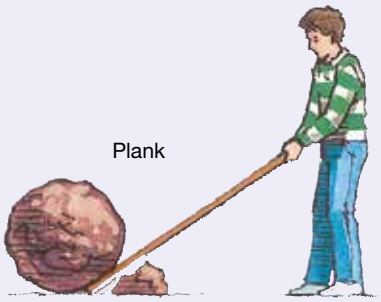
10. Label the load, effort and fulcrum on a copy of each of the levers shown below.
    (a) Which of the levers are speed multipliers?
    (b) Which of the levers are second-class levers?



Shovel



Tongs



Plank



Door

11. Explain why third-class levers are called speed multipliers.
12. (a) What is the mechanical advantage of the lever in Investigation 9.4 when one coin is used to lift a load of three coins?
    (b) To increase the mechanical advantage of the ruler and pencil in Investigation 9.4 to lift a slightly larger load, which way would you need to move the three coins?
13. Explain why door handles are placed as far away from the hinges as possible.

Create

14. Create a poster or short series of PowerPoint slides that could be used to encourage people to warm up before going for their daily run around the block.

Investigate

15. Find out what the scientists in the Movement Science Department of the Australian Institute of Sport are researching to improve the performance of Australian athletes.
16. Serious athletes don't just warm up. They also go through 'cooling down' exercises after strenuous activity. Find out why they do this.

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Complete this digital doc: Worksheet 9.1: Loaded levers (doc-19851)

9.3 Pushing uphill

9.3.1 Inclined planes

Imagine how difficult it must have been for the ancient Egyptians to build the pyramids at Giza.

The Great Pyramid was built from over 200 million blocks of limestone, most with masses over 2 tonnes. It is believed that the blocks were dragged from nearby quarries by gangs of men. The task of lifting the blocks to heights of over 140 metres was made possible by building long ramps of brick and sand. As each layer of limestone blocks was completed, the ramps were extended so that the next layer could be commenced.

WHAT DOES IT MEAN?

The word *ramp* comes from the Old French word *ramper*, meaning 'to climb'.

A **ramp** is a machine because it makes the physical task of raising an object easier. A ramp is simply an **inclined plane** — a surface that is set at an angle to the horizontal. It allows objects to be raised with less effort than would be needed to lift them straight up. Ramps are used in shopping centres and other buildings to allow wheelchairs, prams and strollers to be raised with less effort. Although a smaller effort is needed when using a ramp, the load must be moved through a larger distance. Escalators are moving ramps. The winding mountain road in the photograph on the next page is also a ramp.

Imagine how much shorter the trip would be if the road went straight up the mountain — but no vehicle would be powerful enough to use the road.

When an object is pushed up an inclined plane, energy is transformed from the energy of movement (kinetic energy) into stored energy (potential energy). If an object at the top of an inclined plane is allowed to slide or roll down, some of its potential energy is transformed back into kinetic energy.



9.3.2 Inclined planes at work

Wedges are inclined planes. They can be used to penetrate or split objects, or to stop them from moving. Axes, knives and your front teeth are examples of wedges. They reduce the force needed to cut through objects. If you have ever tried to cut through a hard piece of food like an apple with a blunt knife, you will know the value of a wedge.

INVESTIGATION 9.5

Inclined to make it easier

AIM: To investigate how an inclined plane makes a task easier

Materials:

3 textbooks
500-gram mass with hook
ramp (thin piece of wood)
spring balance

Method and results

- Place three textbooks on top of each other. Measure and record the height of the textbooks.
- Place the 500-gram mass next to the pile of books and use the spring balance to slowly lift the mass so that its base is level with the top of the pile.

1. Record the force measured by the spring balance.
2. Lean a ramp against the pile of books. Measure and record the distance from the bottom of the ramp to where it meets the top edge of the pile of books.
   - Place the 500-gram mass at the bottom of the ramp and use the spring balance to slowly pull it until its far end reaches the top of the pile.
3. Record the force measured by the spring balance.

Discuss and explain

4. Does it take more force to lift the mass straight up or along the ramp?
5. In which case does the mass have to move further — straight up or along the ramp?
6. Which method of raising the mass is better? Why?
7. The mechanical advantage of a simple machine is a measure of the number of times greater a load is than the effort (see section 9.2). What is the mechanical advantage of your ramp?

Screws are inclined planes. A screw is a curved ramp. However, instead of an object being pushed up the ramp, the ramp is pushed down into the object. The ramp cut into a screw is called the **thread**; the distance between two turns of the thread is called the **pitch**. Because the total length of the thread is so great, its force-multiplying effect is very large. Most car jacks use a large screw to lift a huge load with little effort. Similarly, a corkscrew is used to penetrate the tightly fitted cork of a wine bottle with little effort. The cork is then removed by pulling the corkscrew out directly.

This winding mountain road is a ramp.



INVESTIGATION 9.6

Inclined planes on the move

AIM: To investigate how a wedge makes a task easier

Materials:

wooden door wedge
2 rubber bands
2 blocks of wood (soft pine)
self-tapping screw
screwdriver

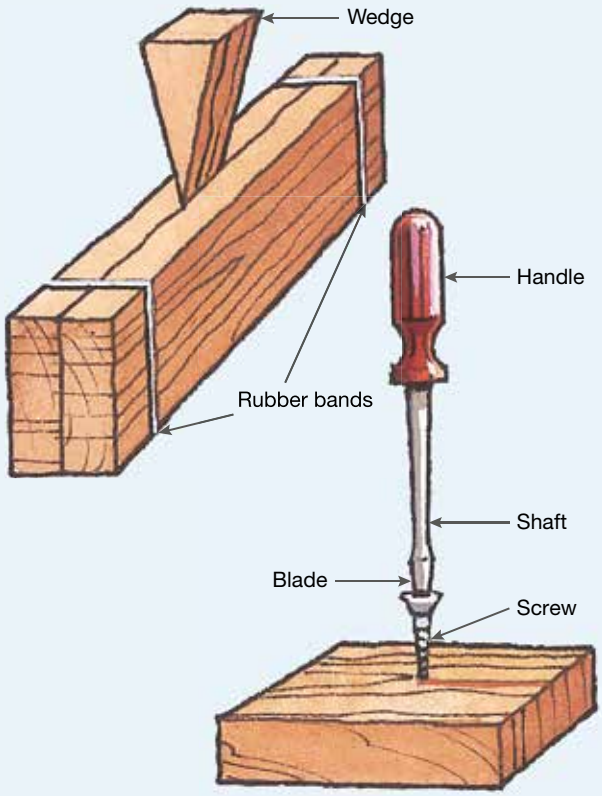
Method and results

- Use two rubber bands to hold the two blocks of wood together. Try to pull the two blocks of wood apart with your fingers. Take care not to break the rubber bands.
- Place the sharp edge of the door wedge between the two blocks and push it down.
- Use the screwdriver to insert the screw halfway into one of the blocks of wood. Look closely at the thread of the screw as it moves into the wood.

1. Does the wedge make it easier to separate the two blocks?

Discuss and explain

2. Would you have been able to get the screw halfway into the wood by pushing straight down on it?



9.3 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is a ramp?
2. Ramps are inclined planes. List two other types of inclined planes.
3. What energy transformation takes place when an object is pushed up an inclined plane?
4. What is the difference between the thread of a screw and the pitch of a screw?

Think

5. A ramp makes it easier to push or pull objects upwards. What is the 'penalty' for making the task easier?
6. Explain why inclined planes are classified as force multipliers.
7. Construct a table with three columns headed 'Ramps', 'Wedges' and 'Screws'. Brainstorm with a partner or small group to list as many examples of each type of inclined plane as you can.
8. Explain how a ramp is able to produce a mechanical advantage.

9.4 Systems: Wheels and axles in a spin

9.4.1 Wheels and axles

A circular doorknob is a simple machine called a **wheel and axle**. It is actually a lever that can rotate. The inner, smaller wheel of the doorknob is the axle. When you open a door you apply an effort to the wheel and the axle pulls on the load to open the door. The fulcrum, or turning point, is at the very centre of the doorknob.

The doorknob in the photo is a force multiplier. You apply a small effort to the wheel to move a large load with the axle. There is, however, a penalty; you pay for the extra force with extra distance. The wheel (handle) moves further than the axle. Imagine, however, how difficult it would be to turn the axle without a handle.

Bathroom taps and car steering wheels are also force-multiplying wheels and axles. Can you think of any others?

This doorknob is a wheel and axle machine. The handle is the wheel, which turns in a circle. The spindle inside is the axle, and it turns in a smaller circle.



9.4.2 Speed it up

Wheel and axle machines can be used to make things move faster. The ceiling fan in the photograph below is a wheel and axle machine. A large force is applied to the axle. Each time the axle turns, the fan blades move a much greater distance in the same amount of time. It is a speed multiplier. The ceiling fan transfers kinetic energy, from the motor that makes the axle turn, to the fan blades.

A car wheel is another example of a speed multiplier. The axle turns when a large force is applied to it. The outside of the wheel moves faster, covering a much greater distance in the same time. Pairs of wheels and axles are sometimes joined together with a chain or belt. This either reduces the effort needed to make one of the wheels turn or makes one of the wheels turn faster. The fanbelt in a car is one example. Wheels and axles joined by belts are also used to operate heavy machinery in factories.

This ceiling fan is a speed-multiplying wheel and axle machine. The fan blades trace out a complete circle. Electricity is used to make the axle turn, and the fan blades move faster than the axle.



INVESTIGATION 9.7

Getting a handle on wheels and axles

AIM: To investigate how wheels and axles make a task easier

Materials:

screw firmly embedded in a block of wood
screwdriver

Method and results

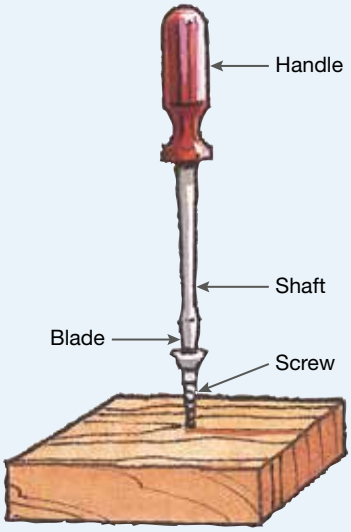
- Try to remove the screw from the block of wood with the screwdriver by turning the shaft instead of the handle.
- Remove the screw by using the screwdriver as it is meant to be used — by turning the handle.
- Use the screwdriver to replace the screw firmly into the wood.

1. Can the screw be removed by turning the shaft?

Discuss and explain

2. What difference does using the handle make to the effort needed to remove the screw?
3. During one full turn of the screwdriver, which moves further — the outside edge of the handle or the outside edge of the shaft?

A screwdriver is a wheel and axle.



These wheels and axles are joined by a belt to operate heavy machinery.



INVESTIGATION 9.8

Wheels and axles at work

AIM: To investigate how wheels and axles can become force or speed multipliers

Materials:

selection of wheels and devices (for example, doorknob, hand drill, toy cars, spinning toys, wind-up toys, taps, screwdrivers, wing nut, small wheels)

Method and results

- Examine the wheel and axle machines provided.
- Draw a diagram, labelling the wheel and axle.

For each machine examined:

1. Write down whether it is a force multiplier or a speed multiplier.
2. Explain, in your own words, how it works.

9.4.3 Getting a lift

A pulley is a special type of wheel and axle that makes it easier for you to lift a load. The wheel has a groove around it so that a rope or cable can be passed over or under it. A pulley does not decrease the size of the force, or effort, needed to lift the load. It changes the direction of the effort.

It is easier to pull down on a rope to lift a load than it is to push the load. Your own weight can be used to advantage.

When more than one pulley is used, a large load can be lifted with a small effort. A system of two or more pulleys therefore acts as a force multiplier. It magnifies the size of the effort. As with other force multipliers, there is a cost. The rope needs to be pulled through a large distance to move the load through a small distance.

A multiple-pulley system is usually called a **block and tackle**. The block is the frame around the pulleys. The tackle is the string or cable joining the load to the effort. With a block and tackle it is possible to lift many times your own weight. Of course, you have to pay for it by pulling over a long distance.

The woman in the photo below is using the pulley to **transfer** energy from herself to the weight to make it move. In order to move the load, her muscles need to **transform** the chemical energy that she has stored by eating food into movement energy of her arms.

A block and tackle system is used in garages to lift engines out of cars. It is also used on cranes, wharves and ships.

A single pulley simply changes the direction of the effort needed to lift a load.



A block and tackle is used to lift or pull heavy loads.



HOW ABOUT THAT!

Archimedes (287–212 BC), a Greek mathematician, invented the multiple pulley system. It is believed that he boasted to King Hiero II of Syracuse: 'Give me a place to stand on, and I shall move the whole Earth'. The king challenged Archimedes to prove it. Archimedes responded by using a system of pulleys to single-handedly drag a ship, fully loaded with cargo and passengers, out of the water and onto land.

INVESTIGATION 9.9

Lifting that load

AIM: To compare the mechanical advantage of three pulley arrangements

Materials:
2 single pulleys
2 double pulleys
1-metre length of string
set of slotted 50-gram masses
5.0-newton spring balance
metre ruler
hook from which to suspend pulleys

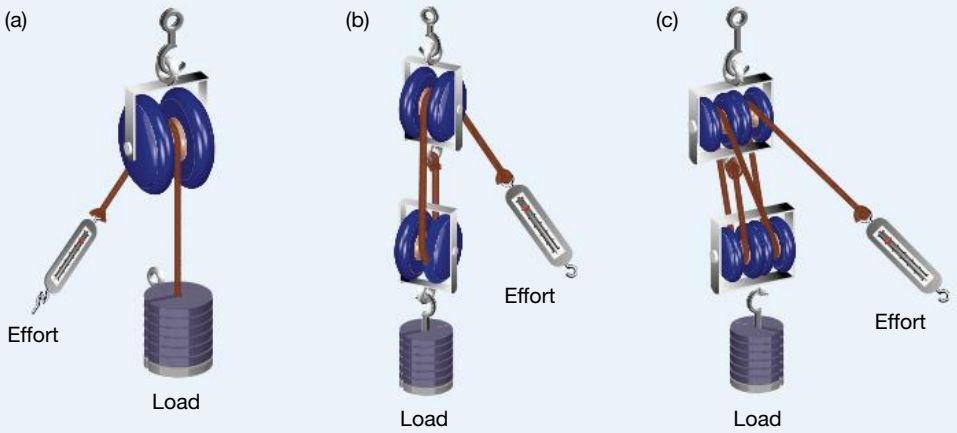
Method and results

1. Draw up a table for your results like the one on the next page.
   - Load the slotted masses to a mass of 400 grams and attach them to one end of the string.
   - Use the spring balance to measure the weight, in newtons (N), of the slotted masses. This weight is the load that must be lifted.
2. Record the load in your table.
   - Thread the other end of the length of string over the wheel of a single pulley and attach it to the spring balance as shown in diagram (a) below.
   - Pull slowly on the spring balance so that the load is lifted slowly and steadily upwards through a distance of 5 cm.
3. Record the force in newtons (N) measured by the spring balance. This force is the effort. Also record the distance through which you had to pull the spring balance to lift the load 5 cm.
   - The distance moved by the effort (your pull on the spring balance) is called the effort distance.
   - Arrange the system with two single pulleys as shown in diagram (b). The pulleys should be about 10 cm apart.
   - Pull slowly on the spring balance to lift the load steadily.
4. In your table, record the force and effort distance needed to lift the load through a distance of 5 cm.
   - Repeat the previous two steps using the system with the two double pulleys shown in diagram (c).

Discuss and explain

5. How does the effort needed to lift the load using two single pulleys compare with that needed to lift it with one single pulley?

The pulley systems to be tested in the experiment: (a) single pulley (b) two single pulleys (c) two double pulleys



6. How does the effort needed to lift the load with two double pulleys compare with that needed to lift it with one single pulley?
7. Would it be true to say that the system with two double pulleys has the same advantage as one with four single pulleys? Why?
8. Looking at your tabulated results, how would you say the effort needed changes as the number of pulleys increases?

9. How does the effort distance change as the effort itself decreases?
10. Predict how much effort would be needed to lift the same load by 5 cm if you used two triple pulleys instead of two double pulleys. How far would you need to pull on a string to lift the load 5 cm?

Lifting a load with pulleys

Pulley arrangement	Load (N)	Load distance (cm)	Effort (N)	Effort distance (cm)	Mechanical advantage (load/effort)
Single pulley		5.0			
Two single pulleys		5.0			
Two double pulleys		5.0			

9.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Which part of a circular doorknob is the wheel? Which part is the axle?
2. Explain why a circular doorknob is called a force multiplier.
3. Explain why a ceiling fan is called a speed multiplier.
4. How is a single fixed pulley useful even though it does not decrease the size of the force needed to lift a load?
5. Why is a system of two single pulleys better than one single pulley for lifting very heavy loads?
6. What is a block and tackle? What is it used for?

Think

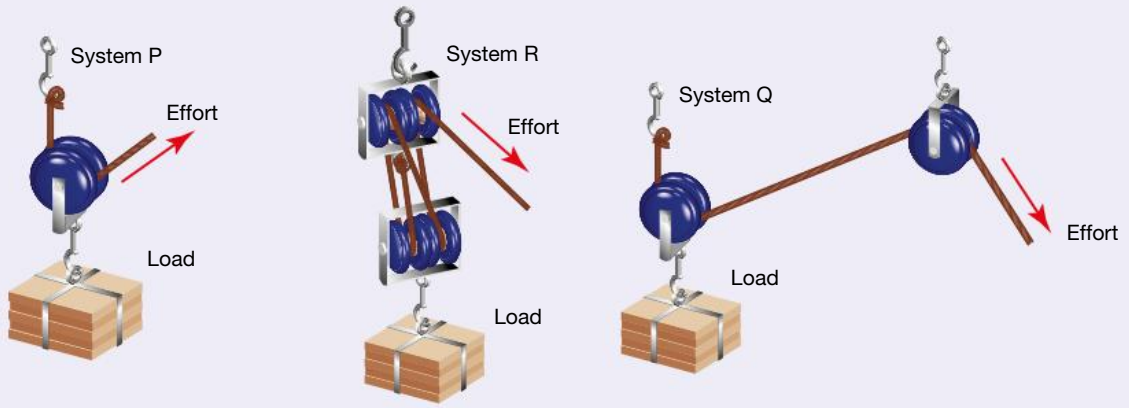
7. Draw a diagram of the car steering wheel shown on the right.
   (a) Draw an arrow to show where the effort is applied when turning right.
   (b) Label the wheel and the location of the axle.
   (c) What is the load being moved by the steering wheel?
   (d) Is the steering wheel a force multiplier or a speed multiplier?
   (e) If you wanted to change your steering wheel to one that was easier to turn, should you get a larger one or a smaller one?
8. Draw up a two-column table with the headings 'Force multipliers' and 'Speed multipliers'. List as many wheel and axle machines as you can think of in the appropriate column.
9. It has been said by many people: 'You don't get anything for nothing'. How does this statement apply to multiple-pulley systems that make it easier to lift a load?
10. Complete the equation:

    load × **load distance** = **effort** × _____.

A car steering wheel is a wheel and axle machine.



11. In the diagram on the next page, which of the systems P, Q and R would you need to:
    (a) apply the least effort
    (b) apply the most effort
    (c) pull the string through the greatest distance
    (d) apply an effort equal to the load
    (e) apply an effort equal to half of the load?



Create

12. Make a model wheel and axle. Use cotton thread and two sets of slotted weights to show how your model can be used as a force multiplier.
    (a) Calculate the mechanical advantage of your wheel and axle.
    (b) Does your model change energy from one form to another? If so, describe the change in detail.

Investigate

13. Investigate the wheels and axles on a bicycle.
    (a) How many are there?
    (b) What is the purpose of each wheel and axle?
    (c) What is the purpose of the chain?
14. Find out more about Archimedes and the machines he invented. He is probably more famous for Archimedes' Principle than for any of his inventions. What is Archimedes' Principle?

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Complete this digital doc: Worksheet 9.2: Measuring forces (doc-19852)

9.5 Getting into gear

9.5.1 Driven by gears

Most people associate gears with cars or bikes, but you can also find gears in the kitchen.

A hand-operated eggbeater has gears that are used to change both the direction and speed of motion.

Each of the **gears** in a clock is simply a wheel and axle with teeth. The teeth of one gear fit between the teeth of another gear. When one gear turns, the other can be made to turn faster, slower or in a different direction. The gears in the clock allow the three hands to move around the face of the clock at different speeds.

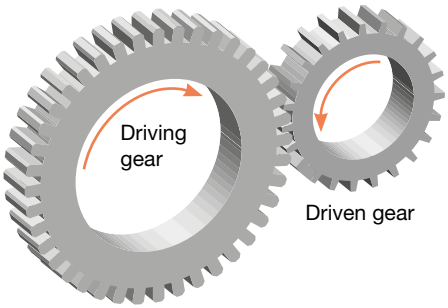
The wheel that is moved first is called the **driving gear**. Usually the driving gear is moved by a person or a motor. On a bicycle, it is moved by pedalling, while in the eggbeater shown on the next page the driving wheel is moved by the handle.

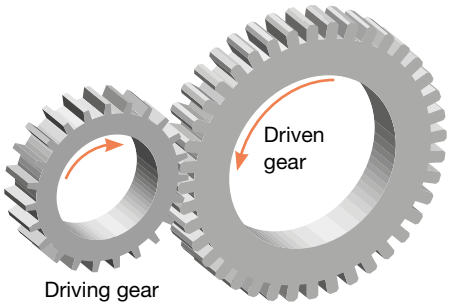
The wheel that is moved by the driving gear is called the **driven gear**. In a hand-operated eggbeater there are two driven gears.

The gears in this clock allow its three hands to move around its face at different speeds.









INVESTIGATION 9.10

Looking at gears

AIM: To investigate how a machine with gears makes a task easier

Materials:

hand-operated eggbeater or hand drill

Method and results

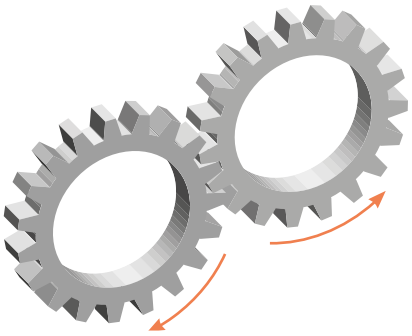
- Identify the driving gear and the driven gear or gears.
- Rotate the driving gear and observe the motion of each driven gear.

1. Count and record the number of teeth on the driving gear and the number of teeth on each driven gear.
2. Use the handle to rotate the driving gear slowly through one complete turn, while your partner counts and records the number of turns completed by each driven gear.

Discuss and explain

3. Which is larger, the driving gear or each driven gear?
4. Which moves faster, the driving gear or the driven gears?
5. Is this system of gears working as a force multiplier or as a speed multiplier?
6. How many times does each driven gear turn for each rotation of the driving gear?
7. Does the number of teeth on each gear seem to affect the way the gear system works? In what way?

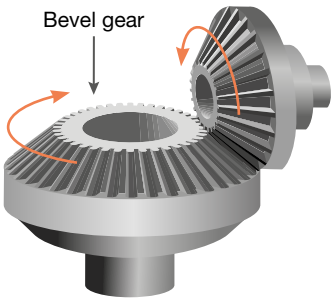
9.5.2 Big wheels, small wheels



Different sizes and arrangements of gears are used to make wheels turn faster, slower or in different directions.

A large driving gear makes a small driven gear move faster, but in the opposite direction. Hand-operated eggbeaters and drills use this combination of gears to make them spin quickly.

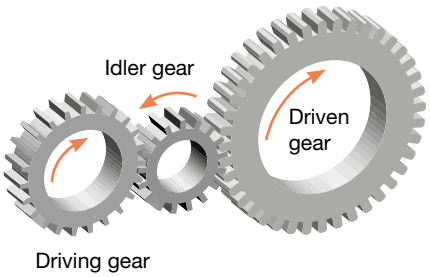
A small driving gear makes a large driven gear move slower but in the opposite direction. This arrangement acts as a force multiplier. It is used to move large loads with a small effort. This arrangement is used in cars to allow them to climb hills or gather speed quickly. It is also used in rotating shopwindow displays to make them turn slowly.



Pairs of gears the same size change the direction of turning without changing the speed.

Gear wheels at right angles to each other can change vertical motion into horizontal motion. Hand-operated eggbeaters and drills use this arrangement.

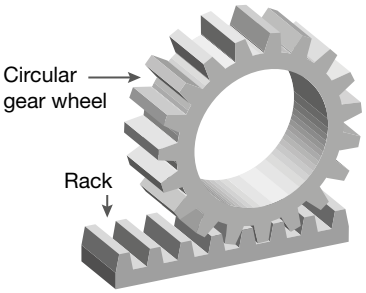
An idler gear can be used between the driving and driven gears to make them turn in the same direction. Why do you think that it is called an idler gear?



Rack and pinion gears consist of a flat row of teeth, called a rack, and a circular gear wheel. A corkscrew uses rack and pinion gears to change the circular movement of the driving gears into the upward, straight-line movement that pulls the cork out.

This corkscrew uses rack and pinion gears.





9.5 Exercises: Understanding and inquiring

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Remember

1. What are gears?
2. What is the difference between a driving gear and a driven gear?
3. Which gear turns faster if:
   (a) the driving gear is larger than the driven gear
   (b) the driving gear is smaller than the driven gear
   (c) the driving gear is the same size as the driven gear?
4. What can gears do, other than make another wheel turn faster?

Think

5. List as many devices that use gears as you can.
6. The driving gear on a hand-operated eggbeater has 40 teeth while each driven gear has 10 teeth.
   (a) How many times will the blades of the eggbeater turn for each turn of the handle?
   (b) How could you change the design of the eggbeater so that you could move the blades faster without moving the handle faster?
   (c) How could you change the design of the eggbeater so that it is easier to turn the handle? What would be the disadvantage of doing this?

Create

7. Use Legotechnic® or a similar kit to build a machine with at least two gears that can be used with a handle to:
   (a) lift a heavy load
   (b) make a wheel turn in the same direction as the handle
   (c) make a wheel turn in the opposite direction from the handle.

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Try out this interactivity: Gears (int-0025)

Try out this interactivity: Gear ratios (int-0746)

Complete this digital doc: Worksheet 9.3: Which way? (doc-19853)

9.6 Compound machines

Science as a human endeavour

9.6.1 On your bike

A bicycle is a compound machine made up of many simple machines. The obvious ones are the front and rear wheels, handbrake and pedals. But if you look carefully you can find many others.

All compound machines are made up of two or more simple machines, including levers, wheels and axles, pulleys and gears.

Front and rear wheels

Each of the front and rear wheels is an example of a wheel and axle. The rear wheel is made to turn by another wheel and axle — the pedals. The axle of the pedals is joined to the axle of the rear wheel by a chain. The rear wheel and axle is a speed multiplier. The rear wheel axle is much smaller than the back wheel. When it turns, the back wheel turns very quickly. The front wheel is pushed along the road by the rest of the bicycle.



Gears

The gears on a bicycle usually act as speed multipliers. Bicycle gear wheels are called sprockets. Although the front and rear **sprockets** are connected by a chain, they work just like gears with teeth that fit together. The front sprockets are larger and have more teeth than the rear sprockets.

The highest wheel speed can be reached with the least effort when the larger front sprocket is used with the smallest rear sprocket. This combination is most suitable when riding quickly on a level road. When riding up a steep slope, speed is less important. If the smaller front sprocket is used with the largest rear sprocket, you can climb the slope with less effort. You do, however, need to make more turns of the pedals.



Handbrake

The handbrake is an example of a first-class lever. The fulcrum is between the effort and the load. When the rider squeezes the handle of the handbrake, the effort is transferred along a cable to the brake pads that push against the wheel.

9.6.2 On four wheels

The car is also a compound machine. But it is made up of many more simple machines than the bicycle. Most of the simple machines in a car are under the bonnet, but the most obvious ones are the wheels and axles that roll along the road, and the steering wheel.

HOW ABOUT THAT!

One of the first bicycles invented was called the 'swiftwalker'. It didn't have pedals. The rider had to push off the ground with one foot to make the bike go forwards. The rider could then sit while the bike coasted forwards. Going downhill was a breeze, but imagine trying to go uphill! To make matters worse, the wheels were made of wood with iron rims covered with leather. It was a very bumpy ride!



The front wheel and axle of this vehicle act as a speed multiplier. A very large force moves the axle in a small circle. The outside edge of the wheel turns in a large circle, and much faster than the axle.



9.6.3 Fuelling compound machines

Machines don't create energy. They reduce the effort you need to apply, or they reduce the distance over which you need to apply a force. The Law of Conservation of Energy applies to all machines. The total energy you can get out of a machine is equal to the amount of energy that you (or a fuel) puts in. However, the total amount of *useful* energy you get out of a machine is always less than the amount that goes into it. That's because some energy is always lost to the machine or the surroundings as heat.

Many simple machines and some compound machines, including bicycles, scooters and skateboards, are fuelled by the energy a person provides. Most motor vehicles are fuelled by petrol, gas, diesel or ethanol. Before 1920, many cars were fuelled by steam, transferring the energy of the gas particles to drive a motor, which turned the wheels. The steam was obtained by burning coal or wood to boil water.

Steam engines were much more suitable for fuelling trains than cars because they could carry large amounts of coal or wood on board. Even though steam-fuelled trains have been largely replaced by diesel or electric trains, there are still many in service throughout the world.

Many of the earliest cars were fuelled by steam.



Steam-fuelled trains are still in use throughout the world, often as popular tourist attractions.



9.6.4 Well-oiled machines

Friction is an enemy of compound machines and some simple machines, such as wheels and axles, gears and pulleys. When moving parts rub against each other, they heat up and cannot move quickly. To avoid problems caused by friction, the moving parts of machines need to be:

- kept free from dirt and dust
- lubricated with grease or oil.

As mechanical systems, machines are designed to transfer energy by the action of a force. Energy transferred within a machine as heat is energy wasted.

Compound machines are designed by **mechanical engineers** and kept safe and in working order by **mechanics**. The challenge for engineers is to design machines that are safe, energy efficient and suitable for the conditions in which they are used. Mechanics are to compound machines what medical practitioners are to people. They are problem solvers — keeping the machines they work on in good working order and finding ways to fix problems and, in some cases, detecting problems that have not been noticed before.

9.6.5 Untouched by human hands

Robots are compound machines that perform physical tasks without direct human assistance. They can be used to do jobs that are unpleasant, dangerous or boring. Robots can work in hot weather, cold weather, under water, under the ground, in outer space and in noisy places. They don't spread germs and they don't get tired.

Most robots are controlled by computers. Some are guided by remote-control units — similar to those used to operate DVD players and TV sets. Some robots can 'see' and 'hear' using video cameras and microphones.

Most robots are used to perform simple tasks that humans would find unpleasant, boring or dangerous. These robots are used to put the parts of a car body together.



Robot vacuum cleaners

No time to clean the house? Maybe a robotic vacuum cleaner can do the work for you. These robotic vacuums are really compound machines that contain a variety of sensors, motors and computer circuits. They are able to sense how large a room is, whether there is something blocking their path and how long it will take to get the vacuuming done. They even find their way back to a charging station when they are low on battery capacity.

Most robot vacuums have five motors in total and are driven by two wheels controlled by two motors. The robot can turn depending on how fast each wheel turns. A third wheel can freely rotate and balances the robot. The other three motors control the vacuum suction, the side sweeping brush and an agitating brush.

What happens when the robot is brought into a new space to clean? It uses an infra-red beam to measure the approximate distance across a room. The computer then calculates approximately how long it should take for the robot vacuum to clean



that room. It starts vacuuming at the centre of the room and spirals out until it reaches the perimeter or an obstacle. When either of these things happens, the robot avoids bumping into the walls or obstacle using a short-range infra-red sensor. Another infra-red sensor is directed at the area in front of the robot. Usually the return signal occurs very quickly from the ground, which is not very far away. However, if stairs or a 'void' are encountered, the return signal takes longer (this is called the 'cliff' effect); this is detected by the robot and it turns around or backs up to avoid disaster.

WHAT DOES IT MEAN?

The word *robot* comes from the Czech word *robota*, meaning 'forced labour'.

9.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. What is the difference between a simple machine and a compound machine?
2. What are sprockets?
3. Which type of simple machine do bicycle pedals act as?
4. Which class of lever is a bicycle handbrake?
5. Where do the following compound machines get the energy from to move and make things happen?
   (a) Bicycle
   (b) Car
   (c) Train
6. Why is it necessary to use more energy to operate a machine than you can get out of it?
7. How do robots differ from other machines?

Think

8. Suggest two reasons why steam was replaced by petrol as a fuel for cars.
9. Where is the load that a bicycle handbrake pushes against?
10. Is a bicycle handbrake a speed multiplier or a force multiplier? Explain your answer.
11. Machines are used to replace various parts of the human body. Artificial arms, hands and legs are all machines. More recently, artificial hearts have been implanted. What are the arguments for and against the use of a machine to replace a failing human heart? What do you think?
12. List some reasons robots would be very useful for packaging food products.
13. Robots are clearly very useful devices. They do, however, have some disadvantages. Construct a table to list the advantages and disadvantages of robots.
14. Should robots be used to replace humans wherever possible in jobs that are unpleasant or boring? Write your opinion and reasons for it.

Investigate

15. Find out how hydraulic machines such as hydraulic lifts, cranes or brakes work.
16. Find out what qualifications are needed to become a:
    (a) mechanical engineer
    (b) motor mechanic.
17. Use the internet or other resources to investigate one of the Australian inventions listed below. Each of them is a compound machine. Report on when and by whom it was invented, how it works and how it makes life easier. Identify at least three simple machines that make the invention work.
    (a) Rotary clothes hoist
    (b) Victa lawn mower
    (c) Stump jump plough

18. Microbots are robots that are small enough to be injected into your veins. Use the internet to answer the following questions about microbots.
    (a) Which harmful things in your bloodstream could microbots be used to destroy?
    (b) How does the size of a microbot compare with the size of:
        (i) a bacterium
        (ii) a human red blood cell?

Imagine

19. It is the year 2050. Computer-controlled robots are used to perform most jobs that humans did in the past. Teachers have been replaced by robots that talk, answer questions, set homework, mark tests and even punish misbehaving students. Robots drive cars, serve in shops, babysit children and even read the news on television.
    (a) Write a story about a day in the life of a student your own age in the year 2050.
    (b) What do you think about this imaginary year 2050? Is it really better?

Brainstorm

20. Cars are compound machines that people rely on to get around. Think of the advantages of having one; but think also of all of the problems that cars cause — air pollution is just one of them.
    (a) Construct a table like the one below. In a small group, 'brainstorm' the advantages and disadvantages of cars, completing the table as you go.
    (b) After you have completed your table, discuss the questions with your group.
        (i) Are cars our essential servants? Could we live without them?
        (ii) Do cars control our lives so much that they are our masters? Are we slaves to our cars?
    (c) Finally, write one or two paragraphs to state your own opinion on whether the car is our servant or our master. Include reasons for your opinion.

The car — servant or master?

Advantages of cars	Disadvantages of cars

21. In a small team, brainstorm a list of the simple machines that you might find inside a typical family car.
22. List as many situations as you can in which robots could be used to rescue people where humans could not.

9.7 Single bubble maps and Venn diagrams

9.7.1 Single bubble maps and Venn diagrams

1. Draw a circle in the centre of a sheet of paper. Draw more circles around the outside and link them to the centre circle.
2. Write ideas that relate to the topic in the outside circles.

how to ...?

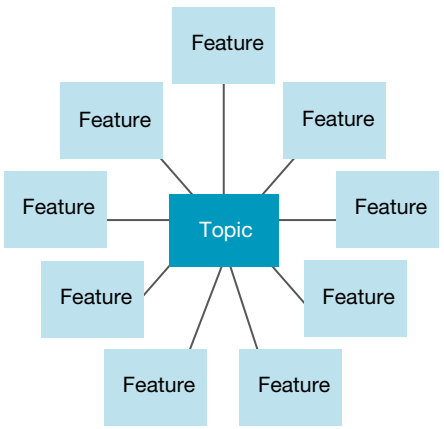
Helps you to identify characteristics of a particular topic

why use?

What do I/we already know about this topic?

question

Single bubble map



Spider diagram; conceptual map; sunshine wheel

also called

comparison

Similarity

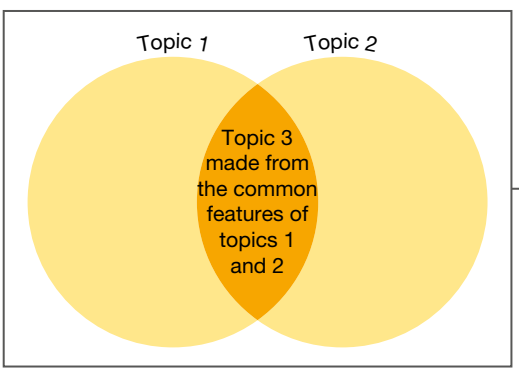
Both identify functions of a topic or theme.

Difference

A Venn diagram can help you identify similarities between two separate topics.

Venn diagram

example



9.7 Exercises: Understanding and inquiring

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Think and create

1. In a small group, brainstorm to create five single bubble maps with the titles shown on the right. You'll probably find the task easier if you start by making five lists. Make each list as long as you can. You can include any machines, both simple and compound, that do not use fuel or electricity. It is possible that some machines might appear in more than one category.
2. Copy and complete the Venn diagram by adding the machines pictured below.

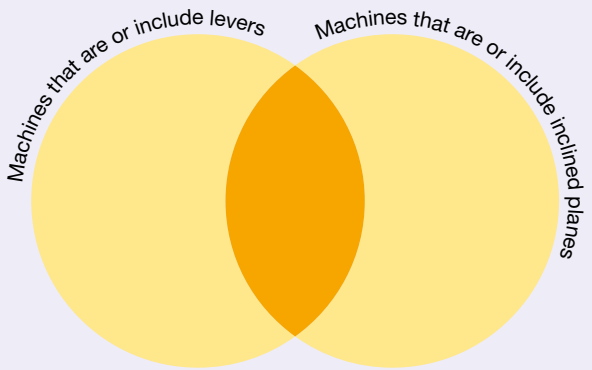
Machines in the garden

Machines in the kitchen

Machines on the road

Machines in sport

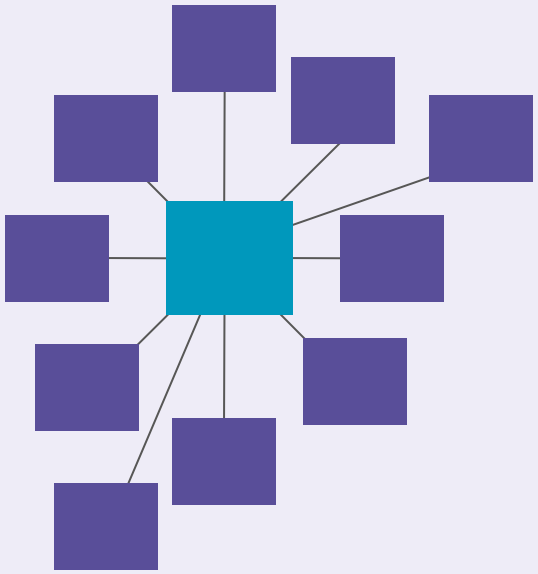
Machines in building





3. Use the machines from exercise 2 to construct five new bubble maps with the following titles.
   (a) Inclined planes
   (b) Wheel and axle
   (c) Speed multipliers
   (d) Force multipliers
   (e) Compound machines

4. Compare your bubble maps with those of other groups to see if you've left out any machines. Add them to your own group's bubble maps. You don't need to redraw the maps — just add more bubbles between the existing ones, as shown in the diagram below.



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9.8 Project: Paper, Scissors, Robot

Scenario

Robots are highly advanced electrical machines that can be programmed to perform specific tasks. Like all compound machines, they are made up of many smaller interacting devices that are referred to by engineers as simple machines. In general, there are considered to be seven types of simple machine — lever, screw, inclined plane, gear, pulley, wheel and axle, and wedge.

Our bodies are able to move around because the muscles, bones, tendons and ligaments also act like simple machines. For example, an incisor is really an organic form of a wedge, while the movement of your forearm is possible because it is a lever, with your elbow acting as the fulcrum.

The robotic hands that prosthetic engineers design are the result of combining processed materials such as metal alloys and polymers to create systems of simple machines that imitate the motion of a real hand as closely as possible.



Your task

- You are going to design and build a robot hand that is capable of performing all of the hand motions used in the game of Paper, Scissors, Rock. You will then use your robot hand to compete with those created by other student groups in your class to find the Paper, Scissors, Robot champions. This tournament will be done as a round-robin competition, with each group playing every other group once. Your robot hand must be sturdy enough to keep functioning throughout the tournament.
- You will also create a user's manual that goes with your robot hand. This will provide a detailed diagram/plan of your robot hand, including an explanation of how it is constructed and how the user makes it move into the three different positions required. In the back of the manual there should also be a 'Troubleshooter' table that will tell the user what the most common problems are that they may experience when using the hand and provide solutions to fix those problems.

9.9 Review

9.9.1 Study checklist

Simple machines

- explain how a mechanical advantage can be obtained from simple machines such as levers, inclined planes, pulley systems and gears
- distinguish between speed- (or distance-) multiplying machines and force-multiplying machines
- describe the effects of forces that can cause objects to change the motion of an object
- recall that you cannot get any more energy out of a machine than you put in
- describe the action of levers in the human body

Compound machines

- distinguish between compound machines and simple machines
- identify how simple machines work together in compound machines such as bicycles, lifts, cranes and hydraulic brakes
- explain how friction can be reduced in machines to reduce energy losses

Science as a human endeavour

- explain how inclined planes made tasks easier in an ancient civilisation
- identify that mechanics and mechanical engineers need to know how simple and compound machines work to apply forces
- explain how sports scientists can use their knowledge of levers in the human body to improve the performance of athletes
- consider and discuss the advantages and disadvantages of a dependence on cars for transport
- identify some of the benefits of robots to humans

Individual pathways

ACTIVITY 9.1
Investigating mechanical systems
doc-6060

ACTIVITY 9.2
Analysing mechanical systems
doc-6061

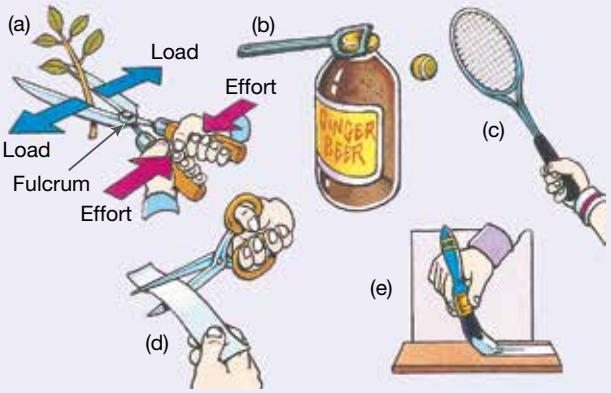
ACTIVITY 9.3
Investigating mechanical systems further
doc-6062

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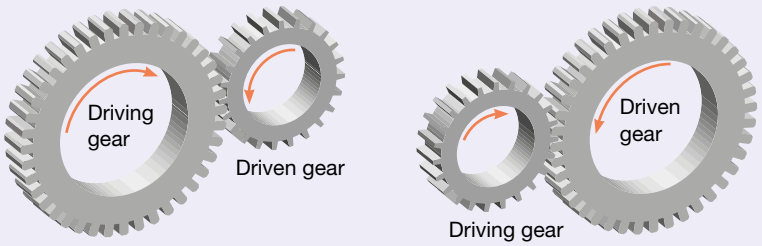
9.9 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

1. Copy the following diagrams and label the fulcrum, load and effort on each of the levers. The first diagram is labelled for you.



2. A student uses a pencil and ruler to model a first-class lever. It is tested by lifting 20-cent coins placed at one end of the ruler.
   (a) Draw a diagram to show how a pencil and ruler can be set up to model a first-class lever. Label the fulcrum, effort and load.
   (b) Calculate the mechanical advantage of the lever when it uses four coins to lift 12 coins.
   (c) If the 12 coins are placed six centimetres from the fulcrum, how far should the four coins be from the fulcrum to lift the larger pile of coins?
3. A flight of stairs is an example of a simple machine.
   (a) Which simple machine is a flight of stairs most similar to?
   (b) Are stairs force multipliers or speed multipliers? Explain your answer.
4. Which of the following is a speed multiplier and which is a force multiplier?



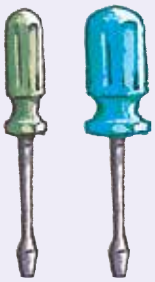
5. The plank below is 3.6 metres long. It is being used as a lever to lift a 40-kilogram box. This represents a load of 400 newtons.



   (a) If the fulcrum were placed in the centre of the plank, what downward effort would the man on the right of the diagram need to apply to raise the box?
   (b) If the man wants to push down on the end of the plank with an effort of only 200 newtons:
      (i) how far along the plank should the fulcrum be
      (ii) what would the mechanical advantage of the lever be?

(c) How could the mechanical advantage of the lever be increased?
(d) Is the plank being used as a speed multiplier or a force multiplier? Explain your answer.
(e) Suggest a different way of using the plank as a simple machine to get the box into the truck.

6. Imagine that you wanted to drive a screw into a length of wood. If you had a choice of using one of the screwdrivers illustrated on the right, which one would you use? State a reason for your choice.



7. A softball bat is an example of a speed-multiplying lever.
   (a) Explain why the softball bat is not a force-multiplying lever.
   (b) Where is the fulcrum of the softball bat?
   (c) Which class (first, second or third) of lever is the softball bat?
   (d) Which other lever is used to help the softball on its way at high speed?
8. The bicycle shown on the right is made up of many simple machines. Identify as many as you can. Classify the simple machines that you identify as levers, inclined planes, wheels and axles, pulleys and gears. If you look thoroughly, you might be surprised at how many you find.



9. Create a poster or a series of PowerPoint slides to explain how one of the following machines works. Ensure that you indicate whether the machine is a speed multiplier or a force multiplier.
   (a) Water tap
   (b) Eggbeater
   (c) Corkscrew
   (d) Bicycle gears

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Complete this digital doc: Worksheet 9.4: Thinking tools: Single bubble maps and Venn diagrams (doc-19854)

Complete this digital doc: Worksheet 9.5: Summing up (doc-19855)

Complete this digital doc: Worksheet 9.6: Looking back crossword (doc-19856)

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GLOSSARY

abiotic factors: describes the non-living things in an ecosystem
acid rain: rainwater, snow or fog that contains dissolved chemicals, such as carbon dioxide, that make it acidic. Acid rain can cause rock to weather faster than pure rain can.
acoustics: the study of sound and how the design of a room or theatre affects what is heard
adaptation: a feature that helps an organism to survive and reproduce in its environment
agriculture: the use of land to grow crops or raise farm animals
air resistance: the force of air pushing on an object as the object moves through the air
alloy: a mixture of a metal with a non-metal or another metal
alum: the common name for the chemical potassium aluminium sulfate
annular solar eclipse: occurs when the moon moves between the sun and the Earth. Because it is smaller, it blocks only the light from the central part of the sun, so that a ring of sunlight is seen
anthers: the stamen of a flowering plant consists of a filament, which supports the anther, which contains the male sex cells of the plant
aqueous solutions: solutions in which water is the solvent
arthropod: animal that has an exoskeleton, a segmented body and jointed legs (e.g. insects, crabs)
assimilate: take in and process
atom: a very small particle that makes up all things. Atoms have the same properties as the objects they make up
autotroph: organism that can produce its own nutrients
bacteria: the smallest life form found on Earth. Some types of bacteria are responsible for decay and disease
bar chart: a diagram using the lengths of rectangles (bars) to show the size of the same property for different objects or at different times. The bars may be horizontal or vertical; also called a column graph
beaker: container for mixing or heating substances
bilateral symmetry: symmetrical or looking the same along one plane
binomial nomenclature: the system of naming organisms developed by Linnaeus. The first term is the genus to which it belongs and the second term is a descriptive name
bioaccumulation: the build-up of a chemical within an organism as a result of its progress along a food chain, inc*r*easing in concentration with repeated doses; also known as biomagnification
biochemist: a scientist who studies the composition and interaction of substances in living things
biodegradable: describes a substance that breaks down or decomposes easily in the environment
biological control: a method of controlling pests by introducing one of their natural enemies
biological survey: a procedure that involves observing, describing and counting organisms. Photographs and, in some cases, samples are taken
biomagnification: *see* bioaccumulation
biomass: material produced by living organisms
biomechanics: the study of how animals, including humans, move
biophysicist: a scientist who studies the forces, energy and electrical processes in living things
biotic factors: describes the living things in an ecosystem
black coal: a harder, drier form of coal than brown coal, formed from peat compressed over millions of years, with most of the moisture driven out by the weight and heat of the layers above; also known as anthracite
blackwater: waste water from the toilet system of a household; raw sewage
block and tackle: system of pulleys in which there are both fixed and moving pulleys
botany: the study of plants
brown coal: a form of coal formed from peat compressed over millions of years, with much of the moisture driven out by the weight and heat of the layers above; also known as lignite

buoyancy: a force which keeps objects floating
carnivore: animal that eats other animals
cellular respiration: the chemical reaction involving oxygen that moves the energy in glucose into the compound ATP. The body is able to use the energy contained in ATP
centrifuging: separating a mixture by rotating the container quickly. The heavier parts of the mixture move to the outside of the spinning container
cerebrum: the largest part of the brain responsible for higher order thinking and decision making
chemical control: the control of plant or animal pests by the use of chemicals
chemical reaction: a chemical change in which one or more new chemical substances is produced
chlorophyll: the green-coloured chemical in plants that absorbs the light energy used in photosynthesis to make food from carbon dioxide and water
circumference: the outer boundary of a circular area
cloud: a visible collection of small water droplets in the air high above the ground
colloid: a mixture in which extremely small particles of one substance are spread evenly throughout another substance
column graph: *see* bar chart.
commensalism: where one organism benefits without affecting the other
community: all the populations of various organisms, both plant and animal, living in a given area at the same time
compost: waste material deliberately left to be decomposed by organisms such as fungi, bacteria and worms
concentrated: describes a solution containing a large amount of solute
concentration: the process of making a substance stronger or purer by removing or reducing the proportion of what is foreign or inessential; for example, separating mineral ore from unwanted soil, sand and other minerals
concept map: a visual thinking tool that shows the connection between ideas
conclusion: what was found out in an investigation. It is a general statement that sums up a number of observations or the results of an experiment. The conclusion of an experiment relates to the stated aim
condense: change state from gas to liquid
conductors: materials that allow electric charge to flow through them
consumer: organism that relies on other organisms for its food
contact force: a force that acts only between objects that are touching
contaminated: describes a useful substance that contains one or more other substances that affect its use
continuum: a visual thinking tool that shows extremes of an idea or where people 'stand' on a particular idea or issue
control group: a parallel experiment where everything is the same as the test set-up except the variable. It is used to ensure that the result is due to the variable and nothing else
controlled: kept the same
controlled variables: the conditions that must be kept the same throughout an experiment
corrosive: describes a chemical that wears away the surface of substances, especially metals
crust: the outer layer of the Earth, including all landforms, rocks and soil
cryptobiosis: a state of suspended metabolism into which an organism enters in response to extreme adverse conditions until such time as conditions are favourable again, at which point normal metabolism is resumed
crystallisation: a separation technique that uses evaporation to separate the parts of a solution. The solvent evaporates and leaves behind the solute as crystals.
cycle: a visual thinking tool that shows order and sequence
data: observations or measurements made and recorded during an investigation
dead: once alive but now not alive

decanting: pouring liquid off the top when sediment has settled to the bottom of the container
decomposers: small organisms that break down dead and decaying matter
deforestation: the removal of trees from the land
denitrifying bacteria: bacteria in the soil that chemically change useful nitrate compounds into poisonous nitrites and ammonia gas
dependent variable: a variable that is expected to change when the independent variable is changed. The dependent variable is observed or measured during the experiment
deposition: the laying down of weathered rock particles and soil by rivers, wind, oceans and glaciers
desalination: the conversion of sea water to fresh water
detritivores: organisms that consume detritus; that is decomposing plant and/or animal parts or faeces
detritus: decomposing plant and/or animal parts or faeces
dichotomous: a diagram used to classify things, by grouping them into smaller and smaller groups that are more and more alike, based on choosing one of two features
dilution: the process of adding more solvent to a solution to make it less concentrated
dissolved: describes a substance that has mixed completely with a liquid so that it is no longer visible. Dissolving requires the substance to separate into very small particles
distillate: the liquid collected during distillation when the evaporated substance condenses
distillation: a separation technique that uses evaporation to separate substances. The mixture is heated so that one substance evaporates. The vapour is collected and condenses into a liquid
distilled water: pure water collected by condensing steam
domains: the three domains of classification are Archaea, Bacteria (true bacteria) and Eukarya (all the living things made up of one or more cells with a nucleus). These three domains are then divided into kingdoms
driven gear: gear that is moved by another gear
driving gear: gear that causes another to move
ecological footprint: estimate of the amount the Earth's productive land and water required to supply the resources for an individual's or group's activities
ecological niche: specific conditions to which an organism is able to live within
ecology: the study of the way in which organisms interact with other organisms and with their environment
ecosystem: community of living things that interact with each other and with the environment in which they live
ectoparasite: parasite that lives outside its host
effort: force used to cause movement
electrons: very light, negatively charged particles inside an atom. Electrons move around the central nucleus of an atom
electrostatic force: a non-contact force of electric charges at rest. We experience electrostatic forces when we pull off a jumper and our hair stands on end
emulsion: a colloid with droplets of one liquid spread evenly through another
endoparasite: parasite that lives inside its host
endoskeleton: skeleton or shell inside the body
enhanced greenhouse effect: an intensification of the greenhouse effect caused by pollution adding more carbon dioxide and other greenhouse gases to the atmosphere; associated with global warming
entomological: relating to insects
entomology: the study of insects
environment: the living and non-living things that affect organisms in a particular place that is, the surroundings of a living thing
erosion: the process of moving weathered rock or soil from one place to another
etymology: the study of words, their origin and their grammar

eutrophication: a form of water pollution involving an excess of nutrients such as nitrates and phosphorus leaching from soils, typically resulting in excessive growth of algae
evaporate: change state from liquid to gas
excrete: get rid of waste
exoskeleton: skeleton or shell that lies outside the body
fair test: a method for determining an answer to a problem without favouring any particular outcome another name for a controlled experiment
fertilisers: chemicals added to soil to provide the nutrients needed for plant growth
filter: a device that allows some materials to pass through. It blocks particles too large to fit through the holes or pores
filter funnel: used with filter paper to separate solids from liquids
filtrate: liquid that has passed through a filter; that is, a porous material through which fluid can pass while suspended particles are retained
filtration: the process of separating suspended particles from fluid through a filter
first trophic level: the lowest level of a food web which contains the most amount of available energy
first-class lever: lever with the fulcrum between the effort and the load
fishbone diagram: a visual thinking tool that analyses and compares
flammable: describes substances such as methylated spirits that burn easily
floatables: substances that are less dense than water so can float on water
floc: a clump of particles heavy enough to sink to the bottom rather than remain floating in a liquid
flocculation: the process of adding a chemical to a suspension to create flocs, which settle to the bottom
flowchart: a visual thinking tool that shows order and sequence
fluid: a substance that flows and has no fixed shape. Gases and liquids are fluids
fog: a visible collection of small water droplets in the air at ground level
food chain: diagram, beginning with a producer or producers, that shows what organisms eat
food web: a number of food chains joined together
force: (noun) a push, pull or twist. Forces are measured in newtons (N). (verb) to push, pull or twist
force multiplier: simple machine that supplies a greater force than the effort used. The effort must be applied over a greater distance than the load is moved
forensic psychology: a branch of psychology (the study of mind and behaviour) dealing with the law
forensic scientists: people who use methodical gathering and analysis of scientific evidence to establish facts that can be presented in a legal proceeding
fossil fuel: substance, such as coal, oil and natural gas, that has formed from the remains of ancient organisms. Coal, oil and natural gas are often used as fuels; that is, they are burnt in order to produce heat
fourth trophic level: the forth level of a food web
friction: a force that acts against the movement of an object. It occurs between any surfaces that are touching and trying to move past each other
froth flotation: process used to separate a mixture of mineral particles by adding a substance that floats to the top with one of the minerals attached
fulcrum: point around which a lever turns
full moon: the view of the moon seen from Earth when the whole of its near side is in sunlight. The shape seen is circular
gangue: leftover waste rock and mineral material. It is produced during the processes that extract mineral ores
gear: toothed wheel that can turn other toothed wheels
geothermal energy: heat energy transferred from rocks below the Earth's surface
germination: first sign of growth from the seed of a plant
global warming: the observed rise in the average near-surface temperature of the Earth

glucose: a simple carbohydrate and the simplest form of sugar
gravity: the force of attraction that exists between any two bodies in the universe that have mass. The gravity at the Earth's surface is the pull on objects near its surface towards the centre of the Earth
gravity separation: separation of heavier particles in a mixture, by shaking or spinning them. The heavier particles move to the bottom of the container
greenhouse effect: a natural effect of the Earth's atmosphere trapping heat, which keeps the Earth's temperature stable. The sun's energy passes through the atmosphere and warms the Earth. Heat energy radiated from the Earth cannot pass through the atmosphere and is trapped
greenhouse gas: one of a number of gases found in the atmosphere that contribute to the greenhouse effect, trapping the sun's heat (for example, carbon dioxide)
greywater: wastewater from the kitchen, bathroom or laundry system of a household; it can be used for watering lawns and gardens, or for other purposes, instead of being drained into the sewerage system
groundwater: rainwater that has soaked into the lower levels of the soil and has saturated the soil
groyne: a jetty built into the sea to prevent the erosion of the beach
gyres: permanent circulating deep ocean currents that enclose huge areas between continents
habitat: the place in which a particular organism lives
habits of mind: reactions to gaining knowledge, studied by Bena Kallick and Arthur Costa
herbivore: animal that eats only plants
heterotroph: an organism that depends on another organism to supply its complex molecules and energy
histogram: a graph with equal intervals marked on the *x*-axis for the values of a quantity, and frequency of occurrence of each value shown by the height of adjoining columns
host: the organism on which a parasite feeds
humus: organic matter resulting from the decomposition of plant and animal tissue in the soil. Humus helps the soil hold water and mineral nutrients needed by plants
hydro-electric: power produced by the energy of falling water
hypothesis: a suggested explanation for past observations that is tested in an experiment
inclined plane: simple machine that uses sloping surfaces to reduce the effort required for a task
independent variable: the variable that the scientist changes to observe its effect on another variable
inference: a suggested logical explanation for an event or occurrence
insoluble: describes a substance that will not dissolve in a liquid
insulators: materials that do not allow electric charge to flow through them
intraspecific competition: members of one species compete for the same resources
introduced species: species that is not native to an ecosystem. It has been brought in from another ecosystem
invertebrates: animals without backbones
kingdom: a scientific classification referring to a group of related phyla with similar features and distinctive characteristics
landfill: an area set aside for the dumping of rubbish
lever: simple machine usually consisting of a long, rigid object that moves around a turning point when a force is applied
lightning rod: conductive metal rod, often attached to the top of tall buildings. Lightning rods help to keep buildings safe from lightning strikes
line graph: a graph made by plotting pairs of data as points and joining the points together, or drawing a line through the middle of the points, called the 'line of best fit'
load: force, such as the weight of an object, resisting motion against which a lever works
lobe: one of the four primary areas of the cerebrum
lubricant: substance with large particles that can slide easily over each other. Lubricants are used between surfaces that rub against each other to reduce wear and increase motion between the surfaces

lunar eclipse: occurs when the Earth moves between the sun and the moon so that some or all of the moon's surface does not receive light from the sun and cannot be seen
machine: device that makes a physical task easier. Machines are energy converters
magnetic field: a map of lines showing the size and direction of a magnetic force. The size of the force is shown by how close together the lines are. The direction at any point is given by the direction in which the north pole of a magnet would face
magnetic force: the force (a push or pull) that acts between magnets (including the Earth) and magnetic objects
manufacturing processes: processes used to make products
marsupial: the order of non-placental mammals that are born at a very early stage of development and then grow inside their mother's pouch
mass: a measure of the amount of material in an object of substance
matrix: a visual thinking tool that analyses and compares
measuring cylinder: used to measure volumes of liquids accurately
mechanical advantage: the advantage of force-multiplying levers or other machines as defined by load/effort
mechanical engineer: a person who uses designs or scientific ideas to design and build devices or structures for a useful purpose and make them work
mechanics: a study of science concerned with physical bodies and forces
meniscus: the curve which a liquid shows when in contact with a surface, specifically within a tube
metabolism: the chemical reactions occurring within an organism that enable the organism to use energy and grow and repair cells
method: the steps of an investigation or experiment
microbiology: the study of micro-organisms, living things too small to see without a microscope
mineral ore: a substance that contains minerals of values, that can be obtained by mining
minerals: substances that make up rocks. Each mineral has its own chemical make-up
mining: the process of removing mineral ore from the ground
monoculture: crops grown on land used for one kind of crop only
monotreme: the order of non-placental mammals that lay leathery-shelled eggs and secrete milk through pores in the skin
multicellular: having many cells. Most plants and animals are multicellular
multiple intelligences: eight types of intelligences suggested by Howard Gardner
mutualism: a relationship between two organisms in which both benefit
natural gas: a fossil fuel consisting of mainly methane
neap tide: a weaker high and low tide that occurs when the sun and moon are not in the same line as the Earth. At such times, the gravitational pull of the sun and the moon work against each other
negative electric charge: the charge on an atom or object with more electrons than protons
neuron: cell designed to carry electrical impulses by which the nervous system functions nerve cells
neutral: having the same number of protons and electrons
neutrons: tiny, but heavy, particles found in the nucleus of an atom. Neutrons have no electrical charge
newton: the unit for measuring forces
niche: the conditions in which an organism lives
nitrifying bacteria: bacteria that change dissolved ammonia into nitrite compounds, or nitrites into nitrate compounds
nitrogen-fixing bacteria: bacteria which take nitrogen containing compounds from the atmosphere and convert them into other compounds, which are able to be contained within soil
non-contact force: a force that acts between objects even though the objects are not touching
non-living: not ever alive, as distinct from dead

non-renewable resources: resources that are not replaced easily. Fossil fuels such as coal, oil and gas are non-renewable resources
north pole: the end of the magnet that, when free to rotate, points to the North Pole of the Earth. The poles of the Earth are the points where the axis of the Earth's rotation meets the Earth's surface
nuclear energy: the energy stored at the centre of atoms, the tiny particles that make up all substances. Nuclear energy can be released from the radioactive metals uranium or plutonium and transformed into electrical energy in a nuclear power station
nucleus: roundish structure inside cells that acts as the control centre for the cell. Plural = nuclei
observations: information obtained by the use of our senses or measuring instruments
ocean wave energy: a renewable energy created by converting the mechanical energy of ocean waves to electrical energy
omnivore: animal that eats plants and other animals
open-cut mining: a method of mining mineral ores that are close to the surface — a large hole is made to expose the rocks, which are then broken up using explosives
orbit: the curved path of a celestial object or spacecraft about a star or planet, for example the path of the Earth around the sun or the moon around the Earth
organisms: living things
osmosis: the process of separating using a membrane through which one constituent cannot pass
ovaries: contain the female sex cells or ova
overburden: rock, soil and vegetation, which are removed before mining can commence
ovule: receptacle within an ovary that contains egg cells
palaeontology: the study of fossils
paper chromatography: method of separating a mixture of different colours. The liquid soaks through the paper and carries the mixture with it. Some substances are carried faster than others so the substances are separated along the paper
parallax error: when scales are read from a different angle, the reading is not accurate. This type of reading error is called parallax error
parasite: organism that lives in or on another organism. The parasite benefits while usually harming the host organism
parasitism: a relationship between two organisms in which one benefits from the other without both benefiting
partial solar eclipse: occurs when the moon moves between the Earth and the sun and prevents some of the sun's light reaching a place on Earth. The part of the sun from which no light is received is not visible
peat: partially decomposed plant matter, buried and compressed over millions of years by layers of other plants in marshy or damp regions
permanent magnet: a magnet that retains its magnetic effect for many years
pesticide: a substance or preparation for destroying pests, usually by being poisonous to them
pharmacology: the study of the effect of drugs on living things
phases: shapes observed in a repeated pattern of changes
phloem: cells carry the food made in the leaves to all parts of the plant
photosynthesis: the food-making process in plants that takes place in chloroplasts within cells. The process uses carbon dioxide, water and energy from the sun
pie chart: a diagram using sectors of a circle to compare the size of parts making up the whole; also called a sector graph
pitch: the distance between two turns of the thread of a screw
placental mammal: the order of mammals in which the young grow inside the mother, receiving nutrition via a cord attached to the placenta, and are born at a well-developed stage
plasma: the yellowish, liquid part of blood that contains water, minerals, food and wastes from cells

platelets: small bodies involved in blood clotting. They are responsible for healing by clumping together around a wound
PMI chart: a thinking tool that helps you visualise and reflect on an idea. It consists of three columns headed 'plus', 'minus' and 'interesting'
pollen: fine powder containing the pollen grains (the male sex cells of a plant)
pollination: transfer of pollen from the stamen (the male part) of a flower to the stigma (the female part) of a flower
pollinators: organisms such as bees, flies, and other organisms which carry pollen either from one area of a plant to another or from one plant to another and which bring about fertilisation of flowering plants
pollutant: harmful substance released into the environment
pollution: the introduction of harmful substances or products into the environment
population: all the individual organisms of one particular species in a given area at one time
porous: having many pores or other small spaces that can hold a gas or liquid or allow it to pass through
positive electric charge: the charge on an atom or object with fewer electrons than protons
pressure: a push or squeeze on an object
prions: abnormal and infectious proteins that cause a variety of degenerative neurological diseases
priority grid: a thinking tool that helps quantify or rank ideas
proboscis: a long feeding tube attached to the head of some insects. It sometimes rolls up when not in use
procedure: the steps of an investigation or experiment, also known as the method
producers: organisms, such as plants, that use photosynthesis to make their own food from the sun's energy
prokaryotic: a type of cell in which there are no membrane-bound organelles, such as the nucleus. Eukaryotic cells do contain a nucleus
properties: the qualities and characteristics of materials and the substances that they are composed of
protein: chemical made up of amino acids needed for the growth and repair of the cells in living things
protoctistan: organism classified as belonging to the Protoctista kingdom
protons: tiny, but heavy, particle found in the nucleus of an atom. Protons have a positive electrical charge
purification: the removal of impurities from metals to produce a pure metal
radial symmetry: a property of an object in which it is symmetrical about one axis
radiochemistry: the study of radioactive substances
ramp: simple machine, called an inclined plane, that reduces the effort required to raise objects to a higher level
raw materials: materials before they are made into a final form
recycling: treating items such as glass, paper, plastic, aluminium and steel so that new products can be made from them
red blood cells: living cells in the blood that transport oxygen to all other living cells in the body. Oxygen is carried by the red pigment, haemoglobin
reduction: bringing a mineral ore into a metallic state by separating the non-metallic constituents
renewable resources: resources that are replaced easily. Energy from the sun, wind and water are renewable resources
repulsion: an opposing force
residue: the material remaining as a solid on a filter paper after a liquid passes through in the filtration procedure
results: the details or data that are recorded from the outcome of an investigation
reverse osmosis: a technique by which a fluid moves under pressure through a membrane from a high solute concentration to a lesser concentration; used to purify water
revolution: movement around an orbit

robot: complex combination of machines designed to perform tasks without human assistance
rotation: the turning of the Earth about its own axis (between the North and South Poles). It takes 24 hours to complete one rotation
safety glasses: plastic glasses used to protect the eyes during experiments
salinity: a measure of how salty a substance is; commonly used to describe soil that contains too much salt for the healthy growth of plants
saprophytes: organisms such as fungi which obtain nutrients from dead organic matter
saturated: unable to dissolve any more solute
screw: curved inclined plane
second trophic level: the second level of a food web above the most energy dense trophic level
second-class lever: lever with the load between the effort and the fulcrum
sector graph: *see* pie chart
sediment (1): the material that collects when suspensions are left to stand. Insoluble substances that collect at the bottom of a container are sediments
sediment (2): a substance deposited on land or in rivers, lakes or oceans
sedimentary rocks: rocks formed from sediments deposited by water, wind or ice. The sediments are cemented together in layers, under pressure.
seed: product of a fertilised ovule
seismology: the study of earthquakes
separating funnel: a pear-shaped glass container, with a tap at its base, used to separate two liquids that do not mix. Opening the tap removes the bottom liquid and the liquid floating on top is left in the funnel
septic tank: a sewage treatment system placed underground in backyards of houses not connected to town sewage treatment plants
sewage: a mixture of water and substances that flow from laundries, bathrooms, kitchens and toilets
sewerage: the system of drains and pipes that takes sewage away from a property
sieving: separating particles of different sizes by allowing the smaller particles to fall through holes in a container
smelting: melting mineral ore in order to separate the metal contained
soil: a complex mixture of the products of weathering and organic matter, both living and dead
solar eclipse: occurs when the moon moves between the Earth and the sun and prevents some or all of the sun's light reaching a place on Earth. The part of the sun from which no light is received is not visible
soluble: describes a substance that will dissolve in a liquid
solute: a substance that is dissolved in a solvent to form a solution
solution: a mixture of a solute dissolved in a solvent. Solutions are transparent but may be coloured.
solvent: a substance in which a solute dissolves to form a solution
south pole: the end of the magnet that, when free to rotate, points to the South Pole of the Earth. The poles of the Earth are the points where the axis of the Earth's rotation meets the Earth's surface
species: a group of animals with many features in common. Members of the same species can mate with each other to produce fertile young under natural conditions
speed multiplier: simple machine that increases the speed of an object. The effort applied must be greater than the load but applied over a shorter distance
sports psychology: the study of how athletes train their minds to help produce greater success in the sports arena
spring tide: very high tide that occurs when there is a new or full moon. At such times, the Earth experiences the combined gravitational attraction of the sun and the moon because all three bodies are in a straight line
sprockets: gears connected by a chain, as on a bicycle

starch: a complex carbohydrate that stores energy in plants
static electricity: a build-up of charge in one place
stigma: the female part of a flower, at the top of the carpel, that catches the pollen during pollination
storyboard: a visual thinking tool that shows order and sequence
streamlined: shaped so that drag through a fluid is minimised
style: the supporting part of a flower which holds the stigma
sucrose: a sugar molecule combining glucose and fructose. It is found naturally in sugar cane and other plants but not in animals
surface tension: the 'firmness' of the surface of a liquid created by the attraction between particles at the surface. The surface acts like an elastic skin
suspended: hanging, not falling or sinking
suspension: a mixture of a gas or liquid and an insoluble substance. The insoluble substance settles to the bottom when the mixture is left to stand
sustainability: able to be sustained or to continue for an indefinite time
sustainable: describes the concept of using the Earth's resources so that the needs of the world's present population can be met, without damaging the ability of future populations to meet their needs
SWOT analysis chart: a visual thinking tool that helps classify or organise thoughts
target map: a visual thinking tool that analyses and compares
technology: the application of science to the design of a device or process
temporary magnet: a magnet that stays magnetic only while it touches a permanent magnet, or one that is magnetic for a very short time
terminal speed: the constant speed reached by a falling body. A body reaches terminal speed when the force of gravity pulling it down is balanced by the air resistance pushing against it
test tube: thin glass container for holding, heating or mixing small amounts of substances
thermometer: a device which measures temperature
thinking hats: a thinking tool developed by Edward de Bono using different coloured hats for different types of thinking
thinking keys: a tool developed by Tony Ryan to help unlock thinking
third trophic level: the third level of a food web above the most energy dense trophic level
third-class lever: lever with the effort between the load and the fulcrum
thread: curved ridge of a screw formed by a winding inclined plane
tidal energy: a renewable energy that can be harvested from the tides in the ocean through the use of large underwater turbines placed in areas of high tidal movement
tide: the regular rise and fall of water level of the ocean, in a cycle close to twelve and a half hours
timeline: a visual thinking tool that helps sequence thoughts
total solar eclipse: occurs when the moon moves between the Earth and the sun so that all of the sun's light to a place on Earth is blocked by the moon
toxic: describes chemicals that are dangerous to touch, inhale or swallow
tracheophyta: plants with a vascular system
traction: a type of friction used to assist movement
transfer: move energy from one object to another using simple machines
transform: change one form (of energy) into another
transpiration: loss of water from plant leaves through their stomata
turbidity: a measure of how 'murky' or 'cloudy' a liquid is
turbines: wheels that, when turned, drive electrical generators. Steam or water are often used to turn turbines.
underground mining: a method of mining mineral ores that are deep below the surface, using shafts and tunnels dug deep into the ground to access the mineral ore
unicellular: describes an organism having only one cell

universe: all of space and the matter and energy contained in it
variable: quantity or condition in an experiment that can change
vascular tissue: structures which transport liquids
vector: organism carrying a disease
Venn diagram: a visual thinking tool that analyses and compares
vertebrae: the small bones that make up the backbone in vertebrates
vertebral column: the spine, or backbone, made up of many small bones called vertebrae
vertebrates: animals with backbones
viroid: smallest known infectious agent made up of very short pieces of naked RNA
virus: small particle that is able to grow and reproduce only inside living cells. The cells are destroyed as the virus leaves the cell. It is debatable whether a virus is a living organism
vulcanology: the study of volcanoes
waning: the change in the moon's appearance between a full moon and the following new moon
water condenser: a glass device for cooling a gas to form a liquid. It is a tube within a tube. The gas flows through the inner tube while water moves through the surrounding outer tube to cool the gas
water cycle: the constant circulation of water on Earth, as it evaporates from the sea, condenses into clouds and precipitates
water table: the top portion of the ground saturated by water
water vapour: the gaseous form of water, especially when diffused in the atmosphere and produced by evaporation at a temperature below boiling point (vs steam, the gaseous form of water produced by boiling)
waxing: the change in the moon's appearance between a new moon and the following full moon
weathering: the process of breaking down rocks by conditions in the atmosphere
wedge: simple machine, called an inclined plane, that reduces the force required to cut through objects or stop them from moving
weight: a measure of the size of the gravity force pulling an object towards the centre of a massive body, such as the Earth. The weight of an object depends on the object's mass
wheel and axle: lever that can rotate. The effort applied to the outside of the wheel produces a greater force on the axle because the effort is moved over a longer distance
white blood cells: living cells that fight bacteria and viruses. They are part of the human body's immune system
wind energy: a renewable energy derived from the wind (caused by uneven heating of the Earth and its oceans by the sun), for example by the use of wind turbines in a wind farm
***x*-axis:** the horizontal axis on a graph
xylem: xylem tissue carries water and minerals from the roots of plants to all other parts of the plant. It consists of long hollow tubes made up of the remains of dead cells
Y chart: a visual thinking tool that helps you visualise and reflect
***y*-axis:** the vertical axis on a graph
zoology: the study of animals

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