GOOD SCIENCE

VICTORIAN CURRICULUM

YEAR 7

EMMA **CRAVEN**

AARON **ELIAS**

Good Science 7 Victorian Curriculum
1st edition
Emma Craven
Aaron Elias
Rebecca Cashmere
Thomas Cosgrove
Sarah Edwards
Haris Harbas
Vicki Maggs
Natalie Stinson

Publisher: Catherine Charles-Brown
Publishing director: Olive McRae
Project editor: Sarah Blood
Proofreader: Kelly Robinson
Indexer: Max McMaster
Typesetter: Paul Ryan
Cover and text designer: Regine Abos
Digital production: Erin Dowling
Permissions researcher: Hannah Tatton
Illustrator: QBS Learning

First published 2021 by
Matilda Education Australia, an imprint of Meanwhile Education Pty Ltd
Level 1/274 Brunswick St
Fitzroy, VIC 3065
T: 1300 277 235
E: customersupport@matildaed.com.au
www.matildaeducation.com.au

National Library of Australia Cataloguing-in-Publication data

Author: Emma Craven, Aaron Elias
Title: Good Science Victorian Curriculum 7
ISBN: 9780655090007

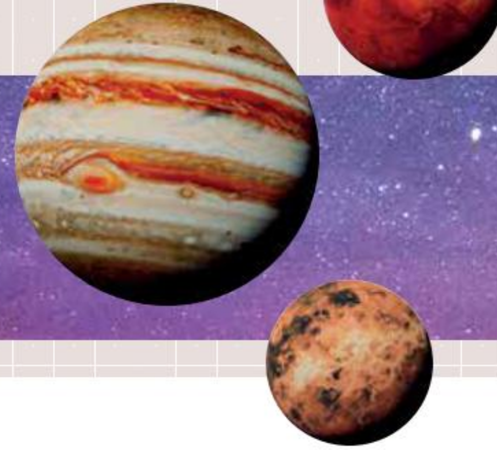
A catalogue record for this book is available from the National Library of Australia at www.nla.gov.au

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

Printed in Malaysia by Vivar Printing
1 2 3 4 5 6 7 25 24 23 22 21 20

MAKE EVERY LESSON A **GOOD** LESSON

CONTENTS



VICTORIAN CURRICULUM SCIENCE **LEVELS 7 AND 8**		
SCIENCE UNDERSTANDING: SCIENCE AS A HUMAN ENDEAVOUR		
VCSSU089	Scientific knowledge and understanding of the world changes as new evidence becomes available; science knowledge can develop through collaboration and connecting ideas across the disciplines and practice of science	▪ Chapter 5: Mixtures ▪ Chapter 7: Earth's resources ▪ Chapter 8: Forces ▪ Good Science 8
VCSSU090	Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations	▪ Chapter 3: Ecosystems ▪ Chapter 5: Mixtures ▪ Chapter 7: Earth's resources ▪ Good Science 8
SCIENCE UNDERSTANDING: BIOLOGICAL SCIENCES		
VCSSU091	There are differences within and between groups of organisms; classification helps organise this diversity	▪ Chapter 2: Classification
VCSSU092	Cells are the basic units of living things and have specialised structures and functions	▪ Good Science 8
VCSSU093	Interactions between organisms can be described in terms of food chains and food webs and can be affected by human activity	▪ Chapter 3: Ecosystems
VCSSU094	Multicellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce	▪ Good Science 8
SCIENCE UNDERSTANDING: CHEMICAL SCIENCES		
VCSSU095	Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques	▪ Chapter 5: Mixtures
VCSSU096	The properties of the different states of matter can be explained in terms of the motion and arrangement of particles	▪ Chapter 4: States of matter
VCSSU097	Differences between elements, compounds and mixtures can be described by using a particle model	▪ Good Science 8
VCSSU098	Chemical change involves substances reacting to form new substances	▪ Good Science 8
SCIENCE UNDERSTANDING: EARTH AND SPACE SCIENCES		
VCSSU099	Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the Sun, Earth and the Moon	▪ Chapter 6: Earth, the Sun and the Moon
VCSSU100	Some of Earth's resources are renewable, but others are non-renewable	▪ Chapter 7: Earth's resources
VCSSU101	Water is an important resource that cycles through the environment	▪ Good Science 8
VCSSU102	Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales	▪ Good Science 8

VICTORIAN CURRICULUM SCIENCE **LEVELS 7 AND 8**		
SCIENCE UNDERSTANDING: PHYSICAL SCIENCES		
VCSSU103	Change to an object's motion is caused by unbalanced forces acting on the object; Earth's gravity pulls objects towards the centre of Earth	▪ Chapter 8: Forces
VCSSU104	Energy appears in different forms including movement (kinetic energy), heat, light, chemical energy and potential energy; devices can change energy from one form to another	▪ Good Science 8
VCSSU105	Light can form images using the reflective feature of curved mirrors and the refractive feature of lenses, and can disperse to produce a spectrum which is part of a larger spectrum of radiation	▪ Good Science 8
VCSSU106	The properties of sound can be explained by a wave model	▪ Good Science 8
SCIENCE INQUIRY SKILLS: QUESTIONING AND PREDICTING		
VCSIS107	Identify questions, problems and claims that can be investigated scientifically and make predictions based on scientific knowledge	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8
SCIENCE INQUIRY SKILLS: PLANNING AND CONDUCTING		
VCSIS108	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8
VCSIS109	In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8
SCIENCE INQUIRY SKILLS: RECORDING AND PROCESSING		
VCSIS110	Construct and use a range of representations including graphs, keys and models to record and summarise data from students' own investigations and secondary sources, and to represent and analyse patterns and relationships	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8
SCIENCE INQUIRY SKILLS: ANALYSING AND EVALUATING		
VCSIS111	Use scientific knowledge and findings from investigations to identify relationships, evaluate claims and draw conclusions	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8
VCSIS112	Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8
SCIENCE INQUIRY SKILLS: COMMUNICATING		
VCSIS113	Communicate ideas, findings and solutions to problems including identifying impacts and limitations of conclusions and using appropriate scientific language and representations	▪ Chapter 1: Science skills ▪ Investigations ▪ Good Science 8

SCIENCE SKILLS

How has good science changed the world?

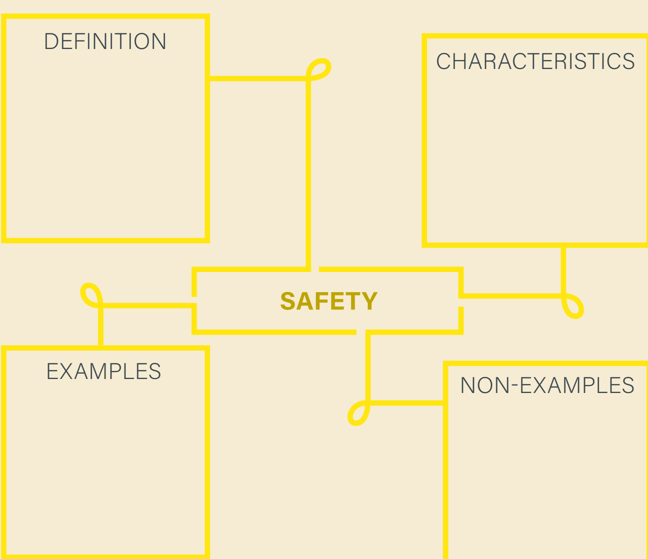
One of the very first things to consider as you embark into the study of science is what constitutes *good science*.

Good science is making sure that everything and everyone is safe, and that investigations and experiments are fair and measure what they are supposed to. It is identifying variables and controlling them carefully, and measuring accurately and precisely.

Good science involves curiosity, a desire to understand the world and a passion for improvement and innovation.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Hypothesis* and *Experiment*.

2 LEARNING LINKS

Brainstorm everything you already know about science skills.

3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.

4 CRITICAL + CREATIVE THINKING

THE REVERSE: What are some ways that you CAN'T get hurt in the science laboratory?

THE ALPHABET: Come up with a safety rule for every letter of the alphabet.

THE DISADVANTAGES: Name three disadvantages of a lab coat and then three improvements to fix those disadvantages.

5 THE ONLY!

Marie Curie was a Polish-French physicist and chemist. She was the first woman to win a Nobel prize and the only person ever to win a Nobel prize in two different scientific fields. Her research was mostly about radioactivity and she discovered two new elements – polonium and radium. Unfortunately she died in 1934 from exposure to radiation – safety guidelines and precautions were not as advanced then as they are now. Her notebooks are so radioactive that even now, nearly 90 years after her death, they still aren't safe to handle!

1.1 SAFETY IN SCIENCE

Figure 1.1 It's important to know where the eye wash station is in your school's science lab.

Figure 1.2 Safety glasses and rubber gloves reduce risk in the laboratory.

Safety is critical in science, because all investigations carry some degree of **risk**. From using a Bunsen burner to dissecting a sheep heart, things can go wrong if we don't plan and act in a safe manner.

1 Get to know good safety practices

Whenever you step into the lab for an investigation, it's important to identify **hazards** and use good safety practices to control the risk of them causing harm.

How many safe practices can you identify in the image below? Use each practice that you identify to make a safety rule for working in science.

It's important to know about these safety tools and materials in the science lab:

- *Safety glasses and shields* protect your eyes from fumes, particles and irritants.
- *Lab coats and aprons* protect your clothes and body from chemical spills, flames and other dangers.
- *Gloves and hand protectors* protect your hands when handling chemicals, biological materials and sharp objects.
- *Fire extinguishers* use dry chemicals (not water) to put out the flames if there is a fire.
- *Eye wash stations* are used if you get something in your eye. Never rub your eye – use the eye wash station to wash it instead.
- *Laboratory hoods*, also called fume hoods, are like exhaust fans in your bathroom or kitchen, removing gases and fumes.

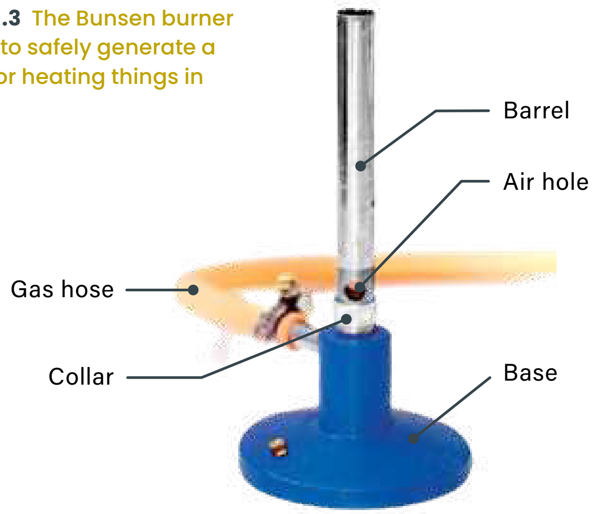
What are the uses of three pieces of laboratory safety equipment?

❷ Get to know Bunsen burner safety

A **Bunsen burner** is a common piece of scientific equipment and is most often used for heating things in the science laboratory. Learning how to set up and safely use a Bunsen burner is extremely important. Misuse can result in severe burns or gas leaks.

A Bunsen burner can operate two main flames: the **safety flame** and the **heating flame**. The safety flame is an orange flame and reaches temperatures of about 300°C. That sounds like a lot, but the heating (blue) flame reaches temperatures of about 1500°C!

Figure 1.3 The Bunsen burner is used to safely generate a flame for heating things in the lab.



SETTING UP AND LIGHTING A BUNSEN BURNER

1. Place a heatproof mat on the lab bench, place the Bunsen burner on top and connect the gas hose tightly to the gas tap.
2. Turn the collar of your Bunsen burner so that the air hole is closed.
3. Time for the safety check! Make sure long hair is tied back, safety glasses are on, you know the location of the fire extinguisher and blanket, and then check the gas hose for any cracks, holes or tears.
4. Ask your teacher to check the set-up of your Bunsen burner and provide any feedback.
5. The lighting of the Bunsen burner is best done by two people. Ask a lab partner to get ready to turn the gas tap on.
6. Light your match or taper before the gas tap is turned on and position it over the top of the barrel.
7. Ask your lab partner to turn the gas tap on.
8. Your Bunsen burner should now be lit. Move away from the burner and extinguish the match.

How hot is the orange flame of a Bunsen burner, and how hot is the blue flame?

KEY TERMS

Bunsen burner
a piece of equipment used in science that produces a single open gas flame

hazard
something that can harm living things, objects or the environment

heating flame
the blue (very hot) flame of a Bunsen burner (approx. 1500°C), used for heating substances

risk
the chance that a hazard will cause harm

safety flame
the orange (cooler) flame of a Bunsen burner (approx. 300°C), used between heating substances

⚠

AFTER YOUR BUNSEN BURNER IS ALIGHT, CALMLY TAKE THE MATCH OR TAPER AWAY FROM THE BURNER.

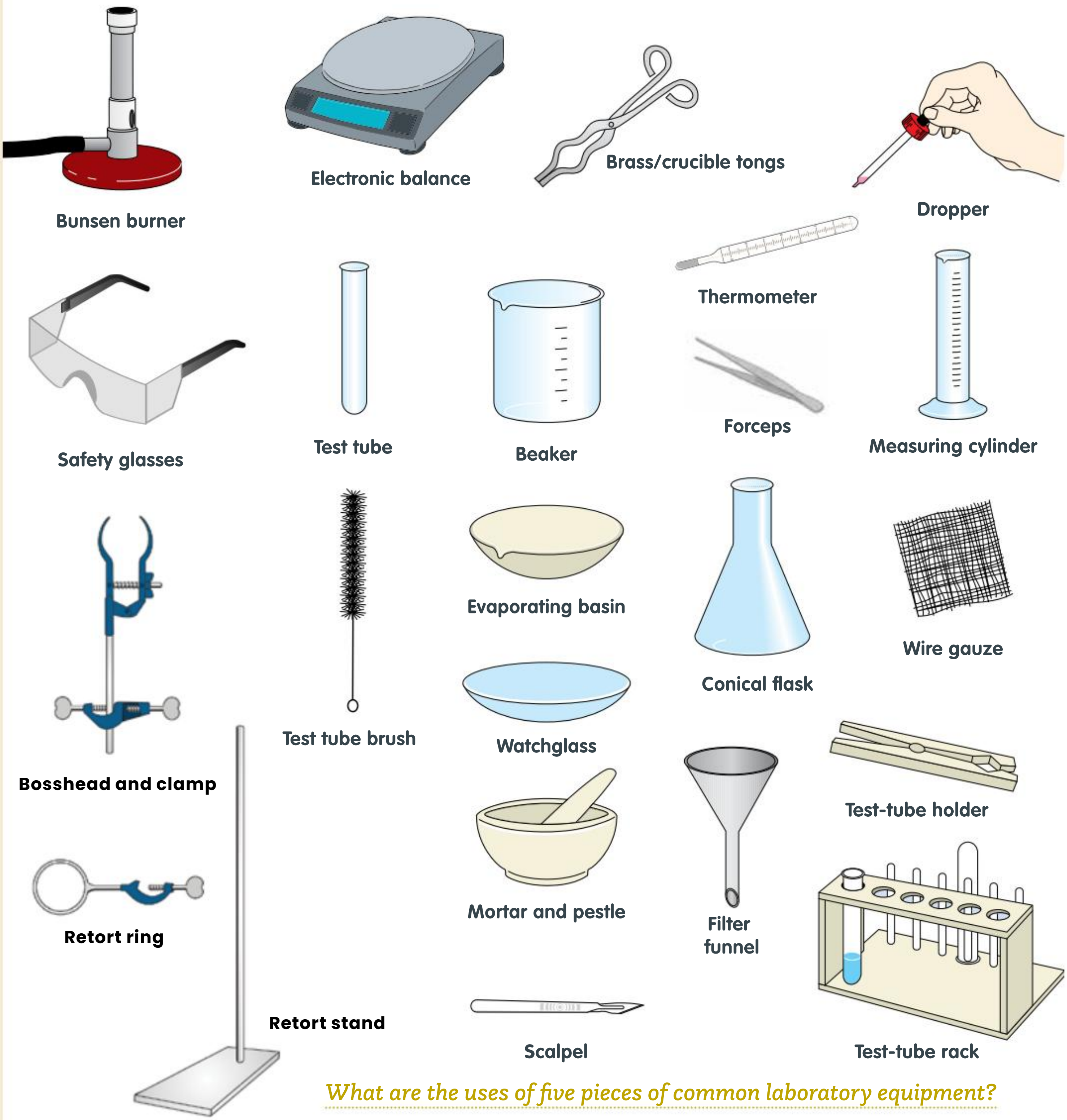
SHAKE OR BLOW THE FLAME AWAY FROM THE BURNER. IF YOU BLOW THE FLAME OUT NEAR THE BUNSEN BURNER, YOU RISK BLOWING OUT THE BURNER FLAME TOO.

IF THIS HAPPENS, CALMLY TURN OFF THE GAS VALVE AND START AGAIN.

1.2 LABORATORY EQUIPMENT

❶ Get to know common laboratory equipment

By learning the names and uses of laboratory equipment, you can select and use the correct equipment for any investigation. Some of the most common equipment is shown here.



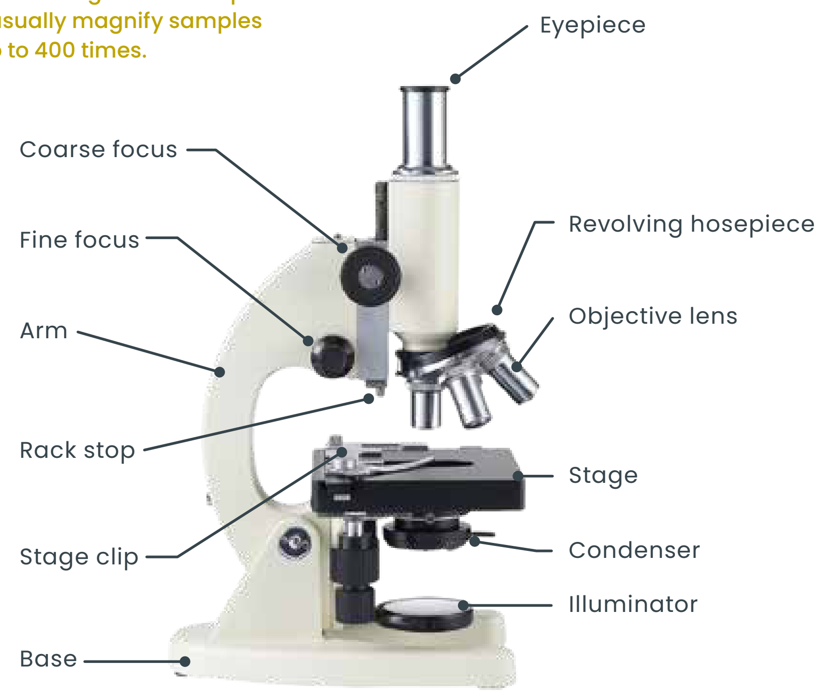
What are the uses of five pieces of common laboratory equipment?

❷ Get to know your light microscope

The most common type of microscope in the school science laboratory is a light microscope. It allows you to study samples by shining a bright light through an extremely thin slice of material. The image is magnified by the microscope's lenses, which you look through.

The eyepiece of a light microscope already magnifies samples by ten times. The objective lens, which is found lower down and usually rotates, then magnifies samples by a further amount. To identify the total magnification, multiply the eyepiece magnification (10) by the objective lens magnification.

Figure 1.4 A light microscope can usually magnify samples by up to 400 times.



SETTING UP AND USING A LIGHT MICROSCOPE

1. Place your microscope on the bench or table, making sure that it's not too close to the edge and that the arm is facing you.
2. Plug your microscope in and turn it on. The illuminator (light) will come on.
3. Lower the stage as far as it can go, using the coarse focus knob.
4. Consider each of the rotating objective lenses. Often they are different colours and have the magnification written on them.
5. Start with the lowest magnification – this is usually 4× (four times). Your microscope eyepiece already has a 10× magnification on its own, so when coupled with the 4× eye piece, what you are looking at will be 40 times the actual size.
6. Carefully insert the microscope slide onto the top of the stage and hold it firmly under the stage clip. Position it so the object you need to see is in the middle of the stage.
7. Look through the eyepiece and slowly bring the stage upwards towards you, using the coarse focus knob. This can take some time and everything will look bright and fuzzy until you get a glimpse of the slide as it comes into focus.
8. When the slide is roughly in focus, use the fine focus to turn it into a clear image.
9. Increase the magnification by changing the objective lens to 10×, 20× or 40×.
10. 40× is usually the highest available magnification and can be tricky to find and focus on. It can also bring the lens extremely close to the slide, enough to crack and break it – monitor this carefully.

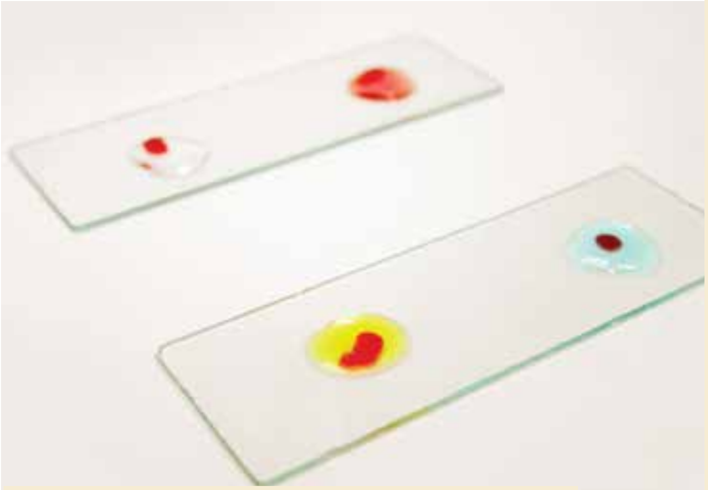


Figure 1.5 Microscope slides are usually made of glass and are very fragile – treat them carefully.

1.3 COLLECTING AND USING DATA

KEY TERMS

inference
an educated guess or judgement based on observations

observation
something you see and know to be true

prediction
a statement about the future based on observation and evidence

primary data
first-hand data, from your own investigation

qualitative
written descriptions and observations

quantitative
numerical information and data

secondary data
second-hand data, from someone else

CALCULATING THE MEAN

To calculate the mean (also known as the average) of a group of numbers, add all the numbers together and then divide them by how many numbers you added together.

For example, to calculate the average growth of plant 3 in the investigation about plants and sunlight (Table 1), you would add 2, 3 and 5, then divide by 3.

The mean would be $(2 + 3 + 5) \div 3 = 3.33$mm.

Data is like evidence – you need it to draw your conclusion. Scientists collect and analyse data to test their hypotheses.

1 Scientists collect different types of data

One way to describe data is that it can be **qualitative** or **quantitative**. Quantitative data relates to quantities – that is, numbers. Quantitative data can include the number of something, the volume, the length, time, or anything that scientists can physically measure or count. Qualitative data relates to the qualities of something – that is, written descriptions or observations about data.

Another way to describe data is as **primary data** or **secondary data**. Primary data is first-hand data that you collect yourself through scientific investigation. Secondary data is second-hand data, gathered by someone else and given to or accessed by you.

To make sure secondary data is valid and reliable (see lesson 1.4), you need to check that it comes from a reliable source. It's also important to make sure the data is accurate. If it is a survey, was the sample size large enough or did it only involve a small number of people? Are the results from just one country or population group?

How are qualitative and quantitative data different?

2 Data needs to be carefully collected and recorded

To ensure that their data is valid, scientists record observations and measurements very carefully. They might do this in a logbook or table for quantitative data. Qualitative data might be recorded in a journal or workbook. Sometimes data is visual and can be recorded with a camera.

When taking measurements and recording quantitative data, use the appropriate units for physical quantities. This table shows some common metric units for physical quantities.

Physical quantity	Measurement and unit	Conversion
Length	Millimetre (mm)	10 mm = 1 cm
	Centimetre (cm)	100 cm = 1 m
	Metre (m)	1000 m = 1 km
	Kilometre (km)	
Mass	Milligram (mg)	1000 mg = 1 g
	Gram (g)	1000 g = 1 kg
	Kilogram (kg)	
Volume	Millilitre (mL)	1000 mL = 1 L
	Litre (L)	
Temperature	Celsius (°C)	

Why is it important to use the correct units when measuring?

❸ Organising data makes it easier to understand

Collecting data isn't the end of the process – the data needs to be analysed and considered. That means it must be well organised and clearly presented, or else it will be difficult to understand.

One of the best ways to arrange and present scientific data is in a table. Always design and rule out your table before you start your investigation – this ensures you are ready and organised to collect the correct data, and that you don't forget to collect important data.

MAKING A GOOD SCIENTIFIC DATA TABLE

1 Use a ruler so that your table is clear and easy to read.
2 Give your table a descriptive and useful title and include a table number, in case you want to refer to it in your investigation report.
3 Include the units in the column headings where needed (e.g. mm).

INFERENCES, OBSERVATIONS AND PREDICTIONS

An **inference** is something you think might be the case, but you don't know for sure. An **observation** is something you see and know is definitely true. A **prediction** is what you think will happen in the future.

In science, an observation can often lead to an inference. You could observe that your cactus is dying, and then infer that this was because it was overwatered. You could then stop watering it and observe it again – this could re-inform and change your inference.

Clear descriptions in titles

Table has a number and title

TABLE 1: EFFECT OF SUNLIGHT ON PLANT GROWTH

Plant environment	Initial plant height (mm)	Growth after 1 week (mm)	Growth after 2 weeks (mm)	Growth after 3 weeks (mm)
Plant 1: no sunlight	181	0	−1	−3
Plant 2: indirect sunlight	175	1	2	4
Plant 3: direct sunlight	178	2	3	5

Units are given at the top of each column

Lines are ruled and easy to follow

Another way to present data is to illustrate it using a chart or graph. This is an excellent visual way to show the data from your table.

Why are tables used to organise data?

Figure 1.6 Charts, graphs and other visual tools can be used to present and explain data.

Figure 1.7 Recording your observations is a great way to gather first-hand data.

1.4 QUESTIONING, PREDICTING AND PLANNING

KEY TERMS

controlled variables
all the things that need to stay the same during an investigation

dependent variable
the thing that will be measured and is altered by the independent variable

experiment
an investigation carried out under controlled conditions, to test a hypothesis

fair test
an investigation in which only one factor is changed and all other variables are kept the same

fieldwork
an investigation conducted in the natural environment, not a laboratory

hypothesis
a scientific statement that can be tested

independent variable
the thing that is purposely changed during an investigation

reliable
provides consistent results when repeated

research
to gather data and information in an organised way to inform a hypothesis or investigation

valid
measures what is intended to be measured

Science is all about investigating – asking questions, looking at data and drawing conclusions about how things work. A scientist is like a detective, but instead of investigating a crime, they're investigating the world. To be useful, a good scientific test needs to follow certain principles.

1 Good science needs to be valid and reliable

When scientists design investigations, they ask themselves 'is this *good science*?'

To figure out if something is good science, you need to check that it's both **valid** and **reliable**. If a test is reliable, you can do the test over and over again and get very similar results. If a test is valid, it measures what it is supposed to measure.

Imagine you design a catapult that launches marshmallows and decide to test it against a friend's design. Just as your friend is firing the catapult, a massive gust of wind blows their marshmallow further than yours – that's not fair, right? It's not a valid outcome because the wind caused the increased distance, not the catapult. The test didn't measure what you wanted it to measure (the power of the catapult); it measured the power of the catapult *and* the power of the wind. It's not reliable because, if you did the test again, the wind might be weaker, stronger or not there at all.

Why does good science need to be valid and reliable?

2 A fair test needs to be controlled

Fair tests are essential for good science. A **fair test** is one in which only one variable is changed and all other variables are kept the same. Variables are the things that can be controlled, changed or measured during an investigation or experiment. There are three main types of variable: independent, dependent and controlled variables.

The **dependent variable** is what you are measuring in an investigation, and is what is altered by the independent variable. Examples include time in seconds or mass in grams. The **controlled variables** are all the things you will keep the same. Examples of controlled variables are temperature, mass, equipment, location and volume.

Figure 1.8
Experiments are carried out in order to test a hypothesis.

The **independent variable** is the one thing you want to change in an investigation. If you change more than one thing, the investigation probably won't be a fair test.

Let's say you decide to put three plants in three different amounts of sunlight to see which plant grows the most. You would make sure the plants were the same size, health and species, and only change the amount of sunlight the plant is getting – this is the independent variable. The dependent variable would be your measurement of the plants' growth (which could be their weight or their size) and the controlled variables are all the other factors.

What are the three types of scientific variable?

❸ A hypothesis is a prediction of the outcome

A **hypothesis** is a prediction made to test something. A good hypothesis involves some reading and research so that scientists can make an informed decision about what they think will happen, before testing it in an investigation. A hypothesis can be supported (found to be correct) or rejected (found to be incorrect).

You use the independent and dependent variables when writing a hypothesis, so the first step is always to identify these. The general rule to use when writing a hypothesis is:

independent variable

If I [do this], then [this] will happen.

dependent variable

Even though this rule has the word 'I' in it, that's not how you write the hypothesis! You should always write it formally and in the third person (don't use *I*, *we*, *you* etc.).

What is a hypothesis?

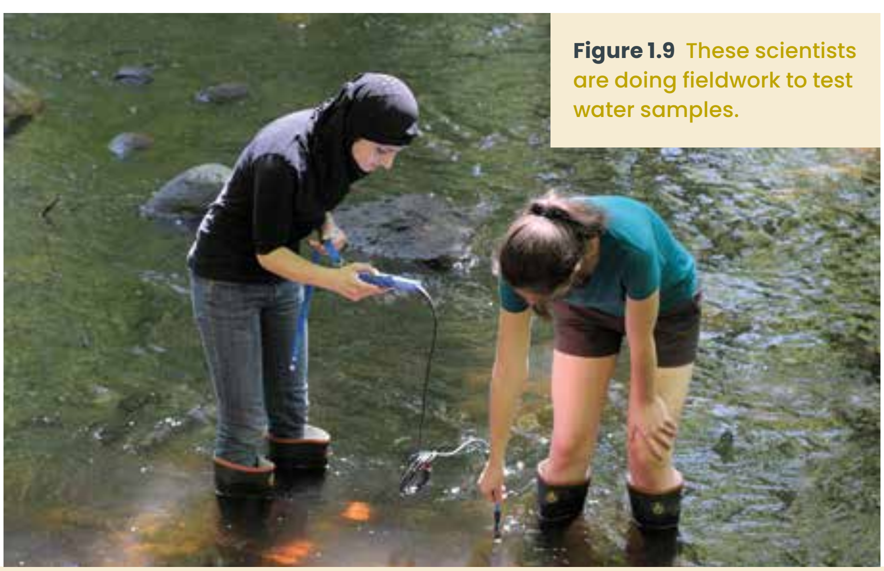


Figure 1.9 These scientists are doing fieldwork to test water samples.

ELEMENTS OF AN INVESTIGATION

Think again about the investigation that involves plants in different amounts of sunlight to see which plant grows the most. The elements of this investigation are:

- *hypothesis*: If a plant is placed in direct sunlight, then it will grow more than a plant in indirect or no light.
- *independent variable*: amount of direct sunlight (one plant is put in a dark cupboard, one is put outside in direct sunlight and one is put near a window)
- *dependent variable*: growth of the plant, in millimetres
- *controlled variables*: species of plant, starting size of plant, health of plant, amount of water given to plant.

TYPES OF INVESTIGATIONS

Scientists do many different types of investigations, depending on their area of science and the information they need to gather.

Fieldwork happens when information and data are collected outside of the laboratory or usual setting. Environmental scientists often do fieldwork, such as collecting water samples from streams to study the water quality or counting the numbers of species of plants and animals in an area.

Experiments are usually carried out to test a hypothesis. Experiments in science include (among other things) those undertaken in chemistry, physics, earth science, and with living things in biology.

Research informs a hypothesis before it is created. Scientists often share their research so they can build scientific understanding and discoveries over time.

1.5 WRITING INVESTIGATION REPORTS

Writing an investigation report is a key skill in science, and one you will use many times during scientific study. By writing a clear, consistent report at the end of your investigation, you ensure that other people will understand your work.

1 An investigation report has a consistent structure

Your investigation reports should typically have a similar structure to the one shown here.

The title should be clear and in plain language. Many scientists write their title as a research question.

HOW DOES THE AMOUNT OF DIRECT SUNLIGHT AFFECT PLANT GROWTH?

Use your research question/title to write your aim. You can start the aim with 'To investigate …'

AIM

To investigate whether the amount of direct sunlight affects growth of a certain species of plant

It is a good idea to include the variables in an investigation report. They can help you to write your hypothesis.

- Independent variable: amount of direct sunlight
- Dependent variable: growth of the plant (in millimetres)
- Controlled variables: species of plant, health of plant, amount of water given to plant

If your investigation is an experiment, then you should include a hypothesis. It should should refer to your independent variable and your dependent variable. Remember to write in the third person.

HYPOTHESIS

If a plant is placed in direct sunlight, then it will grow more than a plant in indirect or no light.

List all materials and equipment with amounts and sizes as simple bullet points.

MATERIALS

- 3 plants of the same species and of similar size
- 250 mL beaker

The method provides clear, step-by-step instructions.

Remember to number the steps of your method, and that traditionally methods are written in the past tense and third person. Methods should be written like a cooking recipe – very simple, clear and detailed. A good idea is to imagine that a younger student has to follow your method.

METHOD

1 Each plant was labelled 1, 2 or 3 and measured at the start of the investigation in order to get a starting height for each. The heights were recorded in a simple table.
2 Plant 1 was placed in a dark cupboard.
3 Plant 2 was placed near a window where it could receive indirect sunlight.
4 Plant 3 was placed outside in direct sunlight but sheltered from rain.
5 The height of the plants was measured every week for three weeks and the growth was recorded in the results table.
6 The plants were watered the same amount every three days.

RESULTS

TABLE 1: EFFECT OF SUNLIGHT ON PLANT GROWTH

Plant environment	Initial plant height (mm)	Growth after 1 week (mm)	Growth after 2 weeks (mm)	Growth after 3 weeks (mm)
Plant 1: no sunlight	181	0	−1	−3
Plant 2: indirect sunlight	175	1	2	4
Plant 3: direct sunlight	178	2	3	5

DISCUSSION

As the results in Table 1 show, the plant that had the most growth was the plant in direct sunlight (plant 3). The plant in direct sunlight had the highest growth, with 2 mm after the first week, 3 mm after the second week and 5 mm after the third week, compared to the plant in no sunlight (plant 1) which had no growth, then shrank and lost growth in weeks 2 and 3.

Use exact figures from your table and compare them to others, to show you have analysed the data.

The results make sense because sunlight is crucial in photosynthesis – the process by which plants transform sunlight into usable energy.

Describe your results (referring to the table or figures) in the discussion and link them to your understanding of science.

One error that may have occurred is in the amount of water given to each plant. The method could be improved by specifying the exact volume of water (in mL). There may have also been some errors to do with accurately measuring the plants. The method could be improved by including photos of the plants against the same ruler backdrop, to improve the accuracy of measurements.

Identify any potential errors here and suggest improvements to the method to try to control these. Discussion questions can be answered here too.

CONCLUSION

The results of this investigation show that the amount of direct sunlight does impact on the growth of this species of plant. The investigation supported the hypothesis that if this species of plant is put in direct sunlight, it will grow more than a plant of that species in indirect or no light. This is due to more sunlight being available for photosynthesis, which is how plants grow.

Your conclusion summarises the investigation by responding to the aim.

Mention whether the results supported or rejected your hypothesis, and briefly summarise the investigation, but don't introduce any new information.

REFERENCES

BBC, 2019. What is photosynthesis? [online] Available at: https://www.bbc.com/bitesize/articles/zn4sv9q. [Accessed 5 January 2019]

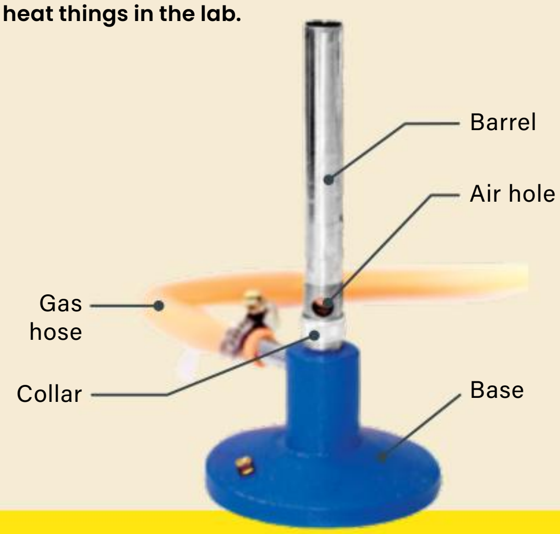
References show the source of any information you used that was not your own.

This is particularly important when you use secondary data.

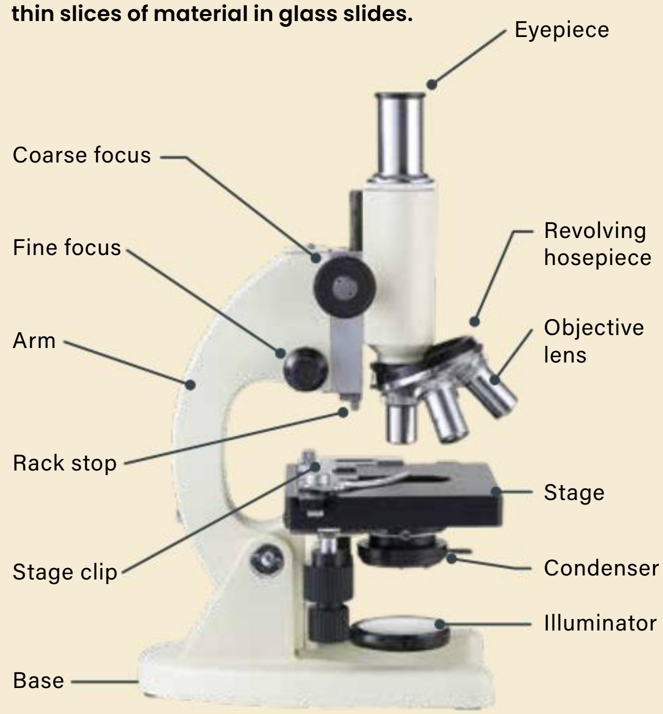
Many investigation reports also include a background information section at the beginning, and it is important to identify in your references where you found that information.

VISUAL SUMMARY

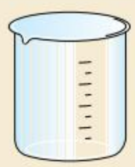
Bunsen burners are used to safely heat things in the lab.



Light microscopes are used to study thin slices of material in glass slides.

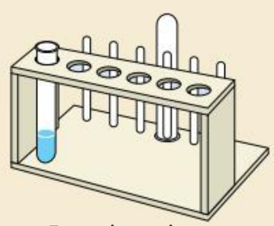


Common laboratory equipment


Beaker


Test tube


Conical flask


Test-tube rack

All investigations start with a hypothesis.

If I [do this], then [this] will happen.

[do this] – independent variable

[this] – dependent variable

Use tables to organise your data.

TABLE 1: EFFECT OF SUNLIGHT ON PLANT GROWTH

Plant environment	Initial plant height (mm)	Growth after 1 week (mm)	Growth after 2 weeks (mm)	Growth after 3 weeks (mm)
Plant 1: no sunlight	181	0	−1	−3
Plant 2: indirect sunlight	175	1	2	4
Plant 3: direct sunlight	178	2	3	5

Table has a number and title

Clear descriptions in titles

Units are given at the top of each column

Lines are ruled and easy to follow

★ FINAL CHALLENGE ★

1. Explain what a hazard is in your own words.
2. Identify three potential hazards in a scientific laboratory and suggest how to minimise the risks of each.
3. Calculate the mean of the following data set: 2, 5, 3, 12, 15.

Level 1 ★☆☆☆☆☆ **50xp**

4. Draw a Bunsen burner and label the key parts.
5. Explain the difference between qualitative and quantitative data and give an example of each.
6. Label the following pieces of laboratory equipment.

____________ ____________ ____________

Level 2 ★★☆☆☆☆ **100xp**

7. What is the difference between the independent, dependent and controlled variables?
8. Label the following statements about Bunsen Burners as true or false.
   - **a** The air hole on a Bunsen burner should be closed when lit.
   - **b** The safety flame on a Bunsen burner reaches a temperature of approximately 100 degrees.
   - **c** The gas should be turned on before the match or taper is lit.
   - **d** The blue flame on a Bunsen burner can reach approximately 1500 degrees.

Level 3 ★★★☆☆☆ **150xp**

9. Is a set of data that has been sourced from the internet an example of primary or secondary data? Explain your answer.
10. If a light microscope has an eyepiece magnification of 10 and an objective lens magnification of 20, calculate the total magnification of a sample observed through both lenses.

Level 4 ★★★★☆☆ **200xp**

11. Write a how-to-guide to help a younger student create a scientific data table.
12. Consider the sample investigation report in lesson 1.5. In your opinion, is the experiment described in the report valid and reliable? Justify your response.

Level 5 ★★★★★★ **300xp**

CLASSIFICATION

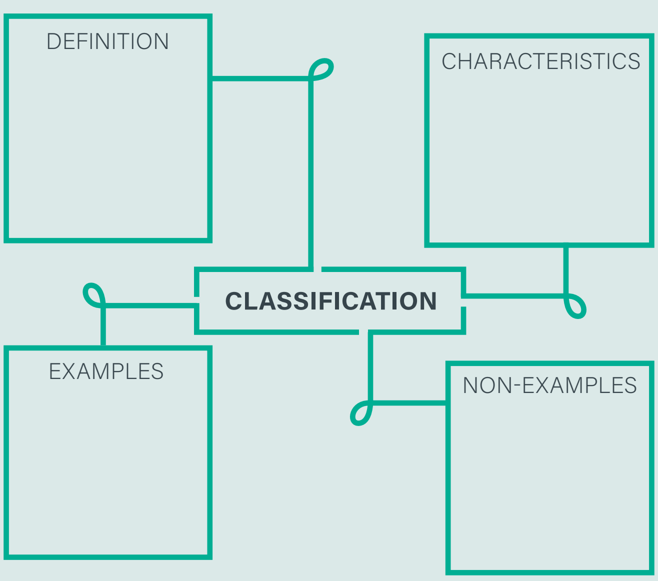
How do living things affect each other?

Scientists use classification systems to organise and identify all living things. This allows them to compare and investigate species, including how closely related they are.

When the first platypus was sent from Australia to scientists in England in the late 18th century, they thought it was a prank, and that someone had sewed a duck bill onto a large water rat. Given that a platypus has a bill, is furry but lives in water, lays eggs and produces venom, it does seem a bit strange! After their initial surprise, scientists were later able to classify the platypus as a monotreme – a special kind of mammal that lays eggs.

1 FRAYER MODEL

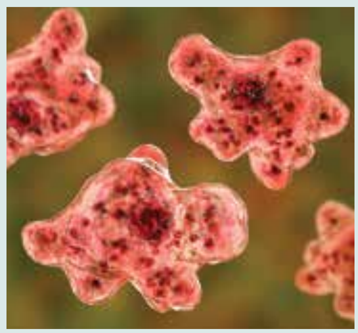
Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Living* and *Non-living*.

2 LEARNING LINKS

Brainstorm everything you already know about classification.



3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.

4 CRITICAL + CREATIVE THINKING

PREDICTION: What could happen if supermarkets decided not to organise products into groups?

VARIATIONS: How many different ways can you classify the entire contents of your pencil case?

INTERPRETATIONS: Imagine that scientists discover a horse that has a horn on its forehead. Think of some different explanations for its existence.

5 THE CLOSEST!

The closest known relative to humans is a species of great ape called the bonobo. The bonobo is an endangered species – these apes are at risk of becoming extinct. They are found in the Congo in Africa and are omnivores, which means they eat both plants and animals, like humans do.

Bonobos are social animals and show empathy, kindness, compassion and patience. Bonobos can recognise themselves in a mirror, which means they are self-aware, like all the great apes.

2.1 CLASSIFYING LIVING THINGS

LEARNING INTENTION

At the end of this lesson I will be able to identify reasons for classifying living things.

KEY TERMS

classification
the process of sorting things into groups or classes

organism
an individual animal, plant or other living thing

taxonomy
the area of science to do with classifying organisms

LITERACY LINK

LISTENING

Read section 1 out loud to a partner, then ask them to summarise what you read. Repeat for section 2, swapping roles.

NUMERACY LINK

CALCULATION

A blue whale weighs approximately 120 000 kg. An average adult German Shepherd dog weighs 30 kg. How many German Shepherds would you need for them to weigh the same as one blue whale?

Figure 2.1 There are many different types of bears on Earth. Classification helps us identify them by organising them into groups.

Classification is the process of sorting things into groups.

Different classification systems exist in many areas in your daily life. For example, your school library classifies books using the Dewey decimal system, which is useful for finding both subjects and authors. You might use a classification system to store your music or video files.

1 Classification means sorting things into groups

Things can be classified for many different reasons, depending on who is doing the arranging, sorting or classifying.

Many scientists use classification. They do so by looking at how the objects they study are similar:

- Chemists classify substances by their physical properties and their chemical reactions with other substances.
- Geologists classify rocks according to how they were formed and their mineral content.
- Astronomers classify objects in the universe by observing properties such as size, density and whether they give off light.

What kinds of things can be classified?

2 Living things are classified by their characteristics

Biologists classify living things. The science of grouping living things is called **taxonomy**, and a biologist who specialises in classification is a taxonomist.

Millions of different types of **organisms** live on Earth. All living things:

- are made of cells
- are made of molecules containing carbon
- have biological characteristics in common, such as being able to grow, move, reproduce and respond to stimuli.

Many other characteristics are shared by only some organisms. Plants and animals have very different characteristics, of course, but the differences between types of animal are also very significant. Consider the differences between dogs and octopuses!

What is the name of the science of grouping living things?

3 The importance of classification

One of the most important reasons to classify living organisms is to work out what relationships exist between different groups. Is a cat closely related to a tiger? They have similarities, but also some very significant differences. Classification systems help biologists learn how these two animals, or any other two living things, are related.

A classification system helps biologists identify newly discovered organisms. These discoveries happen more often than you might think – the more we explore the world, the more new organisms we find. Many of these, such as bacteria, are tiny – but new plants, insects, fish and other animals are also discovered every year.

A classification system helps biologists from different countries to communicate. An Australian wildlife scientist may use different everyday names for trees and plants than a Chinese, French or Indonesian scientist, but if they use the same classification system, they can identify the organism more easily.

What are the benefits of classifying living things?

Figure 2.2 The ninja lanternshark is a small shark with body parts that glow in the dark. It lives deep in the ocean and was not discovered by scientists until 2015.

Investigation 2.1
Observing and classifying

KEY SKILL
Writing a research question

▶ *Go to page **142***

CHECKPOINT 2.1

1 Describe classification in your own words.
2 Give at least three reasons for classifying living things.
3 Explain what is meant by the term *taxonomy*.
4 Identify four situations where things are classified in everyday life.
5 Classify the following objects into three groups: an apple, a car, a fish, a basketball, a mobile phone and a drop of blood. Justify your choice of classification.
6 Give some characteristics of living things.
7 Classification can help identify which species are closely related. Suggest how.

INQUIRY

8 When we classify living things, the first two categories that usually come to mind are plants and animals. Brainstorm with a partner to try to identify other categories of living things.

SUCCESS CRITERIA

- I can describe what classification is.
- I can explain three reasons why classification is useful.

2.2 CLASSIFICATION KEYS

LEARNING INTENTION

At the end of this lesson I will be able to describe some different types of simple keys and apply this knowledge to design and construct my own.

KEY TERMS

dichotomous
divided into two parts

key
a system for identifying characteristics

LITERACY LINK

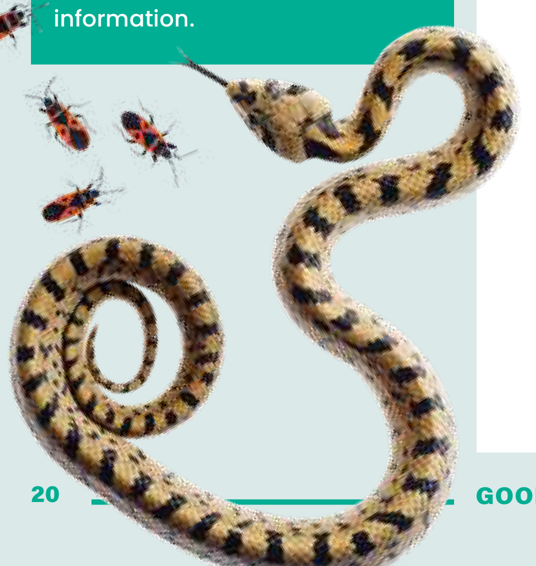
SPEAKING

In your own words, explain to another student what dichotomous keys are and how they are used.

NUMERACY LINK

GRAPHING

Joachim found the following creatures in his backyard: 7 worms, 3 birds, 5 snails, 9 woodlice and 4 spiders. Draw a bar chart to show this information.



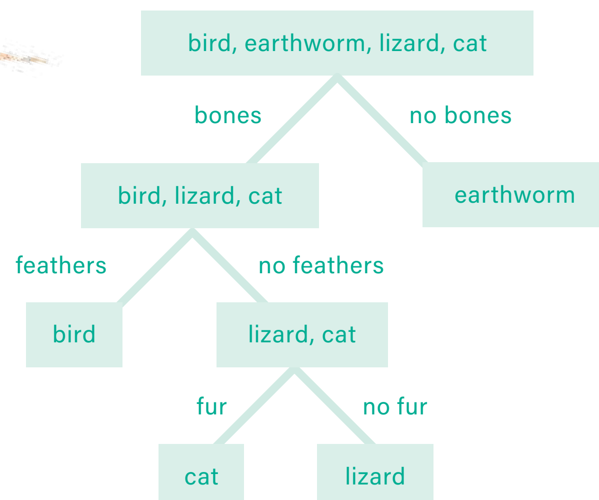
Classification systems are based on **keys**. A key is a system for identifying important characteristics.

Keys for identifying living things may use pictures, words, numbers and instructions. They are used mainly to find the names of organisms.

1 Some keys divide groups using branches

A common type of key is a branching key, which has two or more branches at each level to separate groups. As you move down the branches, you identify characteristics until you determine the right organism.

Consider a small group of animals: a bird, an earthworm, a lizard and a cat. You can use this branching key to identify each organism:



How does a branching key work?

2 Dichotomous keys use questions

Another type of key is a **dichotomous** key. *Dichotomous* means 'divided into two parts', so this key uses statements or questions with only two choices at each step. When a statement is correct, you follow directions to reach the next question, until you determine the organism.

Let's look back to the earlier group of animals – bird, earthworm, lizard and cat. A dichotomous key for identifying this group may look like this:

1 a **Skeleton of bone** .... **go to statement 2**
b **Does not contain bones** .... **earthworm**

2 a **Covered in feathers** .... **bird**
b **Not covered in feathers** .... **go to statement 3**

3 a **Covered with dry scales** .... **lizard**
b **Covered with fur** .... **cat**

What are two types of classification keys?

3 Keys identify a set of important characteristics

The most important part of designing a key is deciding which characteristics it uses to identify organisms.

The characteristics chosen for a key depend on the organisms to be classified. It makes sense for the first steps of a key to be easily observable features; for example, whether an organism has a backbone. When the classification becomes more specific, such as classifying different species of an animal, the key will need more detail; for example, whether an insect has spots on its wings.

The largest group of animals on Earth are the arthropods. *Arthropoda* means 'jointed feet', and all arthropods have legs with joints as well as an exoskeleton, which is outside their bodies.

Table 2.1 shows the five classes (sub-groups) of arthropod, and the physical characteristics by which they are grouped. Can you develop a key that would allow you to identify the class of any arthropod?

Table 2.1 The five classes of arthropod

Class	Characteristics	Examples
Insects	3 body parts (head, thorax, abdomen) 6 legs (3 pairs) 0, 1 or 2 pairs of wings 1 pair of antennae	Fly, mosquito, dragonfly
Crustaceans	3 body parts (head, thorax, abdomen) 10 legs (5 pairs) No wings 2 pairs of antennae	Crab, lobster, prawn
Arachnids	2 body parts (cephalothorax, abdomen) 8 legs (4 pairs) No wings No antennae	Spider, tick, scorpion
Centipedes	Many body segments 1 pair of legs on each segment Flat body cross-section No wings 1 pair of antennae	Centipede
Millipedes	Many body segments 2 pairs of legs on each segment Rounded body cross-section No wings 1 pair of antennae	Millipede

Why do different keys include different characteristics?

Investigation 2.2
Supermarket classification key

KEY SKILL
Identifying and managing relevant risks

▶ *Go to page **143***

CHECKPOINT 2.2

1 Explain the role of a classification key.

2 Describe some structural features of humans that might be used to classify them.

3 Explain the difference between a branching key and a dichotomous key.

4 While exploring the Amazon rainforest, you find a previously undiscovered species of arthropod. It's bright pink, has 10 spiky legs, a head, thorax and abdomen, and it cannot fly. What class would you put it into?

5 Create a branching key that can be used to classify all the different shoes worn by students in your class.

DESIGN AND TECHNOLOGIES

6 Design a simple key to identify organisms in a local habitat of your choice. Use the SmartArt tool in PowerPoint or another suitable tool to present your key.

SUCCESS CRITERIA

- I can name at least two types of classification key.
- I can create a simple key of my own to classify objects or organisms.

2.3 THE LINNAEAN CLASSIFICATION SYSTEM

LEARNING INTENTION

At the end of this lesson I will understand the importance of the Linnaean classification system and describe its key elements.

KEY TERMS

naturalist
someone who studies nature and its history

species
a single, specific type of living organism

LITERACY LINK

WRITING

Create a mnemonic to remember the order of classification: domain, kingdom, phylum, class, order, family, genus, species. An example is 'Dear Katy Perry Can Often Find Green Shoes'.

NUMERACY LINK

GRAPHING

97% of all animal species are invertebrates. Draw a pie chart showing the percentages of invertebrates and vertebrates.

Scientists can classify living organisms in many different ways. What's most important is that every scientist uses the same system, so that their findings can be compared and they can share information.

A system for grouping living things was first proposed by Swedish **naturalist** Carolus (Carl) Linnaeus in 1753. It's known as the Linnaean classification system and has been used by scientists ever since.

1 Eight Linnaean levels, from domain to species

Carolus Linnaeus' system classifies organisms by levels called taxa, and each of these levels is divided into groups. These groups are based mainly on cell and structural characteristics, and also on how the organisms behave and reproduce.

At the highest level, these groups are huge – a single group might contain all plant life in the entire world. As you go down the levels, the groups become more specific and contain less species.

At the top of the system, the most general classifications are domains and kingdoms. The characteristics used to separate these groups are based on cell structure. At the bottom of the system are genuses and **species**. This is where you can identify individual types of organisms.

Here is how the brush-tailed rock wallaby is classified:

Classification level	Classification for brush-tailed rock wallaby
Domain	Eukaryota (living organisms with specialised cells)
↓	↓
Kingdom	Animalia (animals)
↓	↓
Phylum	Chordata (animals with a backbone)
↓	↓
Class	Mammals
↓	↓
Order	Marsupialia (marsupials)
↓	↓
Family	Macropodidae (wallabies, kangaroos, pademelons)
↓	↓
Genus	*Petrogale* (wallabies)
↓	↓
Species	*penicillata* (brush-tailed rock wallaby)

How many levels are in the Linnaean classification system?

2 Every species has a two-word name

All rock wallabies are part of the *Petrogale* genus, and the brush-tailed rock wallaby's species name is *penicillata*. This means that its full scientific name is *Petrogale penicillata*.

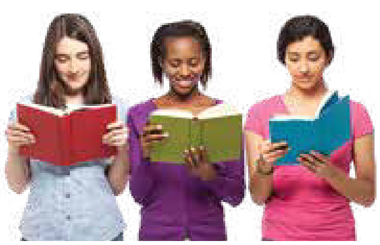
This naming is another important part of the Linnaean system: every species is given a two-word scientific name, in addition to its everyday name in English or other languages. These names are developed according to some strict rules:

- The first word is the genus name and begins with a capital letter.
- The second word is the species name and begins with a lowercase letter.
- The name must be shown in italics (or underlined in handwriting).

The words in these names are usually Latin or Ancient Greek. Because these languages are no longer actively used, they don't change over time like modern languages. This is useful because the meanings stay stable and consistent. Even if scientists don't speak Latin, they can look up the words and find the same meaning each time.

What two things make up a scientific name?

Figure 2.4 Every organism has a two-part scientific name, which describes its genus and species.



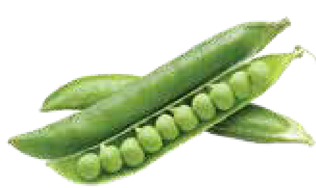
Homo sapiens
Humans

Canis familiaris
Domestic dogs (all breeds)

Felis domestica
Domestic cats (all breeds)

Staphylococcus aureus
Golden staph bacteria

Anopheles gambiae
African malaria mosquitoes



Pisum sativum
Peas

Triticum aestivum
Common wheat

Figure 2.3 The brush-tailed rock wallaby's scientific name is *Petrogale penicillata*.

CHECKPOINT 2.3

1. Explain the difference between a species and an organism.
2. Would you expect there to be more organisms in a species or a genus? Explain your answer.
3. Describe the Linnaean classification system in your own words.
4. Copy and complete these sentences.
   In a scientific name, the first word is the ___________ and begins with a___________. The ___________ word represents the ___________ and begins with a ___________. The name must be written in ___________ or ___________.
5. Explain why it's important for all scientific names to be in the same language.
6. Would you expect the red kangaroo to be in the same genus as the brush-tailed rock wallaby? Why or why not?

RESEARCH

7. Undertake research to identify the scientific names of the following animals: polar bear, black rat and great white shark.

SUCCESS CRITERIA

- I can describe the Linnaean system of classification.
- I can describe how a species' scientific name is formed.

2.4 CLASSIFYING ANIMALS

LEARNING INTENTION

At the end of this lesson I will understand how scientists classify animals.

KEY TERMS

invertebrate
an organism without a backbone or spinal cord

vertebrate
an organism with a backbone or spinal cord

LITERACY LINK

VOCABULARY

Vertebrate and invertebrate are opposites. How many words can you think of that become the opposite by adding only a couple of letters?

From the largest whale to the smallest insect, there are more than 800 000 different animal species in the kingdom Animalia. All animals have many cells and must eat other organisms for energy.

The first question to consider when classifying animals is whether they have backbones.

Figure 2.5 Blue whales are the largest vertebrates in the world. Their skeletons couldn't support their weight on land – they weigh up to 140 tonnes.

1 Vertebrates are animals with backbones

Animals with backbones are called **vertebrates**, named after the small, oddly shaped bones in the spine called vertebrae.

In the classification system, vertebrates are members of the phylum Chordata. This name is used because all vertebrates have a nerve cord inside their backbone, which sends and receives information between body parts.

Table 2.2 shows the five classes of phylum Chordata. The identifying characteristics are their body coverings, how they control their temperature, how they reproduce and how they move.

What is the defining feature of vertebrates?

Table 2.2 **The five classes of vertebrate (phylum Chordata)**

Class	Body covering	Temperature control	Reproduction	Structure for movement	Examples
Fish	Slimy scales	Gain heat from surroundings	Lay eggs	Fins to move through water	Salmon
Amphibians	Naked skin	Gain heat from surroundings	Lay eggs in water	Young (tadpoles) have fins; adults have legs	Frog
Reptiles	Dry scales	Gain heat from surroundings	Lay leathery eggs	Legs for walking on land (except snakes)	Goanna
Birds	Feathers and scales (on feet)	Produce their own heat	Lay hard-shelled eggs	Legs for walking on land and wings for flying	Kookaburra
Mammals	Hair or fur	Produce their own heat	Lay eggs	Legs with different shapes for walking, swimming or flying	Echidna
			Give birth to underdeveloped young		Human
			Give birth to fully developed young		Dog

2 Invertebrates are animals without backbones

The prefix *in*- means 'not', so **invertebrate** means 'not a vertebrate'. In other words, these animals do not have backbones – or any bones at all.

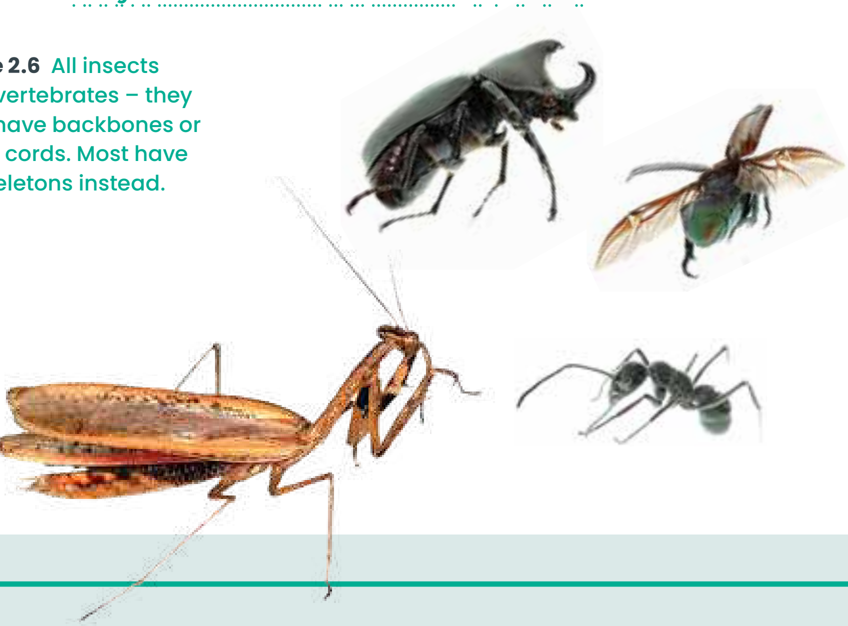
There are many different phyla of invertebrates. They can be grouped by structural features. Most invertebrates have an exoskeleton – a skeleton outside their body. This supports the animal as it moves, but is not made of bone. Invertebrates such as worms don't even have exoskeletons – they have inside structures that support them in other ways.

Table 2.3 Some of the many phyla of invertebrates

Phylum	Characteristics	Examples
Cnidarians	Soft body with one opening	Anemone, coral, jellyfish
Annelids	Segmented worm, round cross-section, lives on land	Earthworm
Platyhelminths	Segmented worm, flat cross-section, freshwater or in another organism	Tapeworm, planarian worm
Nematodes	Unsegmented worm, round cross-section, often in another organism	Round worm, heartworm
Poriferans	Collection of cells, some with hair-like structures, single opening	Sponge
Molluscs	Shelled animal	Snail, clam, oyster
Echinoderms	Body parts arranged around a central point, many 'feet'	Sea star, sea urchin, brittle star
Arthropods	Jointed legs, hard exoskeleton, segmented body	Insect, spider, prawn

What kinds of animals don't have a backbone?

Figure 2.6 All insects are invertebrates – they don't have backbones or spinal cords. Most have exoskeletons instead.



Investigation 2.4

Investigating features of marine animals

KEY SKILL
Identifying the independent variable

▶ *Go to page **144***

CHECKPOINT 2.4

1. Describe the difference between an invertebrate and a vertebrate.
2. Identify the phylum that vertebrates are members of.
3. Give three examples each of vertebrates and invertebrates.
4. Most invertebrates have exoskeletons. Suggest why.
5. Which phyla do the following invertebrates belong to? Use Table 2.3 to help you.
   - a Earthworm
   - b Snail
   - c Mussel (a shelled animal)
   - d Lobster
6. What class of vertebrate am I?
   - a I have scales on my feet but not on my back. My body is covered with feathers not fur. I lay eggs and have legs.
   - b I have no feathers or scales but I am a hairy organism. Wings and fins are not my thing, but I do have useful legs.

EXTENSION

7. Discuss why animals aren't classified according to the environment they live in.

SUCCESS CRITERIA

- I can explain the difference between a vertebrate and an invertebrate.
- I can give at least two examples each of vertebrates and invertebrates.

2.5 CLASSIFYING PLANTS

LEARNING INTENTION

At the end of this lesson I will understand how scientists classify plants.

KEY TERMS

angiosperm
a plant that produces seeds in fruit or flowers

bryophyte
a plant that doesn't contain vascular tissue

gymnosperm
a plant that produces seeds in cones

spore
a tiny part of some plants that is used to reproduce

tracheophyte
a plant contains vascular tissue

vascular tissue
plant tissue that transports fluid and nutrients

LITERACY LINK

WRITING

Identify an angiosperm near your home or school and describe it in exactly 77 words.

NUMERACY LINK

UNITS

A Norfolk Island pine is 59 m tall. Calculate the height of the pine in centimetres, showing the steps you followed.

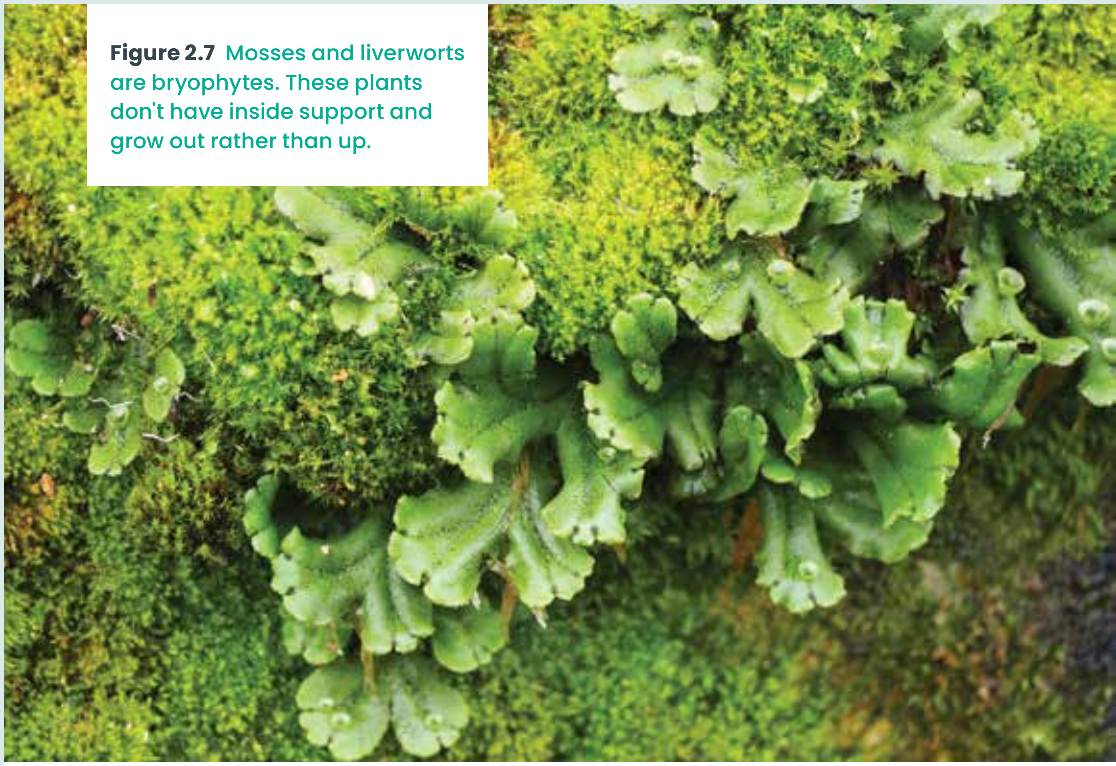


Figure 2.7 Mosses and liverworts are bryophytes. These plants don't have inside support and grow out rather than up.

Kingdom Plantae includes almost 400 000 species of plant. There is an incredible variety of plants in the world, including ferns, mosses and flowering plants. Plants have different types of tissue, and they have a variety of seeds, fruits and flowers.

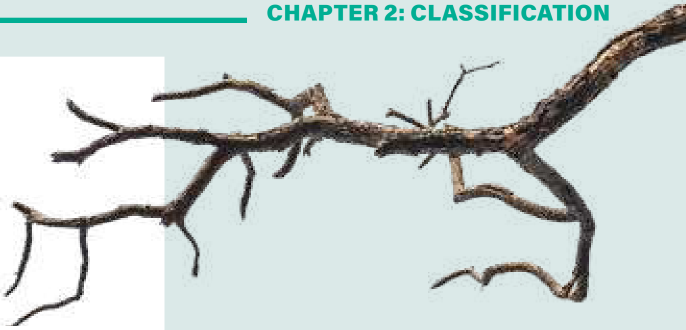
1 Vascular tissues support plants and transport nutrients

Like other living organisms, plants are usually classified by their structure. The first identifying feature is whether a plant has **vascular tissue**. This transports sugars, water and minerals through tiny tubes in the plant, and also supports the plant. It works in a similar way to the bones and blood vessels of humans and other mammals.

Most plants have vascular tissues, and are called **tracheophytes**. They are supported from inside and can grow very tall. Water moves from the soil into the roots, the stem and then the leaves. Glucose is made in the leaves and travels to the rest of the plant, to be used for energy or stored as starch.

Plants that do not contain vascular tissue, such as mosses and liverworts, are called **bryophytes**. They do not have support inside them, so these plants can't grow very high and instead appear as soft coverings on surfaces such as rocks and soil. They don't have true roots or leaves. They reproduce using **spores** and grow in areas where water is freely available, such as next to rivers or waterfalls.

What is vascular tissue?



❷ Seeds, fruits and flowers can be used to classify plants

Tracheophytes can be further divided into plants that produce seeds and those that do not.

Ferns don't have seeds, and instead reproduce using spores. These are small round spheres on the underside of leaves. Spores fall to the ground and grow into heart-shaped plants, which produce male and female cells. Ferns need water for fertilisation and only grow in areas where water is plentiful, such as rainforests.

Gymnosperms produce naked seeds that develop in cones. They have needle-like or thin leaves, and often grow into tall trees with woody trunks. Because they have large root systems, they can collect water from underground supplies and can grow in many different types of environments. Pines, firs, cycads and ginkgoes are all gymnosperms.

Angiosperms produce seeds from flowers and fruits. There are many different types of flowering plants, and this is the largest group of plants found on Earth. Wattles, roses, grass, wheat and eucalypts are all angiosperms.

Figure 2.8 Norfolk Island pines are gymnosperms, which produce cones.

Table 2.4 Characteristics used to identify some classes of plant

Class	Contains vascular tissue?	Produces seeds?	Method of producing seeds	Examples
Bryophytes	No	No	–	Moss, liverwort
Ferns	Yes	No	–	Fern
Gymnosperms	Yes	Yes	Cones	Pine tree
Angiosperms	Yes	Yes	Flowers and fruits	Orange tree

What kinds of plants do not produce seeds?

CHECKPOINT 2.5

1. Identify some common characteristics used to classify plants.
2. Suggest reasons why scientists need to classify plants.
3. Explain the role of vascular tissue in plants.
4. Bryophytes cannot grow very high, preferring to cover areas low to the ground. Suggest why.
5. Is a cherry tree an example of an angiosperm or a gymnosperm? Explain your answer.
6. Why do ferns have spores?
7. a Who am I? I produce seeds from flowers and fruit.
   b Who am I? I don't have seeds and instead reproduce using spores.
   c Who am I? I produce seeds that develop in cones.

ETHICAL CAPABILITY

8. In the world today, species are becoming extinct at an alarming rate. Justify why the preservation of plant species is just as important as the preservation of animal species.

SUCCESS CRITERIA

- I can describe why it's important to be able to classify plants.
- I can state some of the ways that plants are classified.

2.6 CLASSIFYING FUNGI

LEARNING INTENTION

At the end of this lesson I will understand how scientists classify fungi.

KEY TERMS

antibiotic
a substance that kills or slows the growth of bacteria

decomposer
an organism that breaks down and recycles decaying matter

parasite
an organism that gets nutrients from the body of another organism, causing it harm

symbiont
an organism that lives with a host organism, and both organisms benefit

LITERACY LINK

READING

Make a list of five words in this lesson that a primary school student might not understand, then write a definition for each.

NUMERACY LINK

DATA

Jo found six mushrooms. The three growing in sunlight weighed 25 g, 28 g and 22 g, while the three growing in shade weighed 15 g, 35 g and 38 g. What does this data show about where mushrooms like to grow?

When he constructed his classification system, Carolus Linnaeus only recognised two kingdoms: animals and plants. He thought that organisms such as mushrooms and yeast were plants.

Since that time, scientists have classified these organisms in their own category: kingdom Fungi.

1 Fungi are not the same as plants

Fungi are similar to plants in a number of ways. They can't move around, and they reproduce using spores. However, they are different from plants in some important ways:

- Fungi can live in many different places, such as air, water, soil and on plants and animals.
- Instead of roots, fungi have hair-like filaments that grow into whatever they live upon.
- Fungi do not create their own food using photosynthesis.

One of the most important characteristics of fungi is how they receive nourishment. They are **decomposers**, breaking down dead organisms into simple compounds. Fungi do this using enzymes that break down dead plant and animal matter from their surroundings. They then absorb those nutrients through their filaments.

Some fungi are **parasites** that feed on living things. They harm the organisms on which they live so that they can digest the damaged parts. Other fungi are **symbionts**, and actually help the organisms on which they live. A symbiont living on a plant's roots will take sugar and oils from the plant, but the plant gains useful minerals from the fungi when it decays.

What are the main characteristics of fungi?

2 Many fungi are part of our diets

There are more than 70 000 different species of fungi, and many of them can be eaten. Mushrooms, truffles and morels are all edible. Mushrooms are common in Australia and around the world, and they grow in many different environments. Truffles and morels are rarer, and are often considered an expensive delicacy. These fungi grow underground in close relationships with the roots of trees such as oaks.

The fungus that has the biggest part in our diets is yeast. Yeasts are microscopic fungi that feed on sugars and produce carbon dioxide. Unlike most fungi, they are single-celled organisms. They are used to bake bread, because the carbon dioxide gas they produce when they break down the bread flour makes the dough rise. Yeasts are also used to break down sugars in plants to produce some drinks.

How do yeasts cause bread to rise?

Figure 2.9 For many breads, yeast is used to break down flour into sugars. This produces bubbles of carbon dioxide gas, making the dough rise.

3 Fungi can cause and cure diseases

Some fungi can cause diseases such as athlete's foot and ringworm. Tinea pedis, or athlete's foot, is a common skin infection, mostly growing between the toes. A number of different fungi are responsible and you can become infected by walking on surfaces that have microscopic spores on them. There are other forms of tinea, on different parts of the body, caused by these fungi.

Fungi have a great variety of medical uses. British scientist Alexander Fleming made the first **antibiotic** medicine from penicillin fungus in 1928. Since then, antibiotics have become a vital part of treating diseases caused by bacteria.

Yeasts are another fungus important in medicine. Scientists can insert useful genes into them. When the yeast reproduces, it can be used to make medicines. For example, if the yeast cells are combined with the human gene for producing insulin, they can be used to make human insulin, which is used to treat diabetes.

What are some medical uses for fungi?

Figure 2.10 Penicillin fungus was used to make the first antibiotic medicine.

Investigation 2.6
Growing mould

KEY SKILL
Identifying the independent and dependent variables

▶ *Go to page* ***145***

CHECKPOINT 2.6

1. Suggest why fungi were given their own category separate to plants.
2. Describe the role of fungi in medicine.
3. Create a Venn diagram to compare fungi to plants. In the overlapping section of the circles, identify characteristics that fungi and plants have in common. On each side, identify ways in which they are unique.
4. Provide some uses of the fungus known as yeast.
5. Explain how fungi get their energy (hint: it's not through photosynthesis).
6. There are good and bad things about fungi. Summarise these and give your opinion on whether fungi are helpful or harmful organisms.

CRITICAL AND CREATIVE THINKING

7. Fungi are decomposers; they break down dead organisms. Suggest the importance of decomposers to life on Earth by describing what Earth would be like without them.

SUCCESS CRITERIA

- I can describe the difference between plants and fungi.
- I can describe at least two characteristics of fungi.

2.7 CLASSIFYING KINGDOMS PROTISTA AND MONERA

LEARNING INTENTION

At the end of this lesson I will be able to describe organisms in the microscopic kingdoms and suggest how they are classified.

KEY TERMS

algae
organisms living in water that make food by photosynthesis

bacteria
microscopic, unicellular organisms that can live in a range of environments

eukaryote
an organism with a nucleus and structures inside its cell(s)

microorganism
an organism that is only visible under a microscope

plankton
microscopic, animal-like organisms that float or drift in water

prokaryote
an organism without a nucleus or structures inside its cell(s)

protist
a microorganism that is not a fungus or bacteria

NUMERACY LINK

CALCULATION

A particular microscope can make objects appear 40 times larger. How large would a 0.75 mm wide amoeba appear to be in the microscope?

The Linnaean classification system has been changed many times since it was constructed, as we learn more about living things. For example, when scientists invented microscopes they saw that there are many different types of **microorganism**.

We now know that microorganisms do not all belong to the same kingdom. Their simplest classification includes two kingdoms: Protista and Monera.

1 Protists are very simple organisms

One of the microscopic kingdoms is Protista. Organisms in this kingdom are sometimes called protozoa or **protists**, and they are made of a simple, single cell. All protists are **eukaryotes**: organisms with a nucleus and special structures with their cells.

Most protists are single-celled organisms that live in water. A few of them have more than one cell, but they do not have specialised cells. Instead, they consist of large masses of identical cells.

Some protists, known as **algae**, look like plants and make their own food by photosynthesis. Others, known as **plankton**, are more like animals because they absorb their food from the water around them. There's even a third type of protist, moulds, that acts like fungi.

What are some examples of protists?

Figure 2.11 *E. coli* is a type of bacteria found inside the human digestive system.

2 Bacteria are the most common organisms on Earth

The microscopic kingdom Monera includes **bacteria**. They are **prokaryotes**: organisms that don't have a nucleus or special structures in their cells.

Bacteria are the most common organisms on Earth. A single millilitre of water contains a million bacteria. Most bacteria benefit life because they are decomposers, like fungi, which are important in every ecosystem. For example, the human digestive system relies on bacteria in the gut for digesting food. Other bacteria are harmful and cause infections and diseases.

Bacteria reproduce by splitting into two identical cells. When conditions suit the bacteria, some can reproduce every 20 minutes. If this happens, one cell can become more than 16 million in just eight hours! Bacteria can quickly infect another organism in this way.

There are several different ways of classifying bacteria. The two that are most commonly used are their shape and how they gain nutrition:

- Bacteria can be classified into five different basic shapes. The three most common shapes are spheres, cylinders and spirals. Some less common bacteria are shaped like commas and corkscrews.
- Some bacteria make their own food, either by photosynthesis (like a plant), or by changing chemicals in their environment into food. Others act like animals and eat other bacteria to gain nutrients.

What are the main ways to classify bacteria?

3 Archaeans can survive in extreme environments

Archaeans are single-celled microorganisms that also belong to kingdom Monera. These prokaryotes have a similar size and structure to bacteria, but they have different molecules in their cell walls. Archaeans live in very different environments to bacteria. They are sometimes called extremophiles because they can live in very hot, salty and acidic environments.

Some archaeans live in deep-sea hydrothermal vents and volcanic mineral springs. The temperatures in these areas are greater than 90°C! Others live in very salty environments, such as the Dead Sea in Israel, or in very acidic soils.

Some archaeans live in less extreme environments, although humans would not find these places comfortable. Archaeans can live in hot springs, swamps and marshes. A few archaeans live in the digestive systems of humans and other animals.

Scientists have found it difficult to study archaeans, because they live in places that are hard to reach. However, they have managed to find out some things about these organisms. Archaeans reproduce by splitting into cells, they have distinct shapes, and most can move in the water by using their whip-like tails. They can have rectangular or square shapes and, unlike bacteria, do not seem to cause diseases or harmful infections in other organisms.

Why are archaeans also known as extremophiles?

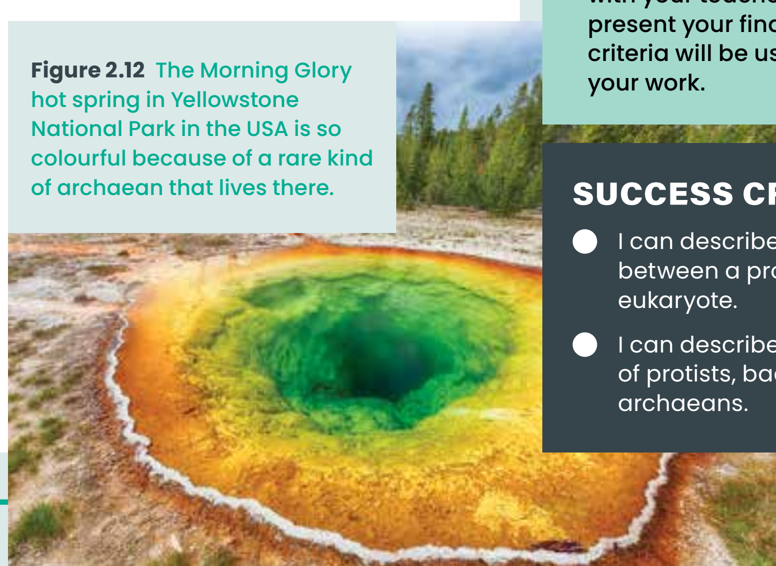


Figure 2.12 The Morning Glory hot spring in Yellowstone National Park in the USA is so colourful because of a rare kind of archaean that lives there.

CHECKPOINT 2.7

1. In your own words, explain what a microorganism is.
2. Summarise some of the different ways that microorganisms can be categorised.
3. Bacteria are the most common organisms on Earth. Suggest why this is the case.
4. List some positives and negatives of bacteria.
5. Suggest how bacteria are able to reproduce so quickly.
6. Explain what is meant by an 'extremophile' and give an example of one.
7. Compare how algae and plankton obtain their energy.

STUDENT VOICE AND AGENCY

8. Research the discovery of penicillin. When you have a good overview, negotiate with your teacher how you will present your findings and what criteria will be used to assess your work.

SUCCESS CRITERIA

- I can describe the difference between a prokaryote and eukaryote.
- I can describe key features of protists, bacteria and archaeans.

VISUAL SUMMARY

Classification is the process of sorting things into groups or classes.

This is useful because scientists are able to:
- see what relationships exist between organisms
- identify new species
- communicate with scientists from other countries using a common process and language.

Some simple classification keys:

BRANCHING

bird, earthworm, lizard, cat
- bones → bird, lizard, cat
  - feathers → bird
  - no feathers → lizard, cat
    - fur → cat
    - no fur → lizard
- no bones → earthworm

DICHOTOMOUS

1 a Skeleton of bone............................go to statement 2
  b Does not contain bones................earthworm

2 a Covered in feathers.......................bird
  b Not covered in feathers.................go to statement 3

3 a Covered with dry scales ....lizard
  b Covered with fur............................cat

The Linnaean classification system was named for Carolus Linnaeus, who proposed grouping living things in 1753.

FUNGI
- decomposers
- reproduce via spores
- don't use photosynthesis

CLASSIFICATION LEVEL

Domain
▼
Kingdom
▼
Phylum
▼
Class
▼
Order
▼
Family
▼
Genus
▼
Species

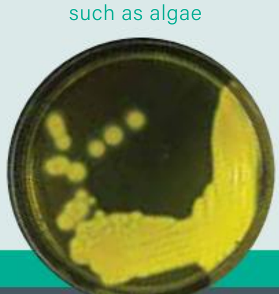
The genus and species make up the scientific name

Homo *sapiens*
(Genus) (species)

ANIMALS
- vertebrates
- invertebrates

PLANTS
- bryophytes – no vascular tissue
- tracheophytes – vascular tissue

PROTISTS & MONERA
- eukaryotes – such as algae
- prokaryotes – such as bacteria



★ FINAL CHALLENGE ★

1. Discuss why classification is useful to scientists.
2. Give three examples of classification keys and outline how to use one of them.
3. Name one organism from each of the five kingdoms.

LEVEL UP!

Level 1
★☆☆☆☆☆
50xp

4. Give two reasons why vascular plants grow much taller than non-vascular plants.
5. State the one characteristic shared by all vertebrates.
6. Using the basic description of all insects in lesson 2.2, draw a diagram of an insect.

LEVEL UP!

Level 2
★★☆☆☆☆
100xp

7. Insects make noises using different parts of their bodies.
   - **a** Suggest some reasons why insects make noises.
   - **b** Using three different examples, describe how insects make noises.
8. Fungi were once classified with plants. Explain why they are now classified in their own kingdom.
9. Describe how species are given a scientific name.

LEVEL UP!

Level 3
★★★☆☆☆
150xp

10. Describe the characteristics that all animals in phylum Chordata possess.
11. Describe the main differences between prokaryotic cells and eukaryotic cells.
12. Name the five main groups or classes of vertebrates. For each, describe three characteristics and give one example.

LEVEL UP!

Level 4
★★★★☆☆
200xp

13. The three groups of mammals are monotremes, marsupials and placentals. Explain how these groups are different and what they have in common.
14. Create a poster that gives both a summary and an image for each of the following: animals, plants, fungi, bacteria, archaeans and protists.
15. Create a simple branching or dichotomous key that you could use to identify four different plants of your choice.

LEVEL UP!

Level 5
★★★★★★
300xp

ECOSYSTEMS

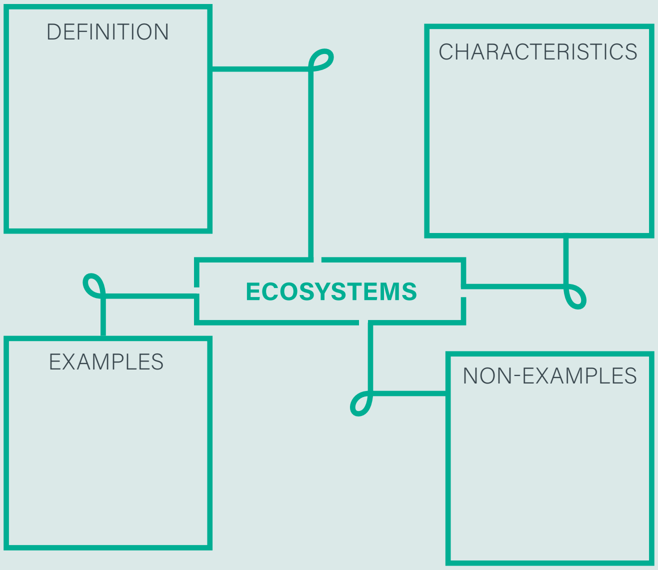
How do living things affect each other?

An ecosystem is a biological community of living things, such as plants and animals, and non-living things, such as air and water. The way that living things interact can be shown using food chains and webs.

Many people struggle to share their home with spiders, but killing them can have a big impact on an ecosystem. Spiders eat insects and pests that might otherwise damage natural plant environments and ruin crops. They are a food source for animals such as birds, so removing them from an ecosystem can be devastating.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Food chain* and *Organism*.

2 LEARNING LINKS

Brainstorm everything you already know about ecosystems.

3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.

4 CRITICAL + CREATIVE THINKING

VARIATIONS: How many ways can you think of to control a fire?

WHAT IF ... there were no more decomposers on Earth?

MISMATCHES: Solve the problem of deforestation using a robot, 20 donkeys and a cabbage.

5 THE SCARIEST!

Not all relationships in an ecosystem are nice ones. Parasites are organisms that live in or on another living thing in order to survive, causing damage or even death. A parasitic, bloodsucking fish lives in the Amazon River – and it's not a piranha. It is called a candiru, also known as the vampire or toothpick fish.

The candiru finds its way behind the gills of other fish. Once there, it sticks out its spines so that the victim bleeds and provides it with a meal. Nasty!

3.1 PRODUCERS, CONSUMERS AND DECOMPOSERS

LEARNING INTENTION

At the end of this lesson I will be able to describe the roles of producers, consumers and decomposers in an ecosystem.

KEY TERMS

carnivore
an organism that eats only animals

consumer
an organism that gains energy by consuming other organisms

decomposition
the process of rotting and decay

herbivore
an organism that eats only plants

omnivore
an organism that eats both animals and plants

producer
an organism that produces energy at the start of a food chain

LITERACY LINK

VOCABULARY

Produce is a verb, but can be changed to a noun by adding an 'r' at the end. This is the same with consume(r) and decompose(r). Think of a list of words that can be changed from verbs to nouns by adding an 'r' at the end.

All organisms within an ecosystem, including humans, depend on interactions with each other for energy, nutrients and survival. Food chains and webs show the feeding relationships between **producers**, **consumers** and decomposers.

1 Producers create their own energy

All energy that enters into a food chain will initially come from the sun. In order to harness this energy and pass it along a food chain, the first organism in a food chain must always be a producer.

Producers can 'produce' their own energy and are most commonly plants. Plants (and other organisms that can photosynthesise) harness the Sun's energy in a process called photosynthesis.

In photosynthesis, water and carbon dioxide are chemically changed into glucose (the sugar energy source) and oxygen.

What is an example of a common producer?

2 Consumers get nutrients from other organisms

Consumers are so named because they 'consume' something else in order to get their energy. They can't create their own energy using the Sun like producers can, so they need to eat (or consume) something else.

If consumers only eat producers they are **herbivores**, which only eat plants. If they only eat other consumers they are **carnivores**, which only eat animals. And if consumers eat both producers and other consumers they are **omnivores**, which eat both plants and animals.

In a food chain, the primary consumer is the consumer that eats the producer. The consumer that eats the primary consumer is called the secondary consumer, and so on.

What is the main difference between omnivores and carnivores?

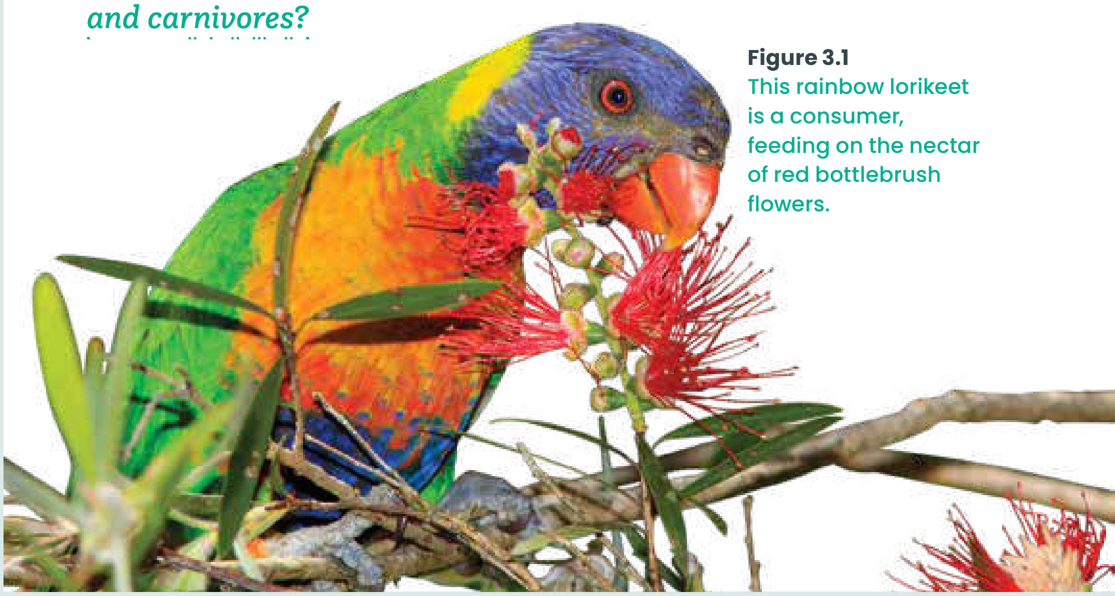


Figure 3.1
This rainbow lorikeet is a consumer, feeding on the nectar of red bottlebrush flowers.

3 Decomposers break down dead matter

The process of breaking down dead matter is called **decomposition**. If decomposition didn't happen, the dead remains and waste materials of organisms would be everywhere, and the nutrients in them would stay trapped inside, never to be used again.

Most bacteria and fungi are neither producers nor consumers, but decomposers. They interact with every other organism in a food web by breaking down dead matter and waste in an ecosystem. This is how they gain their energy to grow, reproduce and survive.

The nutrients of dead organisms are released into the soil to be recycled, making them available to new food chains. Plants take up these nutrients, along with water, through their roots. This allows consumers to obtain these nutrients when they feed. All other organisms, including humans, rely on decomposers to survive.

What are two types of decomposer found in many ecosystems?

Figure 3.2 The decomposers breaking down this dead tree gain its stored energy and recycle its nutrients.

Investigation 3.1
Observing ecosystems

KEY SKILL
Identifying and managing relevant risks

▶ *Go to page **146***

CHECKPOINT 3.1

1 Give some examples of differences between a producer and a consumer.
2 Explain what a decomposer is and describe its importance in an ecosystem.
3 Consider the food web in lesson 3.2. Which organism is the producer? How do you know it is a producer?
4 Draw a Venn diagram of three large interconnecting circles. Label the top of the circles 'producer', 'consumer' and 'decomposer'. In each circle, write some unique characteristics of each organism. In the parts where the circles overlap, write some things they have in common.
5 Define herbivores, carnivores and omnivores in your own words, and give an example of each.

CONNECTING IDEAS

6 Suggest why producers, consumers and decomposers can't exist without each other.

SUCCESS CRITERIA

- I can explain what a producer, consumer and decomposer are and give an example of each.
- I can describe ways that producers, consumers and decomposers interact in an ecosystem.

3.2 FOOD CHAINS AND FOOD WEBS

LEARNING INTENTION

At the end of this lesson I will be able to describe interactions between organisms in terms of food chains and food webs.

KEY TERMS

ecosystem
a community of living and non-living things

food chain
a path of energy through an ecosystem

food web
a system of interlocking food chains

LITERACY LINK

SPEAKING

Explain to another student the difference between a food chain and a food web. Ask them for 'two stars and a wish' – two things you did well in your explanation and one thing you could have done better.

NUMERACY LINK

CALCULATION

Each level up in a food chain only receives 10% of the energy of the lower level. In Figure 3.3, the grass would have to store 10 joules of energy for the grasshopper to receive 1 joule of energy. How much energy would the grass need to store to eventually provide the wedge-tailed eagle with 100 joules of energy?

All living organisms need energy to grow, repair damage and reproduce. Without energy, an organism cannot survive. Plants make their own food and energy, but other organisms – including humans – must feed on other organisms to gain energy.

The feeding relationships between organisms, and the energy transfers in an **ecosystem**, can be shown in **food chains** and **food webs**.

❶ Food chains show the path of energy in an ecosystem

Food chains are diagrams that show one possible path that energy can move through an ecosystem. Energy is transferred between organisms when they eat or are eaten.

Food chains always begin with a producer – a plant or microorganism that can produce energy. This is because they provide the glucose for all other organisms to feed on. Every ecosystem includes producers.

When you draw a food chain, you draw arrows between each organism to show the direction that energy moves. In a food chain for an Australian grassland ecosystem, a grasshopper gains energy from grass, so you would draw an arrow from the grass to the grasshopper.

Figure 3.3 Each organism in a food chain provides energy for the next organism.

Grass Producer → **Grasshopper** Primary consumer → **Blue-tongue lizard** Secondary consumer → **Eastern brown snake** Tertiary consumer → **Wedge-tailed eagle** Quaternary consumer

The other organisms in the food chain – those that feed on organisms to gain energy – are consumers. They can be described in terms of the organisms they feed on.

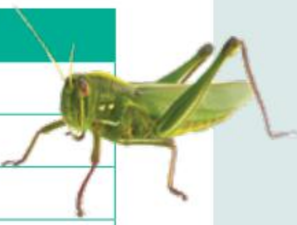
Table 3.1 Types of consumer and how they obtain their energy

Consumer	Obtains energy by ...	Examples
Herbivore	... feeding on producers	Koala, grasshopper
Omnivore	... feeding on producers and other consumers	Sea star, most humans
Carnivore	... feeding on other consumers	Kookaburra, brown snake
Decomposer	... breaking down dead matter	Bacteria, fungi

Organisms can also be described by their position in a food chain.

Table 3.2 Organisms and their positions in a simple food chain

Organism	Position in food chain
Grass	Producer
Grasshopper	Primary consumer
Blue-tongue lizard	Secondary consumer
Eastern brown snake	Tertiary consumer
Wedge-tailed eagle	Quaternary consumer



What type of consumer is a herbivore?

2 Food chains interact to form food webs

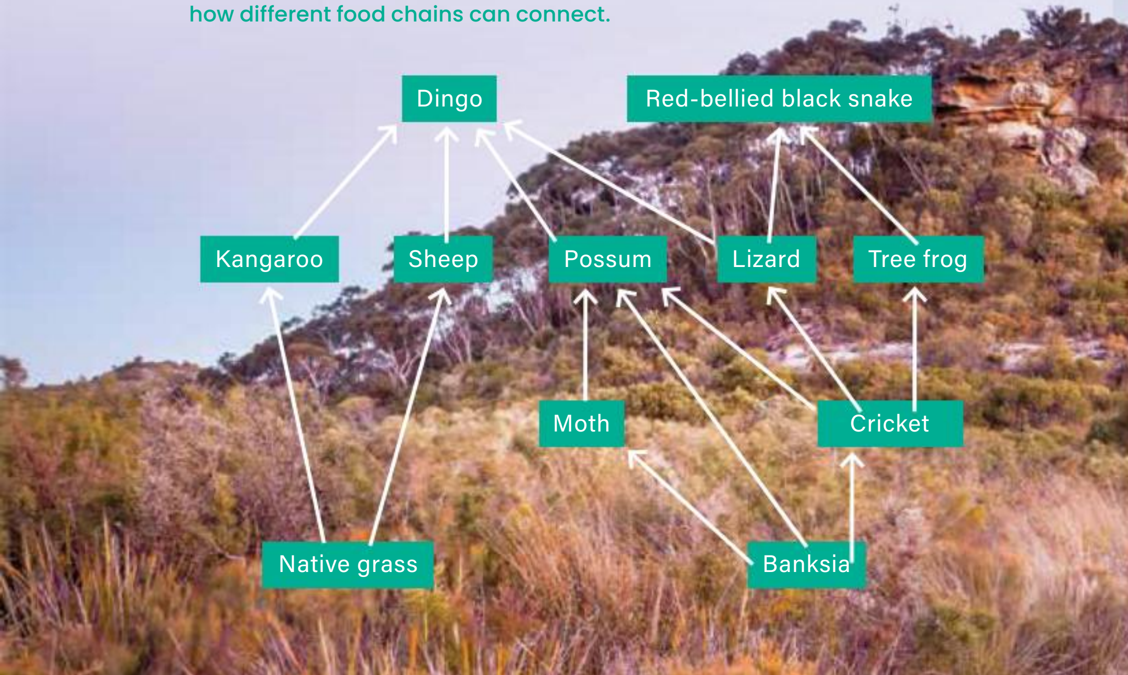
Organisms are usually part of more than one food chain. This is because most organisms don't feed on a single food source, or get eaten by a single consumer. Having more than one food source is important for the survival of a species in changing environments. If a food source runs out, a species is more likely to survive if it has another food supply.

Food webs show all the feeding relationships in an ecosystem. These types of diagram show a much bigger picture of how each organism feeds and interacts. An organism may be a tertiary consumer in one food chain while being a secondary consumer in a different food chain within the ecosystem.

When organisms feed, they only gain a small amount of energy from their food source. They use a large amount of their energy to move, grow, repair cells and reproduce.

What is the difference between a food chain and a food web?

Figure 3.4 This bushland food web shows how different food chains can connect.



Investigation 3.2
Modelling a pond ecosystem

KEY SKILL
Identifying limitations to the method and suggesting improvements

▶ *Go to page* ***147***

CHECKPOINT 3.2

1. Define the term *producer*.
2. What do the arrows in a food chain show?
3. Use the food web in Figure 3.4 to:
   a. draw one food chain
   b. identify the secondary consumer in your food chain.
4. Explain how an organism can be both a secondary and tertiary consumer.
5. If you removed one organism from a food web, what impact could this have on the populations that give and receive energy to that organism?
6. Can a secondary consumer ever be a herbivore (something that does not eat animals)? Explain your answer.

CRITICAL AND CREATIVE THINKING

7. Imagine you're a tiny carbon atom stored in the leaf of a eucalypt tree. Describe a possible journey you could take as you cycle through an ecosystem.

SUCCESS CRITERIA

- I can explain what a food chain is and construct a simple food chain independently.
- I can explain what a food web is and construct a simple food web independently.

3.3 COMMUNITY INTERACTIONS IN AN ECOSYSTEM

LEARNING INTENTION

At the end of this lesson I will be able to describe some key community interactions that exist within an ecosystem.

KEY TERMS

predator
a consumer that kills and feeds on another animal

prey
an organism that is hunted and killed by another for food

symbiosis
a relationship between two or more organisms that live closely together

LITERACY LINK

LISTENING

Read section 1 out loud to a partner, then ask them to summarise what you read. Repeat for section 2, swapping roles.

NUMERACY LINK

MEASUREMENT

This thermometer was left and allowed to stabilise in an ecosystem. What is the temperature of the ecosystem?

If possible, use a thermometer to measure the temperature of an ecosystem outside.

There's more to an ecosystem than just who eats whom. Food chains and food webs are complex and easily affected by internal and external factors. Interactions between organisms can be helpful or harmful, as they are often in competition for resources and not all relationships in an ecosystem are healthy ones!

1 Organisms compete for resources

Competition often occurs when organisms share the same limited resource, such as food, in the same ecosystem.

Consumers compete with each other for the same food. This can occur between different species or members of the same species. Depending on the amount of food available, organisms may be harmed, may starve or may have to find a new food source.

Producers also compete for resources, but not food. Plants compete for space, light, water and nutrients – the things they need to produce energy. Some plants will grow and survive, while others will die.

What are two resources that plants compete for in an ecosystem?

2 Predators and parasites get nutrients from other organisms

Predators are consumers that kill and feed on another animal, their **prey**. Predators in a food web include omnivores and carnivores, both of which eat meat. Carnivores are always predators within a food web, but omnivores are predators in some food chains and prey in others. Predators benefit by gaining energy and nutrients from their prey.

Parasites are organisms that live in or on another organism, the host. Parasites harm the host, but they don't kill it. Examples of parasites include hookworms, which live in the intestines of their human hosts, feeding on nutrients from digested food.

What is the main difference between predators and parasites?

3 Symbiosis is a close relationship

Symbiosis is a relationship that exists between two or more organisms that live closely together. The parasite–host relationship (known as parasitism) is a form of symbiosis, but it is a relationship in which one species benefits while the other species is harmed. There are also some wonderful examples of helpful symbiotic relationships in nature, in which both species benefit from the closeness of the organisms.

Figure 3.5 Ticks are parasites that eat the blood of other animals.

Little oxpecker birds ride around all day on large animals in Africa, eating the insects and other parasites from their backs. In this example both organisms get something good out of the symbiotic relationship – the bird gets tasty food and the large animal gets a beautiful coat free of parasites and insects.

Another example of this mutual symbiosis is the relationship between the spider crab and the algae that lives on its back. The algae is provided with a place to live, and the spider crab is provided with camouflage from predators.

Is all symbiosis helpful to both organisms?

Figure 3.6 Oxpecker birds get their food by eating insects and other parasites from the backs of animals like this rhinoceros.

CHECKPOINT 3.3

1 Give an example of an Australian predator.

2 Identify one example of each of the following.
  a Competition
  b Predation

3 Consider the food web in lesson 3.2. How would competition and predation change if all the crickets were eaten so they were no longer a food source?

4 What resources do plants compete for in an ecosystem?

5 Venus fly traps are both producers and consumers. These plants trap and kill flies and other insects to gain energy and nutrients. Identify the interaction between Venus fly traps and flies.

ETHICAL CAPABILITY

6 After their introduction to Australia, cane toad populations exploded in Queensland. One proposed solution to control their numbers was to introduce a predator to hunt and kill the cane toads. What are some ethical issues (of what is right and what is wrong) regarding this proposal?

SUCCESS CRITERIA

- I can describe how competition can affect food chains and food webs.
- I can describe what a predator is and give an example of a predator and its prey.
- I can explain what symbiosis is in my own words and with an example.

3.4 HOW MICRO-ORGANISMS AFFECT ECOSYSTEMS

LEARNING INTENTION

At the end of this lesson I will be able to describe examples of beneficial and harmful effects that microorganisms can have on living things and the environment.

KEY TERMS

pathogen
a microorganism that can cause disease

unicellular
made of one cell

LITERACY LINK

READING

Find a news article about harmful or beneficial microorganisms. Read the article and carefully summarise it in one paragraph.

NUMERACY LINK

CALCULATION

Krill are tiny crustaceans that weigh about 2 grams each. A blue whale needs to eat about 3600 kilograms of food each day. How many krill will a blue whale eat every day?

Microorganisms are microscopic organisms that are too small to see with the naked eye. They're found at all feeding levels of food webs, in every ecosystem on Earth.

Microorganisms have different roles in ecosystems. Some of these roles benefit other organisms and the environment, while others are harmful and can lead to major changes.

1 Bacteria, fungi and protists are microorganisms

Microorganisms exist all around you. They live in your intestines and on your skin, in the soil in your backyard and in the water you drink. They also live at the bottom of the ocean, in volcanic vents and in the air.

There are three main types of microorganisms: bacteria, protists and fungi. Most are **unicellular** organisms.

Bacteria are extremely small unicellular organisms. They usually exist as large colonies of thousands of organisms. The different sizes and shapes of bacteria can be used to identify them. Bacteria that live in water environments often have hair and tail-like structures, called cilia and flagella, to help them move.

Protists are larger than bacteria and they exist alone, rather than in colonies. Every type of protist has a unique structure that helps it survive. Some protists carry out photosynthesis, and act as producers in ecosystems, while others are consumers and decomposers.

Fungi range in size from unicellular yeasts to multicellular mushrooms. Although they are often grouped with plants, fungi are not producers in an ecosystem because they cannot photosynthesise.

What are the three main types of microorganism in ecosystems?

Figure 3.7 These bacteria use their long flagella and short cilia for movement.

Figure 3.8 Freshwater protists have eyespots that can detect light. They use their flagella to move towards the light to carry out photosynthesis.

2 Some microorganisms are helpful

Many microorganisms have benefits to ecosystems. Producer microorganisms provide the energy source for food chains and webs. Consumer microorganisms break down food into products that other organisms can use. Decomposer microorganisms recycle nutrients and break down harmful waste products.

Here are some other ways that microorganisms benefit the natural world, or are used by humans:

- Penicillin is an antibiotic produced by the *Penicillium* fungus. It stops the growth of harmful bacteria, so it is useful as a medicine. Many other medicines come from fungi.
- Bacteria in the intestines of animals, including humans, help digestion. They break down food to release nutrients, make vitamins and remove wastes.
- Bacteria are used as decomposers in sewage treatment plants. Under controlled conditions, they break down sewage into non-toxic substances. The nutrients in the non-toxic substances are used as fertilisers, and clean water is released to waterways.

What is one beneficial microorganism used in medicine?

3 Some microorganisms are harmful

Some bacteria, fungi and protists are harmful to ecosystems. When these organisms are harmful, they are called **pathogens**.

Bacteria are responsible for many diseases. Food poisoning is a common illness caused by toxins made by *Salmonella* bacteria. This pathogen enters the stomach in contaminated food and can cause diarrhoea, vomiting and stomach cramps.

Protists can also cause illness. Malaria is caused by a protist carried by mosquitoes. When the mosquito feeds, the pathogen enters the animal's bloodstream and infects red blood cells. This causes fever, aches, vomiting and sometimes death.

In water environments, when nutrient levels are too high, some protists and bacteria can reproduce much faster than they are eaten. The water becomes covered in a 'bloom' of algae. This stops light and oxygen from entering the water, which can kill some organisms and allow harmful bacteria to increase.

What is a pathogen?

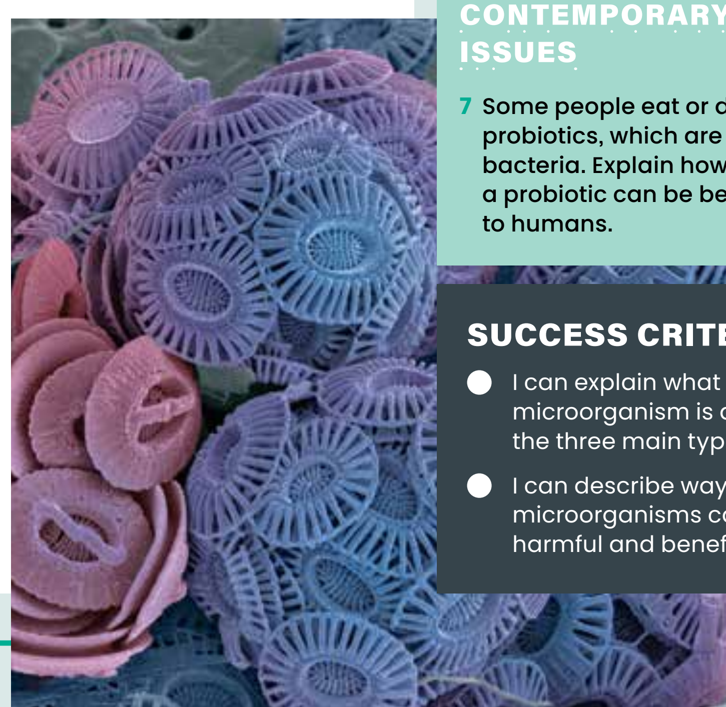


Figure 3.9 Phytoplankton are microorganisms that photosynthesise in oceans. They are producers, supplying marine food webs with energy.

Investigation 3.4
Yeast as a decomposer

KEY SKILL
Identifying the independent, dependent and controlled variables

▶ *Go to page **148***

CHECKPOINT 3.4

1 Write a definition for the term *microorganism*.

2 Are all microorganisms beneficial to an ecosystem? Why or why not?

3 Describe one difference between bacteria and protists.

4 Describe one way that decomposers are beneficial to all ecosystems.

5 Explain why this statement is incorrect:

'Producers are always plants. They are the only organisms that are able to carry out photosynthesis in an ecosystem.'

6 Give one example of how microorganisms can be beneficial and one example of how they can be harmful.

CONTEMPORARY ISSUES

7 Some people eat or drink probiotics, which are live bacteria. Explain how taking a probiotic can be beneficial to humans.

SUCCESS CRITERIA

- I can explain what a microorganism is and list the three main types.
- I can describe ways in which microorganisms can be harmful and beneficial.

3.5 HUMAN IMPACTS ON ECOSYSTEMS

LEARNING INTENTION

At the end of this lesson I will be able to describe how ecosystems can be affected by human activity.

KEY TERMS

biodiversity
the variety of organisms in an ecosystem

deforestation
the removal of trees to make land suitable for other uses

non-biodegradable
does not break down in the environment

pesticides
chemicals used on farms to protect crops by killing pests

urbanisation
the creation of urban areas such as cities

LITERACY LINK

SPEAKING

Write a speech that argues for significantly decreasing levels of deforestation in Australia.

NUMERACY LINK

UNITS

The area of an ecosystem was measured to be 1250 hectares. Convert 1250 hectares into square metres.

Hint: 1 ha = 10 000 m^2.

Human activities often use fossil fuels and **non-biodegradable** materials to meet demand for food, energy and technologies. This can damage food webs, such as by polluting air and removing forests.

Even a seemingly small change in the environment can have a dramatic impact on the feeding relationships in an ecosystem. The balance between producers, consumers and decomposers in a food web can be easily disturbed.

1 Urbanisation and deforestation damage food webs

Urbanisation is the replacement of natural ecosystems with urban areas such as cities and suburbs. This is due to the constant need for more space for increasing human populations. As cities grow, the surrounding land is cleared and many of the organisms in the ecosystem die.

Deforestation is the removal of large trees to make space for urban landscapes and farms. Big trees are the main producers in forest ecosystems, as well as homes and food sources to many herbivores and pollinators. All organisms within food webs are affected by deforestation, because they all depend on the original energy source from these producers.

Removing trees can increase soil erosion and water pollution. This is because the roots of the trees no longer hold the soil together or filter the water flowing through the ecosystem.

What is deforestation?

Figure 3.10 The land covered by this new housing development previously had large trees and an ecosystem for a variety of organisms.

2 Removing or introducing organisms affects biodiversity

Biodiversity is the variety of species within an ecosystem. The more species there are in a food web, the better the chances each type of organism has of survival if the environment changes. If there are fewer organisms, there are fewer food chains and less variety of food sources.

Loss of biodiversity causes major problems. These problems can happen in ecosystems on land or in water; for example, during commercial fishing. If a consumer relies on a single food source, and this source is lost, the consumer will be affected. It will decline, either by individuals moving to a new area or dying. This has a flow-on effect to the consumers that feed on it, and causes greater competition for the reduced food sources available. Humans take organisms out of natural ecosystems for their own use, such as for food. Biodiversity can be affected if too many organisms are taken, because they don't have a chance to repopulate.

Another way humans damage biodiversity is by introducing new organisms into an environment. These species, such as rabbits and blackberries, often thrive and take over the food sources and habitats of other organisms.

What is the name for the variety of different species in an ecosystem?

3 Farming, fossil fuels and plastics can damage the environment

Pesticides are chemicals used on farms to kill pests – including unwanted plants and insects – to protect crops. These chemicals may be passed on to other animals in a food chain that feed on the pest. This can cause a build-up of these chemicals to toxic amounts in an ecosystem, and harm organisms (including humans) that have consumed the pesticide.

Algal blooms can happen when large amounts of nutrients from farms are released into streams. The algae in the streams feed off the nutrients and grow quickly, forming a bloom that covers the surface of the water. This prevents light reaching other producers, which die.

The burning of fossil fuels is a cause of global warming, which has a big impact on the habitat and food sources in food webs. These fossil fuels are also used to make plastics, which are non-biodegradable and enter food webs when animals accidentally consume tiny plastic particles.

How do farming practices and fossil fuels affect ecosystems?

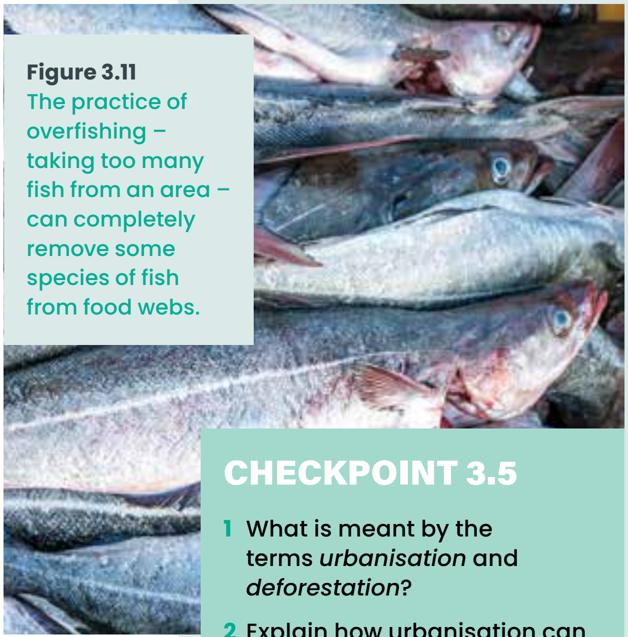


Figure 3.11 The practice of overfishing – taking too many fish from an area – can completely remove some species of fish from food webs.

CHECKPOINT 3.5

1 What is meant by the terms *urbanisation* and *deforestation*?

2 Explain how urbanisation can affect interactions in food chains and food webs.

3 How can an introduced species affect other organisms within an ecosystem?

4 Which has higher biodiversity – a tropical rainforest or a wheat farm? Give evidence to support your answer.

5 Suggest why organisms are more likely to survive in an ecosystem that has high biodiversity.

ETHICS

6 Research coral bleaching and outline some ethical considerations involved in this issue (what is right and wrong). Hint: as well as environmental issues, you could also consider social issues such as jobs and tourism.

SUCCESS CRITERIA

- I can suggest how human activity can affect interactions within food webs and chains.
- I can give an example of the effect of human activities in Australia on natural environments (on land or in water).

3.6 IMPACT OF AGRICULTURE ON ECOSYSTEMS

LEARNING INTENTION

At the end of this lesson I will be able to describe how ecosystems can be affected by agriculture, and how science and technology can contribute to finding solutions to a range of contemporary issues in agriculture.

KEY TERMS

agriculture
the science or practice of farming

cultivation
preparing and using land for crops or gardening

irrigation
supplying water to land or crops

monoculture
the practice of cultivating a single crop in a given area

selective breeding
breeding organisms with desirable traits

yield
the amount of something that is harvested

Farming crops for food production is called **cultivation**. This is part of the practice of **agriculture**, where farmers use land to grow crops and breed animals for food and other products. Agriculture often has negative impacts on ecosystems. Farming is one of the main causes of deforestation, and it often reduces biodiversity.

Scientists work with farmers and governments to come up with ways of cultivation that improve crop **yields** and cause less harm to ecosystems.

1 Monocultures lead to a loss of biodiversity

Some farms grow only a single crop, such as canola or wheat, that covers a very large area of land. These crops are called **monocultures** – other species are removed so that they don't compete for nutrients or feed on the crop. One problem with this loss of biodiversity is that if a disease or pest affects one plant in a monoculture, it can damage all of them because they are all the same.

After a crop is harvested, the soil is ploughed (turned over) to remove the remaining roots of the crop from the soil. This increases seed germination and removes weeds, but it also increases soil erosion and removes nutrients stored in decomposing plants.

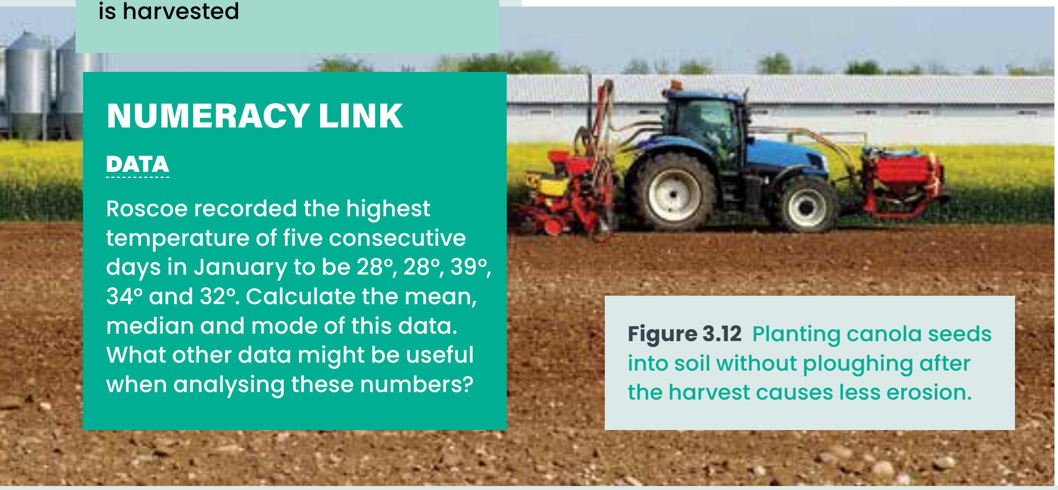
Many farmers are starting to use agricultural methods that allow nutrients to remain in the soil. If the plant matter is left in the soil, without being ploughed, it decomposes, leaving carbon and other nutrients in the soil. This reduces the amount of fertiliser that needs to be added and it is a cheaper method of farming.

What is a monoculture?

2 Chemicals can build up in ecosystems

To give better yields, crops need nutrients. Traditionally, chemical fertilisers have been added to the soil, but fertiliser runs into waterways when there's heavy rain or too much is used. This affects other ecosystems; for example, it can cause toxic algal blooms.

Pesticides and herbicides are used in agriculture to remove pests and weeds from crops. These chemicals can build up in ecosystems, affect other organisms and enter waterways. They can be passed along food chains and cause harm to other organisms.



NUMERACY LINK

DATA

Roscoe recorded the highest temperature of five consecutive days in January to be 28°, 28°, 39°, 34° and 32°. Calculate the mean, median and mode of this data. What other data might be useful when analysing these numbers?

Figure 3.12 Planting canola seeds into soil without ploughing after the harvest causes less erosion.

Reducing and improving chemical use is important in agriculture. Organic fertilisers such as compost and manure add nutrients without causing the same harm as chemical fertilisers. When chemicals are used, they must be registered and controlled. Farmers are required to record their use, including the date, type of chemical and the amount being used.

What is an example of an organic fertiliser?

Figure 3.13 Micro-irrigation systems are replacing traditional spraying methods for some crops.

3 Irrigating crops uses large amounts of water

Have you ever seen a jet of water shooting up high to spray downwards on a crop at a farm? These types of **irrigation** waste a lot of water – some of the water evaporates or doesn't reach the plant, so a large amount needs to be used to soak into the soil.

Micro-irrigation systems are replacing some traditional irrigation sprayers. They are water pipes sitting just above the crops, allowing water to drip slowly on the plants.

Scientists also use scheduling tools to work out the best time to irrigate a particular crop based on rain forecasts, plant stress and temperature. This gives better plant growth and prevents water from being wasted when irrigation isn't needed.

What is irrigation?

4 Selective breeding is used to develop new crops

Some scientists study different species of crop to increase yield and find varieties that can resist drought, pests and diseases. This can be done as part of **selective breeding** programs.

When a disease destroys a crop, a few plants usually survive because they are naturally resistant. Scientists can then breed more of those plants to create an entire crop that's resistant to the disease.

Blackleg is a fungus that damages canola crops in New South Wales and Victoria. Farmers usually use chemical sprays to kill and prevent the spread of blackleg, but the chemicals also affect the ecosystems. Scientists have studied varieties of canola that can resist blackleg. Growing these varieties of canola is the best way to control the effects of blackleg in Australia.

What is selective breeding?

CHECKPOINT 3.6

1 Define agriculture in your own words.
2 Give two examples of crops grown in Australia.
3 Give one example of how scientific knowledge has influenced agriculture.
4 Explain why chemicals are often used in agriculture.
5 Suggest why some farmers are starting to use organic fertilisers.
6 Why do farmers usually grow monocultures rather than a variety of crops?
7 Describe why deforestation is necessary for agriculture.

INQUIRY

8 Undertake some research to suggest one way farmers could improve the productivity of wheat in times of drought.

SUCCESS CRITERIA

- I can explain what agriculture is with at least two examples.
- I can describe how science and technology can contribute to finding solutions to a range of contemporary issues in agriculture.

3.7 INDIGENOUS MANAGEMENT OF ECOSYSTEMS

LEARNING INTENTION

At the end of this lesson I will be able to describe how land management practices of Aboriginal and Torres Strait Islander peoples can help inform sustainable management of the environment.

KEY TERMS

euryhaline
the ability to survive in water with various salinity levels, from fresh to very salty

evolve
change over many generations to adapt to the environment

sustainably
to use a resource in a way that avoids depletion and maintains balance

LITERACY LINK

READING

The Dreaming stories of Aboriginal and Torres Strait Islander people were one way of passing knowledge between generations. Find one story from your local area and summarise the message that it contains.

NUMERACY LINK

CALCULATION

The small sawfish usually has 23–34 teeth on each side of the 'saw'. If a fisherman catches five sawfish, calculate the total approximate number of teeth.

Aboriginal and Torres Strait Islander people have been managing the land **sustainably** for tens of thousands of years. Their ecological knowledge has been passed from one generation to the next.

Today, scientists work closely with Indigenous land managers to learn more about the conservation of ecosystems. The National Environmental Science Program is one such initiative in which Indigenous Australians partner with scientists and governments to undertake environmental and climate research.

1 Ecosystems can be managed with fire

By lighting relatively low-intensity, slow-burning and controlled fires at specific times of the year, Indigenous Australians managed fuel levels and encouraged the growth of key plant species. Because of this practice, some Australian plant species **evolved** to require fire as part of their life cycle. These plants need fire to open seed pods or to clear away competition, and fire also adds nutrients back into the soils. Smoke also helps some seeds to germinate.

Indigenous Australians also used fire to flush out animals so they could be easily hunted.

Since the European colonisation of Australia, the use of fire to manage ecosystems has declined. This has caused a loss of biodiversity in some ecosystems. However, burning practices are being used again in many regions, which has improved biodiversity and led to a return of some species.

Why do some Australian plants need fire?

Figure 3.14 Indigenous fire management practices are now being reintroduced to some Australian ecosystems to restore biodiversity.

Figure 3.15 Banksia seed pods will only open after being burnt by a relatively cool fire. The seeds can then germinate in the nutrient-rich soil, free from competition.

Figure 3.16
The large-tooth sawfish is critically endangered

2 Indigenous knowledge is helping to manage sawfish populations

Sawfish are some of the world's most endangered marine fish species. Four of the world's five species are found in the estuaries of northern Australia. An estuary is an area where a freshwater river meets the ocean, resulting in brackish, or slightly salty, water. Sawfish are a **euryhaline** species, which means that they can live in water that varies in salinity from fresh to very salty. Very few sharks and rays can do this.

The sawfish populations in Australia's northern estuaries and rivers have declined over the last 50 years, and the species are now protected. Threats to the population include fishing, and barriers across rivers, such as road crossings and dams, that limit the migration of the sawfish up and down the river.

Many Indigenous groups have strong cultural connections to sawfish. They know where and when to find the different species and have noted their decline. Scientists can collaborate with these groups to determine ways of protecting threatened sawfish populations. Indigenous knowledge of past sawfish distribution combined with recent population studies helps to determine strategies that will protect these species from extinction.

What is one threat to sawfish populations?

3 Indigenous knowledge is being used to manage ecosystems

There have been many successful strategies involving Indigenous peoples' ecological knowledge to manage ecosystems:

- The Great Barrier Marine Park Authority works closely with the traditional owners of the land to manage and protect the Great Barrier Reef.
- Indigenous communities are working with scientists to study the effect feral cats have on ecosystems and to determine eradication methods.
- Indigenous researchers are working to conserve biodiversity in urban areas.

What is one way that Indigenous ecological knowledge is used to manage ecosystems?

CHECKPOINT 3.7

1 Describe what is meant by sustainability in regards to ecosystems.
2 List four benefits to an ecosystem of controlled fires.
3 Identify two impacts on ecosystems that do not experience regular slow-burning fires.
4 Explain how returning to a regular slow-burning fire regime benefits Australian ecosystems.
5 How is a sawfish different from other sharks and rays?
6 Predict the impact on an ecosystem if sawfish were removed.
7 Explain why Indigenous knowledge is useful to scientists who are studying current populations of sawfish.

CONNECTING IDEAS

8 Considering their incredible knowledge of Australian ecosystems, suggest other areas of land and water management that Indigenous Australians could lead.

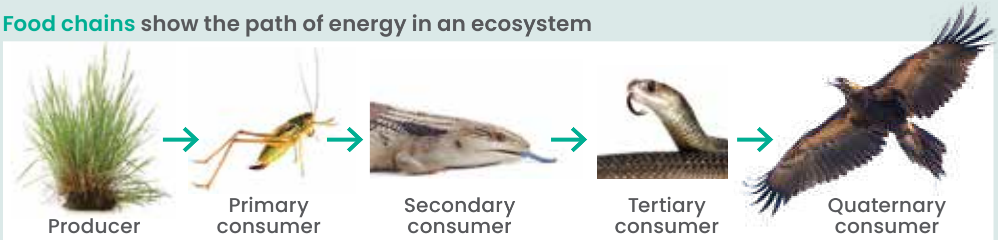
SUCCESS CRITERIA

- I can identify two ways that Indigenous Australians' knowledge and/or practices can be used to help in the sustainable management of ecosystems.

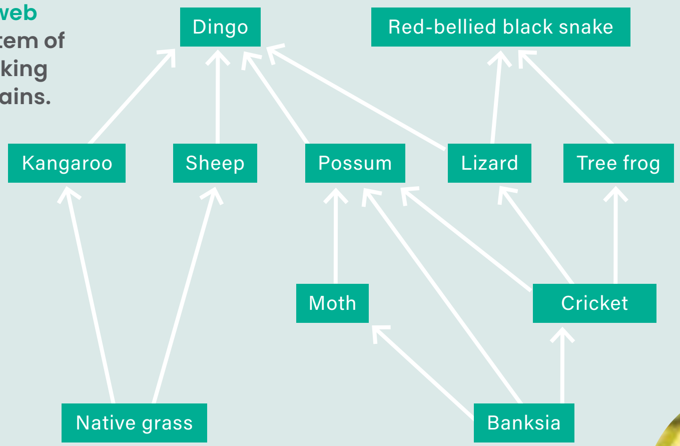
VISUAL SUMMARY

An **ecosystem** is a biological community made up of living things such as plants and animals, as well as non-living things such as air and water.

Food chains show the path of energy in an ecosystem



A **food web** is a system of interlocking food chains.



▲ **Producer**
an organism that produces energy at the start of a food chain

◀ **Decomposer**
an organism that gains energy by breaking down dead material

◀ **Consumer**
an organism that gains energy by consuming other organisms

CONSUMER	OBTAINS ENERGY BY
Herbivore	feeding on producers
Omnivore	feeding on producers and other consumers
Carnivore	feeding on other consumers
Decomposer	breaking down dead matter

Some microorganisms are helpful in ecosystems, breaking down dead matter or acting as a food source.

Other microorganisms are harmful, spreading disease or consuming resources needed by consumers.

Human activities can damage the environment. Our actions can destroy ecosystems or reduce biodiversity.

Human activities can also help the environment, such as using science to fight bushfires or changing the way we grow crops.

★ FINAL CHALLENGE ★

Level 1 ★☆☆☆☆☆ 50xp — LEVEL UP!

1. Which type of organism always occupies the start of a food chain?
2. Name the process that producers carry out to obtain energy.
3. Koalas feed on eucalyptus trees. In this feeding relationship, the koala is a ______________ while a eucalyptus tree is a ______________.

Level 2 ★★☆☆☆☆ 100xp — LEVEL UP!

4. In your own words, write a definition for each of the following terms:
   - **a** microorganism
   - **b** deforestation
   - **c** biodiversity
   - **d** monoculture.
5. Give an example of an unpredictable natural event that can cause harm to Australian ecosystems.

Level 3 ★★★☆☆☆ 150xp — LEVEL UP!

6. Explain the difference between a food chain and a food web.
7. Copy and complete the table by filling in the empty spaces to compare the four different types of consumers.

Type of consumer:	**Herbivore**	**Omnivore**		**Decomposer**
Energy is obtained by:		Feeding on both producers and other consumers		Breaking down decaying matter
An example is:	Grass		Kookaburra	

Level 4 ★★★★☆☆ 200xp — LEVEL UP!

8. Suggest why is it important for organisms to have more than one food source.
9. Predict what you might see if you came upon an area that had been impacted by urbanisation the previous year.
10. Describe some of the ways that Aboriginal and Torres Strait Islander peoples' knowledge is being used to manage ecosystems.

Level 5 ★★★★★★ 300xp — LEVEL UP!

11. Draw and fully label a food chain for an ecosystem of your choice that consists of at least five organisms.
12. Outline the role of decomposers in the cycling of nutrients within an ecosystem.
13. Suggest some negative impacts of agriculture on ecosystems and suggest some possible ways to improve or remove these issues.

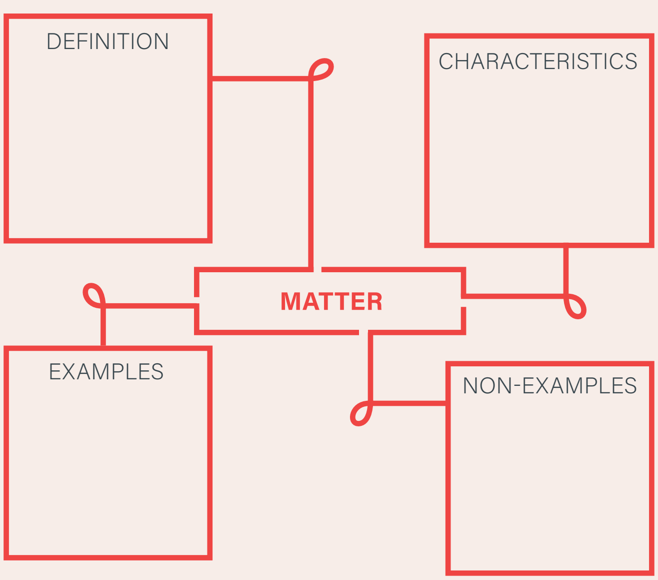
STATES OF MATTER

Is what everything is made of important?

Everything is made of matter. Solid, liquid and gas are the three main states of matter that we observe on Earth. A fourth state of matter, called plasma, occurs in lightning and inside the Sun. Each state of matter can be described by the way particles behave. In many everyday activities – such as melting chocolate, freezing ice cubes and evaporating water when we sweat – we are changing states of matter.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Density* and *Particle*.

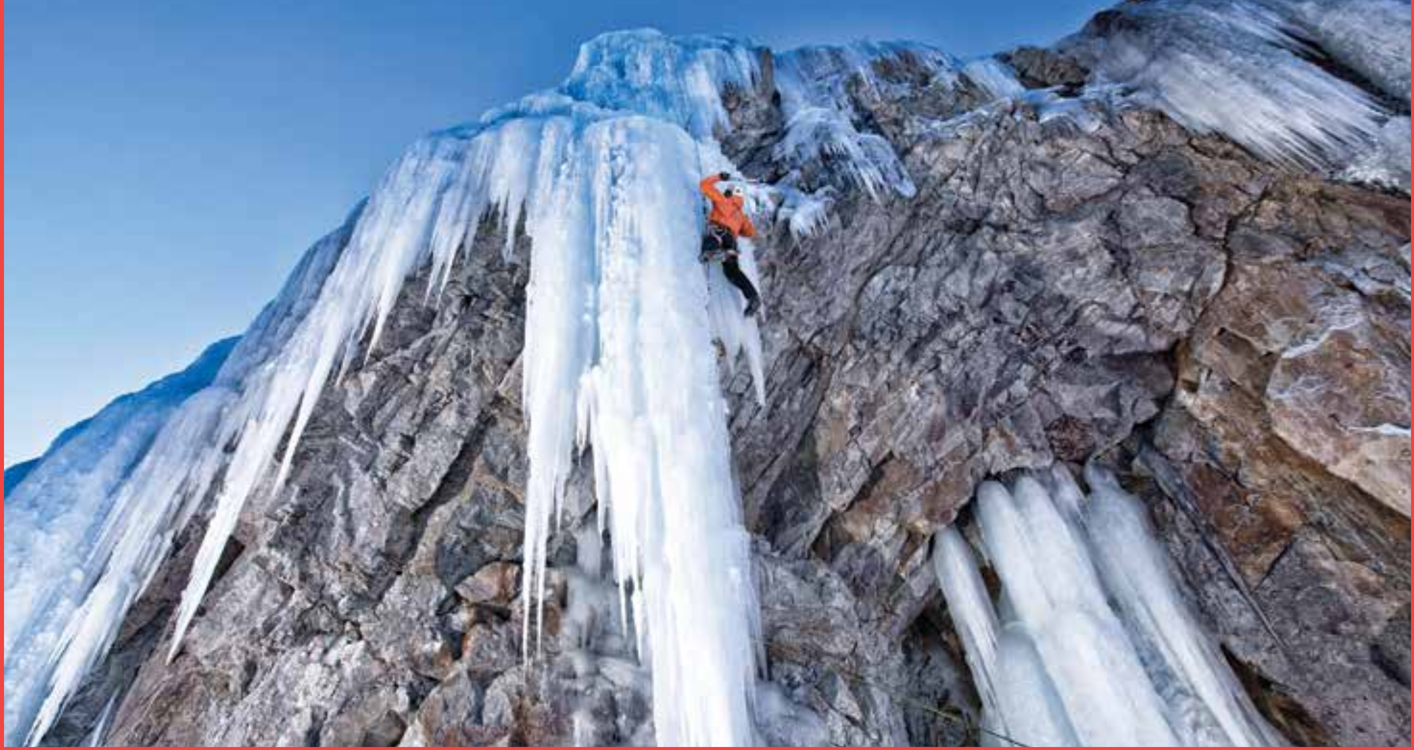
2 LEARNING LINKS

Brainstorm everything you already know about states of matter.




3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.



4 CRITICAL + CREATIVE THINKING

WHAT IF ... all the solids in the world became liquid overnight, and all the liquids became solid?

ALTERNATIVES: List all the ways that you could evaporate something without using fire.

CONSTRUCTION: How could you demonstrate the properties of solids, liquids and gases using a cup, a piece of string and 10 paperclips?

5 THE MOST!

Which of the states of matter do you think makes up most of the universe? You might be surprised to hear that it is plasma. Plasma makes up about 99% of known matter!

Plasma is found in amazing things like flames, stars and lightning. It requires a lot of energy to form. Lightning forms when electrical charges in the atmosphere create so much energy that the air changes from gas to plasma.

4.1 THE PARTICLE MODEL

LEARNING INTENTION

At the end of this lesson I will be able to describe the behaviour of matter in terms of the motion and arrangement of particles.

KEY TERMS

compress
to squash into a smaller space

matter
the particles that make up all physical substances; anything that has mass and takes up space

particle
a very small amount of matter

particle model
a model used to describe the properties of solids, liquids and gases

volume
the amount of space taken up by something

LITERACY LINK

SPEAKING

In 25 words, explain to a partner the difference between the particles in solids and liquids.

NUMERACY LINK

UNITS

Volume can be measured in litres, cubic metres or cubic centimetres. There are 1000 cubic centimetres in a litre, and 1000 litres in a cubic metre. Draw a flow chart showing how to convert between these units.

The **particle model** is a way of describing all the **matter** on Earth. This model states that all matter is made up of tiny **particles**, and that these particles are constantly moving. It can explain why matter behaves in certain ways, and it can predict how matter will be affected by changing conditions such as pressure and temperature.

How can this model be used to describe the properties of solids, liquids and gases?

1 The particles in a solid are packed close together

Solids are materials such as metal or plastic. The particles in solids are packed closely together like bricks in a wall. The particles aren't still; they are constantly vibrating.

A solid has a fixed shape and a fixed **volume**. Because the particles in a solid are very strongly attracted to each other, the solid keeps its shape and doesn't spread out or flow. A solid cannot be easily **compressed**, because there's no room between particles for them to squeeze closer together.

Why isn't a solid able to spread out?

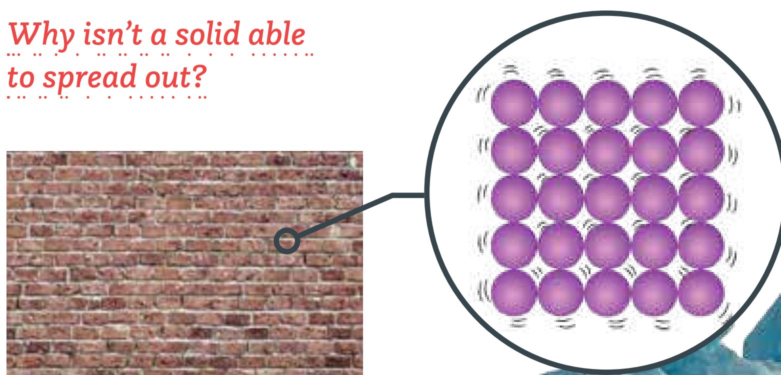


Figure 4.1 The particles in a solid are packed closely together, like bricks in a wall. They vibrate in their positions.

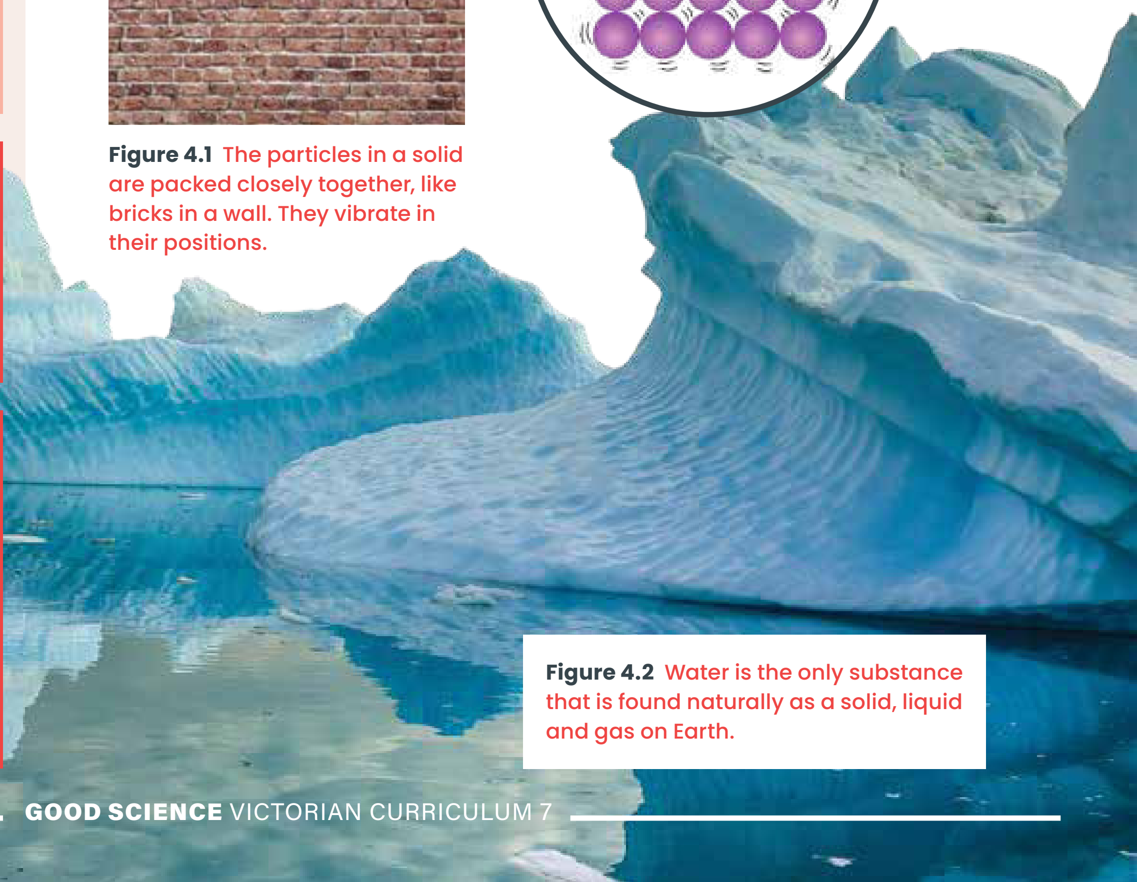


Figure 4.2 Water is the only substance that is found naturally as a solid, liquid and gas on Earth.

2 The particles in a liquid can move past each other

The particles in liquids aren't as close together as they are in solids. The particles are still strongly attracted to each other, but there's room for them to move past each other.

A liquid has a fixed volume but not a fixed shape. A liquid will take on the shape of its container, because the attraction between the particles isn't strong enough to stop them from spreading out. A liquid can't be compressed very much, because there isn't much space between particles for them to squeeze closer together.

Why does a liquid take on the shape of its container?

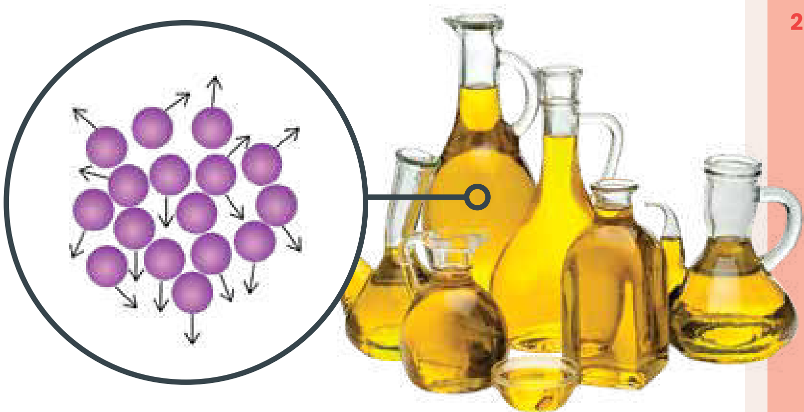


Figure 4.3 The particles in a liquid can move past each other. They will take on the shape of their container.

3 The particles in a gas have large gaps between them

The particles in a gas are very weakly attracted to each other, so they can move around a lot. The particles have large gaps between them, and they are constantly moving in all directions. Some common gases on Earth are oxygen and carbon dioxide. Air is a mixture of gases including oxygen, nitrogen and carbon dioxide.

A gas has neither a fixed shape nor a fixed volume. Gases will spread out to fill up the container they are placed in. A gas can be compressed because there is space between the particles. In a smaller space the gas particles simply have less room to move around.

Why can a gas be compressed?

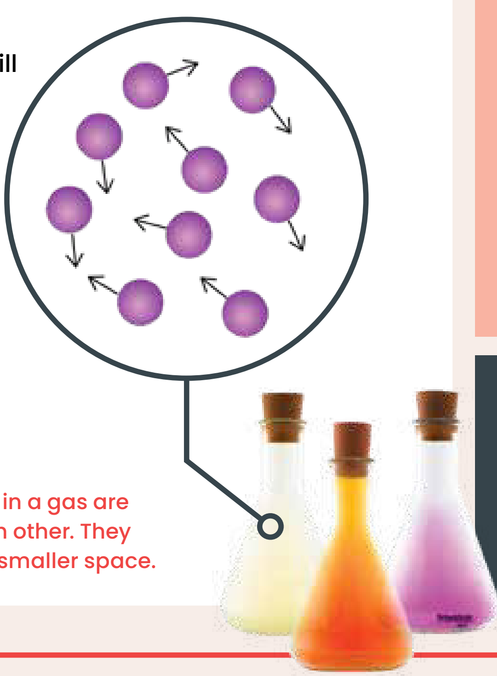


Figure 4.4 The particles in a gas are weakly attracted to each other. They can be squashed into a smaller space.

Investigation 4.1
Compressing liquids and gases

KEY SKILL
Explaining results using scientific knowledge

▶ *Go to page* ***149***

CHECKPOINT 4.1

1 List three solids, three liquids and three gases you have come into contact with today.

2 a My particles are constantly moving all over the place and have a weak attraction to each other. People always tell me that I will go far in life. I do not have a fixed shape or a fixed volume. Who am I?
b My particles are constantly moving (usually over, under or past each other) and have a strong attraction to each other. I tend to go with the flow and do not have a fixed shape (although I do have a fixed volume). Who am I?

3 a How can a brick wall be used to explain the particles in a solid?
b How can a jar of marbles be used to explain the particles in a liquid?
c How can a pool table and balls be used to explain the particles in a gas?

INQUIRY

4 Plasma is sometimes called the fourth state of matter. Use the resources available to you (including your classmates and teacher) to research plasma, and how it differs from the other three states of matter.

SUCCESS CRITERIA

- I can state the three main states of matter.
- I can describe the behaviour of particles in each state.

4.2 HEAT ENERGY AND PARTICLES

LEARNING INTENTION

At the end of this lesson I will be able to discuss how heat energy affects particles in a substance.

KEY TERMS

energy
the ability to do physical things such as move or change

heat
a type of energy

substance
matter that has a fixed chemical make-up

temperature
the measurement of how hot a substance is

transferred
moved from one thing to another

LITERACY LINK

WRITING

An analogy is a way of comparing one thing to another, such as 'The particles in a solid are like bricks in a wall'. Write an analogy to describe the heating of gas particles, then write an explanation of why your analogy is a good comparison.

NUMERACY LINK

GRAPHING

The temperature of a substance was measured every minute for five minutes. The measurements (in degrees Celcius) were 62°, 54°, 48°, 44° and 39°. Display this data in a line graph.

The particle model states that all matter is made up of constantly moving particles. A solid object such as a statue doesn't appear to be moving, but its particles are.

The speed of the particles depends on the amount of **energy** they have. If you increase the energy of the particles, they'll move faster and further away from each other. How can you increase energy? Just add heat!

1 Heat is a type of energy

Energy is needed for matter to do things such as move or change. **Heat** is one type of energy. The more heat energy a **substance** has, the faster and further apart the particles will move.

Heat can be **transferred** from one object to another. For example, in Figure 4.6 the heat energy in the electric kettle element is transferred to the water to boil it.

The same principle applies in solids. Have you ever rested a metal spoon in a hot drink? At first, the metal handle feels cool, but soon warms up and can even burn you. This shows that energy is transferred from the bottom of the spoon all the way to the top. The particles at the base of the spoon are heated and begin to move around more. They bounce up against the particles near them, which in turn gain energy, bouncing into the ones near them, and so it continues, all the way up the spoon to the handle.

How does the speed of particles change when heat is added to a substance?

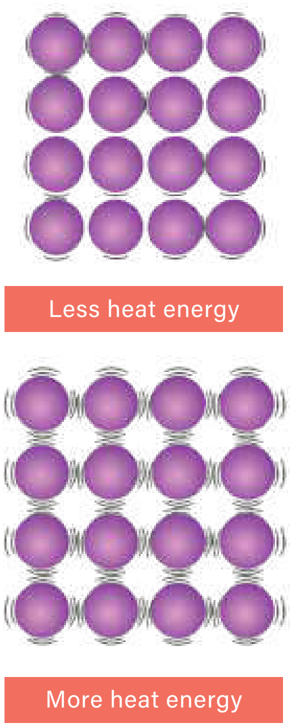


Figure 4.5
The more heat you add, the faster the particles in a substance move.

Figure 4.6
When you heat something, for example when you boil water, you're adding heat energy to it.

❷ Substances lose heat energy when they cool

There are many ways to cool a hot object. You could put it in the fridge, put it in cold water, or just leave it to cool in the air.

Heat energy is transferred from substances with lots of energy to substances with less energy until the particles in both substances have the same amount of heat energy.

When a substance loses energy in this way, the particles slow down and move closer together.

How does the speed of particles in a substance change when heat is removed?

❸ Temperature and heat are not the same thing

Temperature is a measurement of the average amount of heat energy the particles in a substance have. The higher the temperature of a substance, the more heat energy is held by the particles and the faster they move. If heat energy is added to a substance, the temperature will increase. If heat energy is removed from a substance, the temperature will decrease.

If a large iron block and a small iron block were heated in the laboratory to a temperature of 50°C, the larger block would contain more heat energy. This is because it has more particles, even though it is the same temperature as the smaller block.

What is temperature?

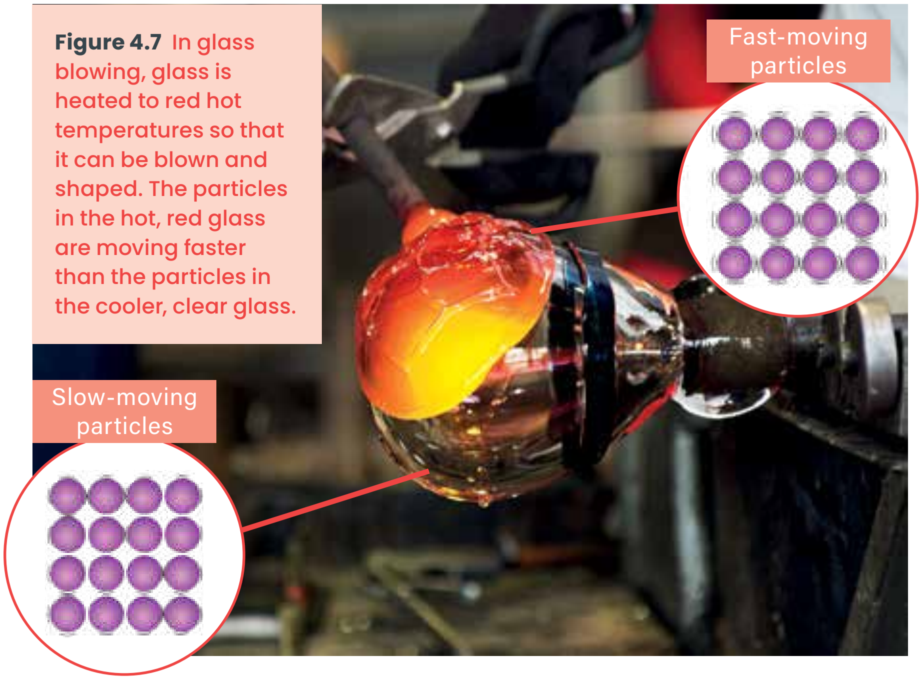


Figure 4.7 In glass blowing, glass is heated to red hot temperatures so that it can be blown and shaped. The particles in the hot, red glass are moving faster than the particles in the cooler, clear glass.

Investigation 4.2
Heating materials

KEY SKILL
Identifying the variables and formulating a hypothesis

▶ *Go to page* ***150***

CHECKPOINT 4.2

1 Copy and complete these sentences. The speed of particles is directly related to the amount of __________ they have. The more __________, the faster they move.

2 Would the particles in a cup of 30°C water move faster or more slowly than particles in a cup of 45°C water? Give evidence to support your answer.

3 In terms of the way the particles behave, how does heating a solid differ to heating a liquid?

4 Imagine you've decided to cook a steak for dinner. You remove it from the freezer and defrost it. Describe how the motion of the particles in the steak would change as it defrosts.

5 Choose an object. Draw a diagram that shows how the particles in that object behave when heat is added and when heat is taken away. Use the diagrams in this lesson to help you.

INQUIRY

6 Design an experiment to investigate whether particles move more slowly as heat energy is removed.

SUCCESS CRITERIA

- I can describe how particles act when heat energy is added and taken away.

4.3 ADDING OR REMOVING HEAT

LEARNING INTENTION

At the end of this lesson I will be able to outline the effect of adding or removing heat on different states of matter.

KEY TERMS

contract
to get smaller; shrink

expand
to get bigger; increase in size

thermal
relating to heat

LITERACY LINK

READING

Write three questions for a classmate based on the information from this section. Swap with your classmate and answer their questions.

NUMERACY LINK

MEASUREMENT

To one decimal place, what is the temperature measured by the thermometer in Figure 4.10?

You now know that the speed of the particles in a substance depends on the substance's temperature. Particles in a hot substance will move quickly, while particles in a cold substance will move slowly.

Some other changes happen when an object is heated or cooled.

1 Solids expand when they are heated

If you add heat energy to a substance, the particles move faster. Because the particles have more energy and are moving faster, they will move further away from each other, so the substance will **expand**. This is called **thermal** expansion.

When a solid is heated, it will expand. Different solid substances expand at different speeds and by different amounts. Most solids do not noticeably change their size. Metals are one type of substance that expand noticeably when heated. When metals cool down again, the particles lose energy and move closer together again. This is called thermal **contraction**.

What is thermal expansion?

Figure 4.8 The expansion of metal in very hot weather can cause fixed metal structures such as train tracks and fences to buckle or bend.

Figure 4.9 The spaces between the joints in a bridge allow the metal to expand in hot weather without causing the bridge to buckle.

2 Liquids expand when they are heated

Thermal expansion also happens in liquids. Heating a liquid causes the particles to move more quickly and further away from each other, so liquids will take up a larger volume as they become warm. They will contract as they cool back down again.

Water that is heated without any room to expand can be very damaging. For example, it can cause pipes to burst. The property of liquids expanding when heated can be used safely, such as in alcohol and mercury thermometers. The liquid inside them expands when the temperature increases.

Why can thermal expansion be a problem?

Figure 4.10 The liquid alcohol inside a thermometer takes up different amounts of space depending on how much heat energy it has, allowing the temperature to be measured.

3 Gases expand or contract with changes in heat

As with solids and liquids, thermal expansion and contraction also happens in gases. Because the particles in gases are already far apart, the expansion and contraction of gases can be very noticeable.

Although most gases are invisible, you can still see that a warm gas will take up more space than a cold gas. You can check this by blowing up a balloon and putting it in a refrigerator. The gases inside it will cool down and contract, making the balloon smaller.

How will the volume of a gas change if it is cooled?

Figure 4.11 The gas in a hot air balloon will expand when it is heated.

Investigation 4.3
Expanding gases

KEY SKILL
Evaluating results for reliability and validity

▶ *Go to page* ***151***

CHECKPOINT 4.3

1. What happens to the particles in a substance when heat energy is added?
2. What happens to the particles in a substance when they lose heat energy?
3. Identify which state of matter (solid, liquid or gas) would show the greatest change in volume if heat energy is added or lost. Use the particle model to help explain your answer.
4. An iron bar is heated from room temperature to 300°C. Would this make the bar expand or contract? Explain your answer using evidence from the text.
5. Describe and include a diagram showing what happens to the particles in the iron bar in question 4.
6. Design a safety feature in a building that would prevent the walls cracking when they expand after heating. You could write a description or draw an annotated diagram.

CONNECTING IDEAS

7. Bridges have expansion joints to prevent buckling in hot weather. What are some other examples of designs that take into account how particles behave in solids, liquids or gases?

SUCCESS CRITERIA

- I can predict the effect of adding or removing heat on:
  - solids
  - liquids
  - gases.

4.4 CHANGING STATES

LEARNING INTENTION

At the end of this lesson I will be able to describe some of the key processes that take place as matter changes states.

KEY TERMS

boiling point
the temperature at which something changes from a liquid to a gas

condensation
changing from a gas to a liquid

evaporation
changing from a liquid to a gas

melting point
the temperature at which something changes from a solid to a liquid

LITERACY LINK

LISTENING

Choose a section from this lesson to read aloud to a partner. Your partner draws a diagram based on what you have read, showing particles during a state change.

NUMERACY LINK

DATA

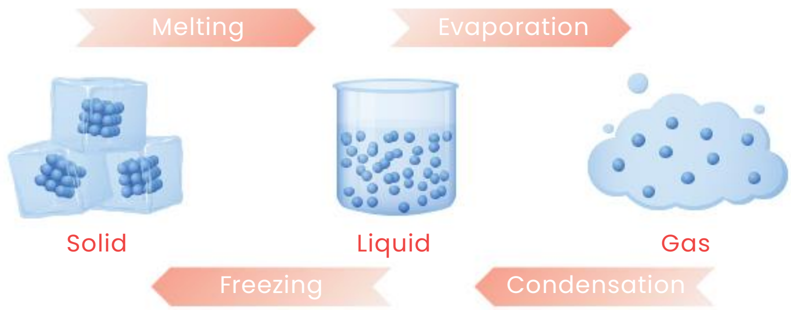
Ash heated some water over a Bunsen burner and recorded the temperature every minute for five minutes. His results were 45°, 54°, 90°, 70° and 75°. Does this data look valid? What should Ash's next step be?

Hint: See lesson 1.4 for a definition of valid data.

Water is the only substance on Earth that exists as a solid, liquid and gas. Solid water is ice. If you heat it, the ice melts into liquid water. If you keep heating, it boils and becomes water vapour.

The particle model and your understanding of how heat affects particles can be used to explain these changes in state.

Figure 4.12 Water can change state from solid to liquid to gas as heat is added. If heat is taken away, the changes are reversed.



1 Solids can melt to liquids when heated

Melting is the change of a solid to a liquid. The **melting point** is the temperature when something changes from a solid to a liquid. This is different for every substance.

The particles of a substance in its solid state are strongly attracted and don't move very much – they just vibrate back and forth. As you add heat energy, the particles move faster and vibrate more. If you add enough heat, the particles have enough energy to break free of the solid structure and move around each other. The substance is now a liquid.

Which state of matter undergoes melting?

Figure 4.13 When particles in a solid such as wax speed up, the solid can melt to form a liquid.

2 Liquids can freeze to solids when cooled

Freezing is the change of a liquid to a solid when cooled. It is the opposite of melting.

The particles in a liquid have enough energy to move around each other. If you cool a liquid, you remove heat energy and cause the particles to move more slowly. If particles lose enough energy, they no longer move around, but instead just vibrate in place. The substance is now a solid.

Freezing is when a liquid becomes which state of matter?

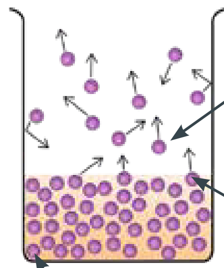
3 Liquids can evaporate to gases when heated

Evaporation is the change of a liquid to a gas.

Evaporation can happen at any temperature. In any liquid, some of the particles will randomly have enough energy to break away from the others. These particles leave the surface of the liquid as a gas. Evaporation is the reason that a puddle will eventually shrink and disappear, even during cool weather.

Boiling is evaporation that happens when a liquid is heated to its **boiling point**. This point is different for every substance. When they have enough heat energy, the particles in the liquid move so quickly that they become a gas inside the liquid. This gas can be seen as bubbles that rise through the liquid and escape.

Figure 4.14 Particles near the surface of a liquid become a gas during evaporation.



What is an example of evaporation?

4 Gases can condense to liquids when cooled

Condensation happens when a gas changes to a liquid when cooled. It is the opposite of evaporation.

Gas particles move very quickly, so they remain separate from the other particles. However, if you remove heat energy and slow the particles down, they no longer have enough speed to overcome the attraction of the other particles. They move closer together to become a liquid.

Have you ever seen water drops form on the outside of a cold glass of water? That's condensation.

What happens when gas particles slow down?

Investigation 4.4
Exploring melting points

KEY SKILL
Representing data

▶ *Go to page* ***152***

CHECKPOINT 4.4

1 Copy and complete these sentences.
Changes in _________ happen when heat ___________ is ___________ or ___________ from a substance.

2 From each pair, identify which state of matter has particles with more energy.
a Liquid or gas
b Gas or solid
c Solid or liquid

3 Describe how heat energy affects what happens to the particles in:
a a solid that is melting
b a liquid that is evaporating
c a gas that is condensing
d a liquid that is freezing.

4 Explain the difference between evaporation and condensation.

5 Create a table to compare the amount of energy and distance between the particles in solids, liquids and gases. *Hint: Use words such as high, low, close and far.*

EXTENSION

6 Sublimation is when a substance changes from solid to gas, without becoming a liquid. Use evidence from the text to propose how this happens.

SUCCESS CRITERIA

- I can describe what happens to particles during:
  - melting
  - freezing
  - boiling
  - condensation.

4.5 DENSITY

LEARNING INTENTION

At the end of this lesson I will be able to explain density in terms of the particle model.

KEY TERMS

density
how heavy something is for its size; mass divided by volume

mass
the amount of matter in an object

What determines whether something floats in water? You might suggest that the **mass** of the object is important. But there must be more to it. Icebergs are extremely heavy, yet are able to float, while coins are much lighter but they sink.

The answer has to do with a property called **density**.

1 Density is how heavy an object is for its size

You can calculate the density of an object by dividing its mass by its volume. In other words, density is a measure of how heavy an object is compared to its size.

Solids usually have higher densities than gases and liquids because their particles can pack more closely together. A coin may be lighter than a log, but a coin-sized piece of the log would be lighter than the coin because metals are denser than wood. So, when comparing two objects of the same size, the heavier one has a greater density.

What two properties is density related to?

LITERACY LINK

VOCABULARY

The words *mass* and *volume* have different meanings when used in a scientific context. Think of three other words that can have different meanings in a science classroom, then use them in sentences to demonstrate their alternative meanings.

NUMERACY LINK

CALCULATION

The mass of a substance is 4900 g, and it takes up a volume of 70 mL. What is its density?

Formula:
density = mass ÷ volume

Figure 4.15 How is a heavy ship able to float on water?

2 Density can be explained using the particle model

In terms of the particle model, density is related to two things.

The first thing to consider is the amount of space between particles. The more tightly packed the particles are, the denser the object.

Second, it depends on the mass of the particles. The heavier the particles are, the denser the object. Imagine a bike with an aluminium frame and the same bike made of steel (iron metal). Although they are the same size, the steel bike is heavier because iron atoms are heavier than aluminium atoms.

What factors affect the density of an object?

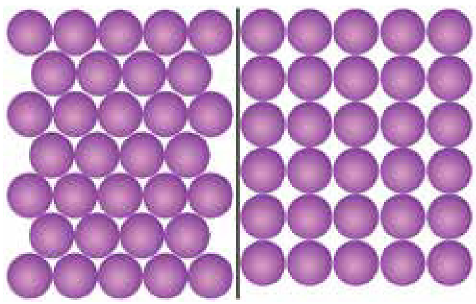


Figure 4.16 The particles on the left are more closely packed than the particles on the right. A substance with particles that are closely packed has a high density.

3 Liquids and gases with lower density float on those with higher density

Liquids and gases with a lower density float on top of substances with a higher density.

Have you ever heard that 'hot air rises'? This is because hot air is less dense than cool air. The space between the particles in the hot air is larger than the space between the particles in the cool air. This is what keeps a hot air balloon in the sky.

Consider the ship in Figure 4.15. It floats on water, which must mean a ship has a lower density than water. How can this be, if the ship is made of metal?

Even though it's made of metal, most of the inside of a ship is air. The air takes up a lot of volume but has very little mass, and so overall the ship has a density that is less than water.

What does a ship contain that allows it to float on water?

Figure 4.17 Liquids of different densities in a container will arrange themselves so that the liquid with the highest density is at the bottom and the liquid with the lowest density is at the top.

Investigation 4.5
Exploring density

KEY SKILL
Writing a research question

▶ *Go to page **153***

CHECKPOINT 4.5

1 What is the formula for calculating density?

2 a List three objects that float in water and three objects that sink in water.
  b Using your knowledge of the particle model, explain why the objects in part a float or sink.
  c Draw a diagram showing high density and low density particles to illustrate the explanation you wrote in part b.

3 In terms of density and particles, explain why a soccer ball weighs much less than a bowling ball of the same size.

4 A fresh egg will sink in a glass of water, but a rotten egg will float. Which of the two eggs has a higher density? Give evidence from the text to support your answer.

5 Predict what would happen if you dropped a six-sided die, a Lego minifigure and a gold earring into the container shown in Figure 4.17. Explain your prediction.

RESEARCH

6 A neutron star contains some of the densest material in the universe. Use the internet to find out about the density of a neutron star.

SUCCESS CRITERIA

- I can describe what density is.
- I can draw a diagram showing high density and low density particles.

VISUAL SUMMARY

Matter is described as the particles that make up all physical substances. It has mass and takes up space.

The three main states of matter

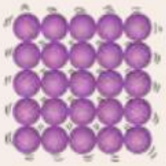
- Solid
- Liquid
- Gas

The particle model is a simple way of describing matter

Solid

Particles in a solid are:

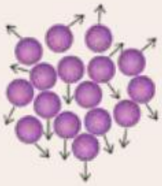
- arranged in a regular pattern like bricks in a wall
- constantly vibrating in a fixed position
- packed very close together with a very strong attraction to each other.



Liquid

Particles in a liquid are:

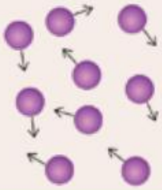
- randomly arranged
- move over and around each other
- packed close together with a strong attraction to each other.



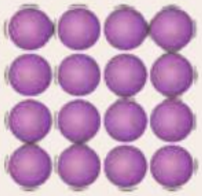
Gas

Particles in a gas are:

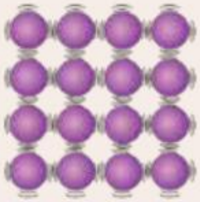
- randomly arranged
- move freely in all directions
- far apart with a weak attraction to each other.



Particles vibrate more when heat is added.

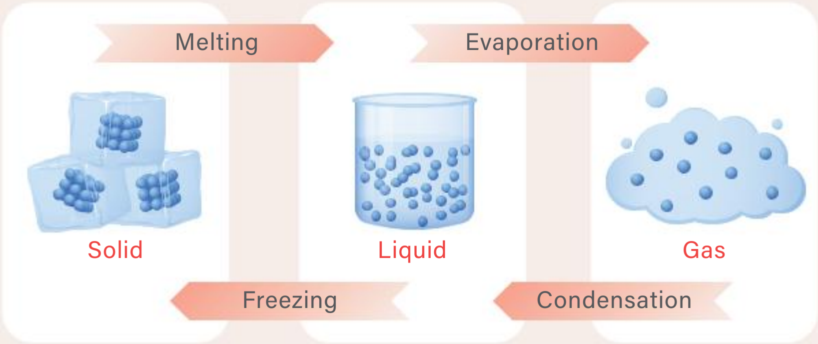


Less heat energy



More heat energy

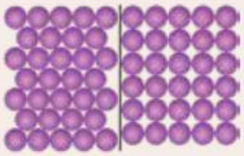
Thermal expansion can happen in solids, liquids and gases.



Density is how heavy an object is for its size:

Mass ÷ volume

Low density substances have more space between particles than high density substances.



★ FINAL CHALLENGE ★

1 Define *matter* in your own words.

2 Copy and complete this sentence: The ________ heat energy that particles possess, the faster they move. If you remove heat energy from the particles, they will ____________.

3 Liquids can become gases in two ways. What are they?

Level 1

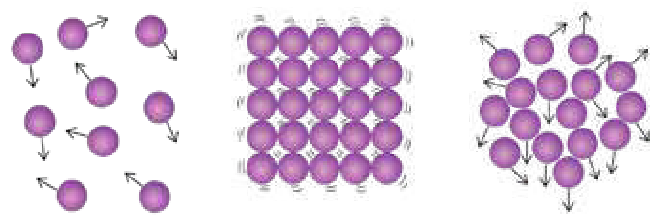
50xp

LEVEL UP!

4 Match these terms to their definitions.

freeze	To heat a solid until it becomes liquid
melt	To heat a liquid until it becomes a gas
evaporate	To cool a liquid until it becomes a solid
condense	How hot something has to get before it melts
melting point	To cool a gas until it becomes a liquid

5 Label each of these diagrams as 'solid', 'liquid' or 'gas'.



________ ________ ________

Level 2

100xp

LEVEL UP!

6 Explain the difference between the particles in a liquid and the particles in a gas.

7 Are particles in a solid always moving? Justify your answer.

8 Describe the effect of adding heat to a:

a solid **b** liquid **c** gas.

Level 3

150xp

LEVEL UP!

9 Draw a diagram that shows the behaviour of particles that are heating, and another that shows the behaviour of particles that are cooling.

10 Explain how and why condensation happens.

11 Explain what the particle model is and suggest why it is referred to as a model.

Level 4

200xp

LEVEL UP!

12 You can calculate density by dividing an object's mass by its volume. Explain why mass and volume are used to calculate density.

13 Using an explanation involving the particle model, suggest why the bridge in Figure 4.9 is designed with this metal feature.

Level 5

300xp

LEVEL UP!

MIXTURES

Is what everything is made of important?

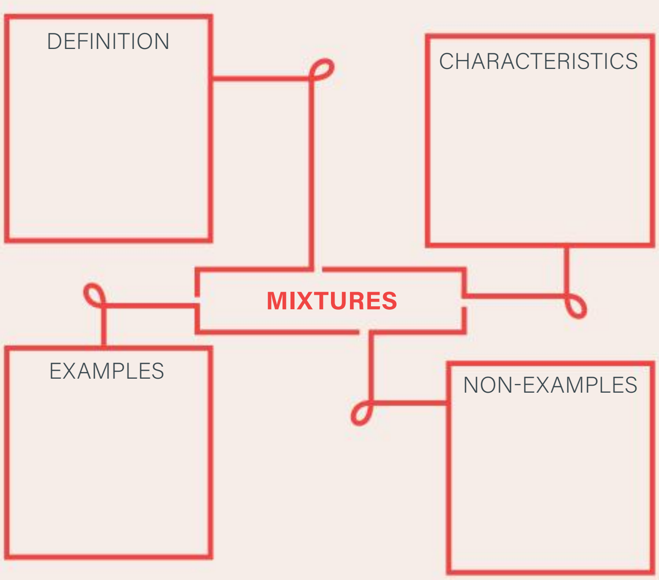
5

If you've ever made pasta at home, you've probably seen mixtures in action. You may have strained pasta from water or thickened a sauce by evaporating excess water. If you had a soft drink with your pasta, you were drinking a mixture called a solution.

Mixtures are different to pure substances because they can be separated. There are many different separation techniques, and we need to use the right ones in the right order for them to be effective. Separation techniques are used every day – from cleaning up oil spills to separating the parts of blood.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



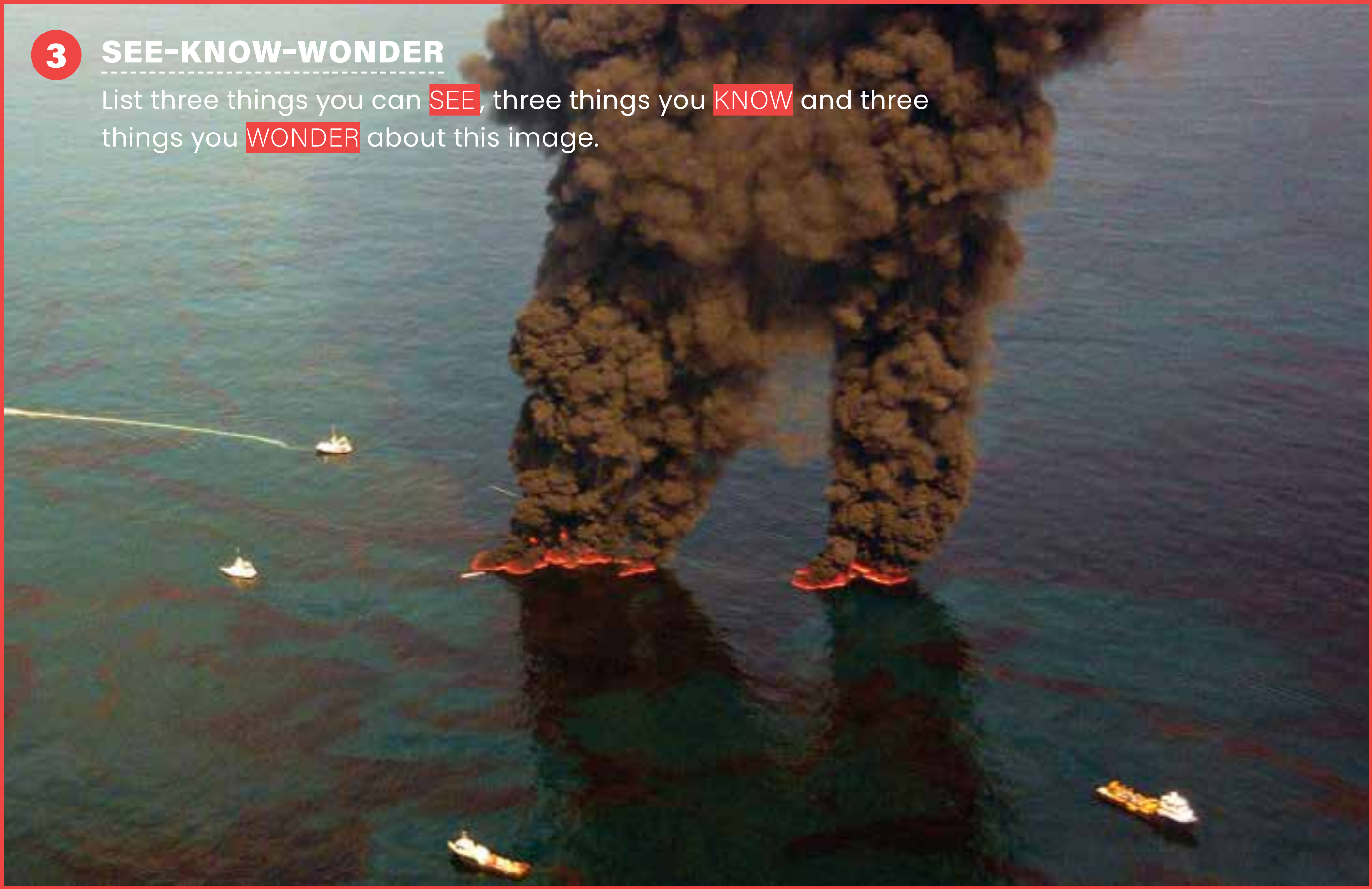
Complete two additional charts for the key terms *Solution* and *Pure substances*.

2 LEARNING LINKS

Brainstorm everything you already know about mixtures.

3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.



4 CRITICAL + CREATIVE THINKING

DIFFERENT USES: List some wildly different uses for filter paper. Think of as many as you can.

THE ALPHABET: Think of a word about mixtures for every letter of the alphabet.

RIDICULOUS! Attempt to support this statement: 'From 2022, every home must process its own waste, including sewage.'

5 THE BIGGEST!

The biggest rubbish dump in the world probably isn't where you think it is – it's in the ocean. The Great Pacific Garbage Patch floats somewhere between Hawaii and California and is estimated to be at least three-quarters of the size of New South Wales. That's huge!

The ocean currents pull in more plastic every day, but there is some good news – a clean-up of the floating dump began in 2018 using floating 'ocean scrapers'. These scrapers are made out of recycled plastics from the garbage patch itself.

5.1 MIXTURES AND PURE SUBSTANCES

LEARNING INTENTION

At the end of this lesson I will be able to explain what a mixture is and why it is important to be able to separate mixtures.

KEY TERMS

mixture
a substance that is composed of different types of particles, all mixed together

ore
a rock found in nature that contains metal

pure substance
a substance that is composed of only one type of particle

LITERACY LINK

SPEAKING

Think of a mixture. A partner then has to try and guess what your mixture is by asking a maximum of 20 'yes' or 'no' questions.

NUMERACY LINK

CALCULATION

A bottle of cordial suggests adding one part cordial to five parts water. How much cordial would you need to make 2.4 litres of cordial solution?

A pizza is a combination of different things. There's the crust, the meat (or other toppings) and the cheese. Each of these ingredients is a **mixture** as well: the crust is made of flour, yeast and water; the meat is made of protein, fat and water; and the cheese is made of protein and fat. All substances can be classified according to what they are made up of – a substance such as water that contains only one type of particle is called a **pure substance**. Other substances that contain combinations of other things are called mixtures. To tell the difference, we need to know what a substance is made up of at the particle level.

1 Pure substances contain only one type of particle

All substances are made up of particles. Some substances, such as sand, are made of particles that are easy to see. Some, such as water, are made of particles that are far too small to see with the naked eye.

In a pure substance, all of the particles it contains are exactly the same. If you took a very powerful microscope and looked at pure water, you would see that every particle in the water is identical.

Other examples of pure substances are oil, salt, iron and diamond.

Combining two or more pure substances will usually create a mixture.

What is a pure substance?

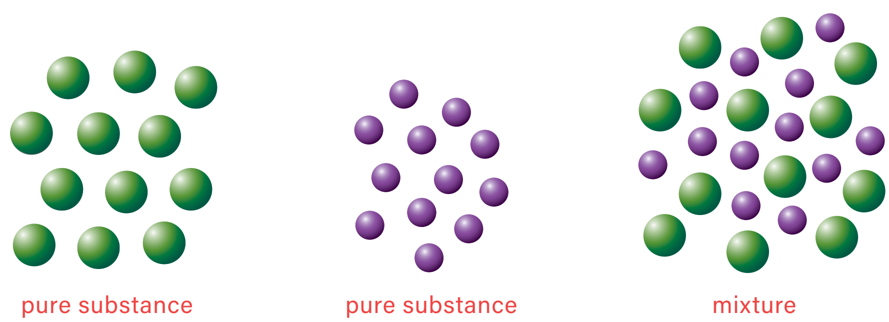


Figure 5.1 The particles in a pure substance are all the same. Combining two pure substances will form a mixture, where the particles are no longer all identical.

❷ Mixtures are made up of different particles

A mixture is a substance where not all of the particles are the same. Mixtures are usually made up of more than one pure substance. Think about a cup of instant coffee. The coffee contains coffee powder, some boiled water from the kettle and perhaps some milk or sugar. This means that coffee is a mixture of all of these substances. A microscope would show that a cup of coffee contains many different types of particles.

Another example of a mixture is the air that we breathe. Air contains mostly nitrogen, oxygen, argon and carbon dioxide particles. When we use the word 'air', we are referring to the mixture of all of these gases.

Figure 5.2 Pizza is an example of a delicious mixture because it is made up of a variety of different substances.

Give two examples of mixtures.

❸ Different mixtures require different separation techniques

It's very easy to make coffee, but can we do it in reverse? Can we take a cup of coffee and separate it out into water, coffee powder, sugar and milk? In fact, we can! It sounds impossible, but by using the correct scientific techniques and equipment, we are able to separate all sorts of mixtures into their parts.

However, it is very important that we use the correct techniques in the correct order. The procedure used to separate coffee from water would be very different from the procedure used to separate nitrogen from oxygen.

Separation of mixtures is very important in our day-to-day lives. There are very few pure substances found in nature, so we need to separate mixtures to extract the pure substances that we want to use.

For example, in order to use aluminium to make a can of soft drink, we need to separate the aluminium from the **ore** that it is found in. Without the correct separation techniques, we wouldn't be able to use this aluminum, or many other pure substances that we use every day.

What is aluminium mixed with in nature?

CHECKPOINT 5.1

1. How are the particles in a pure substance and a mixture different from each other?
2. Draw a diagram showing the particles in:
   a pure water
   b air.
3. Make a list of mixtures you have come into contact with today.
4. In your own words, explain why it is important to be able to separate mixtures.
5. Which of the following are mixtures, and which are pure substances?
   sugar, tea, mud, copper, diamond, soup, sea water
6. Out of all of the substances in question 5, list the ones that you would be able to separate into their components.

RESEARCH

7. There are many different types of mixtures. Use the internet to find out what is meant by a heterogenous mixture, a homogenous mixture, a colloid and a suspension. Give an example of each.

SUCCESS CRITERIA

- I can describe the difference between a mixture and a pure substance in my own words.
- I can give some examples of separation techniques used in everyday life.

5.2 SOLUTE, SOLVENT, SOLUTION

LEARNING INTENTION

At the end of this lesson I will be able to describe mixtures in terms of solute, solvent and solution.

KEY TERMS

aqueous
containing water

dissolve
to mix a solid into a liquid to form a mixture called a solution

insoluble
something that does not dissolve

soluble
something that dissolves

solute
a substance that is dissolved by a solvent

solution
a mixture made up of a solvent and a dissolved solute

solvent
a substance that dissolves a solute

LITERACY LINK

VOCABULARY

The words *solution*, *solvent*, *solute* and *dissolve* are all related in meaning and all contain the letters 'sol'. Can you think of another group of words that are all related and share a common group of letters?

Soft drinks were created as far back as the 1600s! Some contain many, many ingredients – most of which we are blissfully unfamiliar with.

It all starts with water, a **solvent** that can **dissolve** many substances. The ingredients of the soft drink – sugar, flavours and carbon dioxide for fizz – are **solutes**. They are dissolved in the mixture, which is a solution.

1 Solutes dissolve in other substances

A solute is any substance that can dissolve in another substance (the solvent). Solutes can begin as any of the three main states of matter:

- *solid*; for example, sugar, salt and instant coffee are all solutes that can dissolve in water
- *liquid*; for example, cordial can dissolve in water to make a sweet drink
- *gas*; for example, carbon dioxide can dissolve in soft drinks, which makes them fizzy.

Substances that dissolve are said to be **soluble**. Substances that do not dissolve are said to be **insoluble**. A substance that is insoluble in a solvent such as water might be soluble in a different solvent such as an acid.

What is a solute?

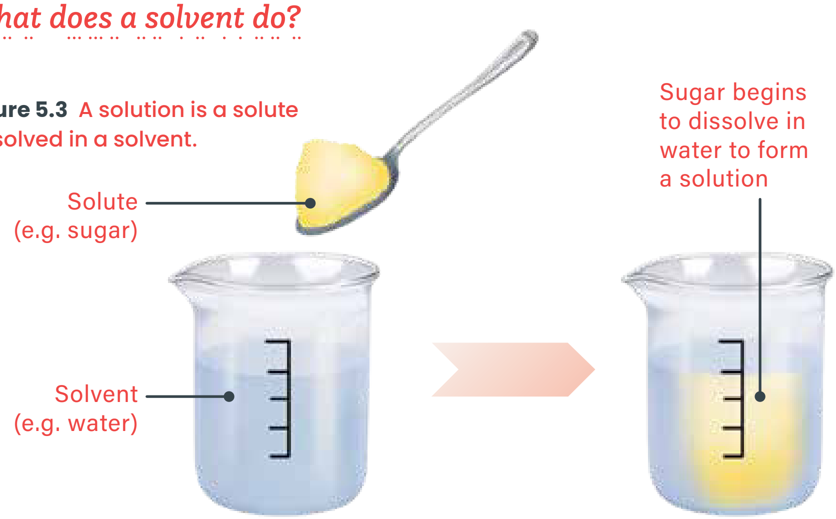
2 Solvents dissolve solutes

A solvent is any substance, usually a liquid, that can dissolve another substance (the solute).

Water is a liquid that can dissolve cordial (another liquid), sugar (a solid), and fizzy carbon dioxide (a gas) in soft drinks.

What does a solvent do?

Figure 5.3 A solution is a solute dissolved in a solvent.



3 Solutions are solutes in solvent

A **solution** is a mixture made up one or more solutes dissolved in a solvent. A cup of black coffee, for example, is a solution made up of:

- solutes – powdered coffee and perhaps sugar
- a solvent – water.

Any solution that has water as a solvent is called an **aqueous** solution.

What is a solution made up of?

4 Solutions, suspensions and colloids

Not all solutions are the same. Different solutes make different solutions. Also, the amount of solute affects the solution.

- *Concentrated solution*: a solution with a lot of solute. Putting 20 tablespoons of cordial in one glass of water gives you a concentrated (and unpleasantly sweet) solution.
- *Dilute solution*: a solution with a very small amount of solute. Putting a quarter of a teaspoon of cordial in a large glass of water makes a dilute (and not sweet enough) solution.

Suspensions and colloids contain particles that behave differently to those in solutions.

- *Suspension*: a mixture with large, insoluble particles that are spread out evenly at first and eventually settle to the bottom. A snow globe, with a mixture of plastic 'snow' particles and water, is a suspension.
- *Colloid*: a mixture with tiny particles spread out evenly that never settle to the bottom. Milk is a colloid because it contains tiny droplets of fat in water.

How do particles in a suspension behave differently to those in a colloid?

Figure 5.4 The liquid in a snow globe is a suspension of plastic particles in water.

INVESTIGATION 5.2
The Tyndall effect

KEY SKILL
Identifying the variables and formulating a hypothesis

▶ *Go to page **154***

CHECKPOINT 5.2

1 Name three solutes.

2 For each of the three solutes above, identify a possible solvent.

3 Describe the difference between a solution and a solvent.

4 Copy and complete this sentence. A solution is a ______ dissolved in a ____________.

5 What is the difference between a concentrated solution and a dilute solution?

6 In each of these aqueous solutions, identify the solute and the solvent.
   a A cup of sweet, black tea
   b A glass of orange juice made from powdered concentrate
   c Sea water

7 A substance is added to a beaker of water. Initially the substance makes the water blue and cloudy. The substance then settles at the bottom of the glass. What type of mixture is described here?

CONNECTING IDEAS

8 Do you think that fog is an example of a colloid? Justify your answer.

SUCCESS CRITERIA

- I can describe solutes, solvents and solutions in my own words.
- I can give an example of a solute, solvent and solution.

5.3 WATER AS A SOLVENT

LEARNING INTENTION

At the end of this lesson I will be able to describe the importance of water as the universal solvent.

LITERACY LINK

WRITING

Write a postcard to a friend about your trip to a country with very limited access to water.

NUMERACY LINK

UNITS

1 cm^3 of water weighs exactly 1 g. How many cubic centimetres would 1.5 kg of water take up?

Water is vital for life on Earth – without water we couldn't survive. Our bodies need water, and so do the plants that we eat. We also need water for daily activities such as cooking and washing.

Water is a solvent that can dissolve other substances. We use it to extract minerals from underground and to make medicines. Water is known as the *universal solvent* because it dissolves more substances than any other liquid.

1 Water is a solvent in daily life

A solvent is any substance, usually a liquid, that can dissolve other substances.

Water is a solvent, and it can dissolve many other substances – solids, liquids and gases. When these substances dissolve, they are called solutes. Water acts as a solvent in daily life in many ways.

- *Human survival*: Water is an essential solvent for humans. Blood is mostly water, and it carries nutrients and oxygen throughout our bodies.
- *Preparing meals*: Water dissolves spices, flavours and other ingredients as food cooks.
- *Washing away dirt*: Water acts as a solvent for soaps and detergents when cleaning dishes, clothes and ourselves.

How does water act as a solvent?

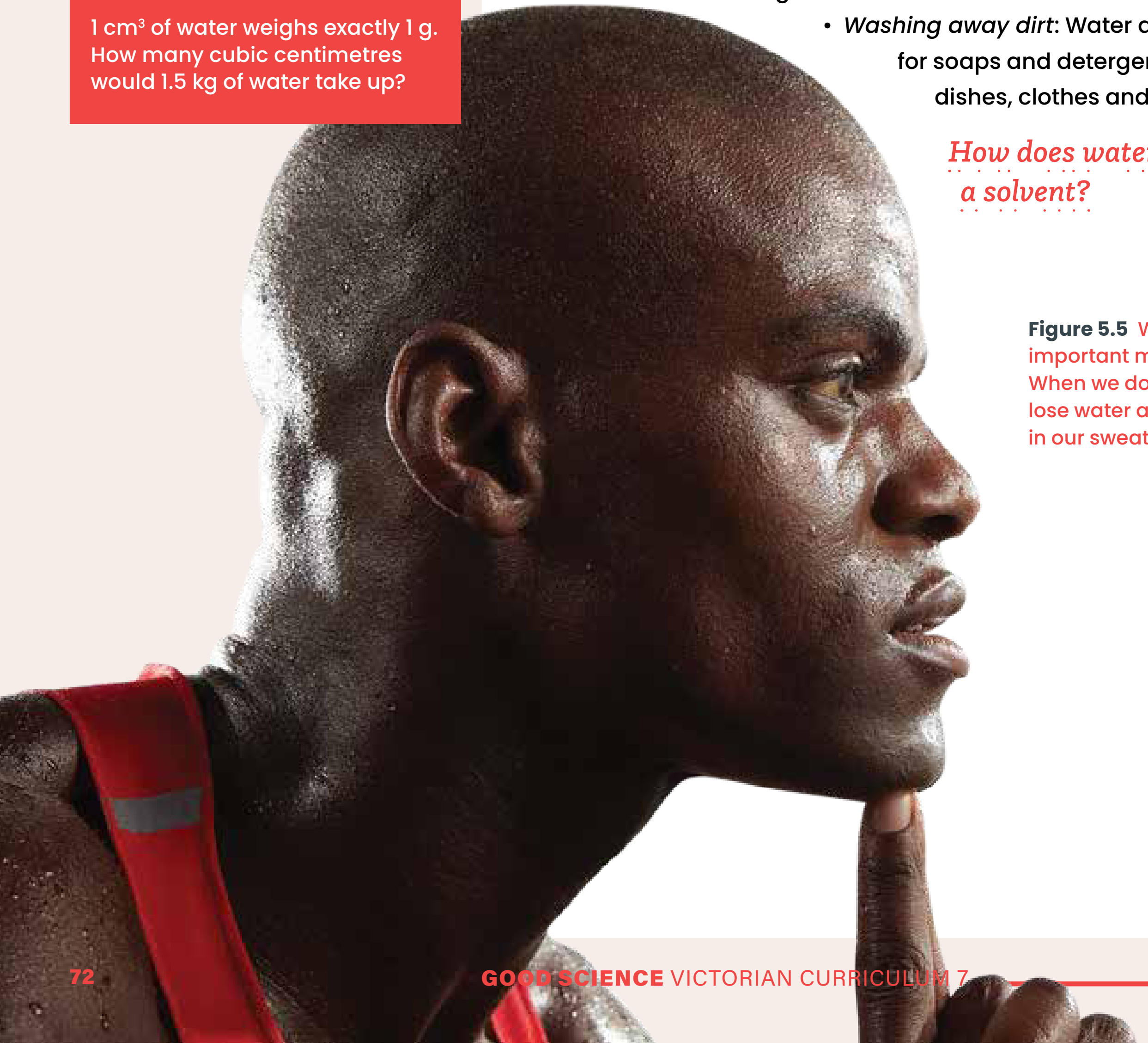


Figure 5.5 Water is a solvent for important minerals in our bodies. When we do intense exercise, we lose water and minerals dissolved in our sweat.

❷ Water is a solvent in the environment

Many essential elements such as iron, zinc and calcium are needed by plants and animals. They exist as minerals in rocks and soil. Water can dissolve many of these minerals, so plants can absorb them from groundwater. Animals eat the plants and as such they receive essential nutrients for their survival.

The water in rivers, lakes and oceans contains dissolved oxygen that is vital to fish and other animals. Similarly, water contains the dissolved carbon dioxide that marine plants need.

What substances can water dissolve?

❸ Water is a solvent in industry

Industries such as mining use water as a solvent to extract different minerals and elements.

Uranium is an element found in rocks located deep underground. It is used as a fuel in the reactors of nuclear power plants and in powering nuclear submarines. In Australia, the major uranium mines use water as a solvent to remove the uranium from the rocks. Instead of digging up the rocks to remove the uranium, acids are dissolved into water that is then pumped into the rocks that contain the uranium. This solution dissolves the uranium, and the acidic water is then pumped back to the surface where it is processed to remove the uranium.

How is water used as a solvent in industry?

Figure 5.6 Water is often the solvent used when medicines are manufactured.

CHECKPOINT 5.3

1. Explain the difference between a solvent and a solute.
2. List three uses of water as a solvent in daily life.
3. What is found in soil and rocks that water can dissolve?
4. Identify how water can be used in industries as a solvent.
5. Explain how water is important for washing away dirt.
6. Explain why dissolved oxygen and carbon dioxide in water is important.
7. Describe how water can be used as a solvent in mining.
8. Explain how water can be used as a solvent in medicine.
9. Water is critically important to the environment. Suggest why.

STUDENT VOICE AND AGENCY

10. Create a scorecard or rubric with five points to assess a partner's knowledge and understanding of this lesson. Ask your partner to explain the use of water as a solvent, and assess their response against your five criteria.

SUCCESS CRITERIA

- I can describe what a solvent is.
- I can state how water is used as a solvent in daily life, industry and the environment.

5.4 SEPARATION TECHNIQUES: FILTERING AND DECANTING

LEARNING INTENTION

At the end of this lesson I will be able to describe the processes of filtration and decantation and suggest when these techniques should be used.

KEY TERMS

decanting
carefully pouring the liquid from a mixture, leaving the sediment behind

filtrate
the liquid that passes through a filter

residue
the solid that does not pass through a filter

sediment
the solid that settles to the bottom of a liquid

LITERACY LINK

LISTENING

Find a picture of a 'Schlenk flask', and describe what it looks like to a partner. Your partner has to try to draw the flask based on your description. Then swap roles, with your partner describing a 'drying pistol'.

Imagine you are stranded in the bush, and the only source of water is a muddy puddle. You scoop some water out with a container, and you notice how dirty it is. After a while, the mud sinks to the bottom of the mixture. You place a cloth over another container and, without disturbing the mud, carefully pour the liquid part of the mixture into the second container.

You've used decanting and filtering to separate the water and mud. You survive!

1 Mixtures can be physically separated

In science, a mixture is two or more substances mixed together that can be physically separated. Mixtures are all around us – concrete, air, mayonnaise, muddy water and sea water are all mixtures.

Some things are not mixtures. Oxygen, pure water and gold are not mixtures – they are pure substances.

Mixtures can contain:

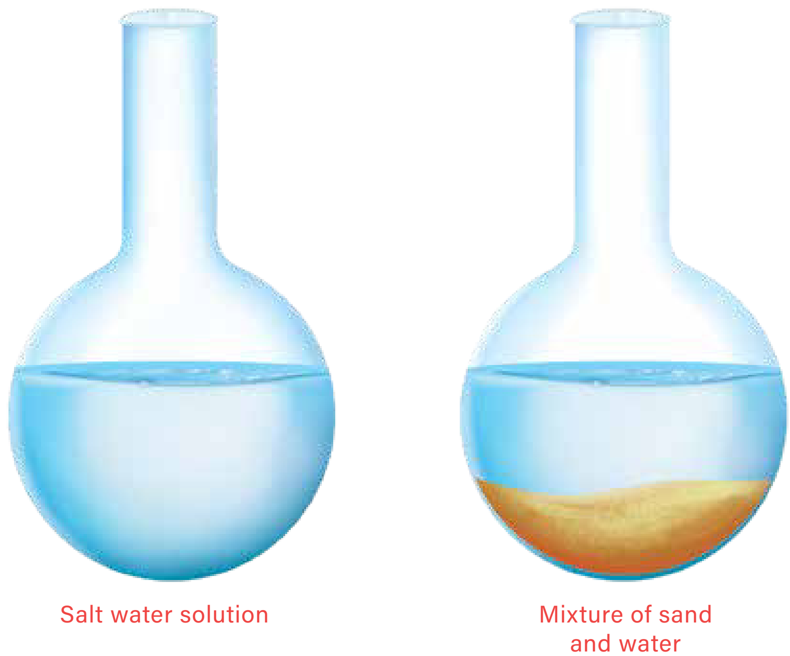
- soluble substances, which will dissolve, such as salt
- insoluble substances, which won't dissolve, such as sand.

Some substances will partly dissolve, meaning that some but not all will dissolve into the solvent.

Scientists use information about solubility to help decide which technique to use to separate a mixture.

What is a the difference between a soluble and an insoluble substance?

Figure 5.7 Salt dissolves in water but sand does not. They are both mixtures.



2 Filtration separates liquids from solids

Filtration is used to separate insoluble substances from liquids. The filter acts like a sieve, using small holes to trap larger particles.

Figure 5.8 shows how filter paper can separate a chalk and water mixture. The solid chalk particles get trapped in the filter paper and the liquid water passes through the filter paper. The chalk left in the filter paper is called the **residue** and the liquid that passes through the filter paper is called the **filtrate**.

How does filtration separate solids and liquids?

Figure 5.8 A filter can be used to separate chalk particles from water.

3 Decanting separates sediments from liquids

Decanting can also be used to separate insoluble solids from liquids. After an insoluble solid in a mixture settles to the bottom of a container, the liquid can be poured out carefully, leaving the solid behind.

Think back to the 'lost in the bush' scenario at the start of this section. The solid mud settled to the bottom of the container as a **sediment**. When the water was poured out from the top, the mud was left behind.

How does decanting separate solids and liquids?

INVESTIGATION 5.4

Purifying muddy water

KEY SKILL
Explaining results using scientific knowledge

▶ *Go to page* ***156***

CHECKPOINT 5.4

1 Which of these is a mixture?
  a Gold
  b Concrete
  c Air
  d Oxygen
  e Pure water
  f Sea water

2 For your answers to question 1, describe how you can tell it is a mixture.

3 Name three soluble substances.

4 Sand is an insoluble substance – suggest how you can tell.

5 Using words and a diagram, explain filtration.

6 Describe the process of decanting in 15 words or less.

7 Compare the physical properties that allow filtration and decanting to work.

8 In a laboratory, you are given a mixture of salt, dust and pebbles. Design a method of separating these three substances.

CRITICAL AND CREATIVE THINKING

9 Design a machine that could utilise elements of filtering or decanting (or both) to solve a problem in everyday life.

SUCCESS CRITERIA

- I can describe filtration and decanting in my own words.
- I can give two examples of situations where filtration and decanting would be used to separate a mixture.

5.5 SEPARATION TECHNIQUES: FROTH FLOTATION AND MAGNETIC SEPARATION

LEARNING INTENTION

At the end of this lesson I will be able to describe the processes of froth flotation and magnetic separation and suggest when these techniques should be used.

KEY TERMS

fractional distillation
a method that separates liquids by using their different boiling points

froth flotation
a method that uses special chemicals to separate minerals from their ores

mineral ore
a mineral that contains useful metals

LITERACY LINK

READING

Read the paragraph describing froth flotation and draw a diagram showing how it works.

NUMERACY LINK

GRAPHING

10 kg of iron ore was separated using magnetic separation, recovering 3.5 kg of iron. Calculate how much of the ore was not iron, then draw a pie chart to show this.

We obtain many useful resources from Earth, such as metals and oil. Once raw materials have been extracted, they must be processed to separate the useful material from the waste.

1 Froth flotation uses water to separate metals

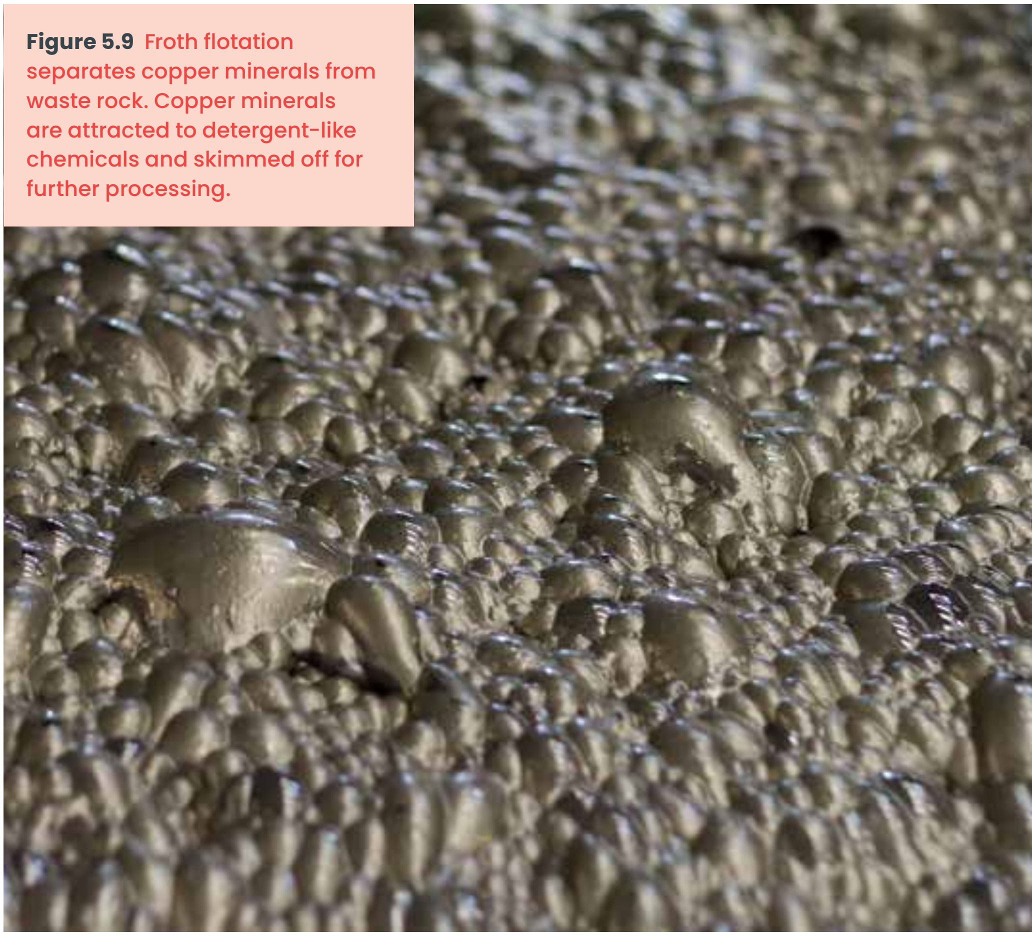
Copper is used for electrical wiring and plumbing pipes. It is rarely found in its pure form; instead, it is found as a **mineral ore** called malachite. Before copper can be purified, it must be separated from the other rocks and material in the ore. This is done using **froth flotation**.

The mixture of unwanted material and copper is dug out of the ground in solid lumps. These are crushed into a fine powder, and mixed with water and some detergent-like chemicals. Air is blown into the bottom of the container, and the malachite is carried to the surface by the air bubbles as it sticks to the chemicals. The waste sinks to the bottom of the tank, unable to stick to the chemicals.

The malachite froth containing the copper is skimmed off the surface. It's then further treated to extract pure copper.

How does froth flotation separate metals from ore?

Figure 5.9 Froth flotation separates copper minerals from waste rock. Copper minerals are attracted to detergent-like chemicals and skimmed off for further processing.



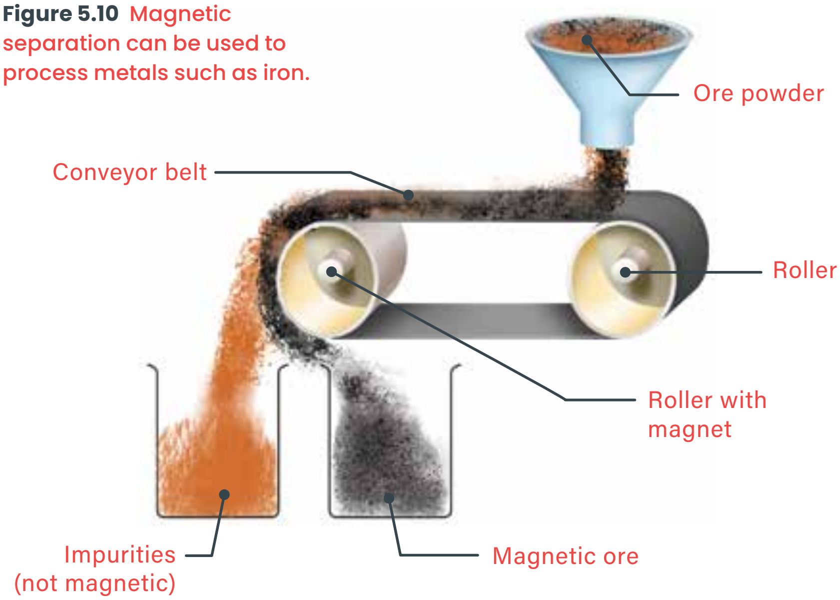
2 Magnets are used to process iron ore

Iron is another vital metal – it's the main component used to make steel. It is magnetic and this property can be used to separate minerals that contain iron from waste rock.

Rock containing iron minerals is crushed into a fine powder then dropped onto a conveyor belt. At the end of the conveyor belt, a magnetic roller attracts the pieces containing iron. As the waste rock reaches the roller, the non-magnetic pieces drop off the belt immediately. The pieces containing the iron are carried further around the belt and collected for processing.

How are magnets used to separate iron minerals from rock?

Figure 5.10 Magnetic separation can be used to process metals such as iron.



3 Crude oil is processed using fractional distillation

Crude oil is a mixture of chemicals such as petrol, oil, kerosene and diesel. Each of these chemicals is useful, so a process called **fractional distillation** is used to separate them from the crude oil.

The crude oil is placed in a piece of equipment called a fractionating column and then heated. As each liquid evaporates, it rises up the column. As it rises, it cools, and when it cools to below its boiling point it becomes a liquid and leaves the column through a tube. Each liquid rises to a different height in the column, depending on its boiling point.

How is crude oil separated into different liquids?

INVESTIGATION 5.5

Froth flotation

KEY SKILL
Identifying and managing relevant risks

▶ *Go to page* ***158***

CHECKPOINT 5.5

1 Identify the difference between copper minerals and waste rock that allows them to be separated by froth flotation.

2 Identify the difference between iron minerals and waste rock that allows them to be separated by magnets.

3 Identify the difference between the components of crude oil that allows them to be separated by fractional distillation.

4 Suggest why it is important to crush rock into a fine powder before froth flotation or magnetic separation.

ETHICAL CAPABILITY

5 The world is very dependant on crude oil, but unfortunately its use has a significant environmental impact. Identify some ethical considerations for the environment as well as society.

SUCCESS CRITERIA

- I can describe froth flotation and magnetic separation in my own words.
- I can give two examples of situations where froth flotation and magnetic separation would be used to separate a mixture.

5.6 SEPARATION TECHNIQUES: EVAPORATION AND DISTILLATION

At the end of this lesson I will be able to describe the processes of evaporation and distillation and suggest when these techniques should be used.

KEY TERMS

condenser
a glass tube cooled by water that cools a gas to become a liquid

crystallisation
separation of a solution by evaporating the solvent, leaving behind solute crystals

distillation
using heating to separate liquids with different boiling points

LITERACY LINK

SPEAKING

Explain to a partner how the process of evaporation works, and describe a situation when it would be used. Then swap roles, with your partner explaining distillation.

NUMERACY LINK

CALCULATION

In a laboratory distillation, 45 g salt is separated per 100 mL of water. If you begin the investigation with 500 mL of water, how much salt do you predict you will have at the end?

Australia is a country that experiences frequent droughts and water shortages. The country is surrounded by oceans; however, salt water cannot be used by land-dwelling living things. One way to use this resource is to separate the salt from the water.

Desalination is a process that uses separation techniques such as evaporation, distillation and crystallisation to purify salt water.

1 Solids can be evaporated and crystallised out of liquids

To separate a solid such as salt from water, without keeping the liquid, we can heat the mixture until the water boils and leaves the mixture as a gas. This method is called evaporation.

Crystallisation – the formation of crystals of the substance that was dissolved in the liquid – will start to happen when most of the liquid has evaporated. Smaller crystals form if the liquid evaporates quickly, and larger crystals form if it evaporates slowly.

What is the difference between evaporation and crystallisation?

Figure 5.11 In the laboratory, a solution of salt water can be heated until the water evaporates and the solid salt begins to crystallise.

Figure 5.12 Salt evaporation ponds are shallow artificial 'ponds' designed to extract salt from sea water. Natural salt ponds are geological formations that occur naturally when water evaporates and leaves behind a salt flat.

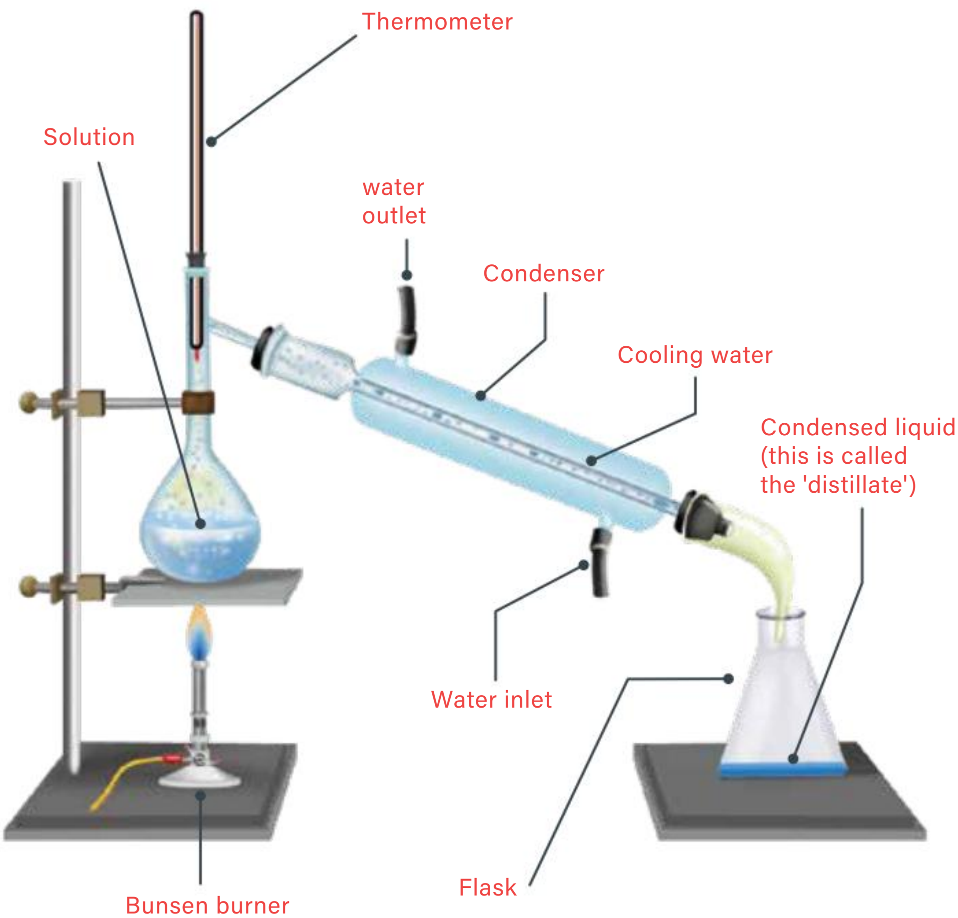
2 Distillation can be used to purify water

Distillation can be used to separate pure water from salt. First, the salt water is heated in a glass flask. The water evaporates and the water vapour is captured. It is then cooled in a tube called a **condenser**, which has cool water flowing around it. This changes the gas to a liquid. This change is called condensation. The condensed liquid is collected in a different beaker, while the salt crystals remain in the flask.

Distillation can also be used to separate two liquids, such as water and alcohol. The physical property that allows these substances to be separated is boiling point (which is different for every substance).

What is distillation?

Figure 5.13 In a laboratory distillation set-up, a Bunsen burner heats a mixture and evaporates the liquid. This gas changes to a liquid in the condenser.



INVESTIGATION 5.6A
Evaporating a solution

KEY SKILL
Identifying limitations to the method and suggesting improvements
▶ *Go to page **159***

INVESTIGATION 5.6B
Growing crystals

KEY SKILL
Identifying the variables and formulating a hypothesis
▶ *Go to page **160***

INVESTIGATION 5.6C
Distillation (Teacher demonstration)
▶ *Go to page **161***

CHECKPOINT 5.6

1 Evaporation and crystallisation are related. Suggest how.

2 Give an example of a mixture that can be separated by evaporation and crystallisation.

3 Describe a situation in which you could separate something using distillation.

4 Identify the physical property of a substance that is used to separate mixtures in distillation.

5 Suggest how you would go about creating large crystals using crystallisation.

CONTEMPORARY ISSUES

6 Research how a desalination plant uses the process of reverse osmosis to purify water. Use labelled diagrams to present your findings.

SUCCESS CRITERIA

- I can describe the difference between evaporation, crystallisation and distillation.
- I can give examples of situations in which each technique could be used to separate mixtures.

5.7 SEPARATION TECHNIQUES: CHROMATOGRAPHY, CENTRIFUGATION AND FUNNEL SEPARATION

LEARNING INTENTION

At the end of this lesson I will be able to describe the processes of chromatography and centrifugation and suggest when these techniques should be used.

KEY TERMS

immiscible
not able to be mixed

paper chromatography
a technique used to separate coloured substances using a strip of paper and a solvent

LITERACY LINK

READING

Read section **1** out loud to a partner. They must come up with three questions about paper chromatography. Then swap roles and repeat for section **2**.

NUMERACY LINK

UNITS

A separating funnel contains 150 mL of liquid. Convert 150 mL to litres.

Formula: 1 mL = 0.001 L

Different mixtures can be separated to find out more about their components or to use their components for different purposes. Forensic scientists sometimes use a process called chromatography to separate colours in inks and dyes to compare samples.

Sometimes mixtures do not mix well together and so a separating funnel can be used to separate the components.

1 Paper chromatography separates colours in mixtures

Many inks and dyes are made of a mixture of different colours. **Paper chromatography** is a separating technique that uses a solvent, such as water, to separate the different colours.

A spot of ink or dye is placed on a strip of paper that is touching a solvent, such as water or methylated spirits. As the solvent travels up the paper, it will dissolve the ink or dye. The more soluble the colour in the solvent, the further it is carried up the paper.

Inks or dyes that are not very soluble don't travel very far on the strip of paper. Dyes that are very soluble in water will travel further.

The result is that the ink or dye mixture separates into its pure components, each of which will have a different colour.

How can colours in inks or dyes be separated?

Figure 5.14 Paper chromatography uses a strip of paper to separate an ink or dye spot.

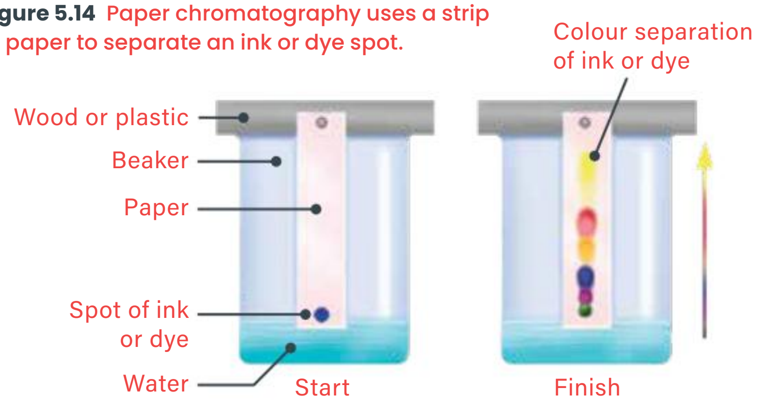


Figure 5.15 Forensic scientists can use chromatography to match pen and ink samples, or to compare dyes in fibre samples.

❷ A separating funnel can be used to separate liquids that don't mix

Many liquids will mix together easily, but some will not. Oil and water do not easily mix – instead, the oil floats on top of the water. It's possible to shake them and get them to mix, but they soon separate.

Liquids that will not mix together are **immiscible**. When two or more immiscible liquids are different densities, the liquids can be separated using a separating funnel.

What can a separating funnel be used for?

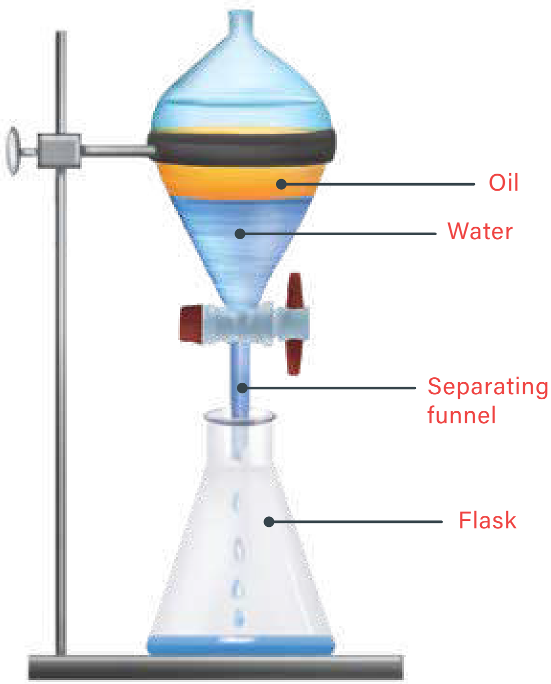


Figure 5.16
Two immiscible liquids can be put into a separating funnel and left to settle into layers. When the tap is opened, the liquid at the bottom runs into the flask.

❸ A centrifuge can be used to separate substances of different densities

Blood is a mixture that maintains life. It contains substances such as red blood cells (which carry oxygen), white blood cells (which fight infections), platelets (which help blood to clot) and plasma (which carries nutrients).

The components of blood can be separated using a **centrifuge**. When this machine spins quickly, the blood components separate into different layers based on **density**. The heavier particles such as red blood cells settle to the bottom, followed by platelets and white blood cells. The lightest particles, such as plasma, remain on the top. These individual components can be given to patients who have lost blood or who have certain blood diseases.

What is a centrifuge used for?

INVESTIGATION 5.7A

Separating colours using paper chromatography

KEY SKILL
Writing a research question

▶ *Go to page **162***

INVESTIGATION 5.7B

Separating two immiscible liquids (Teacher demonstration)

▶ *Go to page **163***

CHECKPOINT 5.7

1. Describe the process of paper chromatography.
2. Identify two solvents that can be used in paper chromatography.
3. You want to compare the components in different inks.
   a. What would you expect to observe if a dye was not a mixture?
   b. What would you expect to observe if a dye was a mixture?
4. Explain why colours separate on filter paper.
5. Identify a situation where a separating funnel could be useful.
6. Would a separating funnel be useful for separating a mixture that had a solute dissolved in a solvent? Explain why/why not.

CONNECTING IDEAS

7. In what ways is chromatography similar and different to the other key separation techniques?

SUCCESS CRITERIA

- I can explain chromatography and centrifugation in my own words.
- I can give examples of mixtures that can be separated by chromatography and centrifugation.

5.8 WATER FILTRATION AND WASTE MANAGEMENT

LEARNING INTENTION

At the end of this lesson I will be able to discuss how science and technology contribute to finding solutions to a range of contemporary issues, including water purification and waste management.

KEY TERMS

disinfection
destroying bacteria, often using special light or chlorine

sewage
semi-liquid human waste

sewerage
pipes that carry sewage

LITERACY LINK

READING

Read section 1, then draw a flow chart with diagrams showing the steps in water purification.

NUMERACY LINK

DATA

Katie is designing an experiment to determine how pure she can make a sample of water. Give an example of qualitative and quantitative data that she could collect for her results.

Many less economically developed countries do not have easy access to clean water, and the people there can get sick or die from diseases carried in water. These countries do not have good systems to manage their waste, creating serious health and environmental hazards in waterways and on land.

Australia has effective ways to purify water and manage wastes. This is better for our health and the environment.

1 Purification makes water safe to drink

Before water is safe to drink, it must be purified. This process kills bacteria and removes substances that are harmful.

In Australia, there are six main steps in water purification.

1 *Screening*: Water passes through mesh screens to remove objects such as twigs and leaves.
2 *Flocculation*: A chemical called alum is added to the cloudy water to make the small floating particles clump together. These clumps are called floc.
3 *Sedimentation*: The floc is heavy and settles to the bottom of the tank to form a sediment. This sediment is collected as sludge.
4 *Filtration*: The water flows through tightly packed beds of different sized pebbles, sand and crushed coal to trap and remove the floc.
5 *Chemical treatment*: Chemicals are added to the water. Fluoride is added to help prevent tooth decay. Chlorine is added to the water to kill harmful organisms such as bacteria. A chemical is added to reduce the acidity of the water.
6 *Aeration*: Oxygen is added to the water to improve the smell and colour.

When the water is safe to drink, it's distributed through pipes to homes, schools, hospitals, businesses and countless other locations.

What steps are involved in water purification?

Figure 5.17 A water treatment plant has many different sections for the different stages, such as chemical treatment and aeration.

❷ Sewage is processed to reduce harm to the environment

Sewage is semi-liquid human waste. When you flush the toilet, the sewage goes into a **sewerage** system and is treated before it eventually goes into the ocean.

Some countries do not have proper sewerage systems. Untreated sewage is not good for human health and the natural environment, so in economically developed countries like Australia it is processed before release.

Figure 5.18 In some less economically developed countries, human waste goes into open sewers and is not treated.

In Australia, there are six main steps in sewage treatment.

1 *Sewerage*: A network of pipes moves sewage from homes and businesses to sewage treatment plants.
2 *Screening*: Screens at the plant act as a sieve and catch large objects, which can be physically removed.
3 *Aeration*: Air is pumped into tanks that hold the sewage. This feeds bacteria, which break down the sewage.
4 *Settling*: Other chemicals are added that cause the bacteria and solids to settle to the bottom of the tank as thick sludge. This sludge is removed and is used in soil and fertiliser products.
5 *Filtration*: The sewage passes through a filter made from pebbles. This traps more solids, which are removed.
6 ***Disinfection***: Special ultraviolet light or chlorine is used to kill harmful bacteria in the sewage before it is released into the ocean.

What steps are involved in sewage processing?

CHECKPOINT 5.8

1 Explain why sewage treatment is critical to a healthy environment.
2 Identify the purpose of flocculation in water purification.
3 Describe what happens during the sewage treatment phase called screening.
4 Identify two different ways of killing harmful bacteria.
5 Explain why the treatment and purification of water are such important processes.
6 What is the purpose of adding fluoride to water?
7 Explain why air is blown into tanks in a sewage treatment plant.
8 Create a table of similarities and differences between water purification and sewage treatment.

ETHICAL CAPABILITY

9 In Victoria, special yellow-topped recycling bins are provided to every household. Unfortunately, if people put any non-recyclable items in these bins, the whole load must go to landfill. Should people caught contaminating recycling be fined? Your response should include a discussion of ethical considerations (what is wrong and what is right).

SUCCESS CRITERIA

- I can describe how water is purified.
- I can describe how sewage is treated.

5.9 CLEANING UP OIL SPILLS

LEARNING INTENTION

At the end of this lesson I will be able to discuss how science and technology contribute to finding solutions to a range of contemporary issues, including oil spills.

KEY TERMS

boom
a floating barrier used to temporarily contain an oil spill

crude oil
oil that has not yet been separated into useable petroleum products

oil slick
a layer of oil on the surface of water

LITERACY LINK

VOCABULARY

Slick is an example of onomatopoeia (a word that sounds like what it describes). Other examples are words like *bang* and *mumble*. How many more can you think of?

NUMERACY LINK

GRAPHING

In five consecutive years, the number of worldwide oil spills was 9, 5, 7, 8 and 5. Display this information in a bar chart.

Oil is one of the most important materials used today. When refined, it fuels the engines of vehicles, powers factories to produce electricity and is an ingredient in the manufacture of plastics. However, its extraction, transport and use have an impact on the environment.

The accidental release of **crude oil** into the environment is called an oil spill. Oil spills in the ocean can have a significant impact on ecosystems. Understanding the properties of oil and how it mixes with water and other chemicals has allowed scientists to work out methods to clean up oil spills.

1 Oil spills can be caused by different incidents

Oil spills into the marine environment can be caused by different events.

Crude oil is extracted by drilling it from reservoirs underground. Often this is done from oil rigs in the oceans. If an accident happens during the drilling or pumping process, crude oil can be released into the ocean.

Ships use oil as fuel. If a ship breaks down, runs aground, collides with another ship or its fuel tanks are damaged, the oil can leak into the water.

Oil is transported by massive ships called oil tankers. If these ships are damaged, the oil that they are carrying can spill into the environment.

What is one way that an oil spill could occur?

2 Oil spills can damage the environment

When oil is spilled into the ocean it forms a thin layer on the surface known as an **oil slick**. Over time, the oil slick will spread out to cover a large area. If it comes into contact with the shore line, the oil will stick to and mix in with the sediments.

The oil on the surface of the ocean stops oxygen and carbon dioxide gas from dissolving into the water from the atmosphere. If the levels decrease enough, this can kill marine plants and animals.

How do oil spills affect the environment?

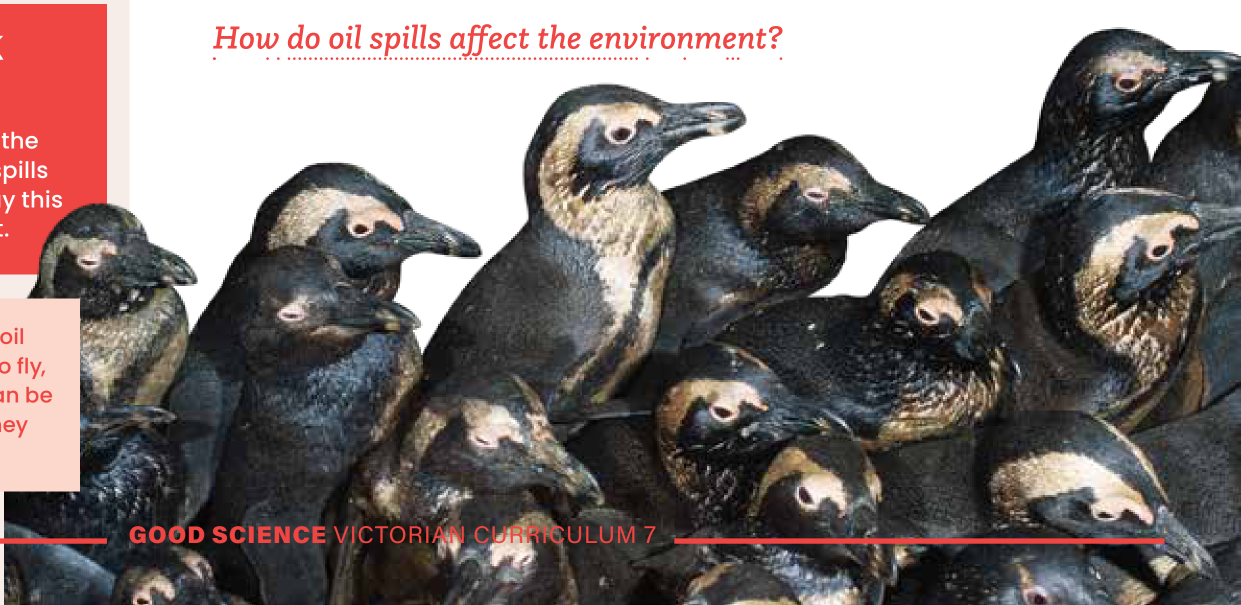


Figure 5.19 Birds caught in oil spills can lose their ability to fly, swim and float, and they can be poisoned by the oil when they try to clean themselves.

3 Oil spills can be contained and filtered

Oil slicks float on top of water because oil is less dense than, and immiscible with, water. There are several different ways that oil slicks can be cleaned up by taking advantage of these properties.

Floating **booms** are used to contain oil slicks. Devices called skimmers are then used to scoop or suck oil from the surface of the water within the enclosed areas. This oil can then be processed in a factory to remove any sea water that was also collected.

Sorbent booms are a special type of boom that work in a similar way to a disposable nappy, but they only absorb oil. The booms can then be removed and disposed of.

If oil hits the shore line it can be difficult to clean up. One way to clean oil from the shore line is to wash the oil back into the water so that it can be easily skimmed off the top. Another way is to remove the contaminated sediment. This is either disposed of in landfill or processed in factories to separate the oil from the sediment.

How are oil spills contained and cleaned up?

CHECKPOINT 5.9

1 Describe one way that an oil spill can happen in the ocean.

2 Describe what happens to oil once it is spilled into the ocean.

3 Why does an oil spill reduce oxygen and carbon dioxide levels in water?

4 Identify two properties of oil that make it easy to clean up when a spill happens in the ocean.

5 Suggest why booms are important in cleaning up oil spills.

6 Explain why clean up crews wash oil on the shore back into the ocean, in reference to being able to collect oil.

PERSONAL AND SOCIAL CAPABILITY

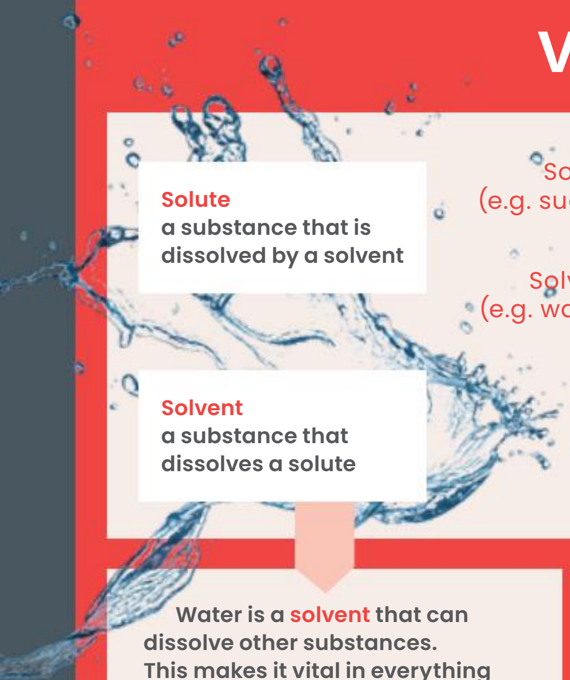
7 Working in a group of 4, create a presentation about the worlds largest oil spills. Negotiate with each team member on your specific roles for the project. After the presentation reflect on your team: Was there a specific leader? How did your team handle conflict? Did everyone participate equally?

SUCCESS CRITERIA

- I can explain how separation techniques can be used to clean up oil spills.

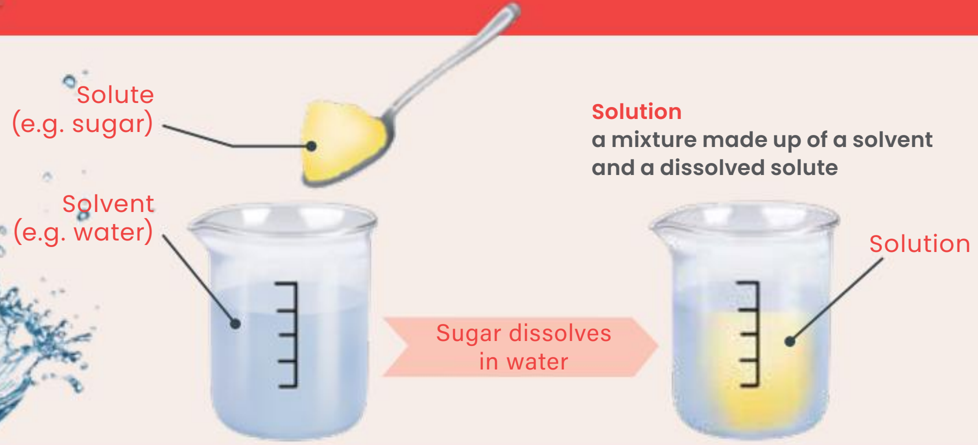
Figure 5.20 Floating booms are used to contain oil spills on the surface of water. The oil can then be skimmed from the surface.

VISUAL SUMMARY



Solute
a substance that is dissolved by a solvent

Solvent
a substance that dissolves a solute

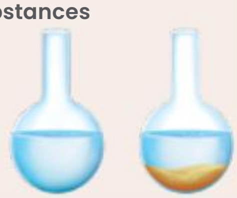


Solution
a mixture made up of a solvent and a dissolved solute

Water is a **solvent** that can dissolve other substances. This makes it vital in everything from digesting food in your stomach to mining sulphur from underground rocks.

PROCESS	USED TO SEPARATE
Filtering	Solid from liquid
Decanting	Solid sediment from liquid
Distillation	Liquids with different boiling points
Evaporation and crystallisation	Solid from a liquid solution, without keeping the liquid
Paper chromatography	Colours

Mixture
two or more substances mixed together that can be physically separated



Colloid
a mixture with tiny particles spread out evenly that never settle to the bottom. Milk is a colloid because it contains tiny fat droplets in water.

Suspension
a mixture with large, insoluble particles that are initially spread out evenly and eventually settle to the bottom

Physical separation is useful in the 'real world'.

Cleaning up oil spills ▶

◀ Extracting salt from sea water

Purifying water ▶

◀ Chromatography

FINAL CHALLENGE

Level 1 — 50xp — LEVEL UP!

1. Define the terms *solute*, *solvent* and *solution*.
2. Briefly summarise how water acts as a solvent in everyday life, in the environment and in industry.
3. Explain why decanting can assist filtration to ultimately result in cleaner water.

Level 2 — 100xp — LEVEL UP!

4. The following table lists separating techniques and different types of mixtures. Draw a line between the separating technique and the mixture that would allow its separation.

Filtration	Iron filings mixed with sand
Decanting	Salty water from which you want to extract pure water
Evaporation	A mixture of fruit pulps floating in water
Distillation	Oil and water
Centrifugation	A solution containing dissolved salt, from which salt needs to be kept
Magnetic separation	Muddy water containing some sand
Separating flask	A solution containing sand and water

Level 3 — 150xp — LEVEL UP!

5. Identify two ways in which water purification and waste treatment are similar, and two ways in which they are different.
6. Compare and contrast distillation and evaporation separating techniques.
7. A snow globe is a suspension but a drink of cordial is a solution. Explain why.

Level 4 — 200xp — LEVEL UP!

8. Select one of the separation techniques in question **4** and write a step-by-step method for its use.
9. The components of blood are separated using a centrifuge. Suggest what physical properties of blood make this possible.
10. Identify four separation methods that you might use in your home. Describe each, and comment on their similarities and differences.

Level 5 — 300xp — LEVEL UP!

11. Identify an industry or occupation that would utilise the following processes:
    a froth flotation
    b magnetic separation
    c fractional distillation.
12. Describe how separation techniques can be employed in order to clean up after an oil spill.

EARTH, THE SUN AND THE MOON

What will Earth be like in 100 years?

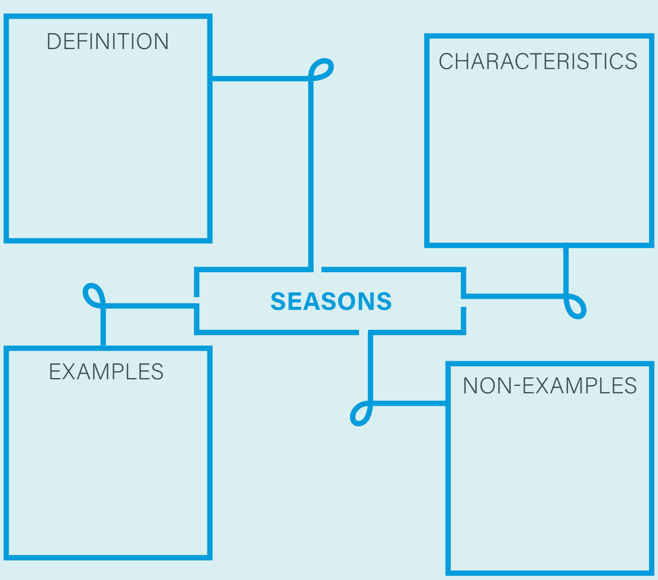
6

Many ancient cultures thought that Earth was at the centre of the universe. They believed that the Sun and the other planets revolved around Earth, and they thought they had proof – these bodies seemed to move around the sky during the day and the night.

We now know that Earth revolves around the Sun, the largest body in our solar system, with the largest gravitational pull. For the same reason, our Moon revolves around Earth. We also understand that the tilt of Earth causes the seasons, and that the rotation of Earth causes day and night.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Eclipse* and *Orbit*.

2 LEARNING LINKS

Brainstorm what you already know about Earth, the Sun and the Moon.

3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.

4 CRITICAL + CREATIVE THINKING

WHAT IF … Earth suddenly began spinning backwards?

COMMONALITY: List three things that the Moon and winter have in common.

FIVE QUESTIONS: Think of five questions that have *eclipse* as the answer.

5 THE DARKEST!

Direct sunlight is not seen for up to six months of the year at the poles of Earth. For about six months at the south and north poles, the Sun is above the horizon (half a year of daylight) and for the other six months it is below the horizon (half a year of night or twilight). Imagine six months without a sunrise or sunset!

This also means that the poles have only two seasons: summer and winter. The seasons are caused by the tilt of Earth towards the Sun – when it's winter, Earth is tilted away.

6.1 DAY AND NIGHT

LEARNING INTENTION

At the end of this lesson I will be able to explain that predictable phenomena on Earth, including day and night, are caused by the relative positions of the Sun, Earth and the Moon.

KEY TERMS

axis
a real or imaginary line through the centre of an object

orbit
the curved path a smaller object takes around another object

revolve
to move in a circular path around another object

rotate
to spin on an axis

LITERACY LINK

READING

Summarise this section into a single paragraph. When you're finished, give yourself one point (for each point below) if your paragraph:

- is easy to understand
- is written in your own words
- includes at least one example
- is written formally and scientifically
- includes a simple diagram or image.

NUMERACY LINK

GRAPHING

Look up the average number of daylight hours in Melbourne for each month of the year. Display this data as a bar chart.

Humans have always wondered about the stars. The Sun and the Moon stood out in the sky and people wondered about them as well.

Little by little our understanding increased. By observing and exploring, scientists worked out what causes day and night.

1 The Sun is at the centre of our solar system

The Sun is the star at the centre of our solar system. It is an enormous, dense ball of gas that produces light and heat. The nuclear reactions inside the core of the Sun are so powerful that the energy produced can light and heat Earth. This light takes about eight minutes to reach Earth.

Earth is one of the planets that **revolves** around the Sun. Earth's **orbit** is roughly the shape of a squashed circle. Earth takes one year to revolve around the Sun.

What star is at the centre of our solar system?

Figure 6.1 The planets in our solar system revolve around the Sun (not to scale).

2 Earth rotates on its axis

Earth is the third planet from the Sun. Earth is roughly a sphere, and it **rotates** on its own **axis**. A full day is 24 hours because Earth takes 24 hours to complete one full rotation on its axis.

Viewed from the north pole, Earth rotates in an anticlockwise direction, so the Sun appears to rise in the east and set in the west. At any one time, half of Earth is in daylight and half is in darkness. The side of Earth facing the Sun has day, and the side facing away from the Sun has night.

How long does Earth take to rotate once on its own axis?

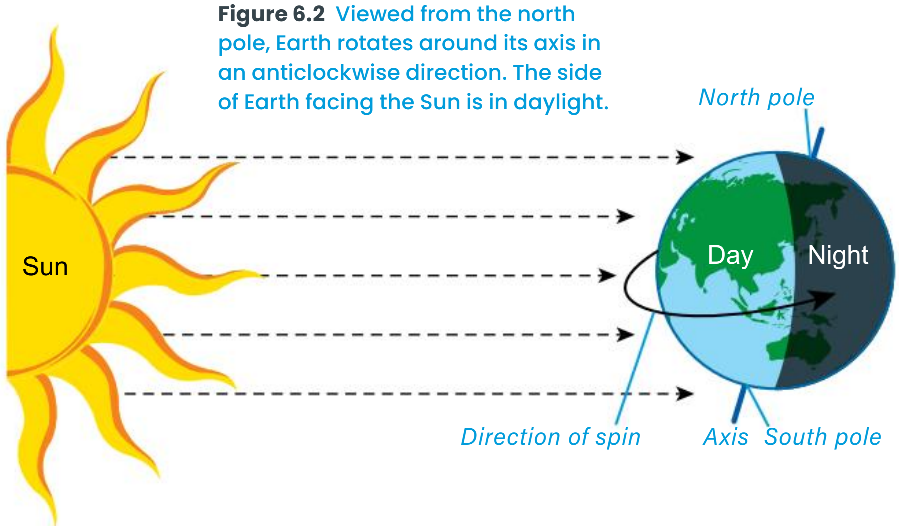


Figure 6.2 Viewed from the north pole, Earth rotates around its axis in an anticlockwise direction. The side of Earth facing the Sun is in daylight.

3 The Moon revolves around Earth

Moons are small bodies that orbit planets. Some planets have more than one moon.

Earth's Moon takes about 28 days to orbit Earth. It also takes 28 days to make one full rotation on its axis. This is why the same side of the Moon is always facing Earth.

Whenever the Moon passes over the side of Earth that is in daylight, it can be seen at the same time as the Sun. When the Moon is on the daylight side of Earth, the night side of Earth has night-time with no visible Moon.

How long does the Moon take to orbit Earth?

Figure 6.3 The same side of the Moon always faces Earth.

INVESTIGATION 6.1

Modelling day and night

KEY SKILL
Writing a research question

▶ *Go to page **164***

CHECKPOINT 6.1

1 Explain each of the following terms in relation to the movement of Earth around the Sun.
   - a Day-time
   - b Night-time
   - c A day
   - d A year

2 Copy and complete these sentences.
   - a The Sun is a ______.
   - b Earth rotates in a/an ____________ direction.
   - c Earth revolves around the ______ and the ______ revolves around Earth.

3 Demonstrate how it's possible to see the Moon during the day. You can use objects around you, draw a diagram or any other method of your choice.

4 Investigate why we can't see most stars during the day.

5 Explain the difference between the words *revolve* and *rotate* by writing two sentences.

6 Until astronauts landed on it, people on Earth had never seen the other side of the moon. Explain why.

RESEARCH

7 Research the length of a day for the other planets in our solar system: Mercury, Venus, Mars, Jupiter, Saturn, Uranus and Neptune.

SUCCESS CRITERIA

- ○ I can explain what causes day and night.
- ○ I can use a simple model or diagram to show what causes day and night.

6.2 SEASONS

LEARNING INTENTION

At the end of this lesson I will be able to explain that predictable phenomena on Earth, including seasons, are caused by the relative positions of the Sun, Earth and the Moon.

KEY TERMS

equinox
the two times each year when night and day are about the same length

solstice
the two times each year when night and day are the most different in length

tilt
a sloping position or lean

NUMERACY LINK

DATA

Kim records the average number of daylight hours per week for three weeks. Her results are 12 hours 50 minutes, 12 hours 57 minutes and 13 hours 4 minutes. In terms of the solstice and equinoxes, what time of year is it?

Ice cream and the beach. Crunchy leaves and warm jackets. Hot drinks and beanies. Beautiful flowers and the first warm weather after the cold. Which of the seasons is your favourite? Did you know that Earth's tilt is why we have seasons?

1 Most places have four different seasons

Most areas around the world experience four separate seasons. Throughout the year, the northern and southern hemispheres experience opposite seasons. So when it's summer in Australia, which is in the southern hemisphere, it's winter in northern hemisphere countries such as the USA and England. The closer you are to the north and south poles, the greater the difference between winter and summer.

In some parts of the world, such as the far northern parts of Australia, there's not much difference between the winter and summer average temperatures. In these tropical areas in the southern hemisphere, there is a wet season from October to March and a dry season from April to September.

What are the four seasons in most parts of the world?

Table 6.1 Earth's non-tropical seasons in the northern and southern hemispheres

Season	Temperature	Time of year	
		Southern hemisphere	Northern hemisphere
Winter	Cool/cold	June – August	December – February
Spring	Warming	September – November	March – May
Summer	Warm/hot	December – February	June – August
Autumn	Cooling	March – May	September – November

2 Earth's tilt causes the seasons

Earth's seasons are due to the **tilt** of its axis. Earth is tilted about 23.5° compared to the path Earth takes around the Sun, which you can see in yellow in Figure 6.5.

The seasons are caused by the intensity of sunlight – how much it spreads on Earth's surface. For example, in January, Australia is directly facing the Sun and the weather is warmer. In June, Australia is not directly facing the Sun, so the sunlight is spread over a larger area, making it cooler.

What causes seasons on Earth?

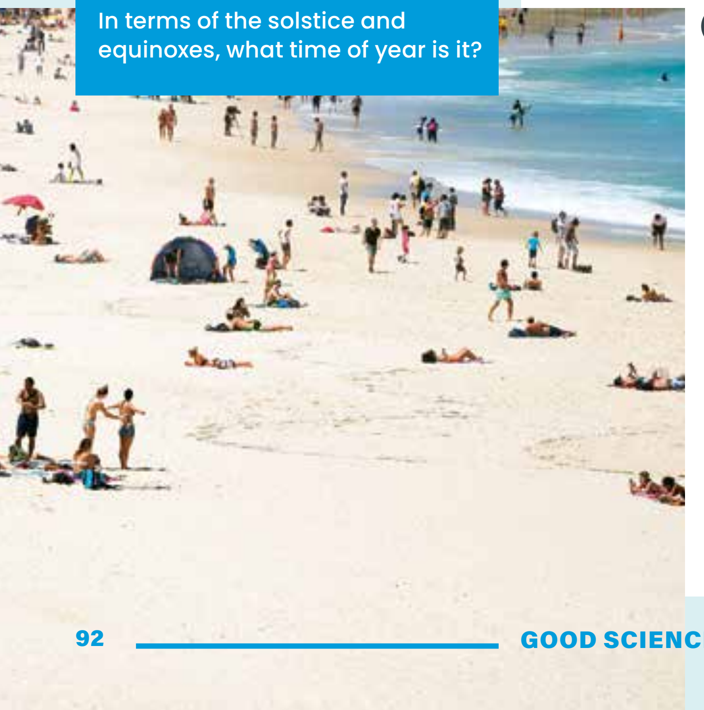


Figure 6.4 When it's summer in Australia, our part of the world is tilted towards the Sun and getting more intense sunlight.

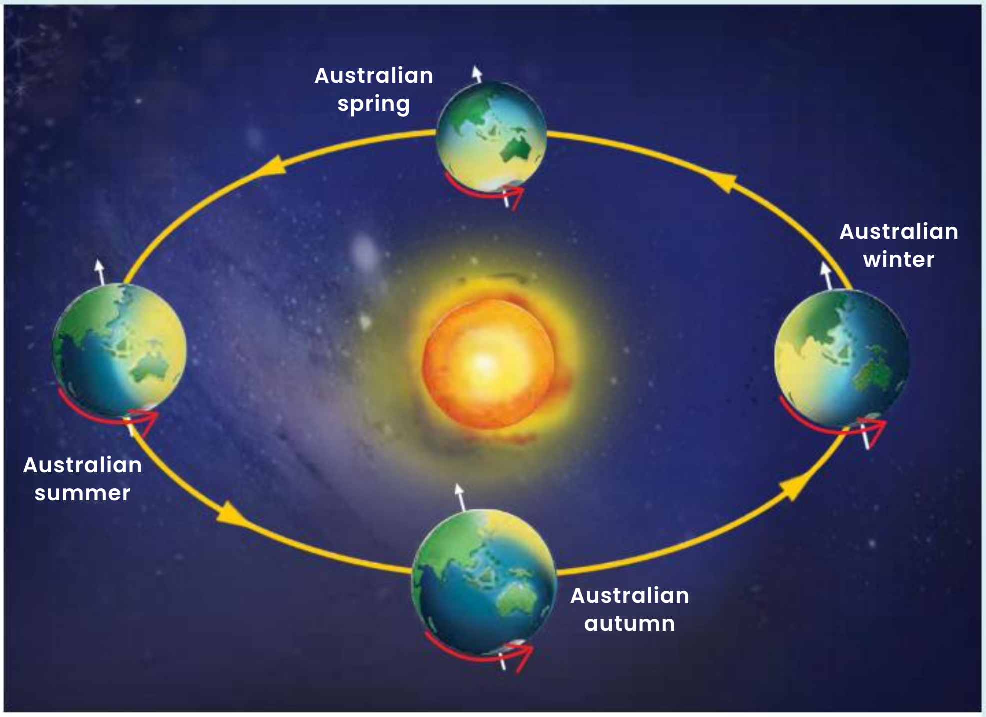


Figure 6.5 Earth's tilt means that different countries have more direct or less direct sunlight, depending on the time of year.

INVESTIGATION 6.2
Modelling the seasons

KEY SKILL
Evaluating results for reliability and validity

▶ *Go to page **165***

3 Equinoxes and solstices – equal and different lengths of day and night

The **equinox** is the period when the day and night are the same length – 12 hours each. Equinoxes happen twice a year, once in spring and once in autumn, and they happen at the same time all around the world. When one hemisphere has spring equinox, the other hemisphere has autumn equinox, and vice versa.

The **solstice** is the time when the day and night are most different. The summer solstice is the day when the Sun reaches the highest point in the sky. It has the longest daylight of the year and the shortest night. The winter solstice has the shortest daylight and the longest night.

Table 6.2 Equinox and solstice dates around the world

Event	Approximate date
Equinox	*23 September* and *20 March* worldwide
Solstice	*21 June:* winter solstice in southern hemisphere and summer solstice in northern hemisphere *21 December:* summer solstice in southern hemisphere and winter solstice in northern hemisphere

In which month is the Australian summer solstice?

CHECKPOINT 6.2

1 Copy and complete these sentences.
  a When the southern hemisphere has summer, the northern hemisphere has ______________.
  b The seasons are caused by how much the sunlight _________ on Earth's surface.
  c The time of year when the length of the day and night are roughly equal is called the ______________.

2 If the summer solstice is when the Sun reaches the highest point in the sky for the whole year, where do you think the Sun will reach during the winter solstice? Why?

3 A common misconception is that summer is caused by that part of Earth being closer to the Sun. Explain why that is not true.

CRITICAL AND CREATIVE THINKING

4 Earth's tilt is stabilised by the Moon's gravitational pull on Earth. Suggest what life on Earth might be like if there was no Moon.

SUCCESS CRITERIA

- I can explain what causes the seasons.
- I can use a simple model or diagram to show what causes the seasons.

6.3 ECLIPSES

LEARNING INTENTION

At the end of this lesson I will be able to explain that predictable phenomena on Earth, including eclipses, are caused by the relative positions of the Sun, Earth and the Moon.

KEY TERMS

annular
ring-shaped

eclipse
the blocking of the Sun's light from Earth

penumbra
the outer part of the Moon's shadow on Earth

umbra
the inner part of the Moon's shadow on Earth

NUMERACY LINK

UNITS

A total solar eclipse occurs somewhere on Earth every 1.5 years on average. Convert 1.5 years to minutes.

NEVER LOOK DIRECTLY AT THE SUN, INCLUDING DURING A SOLAR ECLIPSE. LIGHT FROM THE SUN CAN DAMAGE YOUR EYES.

ALWAYS USE AN INDIRECT METHOD OF OBSERVATION, SUCH AS A PINHOLE PROJECTED ONTO ANOTHER SURFACE.

The Sun is about 400 times wider than the Moon, and the Sun is about 400 times further away from Earth than the Moon is. This means that the Sun and the Moon appear nearly the same size as seen from Earth.

As Earth and the Moon move, there are times when they and the Sun line up, in events called **eclipses**.

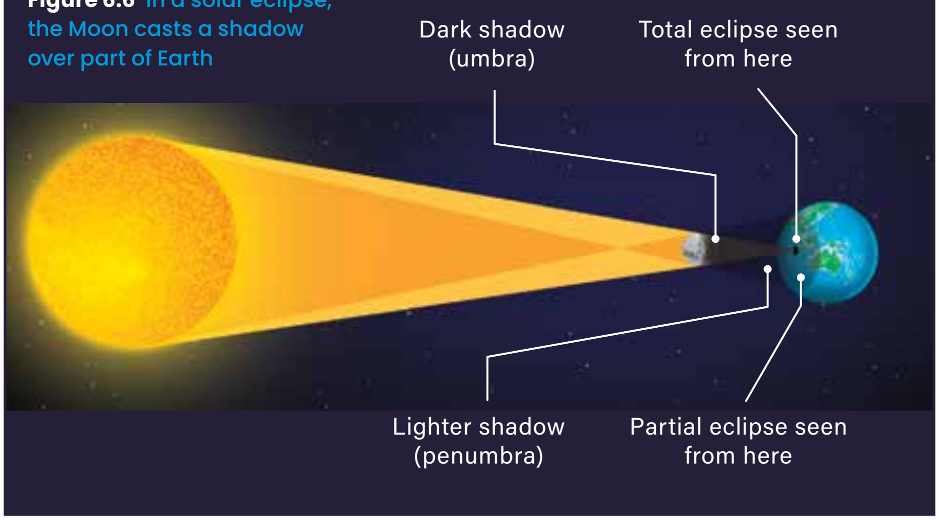
1 The Moon blocks the light of the Sun during a solar eclipse

A solar eclipse happens when the Moon passes between the Sun and Earth. The Moon blocks sunlight and casts a shadow on Earth. The centre of this shadow is the **umbra**, and the outer ring of the shadow is the **penumbra**.

There are three types of solar eclipses, and they differ in how much the Moon blocks out the light of the Sun, as seen by a viewer on Earth. A total solar eclipse can be seen when the Moon completely lines up with both the Sun and Earth. People within the umbra see the Moon completely block the light of the Sun, but those within the penumbra only see it block part of the Sun.

An **annular** solar eclipse happens when the Moon is further away from Earth, making it appear smaller than usual. Because of this, the Moon only covers the centre of the Sun. During an annular eclipse, we can see the outer edges of the Sun. This is called an annulus or 'ring of fire'.

Figure 6.6 In a solar eclipse, the Moon casts a shadow over part of Earth



Partial solar eclipses occur when the Sun, Moon and Earth aren't completely lined up. The Moon only blocks part of the Sun when this happens. There's no umbra in a partial eclipse – everyone who sees it is in the penumbra.

What are the three types of solar eclipse?

2 Earth blocks the light of the Sun during a lunar eclipse

A lunar eclipse happens when Earth passes directly between the Sun and the Moon. Depending where you are on Earth, Earth blocks some or all sunlight and casts a shadow on the Moon.

Lunar eclipses always happen when the Moon is full. Full moons happen once every 29.5 days, which is the time the Moon takes to make one full revolution around Earth. During most months, the full Moon happens when the Moon does not line up with the Sun and Earth. During a lunar eclipse, the Moon is aligned with the shadow cast by Earth.

There are three different types of lunar eclipse, much like there are three types of solar eclipse. Each type is named according to how much Earth blocks the light of the Sun, as seen by a viewer on Earth.

A total lunar eclipse is seen when the Sun, Earth and Moon are perfectly in line, so Earth's shadow completely blocks the Moon. Total lunar eclipses are known as 'blood moons' because the Moon changes to a striking red colour.

Figure 6.7 In a total lunar eclipse, the Moon falls within the darker shadow cast by Earth.

Partial lunar eclipses are seen when the Sun, the Moon and Earth aren't completely in line. Only part of the Moon is covered by Earth's shadow. During a partial eclipse, you can see the curved shape of Earth's shadow on the Moon.

Penumbral lunar eclipses happen when the Moon only passes through the penumbra, which is the outer edge of Earth's shadow. These eclipses are often not noticed because the Moon appears only slightly dimmer than a regular full Moon.

When do lunar eclipses happen?

INVESTIGATION 6.3
Modelling a solar and lunar eclipse

KEY SKILL
Referencing sources of information

▶ *Go to page **166***

CHECKPOINT 6.3

1 Copy and complete these sentences.
   a During a solar eclipse, the Moon casts a ____________ on Earth.
   b An annulus is also known as a ______________.
   c Partial solar eclipses happen when the Sun, Earth and the Moon ______________.

2 Copy and complete these sentences.
   a Lunar eclipses always happen during a ______________.
   b Penumbral eclipses make the Moon appear ____________.

3 In what ways is a total lunar eclipse different to a penumbral lunar eclipse?

4 Explain what a blood moon is and how it is caused.

EXTENSION

5 Write two truths and one lie about lunar eclipses. Swap with a partner to test your knowledge.

SUCCESS CRITERIA

- I can explain what solar and lunar eclipses are, including how they occur.
- I can explain the difference between a partial, annular and total solar eclipse.
- I can explain the difference between a total, partial and penumbral lunar eclipse.

6.4 MODELS OF THE SOLAR SYSTEM

LEARNING INTENTION

At the end of this lesson I will be able to explain, using examples, how scientific knowledge and understanding of the world change as new evidence becomes available.

KEY TERMS

evidence
facts and observations that can be used to support or oppose a theory

model
a simplified way of explaining something complex and real based on evidence

LITERACY LINK

VOCABULARY

The prefix *geo-* means *earth*. Think of three words starting with *geo-* and explain how they relate to Earth.

NUMERACY LINK

CALCULATION

Earth has a radius of 6378 km, while the planet Neptune has a radius of 24 776 km.

Create a ratio in its simplest form to compare Earth's radius to Neptune's.

The Sun has guided all living things on Earth since life began. When looking at the sky, we can understand how early civilisations thought the Sun and stars revolved around Earth.

The Ancient Greeks were the first people known to make **models** of nature to explain patterns that they observed. These models allowed them to try to make sense of the world around them using reasoning.

1 The geocentric model put Earth at the centre of the universe

Perhaps the first model of the solar system was the geocentric model, which stated that Earth was at the centre of the universe. The word *geocentric* comes from 'geo' (Earth) and 'centric' (centred).

Aristotle (384–323 BCE) was one of the earliest known writers on astronomy. His observations were made with only the naked eye. He argued that:

- Earth was a sphere at the centre of the universe
- the planets and the Sun orbited on many perfect and unchanging spheres
- these spheres revolved around the unmoving Earth.

Claudius Ptolemy (100–175 CE) was another early philosopher and scientist. He supported the idea that Earth was at the centre of the universe, but he suggested that the planets and the Sun revolved around a point outside Earth.

What are the main features of the geocentric model?

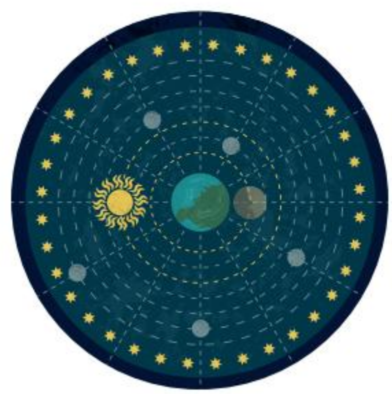


Figure 6.8 Stonehenge is a circle of standing stones in England, built about 5000 years ago. It was probably used as a calendar and a way to predict solstices.

Figure 6.9 In the geocentric model, Earth was at the centre of the universe and the planets and the Sun revolved around it.

❷ The heliocentric model put the Sun at the centre of the universe

The heliocentric model replaced the geocentric model. 'Helios' was the Greek god of the Sun – this model got its name because it stated that the Sun was at the centre of the universe.

The heliocentric model was created by Nicolaus Copernicus (1473–1543 CE), who used mathematics (rather than a telescope) to explain the motion of objects in the heavens. His model proposed that:

- the Sun, rather than Earth, was at the centre of the universe
- Earth and the planets moved in circular orbits around the Sun.

Many people didn't agree with the heliocentric model. Some thought it was dangerous, because it suggested that humans were not the most important beings in the universe. In particular, the early Catholic Church refused to accept this model.

Galileo Galilei (1564–1642 CE) was one of the first astronomers to use a telescope. His observations of the solar system provided **evidence** that overwhelmingly supported the heliocentric model. He faced punishment by the Catholic Church for his work and was placed under house arrest.

Eventually the heliocentric model was accepted around the world. But, as telescopes developed, people noticed that stars didn't orbit the Sun. By the early 19th century, scientists realised that although the Sun is the centre of our solar system, it isn't the centre of the universe.

What are the main features of the heliocentric model?

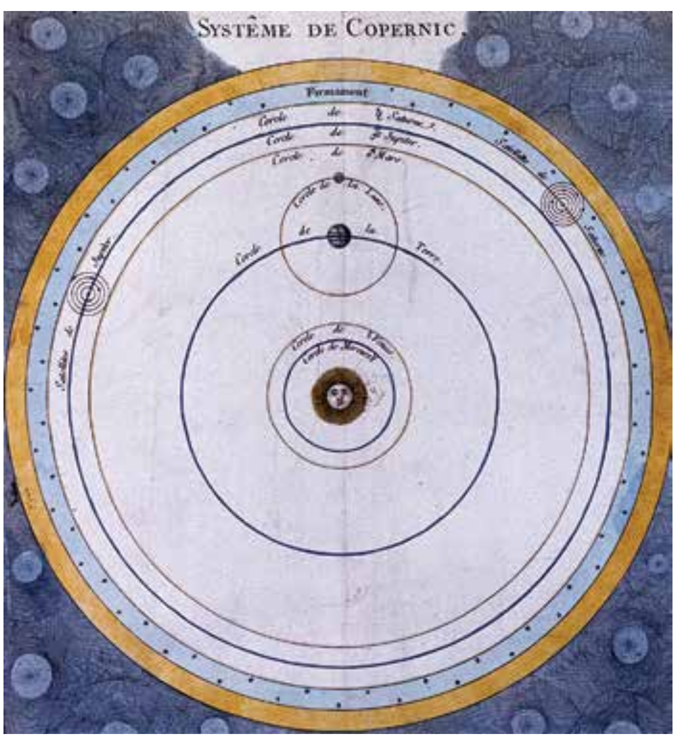


Figure 6.10
In the heliocentric model, the Sun was at the centre of the universe and the planets had circular orbits.

CHECKPOINT 6.4

1 True or false?
   a *Geo* means 'planet'.
   b The Ancient Greeks believed that Earth was round.
   c Copernicus made observations using a telescope.
   d The heliocentric model stated that the Sun was at the centre of the universe.
2 Create a Venn diagram to compare and contrast the geocentric and heliocentric models of the solar system.
3 Describe the contributions towards our current understanding of the solar system made by:
   a Ptolemy
   b Aristotle
   c Galileo.
4 Copernicus first presented the heliocentric model, which was thought to be dangerous. Explain why.

INQUIRY

5 Research the scientists who have contributed to increasing our knowledge of the solar system through time. Organise their discoveries on a timeline to demonstrate your learning.

SUCCESS CRITERIA

- I can explain how historical models of the solar system changed over time.

6.5 THE TECHNOLOGY OF DISCOVERY

LEARNING INTENTION

At the end of this lesson I will be able to explain, using examples, how scientific knowledge and understanding of the universe change as new technology becomes available.

KEY TERMS

astronomer
a scientist who studies space and the objects within it

galaxy
a large system of stars

LITERACY LINK

SPEAKING

Role-play with a partner that you are news reporters in 1969. Create a 3–5 minute news report on the first successful human-piloted expedition to land on the Moon.

NUMERACY LINK

CALCULATION

Venus has a radius of approximately 6000 km. Calculate the circumference of Venus using the formula $C = 2\pi r$

When we look out into space, we are actually looking back in time to planets and stars that may be extremely similar to our Earth, or almost unimaginably different.

People throughout history have always been curious. Technology has allowed us to discover distant objects and events and wonder about more things than ever before.

1 Edwin Hubble first calculated the true size of the universe

Until the early 20th century, **astronomers** thought that the entire universe consisted of just one group of stars. They thought that the universe was only a single **galaxy**, with the stars in it relatively nearby. In the 1920s, astronomer Edwin Hubble was studying a star in what was called the Andromeda Nebula. He worked with a 2.5-metre telescope at Mt Wilson in California. His observations led him to conclude that:

- Andromeda was not nearby, but very distant
- it was not a cloud of gas or nebula but a galaxy like ours (it's now known as the Andromeda Galaxy)
- there are an incredible number of galaxies in the universe
- each of these galaxies contains tens of millions of stars.

This completely changed our understanding of the universe!

Edwin Hubble went on to create a system to classify galaxies according to how they look. Also, he proved that the entire universe is expanding at the same rate everywhere. He is now considered to be one of the most important astronomers in history, and the Hubble Space Telescope is named after him.

What did astronomers think the universe looked like before Edwin Hubble's work?

2 The Hubble Space Telescope orbits Earth

The orbit of the Hubble Space Telescope is about 600 km above Earth. The space shuttle *Discovery* placed it in orbit in 1990. Because it's outside Earth's atmosphere, it can be used to observe light and radiation filtered out by Earth's atmosphere.

Figure 6.11 The Hubble Space Telescope has provided us with information about deep space since 1990.

Hubble researchers collect information to answer questions such as these:

- What is the size of the universe?
- How are stars formed?
- How fast is the universe growing?

The Hubble Space Telescope has special features that allow it to perform this mission:

- a 2.4-metre mirror to collect light from deep space
- cameras that detect different types of light
- instruments that separate and analyse the collected light
- systems that control where the telescope is pointed and keep it in orbit.

How is the Hubble Space Telescope different to telescopes on Earth's surface?

3 Humans first walked on the Moon in 1969

The *Apollo 11* mission was the first human-piloted effort to land on the Moon. Neil Armstrong, Michael Collins and Edwin 'Buzz' Aldrin Jr formed the crew on this historic mission. The US space agency, NASA, succeeded in their attempt on 20 July 1969. Since then, humans have landed on the Moon four more times.

One of the main aims of these missions was to collect rock samples from the Moon's surface for study back on Earth. The missions collected more than 382 kilograms of lunar samples. These samples allowed scientists to develop theories about the origin of the Moon.

Lunar samples show that some of the Moon's matter comes from Earth, and some comes from another source. The current theory for the Moon's origin is that a very young Earth was hit by a stray body about half its size. This collision threw debris out around Earth, which eventually collected together to form the Moon.

What was the first human-piloted effort to land on the Moon?

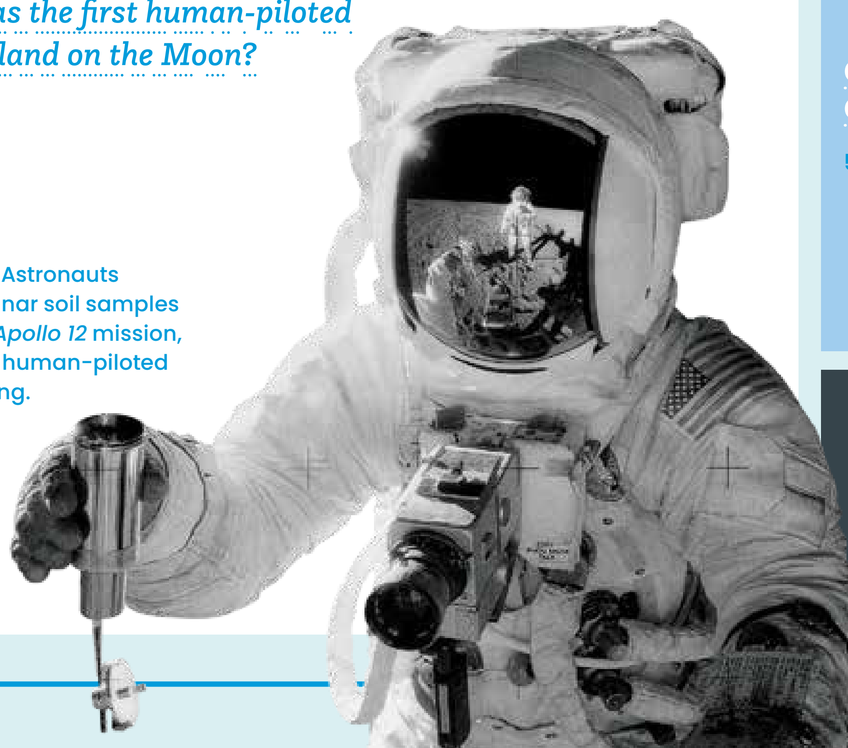


Figure 6.12 Astronauts collected lunar soil samples during the *Apollo 12* mission, the second human-piloted Moon landing.

INVESTIGATION 6.5

Making a simple telescope

KEY SKILL
Writing a research question

▶ *Go to page* ***168***

CHECKPOINT 6.5

1 Copy and complete these sentences.
   a The Andromeda Galaxy was once thought to be a ______________.
   b Edwin Hubble used a ______________ to study space.
   c Each ______________ contains tens of millions of stars.
   d The universe is ______________ at the same rate everywhere.
   e The Hubble Space Telescope can collect ______________, ______________ and ______________ light.

2 Describe the role of an astronomer.

3 How has the Hubble Space Telescope increased scientific understanding of the solar system?

4 Describe some of the ways that the first expedition to the Moon has contributed to scientific understanding.

CRITICAL AND CREATIVE THINKING

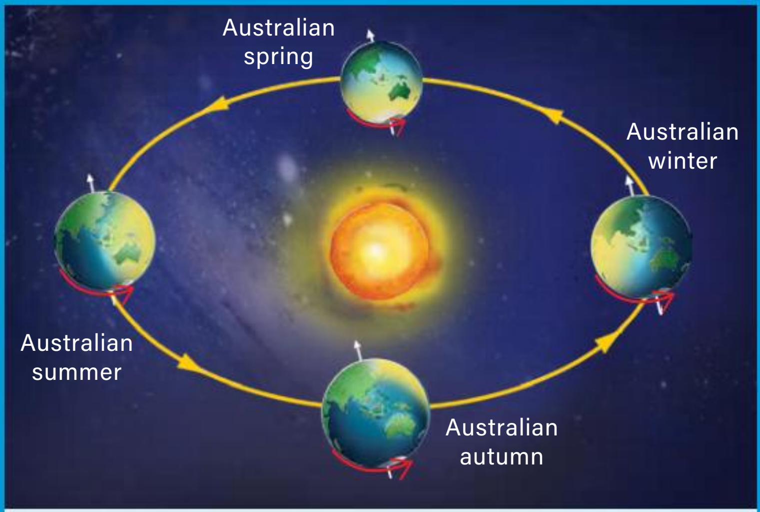
5 Imagine you are part of a mission to Mars. List the five most important pieces of technology for this mission and justify why you have included each of them.

SUCCESS CRITERIA

- I can describe how advances in telescopes, space probes and other technology have provided new evidence about space.

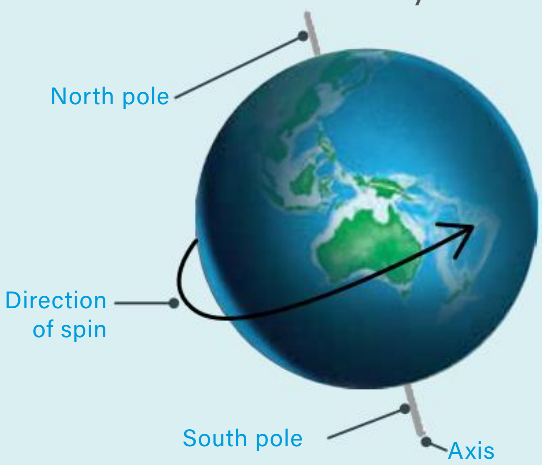
VISUAL SUMMARY

The Sun is the star at the centre of our solar system.



▲ Earth is tilted on its axis, which is what causes seasons. Its orbit around the Sun is an oval shape, which causes days and nights to become longer and shorter.

Earth:
- is the third planet from the Sun
- is roughly a sphere
- rotates on its own **axis** once every 24 hours.



▼ In a lunar eclipse, Earth casts a shadow that covers the Moon.

The Hubble Space Telescope has provided us with information about deep space since 1990.

▼ In a solar eclipse, the Moon casts a shadow over part of Earth.

Geocentric model
- Aristotle argued that Earth was at the centre of the universe.
- Ptolemy suggested that the planets revolved around a point outside Earth.

Heliocentric model
- Nicolaus Copernicus proposed that the Sun, rather than Earth, was at the centre of the universe.
- Galileo Galilei provided mathematical evidence that supported the heliocentric model.

FINAL CHALLENGE

1. In your own words, explain what causes a solar eclipse.
2. How did Galileo provide evidence to support Copernicus' heliocentric model of the solar system?
3. When Australia, which is in the southern hemisphere, is experiencing winter, what season is France experiencing in the northern hemisphere?

LEVEL UP!

Level 1

50xp

4. Draw a diagram showing the positions of Earth, the Sun and the Moon during:
   - **a** a lunar eclipse
   - **b** a solar eclipse.
5. Earth's seasons are caused by the tilt of its rotation. Explain why.

LEVEL UP!

Level 2

100xp

6. Describe the difference between an equinox and a solstice.
7. How long does it take for:
   - **a** Earth to rotate once on its own axis?
   - **b** the Moon to orbit Earth?

LEVEL UP!

Level 3

150xp

8. Describe how human missions to the Moon have led to increased scientific understanding of the solar system.
9. Design a model that could be used to explain how day and night occurs on Earth. Provide an annotated diagram of your model as well as a list of materials.
10. Early astronomers believed that Earth was the centre of the universe. Why do you think this was a popular idea?

LEVEL UP!

Level 4

200xp

11. Do you think the Moon experiences day and night? Justify your response.
12. Predict how the seasons would change if Earth's rotation was not tilted.
13. Describe the three types of solar eclipse in your own words, and draw an annotated diagram of each.

LEVEL UP!

Level 5

300xp

EARTH'S RESOURCES

What will Earth be like in 100 years?

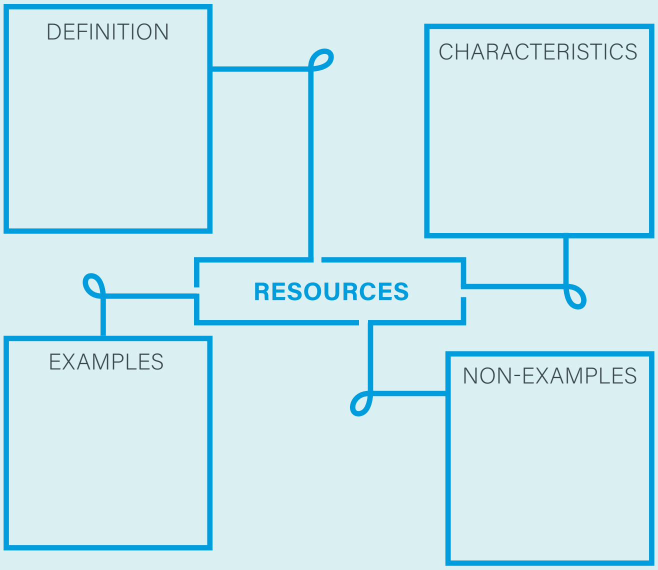
7

Resources can be described as the things that living things need to survive. We use many different resources in our daily lives, for food, for shelter and to make our lives easier. Some of these resources are found naturally, while others are made.

We need to think carefully about how we use Earth's resources. Managing our resources wisely will make sure that they are still able to be used by future generations.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Renewable* and *Fossil fuel*.

2 LEARNING LINKS

Brainstorm everything you already know about resources.

3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.

4 CRITICAL + CREATIVE THINKING

VARIATIONS: How many ways can you reuse a plastic bag?

DISADVANTAGES: List as many disadvantages of recycling as you can. Now list ways of eliminating these disadvantages.

MISMATCHES: If you had a giant bucket, the world's largest diamond and a windmill, how could you solve the problem of plastic that ends up in the ocean?

5 THE MOST WASTEFUL!

We're good at many things in Australia, but recycling and reusing materials are not among them. Australians throw out a lot of stuff. Every year we generate hundreds, even thousands, of kilograms of waste per person.

Waste, including plastic waste, can end up in the oceans. There is so much plastic in oceans that scientists predict that by 2050 there will be more plastic than fish in the ocean! Sea life can get tangled up in plastic, eat it, or even be suffocated by it.

7.1 WHAT IS A RESOURCE?

LEARNING INTENTION

At the end of this lesson I will be able to classify a range of Earth's resources as renewable or non-renewable.

KEY TERMS

made resource
a resource that is manufactured from natural resources

natural resource
a resource that is valuable in its natural form

non-renewable resource
a resource that can run out, or one that takes longer than a human life span to be restored

renewable resource
a resource that cannot run out, or one that can be restored in a human life span

resource
a source of something that is useful

LITERACY LINK

VOCABULARY

An antonym is a word that is the opposite of another word. Identify any pairs of antonyms in this spread, then think of an antonym for the words *replenish* and *natural*.

NUMERACY LINK

MEASUREMENT

The wind turbine in Figure 7.1 is shown at a 1:2000 scale. Measure the height of the turbine in the photo, then calculate the height of the real turbine.

Anything that a person can use is a **resource**.

Natural resources, such as vegetables, oxygen, timber and wool, don't need to be changed much or at all before we can use them. Some natural resources are processed to become something that's very different and also useful. These are **made resources**, such as plastic, concrete and some fabrics.

Figure 7.1 These wind turbines create electricity from the motion of the wind, which is a renewable resource.

1 Natural resources are useful in their natural form

Natural resources are useful in their natural form – we don't need to change them into something different before we use them.

Fresh food and water are two common natural resources. Water is collected from rivers and lakes to supply towns and farms. Fish are taken from the oceans to provide food. Fruit and vegetables are grown and harvested for food.

What is a natural resource?

2 There are renewable and non-renewable resources

Some natural resources replenish themselves, and the length of time this takes depends on the type of resource.

A **renewable resource** can be infinite (can never run out), such as wind or sunlight, or will replenish itself within the average human life span (about 80 years). Crops are considered renewable because they can grow back within a human life span.

A **non-renewable resource** is finite (can run out), or only replenishes itself over a much longer period than a human life span. Fossil fuels such as coal, oil and gas are

Figure 7.2 Cotton is a natural resource because the fibre from the cotton plant is not changed a lot to make clothes – it is the same basic material.

non-renewable resources. Coal (the compressed remains of ancient plants) takes hundreds of millions of years to form, and it only forms under certain conditions.

Some trees can grow back in a life span, but some are many hundreds of years old. This means that trees can be renewable or non-renewable.

What is the difference between a renewable and non-renewable resource?

3 Made resources are made from natural resources

Not every resource can be used without changing it. Made resources are manufactured from natural resources, and they are very different to the original resource.

There are an incredible variety of made resources. Plastic packaging and polyester fabrics are made from oil extracted from the ground. Medicines are made from many different natural products. Steel is made by mixing iron metal with carbon and other substances. Another term for made resources is synthetic resources.

What is a made resource?

Figure 7.3 The coal extracted from this mine took millions of years to form.

INVESTIGATION 7.1
Classifying resources used in the classroom

KEY SKILL
Representing data

▶ *Go to page* ***169***

CHECKPOINT 7.1

1 A ___________ is something that societies use in everyday life.
A ___________ resource can be restored within a ____________ life span.
A non-renewable ____________ is finite or takes much ________ to restore.

2 List three examples of natural resources and three examples of made resources.

3 List three examples of renewable resources and three examples of non-renewable resources.

4 Identify if these resources are renewable or non-renewable.
a Banana
b Cotton
c Coal
d Copper
e Paper
f Plastic
g Wind
h Water

ETHICAL CAPABILITY

5 Research the natural resources used to make a smartphone. Discuss some of the ethical issues involved in smartphone manufacturing (what is right and wrong).

SUCCESS CRITERIA

- I can describe the difference between non-renewable and renewable resources.
- I can give three examples of each type of resource.

7.2 NON-RENEWABLE RESOURCES

LEARNING INTENTION

At the end of this lesson I will be able to describe some features and examples of non-renewable resources.

KEY TERMS

finite
limited in size or amount

fossil fuel
a natural fuel formed over millions of years from the remains of living things

LITERACY LINK

READING

Quickly scan these two pages, reading the headings and considering the images. What can you predict about this text? What do you think it will be about and include? Also consider what you may already know about this topic.

NUMERACY LINK

UNITS

Electricity is often measured in kilowatt hours (kWh), which is the amount of energy that would be used in one hour by 1000 1 W lamps. By multiplying the number of kilowatt hours by 3 600 000 they can be converted to joules, another measure of energy. Convert 15 kWh into joules.

Non-renewable resources run out or are not replenished in a human life span.

Fossil fuels such as coal, gas and oil, as well as rocks and minerals, are some examples of non-renewable resources that humans use. Some of these resources take thousands or even millions of years to form.

1 Fossil fuels include coal, oil and gas

Fossil fuels include coal, crude oil and natural gas. These resources are produced from the remains of ancient plants and animals, in processes that take hundreds of millions of years. While fossil fuels are still being formed today, they are being removed and used at a rate that is much faster than they are being restored.

Coal is formed from the remains of ancient swamps. This plant matter builds up over time and doesn't decay. As the plant matter is buried, heated and squashed under tonnes of soil, the water and impurities are squeezed out and it slowly changes into coal.

Oil and natural gas are formed from the remains of tiny marine organisms, such as algae and plankton, that die and sink to the bottom of the ocean. Conditions at the bottom of the ocean stop them from breaking down, so the remains build up in the sediment. This happens over millions of years. As the sediments are buried, heated and squashed, the remains undergo chemical reactions that produce oil and natural gas.

Fossil fuels are often burnt to provide heat energy. In power plants, this heat energy is used to change water into steam, which then spins large, fan-like machines called turbines. The use of fossil fuels creates large amounts of carbon dioxide which is released into the environment. This increase in carbon dioxide gas leads to air pollution as well as climate change.

How are fossil fuels formed?

2 Nuclear fuels are rare and finite

Nuclear fuels are used to power nuclear power stations, which operate similarly to coal power stations in that they produce heat that turns a turbine to generate electricity. The most common nuclear fuel is uranium, which is mined in 19 countries including Australia.

Only very small quantities of uranium are needed to power a nuclear power plant, but uranium is still considered non-renewable because it is a **finite** resource – there is only a limited amount available on Earth.

The use of nuclear power is a controversial issue. If something does go wrong, the effects can be long-lasting and extremely dangerous.

Why is uranium considered non-renewable?

3 Rocks and minerals provide metals

Rocks and minerals are non-renewable resources because there are only limited amounts close to Earth's surface that humans can access. Rocks are useful resources as building materials. They can be cut to create building stone or crushed to add strength to roads and concrete.

Rocks can contain minerals that hold useful metals such as aluminium, copper and iron. These minerals are known as metal ores, and when they are found in large amounts they are called mineral deposits. Mining and extraction processes remove and purify metals from their ores for use to manufacture many items.

Table 7.1 Common metals mined in Australia

Metal	Mineral ore/s	States mined	Useful property	Use
Iron	Hematite, magnetite	WA	Strong	Steel
Aluminium	Bauxite	Qld, NT	Lightweight	Aluminium cans, aircraft
Copper	Chalcopyrite	Qld, SA, NSW, WA	Good conductor of electricity	Electrical wiring, computers, coins
Zinc	Sphalerite	Qld, NSW, NT, Tas, WA	Resistant to corrosion	Galvanising steel, zinc creams

Why are rocks and minerals non-renewable resources?

Figure 7.4 Huge amounts of stone, such as this marble, are quarried for use as building materials.

INVESTIGATION 7.2

Investigating soil erosion

KEY SKILL
Identifying the variables and formulating a hypothesis

▶ *Go to page **170***

CHECKPOINT 7.2

1 Give five examples of non-renewable resources.
2 Explain how fossil fuels are used as a resource.
3 What are some of the problems with using fossil fuels as a resource?
4 Why are minerals, fossil fuels and nuclear fuels all non-renewable resources?
5 Justify why recycling is important to manage a non-renewable resource.
6 Of the three non-renewable resource categories discussed in this section, identify which one you think is the most important. Justify your response.
7 Fossils fuels are considered finite. Explain why.

ETHICAL CAPABILITY

8 The use of nuclear power is an ethical issue. Brainstorm some of the social, economic and environmental considerations of nuclear power.

SUCCESS CRITERIA

- I can explain what a non-renewable resource is.
- I can give examples of some non-renewable resources and their features.
- I can describe what a fossil fuel is.

7.3 RENEWABLE RESOURCES

LEARNING INTENTION

At the end of this lesson I will be able to describe some features and examples of renewable resources.

KEY TERMS

biofuel
a substance produced from living things that can be burnt to create energy

hydropower
electricity generated by flowing water turning a turbine

solar energy
heat and light energy from the Sun

LITERACY LINK

WRITING

Consider the first paragraph in this lesson. Rewrite it to make it sound more technical and scientific. Your goal is to make the language more formal.

NUMERACY LINK

GRAPHING

In 2014, 73% of Australia's electricity came from coal, 13% from natural gas, 7% from hydropower, 4% from wind, 2% from solar and 1% from bio-energy. Display this data as a pie chart.

We use renewable resources for food, materials and energy. Some renewable resources can replenish within a human life span, and some will never run out. Renewable resources can be from living things, such as plants and animals, and from non-living things, such as the Sun, wind and water.

The living parts of the world contain many different renewable resources, including plants and animals. **Solar energy**, wind and water are non-living renewable resources. We can use these and other resources for food, fuel and power.

Figure 7.5 The oils from some plants can be made into biodiesel.

1 Living things provide many renewable resources

Living things are important resources that provide us with food, materials and even energy. If we manage our use carefully, living resources can restore within a human life span.

Trees are grown and harvested to provide materials such as timber and paper. Other plants provide fruit and vegetable crops. Animals provide meat and materials such as wool, leather and honey.

Biofuels are fuels produced from plant and animal waste. Wood is a biofuel that has been used by humans for hundreds of thousands of years.

What are some examples of living things as resources?

2 Wind power is a renewable resource

You have probably seen a windmill or even a whole wind farm before, in Australia or overseas. Denmark uses the most wind power – around 43% of its power is generated from wind farms.

To create electricity, windmill blades are moved by the wind, and the rotation of the blades powers a generator (similar to coal, nuclear and **hydropower** generation). The costs of wind power are fairly low but wind does have some disadvantages. For example, the electricity supply is not constant because if it's not a windy day then no power can be generated!

How is the wind useful as a resource?

3 Flowing water can generate power

The energy from moving water, such as waves or in dams, can be harnessed to create electricity. In the same way that wind power uses moving air to turn a turbine, hydropower uses water. The falling or flowing water turns the turbine, which then generates electricity.

As a resource, water is also used by humans for drinking and household use, but the vast majority is used in farming and by industry in factories. Most of the water that is used by humans is fresh (not salt water) and these sources must be managed carefully to make sure they don't run out or become polluted or unusable.

How can water generate power?

4 The Sun can create electricity

The heat and light energy we get from the Sun is called solar energy. It is the starting point for most of the processes on Earth. Without the Sun's heat and light, nothing would live on Earth – our planet would be a cold, airless rock.

Plants use the energy from the Sun for photosynthesis, which enables them to grow. This energy is then passed on to the organisms that eat the plants. The Sun's heat warms the air unevenly, causing air of different temperatures to meet and move as wind.

Solar power panels, like the ones you see on the roofs of houses, convert sunlight into electricity. Solar thermal systems also use sunlight to heat water or air in buildings.

What can solar power panels change solar energy into?

Figure 7.6 Dams throughout the Snowy Mountains are used to generate hydroelectricity. The movement of falling water is used to spin turbines.

INVESTIGATION 7.3A

Designing a windmill to lift a weight

KEY SKILL
Representing and recording data using a table

▶ *Go to page* ***171***

INVESTIGATION 7.3B

Making bioplastic

KEY SKILL
Identifying and managing relevant risks

▶ *Go to page* ***172***

CHECKPOINT 7.3

1 Identify two examples of resources provided by:
  a living things
  b air
  c water
  d the Sun.

2 Identify four examples of renewable energy resources.

3 Explain why the time taken to restore a resource is important for determining whether it is renewable.

4 Explain how wind, water and solar power each create electricity.

5 Hydroelectric schemes use the movement of water to spin big turbines to generate electricity. Can you think of any impacts on the environment that could be caused by hydroelectric schemes?

STUDENT VOICE AND AGENCY

6 As a class, organise and hold a debate about the use of renewable energy resources in Australia.

SUCCESS CRITERIA

- I can explain what a renewable resource is.
- I can give examples of some renewable resources and their features.

7.4 CONSERVING EARTH'S RESOURCES

LEARNING INTENTION

At the end of this lesson I will be able to investigate some strategies used by people to conserve and manage non-renewable resources.

KEY TERMS

population
all the living things of one species in a particular area

recycle
to change something into something else that is useful

sustainable
able to be maintained at a certain rate or level

LITERACY LINK

LISTENING

Interview a partner asking how they reduce, reuse and recycle in their lives. Summarise their main ideas into bullet points and highlight any that you may wish to use in your own life. Switch roles, then share your ideas in a class discussion.

NUMERACY LINK

CALCULATION

In 2017–18, Australia consumed 3.4 million tonnes of plastic, but only recycled 9.4% of this. How much plastic (in tonnes) was not recycled and therefore ended up in landfill or in the ocean?

Using a resource in a **sustainable** way means using it in a way that allows others to use it in the future. This might mean reusing a resource or limiting the amount that is used.

1 Reducing resource use

Some resources can be restored in a human lifetime, but this may only happen if they are used sustainably.

Overfishing is an example of a renewable resource being used unsustainably. If too many fish are taken from wild **populations**, there won't be enough wild fish left to breed, leaving no fish left for the future. Many natural fish populations are much smaller than they were 100 years ago. To combat this, governments place size and catch limits on people who fish individually or for their business. They do this so that young fish have time to grow and breed, and that enough fish are left to maintain the population.

What may happen to a renewable resource if it is used unsustainably?

2 Non-renewable resources should be used carefully

It's important that the world manages its use of non-renewable resources – particularly fossil fuels and minerals – so that the environment is healthy and there will be enough resources available for future generations. There are three major ways to manage these resources.

One way is to reduce the amount of a resource that is used. Governments can influence how much a resource costs. If costs are high, people will use less. Some groups encourage citizens to change their habits so that they use less resources, such as fuel.

Another way is **recycling**. Materials such as plastics and metals can be collected and recycled into new items. This means that the resources can be used more than once.

The third way is to find other resources. Scientists and engineers are working to find and develop other ways of using different electricity sources. In Australia, more and more of our electricity supplies come from hydroelectric, solar and wind sources.

What are three ways to conserve a non-renewable resource?

Figure 7.7 Local councils provide colour-coded bins to help people separate their rubbish and recycling.

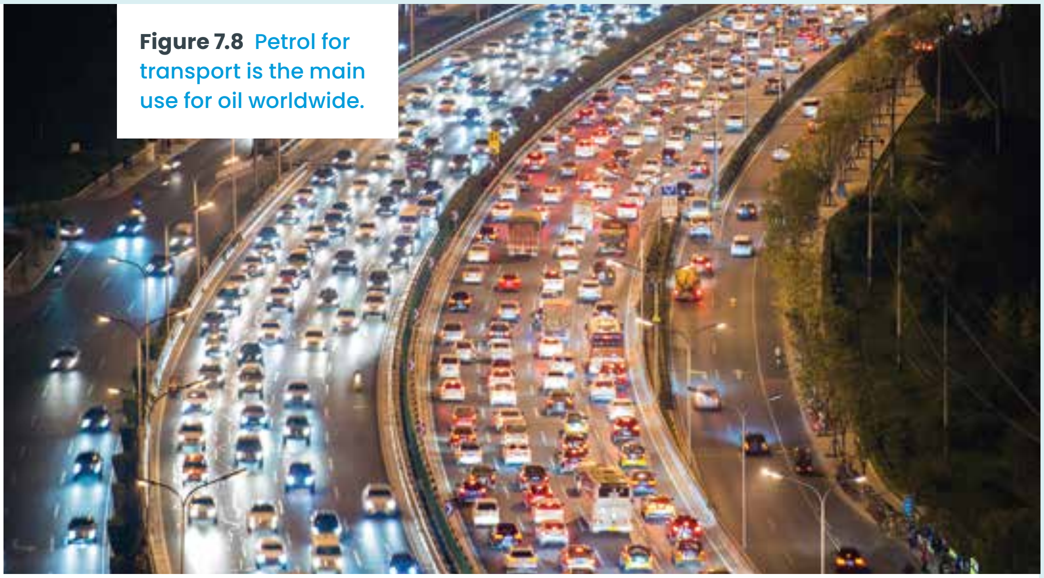


Figure 7.8 Petrol for transport is the main use for oil worldwide.

INVESTIGATION 7.4

The sustainability game

KEY SKILL
Representing data

▶ *Go to page* ***173***

❸ Non-renewable resources need to be reused and recycled

Some items are designed and made to be reused again and again, such as reusable coffee cups and glass milk bottles. Items can also be repurposed – that is, used in a different way than they were originally intended. For example, old car tyres may be used to make the walls of a house.

If an item has come to the end of its useful life, the materials in it should be recycled. Recycling is where an item is broken down into raw materials that can be made into new products. Aluminium is a resource that is easily and cheaply recycled – in fact, recycling aluminium uses only 5% of the energy and produces only 5% of greenhouse gas emissions that obtaining new aluminium from mining requires.

What is the difference between reusing and recycling?

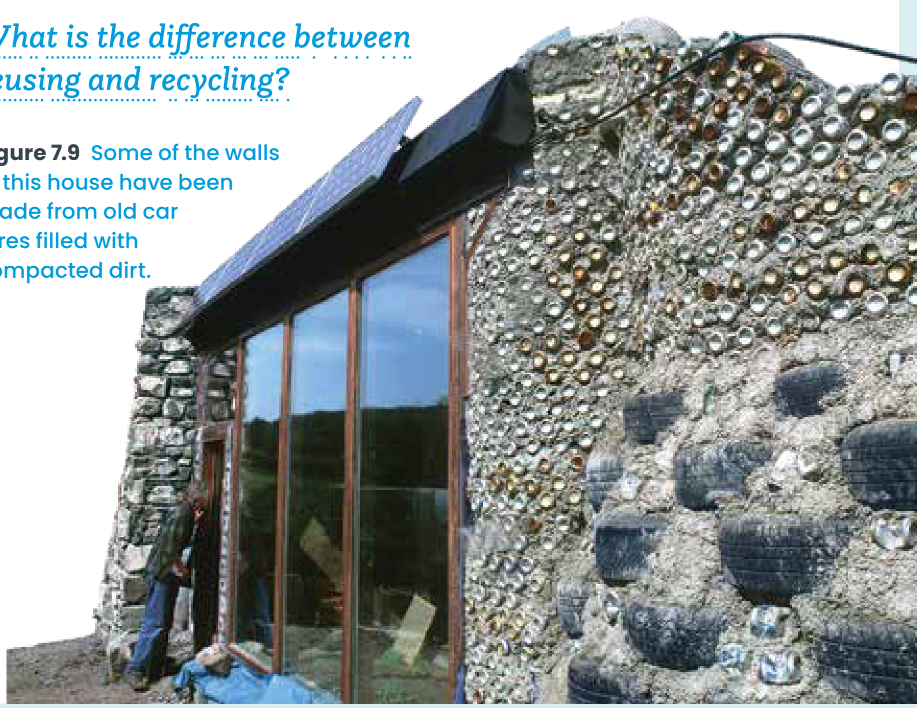


Figure 7.9 Some of the walls of this house have been made from old car tyres filled with compacted dirt.

CHECKPOINT 7.4

1 Identify what could happen if a resource was not managed sustainably.

2 Explain how overfishing can be prevented.

3 List four other renewable resources that need to be managed sustainably.

4 Explain, using examples, how the following strategies can be used to conserve resources.
   a Reducing consumption
   b Reusing items
   c Recycling materials

5 Explain why it is beneficial to recycle aluminium cans.

6 Is it more important to conserve renewable or non-renewable resources? Justify your response.

INQUIRY

7 Find out how your school manages its resources, such as water, electricity and paper. Can you suggest ways that the resources can be used more sustainably?

SUCCESS CRITERIA

- I can explain why it's important to sustainably manage resources.
- I can give examples of how to conserve and manage resources.

7.5 SCIENTISTS INVOLVED IN MINING

LEARNING INTENTION

At the end of this lesson I will be able to explain how knowledge of the location and extraction of mineral resources relies on expertise from different scientists.

KEY TERMS

exploration
processes undertaken to find rocks that contain minerals

mineral deposit
rocks that contain a particular mineral

ore body
a mineral deposit that is profitable to mine

rehabilitation
processes that return the environment to close to how it was before mining

LITERACY LINK

READING

Read this lesson carefully, highlighting any key points. Then write a paragraph explaining the difference between the following terms: mineral, mineral deposit, ore body, mineral ore.

NUMERACY LINK

CALCULATION

Magnetite is a type of iron ore that contains 72.4% iron. If a miner found a 12.5 kg block of magnetite, how much iron would it contain?

Figure 7.10 A geologist who works in a mine will make sure the best locations are being mined.

Mining allows us to access resources from Earth that we use in our everyday lives. The process of locating, removing and processing a resource requires expertise from scientists in many different areas.

1 Geophysicists and geochemists search for resources

To meet the demand for resources, mining companies conduct **exploration** to find areas that have high concentrations of the **mineral deposits** that contain the resource that they want to mine. If they are granted permission from the government and landholders to explore in a particular area, they use many different exploration techniques to find these deposits and to work out whether they will be profitable to mine.

Geophysicists use equipment that can tell them what types of rock might be underneath the surface. They can compare the densities of the rocks, and figure out whether they are magnetic or radioactive. They can even measure how long sound takes to travel through rocks.

Geochemists analyse the chemical make-up of soil samples, water and even plants on the surface to search for clues about the minerals in the rocks under Earth's surface.

Three-dimensional modellers process all of the data that has been collected to build up a picture of what is happening underground.

What scientists are involved in the search for mineral deposits?

❷ Geologists and geotechnical engineers work in mining

An **ore body** is a mineral deposit that is profitable to mine. After an ore body has been located, mining companies need to work out the most cost effective, safe and environmentally friendly way of removing the ore from the surrounding rock.

Geotechnical engineers will gather information on the site and create a plan to construct the mine safely.

Mining geologists analyse the ore and decide if they should keep mining a particular area or move to a new one.

What do mining companies need to consider before they begin mining?

❸ Metallurgical engineers extract metals from ore

After ore has been removed, it needs to be processed to extract (take out) the resource inside. The main processes involve crushing the ore and using chemical reactions to separate the resource from the other elements in the mineral.

Metallurgical engineers specialise in extracting metals from ore. They analyse the ore mineral and determine the most effective method for extraction of the metal. They monitor the extraction process to make sure that it is efficient and safe for the environment.

Why must ore be processed after it is removed from the ground?

❹ Environmental scientists rehabilitate mine sites

At all times throughout the mining process, a mining company must take care to protect the natural environment. When mining is finished in Australia, any land that has been impacted by the mine must undergo **rehabilitation** to attempt as much as possible to return it to the way it was before the mining began.

Environmental scientists identify ways to protect and restore the natural environment before, during and after mining.

Why is rehabilitation of a mine site important?

Figure 7.11 Iron ore is removed from the ground and processed to extract resources.

EXPERIMENT 7.5

Mining for chocolate chips

KEY SKILL
Identifying limitations to the method and suggesting improvements

▶ *Go to page **174***

CHECKPOINT 7.5

1 Identify the four main stages of the mining process.
2 Identify the types of scientists and engineers involved in each stage of mining.
3 Companies exploring for gold often focus on areas where there are gold mines. Propose a reason why they might do this.
4 Propose an impact on the finished product if the metallurgical engineer did not pay careful attention to the extraction process.
5 Propose what impacts there may be to the environment if mining companies did not employ environmental scientists.

RESEARCH

6 Many different resources are mined in Australia. Research one and present information about the:
- location of a major mine
- types of exploration techniques used to find the deposit
- mining method used
- methods used to process the ore and extract the resource
- methods used or planned to rehabilitate the mine site.

SUCCESS CRITERIA

- I can describe the role of geologists, metallurgical engineers, geophysicists and environmental scientists in the mining process.

7.6 RESOURCE USE AND THE ENVIRONMENT

LEARNING INTENTION

At the end of this lesson I will be able to describe how solutions to contemporary issues (such as power generation) may have an impact on other areas of society and involve ethical considerations.

KEY TERMS

ethics
beliefs about what is right and wrong

habitat
the place where an animal or plant naturally lives

LITERACY LINK

SPEAKING

Prepare speaking cue cards for a debate that argues for and against single-use plastic items. Try your arguments against those of a classmate.

NUMERACY LINK

DATA

Jenny designed a survey to find out her local community's recycling level. Her results came back with 95% of people saying that they recycle. Is this data valid? Why or why not?

Hint: See lesson 1.4 for a definition of valid data.

Figure 7.12 The Super Pit is the biggest open-pit gold mine in Australia. Extracting this important resource affects the environment.

Using and obtaining resources from Earth usually damages (or even destroys) the natural environment.

A balance must be struck between the need for a resource and conserving the environment. When making these decisions it is important to understand how obtaining the resource may impact on other areas of society and the ethical considerations that are involved.

1 How will we benefit from this resource?

Resources that we obtain from Earth can provide us with food, shelter and other ways to make our lives easier. We not only need to consider the benefits of using a resource to make various products, but we also need to consider other ways that the resource can be of benefit to society. For example, mining makes a significant contribution to Australia's economy, providing many people with jobs.

What are some ways that society can benefit from a resource?

2 Ethical issues must be considered

Ethics form a system of moral principles that considers what is good for individuals, society and Earth. Ethics can be simply described as considering what is good and bad, or what is right and wrong. Many ethical issues are debatable and contestable and these discussions are important in helping people to build their own world views. By analysing and evaluating ethical issues, we have the opportunity to see things from new perspectives, to become more open minded and ultimately to form opinions on the decision-making that affects our lives.

3 Ethical considerations for resource use

Obtaining a resource may change, pollute or destroy native **habitats** or reduce the biodiversity of an area. Sometimes it is the use of the resource that can be damaging to the environment. The burning of fossil fuels results in the release of carbon dioxide into the atmosphere at levels well above what would naturally occur. Carbon dioxide traps heat in the atmosphere that would normally escape into space. This has caused average global temperatures to rise and is contributing to climate change. If we are to limit the amount of carbon dioxide being emitted, we need to use alternatives to fossil fuels to produce energy.

What is an example of an ethical consideration?

4 Ethics involves considering different opinions

Before a resource is extracted and used, information and opinions are gathered about the resource and the local environment so that choices and decisions can be made.

There are always groups of people with different opinions and this can make the final decision difficult to make. Coal is one of the resources that is frequently debated in Australia. Different groups will be affected in different ways depending on the choices that are made.

Table 7.2 **Different impacts and points of view about mining and using coal**

Group	Impact and point of view
Mining company	Wants to extract as much coal as possible, spending as little as possible to maximise profits
Energy company	Wants to utilise a cheap fuel source (such as coal) to meet electricity demands
Coal industry workers	Want the industry to continue to provide them with work
Environmentally conscious people	Want the mining and burning of coal to stop so that carbon dioxide emissions are greatly reduced and ecosystems are protected
Renewable energy companies	Want governments to support renewable energy technologies so that renewable energy becomes the primary source of electricity as well as a source of employment
People living near mines and power plants	May be concerned by damage to the local environment and that pollution could be harming their health
Scientists	Have undertaken many studies showing that the burning of fossil fuels such as coal is causing climate change

Why can making decisions about using resources be difficult?

CHECKPOINT 7.6

1 Describe how obtaining and using a resource can be of benefit to society.

2 Describe how the natural environment can be affected by obtaining or using resources.

3 What gas is released into the atmosphere when a fossil fuel is burnt? Describe the environmental impact of this gas.

4 Outline some ways that mining impacts on:
a the environment
b society and people
c industry and the economy.

5 Brainstorm some ways that mining companies could reduce their impact on the environment.

6 Stopping coal mining in Australia would reduce a significant portion of income coming into the country's economy, but would stop considerable environmental damage from the mining and use of the coal. Does the benefit of conserving the environment outweigh the cost to the economy? Use evidence to support your response.

INQUIRY

7 Research your local energy supplier. Find out where your energy is sourced from. What percentage is renewable and what percentage is non-renewable? Discuss some ethical considerations (what is right and wrong) about how your power is generated.

SUCCESS CRITERIA

- I can describe some ethical considerations of obtaining and using resources.
- I can describe some different points of view people may have on the use of non-renewable resources in Australia.

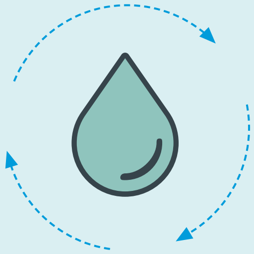
VISUAL SUMMARY

Non-renewable resource
a resource that can run out, or one that takes longer than a human life span to be restored

Renewable resource
a resource that cannot run out, or one that can be restored in a human life span

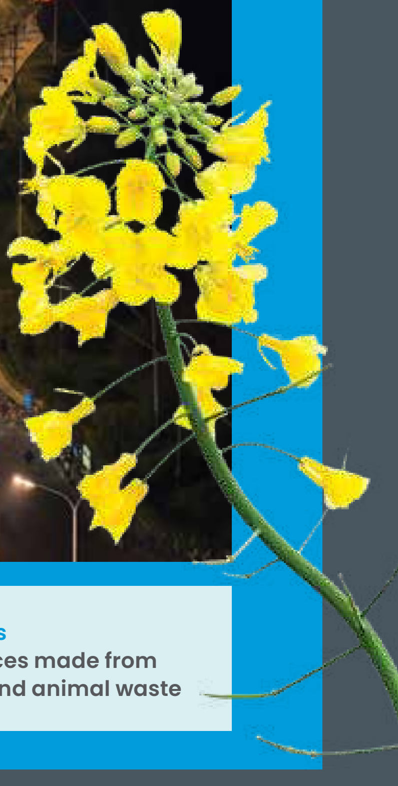
Fossil fuels are non-renewable resources:
- Coal
- Oil
- Gas

Earth has many renewable resources:
- Wind
- Water
- Sun



Recycling is one way to conserve and manage non-renewable resources.

Using resources sustainably means the demand for resources needs to be balanced with maintaining the environment.



Key stakeholders
- government
- local communities
- mining companies
- environmentalists
- clean energy providers
- technology companies

Biofuels
resources made from plant and animal waste

★ FINAL CHALLENGE ★

1. What is the difference between a renewable and a non-renewable resource?
2. Explain what fossil fuels are in your own words and give three examples.
3. List one resource that comes from each of the biosphere (living things), lithosphere (land), atmosphere (air) and hydrosphere (water).

Level 1 ★☆☆ ☆☆☆ 50xp — LEVEL UP!

4. Match each resource with some of its uses.

Resource	Uses
Oil	Drinking, habitats, electricity generation
Metal	Building materials, paper products, food
Trees	Fuel products, plastics, cosmetics
Water	Fuel, electricity generation
Coal	Clothing products, food, transport
Animals	Building materials, electrical wiring, technology

Level 2 ★★☆ ☆☆☆ 100xp — LEVEL UP!

5. Explain why soil is considered to be a non-renewable resource.
6. Identify and describe the uses of three different resources obtained from rocks.
7. Explain what is meant by the sustainable use of resources.
8. A wind turbine's output varies over 6 months. Create a column graph using this data.

Month	Jan	Feb	Mar	April	May	June
Percentage of possible output	80%	70%	40%	60%	40%	50%

Level 3 ★★★ ☆☆☆ 150xp — LEVEL UP!

9. 'Reduce, Reuse and Recycle' is a common slogan. Use your knowledge of resources to explain why it is important.
10. Identify two non-renewable resources and suggest a renewable alternative for each of them.

Level 4 ★★★ ★☆☆ 200xp — LEVEL UP!

11. There are limited amounts of fossil fuels, and if their use continues, we will run out of them in less than 100 years. Discuss the impact this will have on the resources that we have available.
12. Describe some ethical considerations that need to be reflected upon in relation to the use of non-renewable resources (such as coal) in Australia.

Level 5 ★★★ ★★★ 300xp — LEVEL UP!

FORCES

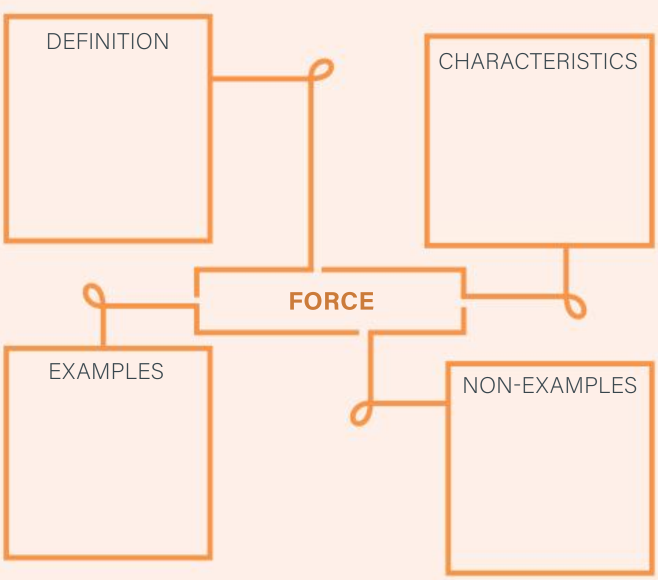
How do physical objects interact with each other?

Have you ever watched Formula One racing? The cars speed around the track, sometimes at more than 200 kilometres per hour.

Every aspect of each car is designed to keep them safely on the track, while not slowing them down too much. Their shape is low and streamlined so that the air flows over them. Their tyres propel the car forward but also provide enough friction to stop it sliding off the track. The hard metal cage of the inside of the car absorbs the force of the car in a crash, helping to protect the driver.

1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Friction* and *Motion*.

2 LEARNING LINKS

Brainstorm everything you already know about forces.

3 SEE-KNOW-WONDER

List three things you can SEE, three things you KNOW and three things you WONDER about this image.

4 CRITICAL + CREATIVE THINKING

THE DISADVANTAGES: List five disadvantages of shoes. Now think of some ways to correct or eliminate these disadvantages.

B-A-R: Consider an everyday family car. What would you make ***bigger***, what would you ***add*** and what would you ***replace***?

RIDICULOUS! Justify this statement: 'All speed limits should be changed to be speed minimums'.

5 THE FASTEST!

In 2009, athlete Usain Bolt officially became the fastest person on Earth. He still holds the record for the fastest human speed – 44.72 km/h – which he ran at the World Championships in Berlin.

Bolt was born in a small town in Jamaica. As a child, all he thought about was sport, and he played cricket and soccer before being identified as an extremely fast sprinter.

Bolt went on to win nine Olympic gold medals and break many world records – even his own. All of this is even more incredible considering he has a medical condition that has made one of his legs more than one centimetre shorter than the other.

8.1 BALANCED FORCES

LEARNING INTENTION

At the end of this lesson I will be able to describe what a force is and discuss forces in terms of being balanced.

KEY TERMS

force
a push, pull or twist on an object when it interacts with another object

friction
a force opposite to the motion of surfaces in contact

interact
to act on each other

motion
the change in position of an object over time

stationary
not moving

LITERACY LINK

VOCABULARY

Use the words force, friction, interact and motion in sentences that have nothing to do with science.

NUMERACY LINK

UNITS

An object is falling at a speed of 6 metres per second (m/s). Convert this speed to kilometres per hour (km/h) by multiplying by 3.6.

Every object on Earth is always being acted upon by **forces**, such as gravity and **friction**. When all the forces on an object are balanced, the object will continue doing whatever it's been doing, whether that's remaining still or continuing to move.

You can look at the forces on an object to predict what will change about the object or its **motion**.

1 Forces happen when objects interact

A force is a push, pull or twist on an object that happens when it **interacts** with another object. The interaction could make the object move, stop moving, change direction or change shape.

A ball sitting in the middle of an oval won't move until it's forced to. If you kick the ball, several things happen. The ball changes shape for a moment, because the kick has applied a force to the ball. The ball moves in the direction of the force from the kick. As it moves, it gets its shape back. Finally, it hits the ground and stops, rolls or bounces.

Each of these events is an applied force – a force on one object by a person or another object. You can describe each effect as pushing, pulling or twisting an object. The force from the kick, for example, is a push.

What are the three possible effects of a force?

2 A stationary object is affected by balanced forces

Even objects that are **stationary** have forces acting on them. Take a book and put it on a table. The book doesn't move, but it's still interacting with the table, and that means forces are acting on it.

Figure 8.1
The forces acting on the book are equal but opposite, so they balance out. This is represented by the two arrows being the same size.

What would happen if the table suddenly vanished? The book would fall to the floor due to gravity, the force on all objects in Earth's gravitational field.

The table applies a force on the book, which is called the normal force. The normal force is the same size as the force of gravity but it acts in the opposite direction, preventing the book from falling. The forces acting on the book are balanced, so it remains stationary.

What are balanced forces?

3 A moving object might also be affected by balanced forces

If a stationary object is affected by balanced forces, does that mean the forces affecting a moving object are not balanced? Not always.

When forces on an object are balanced, the object keeps doing what it's been doing. If a moving object keeps going in the same direction and at the same speed, then all the forces acting on it are balanced. When a car moves at a constant speed, the force from the car's engine is balanced by forces acting in the opposite direction, such as friction on the tyres.

Sometimes these forces are almost balanced, such as when an ice hockey puck slides across an ice rink. After the person slides the puck, they can't apply any more force. The surface of the rink is slippery, so the puck keeps sliding at *almost* the same speed until it hits something.

How can objects in motion have balanced forces?

Figure 8.2 An ice hockey puck slides across the slippery surface of an ice rink. It moves, but the forces on it are balanced.

INVESTIGATION 8.1

Push, pull or twist

KEY SKILL
Identifying and managing relevant risks

▶ *Go to page* ***175***

CHECKPOINT 8.1

1. Explain what forces are, using an example.
2. You can apply a force in three ways: a push, a pull and a twist. Give an everyday example of each.
3. Describe what it means for the forces on an object to be balanced.
4. Describe two forces that could be acting on a stationary object.
5. Using your understanding of balanced forces, suggest the characteristics of unbalanced forces.
6. A motorbike is travelling down the road at a constant speed of 100 km/h. Are the forces on the motorbike balanced? Explain your answer.

CONNECTING IDEAS

7. A soccer ball has a rubber bladder inside and a synthetic outer covering. These prevent it from getting waterlogged in rainy conditions, which would change the way the ball reacted to the force of a kick. Identify another piece of sporting equipment that has been designed to optimise the forces applied to it during use, and explain how it achieves this.

SUCCESS CRITERIA

- I can define forces.
- I can explain what balanced forces are, using an example.

8.2 UNBALANCED FORCES

LEARNING INTENTION

At the end of this lesson I will be able to predict the effect of unbalanced forces acting in everyday situations.

LITERACY LINK

WRITING

Describe three situations you were in today in which there were unbalanced forces acting on you. Write down what each of those forces was.

NUMERACY LINK

MEASUREMENT

A force meter like the one below is used to measure the size of forces. How many newtons is the force meter reading?

Every day, you push, pull and twist objects to change the way they move. When this happens, the forces on these objects become unbalanced.

The effect of unbalanced forces can be seen any time an object starts or stops moving, speeds up or slows down, or changes direction.

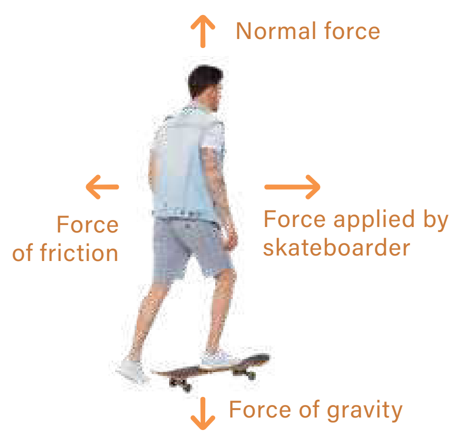
1 Adding or removing a force can unbalance the forces on an object

There are several ways that the forces acting on objects, including us, become unbalanced. Here are two examples.

A force can be added.

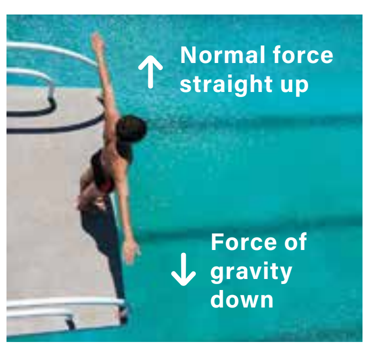
1. **A skateboarder stands still on his board.**

2. **The skateboarder pushes off, adding a force in the direction of his movement.**

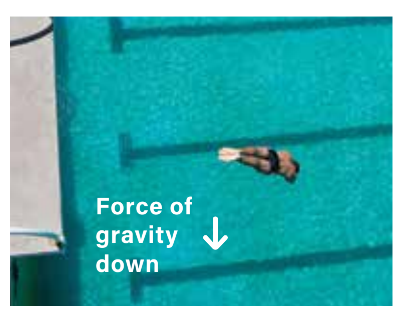


A force can be removed.

1. **A diver stands on a diving board.**



2. **The diver jumps off the board, removing the normal force opposing the force of gravity.**



What can cause forces to become unbalanced?

❷ We can predict how forces will affect motion

When the forces acting on an object are unbalanced, that object's motion will change. If you look at how the forces are unbalanced, you can describe how the motion of the object will change.

It's easy to predict how a stationary object such as a basketball will move when you apply a force to it, such as by throwing. A force acting in the opposite direction to an object's movement is also fairly easy to predict. For example, a rolling ball on a flat floor will slow down and eventually stop due to friction.

How can you explain the change in motion of an object?

❸ Forces can be added up to work out their effect

It is easy to predict the motion of an object when only a single force is acting on it. But when many forces act on an object, adding them up is the best way of working out how it will behave.

When you hold a basketball, there are two forces acting on it – the force of gravity pulling it down and the normal force from your hands holding it up. These forces are balanced. If you push a ball away from you to pass it, you're applying a third force to the ball. The forces acting on it become unbalanced, and the ball moves away from you.

In what direction does the ball move? You can work this out by adding up the forces acting on the ball. The force of gravity and the force from your hands holding the ball cancel each other out, leaving only the force from the push.

What happens when you unbalance the forces on an object?

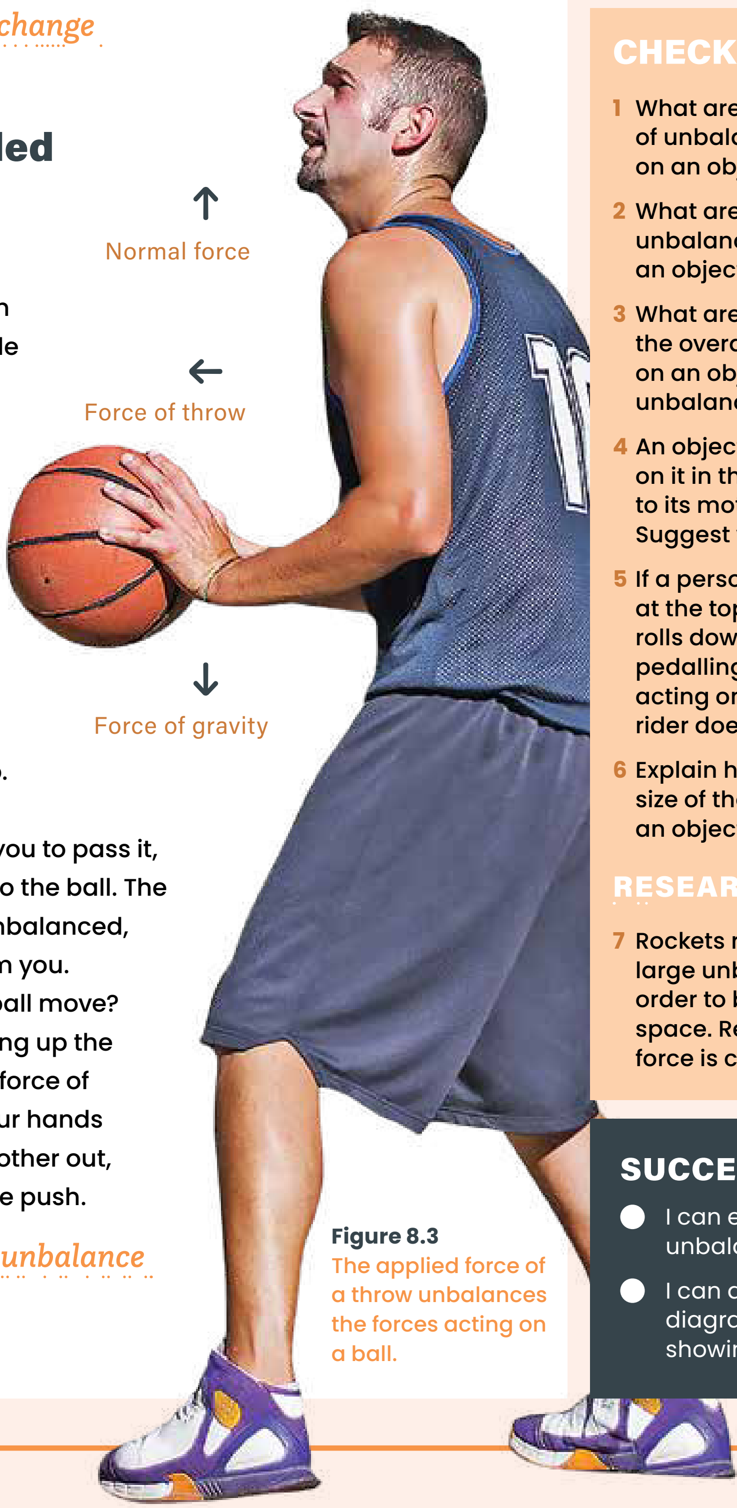


Figure 8.3
The applied force of a throw unbalances the forces acting on a ball.

INVESTIGATION 8.2
Blowball

KEY SKILL
Identifying and managing relevant risks

▶ *Go to page **176***

CHECKPOINT 8.2

1. What are the possible results of unbalanced forces acting on an object?
2. What are the three ways that unbalanced forces can change an object's motion?
3. What are two ways that the overall forces acting on an object can become unbalanced?
4. An object with a force acting on it in the opposite direction to its motion will slow down. Suggest why.
5. If a person is sitting on a bike at the top of a hill, then slowly rolls down the hill without pedalling, describe the forces acting on the bike and why the rider doesn't need to pedal.
6. Explain how you think the size of the force applied to an object affects its motion.

RESEARCH

7. Rockets require an extremely large unbalanced force in order to be launched into space. Research how this force is created.

SUCCESS CRITERIA

- I can explain what unbalanced forces are.
- I can draw a simple force diagram with arrows showing unbalanced forces.

8.3 THE SIZE AND DIRECTION OF FORCES

LEARNING INTENTION

At the end of this lesson I will be able to identify characteristics of specific forces in terms of size and direction.

KEY TERMS

magnitude
the size or power of an object, energy or force

net force
the sum of all forces acting on an object

LITERACY LINK

WRITING

Outline a situation in which you have had to think about both the size and direction of a force that you've applied to an object.

NUMERACY LINK

UNITS

The formula to convert kilograms to newtons is:

1 kg = 9.807 N

Convert these to newtons:

a 1 kg
b 5 kg
c 120 kg

Every moment of the day, you're either applying forces to objects or having forces applied to you.

Each force has two key characteristics. The direction of the force affects the direction that an object moves, and whether it slows down or speeds up. The size, or **magnitude**, of the force affects how much the object might move, or how quickly it speeds up or slows down.

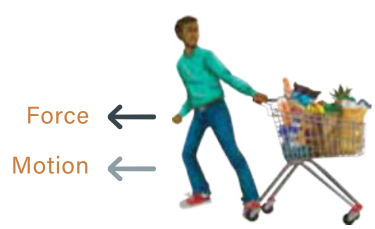
1 Every force acts in a certain direction

A force is shown in a diagram as an arrow that points outwards from an object. The direction that the arrow is pointing indicates which way the force is acting on an object.

Imagine you and your family are at the supermarket, and you're handling a shopping trolley. In what directions could you apply force?

① **You could push the trolley. This applies force in a forwards direction and makes the trolley move that way.**

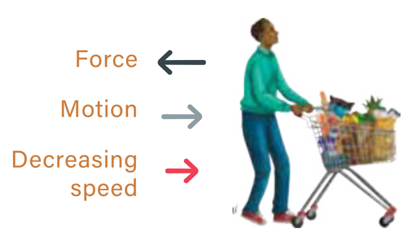
② **You could pull the trolley to make it move backwards.**



③ **You could try swinging the handle to the side to make it spin. The force is directed to the side of the trolley, but the motion is a turn, rather than a sideways push.**

④ **If you started running while pushing the trolley ahead of you, you could keep pushing on it to make it go faster.**

⑤ **The only way to stop the trolley quickly would be to apply a force in the opposite direction.**



The direction of the applied force determines the direction an object will move. It can also determine if the object speeds up, slows down or changes direction.

How does the direction of a force affect how an object moves?

2 Every force has a magnitude (size)

A force can be strong or weak, great or small. As with direction, the size of the force should be shown when drawing diagrams. A larger force arrow means a larger force. Force is measured in newtons (N). The **net force** is the sum of all forces acting on an an object.

After your family finishes at the supermarket, it's time to head home and make dinner. At home, you need to set the table. How much force should you apply when you shut the cutlery drawer?

1 If you slam the cutlery drawer with a large force, it will close quickly.

2 The drawer frame applies a force of the same size and opposite direction to stop the drawer. This is what causes the loud slamming noise.

3 If you close the drawer more gently (using a smaller force), it will take longer to close or may not close at all.

4 The drawer frame applies a force of the same size and opposite direction to stop the drawer. Because the force is much smaller, there's no slamming sound.

How does the size of a force affect how an object moves?

CHECKPOINT 8.3

1 What are two key characteristics of forces?

2 How are these two characteristics shown in force diagrams?

3 What happens differently when you apply a force in the same direction as an object's motion, as compared to applying a force in the opposite direction to an object's motion?

4 In terms of forces, how can you make a ball go further when throwing it?

5 Draw a simple force diagram showing a ball rolling off a table.

6 Vehicles must be able to both speed up and slow down, and to do so they can apply forces onto the wheels in both directions. What main part of a car applies a force in the forward direction? Which parts of the car apply forces in the opposite direction?

7 Why is it important for vehicles to be able to apply very large and very small forces?

EXTENSION

8 Whenever you play a sport, make a piece of art or play a musical instrument, you apply a variety of forces during each activity. Choose an example from the list above. Explain how and why you change either the magnitude or direction of the forces you apply to an object (the sports equipment, the medium of your art or the musical instrument) during this activity.

SUCCESS CRITERIA

- I can describe the result of a change in the direction of a force.
- I can describe the result of a change in the size of a force.

8.4 FRICTION

LEARNING INTENTION

At the end of this lesson I will be able to analyse some everyday situations where friction operates to oppose motion and produce heat.

KEY TERMS

inclined
tilted up at an angle from horizontal

static friction
a friction force that keeps an object in place on a surface

LITERACY LINK

READING

Read Section 1 out loud to a partner, then ask them to to think of three questions about what you read. Repeat for Section 2, swapping roles.

NUMERACY LINK

DATA

Shoshana measures the force required to push an object up an incline. She carries out the experiment four times and obtains the following results: 52 N, 48 N, 57 N and 51 N. Calculate the average force required, and explain why she measured the force four times.

Friction is a force that acts in the opposite direction to the motion of an object. It depends on the mass of an object and the types of surfaces involved.

Even if an object isn't moving, a force of friction may be stopping it from slipping or sliding. Air resistance and 'drag' are common names for the friction on objects as they interact with the air around them.

1 Static friction prevents objects from moving

Objects don't have to be moving for friction to act upon them. **Static friction** can act on objects, keeping them in place on a surface.

Any time you've taken a step without slipping, that was due to static friction. Imagine trying to run with no static friction. It would be like trying to run on ice! Your feet would slip out from under you with every step because they wouldn't be able to get traction on the ground.

Static friction also applies to objects on an **incline**. You can stand on a ramp or slope without sliding down because the interaction between the slope and the soles of your shoes produces a friction force large enough to oppose the forces acting downhill.

If you're standing still and not sliding, the static friction force must be equal to the downhill force.

If the downhill force is greater than the maximum friction force of your shoe, you'll begin to slip. This maximum depends on the materials of the slope and of your shoes.

What stops objects from sliding down slopes?

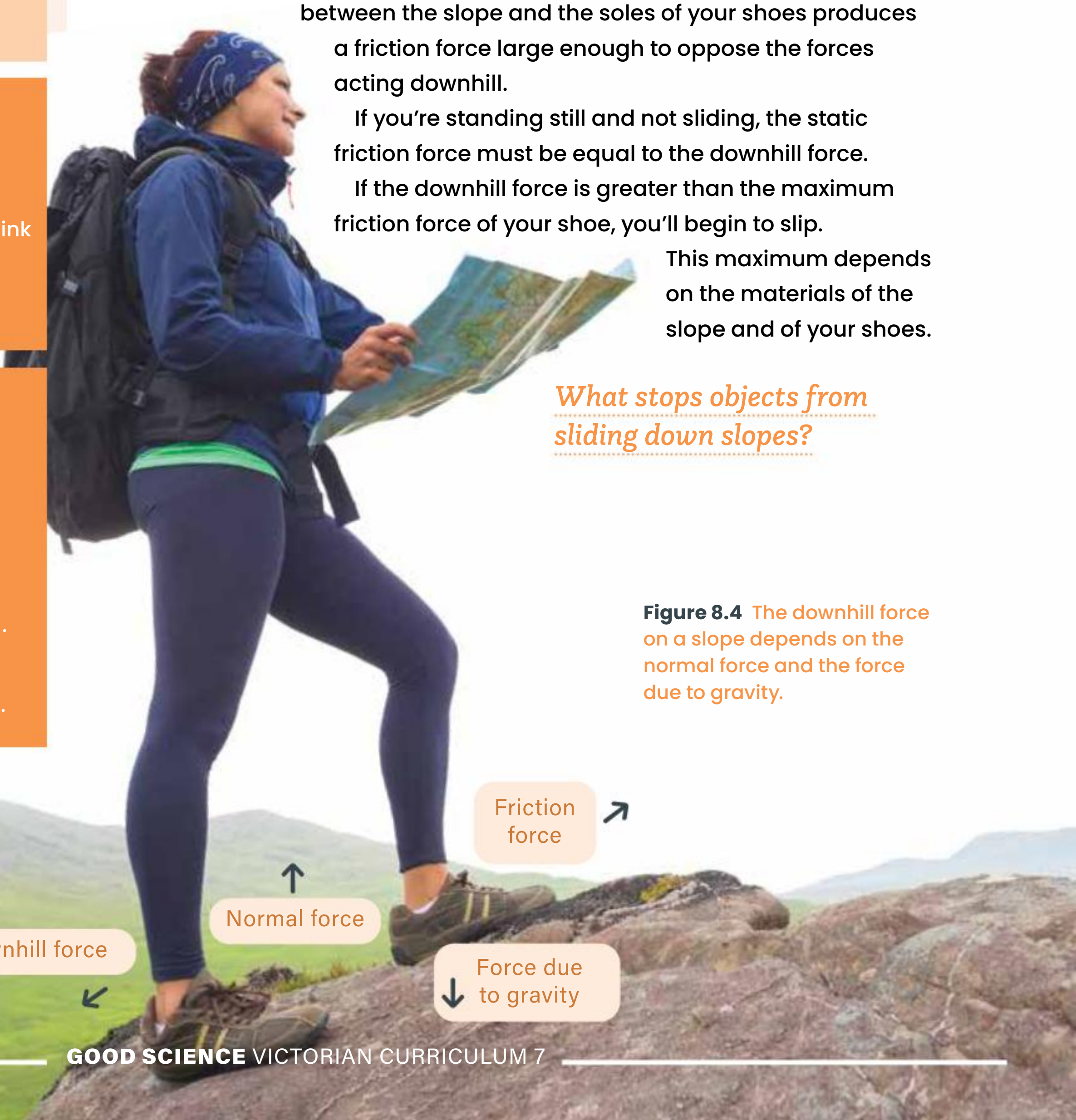


Figure 8.4 The downhill force on a slope depends on the normal force and the force due to gravity.

❷ Kinetic friction makes moving objects slow down or stop

When an object starts to move or slide, that doesn't mean friction has gone away. Whatever the object is moving along or through – whether it's a solid surface, water or just air – a kinetic friction force is acting on it.

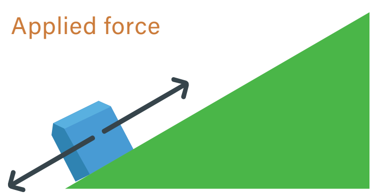
Have you ever ice-skated, or slid across a polished floor in socks? If so, you know that sometimes the kinetic friction forces can be pretty small, and you can keep moving for a long time. But you come to a stop eventually, even without running into something. This is because of the continual action of kinetic friction against your movement.

The kinetic friction acting on a moving object is less than the static friction needed to keep it still. If you were pushing a box up a ramp, getting it moving requires slightly more force than keeping it moving.

Which is larger: static friction force or kinetic friction force?

① **When the box is stationary, static friction force = applied force.**

Applied force

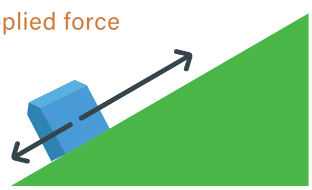


Static friction force

The box won't slide until the applied force is more than the static friction force.

② **When the box is moving, applied force only needs to overcome the kinetic friction force, which is less than the static friction force.**

Applied force



Kinetic friction force

The kinetic friction force depends on the speed of the objects and the size and material of the surfaces in contact.

❸ Heat is a product of friction

Place your hands together, apply a little bit of pressure and then quickly rub them back and forth. It shouldn't take long for a bit of heat to build up. This heat is caused by the friction between the particles of your hands as they rub against each other.

If you have ever seen a video or picture of a space shuttle re-entering Earth's atmosphere, then you've seen how much heat friction can generate at high speeds. This is because of the high number of collisions between particles in the air and the shuttle. The air gets hot enough to form a glowing, fiery cloud around the shuttle.

What causes surfaces to produce heat when they interact?

INVESTIGATION 8.4
Heat from friction

KEY SKILL
Identifying the variables and formulating a hypothesis

▶ *Go to page* ***177***

CHECKPOINT 8.4

1 Explain the difference between friction and static friction.
2 Describe some ways that you could increase the friction of the surface of the floor your feet are on right now.
3 What does friction oppose?
4 What are two types of friction?
5 Which friction force is larger: the maximum static friction force or the kinetic friction force?
6 What type of energy is the main by-product of friction?
7 Outline three factors that affect the kinetic friction force.
8 A lot of machines use special materials and substances to minimise the friction between moving parts. Explain why this is done.

INQUIRY

9 Compare the soles of a pair of sneakers to those of a pair of school shoes. Identify the key differences and explain why they might be different with regard to friction.

SUCCESS CRITERIA

- I can explain the difference between kinetic and static friction forces.
- I can explain why friction can produce heat.

8.5 FACTORS AFFECTING FRICTION

LEARNING INTENTION

At the end of this lesson I will be able to investigate factors that influence the size and effect of frictional forces.

KEY TERMS

coefficient of friction
a value that indicates how easily an object moves when interacting with another material

lubrication
a substance that makes a surface slippery or smooth

LITERACY LINK

VOCABULARY

Lubricate is a verb that can be changed into a noun by removing the *-e* and adding *-ion* to the end, to form *lubrication*. Think of three other verbs that can be changed into nouns in the same way.

NUMERACY LINK

GRAPHING

Different surfaces were tested in an experiment to determine their coefficients of friction. The results were:

- Concrete: 0.95
- Rubber: 0.86
- Wood: 0.54
- Ice: 0.19

Display this data in a bar chart.

Friction is an essential part of movement. It is always there when objects start, stop and continue moving.

The moving parts of machines and vehicles, such as engines and tyres, are carefully designed to minimise or make the best use of this force.

1 Different materials apply different amounts of friction

Why aren't the bottoms of your sports shoes made out of metal? They would be much more durable and easier to clean. It would also be very hard to get traction when running in them – but why?

Rubber, even without shoe patterns, is much less slippery than a sheet of metal. This is because of how the particles of the materials interact. A material's **coefficient of friction** is a measure of how easily an object moves when interacting with another material.

Rubber has a high coefficient of friction, so rubber soles grip the ground strongly and get more traction than other materials. Metals have a low coefficient of friction, so they don't get as much traction on the ground. This makes metals the right materials for ice skates, which need to glide rather than grip.

You can place water, oil or grease between two surfaces to reduce the friction between them. This **lubrication** means that the surfaces are interacting with the slippery material of the lubricant rather than with each other.

Why do different materials generate different friction forces when they interact?

Figure 8.5 Some artificial hip joints have a special layer of carbon to lubricate the surface, so that they move more easily.

❷ Other forces in an interaction can change a friction force

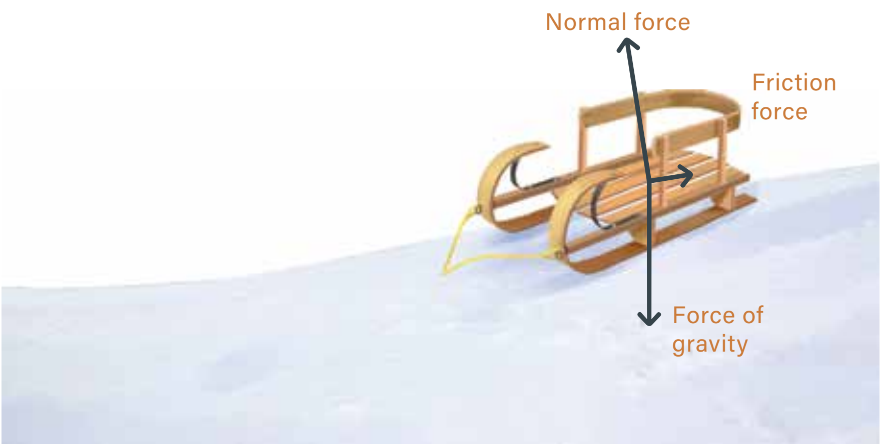
Imagine you're packing equipment into a sled on a ramp. Which do you think would be more likely to slide away: a sled with a little equipment on it, or a fully packed sled?

The fully packed sled would be more likely to slide off. This is because friction is due to the material's coefficient of friction *and* how much the objects are being pushed together by other forces.

At the start of this chapter you learnt about the forces acting on a stationary object. A book on a table is pulled down by gravitational forces, but it stays in place because the normal force applied by the table pushes it back up.

Figure 8.6 shows how the friction force keeps the stationary sled in balance.

Figure 8.6 A sled on a ramp is affected by gravity, the normal force and the friction force. If these forces balance, the sled will not move.



If you loaded the sled with more equipment, the force of gravity and the normal force would increase. This means the friction force would also increase to keep the sled still. But there's an upper limit to the friction force, depending on the materials of the sled and the ramp. Eventually the friction force wouldn't be strong enough to balance the other forces, and the sled would slide away.

Let's look at this another way – how do you use your brakes when riding a bike? When you need to slow down or stop quickly, what do you do with the brakes? You apply a larger force on them. Why? You do this because the larger force applies more friction on your wheels from the brake pads, causing them to slow down more quickly.

How does the normal force affect the friction force?

INVESTIGATION 8.5

Friction of materials

KEY SKILL
Explaining results using scientific knowledge

▶ *Go to page **178***

CHECKPOINT 8.5

1 What two aspects of materials determine the level of friction they have when they interact?

2 What does the coefficient of friction measure?

3 How can you make an object have less friction when interacting with another?

4 Why does more mass generally result in a greater friction force?

5 On bicycles, brakes are generally made out of two rubber pads that apply pressure on the rim of the wheel to slow it down. Why are they made out of rubber?

6 Explain why people need to drive more carefully when it is raining.

7 Why do tyres on cars and bikes have to be replaced occasionally?

RESEARCH

8 Curling is a sport where a large stone is pushed down an icy track. Players use brooms to manipulate the friction between the ice and the stone, speeding it up or slowing it down. Research and describe another activity that involves manipulating friction, and explain how the participants do this.

SUCCESS CRITERIA

- I can describe some causes of differences in friction.

8.6 GRAVITY

LEARNING INTENTION

At the end of this lesson I will be able to understand how Earth's gravity pulls objects towards the centre of Earth.

KEY TERMS

gravitational force
the force that attracts physical objects with mass towards each other

weight
the force of a gravitational field on the mass of a body

LITERACY LINK

SPEAKING

Using your own words, explain to a partner the difference between mass and weight. Then swap roles, with your partner describing the factors that affect the size of a gravitational force.

NUMERACY LINK

MEASUREMENT

Ask your teacher for a scale to accurately measure the mass of your pencil case. Convert this mass to weight by multiplying by 9.807. Make sure to give your answer in newtons (N).

Every object in the universe is made of matter and has mass. This means it creates gravity, which attracts other objects. The larger the object, the stronger its gravitational attraction to other objects. The closer two objects are, the greater the **gravitational force** acting on each one.

Gravitational forces act towards the centre of the object that creates them. That's why, no matter where you are on Earth, all objects fall towards Earth's centre.

1 Gravity is always an attractive force

All objects with mass have a gravitational force that attracts other objects towards it. The size of this force depends on two things: the mass of the object generating it and the distance between the two objects.

Although the size of gravitational force varies, the direction does not. Any force due to gravity will *always* be an attractive force. This means that it pulls objects towards the centre of whatever mass generates the gravitational force.

Whenever you drop something, it falls to the ground, wherever you are in the world, because the attractive force is directed to the centre of Earth's mass. Why Earth? Because it's by far the most massive object that affects us every day. The Sun is much more massive, but is so far away that it has little effect on people and objects compared to Earth's gravity.

Do gravitational forces push, pull or twist objects?

2 Gravitational forces change with distance

The gravitational force between two objects depends partly on their distance from one another. Two rocks floating in space one metre apart will have a greater attraction to each other than if they were 100 metres apart.

On Earth's surface, gravity is constant because the distance from the centre of Earth is about the same everywhere. The gravitational force of Earth always acts towards the centre of the planet. If an object moves further away from Earth, such as spacecraft flying to the International Space Station, the gravitational force from Earth is much smaller.

Figure 8.7 Because these astronauts are far away from Earth, the gravitational force on them is much less.

Imagine a mattress with a bowling ball in the centre, making a hollow. If you place some marbles around the mattress, they'll eventually roll into the hollow made by the bowling ball. They might roll slowly when they're near the edge of the mattress, but they will roll faster as they get closer to the bowling ball, where the slope gets steeper. This is very similar to the way that objects are affected by Earth's gravity.

Why is gravity on Earth constant?

3 An object's weight depends on gravity

You may have heard people talk about **weight** in terms of grams and kilograms, but these are actually units of mass. What's the difference between mass and weight?

An object's mass is the amount of matter it contains. That bowling ball on the mattress contains a specific amount of matter. Putting the ball in different places – on a mattress, up a mountain, on the Moon or floating in space – won't change its mass. Mass is measured in grams and kilograms.

An object's weight is a measurement of the pull of gravity on an object. Changing the gravity acting on an object will change its weight. This is why astronauts on the Moon weigh less and can move around with huge jumps. It's also why astronauts on the International Space Station float weightlessly, even though their bodies still have mass. The metric unit used to measure weight is the newton (N).

Why don't we usually use newtons when talking about weight? It's because there are very few circumstances on Earth where the force of gravity changes. It stays constant, so we just use kilograms instead.

What is the difference between mass and weight?

Figure 8.8 Mass doesn't change, wherever you are, but weight does.

INVESTIGATION 8.6

Measuring gravity

KEY SKILL
Identifying limitations to the method and suggesting improvements

▶ *Go to page **179***

CHECKPOINT 8.6

1 Explain what gravity is, in your own words.
2 What two things affect the amount of gravity something has?
3 Explain the difference between mass and weight.
4 If objects are attracted to one another due to gravitational forces, provide a reason why planets orbit around the Sun rather than crashing together.
5 What metric unit is weight measured in?
6 How can an object's weight change if its mass remains constant?
7 On the Moon, an object weighs 90 N. Objects weigh 6 times more on Earth than they do on the Moon. Calculate the object's weight on Earth.

CONNECTING IDEAS

8 If you were to visit three other planets in our solar system, your weight would be different on each planet. Explain why your weight would change.

SUCCESS CRITERIA

- I can describe gravity, including what causes gravity.
- I can explain the difference between mass and weight.

8.7 UNBALANCED GRAVITATIONAL FORCES

LEARNING INTENTION

At the end of this lesson I will be able to describe everyday situations where gravity acts as an unbalanced force.

KEY TERMS

acceleration
any change in the speed or direction of an object

LITERACY LINK

READING

Read this lesson carefully, highlighting any key points. Then summarise the lesson in a short postcard addressed to your teacher. Make sure you explain what gravity is and how it acts on objects.

NUMERACY LINK

CALCULATION

A falling object will gain speed at a rate of 9.8 metres per second (m/s) for every second it is falling. If the object has been falling for 5 seconds, how fast is it travelling?

When an object speeds up, slows down or changes direction, the forces acting on the object are unbalanced. This means that when all the forces acting on an object are added together, they don't completely cancel each other out.

Falling objects are a perfect example of unbalanced forces, because the strongest force acting on the object is gravity pulling it down. A falling object will fall faster and faster until the forces acting on it become balanced.

1 Gravity is always acting, even on stationary objects

If an object is on the ground, not moving, you might assume that no forces are acting on it. But *every* object on Earth is affected by Earth's gravitational force.

As you saw in lesson 8.1, a stationary object on a surface has a gravitational force pulling it downwards. The downwards force is balanced by the force of the surface pushing up on the object in response to the gravitational force. So the gravitational force acting in a downwards direction is the same size as the force acting in an upwards direction.

If the object was *not* in contact with a surface, the main force acting on it would be the force of gravity pulling it down. The forces acting on the object would therefore be unbalanced and the object would fall.

What are the main balanced forces acting on a stationary object?

2 Gravity causes falling objects to accelerate

Imagine that you place a basketball at the edge of a table and slowly push it off the edge. The forces acting on the basketball are now unbalanced, so the ball will speed up, slow down or change direction. Which of these applies to the ball? It's not slowing down – that would mean it comes to a stop before it hits the ground. It's not changing direction either – it's always heading to the centre of Earth. That means it must be speeding up – this change of speed is called **acceleration**.

In the instant before an object begins falling, it has a speed of zero – it's not moving. Then when an object falls, it moves faster and faster downwards until it reaches a surface. This change of speed is acceleration due to gravity. The gravitational force on the object is not balanced by another force, so the object accelerates in the direction of the gravitational force.

On the surface of Earth, acceleration due to gravity is constant. The speed of a falling object gets faster and faster, but it gets faster and faster at the same rate. That's because the gravitational force acting on it is always the same – the force of Earth's gravitational field.

Why do objects speed up when they fall?

3 Gravity can cause objects to slow down or change direction

Sometimes when an object is forced upwards, gravity can cause the object to slow down or change direction, rather than speed up.

Imagine that you pick up the basketball you dropped, and you take a shot at the basket. What do you expect to happen? First, the ball flies up and out, gaining height while moving closer to the basket. At some point, it stops going up and starts coming down, even though it's still moving away from you, until (hopefully) it swooshes through the basket.

The changes in the ball's flight are all due to unbalanced forces. After you release the ball, you can't put any additional force on it – it's literally out of your hands! When the ball is in flight, the largest force, gravity, will pull the ball back to the ground. It doesn't matter how much force you initially give the ball – after it has left your hands, gravity will immediately start slowing it down and eventually pull it back to Earth.

Gravity is always an attractive force, pulling objects towards the centre of Earth. But it's the overall sum of unbalanced forces that determines how objects move, and when they fall to the ground.

What is an example of gravity causing an object to slow down or change direction?

Figure 8.9 When you shoot a basketball, you need to account for gravity acting on the basketball.

CHECKPOINT 8.7

1 On the surface of Earth, in which direction does a force due to gravity act?

2 How would an object with overall unbalanced forces acting on it move differently to an object with overall balanced forces acting on it?

3 Give an example of an object on Earth that has balanced forces acting on it, and describe how it would move.

4 Give an example of an object on Earth with unbalanced forces acting on it, and describe how it would move.

5 Provide an example where unbalanced forces allow an object to move away from the ground, and an example where unbalanced forces move an object towards the ground.

6 You experience unbalanced forces any time you walk upstairs or drop something. For one of these situations, describe the source of the forces at work.

RESEARCH

7 Drones, rockets, space shuttles and aeroplanes all generate an upward thrust in order to lift off the ground. Choose one example to research and describe the mechanism it uses to move against the force of gravity. Outline any positives and any negatives of your chosen method of lift-off.

SUCCESS CRITERIA

- I can describe how gravity acts on objects when they are moving and when they are stationary.
- I can give examples of everyday situations where gravity acts as an unbalanced force.

8.8 REDUCING THE IMPACT OF FORCES

LEARNING INTENTION

At the end of this lesson I will be able to describe some examples of technological developments that have contributed to finding solutions to reduce the impact of forces in everyday life.

KEY TERMS

deform
to change shape

impact
the effect of a force

LITERACY LINK

SPEAKING

Pretend that your partner is a student in primary school. Explain to them how a crumple zone works. Then swap roles, with your partner explaining how an airbag works.

NUMERACY LINK

GRAPHING

In a particular city, the percentage of new cars sold that had airbags was recorded each year. The results were 18% in 2006, 24% in 2007, 32% in 2008, 45% in 2009 and 60% in 2010. Display this data in a line graph.

Many activities involve forces that can be uncomfortable, painful or even harmful.

Engineers and scientists have developed products that can reduce the **impact** of these forces. These products decrease the forces we feel by absorbing them or spreading them over a larger area.

1 Shoes can reduce forces on your feet

When was the last time you ran barefoot across dirt or gravel? All it takes is landing on a pointy rock to remember to wear footwear next time!

Most footwear has a sole made out of some combination of rubber, foam or other synthetic material. The design of these soles is meant to:

- provide grip, or traction, on a variety of surfaces
- reduce the force of impact from walking or running on a variety of surfaces.

When you step on a pointy rock wearing shoes, the sole briefly changes its shape – it **deforms** around the rock, spreading the contact force over a greater area.

When you're walking or running, the impact of the ground can be evenly spread out across your foot, if your shoes are designed well and fit you properly. Next time you put on your sports shoes, take a look at how they're designed. You should be able to see how the design minimises the forces you feel when running.

How do shoes reduce the force of objects such as rocks?

2 Crumple zones absorb some impact in car accidents

Vehicles let us travel much faster than we can on our own. This increased speed comes with more risk. Why would you rather bump into a wall while walking than when running? It's because the forces you experience are much greater at higher speeds than at lower ones.

If a modern car crashes into another object, its design means it will deform. This reduces the forces on the driver and any passengers. The front and rear of the car each have an area that is designed to deform during a collision. This area is called a crumple zone.

How do crumple zones protect us? Think of it like running into a wall, but this time you're holding a cardboard box in front of you. The box will be crushed first, absorbing some of the impact before it reaches you.

How does a crumple zone reduce the forces of a collision on people in a car?

Figure 8.10 The front and back sections of modern cars act as crumple zones if there is a collision.

❸ Airbags absorb impact for individual car passengers

Almost all modern cars have airbags built into surfaces. Airbags work in a similar way to crumple zones, but instead of providing overall protection for people inside the vehicle, they protect the individual passengers in particular ways.

① **The bag inflates upon collision.**

② **The passenger keeps moving forward until they contact the airbag.**

③ **The airbag slows the passenger's movement and begins to deflate upon contact.**

④ **The passenger slows to a stop, but takes longer to do so because of the airbag. This means they endure a force that is less than if there was no airbag.**

How do airbags reduce the forces of a collision on people in a car?

INVESTIGATION 8.8

Crash cushions

KEY SKILL
Drawing conclusions consistent with evidence

▶ *Go to page* ***180***

CHECKPOINT 8.8

1 Other than grip or traction, what else does a shoe's sole provide to the wearer?

2 Why do cars need specially designed safety features for people?

3 How do the sole of a shoe and the crumple zones and airbags of a car all behave in response to forces?

4 Why are straps on a large backpack often several centimetres wide and padded?

5 Give an example of a safety feature that deforms to reduce the impact of a force that hasn't already been mentioned on this page.

6 Explain why a collision involving a cyclist or motorcyclist can be more hazardous to the riders, compared to a collision with only cars involved.

CHALLENGE

7 Design your own wearable safety equipment for cyclists, highlighting its key safety features and how it would increase the safety of a rider during a collision.

SUCCESS CRITERIA

- I can describe some everyday examples of technology that reduce the impact of forces.

8.9 SIMPLE MACHINES

LEARNING INTENTION

At the end of this lesson I will be able to describe some simple machines, such as levers, pulleys, gears and inclined planes.

KEY TERMS

fulcrum
the point on which a lever turns when moving an object

lever
a bar acted upon at different points by two forces

pulley
a wheel with a grooved rim for carrying a cable

LITERACY LINK

LISTENING

Find a diagram online of a Rube Goldberg machine. Sit back-to-back with a partner and describe the machine, while your partner attempts to recreate it from your description. Then swap roles and try to recreate a different Rube Goldberg machine described by your partner.

NUMERACY LINK

CALCULATION

If you double the length of a lever, the force required to lift something halves. If a lever required 1 N of force to lift a load, how much force would be required if the lever was quadrupled in length?

Early machines built by humans were designed to make work easier. They are simple machines such as **levers**, **pulleys** and inclined planes.

Simple machines make work easier by increasing the size of the force on an object, or by decreasing the amount of force needed to move an object.

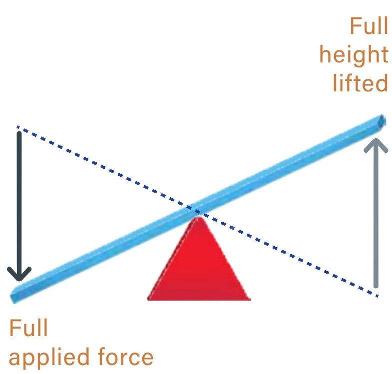
1 Levers increase the size of a force

Levers come in a range of shapes and sizes, but the essential parts are always the same: a long arm or beam that rests or turns around a **fulcrum**.

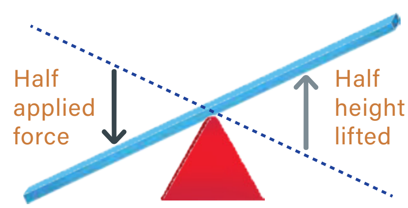
When you were younger, you probably played on a seesaw, which is a lever resting on a fulcrum. You might have noticed that the closer to the centre/fulcrum you sat, the easier it was for someone on the other end to move you up and down. This makes levers helpful machines – the closer to the fulcrum that an object is, the less force is needed to move it.

When you were on the seesaw, did you also notice that when you sat near the centre, the height you moved up and down was less? This is the other aspect of a lever – the closer an object is to the fulcrum, the less distance it can be moved.

1 If you sit on the end of a seesaw, you need a greater mass or force on the other end to lift you all the way up.



2 If you sit halfway towards the fulcrum, you only need half the applied force, but you are only lifted half as high as before.



The height that a lever can lift an object depends on the length of the arms on either side of the fulcrum, and on the applied force. If you use a claw hammer to pull out a nail, the handle moves a lot further down than the nail moves up, but less force is needed to pull out the nail.

When using a lever, what affects the height an object is lifted and the force needed?

❷ Pulleys redirect a force being applied

A pulley is another simple machine. It's a wheel on an axle (which allows the wheel to rotate), with a rope or wire resting on the rim of the wheel so it can be pulled back and forth.

Similar to levers, pulleys work by reducing the force required to lift an object. When they do, they also reduce the height that an object is lifted.

① **When using one pulley, the force to lift an object is equal to the force due to gravity on that object. For every metre you move when pulling the object up, it moves up by a metre.**

② **When using two pulleys, the force to lift an object is half the amount of force due to gravity on that object. For every metre you move when pulling the object up, it only moves up by half a metre.**

In the same way as a lever, and like the seesaw opposite, while the force required to lift an object using two pulleys is halved, the distance it moves is also halved. The more pulleys you use, the less force you need but the less distance the object will move. For example, three pulleys only require a third of the original force, but only move the object a third of the distance.

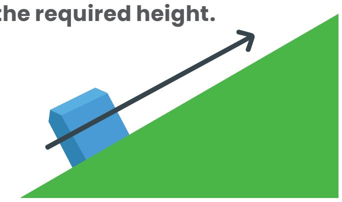
What percentage of force could lift an object with five pulleys, compared to one pulley?

❸ Inclined planes change the direction of force

Rather than lift an object directly up, you could slide it up a ramp, also known as an inclined plane. When you do this, the force needed to move the object up the ramp is much less than if you pick the object straight up. This is because the force you are working against isn't the full force going straight down, but a reduced force at an angle along the surface of the inclined plane.

How does a ramp help walkers if it has to be longer?

① **More force is required for steeper ramps, but there is less distance to get to the required height.**



② **Less force is required for shallower ramps, but there is more distance to get to the required height.**

INVESTIGATION 8.9A

Investigating levers

KEY SKILL
Identifying limitations to the method and suggesting improvements

▶ *Go to page **182***

INVESTIGATION 8.9B

Investigating pulleys

KEY SKILL
Representing data

▶ *Go to page **183***

CHECKPOINT 8.9

1 What is a simple machine?

2 What are simple machines designed to do?

3 Give three examples of simple machines, and identify a real-world situation where each one is used.

4 An object sits on a lever, a third of the way along the arm from the fulcrum. A force applied to the other side of the lever raises the object 10 cm. How high would the object be raised if it were placed at the end of the arm?

5 If you can only generate a quarter of the force required to lift an object, what is the fewest number of pulleys you would need to lift it?

EXTENSION

6 A screw can be described as 'an inclined plane wrapped around a nail'. Explain how this means that a screw is easier than a nail to put into a piece of wood, and why it takes longer to insert than a nail.

SUCCESS CRITERIA

- I can explain what a simple machine is and outline the benefits of them.
- I can give at least four examples of simple machines.

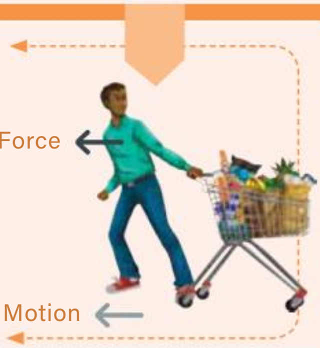
VISUAL SUMMARY

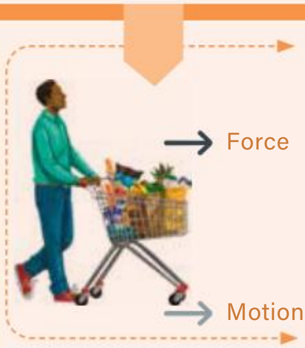
Forces are the result of objects interacting with each other or with a field.

A stationary object is affected by balanced forces.

Adding or removing a force can unbalance an object.

Every force acts in a specific direction and has a size or magnitude.





We can use simple machines to change how a force is applied.

- **Levers increase the size of a force.**
- **Pulleys redirect the force being applied.**
- **Inclines change the direction of a force.**

Engineers and scientists have developed products that can reduce the impact of forces, such as crumple zones in cars or the treads of shoes.

Friction is a force that can be described as the resistance of motion when one object rubs against another.

★ FINAL CHALLENGE ★

1. Describe what a force is in your own words and identify the three types of forces.
2. All forces have two properties or characteristics. What are they?
3. Define *friction* in your own words.
4. Explain what gravity is and list the two factors that affect its strength.

Level 1 ★☆☆☆☆☆ 50xp

LEVEL UP!

5. Examine surfaces that are designed to either increase or decrease friction; for example, the sole of a running shoe, a tyre tread or the hinge on a door. What can you observe about the differences in these surfaces?
6. Make a list of ways you use simple machines such as pulleys or ramps in your everyday activities to make them easier.

Level 2 ★★☆☆☆☆ 100xp

LEVEL UP!

7. From the list below, identify the examples of unbalanced forces.
   - A phone sitting on a table
   - A bike picking up speed as it rolls down a hill
   - A car braking
   - A duck sitting still on the surface of a dam
   - A ball bouncing off a wall
8. Compare the motion of balanced forces compared to unbalanced forces when acting on the same object.
9. Explain how mass and weight are different and give an example.

Level 3 ★★★☆☆☆ 150xp

LEVEL UP!

10. In two minutes, brainstorm as many ways as you can to use a simple machine to lift a heavy crate of books from the ground floor to the first floor of your school.
    a. Which simple machine from your list would make the task easiest for you?
    b. Draw a plan of your simple machine that you could share with an engineer.
11. From personal experience, evaluate how well different types of shoes reduce the force on your feet when running.

Level 4 ★★★★☆☆ 200xp

LEVEL UP!

12. Write a short paragraph about what your life would be like if you could turn friction on and off.
13. Create a sketch of a shoe, helmet or car that would be perfect at reducing the impact of forces. Label features on your sketch that demonstrate this.

Level 5 ★★★★★★ 300xp

LEVEL UP!

INVESTIGATIONS AND KEY SKILLS

BIOLOGICAL SCIENCES

2.1 Observing and classifying
2.2 Supermarket classification key
2.4 Investigating features of marine animals
2.6 Growing mould
3.1 Observing ecosystems
3.2 Modelling a pond ecosystem
3.4 Yeast as a decomposer

CHEMICAL SCIENCES

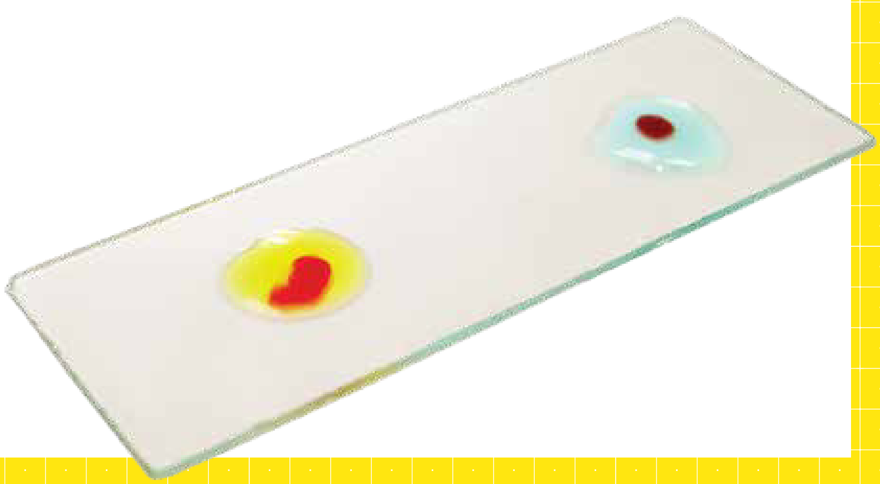
4.1 Compressing liquids and gases
4.2 Heating materials
4.3 Expanding gases
4.4 Exploring melting points
4.5 Exploring density
5.2 The Tyndall effect
5.4 Purifying muddy water
5.5 Froth flotation
5.6A Evaporating a solution
5.6B Growing crystals
5.6C Distillation (Teacher demonstration)
5.7A Separating colours using paper chromatography
5.7B Separating two immiscible liquids (Teacher demonstration)

EARTH AND SPACE SCIENCES

6.1 Modelling day and night
6.2 Modelling the seasons
6.3 Modelling a solar and lunar eclipse
6.5 Making a simple telescope
7.1 Classifying resources used in a classroom
7.2 Investigating soil erosion
7.3A Designing a windmill to lift a weight
7.3B Making bioplastic
7.4 The sustainability game
7.5 Mining for chocolate chips

PHYSICAL SCIENCES

8.1 Push, pull or twist
8.2 Blowball
8.4 Heat from friction
8.5 Friction of materials
8.6 Measuring gravity
8.8 Crash cushions
8.9A Investigating levers
8.9B Investigating pulleys



KEY SKILLS

Writing a research question	Investigation 2.1 Investigation 4.5 Investigation 5.7A Investigation 6.1 Investigation 6.5
Identifying and managing relevant risks	Investigation 2.2 Investigation 3.1 Investigation 5.5 Investigation 7.3B Investigation 8.1 Investigation 8.2
Identifying the independent variable	Investigation 2.4
Identifying the independent and dependent variables	Investigation 2.6
Identifying limitations to the method and suggesting improvements	Investigation 3.2 Investigation 5.6A Investigation 7.5 Investigation 8.6 Investigation 8.9A
Identifying the independent, dependent and controlled variables	Investigation 3.4
Explaining results using scientific knowledge	Investigation 4.1 Investigation 5.4 Investigation 8.5
Identifying the variables and formulating a hypothesis	Investigation 4.2 Investigation 5.2 Investigation 5.6B Investigation 7.2 Investigation 8.4
Evaluating results for reliability and validity	Investigation 4.3 Investigation 6.2
Representing data	Investigation 4.4 Investigation 7.1 Investigation 7.4 Investigation 8.9B
Referencing sources of information	Investigation 6.3
Representing and recording data using a table	Investigation 7.3A
Drawing conclusions consistent with evidence	Investigation 8.8

Investigation **2.1**

Observing and classifying

120 min

Level 1

KEY SKILL

WRITING A RESEARCH QUESTION

Turn the aim of this investigation into a question that asks what you are trying to discover. This is called a research question.

Hint #1: *Make sure that your research question has a question mark at the end.*

Hint #2: *Your research question can also be used as a title for an experiment report.*

AIM

To investigate different ways of classifying living things

MATERIALS

- notebook
- camera
- paper

METHOD

1 Visit an area near your school or home where there are animals and plants. This could be a natural space, such as a beach or area of bushland, or a built space, such as a park.

2 Record at least 10 different plants that you find in the area. Photograph each one if possible.

3 Record at least 10 different animals that you find in the area. Photograph each one if possible. If the animals belong to other people, such as pets being walked, ask permission before taking the photo.

4 In class, print out each of your photos and label it with the name of the organism. Alternatively, write the name of each animal or plant you recorded on an individual slip of paper.

5 Sort all of the organisms you found into 3–5 different groups. The organisms in each group should have similar features.

QUESTIONS

1 What features did you use to sort the organisms?

2 Were there any organisms that could have fitted into two or more groups? If so, how could you have changed the groups so that each organism only fitted into one group?

3 Compare your sorting groups to those of other students. How did they sort the organisms differently?

4 Why do you think it's important to be able to classify things into groups?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **2.2**

Supermarket classification key

120 min

Level 1

KEY SKILL
IDENTIFYING AND MANAGING RELEVANT RISKS

Brainstorm with a partner to identify three possible hazards or risks that may be involved in this investigation. Suggest one way that each hazard or risk could be reduced.

Hint #1: *If you weren't able to visit a supermarket for the purposes of this activity, just imagine that you did!*

AIM

To investigate the design and use of classification keys

MATERIALS

- notebook

METHOD

1. Working in pairs, design a classification system for items you would find in a supermarket. Choose a particular set of items – such as fruits and vegetables, dairy, hygiene products, snacks – rather than try to accommodate every item. Your key should have three or four levels of classification.
2. Visit a local supermarket (or look online) and apply your key to at least 20 different items. Record where each item falls in your key.

QUESTIONS

1. Explain how you designed your key.
2. Did you find any items that should have fitted the key but didn't? If so, suggest a way to adjust the key so that the item would have fitted.
3. Compare your key to those of other students. How did they design theirs differently?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **2.4**

Investigating features of marine animals

45 min Level 3

KEY SKILL

IDENTIFYING THE INDEPENDENT VARIABLE

The independent variable is the one thing that you purposefully want to change in an investigation. If more than one thing is changed, then the investigation will no longer be a fair test.

Hint #1: *In this investigation, you are using the same equipment to dissect each organism and you are investigating the same thing (their physical structures), but you are comparing three different things. What are you comparing? That will be your independent variable.*

AIM

To investigate the physical and skeletal features of different marine animals

MATERIALS

- 1 whole fish
- 1 large, whole prawn
- 1 squid
- hand lens
- dissecting board
- dissecting kit
- disposable gloves

METHOD

1. Place the fish, squid and prawn on separate dissection boards.
2. In groups of three or four, observe the external features of the fish and record your observations.
3. Open the fish's mouth and look inside, using the hand lens to magnify the details. While looking in the mouth, use a dissection probe to open the gill covers on the head. Record your observations.
4. Carefully cut open the fish lengthwise so that you can see its skeleton. Record your observations.
5. Use a probe to open the prawn's mouth, and look inside through the hand lens. Try to identify whether the prawn has gills and, if so, where they are located. Record your observations.
6. Feel the outside of the prawn, then peel it and cut it in half. Record your observations.
7. Use a probe to open the squid's mouth and look inside through the hand lens. Try to identify whether the squid has gills and, if so, where they are located. Record your observations.
8. Feel the outside of the squid, then peel it and cut it in half. Record your observations.

QUESTIONS

1. Which of the three marine animals are vertebrates (with skeletons) and which are invertebrates (without skeletons)?
2. Draw a series of diagrams showing the external and internal features of each of the specimens.
3. What differences are there between the gill structures of the three animals?
4. How would you design a key to classify marine animals based on their skeletons and gill structures?
5. What internal physical features does each specimen contain that are unique or similar to each other?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

WEAR EYE AND HAND PROTECTION. TAKE CAUTION WITH CUTTING IMPLEMENTS. DISPOSE OF ALL MATERIALS AS DIRECTED BY YOUR TEACHER. WASH YOUR HANDS AFTERWARDS.

Investigation **2.6**

Growing mould

30 min | Level 1

KEY SKILL
IDENTIFYING THE INDEPENDENT AND DEPENDENT VARIABLES

The independent variable is the one thing that you purposefully want to change in an investigation. If more than one thing is changed, then the investigation will no longer be a fair test. The dependent variable is what you will be measuring.

Hint #1: *The dependent variable is what will be changed by the independent variable.*

AIM

To investigate the conditions in which mould and fungus grow

MATERIALS

- 4 pieces of bread
- assorted kitchen scraps (e.g. fruit peels, carrot shavings, coffee grounds)
- disposable gloves
- water
- plastic sandwich bags
- paper plates
- hand lens

METHOD

1. Splash the pieces of bread with water so that they are damp. Place each piece in an individual plastic bag, but don't seal the bags.
2. Place two bags in an area where they will receive direct sunlight. Place the other two somewhere that has about the same temperature but that doesn't receive direct sunlight.
3. Place the food scraps on two paper plates. Put one plate next to the bread specimen in sunlight, and the other plate next to the bread in the darker spot.
4. Leave the bread and scraps alone for 2–4 days, then observe any spots of mould growing. Record your observations in your notebook, and sketch any stalks that are growing.
5. Wait a few more days until there is a large patch of mould on the bread and scraps. Observe the large patch using the hand lens and record your observations.

QUESTIONS

1. Which set of bread had the most growth on it – the one in the light or the one in the dark? Why do you think this is?
2. Did some kitchen scraps have more mould than others? Which types of scraps grew more mould?
3. What kinds of structures and growths did you observe through the hand lens?

DISCUSSION

1. What was the relationship between your independent and dependent variables? How did they affect each other?
2. Why do you think it's important to have only one independent variable?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

TAKE CAUTION WHEN WORKING WITH MOULD TO AVOID SPREAD OR CROSS CONTAMINATION. DISPOSE OF IT AS DIRECTED BY YOUR TEACHER. WASH YOUR HANDS AFTER THIS INVESTIGATION.

NEVER CONSUME ANYTHING IN THE SCIENCE LABORATORY.

Investigation **3.1**

Observing ecosystems

120 min | Level 2

KEY SKILL

IDENTIFYING AND MANAGING RELEVANT RISKS

Brainstorm with a partner to identify three possible hazards or risks that may be involved in this investigation. Suggest one way that each hazard or risk could be reduced.

AIM

To investigate activity in a local ecosystem

MATERIALS

- pen and paper
- gardening gloves
- camera (optional)

METHOD

1. Find a small ecosystem (e.g. tree, pond, rose bush) in or near your school.
2. Record all the different plants in the ecosystem.
3. Look for small organisms living on the plants. Look on the underside of leaves, in the branches and grasses. Record the names of any organisms you find. Photograph your findings if possible.
4. Using gardening gloves, carefully turn over fallen leaves, and look under rocks and soil. Record any organisms that you observe. Photograph your findings if possible.
5. Sit quietly and record the different organisms you can see and hear in this ecosystem. Some organisms may move in and out of the ecosystem or may be nocturnal. Photograph your findings if possible.

BEWARE OF DANGEROUS ORGANISMS SUCH AS SPIDERS AND STINGING PLANTS IN YOUR ECOSYSTEM. MAKE SURE YOU WEAR GARDENING GLOVES.

QUESTIONS

1. Identify one producer and one consumer you found.
2. What is another name for a secondary consumer? Did you find any secondary consumers?
3. Did you see any evidence that decomposers were present in your ecosystem? Explain your answer.
4. Draw two food chains using the information you gathered.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **3.2**

Modelling a pond ecosystem

30 min

Level 1

KEY SKILL

IDENTIFYING LIMITATIONS TO THE METHOD AND SUGGESTING IMPROVEMENTS

When you write a formal investigation report there is always a discussion section that includes a discussion of potential errors. These errors are limitations (or problems) with the method. For each error, you list a way to control it (your suggested improvement).

Hint #1: *Brainstorm three potential errors that might have occurred in this investigation that could have affected or changed the results you collected (for example, if through human error something was not measured accurately). Now work with a partner to suggest ways each error could be controlled.*

AIM

To investigate a pond ecosystem using a model

MATERIALS

- clear glass jar with lid
- sand
- pond water containing water fleas, water snails and microscopic organisms
- *Myriophyllum* (water weed)

METHOD

1. Add sand to your jar to form a 2–3 cm layer.
2. Slowly fill your glass jar with pond water until it is almost full. Make sure you have some water fleas and a snail in your jar.
3. Add 2 or 3 pieces of the plant to your jar.
4. Place the lid on your jar and seal it. Weigh the jar and record the initial mass in your notebook.
5. Place your jar near a window, but out of direct sunlight.
6. Every few days for 2 weeks, make observations about your ecosystem and re-weigh the jar to record the mass. Record your observations.
7. Draw a diagram of your model ecosystem.

QUESTIONS

1. What changes did you observe in your ecosystem over the 2 weeks?
2. Where do the different organisms gain their energy to survive in the jar?
3. Why was there a change in mass? Suggest a reason for this.
4. Draw one food chain for this ecosystem.

CONCLUSION

Copy and complete:

‘The results show that: (*respond to the aim*)’.

Investigation **3.4**

Yeast as a decomposer

30 min

Level 1

KEY SKILL

IDENTIFYING THE INDEPENDENT, DEPENDENT AND CONTROLLED VARIABLES

The independent variable is the one thing that you purposefully want to change in an investigation.
The dependent variable is what you will be measuring.
The controlled variables are all the things you need to keep the same throughout the investigation.
Hint #1: *Brainstorm with a partner three things that will be or were kept the same in your investigation, these will be the controlled variables.*

AIM

To investigate the action of yeast as a decomposer

MATERIALS

- pieces of banana, cut to 1 cm thickness
- sachet of active yeast
- 4 Petri dishes with lids
- water
- tweezers
- marker pen
- hand lens

METHOD

1. Using tweezers, place a piece of banana in each Petri dish. Add 1 mL of water to each dish.
2. Place the lids on two of the Petri dishes. Label one of these as 'no yeast, cold' and the other as 'no yeast, warm'.
3. Open the yeast sachet and sprinkle equal amounts of yeast evenly over the banana in the remaining two Petri dishes.
4. Place the lids on these two Petri dishes. Label one as 'yeast, cold' and the other as 'yeast, warm'.
5. Place the two Petri dishes labelled 'warm' in a warm place chosen by your teacher, and the two labelled 'cold' in a cold place chosen by your teacher.
6. Make and record a prediction about what will happen to the contents of each Petri dish over the next five lessons.
7. Record observations for each Petri dish over the next five lessons. Use a hand lens to look at the Petri dishes containing yeast.

QUESTIONS

1. Does decomposition happen faster in warm or cold conditions?
2. Where is the yeast getting oxygen and food from?
3. Some people have compost bins in their back yards to return nutrients into their vegetable gardens. How do compost bins prepare the nutrients? Why is this a benefit to a vegetable garden?
4. Often compost bins are black, have holes on the sides and contain earthworms. How do each of these features help decomposers?
5. Why was it important to use tweezers and keep the lid sealed during the investigation?

DISCUSSION

1. What was the relationship between the independent and dependent variables?
2. You identified three controlled variables. How many more can you think of now that you have completed the investigation?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **4.1**

Compressing liquids and gases

15 min

Level 1

KEY SKILL

EXPLAINING RESULTS USING SCIENTIFIC KNOWLEDGE

When you write a formal investigation report there is always a discussion section that includes your analysis and explanation of the data you collected. This is where you get to explain your results by linking them to what you already knew about the science of what you are studying.

Hint #1: *You can use the following sentence stem to write about your results: 'My data shows … and this makes sense because ….'*

AIM

To investigate the compressibility of liquids and gases

MATERIALS

- plastic syringe
- water
- small beaker

METHOD

1. Draw some water into the syringe so that it is about half full.
2. Hold your finger over the nozzle so that water cannot come out, then try to push in the plunger. Are you able to compress the water? Record your observations.
3. Empty the water from the syringe and pull the plunger back so that the syringe is half full of air.
4. Again, holding your finger over the nozzle, try to push in the plunger. Are you able to compress the air? Record your observations.

QUESTIONS

1. What do the results tell you about the compressibility of liquids?
2. What do the results tell you about the compressibility of gases?
3. Use the particle model to explain your results.
4. How could you investigate the compressibility of solids using an ice cube?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **4.2**

Heating materials

30 min · Level 1 · ⚠

KEY SKILL

IDENTIFYING THE VARIABLES AND FORMULATING A HYPOTHESIS

Before you formulate a hypothesis, identify your independent, dependent and controlled variables.
The independent variable is the one thing that you purposefully want to change in an investigation.
The dependent variable is what you will be measuring.
The controlled variables are all the things you need to keep the same throughout the investigation.
To formulate your hypothesis use the following sentence stem: It can be hypothesised that if *(something to do with your independent variable)*, then *(something to do with your dependent variable)*.
Hint #1: *If you get stuck, use the prompts in Lesson 1.4 to help you.*

AIM

To investigate how quickly different materials can heat up

MATERIALS

- 3 large spoons (one metal, one wooden, one plastic)
- wax (e.g. from a candle) or butter
- water
- 500 mL beaker
- Bunsen burner, heatproof mat, tripod, gauze mat and matches OR kettle

METHOD

1. Scoop a small amount of wax on to each spoon.
2. If using a kettle, half fill the beaker with hot water from the kettle. Place all three spoons into the water, handle side down.
3. If using a Bunsen burner, set it up on the heatproof mat, with the tripod and gauze mat. Half fill the beaker with water, then place all three spoons into the water, handle side down. Ignite the burner and heat the water.
4. Observe how quickly the wax melts on each spoon. Record your observations.

DISCUSSION

1. Which material was able to conduct heat the best?
2. What evidence led you to this answer?
3. If you were to design a cooking utensil that ensured heat was not transferred to the person using it, what materials would you consider best to use and why?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

⚠ **AN OPEN FLAME IS A HAZARD. TAKE CAUTION. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.**

Investigation **4.3**

Expanding gases

30 min

Level 2

KEY SKILL

EVALUATING RESULTS FOR RELIABILITY AND VALIDITY

In order for our investigations to be considered scientific, we need to check that our results were reliable and valid. It sounds like a difficult thing to check but it's actually simple. If your results are reliable it means that if you repeated your test or investigation you would get the same results. If your results are valid it means that you were able to measure what was intended to be measured.

Hint #1: *If someone makes a human error (for example, dropping something, adding too much or too little of a substance, spilling something or using different equipment each time) then the results are probably not valid or reliable.*

AIM

To investigate how the volume of a gas changes when heated

MATERIALS

- balloon
- conical flask
- 2 beakers (large enough to fit the conical flask inside)
- ice water
- hot water from tap
- string
- ruler

METHOD

1. Inflate and deflate the balloon a couple of times to stretch it out.
2. Blow up the balloon so that it has a diameter of about 10 cm. Place the balloon over the neck of the conical flask.
3. Wrap the string around the widest part of the balloon and mark the string where the two parts touch. Unwrap and measure the string with a ruler. Record the circumference of the balloon at room temperature.
4. Half fill one of the beakers with ice water and place the conical flask inside the beaker. Let it stand for 5 minutes.
5. Use the string to measure the circumference of the balloon after the air has been cooled by the water and record the measurement.
6. Transfer the conical flask to the beaker containing hot water. Let it stand for 5 minutes.
7. Use the string to measure the circumference of the balloon after the air has been warmed by the water, and record the measurement.

QUESTIONS

1. What effect did heating have on the circumference of the balloon?
2. What would you expect to happen to the circumference of the balloon if the water was heated further?

DISCUSSION

1. Use the particle model to explain why this happened.
2. How could you improve the reliability of your results?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **4.4**

Exploring melting points

60 min | Level 2

KEY SKILL

REPRESENTING DATA

When you write a formal investigation report there is always a results section that includes your data, often as a table, chart or image. Choosing how to represent your data so that it can be clearly communicated to someone reading your investigation report is an important skill. In this investigation, after you have collected and recorded your data in the results table, turn your table into a chart or graph.

Hint #1: *There are many ways to visualise your data, such as bar charts, line graphs and pie charts. Make sure you choose the best one for your data set.*

AIM

To investigate the melting and boiling points of different household substances

MATERIALS

- household liquids (e.g. water, vinegar, dishwashing liquid, cooking oil, juice, milk, candle wax, soft drink)
- ice-cube tray (to make ice cubes small enough to fit inside the test tubes)
- test tubes (one for each substance, large enough to fit ice cubes)
- thermometer
- large beaker
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- matches

RESULTS

TABLE I1.4

Sample	Melting point	Boiling point

OPEN FLAMES, HOT LIQUID, WAX AND STEAM ARE HAZARDS. TAKE CAUTION. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.

METHOD

1. The day before the investigation, pour each substance into a separate ice cube mould. Place the trays in a freezer overnight.
2. Collect your solid, frozen samples.
3. Copy the results table into your notebook, adding a title and rows as needed.
4. Set up the Bunsen burner, tripod and gauze mat.
5. Half fill a large beaker with water. This will act as your water bath for the test tube samples.
6. Remove one of the samples from the ice-cube tray and place it into a test tube. Place the test tube into a large beaker. Continue to place test tubes into the beaker if space permits.
7. Set up the apparatus.
8. Light the Bunsen burner beneath the beaker and heat the sample until it has completely melted. Use the thermometer to measure the melting point of the sample and record in your table.
9. If time permits, continue to heat the sample until it begins to boil. If you are boiling several samples together, make sure that there is some space between the test tubes.
10. Use the thermometer to measure the boiling point of the sample and record in your table.
11. Repeat steps 6–10 for the rest of your samples.

QUESTIONS

1. Which substances had low melting points?
2. Which substances had high melting points?
3. Which substances had low boiling points?
4. Which substances had high boiling points?
5. Consider the classroom you are currently in. Can you identify something in the room that would have a very high melting point? Justify your answer.

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **4.5**

Exploring density

30 min

Level 2

KEY SKILL

WRITING A RESEARCH QUESTION

Turn the aim of this investigation into a question that asks what you are trying to discover. This is called a research question.

Hint #1: *Make sure that your research question has a question mark at the end.*

Hint #2: *Your research question can also be used as a title for an experiment report.*

AIM

To investigate the relative densities of some household liquids and objects

MATERIALS

- honey
- corn syrup
- maple syrup
- dishwashing liquid
- water with food dye (to make it easier to see)
- vegetable oil
- isopropyl alcohol
- plastic building brick (e.g. Lego)
- die
- coin
- ping-pong ball
- measuring jug
- 1 L measuring cylinder (or any tall glass container)

METHOD

1. Use the measuring jug to measure out roughly equal amounts of each liquid to be poured into the measuring cylinder. Depending on the size of your cylinder or container, you may choose to use 100 mL of each liquid.
2. Pour the honey into the cylinder, followed by the corn syrup, maple syrup and dishwashing liquid. Carefully pour the water down the inside of the cylinder to ensure it doesn't splash. Add the vegetable oil and isopropyl alcohol in the same way. You should have a multi-layered cylinder of liquids, with the densest at the bottom.
3. Gently drop the plastic building brick into the measuring cylinder. It will sink through the liquids that are less dense than it, and float on any that are denser.
4. Predict where you think the coin, die and ping-pong ball will stop sinking in the cylinder. Add them, one by one, to check if you are correct.

QUESTIONS

1. Which object had the highest density? Suggest how you could tell.
2. What was the role of the liquids in this investigation?
3. Can you think of an object that could float on top of all the liquids?
4. Rank the liquids from most to least dense.

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

ISOPROPYL ALCOHOL IS FLAMMABLE. KEEP IT AWAY FROM SOURCES OF SPARKS AND FLAMES.

Investigation **5.2**

The Tyndall effect

KEY SKILL

IDENTIFYING THE VARIABLES AND FORMULATING A HYPOTHESIS

Before you formulate a hypothesis, identify your independent, dependent and controlled variables.
The independent variable is the one thing that you purposefully want to change in an investigation.
The dependent variable is what you will be measuring.
The controlled variables are all the things you need to keep the same throughout the investigation.
To formulate your hypothesis use the following sentence stem: It can be hypothesised that if *(something to do with your independent variable)*, then *(something to do with your dependent variable)*.
Hint #1: *If you get stuck, use the prompts in Lesson 1.4 to help you.*

AIM

To investigate three types of mixtures: solutions, suspensions and colloids

MATERIALS

- 8 prepared mixtures of pure water and the following substances:
  1. milk
  2. soil
  3. soluble starch
  4. food colouring
  5. salt
  6. sugar
  7. flour
  8. cooking oil
- 8 test tubes
- test-tube rack
- 10 mL measuring cylinder
- marker pen
- torch
- labelling tape
- stirring rod

RESULTS **TABLE I5.2**

Mixture	Brief description	Separates upon standing?	Exhibits Tyndall effect?	Classification
Milk				
Soil				
Starch				
Food colouring				
Salt				
Sugar				
Flour				
Cooking oil				

45 min

Level 2

METHOD

1 Copy the results table into your notebook, adding a title and rows as needed.
2 Using a marker, number the test tubes 1–8.
3 Measure 10 mL of each of the mixtures, using a measuring cylinder, and transfer into the appropriate test tubes.
4 Observe the mixtures. Record a description of each in your table.
5 After stirring, record which mixtures separate upon standing.
6 Make the room as dark as possible, or use an under-bench cupboard. Shine a torch on each mixture that does not separate upon standing. In your table, describe if the mixture exhibits the Tyndall effect – if light is scattered by the fine particles.
7 Classify each mixture as a solution, suspension or colloid.

QUESTIONS

1 The effect of scattering particles by light is known as the ____________ ______________.
2 a If a mixture is left to stand and then separates out, it is a ___________.
  b If a mixture does not separate when left standing and the Tyndall effect is not seen, it is a ______________.
  c If a mixture does not separate when left standing and exhibits the Tyndall effect, it is a ________________.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **5.4**

Purifying muddy water

KEY SKILL

EXPLAINING RESULTS USING SCIENTIFIC KNOWLEDGE

When you write a formal investigation report there is always a discussion section that includes your analysis and explanation of the data you collected. This is where you get to explain your results by linking them to what you already knew about the science of what you are studying.

Hint #1: *You can use the following sentence stem to write about your results: 'My data shows ... and this makes sense because ...'.*

AIM

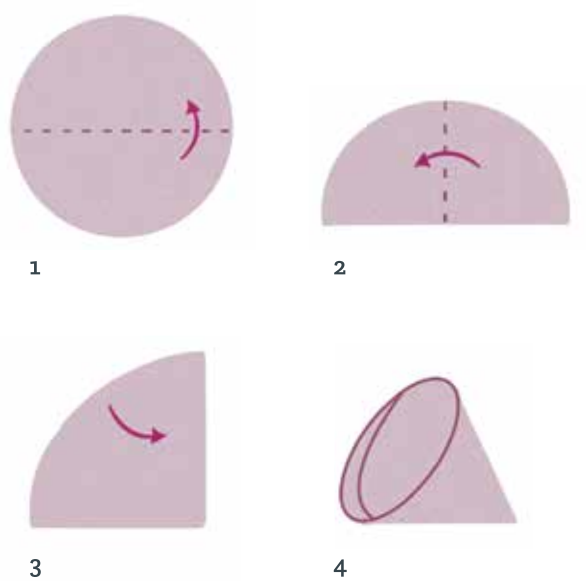
To purify muddy water using decanting and filtration

MATERIALS

- soil and sand
- conical flask
- 250 mL beaker
- filter funnel
- filter paper
- glass stirring rod
- teaspoon
- wash bottle

METHOD

1. Copy the results flowchart into your notebook.
2. Half fill the beaker with water.
3. Add 1 teaspoon of soil into the beaker and stir until a suspension forms.
4. Add 1 teaspoon of sand into the beaker and allow the sand to settle to the bottom.
5. Fold the filter paper as shown and place it in the funnel.
6. Set up the filtration apparatus as shown.
7. Carefully pour the mixture from the beaker into the conical flask by decanting, without disturbing the sand on the bottom of the beaker.
8. Record your observations in the flowchart.



30 min

Level 1

RESULTS

Mixture:

↓

Process: decanting → *Substance separated:*

↓

Process: filtration → *Substance separated:*

↓

Substance separated:

QUESTIONS

1 Explain the terms *suspension* and *sedimentation* with reference to the mud and sand used in the investigation.

2 Explain how decanting was used to separate sand.

3 Describe the physical properties that allowed you to separate the mud and the sand.

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **5.5**

Froth flotation

20 min | Level 1

KEY SKILL

IDENTIFYING AND MANAGING RELEVANT RISKS

Brainstorm with a partner to identify three possible hazards or risks that may be involved in this investigation. Suggest one way that each hazard or risk could be reduced.

AIM

To investigate the froth flotation process

MATERIALS

- kerosene
- liquid detergent
- mixture of 3 parts sand to 1 part iron filings
- water
- teaspoon
- large test tube
- rubber stopper

KEROSENE IS A HAZARD. IT IS HIGHLY FLAMMABLE. NEVER USE IT NEAR MATCHES OR OPEN FLAME. NEVER INHALE OR INGEST IT. WASH YOUR HANDS IMMEDIATELY IF IT COMES INTO CONTACT WITH YOUR SKIN.

METHOD

1. Pour one teaspoon of the sand and iron mixture into the test tube.
2. Add water until the test tube is about half full, then insert the stopper and shake the test tube for 10 seconds. Record your observations.
3. Remove the stopper and add 3 drops of kerosene and 7–8 drops of detergent. Insert the stopper and shake the test tube for another 10 seconds. Record your observations.

QUESTIONS

1. What did you observe in the test tube after you added the kerosene and detergent?
2. Explain why the iron filings acted as they did.
3. Suggest how froth flotation could be used in industrial separation.

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **5.6A**

Evaporating a solution

30 min | Level 2

KEY SKILL

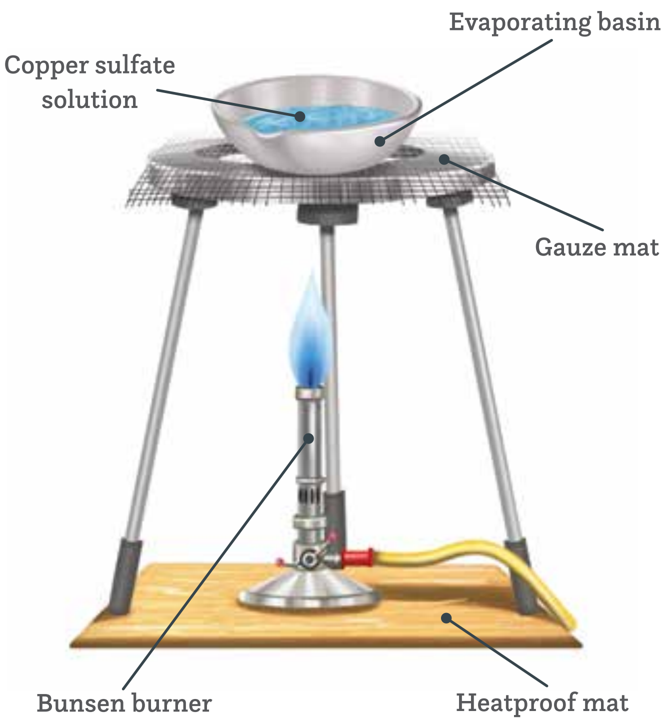
IDENTIFYING LIMITATIONS TO THE METHOD AND SUGGESTING IMPROVEMENTS

When you write a formal investigation report there is always a discussion section that includes a discussion of potential errors. These errors are limitations (or problems) with the method. For each error, you list a way to control it (your suggested improvement).

Hint #1: *Brainstorm three potential errors that might have occurred in this investigation that could have affected or changed the results you collected (for example, if through human error something was not measured accurately). Now work with a partner to suggest ways each error could be controlled.*

AIM

To investigate what happens when a solution evaporates



MATERIALS

- copper sulfate solution
- evaporating basin
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- matches

METHOD

1. Place a small amount (5 mL) of copper sulfate solution in an evaporating basin.
2. Set up the apparatus as shown and put on your safety glasses.
3. Place the evaporating basin on the gauze mat and heat the solution.
4. Record your observations as the water evaporates.
5. Turn off the Bunsen burner before the last few drops evaporate.

QUESTIONS

1. Describe the copper sulfate solution prior to the evaporation.
2. Describe the substance after evaporation had occurred.
3. Describe a safety precaution required for this investigation.
4. What happened to the water from the copper solution in this experiment?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

AN OPEN FLAME IS A HAZARD. TAKE CAUTION. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES. COPPER SULFATE IS TOXIC. IF YOU COME INTO CONTACT WITH THE SOLUTION, TELL YOUR TEACHER IMMEDIATELY AND WASH IT OFF YOUR SKIN. ALWAYS WEAR SAFETY GLASSES.

Investigation **5.6B**

Growing crystals

30 min

Level 1

KEY SKILL

IDENTIFYING THE VARIABLES AND FORMULATING A HYPOTHESIS

Before you formulate a hypothesis, identify your independent, dependent and controlled variables.
The independent variable is the one thing that you purposefully want to change in an investigation.
The dependent variable is what you will be measuring.
The controlled variables are all the things you need to keep the same throughout the investigation.
To formulate your hypothesis use the following sentence stem: It can be hypothesised that if *(something to do with your independent variable)*, then *(something to do with your dependent variable)*.
Hint #1: *If you get stuck, use the prompts in Lesson 1.4 to help you.*

AIM

To investigate growing crystals at different temperatures

MATERIALS

- electronic balance
- 30 g of copper sulfate (solid)
- 2 × 100 mL beakers
- hot water from tap
- 2 stirring rods
- cotton
- 2 paperclips

METHOD

1. Add 30 g of copper sulfate to a beaker containing 40 mL of hot water. Stir with a stirring rod until the solid dissolves.
2. Pour half of the volume into another beaker. Cool this beaker by running cold water on the outside.
3. Tie a piece of cotton to each stirring rod and attach a paperclip at the other end. Hang the strings with paperclips inside each beaker.
4. Leave the beakers for several days to allow crystals to grow.
5. Describe what you can see inside each beaker.

QUESTIONS

1. Compare the sizes of the crystals in the two beakers. How could you make the crystals bigger?
2. Identify the independent, dependent and controlled variables.
3. Use the variables identified above to write a hypothesis.
4. Was your hypothesis supported (correct) or rejected (incorrect)?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **5.6C**

Distillation

TEACHER DEMONSTRATION

30 min

AIM

To investigate separating a salt solution using distillation

MATERIALS

- 150 mL beaker containing salt solution
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- matches
- Liebig condenser
- thermometer
- distillation flask
- marble chips
- retort stand with bosshead and clamp
- receiving flask

METHOD

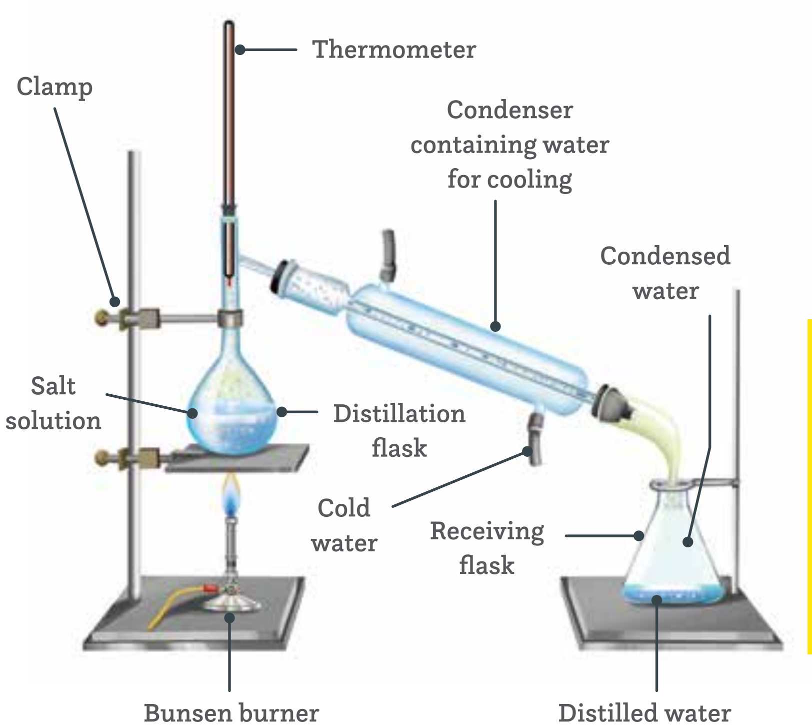
1. Your teacher will set up the apparatus as shown.
2. They will pour the salt solution into the distillation flask, and then add a few marble chips to spread the heat evenly.
3. Your teacher will turn on the water through the condenser, boil the mixture in the flask and collect the water that comes out of the condenser in a small flask.
4. Identify the components separated as residue and distillate.

QUESTIONS

1. Explain why the solution could be separated.
2. Describe the changes of state that happened during the distillation.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.



AN OPEN FLAME IS A HAZARD. TAKE CAUTION. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.

Investigation **5.7A**

Separating colours using paper chromatography

30 min | Level 2

KEY SKILL

WRITING A RESEARCH QUESTION

Turn the aim of this investigation into a question that asks what you are trying to discover. This is called a research question.

Hint #1: *Make sure that your research question has a question mark at the end.*

Hint #2: *Your research question can also be used as a title for an experiment report.*

AIM

To investigate how chromatography can be used to separate colours

MATERIALS

- coloured confectionery; e.g. jelly beans, Skittles, Smarties
- small beaker of water
- filter paper
- plastic pipette
- watchglass

METHOD

1. Place a sample of your chosen confectionery on a watchglass, then put 2 drops of water on the sample.
2. When the colour starts to dissolve, use an eyedropper to collect some coloured solution.
3. Add 1 drop of the coloured solution in the middle of the filter paper. The filter paper can be placed on an empty beaker.
4. Add 1 drop of water and observe what happens. Record your observations.
5. Repeat steps 1–4 using a different coloured lolly.
6. Describe what happens to the sample as the solvent (water) is added.

QUESTIONS

1. Which confectionery colours are single substances and which ones are mixtures?
2. How many different dyes are needed to make all the confectionery colours?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

NEVER EAT ANYTHING IN THE SCIENCE LABORATORY.

Investigation **5.7B**

Separating two immiscible liquids

TEACHER DEMONSTRATION

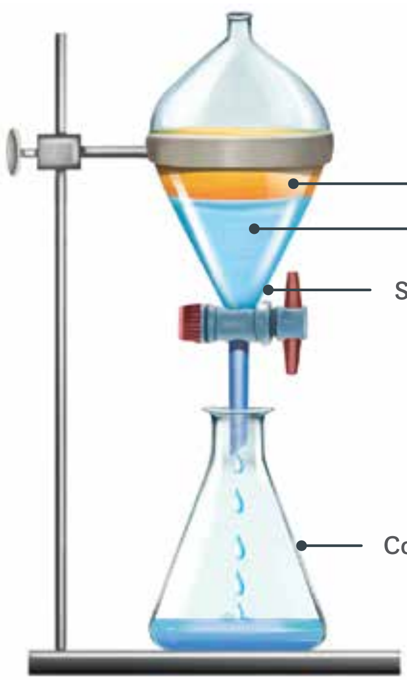
30 min

AIM

To investigate using a separating funnel to separate oil and water

MATERIALS

- 2 × 25 mL measuring cylinders
- oil
- water
- separating funnel
- retort stand with bosshead and clamp
- retort ring
- measuring cylinder
- 2 × 100 mL conical flasks



METHOD

1 Your teacher will set up the separating equipment as shown.
2 They will measure 20 mL of water and transfer it into the separating funnel.
3 Your teacher will measure 20 mL of oil and transfer it into the separating funnel.
4 They will stopper the funnel and shake it. Next, they will place the funnel back into the retort ring and observe the mixture separating. Record your observations.
5 After two obvious layers have formed, your teacher will slowly open the tap and collect the bottom liquid into a flask. Observe the transfer of the contents into a measuring cylinder and measure the volume of the liquid collected.
6 Once your teacher pours out the remaining liquid, measure the volume collected. Record your observations.

QUESTIONS

1 Describe what happened to the mixture when the separating funnel was shaken.
2 Explain why the mixture settled out after some time.
3 Consider the volumes you started with for each liquid and the volumes you recovered at the end. How would you describe the efficiency of separating a mixture using a separating funnel?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **6.1**

Modelling day and night

30 min

Level 2

KEY SKILL

WRITING A RESEARCH QUESTION

Turn the aim of this investigation into a question that asks what you are trying to discover. This is called a research question.

Hint #1: *Make sure that your research question has a question mark at the end.*

Hint #2: *Your research question can also be used as a title for an experiment report.*

AIM

To investigate, using a model, how day and night are explained by the relative positions of the Sun and Earth

MATERIALS

- globe of Earth
- torch

METHOD

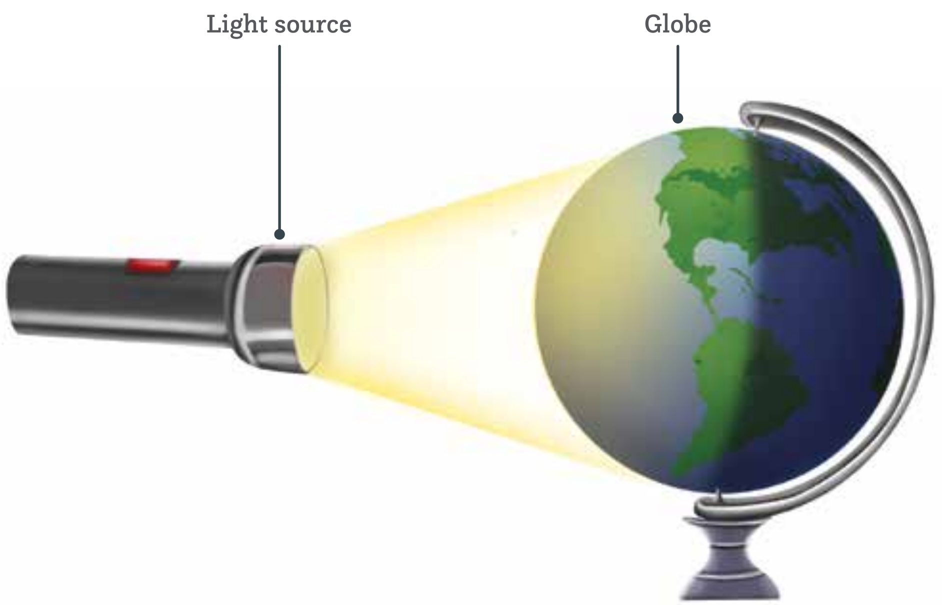
1 Have one person hold the torch. This represents the Sun.
2 Have another person in charge of the globe. This represents Earth. (The globe will have the correct tilt.)
3 Dim the light and aim the torch at the globe. Note that half of the globe is lit and half is in darkness.
4 Rotate the globe anti-clockwise and observe how the light travels over the continents.

QUESTIONS

1 How much of Earth is in daylight at any time?
2 How much of Earth is in darkness at any time?
3 When it is day in Australia, name a continent that has night.
4 Is it possible for New York and New Zealand to both have daylight at the same time?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.



Investigation **6.2**

Modelling the seasons

30 min

Level 2

KEY SKILL

EVALUATING RESULTS FOR RELIABILITY AND VALIDITY

In order for our investigations to be considered scientific, we need to check that our results were reliable and valid. It sounds like a difficult thing to check but it's actually simple. If your results are reliable it means that if you repeated your test or investigation you would get the same results. If your results are valid it means that you were able to measure what was intended to be measured.

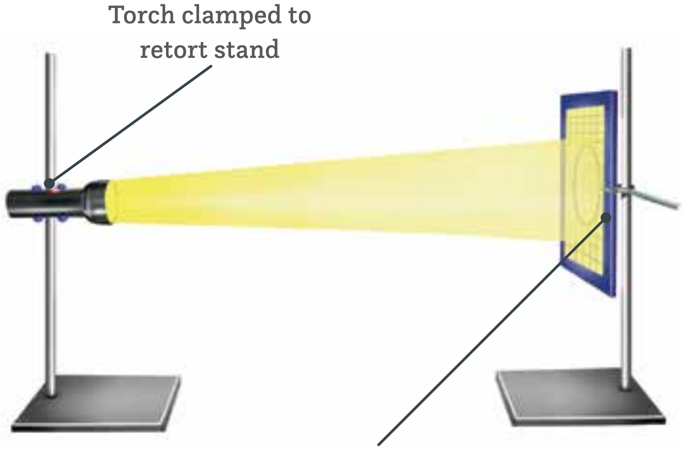
Hint #1: *If someone makes a human error (for example, dropping something, adding too much or too little of a substance, spilling something or using different equipment each time) then the results are probably not valid or reliable.*

AIM

To investigate, using a model, how Earth's tilt affects how the Sun's rays strike Earth and cause seasons

MATERIALS

- backing board
- clips
- 7 sheets of graph paper
- 2 retort stands with bossheads and clamps
- torch
- pencil
- ruler
- protractor



RESULTS

TABLE I6.2

Angle (°)	Area (number of lit squares)

METHOD

1 Copy the results table into your notebook, adding a title and rows as needed.
2 Set up the apparatus as shown.
3 Dim the lights so that the torch makes a clear circle on the graph paper.
4 Check that the board is parallel to the retort stand.
5 Measure and record the distance between the torch and the graph paper.
6 Use a pencil to trace the lit area. Be careful not to move the graph paper.
7 Remove the graph paper and label it 0°.
8 Place another sheet of graph paper on the board and tilt the board by 10° so that the top of the board is further away from the torch. Trace the lit area. Label this sheet with the angle of the board.
9 Repeat step 8 for each angle up to 60°.
10 Count the number of squares inside the traced areas and record them in the results table.
11 Graph your results, with the angle in degrees on the horizontal axis and the area in squares on the vertical axis. Remember to choose an appropriate scale.

QUESTIONS

1 Which angle do you think represents places near the equator? Why?
2 Which angle do you think represents Antarctica? Why?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **6.3**

Modelling a solar and lunar eclipse

KEY SKILL

REFERENCING SOURCES OF INFORMATION

As your science skills become more advanced, you may wish to do some research prior to completing an investigation. This allows you to understand the investigation better; in particular, the science of what is happening. Whenever you do research it is important to get information from trusted sources and to reference where the information came from. When you reference a source, you include details like who the author of the information is, when it was published and the title of the website or article.

Hint #1: *Two widely used referencing conventions are Harvard and APA. You can look these up to learn more about them, or there are even websites that will format your references for you.*

AIM

To investigate, using a model, how solar and lunar eclipses are explained by the relative positions of the Sun, the Moon and Earth

MATERIALS

- tape
- 2 cardboard tubes or roll of paper
- scissors
- aluminium foil
- coathanger wire (20 cm length)
- polystyrene ball (10–12 cm diameter)
- ping-pong ball or small polystyrene ball
- square of heavy card
- retort stand with bosshead and clamp
- torch

METHOD

1 Make a series of small (2 cm), even, vertical cuts around each end of one of the cardboard tubes.
2 Bend the cut pieces of both ends of the cardboard tube outwards and stand the tube upright. Tape one end of the tube to one of the pieces of heavy card to create a base for the model.
3 Tape the base to the polystyrene ball. This is the model of Earth.
4 Insert one end of the wire vertically into the Earth model.
5 Make two small holes in the ping-pong ball for the wire to pass through.
6 Cover the ping-pong ball with aluminium foil. This is the model of the Moon.
7 Bend the wire to secure the Moon as shown. The Moon's equator should be level with Earth's equator.
8 Adjust the torch using the retort stand so that it is in line with Earth's equator. The other cardboard tube can be used to direct the light.
9 Dim the lights.
10 Follow the instructions on page 167 to model the solar and lunar eclipse.

QUESTIONS

1 For each eclipse, which object is in shadow?
2 For each eclipse, which object is casting the shadow?
3 Does everyone in the world see a solar eclipse? What about a lunar eclipse? Who can't see them?
4 Do you see solar eclipses at night or in the day?
5 During a solar eclipse, what would you see if you stood on the Moon and looked at Earth?
6 What is the phase of the Moon during a solar eclipse? What about during a lunar eclipse?
7 Why don't we see a lunar eclipse during every full moon?
8 Do other planets have solar or lunar eclipses?

CONCLUSION

Copy and complete:

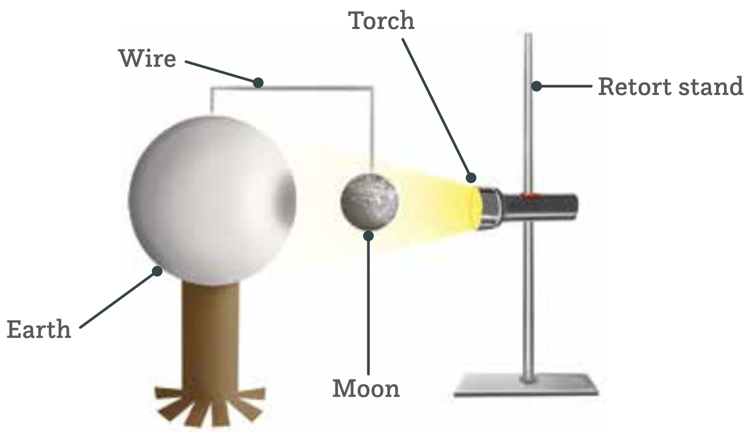
'The results show that: (*respond to the aim*)'.

30 min

Level 2

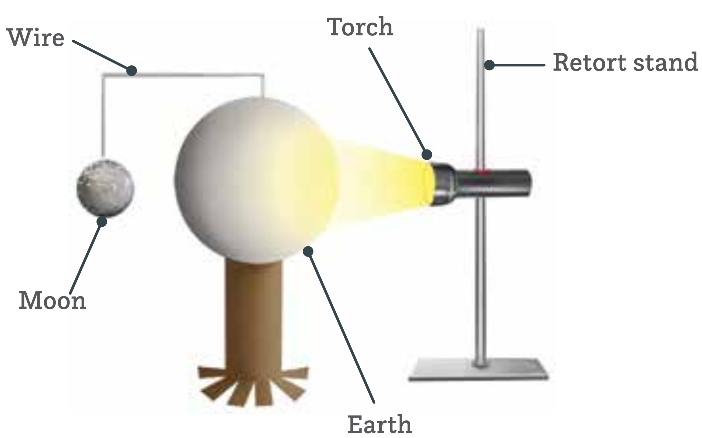
TO MODEL THE SOLAR ECLIPSE:

1. Stand facing the torch and swing the wire around until the Moon casts a shadow on Earth. The Moon is now positioned between Earth and the Sun, blocking Earth's sunlight.
2. Show that the shadow moves by slowly rotating the wire.
3. Bend the wire up so that the Moon only partially blocks the Sun.



TO MODEL THE LUNAR ECLIPSE:

1. Stand facing the torch and swing the wire around until the Moon is completely behind Earth. Earth is now positioned between the Moon and the Sun, blocking the Moon's sunlight .
2. Bend the wire so that only part of Earth's shadow falls on the Moon, to model a partial lunar eclipse.



Investigation **6.5**

Making a simple telescope

30 min
Level 2

KEY SKILL

WRITING A RESEARCH QUESTION

Turn the aim of this investigation into a question that asks what you are trying to discover. This is called a research question.

Hint #1: *Make sure that your research question has a question mark at the end.*

Hint #2: *Your research question can also be used as a title for an experiment report.*

AIM

To investigate how telescopes use lenses to magnify distant objects

MATERIALS

- metre rule
- Blu-Tack or plasticine
- retort stand
- strong convex lens (+14D) or magnifying glass
- weak convex lens (+2.5D) or lens from reading glasses
- greaseproof paper
- lamp

METHOD

1. Attach the weak lens to one end of the metre rule with plasticine or Blu-Tack.
2. Set the metre rule into the retort stand to hold it steady, with the weak lens pointing away from you.
3. Put the lamp on a table at the other end of the room and turn it on.
4. Turn the retort stand until the metre rule is aimed at the lamp.
5. Hold a piece of greaseproof paper just above the metre rule. Move it along the rule until you see a small image of the lamp on the paper. Have a partner hold it at that position.
6. Hold the strong lens at the other end of the metre rule. Using one eye, look through the lens at the image on the paper. Move the lens until the lamp image is magnified.
7. Have your partner take the paper away, but continue looking through the strong lens. You should still see the image of the lamp, although brighter than before.

QUESTIONS

1. Why does this telescope require two lenses, rather than just one?
2. Why is the image brighter once the paper is taken away?
3. How is this simple telescope different to a proper telescope?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

Investigation **7.1**

Classifying resources used in the classroom

45 min

Level 1

KEY SKILL

REPRESENTING DATA

When you write a formal investigation report there is always a results section that includes your data, often as a table, chart or image. Choosing how to represent your data so that it can be clearly communicated to someone reading your investigation report is an important skill. In this investigation, after you have collected and recorded your data in the results table, turn your table into a chart or graph.

Hint #1: *There are many ways to visualise your data, such as bar charts, line graphs and pie charts. Make sure you choose the best one for your data set.*

AIM

To investigate how the resources that are used in common classroom materials are made

MATERIALS

- selection of classroom items (e.g. paper, ruler, eraser, pencil case, calculator)

METHOD

1. Copy the results table into your notebook, adding a title and rows as needed.
2. Select 10 items in the classroom and include them in your table.
3. Identify the materials each item is made from. You may need to do some research.
4. Identify how the major material from each item is obtained.
5. Determine whether the item is made from renewable or non-renewable resources.
6. Compare your list with those of others in your class.

QUESTIONS

1. Compare the number of renewable resources in your table to the number of non-renewable resources.
2. Describe the similarities between the items that are made from renewable sources.
3. Describe the similarities between the items that are made from non-renewable resources.
4. Where are most of the non-renewable resources you listed found in nature?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

RESULTS **TABLE I7.1**

Item	Major resource in item	How is it obtained?	Renewable or non-renewable?
Paper	Paper	Cutting down trees	Renewable
Metal ruler	Aluminium	Mining from deposits in rocks	Non-renewable

Investigation **7.2**

Investigating soil erosion

60 min | Level 1

KEY SKILL

IDENTIFYING THE VARIABLES AND FORMULATING A HYPOTHESIS

Before you formulate a hypothesis, identify your independent, dependent and controlled variables.
The independent variable is the one thing that you purposefully want to change in an investigation.
The dependent variable is what you will be measuring.
The controlled variables are all the things you need to keep the same throughout the investigation.
To formulate your hypothesis use the following sentence stem: It can be hypothesised that if *(something to do with your independent variable)*, then *(something to do with your dependent variable)*.
Hint #1: *If you get stuck, use the prompts in Lesson 1.4 to help you.*

AIM

To investigate factors that influence soil erosion

MATERIALS

- several small seedlings
- soil
- small amount of mulch
- 6 empty soft-drink bottles (equal shape and size)
- piece of board or bench space (30 cm × 30 cm)
- glue or plasticine
- string
- 250 mL beaker
- water

METHOD

1. Cut a rectangle (approximately 10 cm × 20 cm) out of one side of three of the bottles.
2. Using glue or plasticine, position the bottles on their sides (holes facing up) on a table or board so that they will not move. The necks of the bottles should stick out over the edge.
3. Add an equal amount of soil to each of the three bottles.
4. Plant your seedlings in the first bottle.
5. Cover the soil in the second bottle with a layer of mulch.
6. Leave the soil uncovered in the third bottle.
7. Cut the other three bottles in half and carefully pierce a hole on either side to thread the string through so that it can be suspended underneath the necks of the three bottles.
8. Use the beaker to measure 250 mL of water and carefully pour the water into each bottle containing soil, pouring into the bottom of the bottle, away from the neck.
9. When the water has drained through, record your observations of the differences in the water that collects in the buckets underneath the neck.
10. Repeat the watering process over several days, continuing to record your observations.

QUESTIONS

1. Compare the colour of the water in each of the collecting cups.
2. Describe the level of soil remaining in each of the three bottles.
3. Suggest why the colours and levels of soil are different.
4. Farmers will often leave the roots of their old crop in the ground until they are ready to plant their new one. Justify why this is a useful strategy for preserving soil resources.
5. A farmer observed that soil will erode more from paddocks that are on a slope than in paddocks on flat ground. Design an experiment to test how the angle of a slope affects the amount of soil eroded.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **7.3A**

Designing a windmill to lift a weight

60 min

Level 2

KEY SKILL

REPRESENTING AND RECORDING DATA USING A TABLE

In this investigation it is critical to record your data and observations using a suitable table. Before you start your investigation, design a table with appropriate columns and rows to record your data and observations.

Hint #1: *Use a ruler to draw your table so it is neat, clear and easy to read.*

Hint #2: *Give your table a title and a table number.*

Hint #3: *Include any units of measurement in the column or row headings.*

AIM

To investigate which design for a windmill can lift the heaviest weight

MATERIALS

- cotton reel
- string
- piece of dowel to fit through cotton reel
- block of polystyrene
- light cardboard, heavy cardboard, plywood and other materials suitable to make turbine blades
- skewers
- selection of fishing line sinkers or other small weights
- paper cup
- retort stand with bosshead and clamp
- fan

METHOD

1. Insert the dowel through the cotton reel and secure it so that the reel will not spin. This will be how you attach the string that will lift the weight.
2. Insert the other end of the dowel into the polystyrene block. This will be where you insert your turbine blades.
3. Carefully clamp the dowel into the retort stand and clamp. The dowel must still be able to spin freely.
4. Tape one end of the string onto the cotton reel. Thread the other end through the cup.
5. Determine the size, shape and number of blades that your windmill will have. Construct these out of your chosen material.
6. Consider the angle (pitch) that your blades will have compared to the front of the windmill.
7. Put together your windmill from all of your components.
8. Place different weights in the cup. Use the fan to try to turn the windmill blades and lift each weight.
9. Record your observations and the heaviest weight your design could lift. Compare your findings with those of your classmates.

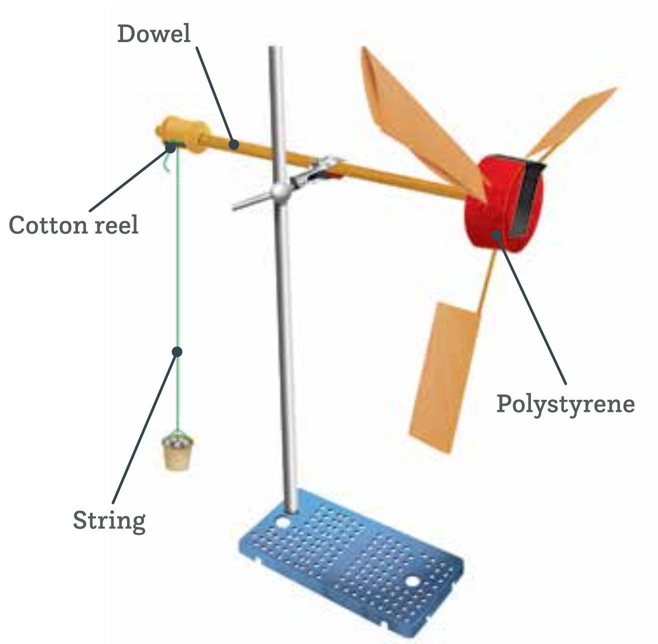
QUESTIONS

1. Which design was able to lift the heaviest weight?
2. Why is the angle of the windmill blades so important?
3. What materials (not provided) do you think would make an even stronger windmill?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.



Investigation **7.3B**

Making bioplastic

30 min | Level 2

KEY SKILL
IDENTIFYING AND MANAGING RELEVANT RISKS

Brainstorm with a partner to identify three possible hazards or risks that may be involved in this investigation. Suggest one way that each hazard or risk could be reduced.

AIM

To investigate how plastic is made using cornflour

MATERIALS

- cornflour
- vinegar
- vegetable glycerine
- water
- aluminium foil
- 250 mL beaker
- hotplate
- stirring rod
- tablespoon
- teaspoon
- spatula
- selection of commercially produced plastics

METHOD

1 Copy the results table into your notebook, adding a title and rows as needed.
2 Set up the hotplate.
3 Add 1 tablespoon of cornflour, 1 teaspoon each of vinegar and glycerine and 4 tablespoons of water to the beaker. Stir with the stirring rod until combined.
4 Place the beaker onto the hotplate and switch on to low heat.
5 Continue stirring the solution until it thickens and starts to become translucent. This will not take long!
6 Carefully pour the plastic onto a sheet of aluminium foil and spread using the spatula.
7 Allow the plastic to completely cool. This will take several hours. If you wish to form the plastic into another shape, leave it spread out on the foil to cool for approximately 1 hour. It can then be carefully moulded into shape before it sets completely.
8 Compare the flexibility of your plastic with the samples provided. Record your observations.
9 Take a piece of your plastic and add it to water. Record your observations.
10 Take a piece of your plastic and heat it in a beaker over the hotplate. Record your observations.

QUESTIONS

1 Describe the properties of the bioplastic you created.
2 Compare these properties to the properties of some conventional plastics.
3 What happened when you added your bioplastic to water?
4 What happened when you reheated your bioplastic?
5 Explain the benefit of using a bioplastic, such as the one you have made, compared to a conventional plastic.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

RESULTS TABLE I7.3B

Material	Flexibility	Behaviour in water	Behaviour when heated

TAKE CAUTION USING THE HOTPLATE. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.

Investigation **7.4**

The sustainability game

30 min Level 1

KEY SKILL
REPRESENTING DATA

When you write a formal investigation report there is always a results section that includes your data, often as a table, chart or image. Choosing how to represent your data so that it can be clearly communicated to someone reading your investigation report is an important skill. In this investigation, after you have collected and recorded your data in the results table, turn your table into a chart or graph.

Hint #1: *There are many ways to visualise your data, such as bar charts, line graphs and pie charts. Make sure you choose the best one for your data set.*

AIM

To demonstrate how to use a resource so that it can continue to be used in the future

MATERIALS

- 60 marbles
- container

METHOD

The aim of the game is to have collected the most number of marbles at the end of eight rounds.

1. Count out 20 marbles into the container (your source), leaving the others as reserves.
2. Copy the results table into your notebook, adding a title and rows as needed.
3. To begin, decide how many marbles you will remove from the 'source'. The number of marbles you remove at each round can only vary by one. For example, if you remove three marbles in round 1, you can take two or four out in round 2.
4. At the end of each round, add one marble from the reserves for every four marbles left in the 'source'. For example, if there are 16–19 marbles left, four should be added. If there are 1–3 marbles left, none should be added.
5. Continue removing and adding marbles until you run out of marbles in the 'source' or make it through eight rounds. Record your results in your table.
6. Construct a graph of your results. Plot the number of marbles taken on the *y*-axis with the number of rounds on the *x*-axis.

QUESTIONS

1. Compare your results to those of other groups. Who collected the most marbles at the end of eight rounds? Who collected the least? Did anyone run out of marbles from the source before the end of eight rounds?
2. Compare the different strategies that were used. What strategies allowed for a sustainable use of the resource? What strategies were not sustainable? Why?
3. Did the marbles in this game represent a renewable or non-renewable resource? Justify your response.
4. How would the rules and outcome of the game have been different for the other type of resource?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

RESULTS **TABLE I7.4**

Round	Number in source at start of round	Number removed from source	Number left in source	Number added to source at end of round

Investigation **7.5**

Mining for chocolate chips

45 min

Level 1

KEY SKILL

IDENTIFYING LIMITATIONS TO THE METHOD AND SUGGESTING IMPROVEMENTS

When you write a formal investigation report there is always a discussion section that includes a discussion of potential errors. These errors are limitations (or problems) with the method. For each error, you list a way to control it (your suggested improvement).

Hint #1: *Brainstorm three potential errors that might have occurred in this investigation that could have affected or changed the results you collected (for example, if through human error something was not measured accurately). Now work with a partner to suggest ways each error could be controlled.*

AIM

To investigate which brand of chocolate chip biscuit contains the highest percentage of 'metal' in the 'ore'

MATERIALS

- chocolate chip biscuit (one of several different brands)
- toothpicks
- cupcake liner
- graph paper
- electronic balance

METHOD

MINING FOR METAL IN ORE

1. Copy the results table into your notebook, adding a title and rows as needed.
2. Place your biscuit in a cupcake liner. Set to zero mass on the electronic balance. Weigh and record the mass of the biscuit, then remove it and any crumbs from the liner.
3. Using the toothpick, carefully remove the chocolate chips from the biscuit, keeping them separate from those of other biscuits.
4. Place the chocolate chips in the cupcake liner. Set to zero mass on the balance. Weigh and record the mass.
5. Calculate the percentage of chocolate chips in the biscuit compared to the 'waste'.
6. Share your results with the rest of the class and calculate an average for all brands of biscuit.

QUESTIONS

1. Which brand contained the highest percentage of chocolate chips?
2. Which brand contained the lowest percentage of chocolate chips?
3. Compare your results with other groups – how did they differ?
4. Compare the class average results to the advertised percentage of chocolate chips – how did they differ?
5. What 'mining' strategies did you use? Could you have easily rehabilitated the biscuits after the chocolate chips were removed? How could you change them so they were more 'environmentally friendly'? How do you think this could impact any profits?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

RESULTS **TABLE I7.5**

Biscuit brand	Total biscuit mass (g)	Mass of chocolate chips (g)	% by mass of chocolate chips	Class average % by mass of chocolate chips	Labelled % of chocolate chips

Investigation **8.1**

Push, pull or twist

30 min

Level 1

KEY SKILL

IDENTIFYING AND MANAGING RELEVANT RISKS

Brainstorm with a partner to identify three possible hazards or risks that may be involved in this investigation. Suggest one way that each hazard or risk could be reduced.

AIM

To investigate the effects of forces on different objects

MATERIALS

- elastic band
- tennis ball
- plasticine or Blu-Tack
- plastic ruler
- metal ruler
- A4 piece of paper

METHOD

1. Copy the results table into your notebook, adding a title.
2. Stretch the elastic band as far as it will go, then slowly let it go back to its normal shape.
3. Drop the tennis ball so that it bounces off the floor, then catch it before it falls again.
4. Squash the plasticine or Blu-Tack into at least three different shapes.
5. Hold one end of the plastic ruler in each hand. Bend the ruler so that it flexes, then let it go back to its normal shape.
6. Repeat step 5 for the metal ruler, if possible.
7. Hold one corner of the paper in each hand. Bring your hands together so that the paper scrunches, then pull them apart until it tears.
8. For each object, record whether the forces you applied acted as a push, pull or twist. Consider all of the different forces that you applied to each object. Record your observations of what else happened when you applied forces.

QUESTIONS

1. Were there any situations where you applied more than one force to an object? What was the effect of applying multiple forces?
2. Which objects changed their shape when you applied a force? Was this change temporary or permanent?
3. Did applying force affect the movement of any objects? If so, why?

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

RESULTS **TABLE I8.1**

Object	Push, pull or twist	Effect of applying force
Elastic band		
Tennis ball		
Plasticine or Blu-Tack		
Plastic ruler		
Metal ruler		
Piece of paper		

Investigation **8.2**

Blowball

30 min Level 1

KEY SKILL

IDENTIFYING AND MANAGING RELEVANT RISKS

Brainstorm with a partner to identify three possible hazards or risks that may be involved in this investigation. Suggest one way that each hazard or risk could be reduced.

AIM

To investigate the effects of unbalanced forces on a ping-pong ball

MATERIALS

- table
- ping-pong ball
- 4 drinking straws

METHOD

1 Gather into groups of four. Each member of the group takes one straw and kneels at a different side of the table.
2 Place the ping-pong ball in the centre of the table.
3 Take turns to blow through your straws to move the ball around the table.
4 Have one group member blow the ball across the table while the others blow on it in the other direction.
5 Have one group member blow the ball across the table while the others blow on it from the sides.
6 Divide into two pairs, with each pair on a different side of the table. As a pair, try to blow the ball across the table and off the side while the other pair does the same.
7 Record observations in your book. In particular, detail how different sized forces were able to affect the motion of the ball.

QUESTIONS

1 At what times were the forces on the ball balanced?
2 Describe what happened to the speed and direction of the ball when you blew on it as it moved towards you.
3 What happened when you blew on the ball as it moved at a right angle to you?
4 Draw a force diagram showing the forces that were acting on the ball as you blew it away from you.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **8.4**

Heat from friction

20 min | Level 1

KEY SKILL

IDENTIFYING THE VARIABLES AND FORMULATING A HYPOTHESIS

Before you formulate a hypothesis, identify your independent, dependent and controlled variables.
The independent variable is the one thing that you purposefully want to change in an investigation.
The dependent variable is what you will be measuring.
The controlled variables are all the things you need to keep the same throughout the investigation.
To formulate your hypothesis use the following sentence stem: It can be hypothesised that if *(something to do with your independent variable)*, then *(something to do with your dependent variable)*.
Hint #1: *If you get stuck, use the prompts in Lesson 1.4 to help you.*

AIM

To investigate the connection between friction and heat

MATERIALS

- microfibre cloth
- wire coathanger
- wooden skewer
- plastic rod
- cardboard roll

METHOD

1. Pick up each item to see how warm or cool it is.
2. Firmly rub the plastic rod 20–30 times with the cloth. Carefully feel it and record how its temperature has changed.
3. Repeat step 2 with each of the other items.
4. Record any other observations you make.

QUESTIONS

1. Which item had the greatest change in temperature?
2. Which item had the least change in temperature?
3. Explain how friction caused the change in temperature.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

Investigation **8.5**

Friction of materials

30 min | Level 2

KEY SKILL

EXPLAINING RESULTS USING SCIENTIFIC KNOWLEDGE

When you write a formal investigation report there is always a discussion section that includes your analysis and explanation of the data you collected. This is where you get to explain your results by linking them to what you already knew about the science of what you are studying.

Hint #1: *You can use the following sentence stem to write about your results: 'My data shows ... and this makes sense because ...'.*

AIM

To investigate how much friction different materials apply to a moving block

MATERIALS

- 5 × 10 × 10 cm block of wood
- 1 m wooden board with a smooth finish
- ruler
- stopwatch
- foil
- cotton cloth
- woollen cloth
- various other materials (if desired)
- cooking oil

METHOD

1. Copy the results table into your notebook, adding a title and rows as needed.
2. Prop the wooden board up on some books to create a ramp.
3. Set the wooden block at the top of the ramp. Release the block and time how long it takes to slide down the ramp and hit the floor. Repeat two more times, then calculate the average time.
4. Cover the underside of the block with foil, then repeat step 3.
5. Cover the underside of the block with the cotton cloth, then repeat step 3.
6. Cover the underside of the block with the woollen cloth, then repeat step 3.
7. Cover the underside of the block with any other materials you want to check, then repeat step 3.
8. Cover the underside of the block with cooking oil, then repeat step 3.

QUESTIONS

1. Which material slowed the block down the most?
2. Which material slowed the block down the least?
3. Explain why the different materials affected the block's slide, referring to the effects of friction.
4. Suggest a material that would have much more friction and much less friction than those you used in this investigation.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

RESULTS TABLE I8.5

Material	Time 1 (s)	Time 2 (s)	Time 3 (s)	Average time (s)
Wood				
Foil				

Investigation **8.6**

Measuring gravity

20 min | Level 1

KEY SKILL

IDENTIFYING LIMITATIONS TO THE METHOD AND SUGGESTING IMPROVEMENTS

When completing a formal investigation report there is always a discussion section that includes a discussion of potential errors. These errors are limitations (or problems) with the method. For each error you list a way to control it (your suggested improvement).

Hint #1: *Brainstorm three potential errors that might have occurred in this investigation that could have affected or changed the results you collected (for example, if through human error something was not measured accurately). Now work with a partner to suggest ways each error could be controlled.*

AIM

To investigate the strength of gravitational force

MATERIALS

- 5 × 50 g masses
- spring balance

METHOD

1 Copy the results table into your notebook, adding a title and rows as needed.

2 Attach a 50 g mass to the bottom of the spring balance. The reading on the spring balance shows the weight of the mass (measured in newtons). Record the reading on the spring balance in your table, as well as the mass (after converting it to kilograms).

3 Repeat step 2, adding another 50 g mass each time, until there is a total mass of 250 g on the spring balance.

4 For each reading, calculate the strength of gravity by dividing the weight by the mass.

QUESTIONS

1 Is there a pattern in your gravitational strength calculations?

2 What can you deduce about the strength of gravity on Earth?

3 How would this investigation be different if you conducted it on the Moon?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

RESULTS TABLE I8.6

Mass (kg)	Weight (N)	Gravitational strength

Investigation **8.8**

Crash cushions

KEY SKILL
DRAWING CONCLUSIONS CONSISTENT WITH EVIDENCE

When you write a formal investigation report there is always a conclusion section that summarises the investigation by responding to (or answering) the aim. To do this you need to draw a conclusion that is consistent with the data or evidence you collected.

Hint #1: *You can use the following sentence stem in your conclusion: 'The results of this investigation show ....'*

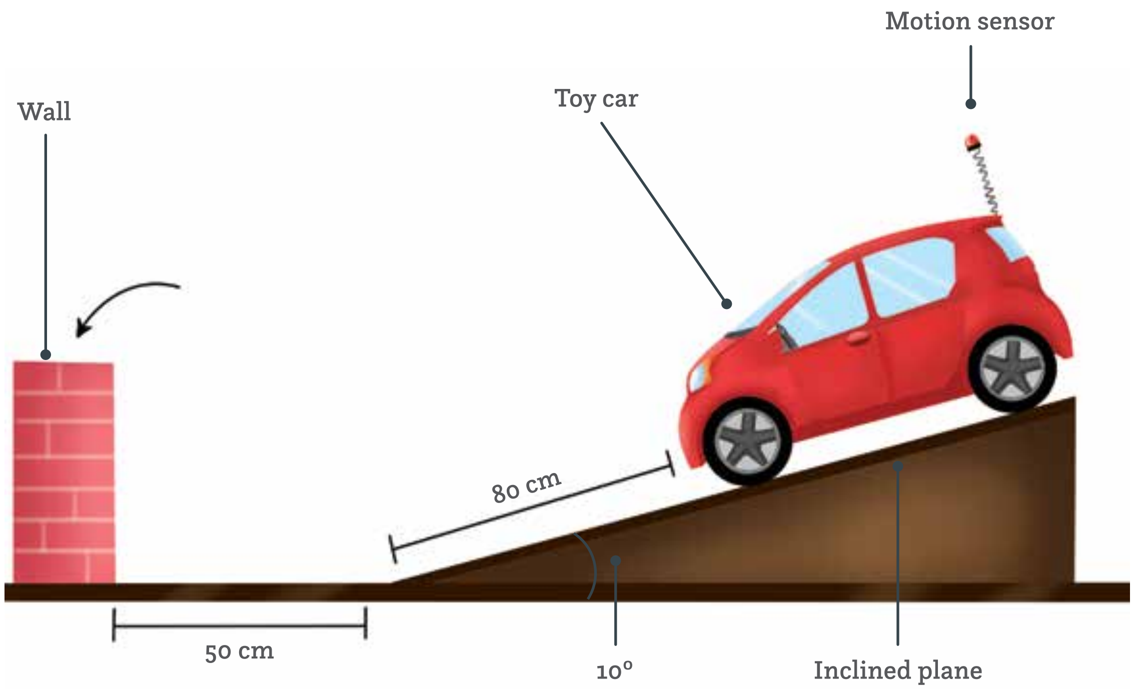
Hint #2: *Make sure your conclusion answers or responds to your aim.*

AIM

To investigate how different materials absorb the impact of forces

MATERIALS

- dynamics cart or large toy car
- motion sensor that can measure force on impact (If this is not available, film the impact in slow motion and make observations based on the video footage.)
- inclined plane
- scissors
- tape
- construction paper, newspaper, cardboard boxes, straws, balloons, sponges, polystyrene and other materials



60 min | Level 2

METHOD

1 Copy the results table into your notebook, adding a title and rows as needed.
2 If you have access to motion sensors, attach a sensor to the cart so that it measures the force of impact when the cart comes to a stop. If motion sensors are not available, set up a device to film the collision in slow motion.
3 Set up the inclined plane as shown.
4 Allow the cart to roll down the plane, collide with the wall and come to a stop. Read the impact measurement from the sensor or make written observations from the slow motion video. Record this data in your table as 'trial 1'. Repeat the trial and record the second measurement or observations.
5 Conduct at least three more trials. For each trial, create a 10 cm 'cushion' out of different materials, place it next to the wall and move the inclined plane back so there is a 50 cm space between the plane and the cushion. Allow the cart to roll down the plane, hit the cushion and come to a stop. Record the impact measurements or video observations in your table.

QUESTIONS

1 Which cushion was most effective at reducing the force of impact?
2 Suggest which materials were most useful for reducing impact, and explain why.
3 Suggest ways in which cushioning materials could be used in cars to reduce the impact of a crash.

CONCLUSION

Copy and complete:
'The results show that: (*respond to the aim*)'.

RESULTS

TABLE I8.8

Trial	Cushion material	Force of impact (first run)	Force of impact (second run)
1	None		
2			
3			
4			

Investigation **8.9A**

Investigating levers

30 min Level 1

KEY SKILL

IDENTIFYING LIMITATIONS TO THE METHOD AND SUGGESTING IMPROVEMENTS

When you write a formal investigation report there is always a discussion section that includes a discussion of potential errors. These errors are limitations (or problems) with the method. For each error, you list a way to control it (your suggested improvement).

Hint #1: *Brainstorm three potential errors that might have occurred in this investigation that could have affected or changed the results you collected (for example, if through human error something was not measured accurately). Now work with a partner to suggest ways each error could be controlled.*

AIM

To investigate the use of a lever to apply force

MATERIALS

- 30 cm ruler
- 2 paper cups
- tape
- approx. 30 marbles
- small cylinder (e.g. whiteboard marker)

METHOD

1. Copy the results table into your notebook, adding a title.
2. Tape the paper cups to the ends of the ruler so that they sit on top and can hold marbles. Label them A and B.

3. Set the ruler on the fulcrum (the cylinder) at the 15 cm mark.
4. Place 6–10 marbles in cup A.
5. Predict how many marbles you would need to put in cup B in order to lift cup A, and record your prediction in your table.
6. Place marbles one by one in cup B until cup A lifts. Record the number in your table.
7. Set the ruler on the fulcrum (the cylinder) at the 10 cm mark, and repeat steps 4–6.
8. Set the ruler on the fulcrum (the cylinder) at the 20 cm mark, and repeat steps 4–6.

QUESTIONS

1. At which position did you need to place more marbles in cup B than in cup A?
2. At which position did you need to place fewer marbles in cup B than in cup A?
3. How accurate were your predictions?
4. What did this investigation demonstrate about the use of levers?

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

RESULTS **TABLE I8.9A**

Fulcrum position (cm)	Marbles in cup A	Prediction for cup B	Actual marbles in cup B
15			
10			
20			

Investigation **8.9B**

Investigating pulleys

45 min

Level 2

KEY SKILL
REPRESENTING DATA

When you write a formal investigation report there is always a results section that includes your data, often as a table, chart or image. Choosing how to represent your data so that it can be clearly communicated to someone reading your investigation report is an important skill. In this investigation, after you have collected and recorded your data in the results table, turn your table into a chart or graph.

Hint #1: *There are many ways to visualise your data, such as bar charts, line graphs and pie charts. Make sure you choose the best one for your data set.*

AIM

To investigate the use of pulleys to apply force

MATERIALS

- spring balance
- suspension beam
- 2 single pulleys
- 2 double pulleys
- 4 m cord
- 1 kg weight
- 1 m ruler

METHOD

1. Copy the results table into your notebook, adding a title.
2. Set up the suspension beam and tie a single pulley to it. Run the 4 m cord through the pulley, then attach the 1 kg weight to one end and the spring balance to the other.
3. Pull the spring balance to lift the weight. The reading on the spring balance is the effort. Record how much effort is required to lift the weight.
4. Measure how far the cord had to be pulled in order to lift the weight by 1 m. Record the distance.
5. Calculate the mechanical advantage of the pulley by dividing the effort by the weight. Record it in your table.
6. Set up two single pulleys on the beam with the cord running through them, then repeat steps 3–5.
7. Set up two double pulleys on the beam with the cord running through them, then repeat steps 3–5.

QUESTIONS

1. Which number of pulleys gave the greatest mechanical advantage?
2. Which number of pulleys required you to pull the cord the longest distance?
3. Predict the mechanical advantage of an eight-pulley system, as well as the distance the cord would have to be pulled.

CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

RESULTS TABLE I8.9B

Number of pulleys	Effort needed to lift weight	Distance load moves (m)	Distance effort moves (m)	Mechanical advantage
1		1		
2		1		
4		1		

GLOSSARY

acceleration any change in the speed or direction of an object

agriculture the science or practice of farming

algae organisms living in water that make food by photosynthesis

angiosperm a plant that produces seeds in fruit or flowers

annular ring-shaped

antibiotic a substance that kills or slows the growth of bacteria

aqueous containing water

astronomer a scientist who studies space and the objects within it

axis a real or imaginary line through the centre of an object

bacteria microscopic, unicellular organisms that can live in a range of environments

biodiversity the variety of organisms in an ecosystem

biofuel a substance produced from living things that can be burnt to create energy

boiling point the temperature at which something changes from a liquid to a gas

boom a floating barrier used to temporarily contain an oil spill

bryophyte a plant that doesn't contain vascular tissue

Bunsen burner a piece of equipment used in science that produces a single open gas flame

carnivore an organism that eats only animals

classification the process of sorting things into groups or classes

coefficient of friction a value that indicates how easily an object moves when interacting with another material

compress to squash into a smaller space

condensation changing from a gas to a liquid

condenser a glass tube cooled by water that cools a gas to become a liquid

consumer an organism that gains energy by consuming other organisms

contract to get smaller; shrink

controlled variables all the things that need to stay the same during an investigation

crude oil oil that has not yet been separated into useable petroleum products

crystallisation separation of a solution by evaporating the solvent, leaving behind solute crystals

cultivation preparing and using land for crops or gardening

decanting carefully pouring the liquid from a mixture, leaving the sediment behind

decomposer an organism that breaks down and recycles decaying matter

decomposition the process of rotting and decay

deforestation the removal of trees to make land suitable for other uses

deform to change shape

density how heavy something is for its size; mass divided by volume

dependent variable the thing that will be measured and is altered by the independent variable

dichotomous divided into two parts

disinfection destroying bacteria, often using special light or chlorine

dissolve to mix a solid into a liquid to form a mixture called a solution

distillation using heating to separate liquids with different boiling points

eclipse the blocking of the Sun's light from Earth

ecosystem a community of living and non-living things

energy the ability to do physical things such as move or change

equinox the two times each year when night and day are about the same length

ethics beliefs about what is right and wrong

eukaryote an organism with a nucleus and structures inside its cell(s)

euryhaline the ability to survive in water with various salinity levels, from fresh to very salty

evaporation changing from a liquid to a gas

evidence facts and observations that can be used to support or oppose a theory

evolve change over many generations to adapt to the environment

expand to get bigger; increase in size

experiment an investigation carried out under controlled conditions, to test a hypothesis

exploration processes undertaken to find rocks that contain minerals

fair test an investigation in which only one factor is changed and all other variables are kept the same

fieldwork an investigation conducted in the natural environment, not a laboratory

filtrate the liquid that passes through a filter

finite limited in size or amount

food chain a path of energy through an ecosystem

food web a system of interlocking food chains

force a push, pull or twist on an object when it interacts with another object

fossil fuel a natural fuel formed over millions of years from the remains of living things

fractional distillation a method that separates liquids by using their different boiling points

friction a force opposite to the motion of surfaces in contact

froth flotation a method that uses special chemicals to separate minerals from their ores

fulcrum the point on which a lever turns when moving an object

galaxy a large system of stars

gravitational force the force that attracts physical objects with mass towards each other

gymnosperm a plant that produces seeds in cones

habitat the place where an animal or plant naturally lives

hazard something that can harm living things, objects or the environment

heat a type of energy

heating flame the blue (very hot) flame of a Bunsen burner (approx. 1500°C), used for heating substances

herbivore an organism that eats only plants

hydropower electricity generated by flowing water turning a turbine

hypothesis a scientific statement that can be tested

immiscible not able to be mixed

impact the effect of a force

inclined tilted up at an angle from horizontal

independent variable the thing that is purposely changed during an investigation

inference an educated guess or judgement based on observations

insoluble something that does not dissolve

interact to act on each other

invertebrate an organism without a backbone or spinal cord

irrigation supplying water to land or crops

key a system for identifying characteristics

lever a bar acted upon at different points by two forces

lubrication a substance that makes a surface slippery or smooth

made resource a resource that is manufactured from natural resources

magnitude the size or power of an object, energy or force

mass the amount of matter in an object

matter the particles that make up all physical substances; anything that has mass and takes up space

melting point the temperature at which something changes from a solid to a liquid

microorganism an organism that is only visible under a microscope

mineral deposit rocks that contain a particular mineral

mineral ore a mineral that contains useful metals

mixture a substance that is composed of different types of particles, all mixed together

model a simplified way of explaining something complex and real based on evidence

monoculture the practice of cultivating a single crop in a given area

motion the change in position of an object over time

natural resource a resource that is valuable in its natural form

naturalist someone who studies nature and its history

net force the sum of all forces acting on an object

non-biodegradable does not break down in the environment

non-renewable resource a resource that can run out, or one that takes longer than a human life span to be restored

observation something you see and know to be true

oil slick a layer of oil on the surface of water

omnivore an organism that eats both animals and plants

orbit the curved path a smaller object takes around another object

ore a rock found in nature that contains metal

ore body a mineral deposit that is profitable to mine

organism an individual animal, plant or other living thing

paper chromatography a technique used to separate coloured substances using a strip of paper and a solvent

parasite an organism that lives in or on another organism, causing it harm

particle a very small amount of matter

particle model a model used to describe the properties of solids, liquids and gases

pathogen a microorganism that can cause disease

penumbra the outer part of the Moon's shadow on Earth

pesticides chemicals used on farms to protect crops by killing pests

plankton microscopic, animal-like organisms that float or drift in water

population all the living things of one species in a particular area

predator a consumer that kills and feeds on another animal

prediction a statement about the future based on observation and evidence

prey an organism that is hunted and killed by another for food

primary data first-hand data, from your own investigation

producer an organism that produces energy at the start of a food chain

prokaryote an organism without a nucleus or structures inside its cell(s)

protist a microorganism that is not a fungus or bacteria

pulley a wheel with a grooved rim for carrying a cable

pure substance a substance that is composed of only one type of particle

qualitative written descriptions and observations

quantitative numerical information and data

recycle to change something into something else that is useful

rehabilitation processes that return the environment to close to how it was before mining

reliable provides consistent results when repeated

renewable resource a resource that cannot run out, or one that can be restored in a human life span

research to gather data and information in an organised way to inform a hypothesis or investigation

residue the solid that does not pass through a filter

resource a source of something that is useful

revolve to move in a circular path around another object

risk the chance that a hazard will cause harm

rotate to spin on an axis

safety flame the orange (cooler) flame of a Bunsen burner (approx. 300°C), used between heating substances

secondary data second-hand data, from someone else

sediment the solid that settles to the bottom of a liquid

selective breeding breeding organisms with desirable traits

sewage semi-liquid human waste

sewerage pipes that carry sewage

solar energy heat and light energy from the Sun

solstice the two times each year when night and day are the most different in length

soluble something that dissolves

solute a substance that is dissolved by a solvent

solution a mixture made up of a solvent and a dissolved solute

solvent a substance that dissolves a solute

species a single, specific type of living organism

spore a tiny part of some plants that is used to reproduce

static friction a friction force that keeps an object in place on a surface

stationary not moving

substance matter that has a fixed chemical make-up

sustainable able to be maintained at a certain rate or level

sustainably to use a resource in a way that avoids depletion and maintains balance

symbiont an organism that lives with a host organism, and both organisms benefit

symbiosis a relationship between two or more organisms that live closely together

taxonomy the area of science to do with classifying organisms

temperature the measurement of how hot a substance is

thermal relating to heat

tilt a sloping position or lean

tracheophyte a plant that contains vascular tissue

transferred moved from one thing to another

umbra the inner part of the Moon's shadow on Earth

unicellular made of one cell

urbanisation the creation of urban areas such as cities

valid measures what is intended to be measured

vascular tissue plant tissue that transports fluid and nutrients

vertebrate an organism with a backbone or spinal cord

volume the amount of space taken up by something

weight the force of a gravitational field on the mass of a body

yield the amount of something that is harvested

INDEX

ACKNOWLEDGEMENTS

The author and publisher are grateful to the following for permission to reproduce copyright material:

PHOTOGRAPHS: AAP/AP, **67** (bottom), /James Ross, **110**; Alamy/Arco/TUNS, **23** (top), /Steve Bloom Images, **17** (bottom), /Martin Bond, **111** (bottom), /byvalet, **62**, /David R. Frazier Photolibrary, Inc., **58** (bottom), /The Granger Collection, **32** (Carolus Linnaeus), /Martin Harvey/Avalon/Photoshot License, **84**, /Ralph Lee Hopkins/National Geographic Image Collection, **54**, **64** (ice), /Dorling Kindersley ltd, **29** (top), /NOAA, **85** (bottom), /Pulsar Imagens **44**, **50** (housing development), /Stefan Jannides/redbrickstock.com, **105**, /Paulo Oliveira, **35** (bottom), /Gerry Pearce, **38**, **50** (snake), **48** (banksia), /robbreece/RooM the Agency, **53** (top), /Scenics & Science, **vi–vii** (top), /Simon Stone/Science Photo Library, **122** (far left), /Martin Shields, **11**, /US Coast Guard Photo, **67** (top); Antarctic Photo Library/Keith Vanderlinde/NSF, **89** (bottom); Auscape/David Wachenfeld, **49**; Getty/Auscape/Universal Images Group, **48**, /Harry How, **119** (bottom), /Hulton Archive/Stringer, **3** (bottom), /Marka/Universal Images Group, **118** (crash test dummy), /Simon McGill, **102** (recycling bin), /Photos.com, **97** (bottom), /Portra, **2** (top right), /Monty Rakusen, **3** (top), /Science Photo Library, **90**, **100** (solar system), /Science Photo Library/STEVE GSCHMEISSNER/Brand X Pictures, **43**, **50** (phytoplankton), /STR/AFP, **89** (top), /Gillianne Tedder, **112**, /Thomas Trutschel/Photothek, **83**, /Taylor Weidman/Bloomberg, **114**, /Olivia ZZ/Moment, **59** (bottom); iStock/1971yes, **130**, /abadonian, **23** (mosquito) ,**113**, /allFOOD, **86** (milk), /alvarez, **23** (humans), /amphotora, **66** (fruit), /Antagain, **32** (moss), **38**, **50** (grass, grasshopper), /ArtbyBart, **76**, /bdspn, **80** (dye), /Collin BH, **52** (ice-cream), /BlackJack3D, **79**, /Bouillante, **37**, /Brina Brunt, **34** (buffalo), /cbpix, **36**, **50** (rainbow lorikeet), /ChaoticMind75, **52** (top), /Daniiielc, **104**, **116** (wind turbines), /Daniil Dubov, **147**, /defun, **25** (bottom), /designer29, **3**, **17**, **35**, **53**, **67**, **89**, **103**, **119** (key icons) /Wenjie Dong, **111**, **116** (freeway), /dottedhippo, **iv–v** (planets), /Dr_Microbe, **16** (amoeba), /dra_schwartz, **31** (top), /ElementalImaging, **64** (hot air balloon), /EricFerguson, **52** (bricks), /fcafotodigital, **55** (top), /Floortje, **143**, /Björn Forenius, **16** (plant), /fotosr, **47**, /Fyletto, **31** (bottom), /GCapture, **176**, /gilaxia, **121**, /GlobalP, **iv** (bottom), **23** (dogs), **25** (top), /Guasor, **40**, /Halfpoint, **2** (bottom left), /hdagli, **107**, /Henrik_L, **41** (top), /HRAUN, **i**, **45**, /iagodina**,** **23** (cats), /idizimage, **iv–v** (top), /Imagvixen, **102** (wind turbines), /imamember, **92**, /industryview, **73** (bottom), /IPGGutenbergUKLtd, **2** (top left), /ISvyatkovsky, **53** (bottom), /ithinksky, **23** (wheat), **39** (top), /jessicaphoto, **96** (bottom), /jgroup, **97** (top), /joingate, **9** (left), /JoKMedia, **151** (string), /kaanates, **23** (peas), /keiichihiki, **34** (fungus), /Kerrick, **50** (flowers), /Viktor_Kitaykin, **28**, **32** (fungi) /Kuzmik_A, **66** (top), **70**, /kyoshino, **151** (beaker), **182** (cup), /lightpix, **34** (hummingbird), /NeilLockhart, **182** (marbles), /Loren Mariani, **103** (bottom), /lovleah, **39** (bottom), /LuCaAr, **41** (bottom), /luoman, **102** (deforestation), /malerapaso, **102** (top), /gonzalo martinez, **88** (eclipse), /Tom Merton, **102** (petrol pump), /Mark Murphy, **6**, **15** (scalpel), /MarkMirror, **34** (top), /mayakova, **162**, /MicrovOne, **60** (top), **64** (matter diagram), /mmz, 138 (car), /monkeybusinessimages, **9** (right), /Moof, **72**, /nechaev-kon, **16** (beetle), /DonNichols, **50** (decomposer), **182** (tape), /ClaraNila, **27** (bottom), /SerrNovik, **133**, /Okea, **149**, **73** ,**86** (water splash), /ooyoo, **108**, **116** (flower), /ourlifelooklikeballoon, **6** (electronic balance, mortar and pestle), /Bill Oxford, **52** (kettle), /Tatiana Pankova, **6**, **15** (thermometer), /Darryl Peroni, **116** (oil rig), /UroshPetrovic, **146**, /Pgiam, **179**, /pinkomelet, **66** (glass), /pixdeluxe, **118** (skateboarder), /pjmorley, **91**, **100** (earth), /pusit771, **4** (top), /Tetiana Rostopira, **104** (cotton), /Rost-9D, **42** (left), **50** (bacteria), /Chris Ryan, **122** (bottom), /PeterJamesSampson, **24**, /Satirus, **29** (bottom), /Sebalos, **66** (salt), /sestovic, **88** (winter forest), /shapecharge, **32** (woman), /shironosov, **118** (weight lifter), /sidewaysdesign, **77**, /CarolinaSmith, **88** (top), /Thomas-Soellner, **59** (top), /Spiderstock, **177**, /spukkato, **78**, **86** (salt), /Ilya_Starikov, **151** (balloon), /stockcam, 118 138 (tennis ball), /Suzifoo, **85**, **86** (hand), /t_kimura, **71**, **86** (snow globe), /taesmileland**,** **151** (ruler), **182** (ruler), /the_guitar_mann, **58** (top), /themacx, **54** (brick wall), /Wesley Tolhurst, **38**, **50** (eagle), /Totojang, **2** (bottom right), /Turnervisual, **38**, **50** (lizard), /Userf3a77fbe_741, **66** (coffee), /ValentynVolkov, **52** (ice cubes), /vasiliybudarin, **69**, /VIDOK, **142**, /ThomasVogel, **15**1 (flask), /volschenkh, **5**, **14** (bunsen burner), /wavebreakmedia, **4** (bottom),**126**, /wavipicture, **16** (toadstools), /Noppasin Wongchum, **27** (top), /xijian, **88** (stars), /xxmmxx, **143** (left), /yakochun, **7** (bottom), **140**, /zetter, **109**, /zmeel, **57**, /zoranm, **34** (fish), /Михаил Руденко, **118** (astronaught); Patrick J. Krug, **17** (top); NASA, **88** (earth), **98**, **99**, **100** (hubble); Nature Picture Library/MYN/Niall Benvie, **16** (top), **20, 21**, **26** (bottom), **32** (lizard, flower); Shutterstock/3dmitruk, **120**, **138** (table), /Akimov Igor, **10**, /ANGHI, **26** (top), /Ann.and.Pen, **18**, **32** (bears), /Benoist, **119** (top), /Orhan Cam, **35** (top), /Dja65, **60** (bottom), /Fablok, **160**, /Pat_Hastings, **63**, **153**, /Daniel Jedzura, **82**, **86** (water purification), /Kamenetskiy Konstantin, **122** (top), **138** (skateboarder), /Kateryna Kon, **30**, **32** (bacteria), /ValentinaKru, **96** (top), /Winston Link, **7** (top), **14** (microscope), /luca pbl, **46**, **50** (tractor), /Gabriele Maltinti, **123**, /Soleil Nordic, **6** (forceps, stand, clamps iron ring), /NsdPower, **182** (marker), /Nsit, **6** (safety glasses), /Pattikky, **23** (bacteria), **32** (algae), /Vladimir Sazonov, **56**, /Spasiblo, **135** (top left), **135** (top right), **138** (crumpled car); Science Photo Library, **2**, (top), **55** (bottom)/Wim Van Egmond, **42** (right), /GEOFF TOMPKINSON, **80**, **86** (scientist), /ZEPHYR, **128**.

OTHER MATERIAL: The Victorian Curriculum F-10 content elements are © VCAA, reproduced by permission. The VCAA does not endorse or make any warranties regarding this resource. The Victorian Curriculum F-10 and related content can be accessed directly at the VCAA website, https://victoriancurriculum.vcaa.vic.edu.au/, **vi–vii**.

The author and publisher would like to acknowledge the following: V.E. Vasquez, D.A. Ebert, & D.J. Long. 2015. Etmopterus benchleyi n. sp., a new lanternshark (Squaliformes: Etmopteridae) from the central eastern Pacific Ocean. 'Journal of the Ocean Science Foundation' 17: 43-55, **19**; COLAS/Robert Brice, **103** (top).

While every care has been taken to trace and acknowledge copyright, the publisher tenders their apologies for any accidental infringement where copyright has proved untraceable. They would be pleased to come to a suitable arrangement with the rightful owner in each case.