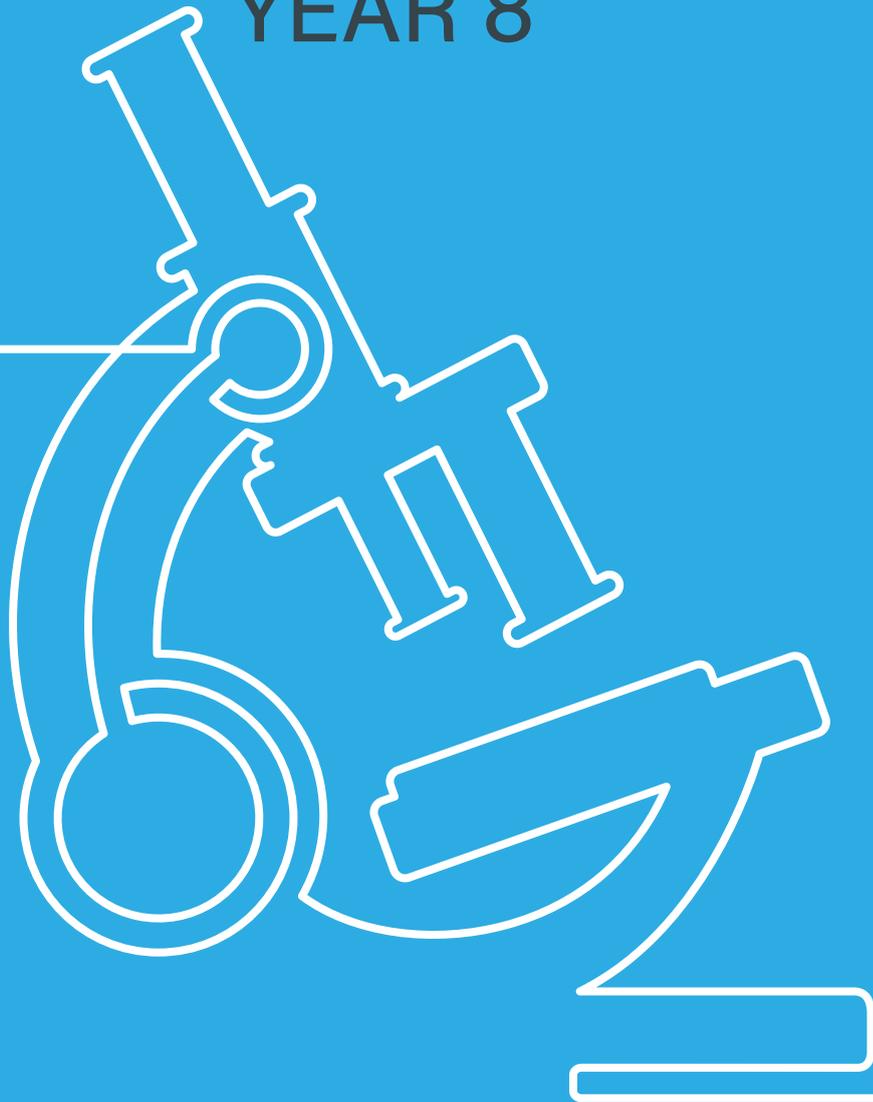


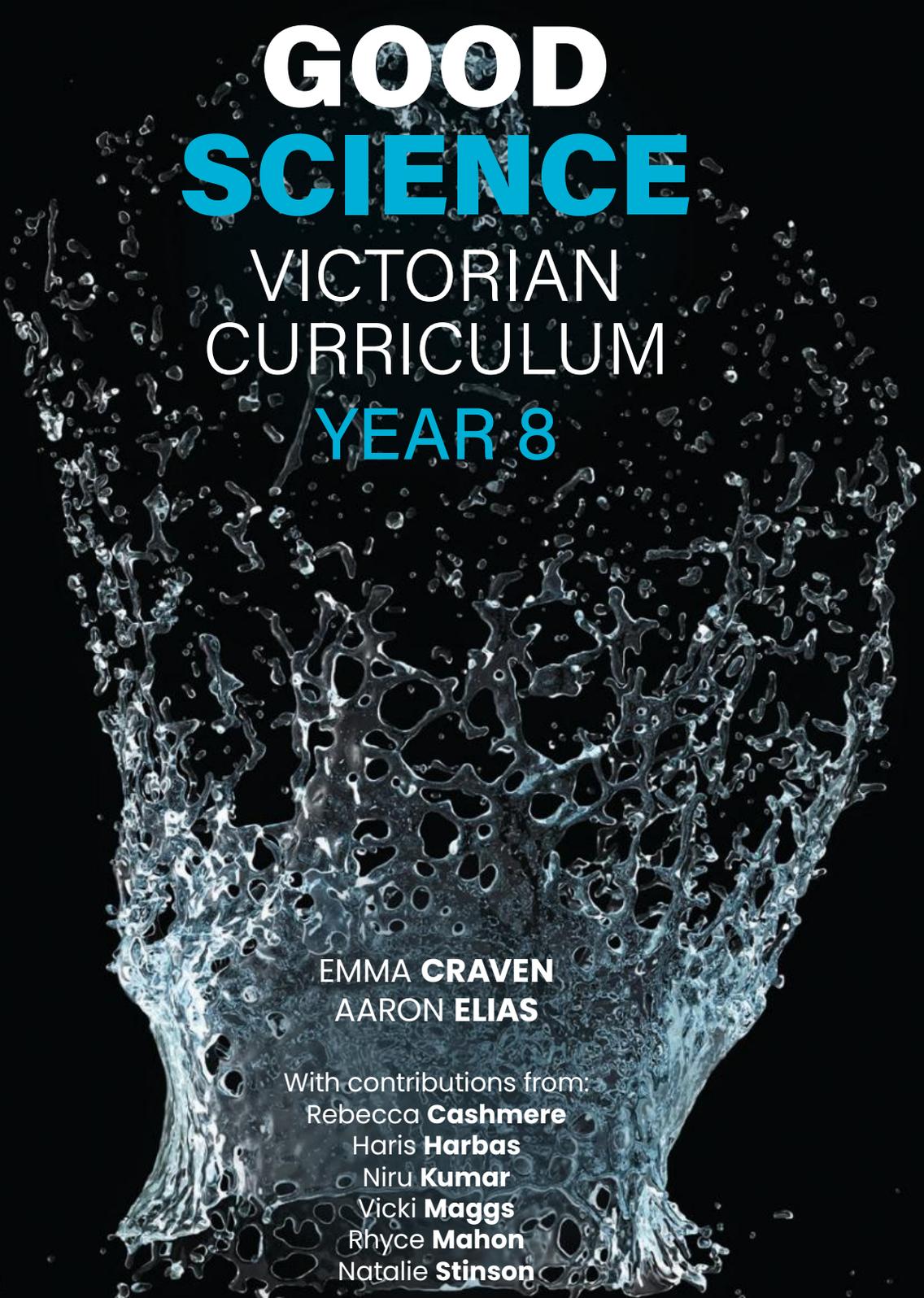
# **GOOD SCIENCE**

VICTORIAN  
CURRICULUM

**YEAR 8**



**EMMA CRAVEN  
AARON ELIAS**



# GOOD SCIENCE

VICTORIAN  
CURRICULUM  
YEAR 8

EMMA CRAVEN  
AARON ELIAS

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Good Science 8 Victorian Curriculum

1st edition

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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

Cover illustrator: Dominic D'Monte

Production controller: Sarah Blake

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

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#### **National Library of Australia Cataloguing-in-Publication data**

Author: Emma Craven, Aaron Elias

Title: Good Science Victorian Curriculum 8

ISBN: 9780655090038

A catalogue record for this book is available from the National Library of Australia at [www.nla.gov.au](http://www.nla.gov.au)

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MAKE EVERY  
LESSON A  
**GOOD**  
LESSON



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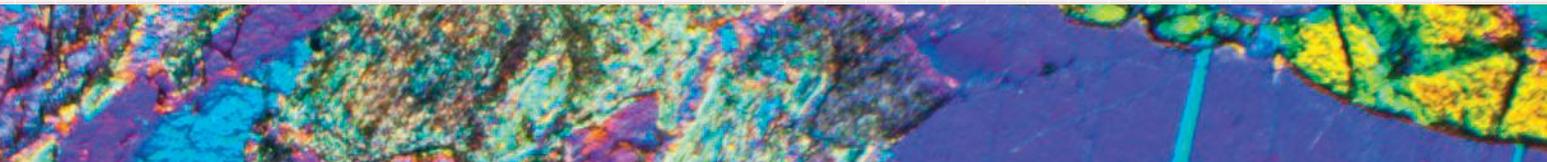
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# CURRICULUM CORRELATION GRID

VICTORIAN CURRICULUM SCIENCE LEVELS 7 AND 8		
<b>SCIENCE UNDERSTANDING: SCIENCE AS A HUMAN ENDEAVOUR</b>		
<b>VCSSU089</b>	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	<ul style="list-style-type: none"> <li>Chapter 3: The structure and properties of matter</li> <li>Chapter 4: Chemical change</li> <li>Chapter 5: Water as a resource</li> <li>Good Science 7</li> </ul>
<b>VCSSU090</b>	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	<ul style="list-style-type: none"> <li>Chapter 2: Body systems</li> <li>Chapter 4: Chemical change</li> <li>Good Science 7</li> </ul>
<b>SCIENCE UNDERSTANDING: BIOLOGICAL SCIENCES</b>		
<b>VCSSU091</b>	There are differences within and between groups of organisms; classification helps organise this diversity	<ul style="list-style-type: none"> <li>Good Science 7</li> </ul>
<b>VCSSU092</b>	Cells are the basic units of living things and have specialised structures and functions	<ul style="list-style-type: none"> <li>Chapter 1: Cells</li> </ul>
<b>VCSSU093</b>	Interactions between organisms can be described in terms of food chains and food webs and can be affected by human activity	<ul style="list-style-type: none"> <li>Good Science 7</li> </ul>
<b>VCSSU094</b>	Multicellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce	<ul style="list-style-type: none"> <li>Chapter 2: Body systems</li> </ul>
<b>SCIENCE UNDERSTANDING: CHEMICAL SCIENCES</b>		
<b>VCSSU095</b>	Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques	<ul style="list-style-type: none"> <li>Good Science 7</li> </ul>
<b>VCSSU096</b>	The properties of the different states of matter can be explained in terms of the motion and arrangement of particles	<ul style="list-style-type: none"> <li>Good Science 7</li> </ul>
<b>VCSSU097</b>	Differences between elements, compounds and mixtures can be described by using a particle model	<ul style="list-style-type: none"> <li>Chapter 3: The structure and properties of matter</li> </ul>
<b>VCSSU098</b>	Chemical change involves substances reacting to form new substances	<ul style="list-style-type: none"> <li>Chapter 4: Chemical change</li> </ul>
<b>SCIENCE UNDERSTANDING: EARTH AND SPACE SCIENCES</b>		
<b>VCSSU099</b>	Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the Sun, Earth and the Moon	<ul style="list-style-type: none"> <li>Good Science 7</li> </ul>
<b>VCSSU100</b>	Some of Earth's resources are renewable, but others are non-renewable	<ul style="list-style-type: none"> <li>Good Science 7</li> </ul>
<b>VCSSU101</b>	Water is an important resource that cycles through the environment	<ul style="list-style-type: none"> <li>Chapter 5: Water as a resource</li> </ul>
<b>VCSSU102</b>	Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales	<ul style="list-style-type: none"> <li>Chapter 6: Earth and the rock cycle</li> </ul>



VICTORIAN CURRICULUM SCIENCE **LEVELS 7 AND 8**

SCIENCE UNDERSTANDING: PHYSICAL SCIENCES

<b>VCSSU103</b>	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	<ul style="list-style-type: none"> <li>• Good Science 7</li> </ul>
<b>VCSSU104</b>	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	<ul style="list-style-type: none"> <li>• Chapter 7: Energy</li> </ul>
<b>VCSSU105</b>	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	<ul style="list-style-type: none"> <li>• Chapter 7: Energy</li> </ul>
<b>VCSSU106</b>	The properties of sound can be explained by a wave model	<ul style="list-style-type: none"> <li>• Chapter 7: Energy</li> </ul>

SCIENCE INQUIRY SKILLS: QUESTIONING AND PREDICTING

<b>VCSIS107</b>	Identify questions, problems and claims that can be investigated scientifically and make predictions based on scientific knowledge	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>
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SCIENCE INQUIRY SKILLS: PLANNING AND CONDUCTING

<b>VCSIS108</b>	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>
<b>VCSIS109</b>	In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>

SCIENCE INQUIRY SKILLS: RECORDING AND PROCESSING

<b>VCSIS110</b>	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	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>
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SCIENCE INQUIRY SKILLS: ANALYSING AND EVALUATING

<b>VCSIS111</b>	Use scientific knowledge and findings from investigations to identify relationships, evaluate claims and draw conclusions	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>
<b>VCSIS112</b>	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	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>

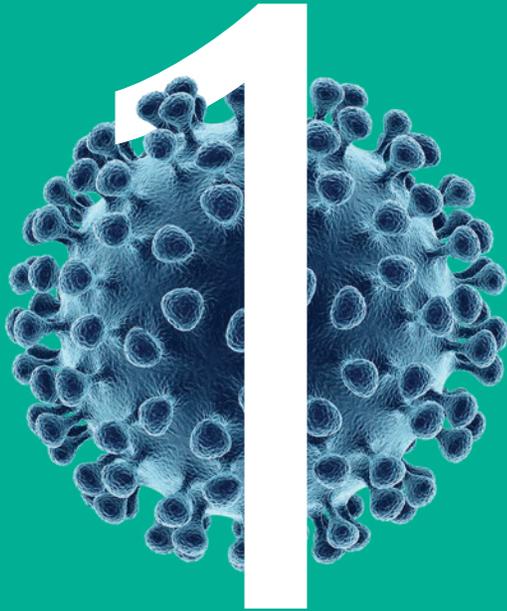
SCIENCE INQUIRY SKILLS: COMMUNICATING

<b>VCSIS113</b>	Communicate ideas, findings and solutions to problems including identifying impacts and limitations of conclusions and using appropriate scientific language and representations	<ul style="list-style-type: none"> <li>• Skills and investigations</li> <li>• Good Science 7</li> </ul>
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# CELLS

How does life result from the structure and function of cells?

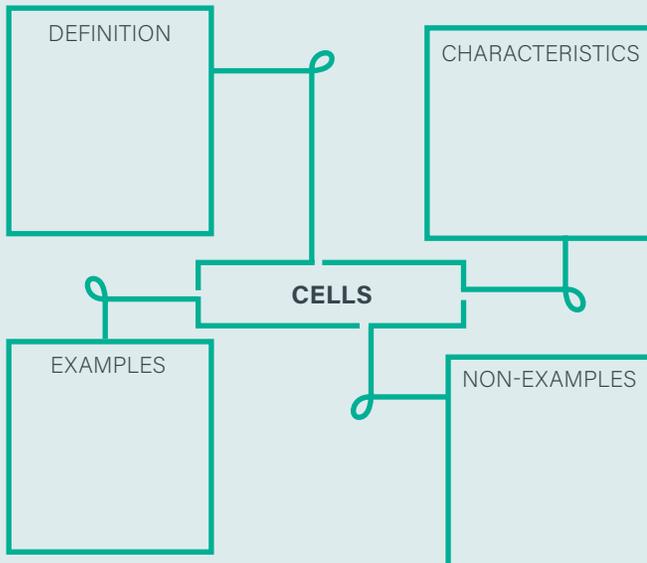


All living things are made of cells, which is why cells are commonly known as the ‘building blocks of life’. However, a cell in an animal looks and acts very differently to a cell in a plant.

There are many different types of cells – even within the human body. They all look very different because they have very different jobs to do. Nerve cells send messages around your body from and to your brain, so they have special features. Blood cells carry oxygen around your body, so they look different too.

## 1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Organelles* and *Unicellular*.

## 2 LEARNING LINKS

Brainstorm everything you already know about cells.



### 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 ...** you found a way to stop cells from ever dying?



**PREDICTION:** What could happen if the nerve cells in your body stopped working?



**THE COMBINATION:** List the features of cells and a mobile phone in two lists. Now combine these features to create a new, single object.

### 5 THE BIGGEST AND THE SMALLEST!

The biggest cell in the human body is the female egg cell (ovum). These cells are about as wide as the thickness of a human hair. The body's smallest cell is the male sperm cell.

Females are born with all the egg cells they will ever have. Males, on the other hand, create millions of new sperm every day after reaching puberty. In females that may have babies, an egg cell will be released once each month. If sperm are present, they will race against each other to try to be the first to reach the egg. The winning sperm will dissolve the outside of the egg and wiggle in to possibly start a new life.



## 1.1

## WHAT ARE CELLS?

## LEARNING INTENTION

At the end of this lesson I will be able to describe cells and some of their key features.

## KEY TERMS

**cell**

the smallest functional unit of an organism

**microscope**

an instrument used to look at objects too small to see with the naked eye

**nucleus**

the control centre of a cell; DNA is found inside the nucleus

**organelle**

a cell structure that has a membrane around it (usually)

**theory**

an explanation that can be supported or disproved using evidence

## LITERACY LINK

**VOCABULARY**

Identify three adjectives (describing words) from this section. Suggest replacement words for all three.

## NUMERACY LINK

**UNITS**

A particular cell is 0.000025 metres wide. Convert this width into millimetres.

Hint: 1 m = 1000 mm

**Cells** are the smallest structural and functional units of living things. This means that they are the smallest part of a living thing that can carry out the functions needed for life, all on their own.

All living things, from the largest and most complex organisms to the smallest and least complex, are made of cells.

## 1 Living things have one or more cells, which come from other cells

Cells were first identified in 1665 by Robert Hooke, an English scientist. He was using a simple microscope to study the bark of a cork tree. The tiny structures he could see through the microscope reminded him of the tiny rooms that monks slept in, also called cells.

Even after cells had been discovered, scientists weren't sure whether all organisms were made of cells. It wasn't until 1839 that scientists developed the 'cell theory', which was based on three ideas:

- All living things are made of one or more cells.
- Cells are the basic building blocks of life.
- Cells arise from cells that already exist.

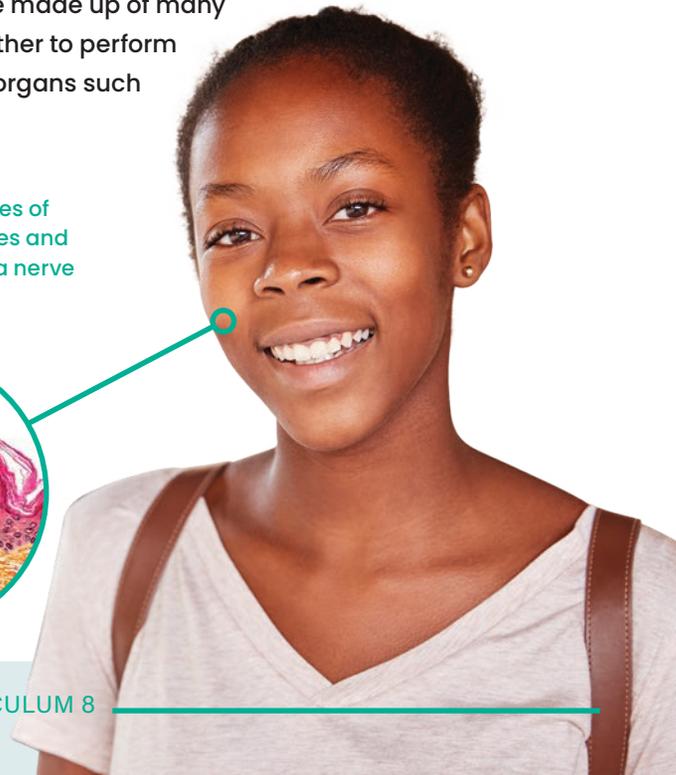
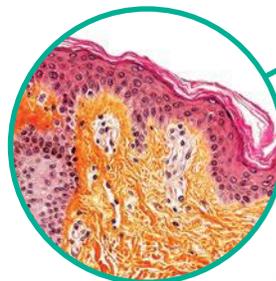
This **theory** helped people to start thinking about living things, and where life comes from, in a scientific way. All of the evidence and discoveries made since then have confirmed the cell theory.

### *What does the cell theory tell us about living things?*

## 2 Cells are the building blocks of life

Cells are the basic building blocks of all living things. Sometimes a single cell is a complete – but very simple – organism itself. More complex organisms are made up of many different cells that work together to perform different functions, creating organs such as bones and hearts.

**Figure 1.1** There are different types of cells, each with different purposes and jobs. This skin cell is different to a nerve cell or a red blood cell.

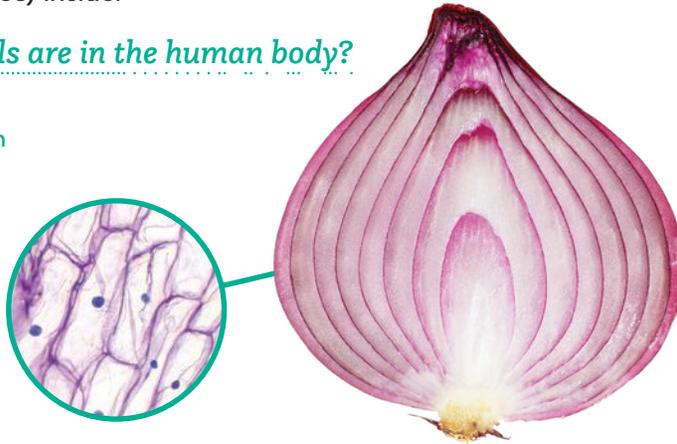


Your body is made up of roughly 32.7 trillion cells. They provide structure, take in nutrients from food and change those nutrients into energy, as well as many other functions. Nearly all your cells contain your genetic material and can make copies of themselves. This allows you to grow new cells in order to replace old or damaged cells or for growth.

Plants are also made up of cells. Their cells have some different features to animal cells, but the cells of plants also have many similarities to those of animals. Both plant and animal cells have a **nucleus** as well as many of the same membrane-bound structures (called **organelles**) inside.

### How many cells are in the human body?

**Figure 1.2** An onion is made of many cells. The cells in a thin layer of onion membrane can be seen using a microscope.



## 3 Microscopes allow us to see and identify cells

Cells can vary a lot in size. The largest cells in the world are ostrich eggs – a single unfertilised egg cell is about 15 cm wide and weighs more than a kilogram! Red blood cells are only 0.008 mm wide – a line of 125 red blood cells is only 1 mm long. Most cells are about this size – far too small for you to see with just your naked eye.

A **microscope** can be used to see cells. The word comes from two Ancient Greek terms: *micro*, which means ‘small’, and *scope*, which means ‘to see’. So a microscope is a tool for looking at small things.

The most common type of microscope in the science laboratory is a light microscope. It allows scientists to study cells by shining a bright light through an extremely thin slice of tissue taken from an organism. The image is magnified by the microscope’s lenses, which scientists look through.

Scientists use chemicals called stains to artificially colour some of the parts of cells. This makes them easier to see under the microscope. In Figure 1.2, a purple stain has been used to colour the onion cell.

Most cell parts can’t be seen under a light microscope because they are too small. Parts of a cell that can be seen under a light microscope include the cell wall, cell membrane, nucleus and chloroplast.

### What is the name of the scientific instrument used to study cells?

#### INVESTIGATION 1.1

Examining cells under a microscope

**KEY SKILL**  
Identifying and managing relevant risks



► Go to page 132

#### CHECKPOINT 1.1

- Cells are described as ‘the building blocks of life’. Suggest why.
- Copy and complete the following sentence.  
Cell theory is made of \_\_\_\_\_ ideas: all \_\_\_\_\_ things are made of \_\_\_\_\_; cells are the \_\_\_\_\_ and cells come from \_\_\_\_\_ that already \_\_\_\_\_.
- Identify three different types of cells.
- Name the scientist who first identified cells.
- Explain why a microscope is necessary to view cells.
- Rewrite the main ideas of cell theory in your own words.
- Suggest why plant and animal cells have some things in common but also many features that are unique.

#### RESEARCH

- Research and provide a summary of how microscopes have led to a better understanding of cells, and how this has led to improved medical treatments for disease.

#### SUCCESS CRITERIA

- I can explain what cells are.
- I can identify what kinds of things are made of cells.

# 1.2

## THE STRUCTURE OF CELLS

### LEARNING INTENTION

At the end of this lesson I will be able to identify structures within cells and describe their function.

### KEY TERMS

**cell membrane**

a thin layer around a cell that controls the substances going in and out

**cell wall**

a stiff layer around a plant or fungal cell that supports the cell

**chloroplast**

a small organelle that allows plants to make food

**cytoplasm**

a jelly-like fluid in which the other parts of a cell sit

### LITERACY LINK

**LISTENING**

Find an image online of an organelle of your choice. Describe the image to a partner, while they attempt to draw it from your description. Then swap roles and try to draw a different organelle described by your partner.

### NUMERACY LINK

**MEASUREMENT**

The cells in Figure 1.4 have been magnified by 300 times. Measure their length using a ruler, then calculate the actual size of the cells.

Think about the city where you live or a city near to your home – what keeps it running? A city only runs successfully when the separate parts all do their jobs well. At the city hall people make and communicate decisions; in factories important items are made; on farms food is grown; and in power plants energy is produced to keep the city going.

In the same way, cells are made up of different parts that each have a particular role.

## 1 Animal and plant cells have a nucleus, cytoplasm and cell membrane

Each part of a cell has a particular function (job) that helps keep the cell healthy.

There are many different cell structures, just as there are different organs in the body. There are some structures that every cell has, while there are others that only some organisms have.

All animal and plant cells have these three structures:

- The nucleus is the central part of the cell, and it controls all the cell’s activity. DNA, the genetic material, is found inside the nucleus. The nucleus is an example of an organelle, a structure surrounded by a membrane.
- The **cytoplasm** is a jelly-like fluid in which other cell structures sit. Many of the chemical reactions in a cell happen in the cytoplasm.
- The **cell membrane** is a flexible envelope that surrounds the cell. It controls substances going into and out of a cell.

### What are the main cell parts and why do cells need them?

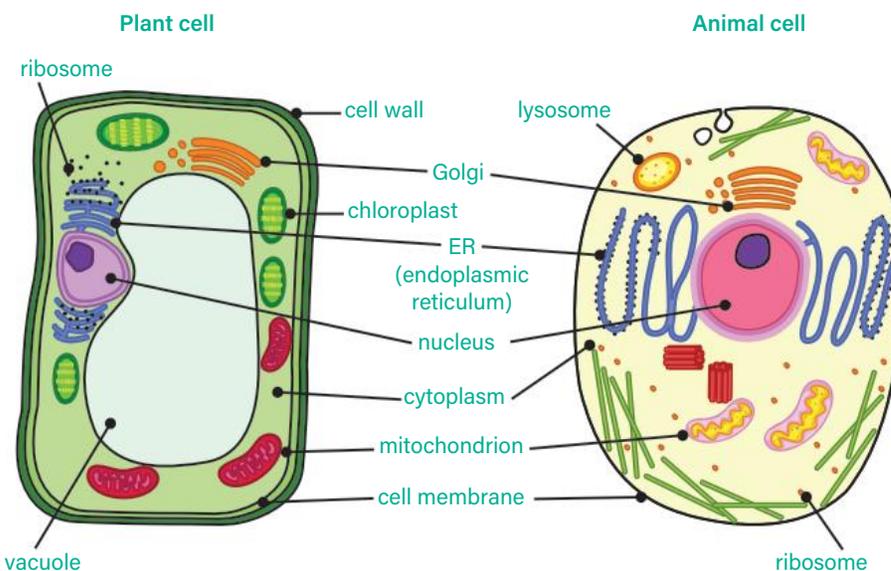
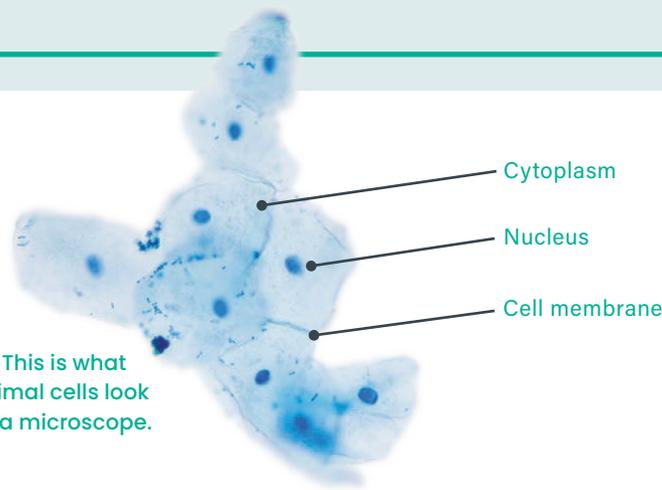


Figure 1.3 Animal and plant cells have some features in common.



**Figure 1.4** This is what typical animal cells look like under a microscope.

## 2 Plant cells have a cell wall and chloroplasts

There are many obvious differences between plants and animals.

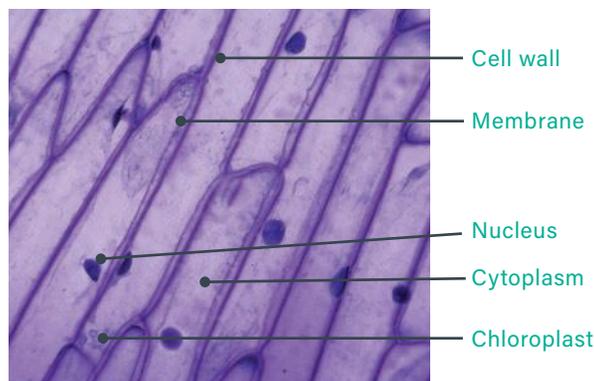
No-one is likely to confuse a cat with a cactus, or a shark with seaweed!

Some differences are not obvious, such as the structures inside plant cells. Plant cells have a nucleus, cytoplasm and cell membrane, just like animal cells, but they have two parts that animal cells do not:

- The **cell wall** is a stiff layer around the cell, outside the cell membrane. It is made of cellulose and helps to protect and support the cell.
- **Chloroplasts** are organelles that act as energy producers. They allow plants to make sugar using the Sun's energy.

Animal cells don't have these structures because they don't need them. Animals have a skeleton or structure to support themselves, and they can move around to get food.

**Figure 1.5** This is what typical plant cells look like under a microscope.

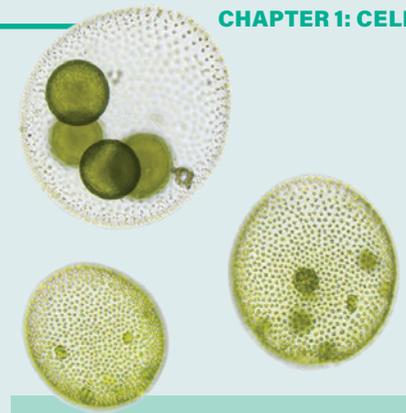


*How are plant cells different to animal cells?*

## 3 Fungal cells are similar to plant cells

You might remember from your studies of classification that fungi are classified separately from plants and animals. In some ways fungal cells are similar to both plant and animal cells – they have a nucleus, cytoplasm, a cell membrane and mitochondria to make energy. Fungal cells also have a cell wall like plant cells, but in fungal cells the cell wall is made of chitin instead of cellulose.

*How are fungal cells different from plant cells?*



### CHECKPOINT 1.2

- 1 Describe what organelles are and give at least two examples.
- 2 Copy and complete the following table.

Structure	Function
nucleus	
cytoplasm	
cell membrane	
cell wall	
chloroplast	

- 3 Identify three structures that are common to both plant and animal cells.
- 4 Which organelles do plant cells have that animal cells don't?
- 5 Suggest why plant cells have a cell wall but animal cells do not.
- 6 How are fungal cells different to plant cells?
- 7 What is the function of a chloroplast? Suggest why animals do not have them.

### EXTENSION

- 8 Draw a diagram of a typical plant cell and a typical animal cell. Annotate the differences between the two cells.

### SUCCESS CRITERIA

- I can state the function of a:
  - nucleus
  - cell membrane
  - cell wall
  - chloroplast
  - cytoplasm.

# 1.3

## WHY CELLS NEED ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to describe why cells need energy and how they obtain it.

### KEY TERMS

**aerobic respiration**

how living organisms produce energy using oxygen

**chlorophyll**

the green pigment in chloroplasts that enables photosynthesis

**mitochondria**

the organelles where respiration happens

**multicellular**

made of more than one cell

**photosynthesis**

the chemical reaction, powered by sunlight, that plants use to change carbon dioxide and water into sugars and oxygen

**stomata**

pores on the surface of a leaf; the site of gas exchange in plants

### NUMERACY LINK

**GRAPHING**

Ron put five plants of the same height in different amounts of shade, measuring their heights after a week. His results were 100% shade: 12 cm, 75% shade: 13 cm, 50% shade: 15 cm, 25% shade: 18 cm and 0% shade: 24 cm. Show this data in a bar chart.

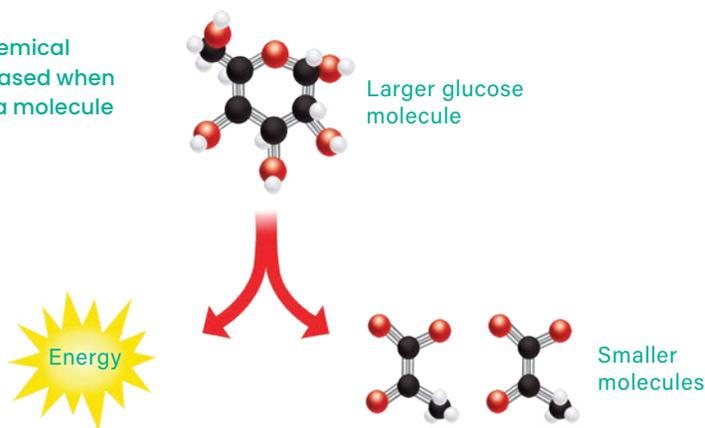
**Multicellular** organisms are made up of many different types of cells, carrying out specialised functions for survival.

To perform these functions, cells need a constant supply of energy. Animal cells get their energy from food, and plant cells get their energy from sunlight. The energy from these sources is gained by cells using chemical reactions.

## 1 All cells need energy to survive

Without a continuous supply of energy, cells can't perform important functions, and they die. The only type of energy that cells can use is chemical energy. A major source of chemical energy for multicellular organisms is obtained by breaking the bonds of glucose, a type of sugar molecule.

**Figure 1.6** Chemical energy is released when the bonds of a molecule are broken.



Chemical energy is stored in the bonds of glucose molecules and released when the bonds are broken. Animals get most of their glucose from their food. Other organisms, such as plants, convert energy from the Sun into glucose.

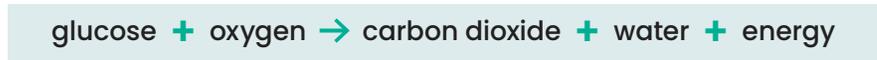
### What form of energy can cells use?

## 2 Respiration is how cells make energy

To release the energy from glucose and other energy-rich molecules, all living cells use the chemical process of respiration. Cells can carry out two main forms of respiration: **aerobic respiration**, which uses oxygen, and anaerobic respiration, which happens without oxygen.

Aerobic respiration provides multicellular organisms with most of their energy. It takes place mostly in cell organelles called **mitochondria**. Because energy is being released during respiration, the mitochondria are often called the powerhouses of a cell. The number of mitochondria in a cell is usually related to the functions of the cell.

The overall process of aerobic respiration can be summarised as:



In animals, glucose is obtained from food and oxygen is taken in from the environment across special surfaces such as lungs or gills. Both substances move into the blood and then to the cells. Plants absorb most of the oxygen they use through their leaves.

In all living cells, the chemical energy produced during respiration is transported to the parts of the cell that need it, while the carbon dioxide and water are removed from the cell.

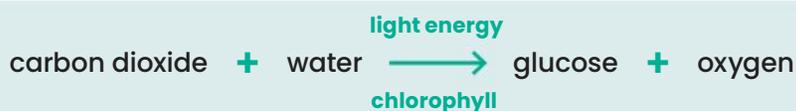
### What is the formula for cellular respiration?

## 3 Photosynthesis is how plants make food

Plants rely on **photosynthesis** to make their own food, using light energy, water and carbon dioxide.

One of the main reasons they are able to do this is because their cells have special structures called chloroplasts. Chloroplasts contain **chlorophyll**, a green pigment that absorbs light energy.

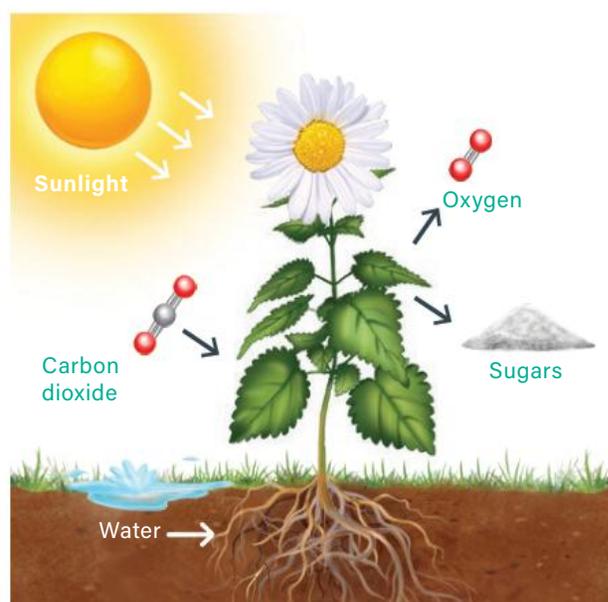
The overall process of photosynthesis can be summarised as:



To fuel photosynthesis, light energy from the Sun is absorbed by chlorophyll within a plant's cells. This energy is then used to change water (absorbed through the roots) and carbon dioxide (absorbed from the surrounding air or water) into oxygen and glucose (or other sugars).

The glucose produced from this reaction is either used in respiration or stored for later use. The oxygen moves into the environment through special pores (openings) in the leaves called **stomata**, or it is used during respiration.

### What are the substances needed for photosynthesis?



**Figure 1.7**  
During photosynthesis, sunlight enables a plant to transform water and carbon dioxide into oxygen and glucose.

### INVESTIGATION 1.3

#### Photosynthesis and respiration

**KEY SKILL**  
Representing and recording data using a table

► Go to page 133



### CHECKPOINT 1.3

- 1 What form of energy is usable by cells?
- 2 Where is energy stored in molecules and how is it released?
- 3 Where do plants get the carbon dioxide and water for photosynthesis?
- 4 Where do animals get the glucose and oxygen for respiration?
- 5 Explain the role of chloroplasts in photosynthesis.
- 6 True or false?
  - a The special pores on a leaf's surface are called stomata.
  - b Carbon dioxide gas exits plant leaves and goes into the atmosphere.
  - c During photosynthesis, water is split into hydrogen and oxygen gases.
  - d During photosynthesis, light energy is used to generate chemical energy.
  - e Photosynthesis is an energy-producing reaction.

### CONNECTING IDEAS

- 7 Explain the relationship between photosynthesis and cellular respiration.

### SUCCESS CRITERIA

- I can state the word equations for respiration and photosynthesis.
- I can explain where multicellular organisms obtain the materials required for respiration and photosynthesis.

# 1.4

## HOW CELLS MAKE ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to explain how energy is created for cell activities.

### KEY TERMS

#### glucose

a type of sugar that is the energy source for cells

#### respiration

a chemical reaction that converts glucose to energy

### LITERACY LINK

#### READING

Write a tweet to summarise cellular respiration in 280 characters or less.

### NUMERACY LINK

#### DATA

Liz measured the number of oxygen bubbles produced per minute by an underwater plant to test the rate of photosynthesis under different amounts of light. She measured 12, 14, 16, 17 and 23 bubbles. Did she increase or decrease the amount of light between each measurement? How can you tell?



**Respiration** is a chemical reaction that happens in all living cells of plants and animals. The energy that cells need to live is stored in **glucose**, which is a type of sugar.

Through respiration, energy is released from glucose so that all the chemical processes needed for life can happen.

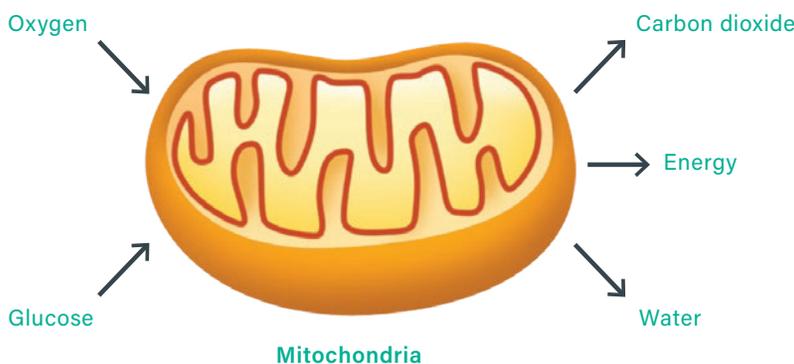
## 1 Respiration happens in mitochondria

Respiration happens in organelles called mitochondria, which are found in both plant and animal cells. Mitochondria are called the ‘powerhouses’ of cells because they take in nutrients from cells, break them down and change them into energy that cells can use. Animals and plants don’t respire in the same way, and they gain energy from different nutrients, but mitochondria have the same purpose in all species.

Mitochondria are extremely tiny. Some cells have several thousand mitochondria because they need a lot of energy, such as muscle cells in animals. Other cells have lower energy needs, so they have fewer mitochondria or none at all.

### *In which part of a cell does respiration happen?*

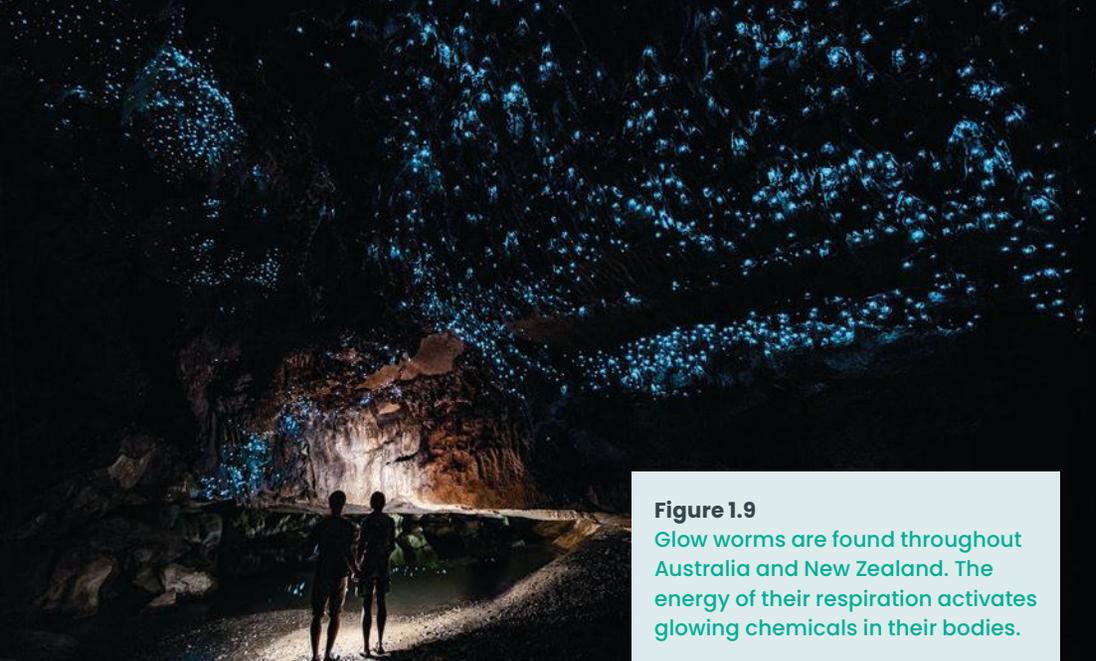
**Figure 1.8** Glucose and oxygen are needed for cellular respiration. Carbon dioxide, water and energy are produced.



## 2 Respiration uses glucose and oxygen

Oxygen and glucose are needed for respiration. During respiration, glucose combines with oxygen to form carbon dioxide, water and energy. Carbon dioxide and water are the waste products.

During the day, in plants, oxygen and glucose are produced by photosynthesis. Extra glucose is stored in plants as oils, fats and starch. At night, plants do not photosynthesise because sunlight isn’t available. During the night, plants use oxygen taken in through their leaves or made during photosynthesis, and they use glucose from their stored starch.



**Figure 1.9**  
Glow worms are found throughout Australia and New Zealand. The energy of their respiration activates glowing chemicals in their bodies.

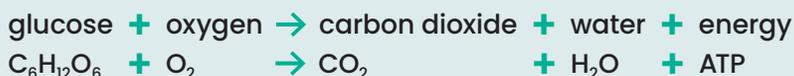
The process of respiration is different for animals. They breathe in oxygen as part of the air, and it enters their cells through their blood. The glucose needed for respiration is found in the blood. It comes from food that animals eat and digest.

The energy released during respiration is used in many different ways. Animals, including humans, use it in their cells to power any activities or work they undertake. Plants don't require as much energy as animals do, but they still use energy for cellular action, such as absorbing salts from the ground or moving nutrients through their systems.

### What are the two substances that mitochondria need for respiration?

## 3 Respiration is a chemical reaction

Respiration is a chemical reaction, and so it can be represented using a chemical equation. In any chemical equation, the reactants (the substances that change) are shown on the left-hand side of the arrow. The products (the substances formed) are shown on the right-hand side:



Oxygen and glucose are transported into the mitochondria, where the chemical reaction happens. Carbon dioxide, water and energy leave the mitochondria. The energy is carried in a substance called adenosine triphosphate, or ATP.

Cells need to remove carbon dioxide because it reacts with water to make an acid. Too much acid is toxic to cells. To prevent this, animals release carbon dioxide when they breathe out, while plants release it through the surfaces of their leaves when they respire.

### Why do cells need to get rid of carbon dioxide?

#### INVESTIGATION 1.4A

Cellular respiration  
in yeast

KEY SKILL  
Representing data

► Go to page 134



#### INVESTIGATION 1.4B

Energy from food

KEY SKILL  
Identifying the  
independent and  
dependent variables

► Go to page 135

## CHECKPOINT 1.4

- 1 Define *respiration*.
- 2 What two reactants are needed for respiration to happen?
- 3 What are the three things generated during respiration?
- 4 What is the main purpose of respiration?
- 5 Write both a word and a chemical equation for respiration.
- 6 What form of energy can be used by cells?
- 7 True or false? 'Respiration is the burning of food to release energy.' Explain your choice.

## CONNECTING IDEAS

- 8 Suggest what happens to the carbon dioxide produced in respiration.

## SUCCESS CRITERIA

- I can explain what respiration is and why it is important.
- I can identify the equation for respiration.
- I can state where respiration occurs.

# 1.5

## CELL DIVISION

### LEARNING INTENTION

At the end of this lesson I will be able to outline the role of cell division in growth, repair and reproduction in multicellular organisms.

### KEY TERMS

#### cancer

the uncontrolled growth of cells in some part of the body, which then spreads to other body parts

#### chromosome

a thread-like molecule of genetic information in the nucleus of a cell

#### meiosis

complex cell division, where new cells are not identical to the original cell

#### mitosis

simple cell division, where new cells are identical to the original cell

### LITERACY LINK

#### VOCABULARY

Use the four key terms above to create a mind map. Link the terms with a line, writing along the line what the link is. You may add as many additional terms as you like.

### NUMERACY LINK

#### CALCULATION

Stomach cells last for an average of 5 days. How many times will each stomach cell have regenerated over the lifetime of a 70-year-old person?

You started your life as an egg cell fertilised by a sperm cell. This egg cell divided into two, then four, then eight, and so on, until you eventually became the roughly *32.7 trillion* cells that you are today.

None of this would have been possible without cell division. Cells can divide by **mitosis** or **meiosis**. These processes are important for organisms to grow, repair body tissues and reproduce.

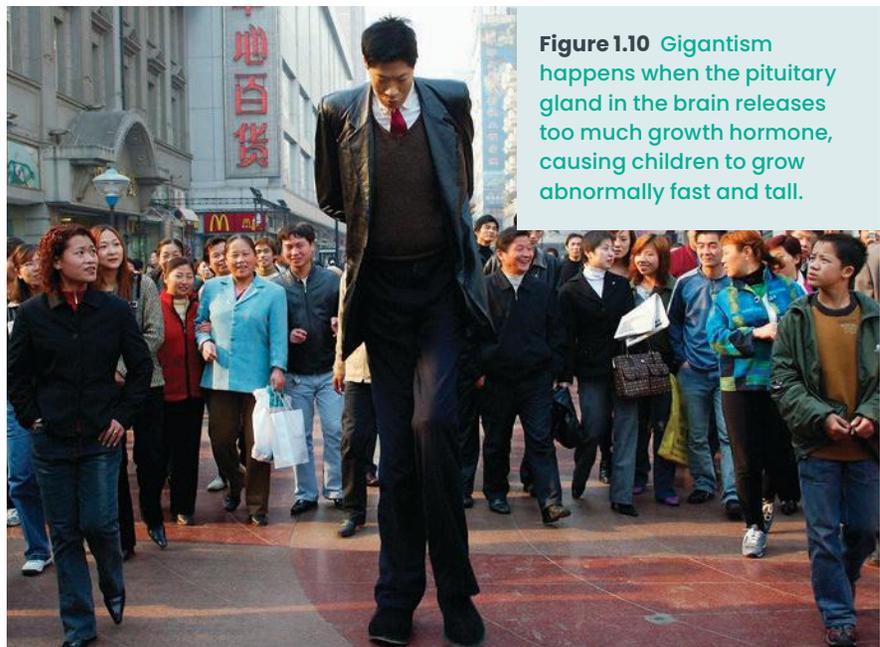
## 1 Organisms grow and mature as their cells divide

Growth happens when body tissues increase in size. This isn't due to cells getting larger, but to cells dividing to create more cells. As the number of cells in a tissue increases, the size of the tissue also increases, causing the organism to grow.

Growth is influenced by many factors, but it's the genetic material inside cells that usually determines the overall height and structure of an organism. This is the reason that humans don't grow to the size of elephants!

Sometimes the genetic material inside cells is damaged by factors such as ultraviolet light or chemicals. This damage can cause them to divide uncontrollably, producing lots of unwanted cells. These cells eventually form lumps or growths called tumours, which can affect the function of surrounding tissues or organs. Some cells may spread to other parts of the body – this is called **cancer**.

### What is uncontrolled cell growth called?



**Figure 1.10** Gigantism happens when the pituitary gland in the brain releases too much growth hormone, causing children to grow abnormally fast and tall.

## 2 New cells replace old or damaged cells

If you fall over and scrape an elbow or a knee, it doesn't usually take long for the tissue to scab over and heal. This is because the cells you damaged were quickly replaced with new ones by mitosis.

Cells are constantly dividing to replace cells that are damaged or old. This important process makes sure cells in the body are healthy and can perform the functions needed for survival. Some cells, such as the cells of the stomach and intestines, only last a few days because they are exposed to really difficult conditions that wear them down. Others, such as liver cells, live much longer because they are less likely to be damaged.

Not all body cells can be replaced. Some cells, such as nerve and heart muscle cells, are unable to divide, meaning that any damage to these cells can be permanent.

*Why do cells sometimes need to be replaced?*

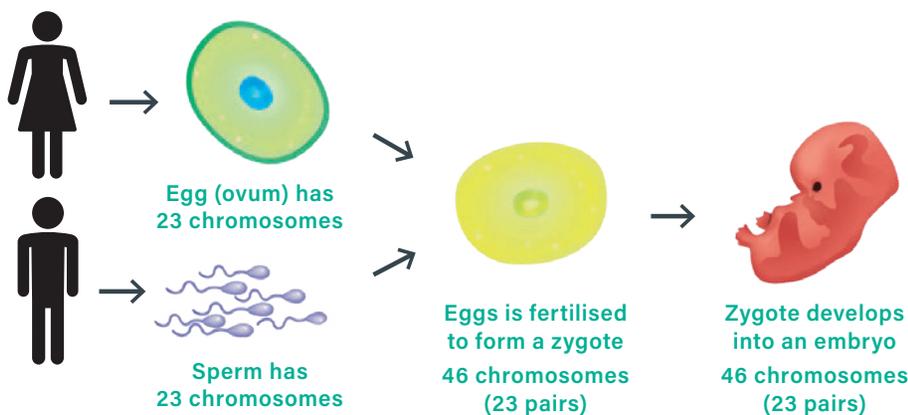
## 3 Meiosis makes cells with half the full number of chromosomes

Much like other body cells, sex cells (called gametes) need to divide in order to reproduce. But instead of dividing once, they divide twice in a process called meiosis. This extra division produces sex cells that have half the usual number of **chromosomes** found in other cells of the body.

When an egg cell is fertilised by a sperm cell, the number of chromosomes is restored – two halves make a whole. Therefore, most organisms begin life with a full set of chromosomes. Meiosis ensures that organisms don't have too many chromosomes.

*What process is used by sex cells to reproduce?*

**Figure 1.11** A normal human body cell contains 46 chromosomes. Meiosis produces either egg (ovum) or sperm cells, which have 23 chromosomes each. When a sperm fertilises an egg, the full number of chromosomes is restored.



### CHECKPOINT 1.5

- 1 Explain why cells need to divide.
- 2 What is one of the main factors that influences the growth of an organism?
- 3 Why do tumours form?
- 4 Provide definitions for mitosis and meiosis in your own words.
- 5 Identify these statements as true or false.
  - a Organisms grow because their cells increase in size.
  - b When cells are damaged, meiosis creates new ones.
  - c All body cells can be replaced in cell division.
  - d Sex cells have a full set of chromosomes after they divide.
  - e All cells have the same life expectancy.
- 6 Cells need to be replaced when they are damaged. Explain what could happen to an organism if this didn't happen.

### RESEARCH

- 7 It is thought that one day scientists will be able to use stem cells to regrow human body parts. Conduct research to find out the answers to these questions.
  - What are stem cells?
  - How are stem cells different to other cells in the body?
  - Name one place in the human body where stem cells could be found.
  - What are some of the medical benefits of stem cells?
  - Why is stem cell research controversial?

### SUCCESS CRITERIA

- I can give three reasons for cell division.
- I can define mitosis and meiosis.

# 1.6

## CREATING NEW CELLS

### LEARNING INTENTION

At the end of this lesson I will be able to describe how new cells are produced by cell division.

### KEY TERMS

#### binary fission

a process where very simple cells divide into identical halves

#### meiosis

complex cell division, where new cells are not identical to the original cell

#### mitosis

simple cell division, where new cells are identical to the original cell

### LITERACY LINK

#### SPEAKING

Explain the process of mitosis to a partner, including how it works and when it occurs. Then swap roles, with your partner explaining binary fission.

### NUMERACY LINK

#### CALCULATION

A single-celled bacteria splits in half every hour to create new cells, which also split and multiply.

If you start with one cell, how many bacteria cells will you have after seven hours?

Before the cell theory was developed, scientists weren't sure how organisms were made. Some thought that living things were made out of non-living matter; for example, fleas being created from dust.

Now we understand that the cells of living organisms divide or split into new cells. This can happen in three different ways.

## 1 Single-celled organisms reproduce by binary fission

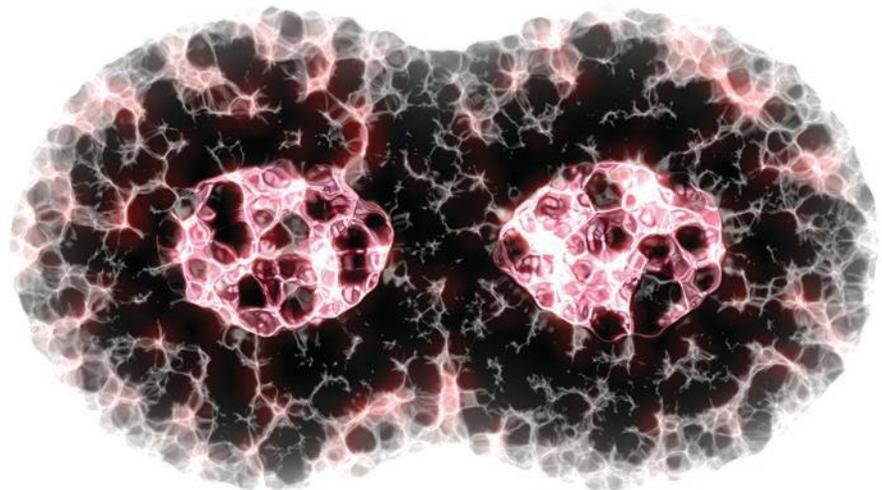
Some very simple organisms consist of just one cell. This cell carries out all of the functions that the organism needs to survive. These organisms don't need partners to reproduce or multiply – they just split in half, in a process called **binary fission**.

Before a cell undergoes binary fission, the genetic material inside it builds up until the amount of it doubles. The cell then splits in two, and each new cell includes half of the genetic information.

Only very simple cells, such as bacteria, can reproduce by binary fission. As well as being simple, binary fission is fast – some bacteria can split in half every 20 minutes.

### *How do simple cells reproduce?*

**Figure 1.12** Single-celled organisms such as bacteria reproduce by splitting into two identical halves.



## 2 Mitosis is simple cell division

The cells of plants and animals are complex, and they contain genetic information. This information is in the nucleus of each cell, in threads called chromosomes. When new cells are formed, the chromosomes of the original or 'parent' cell are shared with the new 'daughter' cells.

The most common type of cell in your body is a somatic cell. *Somatic* comes from a Greek word meaning 'body' – somatic cells make up

most of your body. Your body makes new somatic cells using **mitosis**, or simple cell division. During this process, a parent cell divides in half, creating two new daughter cells. The chromosome threads in the parent cell split in half, and each daughter cell receives an identical set of chromosomes. This means that each of these new cells is identical to the parent cell.

The major purpose of mitosis is for the organism to grow and replace worn out or dead cells. It happens faster in the growing regions of the body such as nails, hair and skin in animals, and in the shoots and roots of plants.

*In what type of cell does mitosis happen?*

### 3 Meiosis is complex cell division

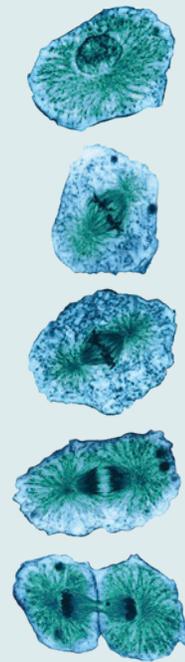
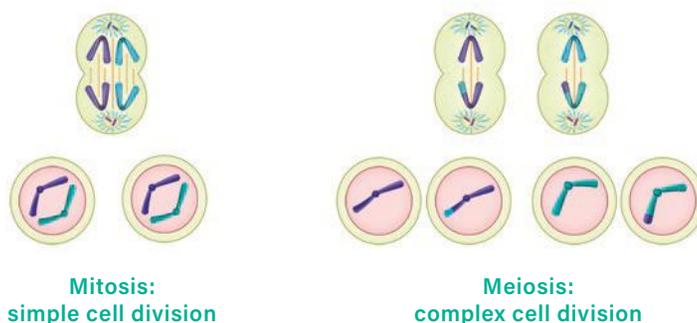
As well as somatic cells, your body contains reproductive cells. These cells pass half of the genetic information that makes you unique to the next generation. They include the gametes (sperm or egg) and germ cells (cells that go on to become gametes).

Sperm and egg cells are produced by a complex process called **meiosis**. First, the parent cell divides in half to create two new daughter cells, as happens during mitosis. Unlike in mitosis, each of these cells divides again so there are four daughter cells. Each is different – to both its parent *and* its sister.

When a parent cell divides the first time during meiosis, the chromosome threads don't split in half. Instead, the nucleus splits in half, and each half holds half of the threads. When the rest of the cell divides, each half carries one of the nucleus halves, which then becomes the nucleus of the new cell. This means that each daughter cell only carries half of the chromosomes of the parent cell. During reproduction, when the sperm and egg unite to form a single cell, the number of chromosomes is restored in the offspring. The fertilised egg has all the chromosomes needed to be a functioning cell.

*In what type of cell does meiosis happen?*

**Figure 1.13** The main difference between mitosis (left) and meiosis (right) is how much of the parent cell's genetic information is transferred to the daughter cells.



#### CHECKPOINT 1.6

- 1 Identify three ways in which cells reproduce.
- 2 Create a simple flow chart that outlines the steps involved in binary fission.
- 3 Explain the difference between mitosis and meiosis.
- 4 Bacteria reproduce very quickly – suggest why.
- 5 Where in plant and animal cells does mitosis happen?
- 6 What are the reproductive cells in humans called?
- 7 Give some reasons that cells may need to be replaced through mitosis.

#### CONNECTING IDEAS

- 8 In meiosis, why is the genetic material of daughter cells different from that of their parents? Why might this be an advantage?

#### SUCCESS CRITERIA

- I can explain how new cells are formed.
- I can describe the difference between binary fission, mitosis and meiosis.

# 1.7 UNICELLULAR AND MULTICELLULAR ORGANISMS

## LEARNING INTENTION

At the end of this lesson I will be able to identify the differences between unicellular and multicellular organisms.

## KEY TERMS

### differentiated cell

a cell that has specialised functions

### eukaryote

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

### multicellular

made of more than one cell

### prokaryote

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

### protozoan

a unicellular eukaryote that moves and feeds on organic matter

### unicellular

made of one cell

## LITERACY LINK

### WRITING

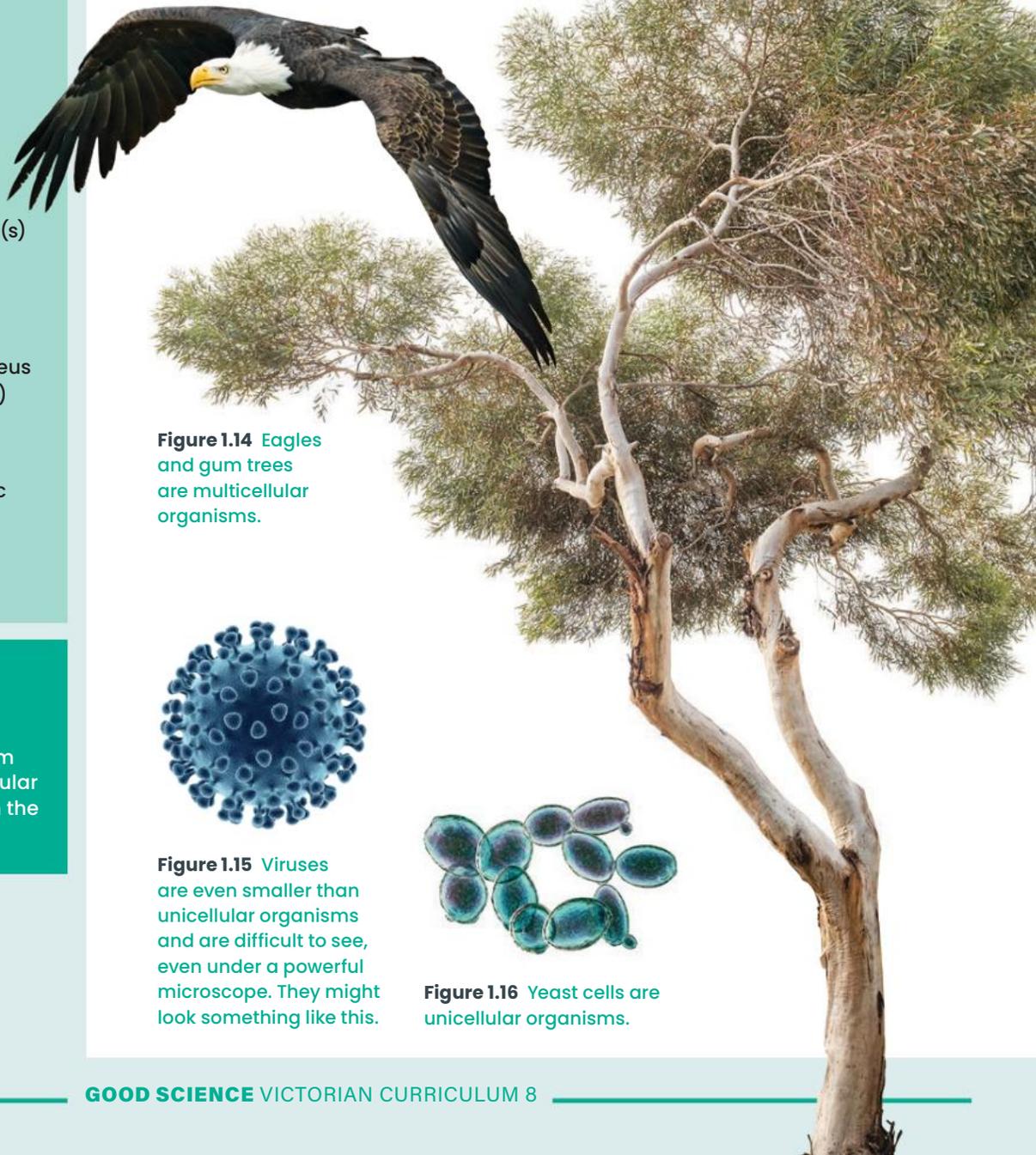
Write a short paragraph from the point of view of a unicellular organism, detailing a day in the organism's life.

Organisms can have one or many cells. Single-celled organisms are **unicellular** – *uni* means 'one'. **Multicellular** organisms have more than one (and often many) cells.

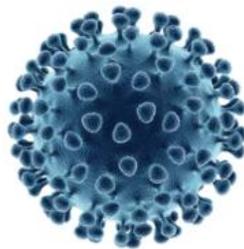
Bacteria, and some types of plant and fungi, are examples of unicellular organisms. Multicellular organisms include humans, other mammals, birds, trees and mushrooms. Multicellular organisms can be much larger and more complex than unicellular organisms.

## 1 Unicellular organisms consist of one cell

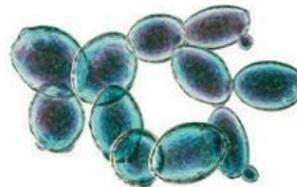
Unicellular organisms are microscopic and cannot be seen with the naked eye. In these organisms, all life processes, such as digestion, feeding and reproduction, happen in one tiny cell.



**Figure 1.14** Eagles and gum trees are multicellular organisms.



**Figure 1.15** Viruses are even smaller than unicellular organisms and are difficult to see, even under a powerful microscope. They might look something like this.



**Figure 1.16** Yeast cells are unicellular organisms.

Most unicellular organisms are **prokaryotes**. This means they don't have the same structures as plant and animal cells. They don't have a nucleus, mitochondria or organelles contained in plant and animal cells. There are two kinds of prokaryotes: bacteria and archaeans. Bacteria are found in every environment – a single millilitre of water contains a million bacterial cells. Archaeans aren't as common, and many exist in environments we would find hostile, such as hot springs – but they also exist in our own bodies.

Unicellular organisms can also be **eukaryotes**. Eukaryotes have a nucleus and mitochondria, and some have chloroplasts, so they're similar to plant cells. In fact, some eukaryotes are simple plants, such as green algae. The patches of algae we might see in the wild are actually huge colonies of single-celled plants. Similarly, yeast is a single-celled fungus.

Prokaryotes and eukaryotes have cell parts that help them to survive and reproduce after they reach a certain size. Prokaryotes reproduce through a simple process called binary fission; eukaryotes divide and reproduce through mitosis and meiosis.

Unicellular organisms don't have senses, but they respond to various conditions such as changes in temperature and light, and to touch. Certain eukaryotes called **protozoans** can even move, propelling themselves through water or liquid using tiny hair-like or oar-like structures. They use this movement to chase down and digest other microscopic organisms.

*What are the different types of unicellular organism?*

## 2 Multicellular organisms are made up of many different cells

Most animals, plants and fungi are multicellular organisms. Some are large and some are microscopic, but they all have bodies made up of more than one cell.

Multicellular organisms have hundreds of **differentiated cells** with specific functions. These cells make up organs such as the liver, heart and kidneys, which do different things for an organism's survival.

Multicellular organisms have many advantages over unicellular organisms. The main one is that no single cell in a multicellular organism's body has to perform every function needed to survive. This leads to less work and stress for the cells, which means the organism can grow larger and live for longer.

*What is the characteristic shared by all multicellular organisms?*

### INVESTIGATION 1.7A

Observing unicellular organisms

#### KEY SKILL

Identifying and managing relevant risks

► Go to page 136

### INVESTIGATION 1.7B

Observing specialised cells in multicellular organisms

#### KEY SKILL

Writing a research question

► Go to page 137



## CHECKPOINT 1.7

- 1 How do unicellular organisms reproduce?
- 2 What characteristics do unicellular organisms have in common?
- 3 List four differences between unicellular and multicellular organisms.
- 4 Discuss two benefits of multicellular organisms over unicellular organisms.
- 5 Explain the difference between prokaryotic cells and eukaryotic cells.
- 6 Do humans have prokaryotic cells or eukaryotic cells? Justify your answer.
- 7 Name some differentiated cells in humans.

## EXTENSION

- 8 Create two models of typical eukaryotic and prokaryotic cells. Provide an information sheet with your models that outlines the key features of each cell type.

## SUCCESS CRITERIA

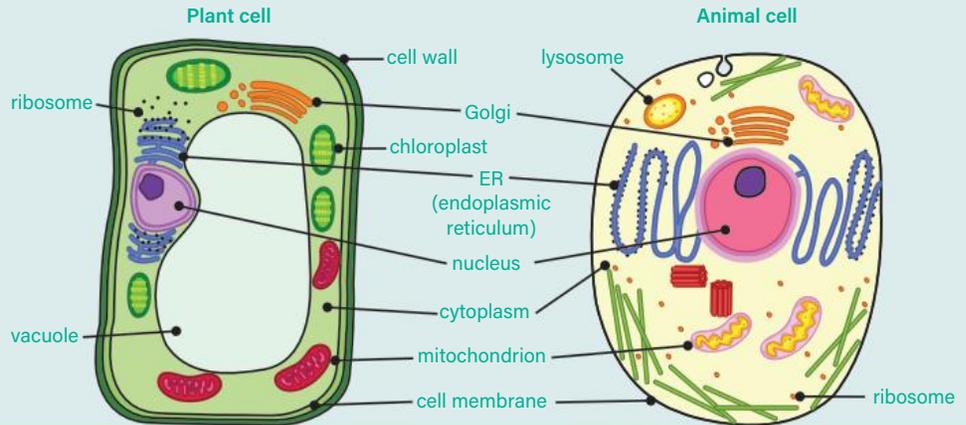
- I can describe at least three differences between unicellular and multicellular organisms.

# VISUAL SUMMARY

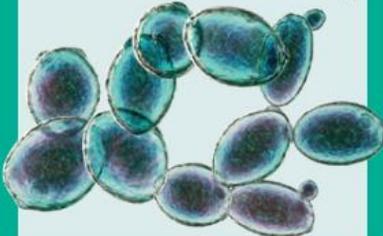
**Cells** are the smallest structural and functional units of living things.

The cell includes structures, some of which are called organelles. Animal cells have structures including the nucleus, cell membrane and cytoplasm.

The cells of plants have the same structures as animal cells, as well as a cell wall and chloroplasts, which produce food.

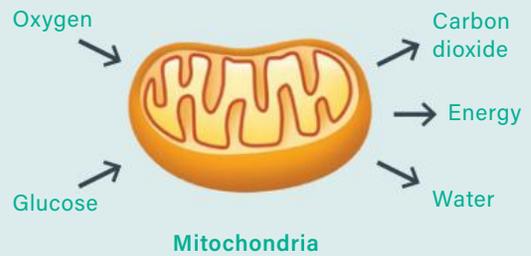


Organisms can have one or many cells. Single-celled organisms, such as prokaryotes and some eukaryotes, are called unicellular – *uni* means 'one'.



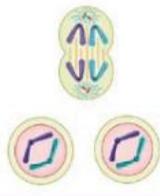
Multicellular organisms, such as animals and most plants, are made up of many cells.

Organisms make energy through cellular respiration, a chemical reaction that occurs in the mitochondria of cells.



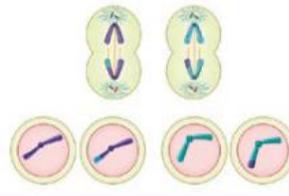
New cells are created through three processes – binary fission, mitosis and meiosis.

Mitosis: simple cell division



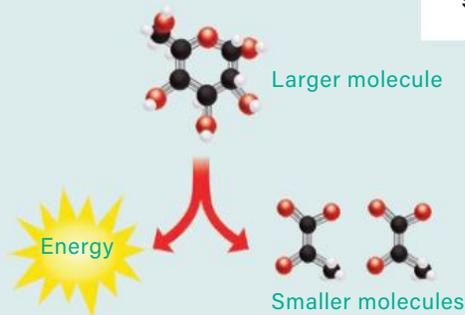
The main difference between mitosis and meiosis is how much of the parent cell's genetic information is transferred to the daughter cells.

Meiosis: complex cell division

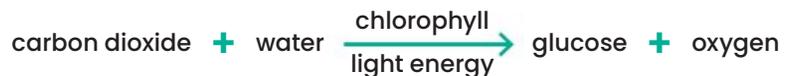


Multicellular organisms make energy through the process of cellular respiration.

Animals gain their energy from glucose and oxygen.



Plants use **photosynthesis** to capture energy from light and produce food from carbon dioxide and water.



## ★ FINAL CHALLENGE ★

- 1 Describe the main ideas of cell theory, in your own words.
- 2 Explain how the use of microscopes and stains can help you to view cells better.
- 3 Are all cells the same? Use two examples to explain your answer.



### Level 1



50xp

- 4 Draw a table to list the differences between plant and animal cells.
- 5 Choose three cell structures and explain their function. Provide a diagram of a cell showing these structures.
- 6 Give some reasons why cell division (binary fission, mitosis and meiosis) needs to occur.



### Level 2



100xp

- 7 Describe what respiration is, in your own words.
- 8 Write the equation for respiration. Circle the reactants in blue and the products in red.
- 9 Summarise the similarities and differences between plant cells and fungal cells.



### Level 3



150xp

- 10 Identify the three processes that lead to the formation of new cells in living things.
- 11 Draw a table to summarise the differences between the processes you mentioned in question 10.
- 12 Explain the difference between a prokaryote and eukaryote and give an example of each.



### Level 4



200xp

- 13 Name the four organs found in plants and describe their functions.
- 14 Explain the purpose of respiration and why respiration is an important process in all living things. What would happen if our cells did not respire?
- 15 Imagine that a cell is a city. Identify at least five features of a cell and compare them to a city by giving them each a role. For example, the nucleus might be the city's mayor, giving out instructions and organising what is going on in the cell.



### Level 5

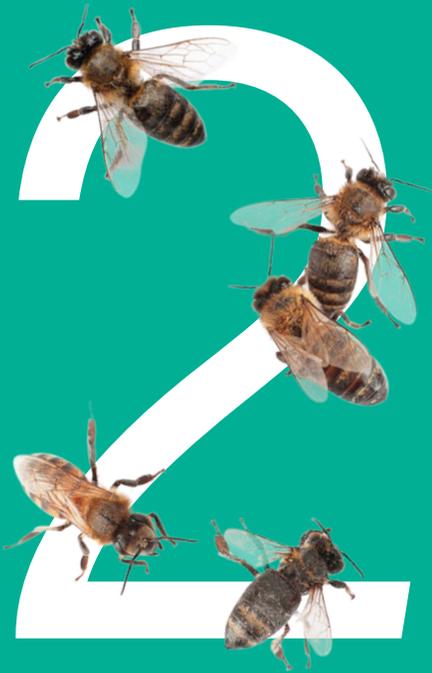


300xp



# BODY SYSTEMS

How does life result from the structure and function of cells?

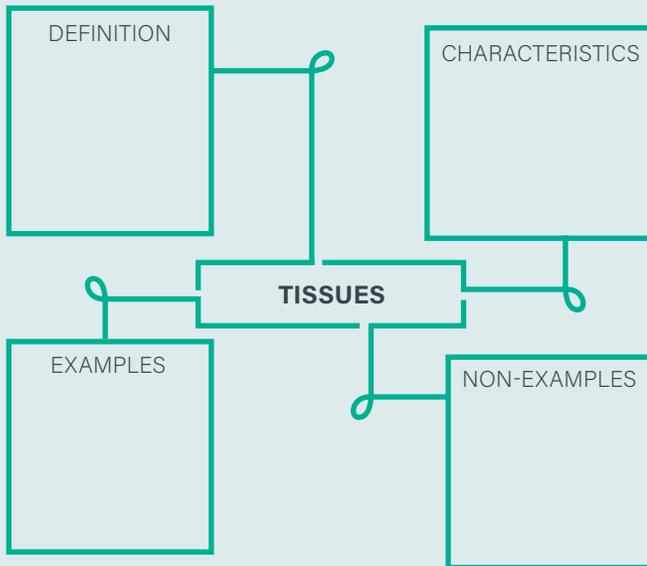


Living things are made up of systems that work together for the best chance of survival. Systems in plants support photosynthesis, using sunlight to produce energy and oxygen. Systems in animals take in food and process it to produce energy, and to support gas exchange, waste removal, sexual reproduction and more.

Organisms have evolved over billions of years, becoming extremely complex over this long time. When we investigate and learn about these systems, we discover the many intricate parts and functions of a living cell, and how they work together in multicellular organisms.

## 1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Organs* and *Multicellular*.

## 2 LEARNING LINKS

Brainstorm everything you already know about body systems.



**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:** In how many ways can living things excrete?



**COMMONALITY:** Find as many points of commonality as you can between your heart and your lungs.



**PREDICTIONS:** Write a series of predictions for a situation where half the plants on Earth could no longer photosynthesize.

**5 THE MOST BABIES!**

The woman who holds the record for having the most children is Mrs Vassilyev, a peasant woman from Russia who allegedly had 69 children! This was said to include 16 pairs of twins, seven sets of triplets and four sets of quadruplets. The births apparently happened in a period between 1725 and 1765. (Historical records aren't always reliable, so it's important to be sceptical about this claim.) Still, Mr Vassilyev obviously did not think that 69 children was enough – he is said to have had 18 more children with a second wife.



# 2.1

## BODY SYSTEMS IN ACTION

### LEARNING INTENTION

At the end of this lesson I will be able to explain that the systems in multicellular organisms work together to provide the requirements for life.

### KEY TERMS

#### body system

a group of organs working together

#### hormone

a chemical substance produced by the body that controls the activity of certain cells or organs

#### organ

a group of tissues with a specific function

#### tissue

a group of cells with a similar structure and function

### LITERACY LINK

#### VOCABULARY

The words *organ*, *cell* and *tissue* all have other, non-scientific meanings. Write a sentence using all three words in a scientific context, and another using their non-scientific meanings.

### NUMERACY LINK

#### DATA

Yaz records the weights (in grams) of 10 sheep hearts: 239, 244, 244, 249, 250, 252, 255, 261, 265, 270. Calculate the mean, median and mode of this data. What could Yaz conclude about these hearts?

**Body systems** exist in almost every multicellular organism. These specialised **organs** and **tissues** have a common purpose.

For an organism to survive, each system must work with the others, often passing materials from one system to the next.

## 1 Cells work together as tissues, organs and systems

Unicellular organisms work alone – a single cell must carry out all of the major life functions. Multicellular organisms, such as humans, are made up of many different types of cells. More cells are available to share the workload, so different cells have specific functions.

Cells with similar functions form tissues, such as blood or muscles. Different tissues working together are organs, such as the heart, brain and lungs. Two or more organs connected and working together form a body system. The organs and tissues in each system are specialised to perform specific roles that serve a common purpose.

*What is the difference between a tissue and an organ?*

## 2 Animals have several body systems

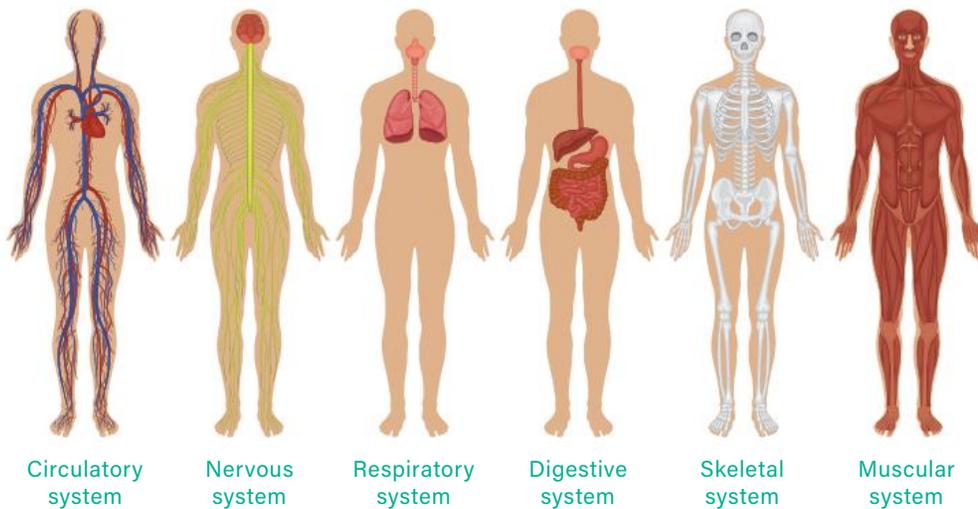
Multicellular organisms are incredibly diverse, so the number and type of body systems can differ between organisms. Most animals, such as humans, have 11 major body systems. These are the:

- *circulatory system* – moves nutrients, gases and waste products around the body
- *nervous system* – detects, processes and sends electrical signals
- *respiratory system* – exchanges gases with the environment
- *digestive system* – breaks down and absorbs food
- *muscular system* – allows movement through the use of muscles
- *skeletal system* – provides support and structure to the body and organs
- *endocrine system* – produces the **hormones** that control growth and development
- *excretory system* – removes body wastes
- *reproductive system* – produces sex cells and supports pregnancy and birth
- *immune system* – makes the white blood cells that fight diseases and infections
- *integumentary system* – protects the body from damage.

Some of these systems can be identified in other ways. For example, the body's skeleton and muscles can be considered separately as the skeletal and muscular systems, or together as the musculoskeletal system.

*What are three examples of body systems in humans?*

**Figure 2.1** The human body consists of different systems that work together to provide cells with what they need to survive.



Circulatory system

Nervous system

Respiratory system

Digestive system

Skeletal system

Muscular system

### 3 Body systems work together to meet cell needs

Body systems must work together to provide cells with everything they need to function and survive, such as gases, nutrients and water. One of the best examples of this is in the human body.

The human circulatory system is connected to every other system in the body. It transports nutrients, dissolved gases and waste products between cells. Without the circulatory system, other systems would not be able to function.

#### How do body systems work together to give cells what they need?



Important materials like oxygen and nutrients are transported in blood through a vast network of blood vessels in the body's circulatory system. Arteries carry blood away from the heart and veins carry blood towards the heart.



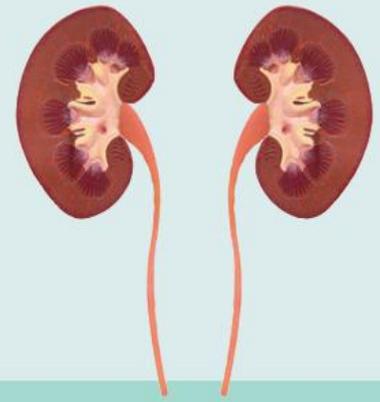
Oxygen and carbon dioxide are exchanged between the lungs and blood. The oxygen in the lungs is moved into the blood and delivered to the cells for respiration. The carbon dioxide produced by cells is taken to the lungs to be removed.



Food is broken down into nutrients by the digestive system. These nutrients are absorbed into the blood, where they are transported to the cells that need them.



Waste products produced from cellular processes move from the cells into the surrounding blood, to be removed by the organs of the excretory system.



### CHECKPOINT 2.1

- Order these terms (starting with the smallest structure) to match their organisation within multicellular organisms: *tissue, cell, organ, system*.
- Using an example, describe the difference between an organ and a tissue.
- Which system is responsible for the removal of wastes?
- Suggest what could happen if something went wrong with the digestive system.
- Cells require oxygen and water to survive. Suggest which body systems assist cells to obtain these materials.
- Both the circulatory and respiratory systems are responsible for ensuring oxygen gets to our cells. Explain why.

### STUDENT VOICE AND AGENCY

- Compare a body system of a human with a body system of a different animal. The choice of which system and which animal is up to you.

### SUCCESS CRITERIA

- I can list the order of organisation from cells to systems.
- I can explain how systems work together to provide cell requirements, and provide a specific example.

# 2.2

## TISSUES AND ORGANS IN ANIMALS

### LEARNING INTENTION

At the end of this lesson I will be able to identify the relationship between cells, tissues and organs in animals.

### KEY TERMS

#### differentiate

to change to have a particular function

### LITERACY LINK

#### READING

Identify three terms from this section that you are unfamiliar with. Write definitions for each in your own words.

### NUMERACY LINK

#### CALCULATION

An adult's small intestine is about 6 metres long, and food takes around 7 hours to pass through it. Convert 7 hours to seconds, then calculate the speed of food in the small intestine.

Hint:  $speed = distance / time$

In multicellular organisms, cells work together so that organisms can survive.

In humans and animals, cells with similar functions group together to form tissues. Different tissues have different functions, and two or more tissues work together to form organs. Sets of organs work together as body systems, as discussed in lesson 2.1.

## 1 Tissues are groups of specialised cells

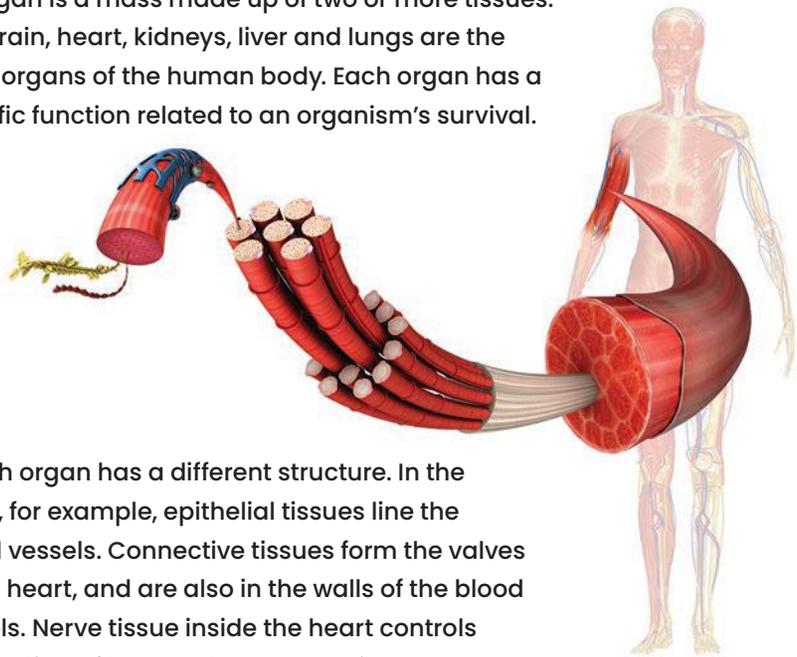
Before an unborn animal starts to develop, the beginning cells of its body are not specialised. These cells are called stem cells. As the animal grows, the cells **differentiate** and become specialised to carry out different functions. A group of like cells make up a tissue. There are four main types of tissue:

- *Epithelial tissue* forms the skin, as well as the body's inner linings.
- *Connective tissue* transports substances (such as nutrients) to where they're needed.
- *Muscle tissue* contracts and relaxes to carry out different functions.
- *Nerve tissue* transmits information between the brain and other organs.

*What are the different types of tissues?*

## 2 Organs perform the body's main functions

An organ is a mass made up of two or more tissues. The brain, heart, kidneys, liver and lungs are the main organs of the human body. Each organ has a specific function related to an organism's survival.



Each organ has a different structure. In the heart, for example, epithelial tissues line the blood vessels. Connective tissues form the valves of the heart, and are also in the walls of the blood vessels. Nerve tissue inside the heart controls the beating of the heart muscle, which pumps the blood out of the heart. All these tissues work together to keep the heart working efficiently.

*What are organs made up of?*

**Figure 2.2** Human cells make tissues, specific tissues make organs and sets of organs make body systems.

### 3 Sets of organs work together in systems

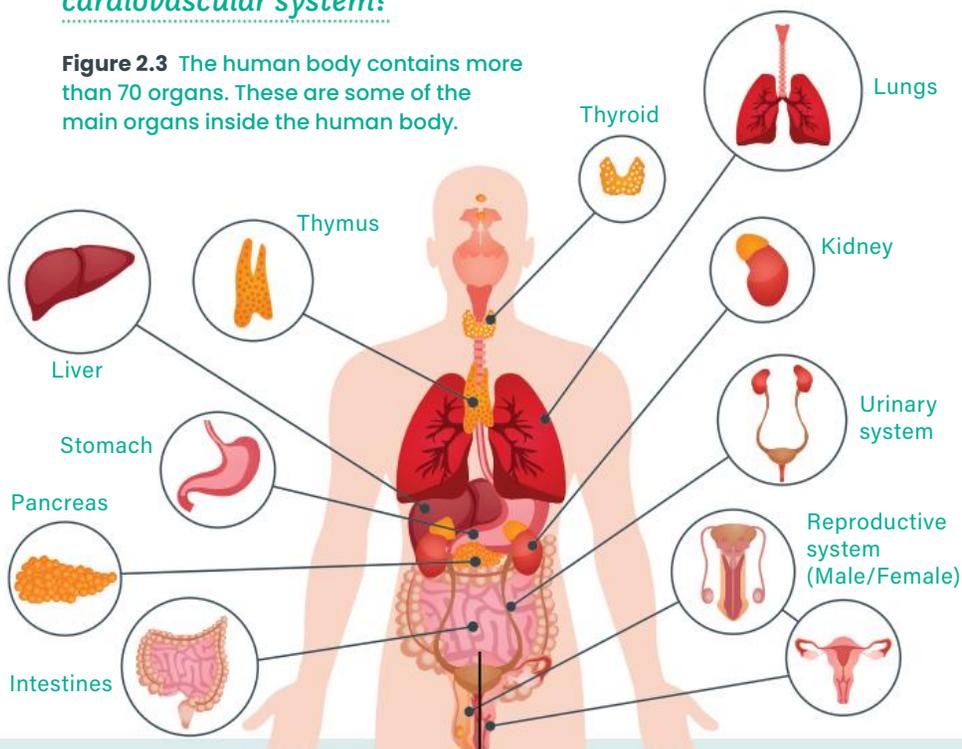
The function of an organ isn't useful on its own – your heart can pump blood, but that blood then has to reach the other parts of your body. Each organ is part of a body system in an organism, along with other necessary tissues (such as blood). All of an organism's different body systems must work with other systems.

The human body has several different body systems, each with its own function, as discussed in lesson 2.1. The following table lists some of the systems and their organs.

Body system	Function	Major organs and tissues
Cardiovascular/circulatory	Transports oxygen and nutrients to cells	Heart, blood
Nervous	Transmits nerve impulses between parts of the body	Nerves, brain, spinal cord
Digestive	Breaks down food so that nutrients can be absorbed	Oesophagus, stomach, liver, large and small intestines
Respiratory	Allows exchange of gases	Lungs, trachea, larynx, nasal passages
Excretory/urinary	Removes waste formed from digestion	Kidneys, ureters, urethra, bladder
Reproductive	Produces gametes (sex cells) and sex hormones	Female: ovaries, vagina, uterus, fallopian tubes Male: penis, testes, seminal glands

#### What is the function of the cardiovascular system?

**Figure 2.3** The human body contains more than 70 organs. These are some of the main organs inside the human body.



#### CHECKPOINT 2.2

- 1 Give one example of a type of cell, an organ and a body system.
- 2 Describe the role of the nervous system.
- 3 Which body system does the heart belong to?
- 4 List the tissues that make up the heart. How do these tissues help it to function?
- 5 Draw a flowchart to show the levels of organisation in a multicellular organism.
- 6 List the functions of four tissues of your choice.

#### CRITICAL AND CREATIVE THINKING

- 7 Draw an outline of the human body and label where each of these organs and glands are located: heart, lungs, stomach, liver, ovaries, kidneys, adrenal glands, pituitary gland, brain, thyroid gland, small intestine and large intestine.

#### SUCCESS CRITERIA

- I can explain the relationship between cells, tissues and organs.
- I can give examples of at least one type of cell, tissue and organ.

# 2.3

## TISSUES AND ORGANS IN PLANTS

### LEARNING INTENTION

At the end of this lesson I will be able to identify the relationships between cells, tissues and organs in plants.

### KEY TERMS

**epidermis**

the outer layer of cells

**vascular tissue**

the tissue that transports fluids and nutrients through a plant

### LITERACY LINK

**WRITING**

Create an analogy for the following parts of a plant: the roots and the leaves.

### NUMERACY LINK

**GRAPHING**

The stem of a plant is 12 cm high when first planted. It then grows 2 cm each month for 7 months. Display this data using a line graph.



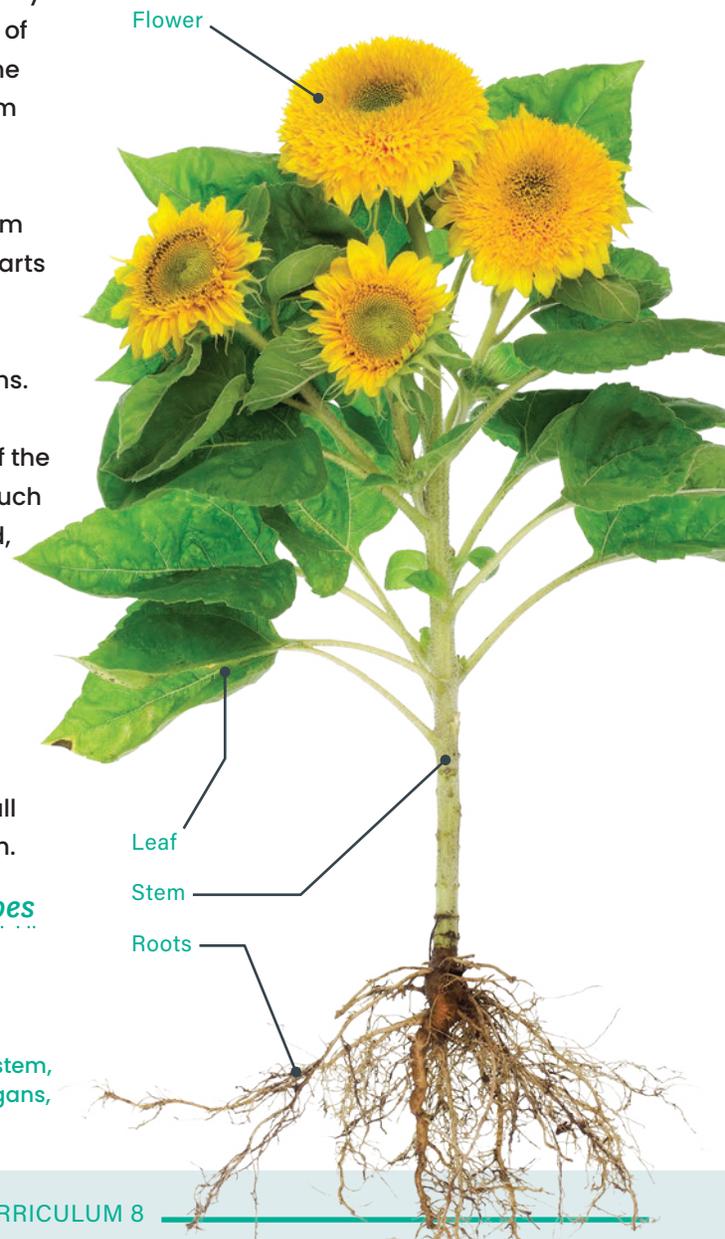
Plants also have organs and tissues, but theirs are much simpler than those of animals. A group of cells with similar structure and functions make plant tissues, and two or more tissues work together as organs.

The organs and tissues carry out the vital functions of a plant such as photosynthesis, respiration, reproduction and the transport of water and nutrients.

## 1 Plants have four types of organs

Animals, including humans, have many different organs, all of which carry out very specialised functions. Plants only have four different types of organs. These organs are simple, but some of them carry out multiple functions:

- *Roots* absorb water and minerals from the ground. They also anchor plants in place so that they can continue to absorb nutrients.
- The *stem* is the main body of the plant – the trunk of a tree is the same as the stem of a rose. The stem supports and lifts the leaves, and it carries nutrients and water from the roots to the other parts of the plant.
- *Leaves* are where photosynthesis happens. Sunlight is absorbed through the surfaces of the leaves, and products such as oxygen are released, or re-used during respiration.
- Plants also have *reproductive organs*, such as flowers, fruits and seeds. These have many forms, but they all have the same function.



### What are the four types of organs in plants?

**Figure 2.4** The four types of plant organs are the roots, stem, leaves and reproductive organs, such as flowers.

## 2 Plants have a small number of tissue and organ systems

Humans have 11 major body systems, but plants only have two systems.

The first system is the *root system*, which consists of all the organs found underground. This system absorbs nutrients and water from the ground. The roots are part of this system, and so are any underground reproductive organs of the stem. The part of a potato plant that you eat is actually part of the stem; it grows underground as part of the root system.

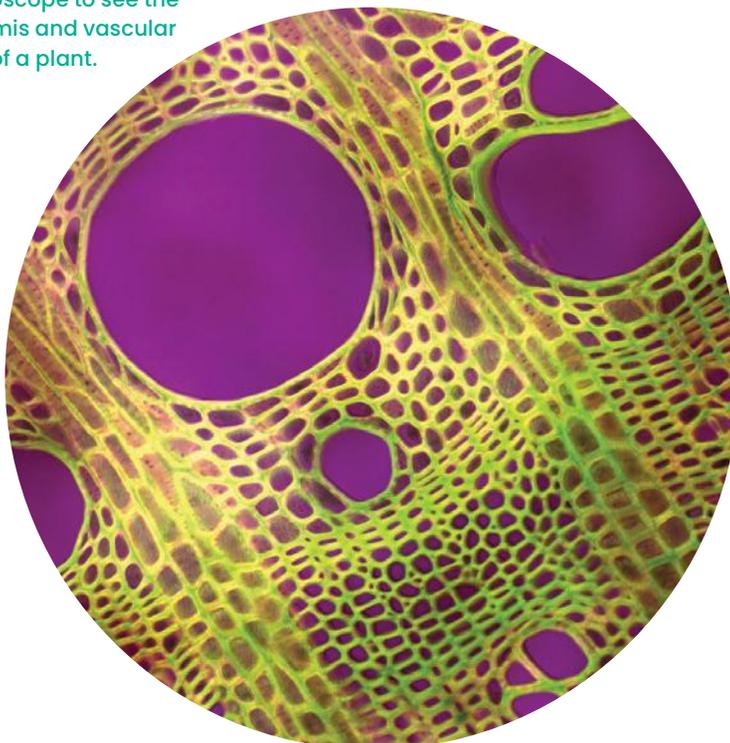
The second system is the *shoot system*, which mostly consists of the organs that grow above the ground. These parts of the plant absorb sunlight, and are where photosynthesis happens. The stem, fruit, flowers and leaves generally form the shoot system.

Plants also have four tissue systems that perform important functions, but don't combine to form organs:

- The **epidermis** is like the skin of the plant. These tissue cells form the outer surface of the leaves and the plant body.
- **Vascular tissue** transports fluids and nutrients through the plant, much like blood vessels do in your body.
- *Ground tissue* is the cells that make nutrients during photosynthesis and store nutrients for later use.
- *Meristematic cells* change to form various organs of a plant and are responsible for growth.

### What are the two organ systems found in plants?

**Figure 2.5** You can use a microscope to see the epidermis and vascular tissue of a plant.



### INVESTIGATION 2.3

Water transport in plants

**KEY SKILL**  
Identifying the controlled variables

► Go to page 138



### CHECKPOINT 2.3

- 1 How many types of organs and organ systems do plants have?
- 2 Identify the tissues that make up the transport system in plants.
- 3 Where do plants obtain water from?
- 4 Name two important plant organs and state their functions.
- 5 Name the two organ systems in plants and describe their functions.
- 6 Describe the roles of the flowers, fruits and seeds in plants.
- 7 Outline the role of the vascular tissue in plants.

### INQUIRY

- 8 The vascular tissue has two types of specialised cells. Find out what they are and list their functions.

### SUCCESS CRITERIA

- I can explain the relationship between plant cells, tissues and organs.
- I can give examples of at least one type of plant cell, tissue and organ.

# 2.4

## BLOOD, BONES AND MUSCLES

### LEARNING INTENTION

At the end of this lesson I will be able to describe the role of the circulatory and musculoskeletal systems in maintaining a human as a functioning multicellular organism.

### KEY TERMS

#### blood vessel

a tube such as a vein or artery that carries blood in the body

#### cartilage

connective tissue that holds bones together

#### tendon

connective tissue that connects muscle to bone

### LITERACY LINK

#### LISTENING

Interview someone in your class who has broken a bone or damaged a muscle. Find out what happened, how long it took to mend and what the experience was like. Write a transcript of your interview.

### NUMERACY LINK

#### MEASUREMENT

Find your pulse and record the number of times your heart beats in 30 seconds. Calculate how many times it would beat in a day.

We all rely on body systems to move. These systems are made up of specialised organs and tissues, such as bones and muscles, working together.

Like other processes in the body, movement requires a constant supply of energy. The circulatory system is vital to this energy production because it supplies all cells with oxygen for respiration.

## 1 The circulatory system moves materials around the body

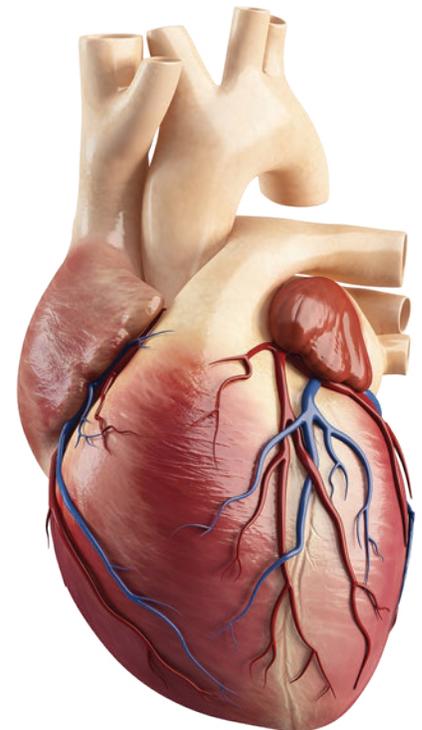
Your heart, **blood vessels** and blood make up your circulatory system. This system delivers oxygen, nutrients and other substances to every tissue in your body. It also helps your body to remove waste products, such as carbon dioxide.

Oxygen passes from the lungs into the blood, and is then transported through veins to the heart. An adult human's heart can beat more than 115 000 times a day, making it the hardest working muscle in the body.

The heart has two 'filling' chambers, called atria, and two 'pumping' chambers, called ventricles. Entry to these chambers is controlled by special valves. Oxygen-rich blood comes in through the atria, is pumped out through the ventricles, and is then distributed through arteries to the rest of the body.

*What does the circulatory system do?*

Figure 2.6 The heart pumps blood throughout the body.



## 2 The skeletal system supports and protects the body

The human skeletal system consists mostly of bones and **cartilage** – a connective tissue that holds the bones together. Bones are made up of living cells and so they need oxygen and nutrients to survive, grow and repair.

Human bones come in all shapes and sizes. More than half of them are in the hands and feet. The largest bone is called the femur, and it is in the top part of the leg. The smallest bones – the stapes – are in the ears.

Functions of the human skeleton include:

- *support* – Without a skeleton, the human body wouldn't be held upright and would collapse into a big blob of tissue and water.
- *protection* – The brain is protected by the skull, the vertebrae protect the spinal cord and the ribs protect the heart and lungs.
- *muscle attachment* – Muscles are attached to the bones by special fibres called **tendons**.
- *blood cell production* – Red blood cells and other blood components are made in the marrow at the centre of bones.
- *mineral storage* – Vital elements such as calcium and phosphorus are stored in the bones and released when they are needed.



#### INVESTIGATION 2.4

Dissecting a sheep's heart

**KEY SKILL**  
Identifying and managing relevant risks

► Go to page 139



### What does the skeletal system do?

## 3 The muscular system allows the body to move

The main role of the muscular system is movement. Without working muscles, you wouldn't be able to walk around, your heart wouldn't beat, and food would take much longer to break down and move through your digestive system. Muscles let you smile when you're happy and frown when you're not.

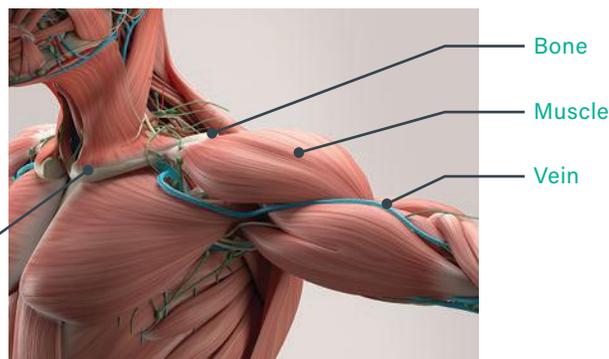
Much like the bones of the skeletal system, muscles can vary in size and shape. The largest muscle in the human body is the gluteus maximus – this is the scientific name for a muscle in the buttocks. The smallest muscles are in the ear.

Muscles work by contracting and relaxing. When muscles contract, the fibres in them shorten and thicken. When they relax, the fibres become longer and thinner. Many muscles work in pairs to coordinate body movements – when one contracts, the other relaxes. When the biceps of your arm contracts, the triceps on the opposite side of your arm relaxes, pulling the forearm up. When the biceps relaxes, the triceps contracts, pulling the forearm down.

### What does the muscular system do?

**Figure 2.7** Muscles, bones and blood work together in systems that maintain essential functions.

Connective tissue where bone meets muscle



## CHECKPOINT 2.4

- 1 What organs make up the circulatory system?
- 2 Explain how the muscular and skeletal systems work together in the body.
- 3 What does the circulatory system transport around the body?
- 4 One of the roles of the skeletal system is organ protection. Suggest why.
- 5 What is the difference between a vein and an artery?
- 6 Where are the biggest and smallest muscles in the body?
- 7 Give three examples of muscles in the human body and where they are located.

## INQUIRY

- 8 Use the internet to research voluntary and involuntary muscle movements. Make a summary of each.

## SUCCESS CRITERIA

- I can describe the role of the circulatory system.
- I can describe the role of the skeletal system.
- I can describe the role of the muscular system.

# 2.5

## ENERGY IN, WASTE OUT

### LEARNING INTENTION

At the end of this lesson I will be able to describe the roles of the digestive, excretory and respiratory systems in maintaining a human as a functioning multicellular organism.

### KEY TERMS

#### digestion

the physical and chemical processes that break down food in the body

#### enzyme

a chemical that speeds up a reaction (e.g. digestion of food)

#### excretion

the elimination of cellular waste from the body

### LITERACY LINK

#### SPEAKING

Explain to a partner the roles of the respiratory, digestive and excretory systems, using only one sentence for each system. Then listen to your partner's sentences, and discuss and agree on one sentence for each system.

### NUMERACY LINK

#### UNITS

Energy in food is usually measured in kilojoules (kJ) or calories (cal). There are 4.18 kJ in 1 cal. If a burger contains 600 calories, how much is that in kilojoules?

Did you know that cows have four stomachs? They need them to break down the tough plant material they eat.

Humans have just one stomach, and as part of the digestive system it works closely with the excretory system to take food in, keep all the things the body needs and get rid of the rest. The respiratory system does something similar, taking in oxygen and then getting rid of carbon dioxide.

## 1 The digestive system releases the nutrients in food

Think of your most recent meal and why you ate it. Were you hungry? Did it just look yummy? Did you want to obtain the nutrients for important cellular processes? If you answered 'yes' to the third question then your mind and your body are on the same page!

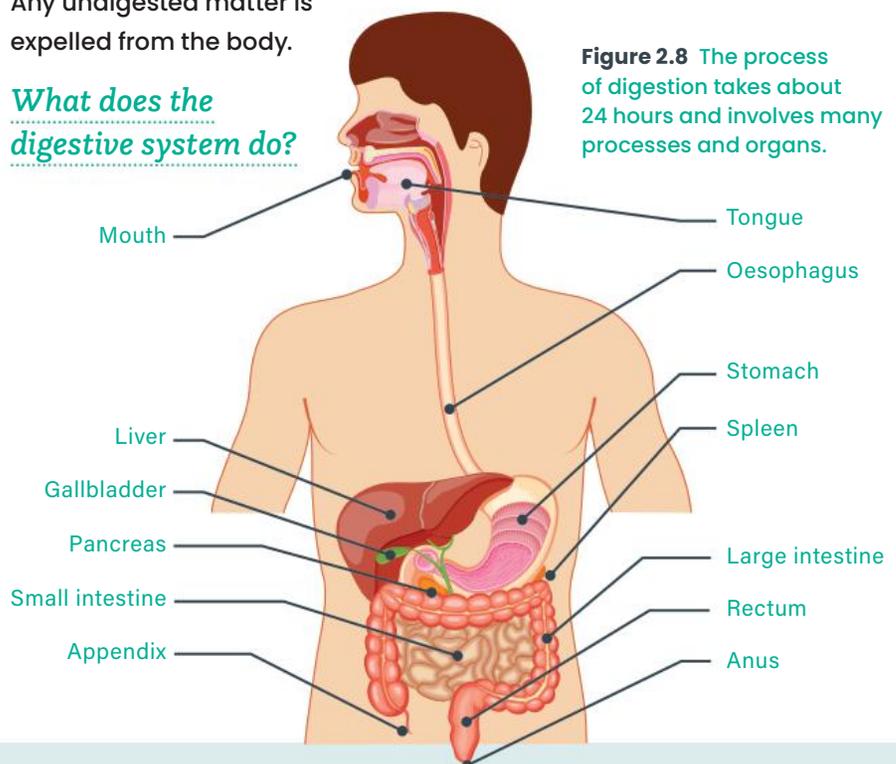
Humans and other animals need to consume food to obtain the nutrients inside it. These are essential for energy production, growth, tissue repair and basically all other cellular processes. However, food can't just move directly into the cells. It first needs to be broken down into smaller molecules during **digestion**.

The digestive system in humans is made up of specialised organs that break down food using mechanical (physical) and chemical processes. Digestion begins in the mouth, as the teeth mechanically break food into smaller pieces while **enzymes** work on reactions that dissolve them. The food breaks into smaller and smaller pieces as it travels through the stomach, and then the nutrients move into the small intestine, where they are absorbed through the walls into the bloodstream.

Any undigested matter is expelled from the body.

### What does the digestive system do?

**Figure 2.8** The process of digestion takes about 24 hours and involves many processes and organs.



## 2 The excretory system removes waste from the body

Cells are constantly undergoing chemical reactions. These reactions produce cell wastes that need to be removed from the body before they build up and cause harm. The elimination of cell waste from the body is called **excretion**. Most wastes leave the body in faeces or urine, although some leave in sweat or the breath.

Specialised organs remove different types of cellular waste, and these organs make up the excretory system. Many parts of the human body have some role in excretion, including the skin, lungs and liver. However, there are some specific organs that make up the excretory system:

- The kidneys are two bean-shaped organs found in the lower part of your abdomen. They filter all blood to remove harmful wastes. These wastes are then excreted in urine.
- The urinary bladder is the organ that collects the urine excreted by the kidneys.
- The large intestine is where undigested food particles collect. Any remaining usable water is absorbed through the wall of the intestine, and the remaining solid waste is excreted through the rectum and anus as faeces.

*What does the excretory system do?*

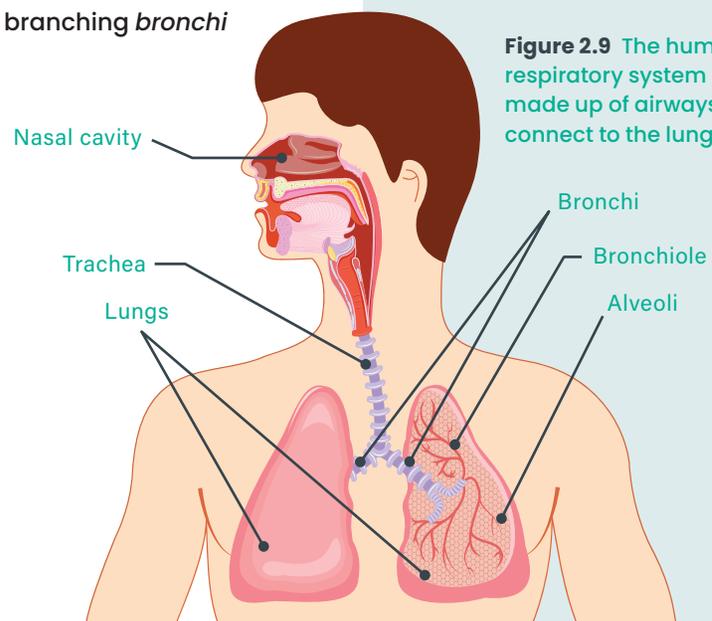
## 3 The respiratory system processes oxygen

Your respiratory system gathers and processes oxygen, a molecule essential to life. You breathe in (inhale) oxygen with air, and release carbon dioxide and water vapour when you breathe out (exhale). This gas exchange is only possible because of the special structures of the respiratory system.

During inhalation, air enters the nostrils or mouth and moves into the *trachea* (windpipe). It then travels into two branching *bronchi* and into smaller passageways called *bronchioles*. From here, the air is passed into clusters of tiny air sacs called *alveoli*. Each alveolus is moist, thin and contains many tiny blood vessels called capillaries.

Oxygen from the air moves through the walls of the alveoli and into the capillaries, where it is then transported in the blood to the cells for aerobic respiration. At the same time, carbon dioxide and water move from the blood into the airways, where they then take the opposite route to leave the system during exhalation.

*What does the respiratory system do?*



**Figure 2.9** The human respiratory system is made up of airways that connect to the lungs.

### CHECKPOINT 2.5

- 1 What is the main purpose of the digestive system?
- 2 The lungs are more like sponges than balloons. Suggest why.
- 3 What is the role of the kidneys in excretion?
- 4 Which body system contains the bronchi, and where in the body are they located?
- 5 Explain how the excretory system ensures the human body is able to function effectively.
- 6 Give some examples of how wastes can leave the body.

### CONNECTING IDEAS

- 7 Compare the respiratory system of a fish with the respiratory system of a human. In what ways are they similar and different?

### SUCCESS CRITERIA

- I can describe the role of the digestive system.
- I can describe the role of the excretory system.
- I can describe the role of the respiratory system.

# 2.6

## HUMAN REPRODUCTION

### LEARNING INTENTION

At the end of this lesson I will be able to describe the reproductive system in humans.

### KEY TERMS

#### embryo

an early stage of development of an unborn baby

#### fertilise

to join a sperm with an ovum

#### foetus

a later stage of development of an unborn baby

#### hormone

a chemical substance produced by the body that controls the activity of certain cells or organs

#### zygote

the first single cell of new life

### LITERACY LINK

#### VOCABULARY

Identify three adjectives (describing words) in this section. Suggest an alternative word for each adjective you identify.

### NUMERACY LINK

#### CALCULATION

The average development period for a human baby is 40 weeks. Convert 40 weeks into seconds.

Most humans have either a male or female reproductive system.

To produce a new human, a sperm from a male must find its way to a female ovum (egg) and wriggle inside.

## 1 The human reproductive system produces new life

The function of the human reproductive system is the production of new life. Before technology such as IVF, new life always began with sexual intercourse between a male and a female. If sexual intercourse happens around the time of ovulation, then the male sex cell (sperm) has a chance to **fertilise** the female sex cell (ovum). The new single cell, or **zygote**, quickly divides and becomes a ball of cells called an **embryo**.

About five days after fertilisation, the embryo moves out of the fallopian tube into the uterus. It then embeds itself into the lining of the uterus, where it receives nourishment from the blood vessels and can develop into a **foetus**. The foetus then grows and develops, receiving nutrients from the mother via the placenta and the umbilical cord.

A human baby develops in the uterus for about 40 weeks. After this, different **hormones** make the muscles of the uterus contract to push the baby out through the vagina. The amniotic sac bursts, fluid is expelled and then the baby is born. About a third of births in Australia are by caesarian section, where a baby is removed surgically through its mother's abdomen.

*What is the role of the human reproductive system?*

## 2 The male reproductive system

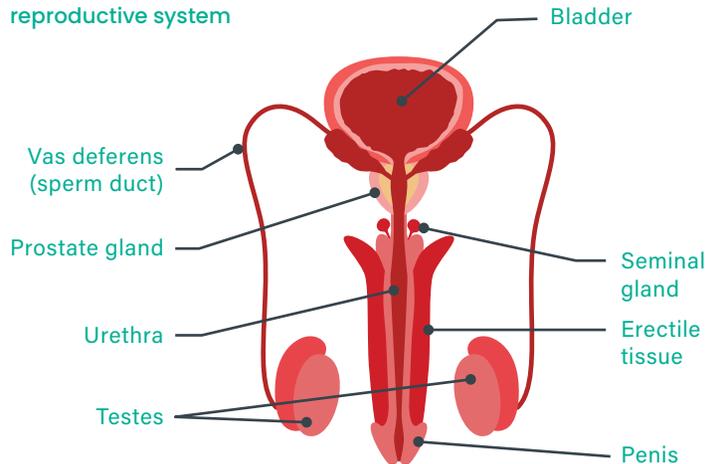
Humans mostly have the same organs – we all have hearts, lungs and brains. The only system that differs between humans is the reproductive system, because male humans have different reproductive organs than female humans.

The testes produce sperm (male sex cells) and the male hormone testosterone. They are in the scrotum, which provides them with some protection and allows them to stay at the right temperature while outside of the body.

When ejaculation happens, sperm move from the testes through the vas deferens (sperm duct) to the seminal gland, where seminal fluid is added. This fluid contains mainly water and glucose to moisten and feed the sperm. The prostate and Cowper's glands both add male hormones. The fluid is now known as semen. Semen travels through the urethra, a tube within the penis, to the outside.

*What are the key parts of the male reproductive system?*



**Figure 2.10** The human male reproductive system**Figure 2.11** Human embryos are created after a sperm fertilises an ovum. The embryo then develops into a foetus, which grows in the uterus for about 40 weeks.

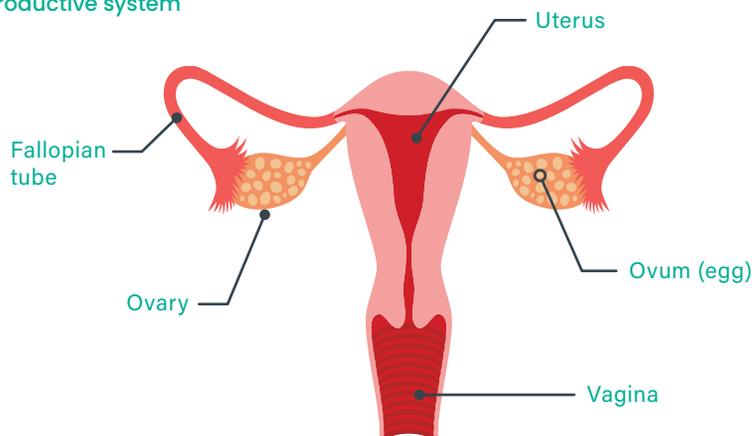
### 3 The female reproductive system

The ovaries are the main organs of the female reproductive system. They produce ova (eggs) and the female hormone oestrogen. In a fertile female, one ovum is usually released from one ovary each month, during ovulation.

The ovum moves down the fallopian tube. If the egg does not meet a sperm, it continues down the fallopian tube and moves through the uterus. Hormones have made the lining of the uterus thicken with blood and tissue.

If fertilisation does not happen, the ovum moves out through the vagina. The uterus lining breaks down and also moves out through the vagina. This is known as menstruation, or a period. On average, this happens once every 28 days after the beginning of puberty and lasts until menopause, which usually happens between the ages of 45 and 55.

#### *What are the key parts of the female reproductive system?*

**Figure 2.12** The human female reproductive system

#### CHECKPOINT 2.6

- 1 Describe the role of the human reproductive system in one sentence.
- 2 What are the male and female sex cells called?
- 3 How long does the time from conception to birth usually take?
- 4 Sperm have tails called flagella. Suggest why.
- 5 What substances make up semen?
- 6 What is menstruation and why does it happen?
- 7 In which part of the female reproductive system does the embryo embed and become a foetus?

#### RESEARCH

- 8 Find out how long pregnancy is for different mammals such as a gorilla, a chimpanzee, a cat, a dog and an elephant.

#### SUCCESS CRITERIA

- I can describe the role of the human reproductive system.
- I can compare and contrast the female and male reproductive systems.

# 2.7

## PLANT REPRODUCTION

### LEARNING INTENTION

At the end of this lesson I will be able to describe the reproductive systems of flowering plants and compare them to the reproductive system of humans.

### KEY TERMS

#### pistil

the female reproductive organs of a flower (stigma, style and ovary)

#### pollen

the fine, powdery substance in the flowers of plants, which contains male sex cells

#### pollination

the movement of pollen from the male part of the plant (anther) to the female part (stigma)

#### stamen

the male reproductive organs of a flower (anther and filament)

### LITERACY LINK

#### READING

Make a list of five nouns, five verbs and five adjectives that you can find in this lesson.

### NUMERACY LINK

#### MEASUREMENT

Ask your teacher for a flower for this activity. Write down three things about the flower that could be measured, and then measure them. Record your data in a table.

Most flowering plants have a shoot system and a root system. Together, these systems help plants to grow and reproduce.

A shoot system contains organs that you would usually find growing above the ground, such as leaves, stems and flowers. The root system contains organs that usually grow underground, such as roots.

## 1 Flowers contain the reproductive organs of plants

The main purpose of flowers is reproduction. Flowers contain the sexual reproductive organs of plants. Many flowers contain both male and female reproductive organs.

The male organs of a flower comprise the **stamen**. It is made up of the:

- *filament* – the stalk that supports the anther
- *anther* – the organ that generates **pollen**, a fine powdery substance that contains the male sex cells of the plant.

The female organs of the flower comprise the **pistil**. It is made up of the:

- *stigma* – the organ where pollen germinates
- *style* – the stalk that connects the stigma and ovary
- *ovary* – the organ that stores the female sex cells (ova or eggs).

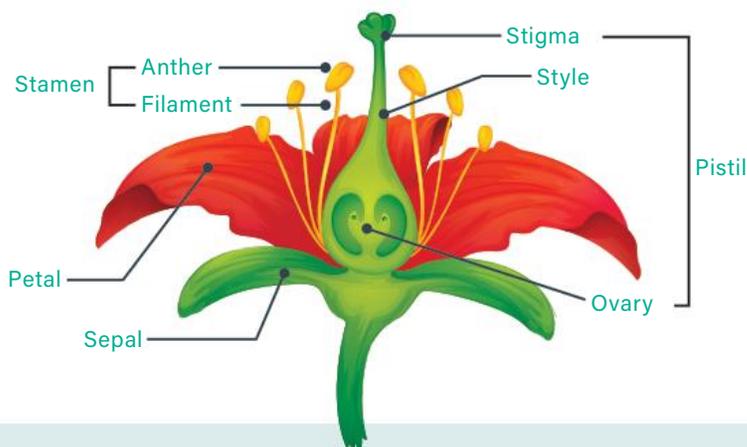
For plants to reproduce, the pollen coating the anthers needs to be moved to the female parts of the flower to fertilise the ovum. This is called **pollination**.

Sometimes this movement is assisted by the wind or rain, but it usually requires the help of pollinating birds and insects, such as bees. Plants attract these organisms by producing flowers that are bright and colourful, smell nice and contain sugary nectar that the birds and insects eat.

Once fertilised, the ova (eggs) become seeds and the ovary swells and enlarges to become a fruit. The seeds in fruit can grow into new plants when conditions are suitable. For some plants, this can take years to happen.

### *What is the main purpose of flowers?*

**Figure 2.13**  
Flowers contain the reproductive organs of the plant. The pistil contains the female parts and the stamen contains the male parts.



## 2 Stems and roots are for support, transport and growth

People tend not to think about the stems and roots of flowering plants – it's the pretty, sweet-smelling flowers that get all the attention. But the stem and roots perform many vital functions, and plants would collapse and die without them.

The stem is the main body of the plant. It does similar things for the plant that the skeletal and circulatory systems do for humans.

These include:

- *support* – helping a plant to stand up and hold the weight of leaves, flowers and fruit
- *transport* – connecting the root and shoot systems of the plant. Water, sugar and other substances move through the stem to provide each system with its requirements
- *growth* – allowing buds to grow from the stem and form into new branches, leaves or flowers.

Roots absorb water and other nutrients from the soil. Water is necessary for photosynthesis and provides the plant with the fluid that dissolves and moves substances around its structure.

Another function of roots is to anchor a plant to the ground. Without roots, trees would fall over in strong winds, and marine plants would wash away in ocean currents.

*What are the main functions of the stem and roots of a plant?*

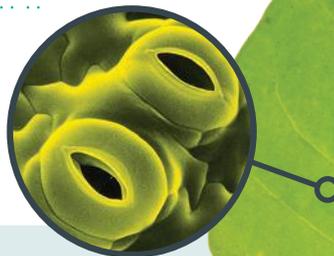
## 3 Photosynthesis happens in leaves

Leaves could be called the solar panels of plants, because their main role is to perform photosynthesis. Leaves have many features that make them perfect for carrying out this process. They are often flat, which increases their surface area, allowing them to absorb more sunlight. They are thin, so carbon dioxide can travel easily into the cells from the environment. Plants contain green pigments called chlorophyll which absorb light energy from the Sun. Veins in plants allow water and other substances needed for photosynthesis to travel to the leaf cells.

If you look at a leaf under a microscope, you will probably notice round pores called stomata. These open and close to allow plants to exchange gases, such as oxygen and carbon dioxide, with their environment. Water can also pass through these pores and water loss is sometimes an unwanted consequence of gas exchange.

*What is the main function of leaves?*

**Figure 2.14** Stomata are tiny pores on the surface of leaves that allow plants to exchange gases with their environment.



### INVESTIGATION 2.7

Dissecting a flower

**KEY SKILL**  
Identifying and managing relevant risks

► Go to page 140



### CHECKPOINT 2.7

- 1 Which body system of a plant contains organs that are usually found above the ground?
- 2 What are the male organs of a flower called?
- 3 What are the female organs of a flower called?
- 4 Describe how a fruit is formed.
- 5 What would happen to most plants if they didn't have a stem?
- 6 Photosynthesis needs carbon dioxide, water and sunlight energy. Explain how leaves help a plant to obtain these resources.
- 7 Roots are usually found underground, so they don't receive the light necessary to carry out photosynthesis. Explain why they are still really important to the process of photosynthesis.

### CONNECTING IDEAS

- 8 Compare and contrast the reproductive system of humans with that of plants. What do they have in common and what is different?

### SUCCESS CRITERIA

- I can outline the differences between the reproductive systems of humans and plants.
- I can describe the main roles of the flower, stem, leaf and root in the body system of a flowering plant.

# 2.8

## ORGAN TRANSPLANT TECHNOLOGY

### LEARNING INTENTION

At the end of this lesson I will be able to describe how advances in technology, combined with scientific understanding of the functioning of body systems, has enabled organ replacement and repair.

### KEY TERMS

#### ethical

relating to principles about what people think is 'wrong' and 'right'

#### Nobel Prizes

world-famous awards given each year for academic, cultural and scientific advances

#### stem cell

a cell that can produce a different type of cell and divide to make more cells

### LITERACY LINK

#### SPEAKING

Write a short speech defending or criticising the following statement, then try out your speech on another student.

Embryonic stem cells should not be used to create organs for organ transplantation.

### NUMERACY LINK

#### UNITS

A heart can only last outside a body for six hours. A particular donated heart has been outside a body for 20 000 seconds. Is it still safe to transplant?

Organ transplantation allows organs, such as the heart, kidneys and skin, to be given to someone who needs an organ because theirs is no longer working.

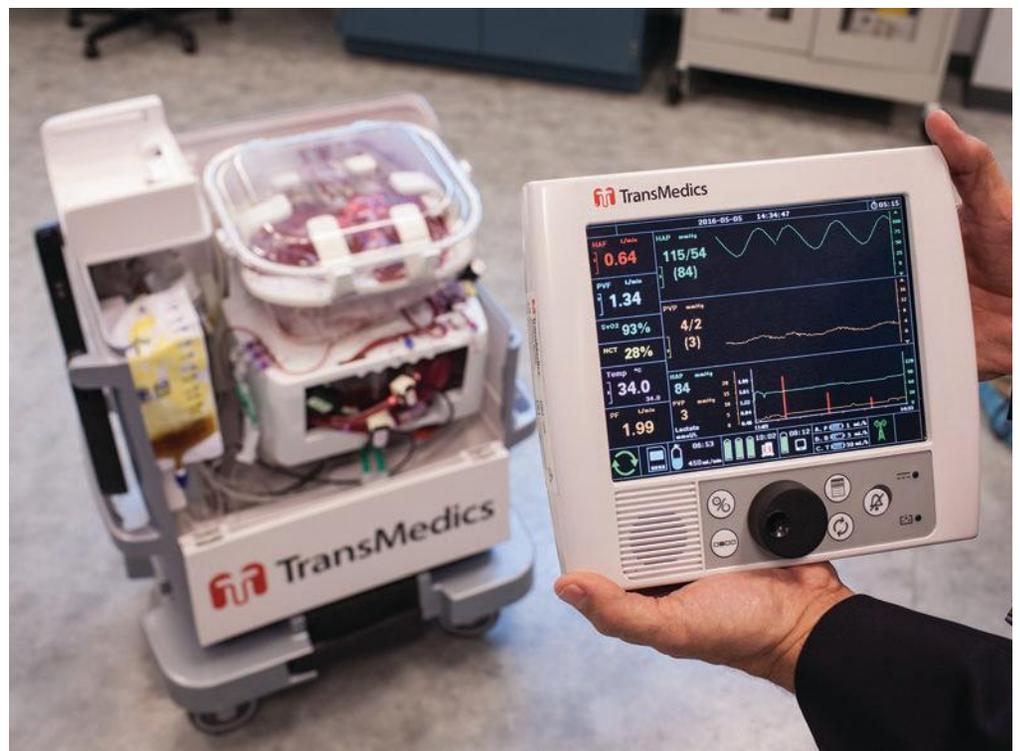
The biggest medical challenge in organ donation is an organ being rejected after someone receives it. Developments in technology mean that donations are now more successful.

## 1 Technology has improved organ transplant medicine

Transplanting organs from one person to another has been tried again and again over hundreds of years, but not very successfully. As doctors and scientists learnt more about the body, organ transplants became more successful.

One problem for organ transplants is keeping the organs fresh and healthy after being removed from the donor. Currently, organs are kept in cold storage during transfer, but this can damage them. In recent medical technology, scientists have made a system that copies the conditions inside the human body, keeping organs fresh and capable of 'surviving' as they're moved from the donor to the recipient.

*How has technology led to more successful organ transplantation?*



**Figure 2.15** Instead of freezing organs, the TransMedics Organ Care System copies the conditions within the human body, keeping the organ alive.

## 2 The human body tries to reject transplanted organs

As with any surgery, things can go wrong during organ transplants. The major cause of problems during transplants is actually the human immune system. The human body is always on the lookout for things that shouldn't be there – that's how our immune systems protect us. Unfortunately, these things include cells from something that would be helpful – in this case, a donor organ.

To avoid this, doctors try to find a very close match between donor and recipient, and anti-rejection medication can be used. The medication tries to stop the body from attacking the new donor organ.

Peter Medawar, a British scientist, worked out why a person's body rejects an organ. This led to the first anti-rejection medication, and he received a **Nobel Prize** for his work in 1960.

*Why does the body try to reject donor organs?*

## 3 Stem cells may allow new organs to be grown

Current research into the use of some types of cells is exciting for the future of organ transplantation. **Stem cells** are cells that can produce any other type of cell. They exist in some places in an adult human body, but some of the most powerful stem cells come from embryos.

The potential benefits are huge – imagine if you could grow a new beating heart out of your own adult stem cells! You wouldn't have to worry about organ rejection either. The new heart would have the same DNA as you, so your body would identify the heart as yours.

There are **ethical** concerns, though. If embryonic stem cells are used, the embryo is destroyed afterwards. Some people consider this to be loss of life, because the embryo could have developed into a baby.

*How could stem cell science change organ transplantation?*

**Figure 2.16** In the near future, it may be possible to grow new organs in a laboratory, ready to transplant without problems to patients.



### CHECKPOINT 2.8

- 1 List some of the organs that can be transplanted.
- 2 Describe how organs are currently transported for organ transplantation.
- 3 Describe some of the risks of organ transplantation.
- 4 Describe at least two ways that developments in technology have led to improvements in organ transplantation.
- 5 Explain why the immune response of trying to kill foreign cells is usually an important and useful thing for the body to do.
- 6 What do you think the job of the immune system is in the human body? Give an example with your explanation.
- 7 Explain how stem cells could be used to make improvements in organ transplantation.

### STUDENT VOICE AND AGENCY

- 8 Would you donate your organs? Conduct research to create a list of the pros and cons of organ donation.

### SUCCESS CRITERIA

- I can explain how developments in technology have led to improvements in organ transplantation.

# 2.9

## THE ETHICS OF ORGAN TRANSPLANTS

### LEARNING INTENTION

At the end of this lesson I will be able to discuss ethical issues that arise from organ transplantation.

### KEY TERMS

#### controversial

creating public disagreement and debate

#### humane

compassionate and sympathetic

### LITERACY LINK

#### WRITING

Write a letter to a friend encouraging them to register as an organ donor.

### NUMERACY LINK

#### GRAPHING

A 2005 poll asked whether stem cell research should be allowed. Of the respondents, 74% said 'yes', 14% said 'no' and the rest said 'not sure'. Draw a pie chart to show this data.

Choosing to be an organ donor, or to receive a transplanted organ, isn't always a straightforward decision. Different groups in society have different beliefs and opinions about organ transplantation.

There are more people waiting for transplants than there are organs available, so animal organs are sometimes used. Also, some people sell organs illegally.

## 1 Organ transplantation raises concerns

There is a huge gap between how many organs are available and how many people need them. In Australia, there are about 1600 people on waiting lists to receive organ transplants. This raises several ethical questions. How do we best select who receives an organ? Should we use organs from children?

Some people – living donors – choose to donate an organ such as a kidney while they are still alive. Some decide that their organs may be donated to others after they die. For potential living donors, there can be pressure to donate an organ, and this can cause stress and relationship issues. The family of a person who has died may be too distressed to agree to the organ donation planned by that person.

*What are some of the issues with organ transplantation?*

## 2 Organ trafficking is a worldwide problem

When there is a need for organs, this is a chance for the illegal sale of human organs. This is known as organ trafficking, or organ trade.

Organ trafficking can affect disadvantaged people who may need money for themselves and their families – they may sell an organ such as a kidney and become sick or die. Cases of kidnapping and stealing organs have been reported all around the world. The price for some organs has been reported to be as high as \$150 000, or even more.

*Why does organ trafficking happen?*



**Figure 2.17** The illegal buying and selling of human organs is a major problem in some parts of the world.

### 3 The use of animal organs is controversial

There are many more people needing organs than there are donors. Some people support the use of animal organs, such as those of pigs or baboons, for transplants. This is a field of medical research called *xenotransplantation*. The Greek prefix *xeno* means 'foreign' or 'different'.

Using animal organs in transplantation has never been entirely successful, because the human body rejects them. The use of animals in science and medicine has always been **controversial**. People concerned about the **humane** treatment of animals may not agree with animal organ transplants.

#### *Why is the use of animal organs controversial?*

**Figure 2.18** Should people use the organs of other animals to improve or save human lives?

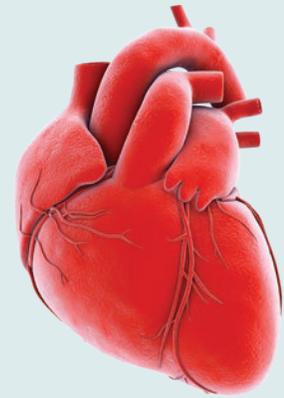


### 4 Some cultures and religious groups have concerns about organ transplants

Different cultures and religious groups have different attitudes about many things, including medicine. They may have different ways of thinking about the value of organ transplantation.

In many religions there is no objection to organ donation and organ transplantation. Some groups support it, seeing organ donation as an act of generosity or compassion. For some there are moral or spiritual concerns. For example, some people believe that the body of a person who has died must remain complete, in readiness for an afterlife. Others may accept an organ donation if the organ no longer contains blood from the donor.

#### *How can culture or religion affect decisions about organ transplantation?*



#### CHECKPOINT 2.9

- 1 Describe at least three ethical considerations about organ transplantation.
- 2 Explain why the illegal trade of organs exists.
- 3 Explain why these groups may be hesitant to undergo organ transplantation.
  - a Indigenous Australians
  - b Romani people
  - c Those of the Jehovah's Witness faith
- 4 Explain why the use of animal organs can be controversial.
- 5 Create a list of positives and negatives in relation to organ transplantation.
- 6 Some people consider the use of pig organs for transplantation to be more acceptable than the use of organs from primates such as baboons, even though primate organs are a closer match to our own. What is your opinion? Defend or criticise the use of pig organs over primate organs.

#### RESEARCH

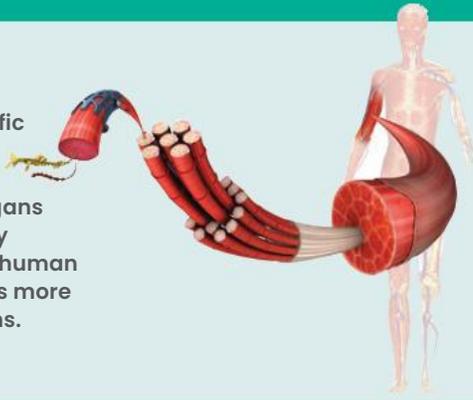
- 7 Research organ trafficking and prepare a short report on the illegal trade of organs.

#### SUCCESS CRITERIA

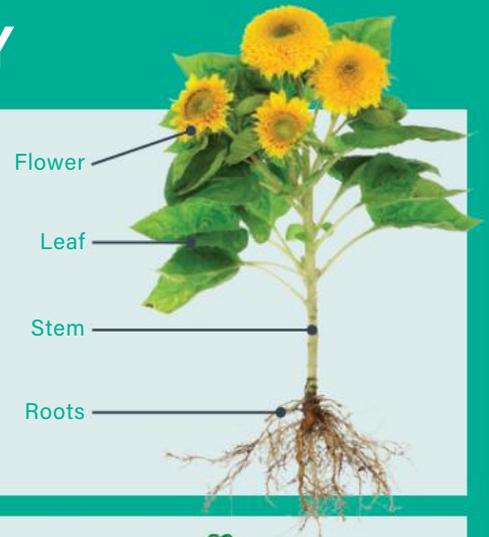
- I can identify three ethical issues with organ transplantation.

# VISUAL SUMMARY

**Animal cells** make up tissues, specific tissues make up organs and these organs make up body systems. The human body contains more than 70 organs.



**Plant cells** also make up tissues and organs. There are four types of plant organ – the roots, stem, leaves and reproductive organs, such as flowers.



Cells combine to make **tissues, organs** and **body systems**. Animals can have more than 10 major body systems that work together to support life.

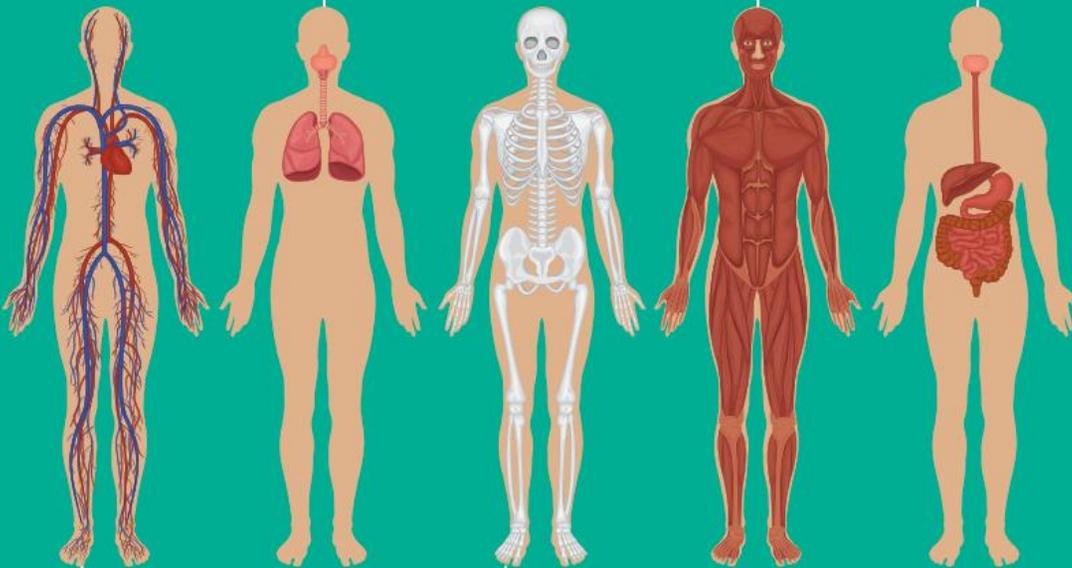
Flowers contain the reproductive organs of plants. They reproduce with the help of wind, water or animals, which move pollen from the male to the female organs during pollination.



The respiratory system, which includes the lungs and trachea, extracts oxygen from air and transports it into the blood.

The muscles of the muscular system contract and relax, allowing the body to move.

The digestive system breaks down food using multiple organs to release nutrients.



The excretory system removes waste from the body through faeces, urine, sweat and breathing.

The male reproductive system generates sex cells, which fertilise the eggs created by the female reproductive system to create new life.

The circulatory system consists of the heart, blood and blood vessels. It moves materials around the body.

The skeletal system consists of bones and cartilage. It supports and protects the body.



## ★ FINAL CHALLENGE ★

- 1 Bones must be both strong and rigid as well as somewhat flexible. Suggest why.
- 2 Copy and complete the following sentence:  
Groups of specialised \_\_\_\_\_ together make up a tissue; groups of tissues together make up an \_\_\_\_\_.
- 3 Why do the muscular and skeletal systems need to work so closely together?



**Level 1**



50xp

- 4 What is the role of the flower in a flowering plant?
- 5 Draw a labelled diagram of the various parts of a flowering plant.
- 6 Explain how the respiratory and circulatory systems work together.



**Level 2**



100xp

- 7 Describe the physical and chemical differences between the food that goes into your mouth and the waste that is eliminated.
- 8 Compare and contrast the reproductive system of a human with that of a flowering plant.
- 9 Outline some ethical considerations of organ transplantation.



**Level 3**



150xp

- 10 Describe the role of the excretory system and suggest what could happen to someone with kidney failure.
- 11 Give an example of two body systems that work together and discuss how they do so.

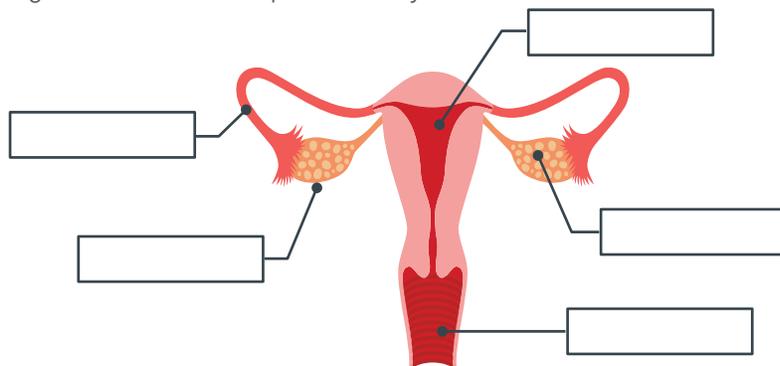


**Level 4**



200xp

- 12 Explain why the male testes must be outside the human body.
- 13 Label this diagram of the female reproductive system:



**Level 5**



300xp



# THE STRUCTURE AND PROPERTIES OF MATTER



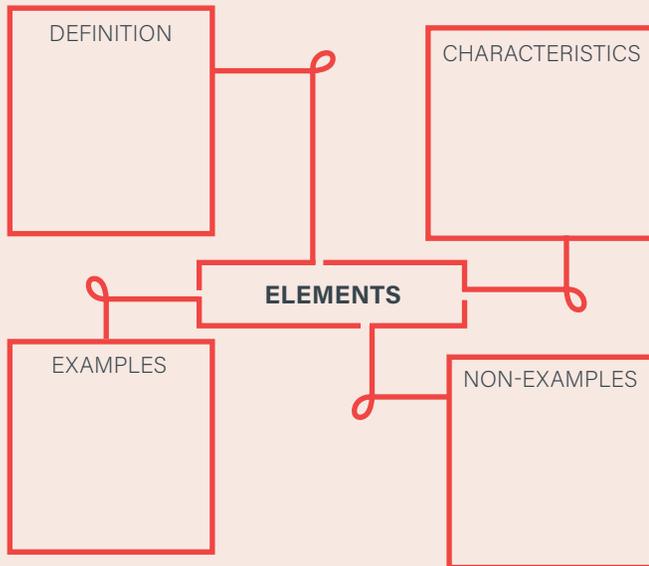
How does chemistry help us understand how things change or stay the same in our universe?

Matter is something that takes up space and has mass. The tiny particles of matter are called atoms. Within these are even smaller particles, such as electrons. An element contains atoms of just one type – for example, the element carbon is made of carbon atoms. The periodic table displays all the known elements.

The properties of substances depend on the element they are made of. Some are good at conducting electricity, such as copper. Some are good at bonding with other elements, such as hydrogen and oxygen, which can bond to become water.

## 1 FRAYER MODEL

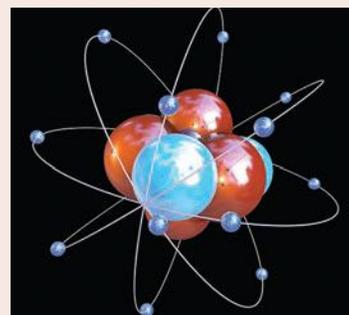
Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Compounds* and *Mixtures*.

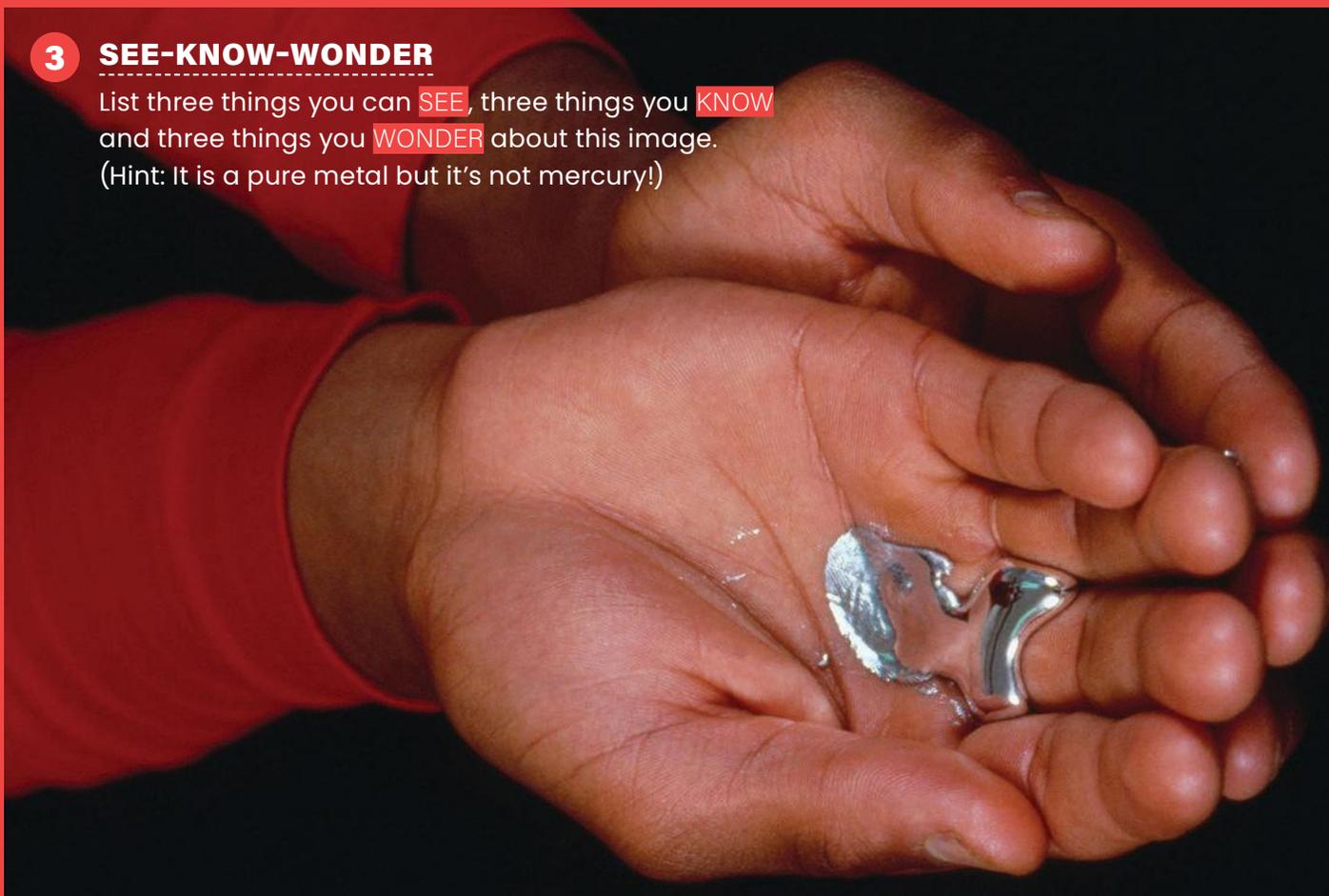
## 2 LEARNING LINKS

Brainstorm everything you already know about the structure and properties of matter.



### 3 SEE-KNOW-WONDER

List three things you can **SEE**, three things you **KNOW** and three things you **WONDER** about this image.  
(Hint: It is a pure metal but it's not mercury!)



### 4 CRITICAL + CREATIVE THINKING



**VARIATIONS:** What strategies can you use to tell if something is a metal or a non-metal? List as many as you can.



**COMMONALITY:** Find some features that oxygen and gold have in common.



**PREDICTION:** Both coal and diamond are made of carbon. If people could change coal into diamonds in their own homes, predict how life on Earth would change.

### 5 THE LIGHTEST!

The lightest element in the periodic table is hydrogen. Hydrogen is even lighter than helium, which is what we fill balloons with so that they float in the air (because air is heavier than helium).

Why don't we use hydrogen instead of helium? Because ... **boom!** Hydrogen is very explosive. The *Hindenburg* was an airship inflated with hydrogen. In 1937 it caught fire, tragically killing 36 people, in a disaster that was caught on film.



# 3.1

## COMMON ELEMENTS

### LEARNING INTENTION

At the end of this lesson I will be able to describe the properties and uses of some common elements, including metals and non-metals.

### KEY TERMS

#### brittle

not able to be bent; will break if stressed

#### compound

a substance containing atoms of two or more elements bonded together in a fixed ratio

#### element

a substance made up of only one type of atom

#### malleable

able to be bent and shaped

#### substance

matter that has a fixed chemical make-up

### LITERACY LINK

#### WRITING

Write a short paragraph explaining the relationship between atoms, elements and compounds.

### NUMERACY LINK

#### DATA

Meredith performs an experiment to determine the temperature at which various solids melt. Give examples of some qualitative and quantitative data she might obtain.

**Elements** are pure **substances**.

Every object in the world is made up of either one type of element or a combination of elements.

Each type of element has different properties, so you can use different substances for different purposes. You can think of elements in two groups: metals and non-metals.



**Figure 3.1** Diamond and graphite are both forms of carbon. Carbon is a non-metal element.

## 1 Non-metal elements share many properties

Non-metal elements share a lot of the same properties. Non-metals have a low melting point, they don't conduct electricity or heat very well, they aren't shiny, and they are **brittle**.

Carbon is a very common non-metal element. Pure carbon has several different forms. Diamond and graphite (the 'lead' in your writing pencil) are both made of pure carbon.

Carbon forms **compounds** with many other elements. All living things contain large amounts of carbon. So does crude oil, which is used for manufacturing petrol, engine oil, candle wax and plastics.

Oxygen is another common non-metal element. Nearly every living thing on Earth needs oxygen to make energy for living cells.

In its pure form, oxygen is a gas. Oxygen can form many compounds with other elements. For example, water is made up of oxygen combined with hydrogen, and oxygen is the most common element in rocks. Oxygen is required for burning – without it, we wouldn't be able to use stoves, engines, rockets or gas heaters.

### *What are two pure forms of carbon?*

**Figure 3.2** Different types of coal contain different amounts of carbon compounds. Some types can be burned to produce electricity.



## 2 Metal elements have the opposite properties to non-metal elements

Metal elements generally have the opposite properties to non-metal elements. Metal elements have a high melting point, they conduct heat and electricity well, they are shiny and they are **malleable**.

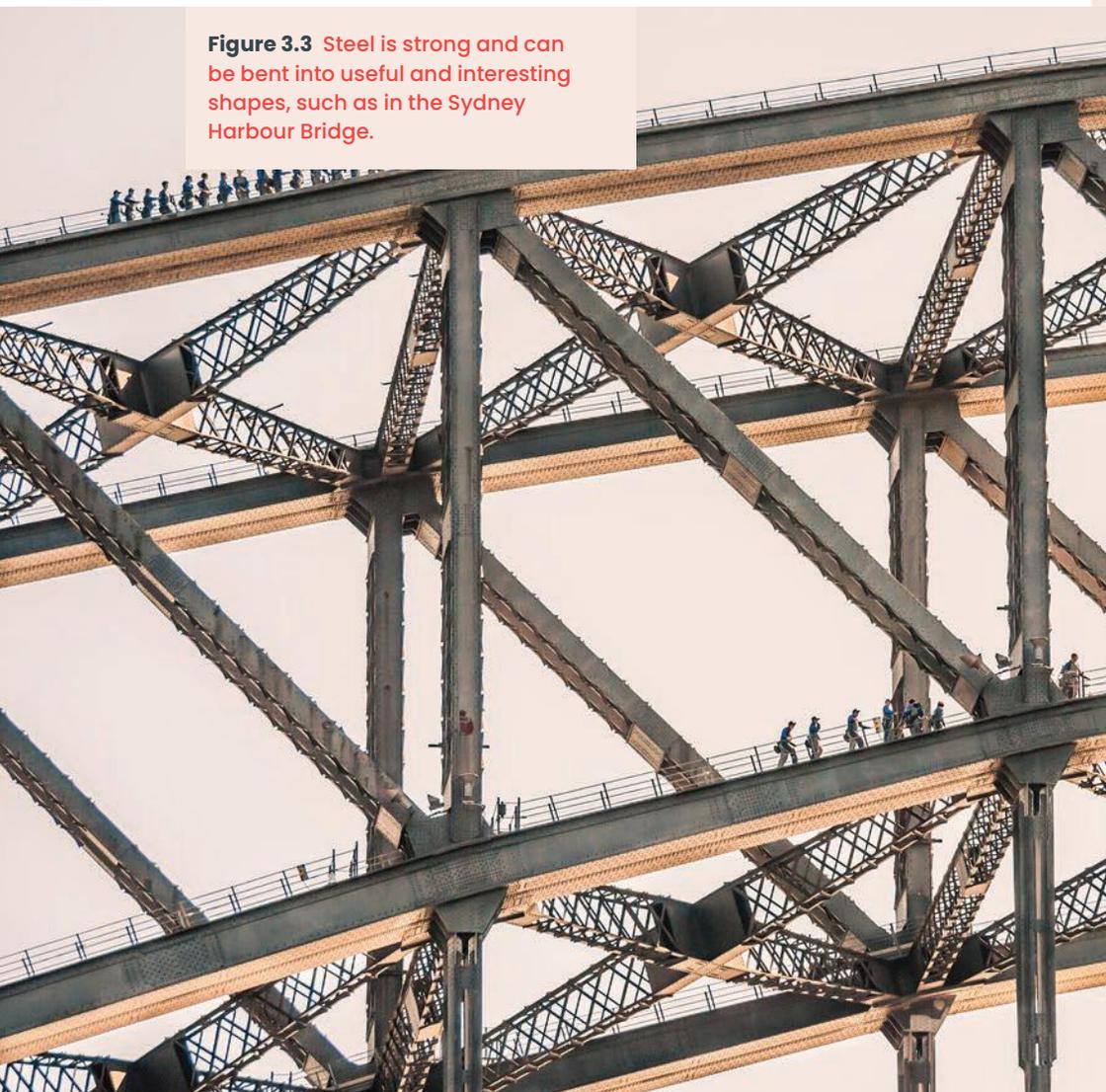
Iron is a common and useful metal element, but in its pure form it is soft and rusts easily. To avoid these problems, iron is usually mixed with other elements such as carbon to create steel. Steel is very strong and rustproof, so it is very useful for tools and construction.

Aluminium, another common metal element, is useful because it's very strong but also relatively lightweight. This makes it an excellent material for making things such as aircraft.

Aluminium is also used in food packaging and storage, such as in aluminium foil and soft-drink cans. Aluminium helps to protect products such as some medicines from air, light and moisture.

*Why is aluminium useful for making aeroplanes?*

**Figure 3.3** Steel is strong and can be bent into useful and interesting shapes, such as in the Sydney Harbour Bridge.



### INVESTIGATION 3.1

Comparing metals and non-metals

**KEY SKILL**  
Explaining results using scientific knowledge

► Go to page 141



### CHECKPOINT 3.1

- 1 What is an element?
- 2 Identify four elements and two compounds that you have heard of.
- 3 List the main properties of metals and non-metals.

- 4 Match each element with its common use.

carbon	making tools
aluminium	food storage
iron	making plastic

- 5 You have been asked to build a rocket for Australia's space program. Would iron or aluminium be a better choice of construction material? Explain your decision.
- 6 You can't light a fire in space. Why do you think this is?

### CRITICAL AND CREATIVE THINKING

- 7 Identify a structure or object that is made of entirely of metal. Suggest why it is made of metal by describing the properties of metals that were advantageous for its design.

### SUCCESS CRITERIA

- I can explain what an element is.
- I can name three properties of metals and non-metals.
- I can describe two uses of metals and two uses of non-metals.

## 3.2

### IDEAS ABOUT THE ATOM OVER TIME

#### LEARNING INTENTION

At the end of this lesson I will be able to describe how scientific knowledge and understanding of the structure and properties of the atom and elements have changed as new evidence has become available.

#### KEY TERMS

##### atom

the smallest unit of an element

##### electron

a negatively charged particle that moves around the nucleus of an atom

##### mass

the amount of matter in a physical body

##### neutron

a neutrally charged particle found in the nucleus of an atom

##### nucleus

the centre of an atom, which contains protons and neutrons

##### proton

a positively charged particle found in the nucleus of an atom

#### NUMERACY LINK

##### CALCULATION

Around 99.9% of an atom's mass is in the nucleus. Calculate the mass of the nuclei in a 1500 kg car, then calculate the mass of the electrons.

As technologies change and scientific understanding increases, so does our understanding of matter.

The ancient Greeks first proposed that matter was made of particles they called *atomos*, meaning 'unable to be divided'. Later, scientists were able to separate matter into pure substances called elements, before discovering that matter was indeed made of tiny particles called **atoms**. Atoms contain even smaller particles.

### 1 Our understanding of matter, elements and atoms has changed over time

Early scientists identified that matter could be broken down into pure substances called elements. They were able to determine that each element had its own set of unique properties.

In 1803, John Dalton was the first modern scientist to propose that all matter was made up of tiny particles called atoms. His experiments showed that each element was made of different atoms that had different **mass**. He proposed that atoms were like tiny solid spheres.

In 1897, Joseph John (JJ) Thomson discovered that atoms had areas with negative charges in them. He assumed that these negative charges sat in a positively charged sphere like plums in a pudding. These negatively charged particles were later called **electrons**.

Ernest Rutherford was a student of JJ Thomson and conducted his own experiments to learn more about atoms. Rather than being a solid sphere, he found that atoms were made up of a **nucleus** orbited by electrons. He found that the nucleus contained positively charged particles called **protons**.

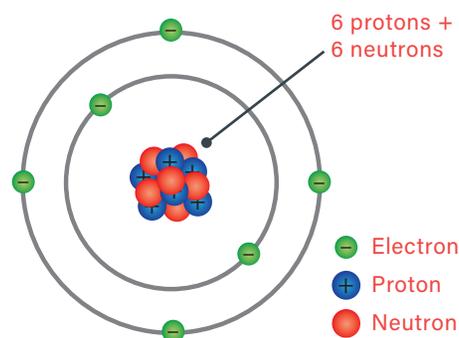
Neils Bohr collaborated with Rutherford to find out more about how the electrons orbited the nucleus, and found that they orbited in different energy levels.

In the 1930s, James Chadwick discovered that the nucleus of an atom also contained neutrally charged particles called **neutrons**.

As scientists learn more about the nature of atoms, they are able to refine models used to explain their structure.

#### *Who first proposed the existence of atoms?*

**Figure 3.4** Today scientists know that atoms are mostly empty space. They have a nucleus that is made up of protons (positively charged) and neutrons (neutrally charged), which is surrounded by electrons (negatively charged).



## 2 The structure of atoms

Today, scientists know that atoms contain a nucleus that is made up of neutrally charged particles called neutrons and positively charged particles called protons. The nucleus is orbited by negatively charged electrons.

Atoms are mostly empty space! If the nucleus of an atom was the size of a pea and placed in the middle of a stadium, the electrons would be orbiting around the outside of the stadium.

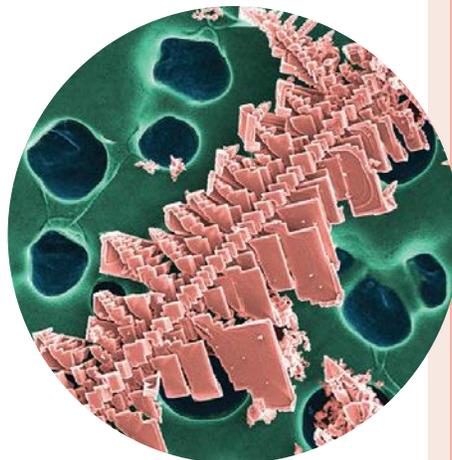
*What are the three main particles that make up an atom?*

## 3 New technologies can be used to learn more about matter

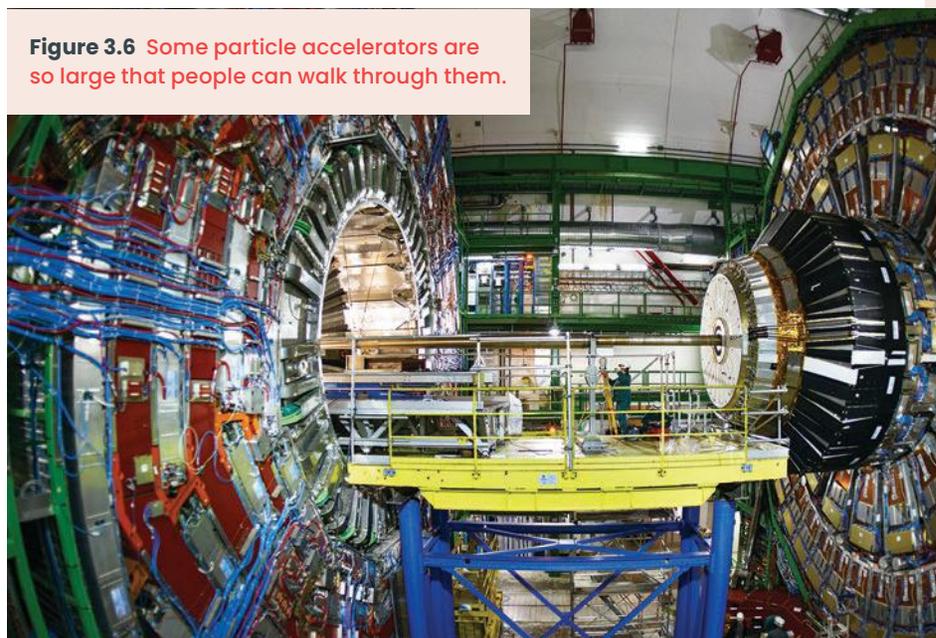
Scientists and engineers continue to study matter, elements and atoms. The electron microscope allows scientists to see how atoms are arranged in different substances and helps them learn more about their properties.

Devices called particle accelerators are used to accelerate tiny particles to enormous speeds and smash them into one another. By analysing these collisions and what remains afterwards, scientists are able to find out more about matter and the universe.

*What does an electron microscope allow scientists to observe?*



**Figure 3.5**  
This image from an electron microscope shows magnesium nanoparticles arranged like dominoes.



**Figure 3.6** Some particle accelerators are so large that people can walk through them.

### CHECKPOINT 3.2

- 1 What was the name the ancient Greeks gave to the particles they thought made up matter?
- 2 Describe the structure of an atom in your own words.
- 3 Identify the modern scientist who first proposed that matter was made of atoms.
- 4 Compare Thomson and Rutherford's models of the atom.
- 5 Identify the particle/s of an atom that:
  - a is negatively charged
  - b is positively charged
  - c is neutrally charged
  - d is located in the nucleus
  - e orbits the nucleus.
- 6 Propose how the development of new technologies can allow an increase in scientific understanding of matter.

### RESEARCH

- 7 Use the internet to research the scientific work that led to our current understanding of matter. Use this information to make an annotated timeline. Include any breakthroughs or advancements you discover, such as the discovery of electrons and the creation of the particle accelerator.

### SUCCESS CRITERIA

- I can describe some of the key breakthroughs that led to the current understanding of the atom.
- I can describe at least two technologies that further scientific understanding of the atom.

# 3.3

## ELEMENTS, COMPOUNDS AND MIXTURES

### LEARNING INTENTION

At the end of this lesson I will be able to describe at a particle level the difference between elements, compounds and mixtures, including the type and arrangement of particles.

### KEY TERMS

#### chemical bond

a force that holds atoms together

#### lattice

a three-dimensional shape made up of a repeating pattern of atoms

#### mixture

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

#### molecule

two or more atoms chemically bonded 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

Considering Figure 3.9, estimate how much water is on top of the mixture. What could you use to measure this more accurately?

Substances can be elements, compounds or **mixtures**. Elements contain one type of atom and compounds have more than one type of atom, bonded together. The atoms in compounds can be in **molecules** or arranged in a **lattice**.

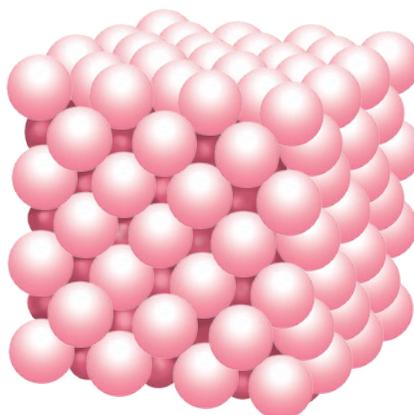
A mixture can contain many types of particles, but the parts of the mixture are not bonded together.

## 1 An element contains only one type of atom

An element is a pure substance that is made up of only one type of atom. Gold is an element because it is made only of gold atoms. Likewise, aluminium is made of only aluminium atoms and hydrogen gas is made of only hydrogen atoms.

*How many types of atom does an element contain?*

**Figure 3.7** Pure gold is made of only gold atoms. Gold atoms are usually coloured pink in scientific illustrations.



## 2 A compound is made of different elements bonded together

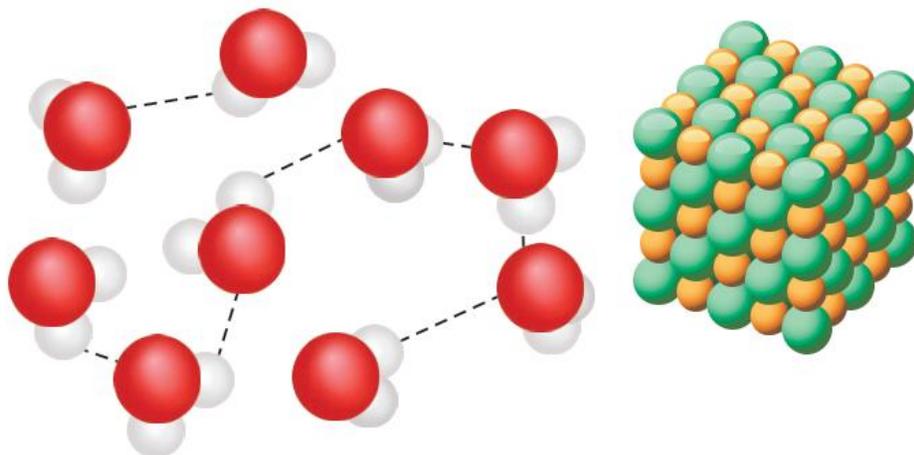
A compound is a substance made up of more than one type of atom **chemically bonded** together in a fixed ratio. Water is a compound: every water particle contains one oxygen atom chemically bonded to two hydrogen atoms. Sodium chloride (table salt) is also a compound because it's made up of sodium and chlorine atoms bonded together.

Some compounds can be made up of molecules, which are structures where the atoms are chemically bonded together. Water is an example of a molecule.

Other compounds form a lattice, where the atoms are bonded together in a repeating pattern. Sodium chloride is an example of a lattice.

*Why is water considered to be a compound?*

**Figure 3.8** Compounds are usually molecules (left) or lattices (right).

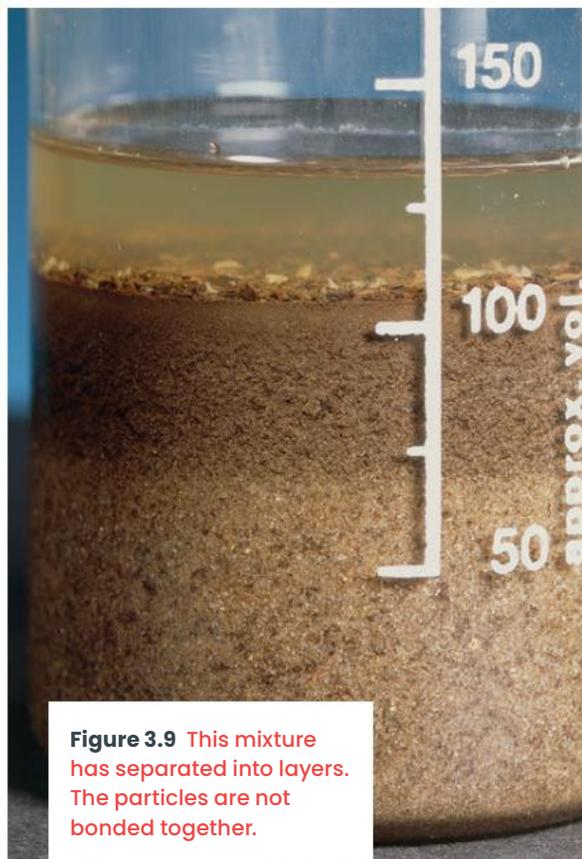


### 3 A mixture is made up of different substances that are not bonded together

A mixture contains two or more elements and/or compounds that are not bonded together and are able to be easily separated. Although a compound contains atoms of different elements, it is much more difficult to separate them than in a mixture.

Sea water is a mixture of salt and water, and if you boil it the water will become a gas, leaving the salt behind. The hydrogen and oxygen atoms in water cannot be separated by boiling it, and the salt compound is not separated either.

*What is the difference between a mixture and a compound?*



**Figure 3.9** This mixture has separated into layers. The particles are not bonded together.

#### INVESTIGATION 3.3

##### Separating a mixture

KEY SKILL  
Writing a research question

Go to page 142



#### CHECKPOINT 3.3

- Use diagrams to illustrate the difference between elements, compounds and mixtures.
- Explain how you could tell if a substance is a compound or a mixture.
- Describe the difference between a lattice and a molecule.
- Categorise these substances as elements, compounds or mixtures.
 

a gold	d soil
b carbon dioxide	e oxygen
c milky tea	f water
- You have been given a jar that contains salt water and sand. Propose a method that you could use to separate the sand, the water and the salt.

#### EXTENSION

- The air in Earth's atmosphere is a mixture of elements and compounds. Work with a partner to find out the major components of the atmosphere and identify them as elements or compounds.

#### SUCCESS CRITERIA

- I can describe the particles in:
  - elements
  - compounds
  - mixtures.
- I can summarise the differences between the particles in elements, compounds and mixtures.

# 3.4

## THE PERIODIC TABLE

### LEARNING INTENTION

At the end of this lesson I will be able to describe the design and features of the periodic table of elements.

### KEY TERMS

#### chemical formula

a group of chemical symbols showing the number of atoms of each element in a compound

#### chemical symbol

a symbol of one or two letters used to represent an element

#### chemist

a scientist who studies elements and compounds

#### periodic table

a table of all known elements and their chemical symbols

### LITERACY LINK

#### SPEAKING

Choose one section from this lesson and rewrite it as a dialogue between two people. Perform your dialogue with a partner.

### NUMERACY LINK

#### CALCULATION

A block of calcium weighs 1 kg and contains  $x$  atoms. In terms of  $x$ , how many boron atoms would you need to weigh the same amount?

Hint: the atomic mass will help!

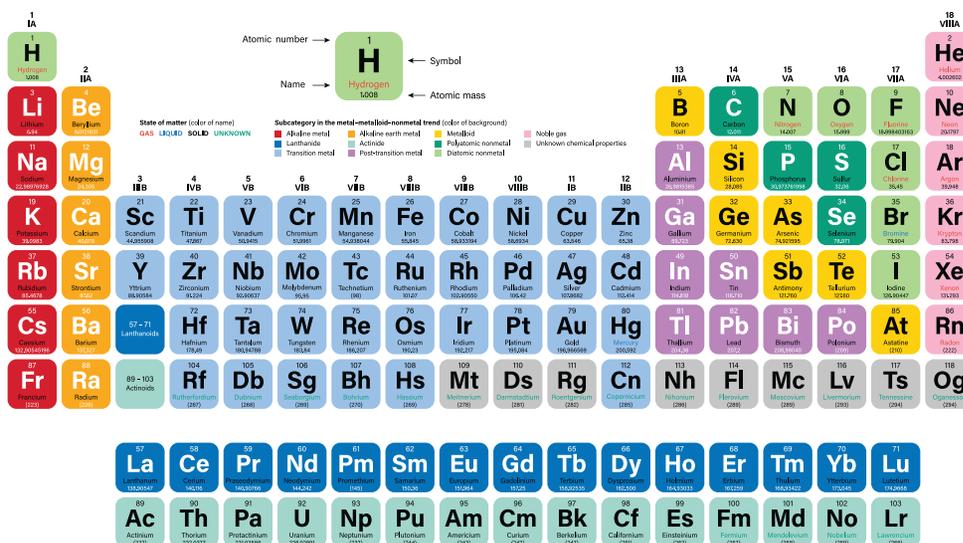


Figure 3.10 The periodic table shows all known elements and their chemical symbols. You can view a larger image of the periodic table on page 54.

The **periodic table** organises information for every known element in the universe. It has been designed to group elements with similar properties together. The table also provides information about the atoms of an element.

The symbols used in the periodic table are universal. This means that regardless of which language you speak or country you live in, you can understand the periodic table.

## 1 Chemical symbols always stay the same

The English name for the 47th element on the periodic table is *silver*. In French it's *argent*, in Spanish it's *plata*, while in Russian it's *серебряный*. Although elements have different names in different languages, they always have the same chemical symbol. No matter where you are in the world, the **chemical symbol** for silver is always Ag.

In the case of silver, 'Ag' doesn't make much sense to English speakers, but it seems a perfect symbol if you are French and use the word *argent* for that element. Likewise, the K symbol for potassium makes sense if you know that the Latin word for potassium is *kalium*.

Table 3.1 Symbols and origins of some element names

Element	Symbol	Origin of symbol
Sodium	Na	Latin word <i>natrium</i>
Iron	Fe	Latin word <i>ferrum</i>
Strontium	Sr	Scottish Gaelic word <i>sron</i>

What is the chemical symbol for silver?

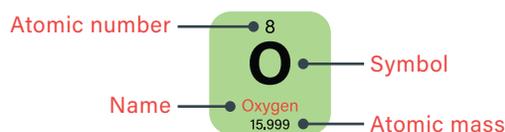
## 2 The periodic table can tell you about the atoms of an element

Each element is represented by its own square on the periodic table. The information on this square can tell you a lot about the element.

The atomic number states how many protons are in the nucleus of an atom of the element. This is the same as the number of electrons in a neutrally charged atom of that element. This is because the positive charges of the protons will cancel out the negative charges of the electrons.

The atomic mass refers to the mass of an average atom of the element. This is measured in atomic mass units (amu).

Electrons do not weigh very much, so most of the mass of an atom is in the nucleus. The number of neutrons in an atom can be calculated by subtracting the atomic number from the atomic mass (to the nearest whole number).



**Figure 3.11**  
The information in the periodic table can tell you a lot about the element.

*How can you determine the number of protons in an atom of an element?*

## 3 Chemical symbols can represent compounds but not mixtures

Chemical symbols can also be used to represent compounds.

For example, water has the **chemical formula**  $\text{H}_2\text{O}$ ; this means that there are two hydrogen atoms for every one oxygen atom. This ratio will never change. Water will always have exactly two hydrogens for every oxygen.

Mixtures cannot be represented by a chemical formula, as the ratio is not constant.

Let's say you had a bucket of salt water. The ratio between the elements could easily be changed by adding more salt, or evaporating some water. Another **chemist** in another lab might also have some salt water, but she might have added two teaspoons of salt instead of just one. Unlike compounds, the ratios between elements in a mixture are easily able to change, and so we cannot use chemical symbols to represent mixtures.

*Why can't a chemical formula be used to represent a mixture?*

### CHECKPOINT 3.4

- Briefly describe the periodic table, including how it is organised and how it can be used.
- Copy and complete this table. (You may need to refer to the larger periodic table on page 54 to help you.)

Element	Symbol
Carbon	C
Oxygen	
	Na
Fluorine	
	Cu
Calcium	
Tungsten	

- An atom was determined to contain 18 protons. Identify the element.
- What does the atomic mass tell us about an element?
- Use the periodic table to help you calculate the number of neutrons in an atom of nitrogen.
- Identify two benefits of using chemical symbols instead of element names.
- What can the chemical formula of a compound tell you about the substance that the name cannot?

### RESEARCH

- Use the internet to find out where these elements got their symbols from.
  - lead (Pb)
  - tin (Sn)
  - gold (Au)
  - mercury (Hg)
  - antimony (Sb)

### SUCCESS CRITERIA

- I can describe the key features of the periodic table.
- I can explain the need for universal chemical symbols.

## 3.5

COMMON  
COMPOUNDS

## LEARNING INTENTION

At the end of this lesson I will be able to identify some examples of common compounds.

## KEY TERMS

**compound**

a substance containing atoms of two or more elements bonded together in a fixed ratio

**molecule**

two or more atoms chemically bonded together

## LITERACY LINK

**VOCABULARY**

Consider the compound carbon dioxide. What clues are in the name that tell you what the compound may be made of? What do you think carbon trioxide would look like? Explain your answer.

*Hint: think about other words that start with 'tri'.*

## NUMERACY LINK

**GRAPHING**

Each molecule of glucose contains 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms. Draw a pie chart to show this ratio.

**Compounds** are substances that contain atoms of two or more different elements bonded together in a fixed ratio.

Compounds are found throughout the universe because many atoms are unstable on their own and so bond with others. They are vital to life and survival – we could not exist without compounds such as water, carbon dioxide and sodium chloride.

**1 Water is a compound vital for life**

A very well known example of a compound is water. Every living thing on Earth needs water to survive.

Each water **molecule** is made up of one oxygen atom bonded to two hydrogen atoms. This can be written as the capital letter H (for hydrogen), the number 2 (to show that there are two hydrogen atoms) and the capital letter O (for oxygen).

When you write compounds in this way, the number should be written as a subscript – so water is  $H_2O$ .

*What types of living things need water to survive?*

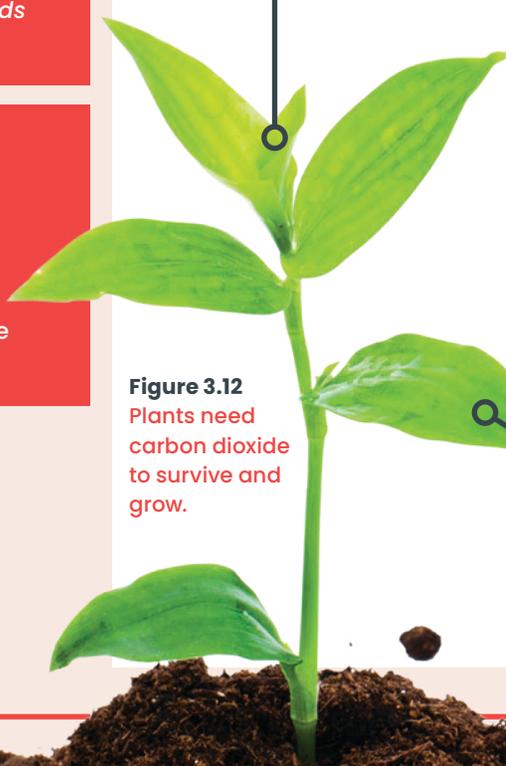
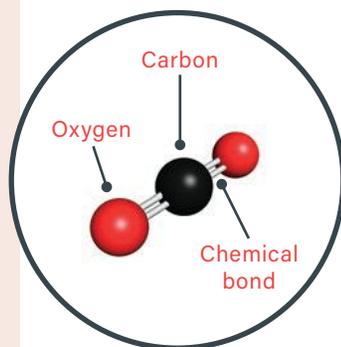
**2 Carbon dioxide is essential for plants**

Carbon dioxide is another compound that's essential to life.

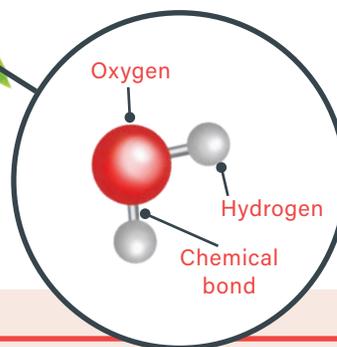
Humans and other animals breathe in oxygen and breathe out carbon dioxide as a waste product. Plants use carbon dioxide to make energy to survive. A product of this reaction is oxygen, which plants release into the atmosphere, and the cycle continues.

Carbon dioxide is a gas at room temperature. Each carbon dioxide molecule contains one carbon atom (written as C) bonded to two oxygen atoms – so its chemical formula is  $CO_2$ .

*Why do plants need carbon dioxide?*



**Figure 3.12**  
Plants need carbon dioxide to survive and grow.



### 3 Ammonia is used in many farm and household products

Ammonia is used to make products such as fertilisers to help plants grow, and to make clothes and cleaning products. At room temperature, ammonia is a gas that is poisonous to humans, which is why some cleaning products must be handled carefully.

Each ammonia molecule is made up of one nitrogen atom (written as N) bonded to three hydrogen (H) atoms – so the chemical formula is  $\text{NH}_3$ .

*What elements make up ammonia?*

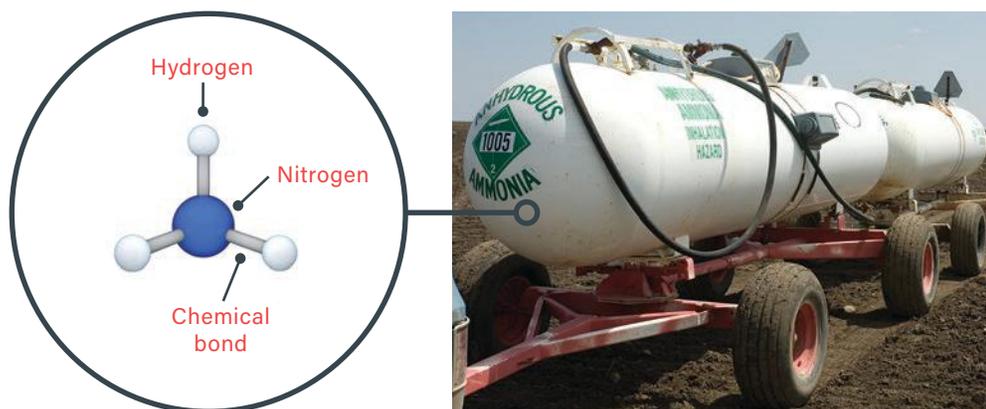


Figure 3.13 Ammonia is used to make fertilisers, which help farm crops grow.

### 4 Sodium chloride is used in many foods

Sodium chloride is better known as table salt – the same substance that is added to fish and chips.

The chemical formula for sodium chloride is  $\text{NaCl}$  – that's one atom of sodium (Na) and one atom of chlorine (Cl). Sodium chloride is a compound that does not form molecules but has a lattice structure, with alternating sodium and chlorine atoms.

*What is sodium chloride better known as?*



Figure 3.14 Table salt is a lattice containing sodium and chlorine, known as sodium chloride.

#### INVESTIGATION 3.5

Properties of compounds

KEY SKILL  
Explaining results using scientific knowledge

Go to page 143



#### CHECKPOINT 3.5

- 1 Explain how a compound is different to an element.
- 2 Name three uses of ammonia.
- 3 What types of atoms make up table salt?
- 4 Classify the four compounds in this section as solids, liquids or gases at room temperature.
- 5 What is produced by plants that is so important for humans?
- 6 What do humans produce that is so important for plants?
- 7 Suggest how you could break compounds into individual atoms.
- 8 Water and carbon dioxide are essential to life on Earth. Explain why.

#### CONNECTING IDEAS

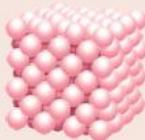
- 9 Identify at least three important compounds found in everyday life that have not been mentioned in this lesson, and explain their roles on Earth.

#### SUCCESS CRITERIA

- I can explain what a compound is.
- I can identify some examples of common compounds.

# VISUAL SUMMARY

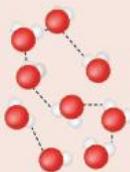
An **element** is made of only one type of atom.



Gold

Pure gold is made of only gold atoms.

A compound has two or more types of atoms bonded together.



It includes substances such as water, carbon dioxide and ammonia.

**Non-metal elements** (for example: carbon, oxygen)

- low melting point
- do not conduct electricity or heat well
- brittle
- not shiny

**Metal elements** (for example: iron, aluminium)

- high melting point
- conduct heat and electricity well
- malleable
- shiny

Sodium Chlorine



A mixture contains two or more types of atom without a chemical bond. It includes substances such as milk, dirt and air.



John Dalton was the first modern scientist to suggest the existence of **atoms**.



JJ Thomson discovered the charged particles called **electrons**.



Ernest Rutherford proved that atoms had a **nucleus**.

Atomic number →		1		← Symbol														18																																									
		H		← Name		Hydrogen		← Atomic mass										2																																									
		1.008																4.002602																																									
3	Li	4	Be	5	B	6	C	7	N	8	O	9	F	10	Ne	11	Na	12	Mg	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar																												
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr																								
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe																								
55	Cs	56	Ba	57-71	Lanthanoids					72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn																				
87	Fr	88	Ra	89-103	Actinoids					104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Cn	113	Nh	114	Fl	115	Mc	116	Lv	117	Ts	118	Og																				
57	La	58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu	89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr

The periodic table shows all known elements and their chemical symbols.

## ★ FINAL CHALLENGE ★

- 1 Describe the difference between an element and a compound.
- 2 Name three compounds and three elements.
- 3 Copy and complete using the correct answers in the underlined parts of these sentences.

Oxygen is a metal/non-metal that exists in gas/liquid form naturally. A common property of non-metals is that they have a high/low melting point, are brittle/strong and they do/don't conduct electricity. The opposite/same can be said of metals.

**Level 1**

**50xp**


- 4 Copy and complete the table by stating whether the elements are examples of metals or non-metals.



Carbon	
Gold	
Oxygen	
Mercury	
Potassium	

**Level 2**

**100xp**


- 5 Describe the contributions of Rutherford and Dalton to our knowledge of the properties and structure of elements.
- 6 List how many of each type of element is in each of the following compounds:  
**a** CO<sub>2</sub>      **b** H<sub>2</sub>O      **c** NH<sub>3</sub>

**Level 3**

**150xp**


- 7 Explain why the chemical symbol for potassium is not P.
- 8 Explain how the development of either the electron microscope or particle accelerator has contributed to our understanding of the structure and properties of matter.
- 9 Describe the two ways that particles are usually arranged in compounds.
- 10 A mixture is not the same as a compound. Explain why.

**Level 4**

**200xp**


- 11 Justify the use of universal symbols in the periodic table.
- 12 Research and prepare a response to this research question.  
 'How did the ancient Egyptians use their knowledge of the properties of elements and compounds in their lives?'

**Level 5**

**300xp**




# CHEMICAL CHANGE

How does chemistry help us understand how things change or stay the same in our universe?



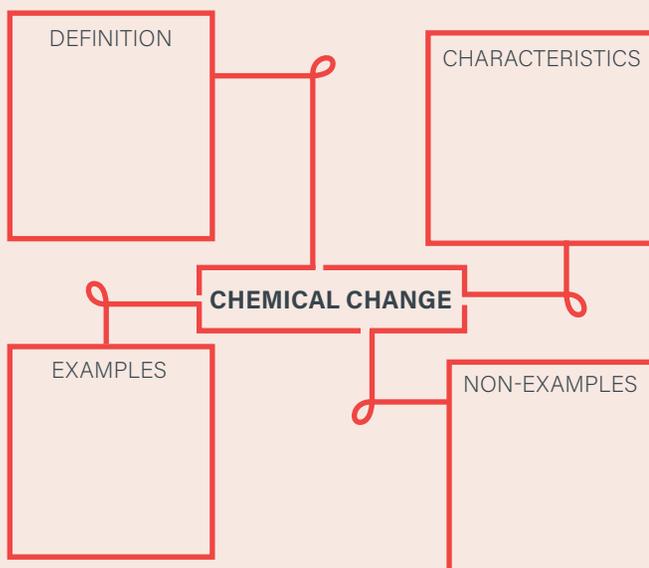
Chemical changes can happen on a very large scale. Explosions are huge chemical reactions.

On a smaller scale, chemical changes take place in your body all the time. They happen in your mouth to break down your food and continue in the rest of your digestive system to change the food into energy your body can use.

From using fire to the latest scientific research, humans have learnt to use chemical changes and to create their own.

## 1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *Physical change* and *Corrosion*.

## 2 LEARNING LINKS

Brainstorm everything you already know about chemical change.





### 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



**FIVE QUESTIONS:** Write five questions that have 'chemical change' as the answer.



**VARIATIONS:** How many different ways can you change the way something looks without altering what it's made of?



**COMBINATIONS:** List the features of a rotten banana and of a plastic ball, and then combine some of these features to invent a new object.

### 5 THE MOST EXPENSIVE COLLABORATION!

The most expensive thing ever made by humans is the International Space Station (ISS), which cost around 220 billion dollars! The ISS is the size of a five-bedroom house, but it's a giant laboratory that moves in low orbit around Earth.

The ISS is one of the best examples of scientific collaboration in human history. Many countries contributed towards the cost of making it, and more than 15 countries have sent their scientists up to the ISS. The longest stay on the ISS was 665 days!



# 4.1

## PHYSICAL AND CHEMICAL CHANGE

### LEARNING INTENTION

At the end of this lesson I will be able to demonstrate that a chemical change involves substances reacting to form new substances.

### KEY TERMS

#### chemical change

a change in properties, with a new substance formed

#### physical change

a change in appearance, with no new substances formed

#### reversible

can be taken back to its previous state

### LITERACY LINK

#### READING

Read sections 1 and 2 carefully, then summarise physical and chemical change in three words each.

### NUMERACY LINK

#### UNITS

It takes 38 minutes for a particular amount of salt to dissolve in a beaker of water. How many seconds is this?

Changes happen around us all the time: the ice caps of the north pole melting, explosions during New Year's Eve fireworks, toast burning, nails rusting and food rotting.

These changes are all either physical or chemical changes. When no new substance is formed, and the process is **reversible**, it's a physical change. If a new substance is produced and the process is not reversible, then this is a chemical change.



**Figure 4.1** The sugar in the left pan is melting, which is a physical change – no new substances are formed. The sugar in the right pan has been heated more and it has chemically changed into a new substance: caramel.

## 1 Physical changes do not affect the properties of a substance

When a substance undergoes a **physical change**, the substance keeps its original properties. Physical changes can include changes of state, such as melting and evaporation, or other changes, such as crushing or stretching.

When water changes state from solid (ice) to liquid (water) to gas (steam), this is a physical change. All three states of water still consist of molecules of water.

Physical changes can be reversed. Think about hot, melted wax – when the melted wax cools and hardens, it still looks the same. The wax has undergone a physical change.

Some examples of physical changes are:

- salt and sand being mixed
- paper being cut
- evaporation
- a ruler breaking
- salt being dissolved in water.

*What is a physical change?*



## 2 Chemical changes can make new substances

A **chemical change** happens when a new substance is formed during a chemical reaction. Chemical reactions cause the atoms in the substance to rearrange and form new substances.

We can look for evidence that chemical change has happened.

Some observations may include:

- there is a colour change
- a gas (bubbles) is released
- a new substance is formed
- heat is absorbed or released
- a precipitate (solid bits within a liquid) is formed.

Chemical changes are not reversible. When you cook a pancake, it cannot be 'uncooked' and become batter again. This is a chemical change.

Some other examples of chemical changes are:

- burning wood
- a banana rotting
- a battery working
- fireworks
- rusting iron
- cookies baking.

### What is a chemical change?

**Figure 4.2** When metals burn, they form new substances. Each burning metal gives off a different colour of light. This is a chemical change.



### INVESTIGATION 4.1

Physical and chemical changes

(Teacher demonstration)

► Go to page 144



### CHECKPOINT 4.1

- 1 How are physical and chemical changes different?
- 2 Chemical change produces new substances. How are the new substances made?
- 3 List three pieces of evidence that could show that a chemical change has happened.
- 4 Put a P next to the physical changes and a C next to the chemical changes.
  - a ice melting
  - b a cake baking
  - c paper burning
  - d chocolate powder mixing into milk
  - e cardboard being cut
  - f wax melting
- 5 One sign that a chemical change has taken place is that gas is released and forms bubbles. Suggest why this is a sign of chemical change.
- 6 Give an example of a chemical change not already mentioned and justify why it is a chemical change and not a physical one.

### INQUIRY

- 7 Fireworks involve chemical reactions that produce coloured light. Use the internet to find out what chemical reactions take place and what produces the different colours.

### SUCCESS CRITERIA

- I can explain the difference between a physical and a chemical change.
- I can identify evidence for a chemical change.

## 4.2

### CHEMICAL CHANGES IN EVERYDAY LIFE

#### LEARNING INTENTION

At the end of this lesson I will be able to describe some chemical changes that occur in everyday life.

#### KEY TERMS

##### corrosion

the breaking down or destruction of a substance, especially a metal, through a chemical reaction

##### product

a substance formed during a chemical reaction

##### reactant

a substance that takes part in a chemical reaction

#### LITERACY LINK

##### VOCABULARY

The prefix 'photo' means 'light'. Try to think of three words that contain the word 'photo', and explain what they have to do with light.

*Hint: one word is on this page!*

#### NUMERACY LINK

##### DATA

Jonah puts an iron nail in a petri dish of salt water. Over the next week, he measures the mass of the nail as it rusts in the water. His results were 0.79 g, 0.81 g, 0.83 g, 0.84 g and 0.85 g. What does this data tell us about the mass of an object as it rusts? Why do you think this is?

**Figure 4.3** Stain removers contain ingredients that break down stains into molecules that can be washed away.



A chemical reaction produces a chemical change. In a chemical reaction, one or more substances, the reactants, are changed to one or more new substances, the products. This happens as the reaction causes the atoms to rearrange to create new substances as products.

### 1 Photosynthesis is a chemical reaction within plants

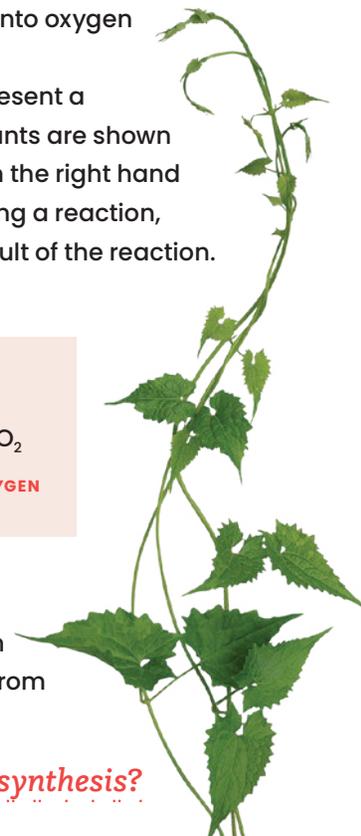
Photosynthesis is a chemical reaction in which plants use energy from sunlight to transform water and carbon dioxide into oxygen and glucose.

We always use a word or chemical equation to represent a chemical reaction. In a chemical equation, the reactants are shown on the left hand side of the arrow and the products on the right hand side. The **reactants** are substances that change during a reaction, while the **products** are substances that form as a result of the reaction.



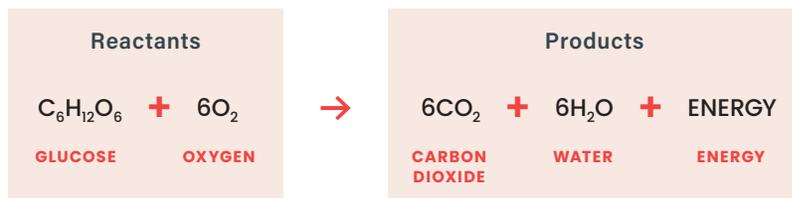
This equation shows that atoms in carbon dioxide and water have reacted and been rearranged to form glucose and oxygen. The products are very different from the reactants – they are completely new substances.

*What are the reactants and products of photosynthesis?*



## 2 Cellular respiration combines oxygen and glucose

Cellular respiration is the way that cells of all living organisms obtain energy. During cellular respiration, oxygen (from the air) and glucose (from food) combine. This chemical reaction produces carbon dioxide, water and energy.



Does this reaction look familiar? Remember that during photosynthesis, carbon dioxide and water change into oxygen and glucose, in the presence of sunlight. This means that cellular respiration is the opposite process of photosynthesis. The atoms in the reactants are rearranged to form new substances (products).

*What are the reactants and products of respiration?*

## 3 Rust is a chemical change

When some metals come into contact with oxygen in the air, they combine in a chemical reaction. This type of reaction is known as **corrosion**. Corrosion can cause metal objects to become weaker and break down. In a corrosion reaction, the reactants are the metal and oxygen. The product is a new substance called a metal oxide.

When objects made from iron react with oxygen they produce iron oxide. This is commonly known as rust.

Some metals are less likely to corrode than others. Galvanised iron is made by coating iron with a thin layer of zinc. Zinc is more reactive than iron, so oxygen will corrode the zinc and leave the iron alone.

*What is rust?*

**Figure 4.4** Rust is also known as iron oxide. It is produced when iron comes into contact with oxygen in the air and reacts. This is an example of a corrosion reaction.



### INVESTIGATION 4.2A

Corrosion of iron

KEY SKILL  
Identifying and managing relevant risks

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### INVESTIGATION 4.2B

Preventing corrosion

KEY SKILL  
Identifying the independent, dependent and controlled variables

► Go to page 146



## CHECKPOINT 4.2

- 1 What must happen for a chemical change to occur?
- 2 Explain the difference between a reactant and a product in a chemical reaction.
- 3 Identify the products formed during photosynthesis.
- 4 Identify the products formed during cellular respiration.
- 5 Identify the reactants in the reaction that forms rust.
- 6 A herbivore is an animal that eats plants. Suggest where the glucose in the herbivore's cells originally came from.
- 7 Suggest why using the chemical formula of substances when writing chemical equations is useful.

## CONNECTING IDEAS

- 8 This lesson includes some important and well-known chemical reactions. Working with a partner, think of as many things as you can that work because of chemical reactions.

## SUCCESS CRITERIA

- I can explain what a chemical change is.
- I can identify at least three examples of chemical changes that occur in everyday life.

# 4.3

## COMPARING PHYSICAL AND CHEMICAL CHANGE

### LEARNING INTENTION

At the end of this lesson I will be able to compare physical and chemical changes in terms of the arrangement of particles and reversibility of the process.

### KEY TERMS

#### electrolysis

passing electricity through a substance to break it up

#### model

a simplified way of explaining something complex and real based on evidence

### 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

If you had 8 molecules of  $H_2O$  (water), how many hydrogen atoms do you have in total? How many oxygen atoms do you have?



**Figure 4.5** Particles exist all around us as solids, liquids and gases.

Now that you know how physical and chemical changes differ, it's time to look at how these changes take place.

Like a scientist, you can use a **model** to understand and explain your observations, because the particles in chemical reactions are too small to see.

## 1 The particle theory models the nature of matter

There are five main ideas in the particle theory. This model is helpful to remember as you study chemical reactions:

- 1 All matter is made up of tiny particles.
- 2 All the particles are constantly moving.
- 3 Forces of attraction hold the particles together.
- 4 The further apart the particles are, the weaker the forces of attraction.
- 5 Particles at higher temperatures move faster and with more energy than those at lower temperatures.

*What is one of the main ideas in the particle theory?*

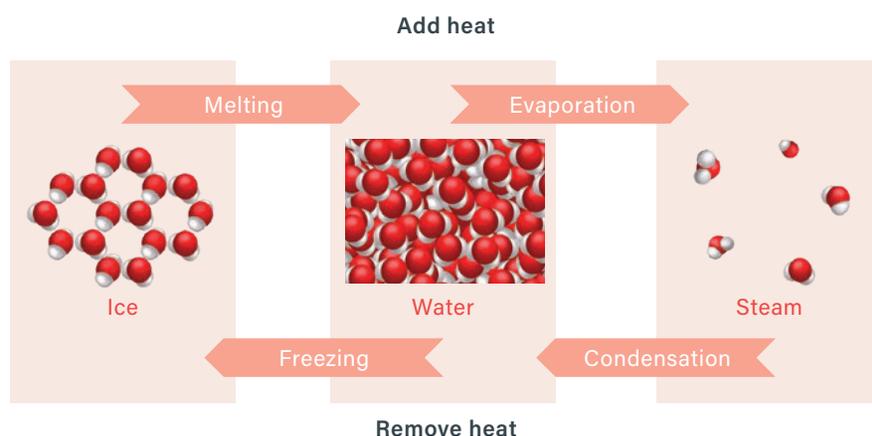
## 2 Particles do not change during a physical change

In a physical change, no new products form and the reaction is generally reversible. There is no change to the make up of atoms or molecules of the substance.

You can easily change the state of water by freezing, melting or boiling it. The water molecules stay the same each time, whether the water is a solid (ice), liquid (water) or gas (steam). The molecules will move faster or slower depending on their state, but they don't stop being water molecules.

*What happens to water molecules as they change from one state to another?*

**Figure 4.6** Water molecules can exist as a solid, a liquid or a gas.



### INVESTIGATION 4.3

Burning steel wool (Teacher demonstration)



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### CHECKPOINT 4.3

- 1 What is the particle theory of matter?
- 2 Explain in terms of particles what happens when ice changes to water.
- 3 What is the molecular formula of water?
- 4 Copy and complete. Physical changes are \_\_\_\_\_, and no new \_\_\_\_\_ are produced. Chemical changes are \_\_\_\_\_. In a chemical change \_\_\_\_\_ substances are \_\_\_\_\_.
- 5 Use diagrams of particles (such as molecules) to show the difference between a chemical and a physical change.
- 6 Write a word equation for the decomposition of water into hydrogen and oxygen gas.

### EXTENSION

- 7 Consider the physical change of water from liquid to gas. Now consider the chemical change of water when it breaks down to form hydrogen and oxygen. Compare the differences in terms of energy for the physical changes in water and the chemical changes in water.

### SUCCESS CRITERIA

- I can explain the difference between a physical and a chemical change.
- I can use the particle model to compare and contrast physical and chemical changes.

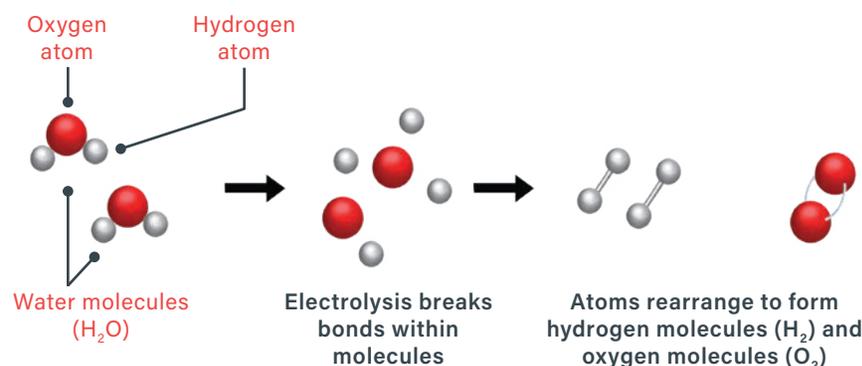
## 3 Particles change during a chemical change

In a chemical change, new substances are formed and the reaction is not reversible. The particles at the beginning of the reaction are *not* the same as those at the end. For example, as a reaction happens, the original molecules are broken down into atoms that are then rearranged to form molecules of new substances.

Water molecules are made up of two hydrogen atoms and one oxygen atom, so the molecular formula of water is  $\text{H}_2\text{O}$ . Breaking apart water molecules isn't easy, but it can be done using **electrolysis**. This involves passing electricity through the molecules. The electrical energy breaks the strong bonds holding the oxygen and hydrogen atoms together. The atoms of these reactants then rearrange and combine to form hydrogen gas and oxygen gas, which are the products of the reaction.

*What products are formed when electrolysis is performed on water?*

**Figure 4.7** The bonds inside water molecules break when electrical energy passes through them. Oxygen and hydrogen gases are formed.



## 4.4

## MAKING NEW MATERIALS

## LEARNING INTENTION

At the end of this lesson I will be able to describe how science and technology contribute to finding solutions to a range of contemporary issues including the manufacture of new materials.

## KEY TERMS

**biodegradable**

able to be broken down by natural processes; for example, by bacteria

**fossil fuel**

a natural fuel formed over millions of years from the remains of living things

**polymer**

a substance consisting of large molecules made up of many small repeating units

## LITERACY LINK

**SPEAKING**

Write a short speech that aims to convince people that society should support scientific research into making new materials. Try your speech out on a partner.

For many years, scientists have made new materials such as plastic from **fossil fuels**. But fossil fuels are a limited resource that take millions of years to form. One day, those fossil fuels will run out.

Scientists need to research ways of producing and testing materials that will be better, longer lasting and easier to use.

## 1 Plastics are useful but not environmentally friendly

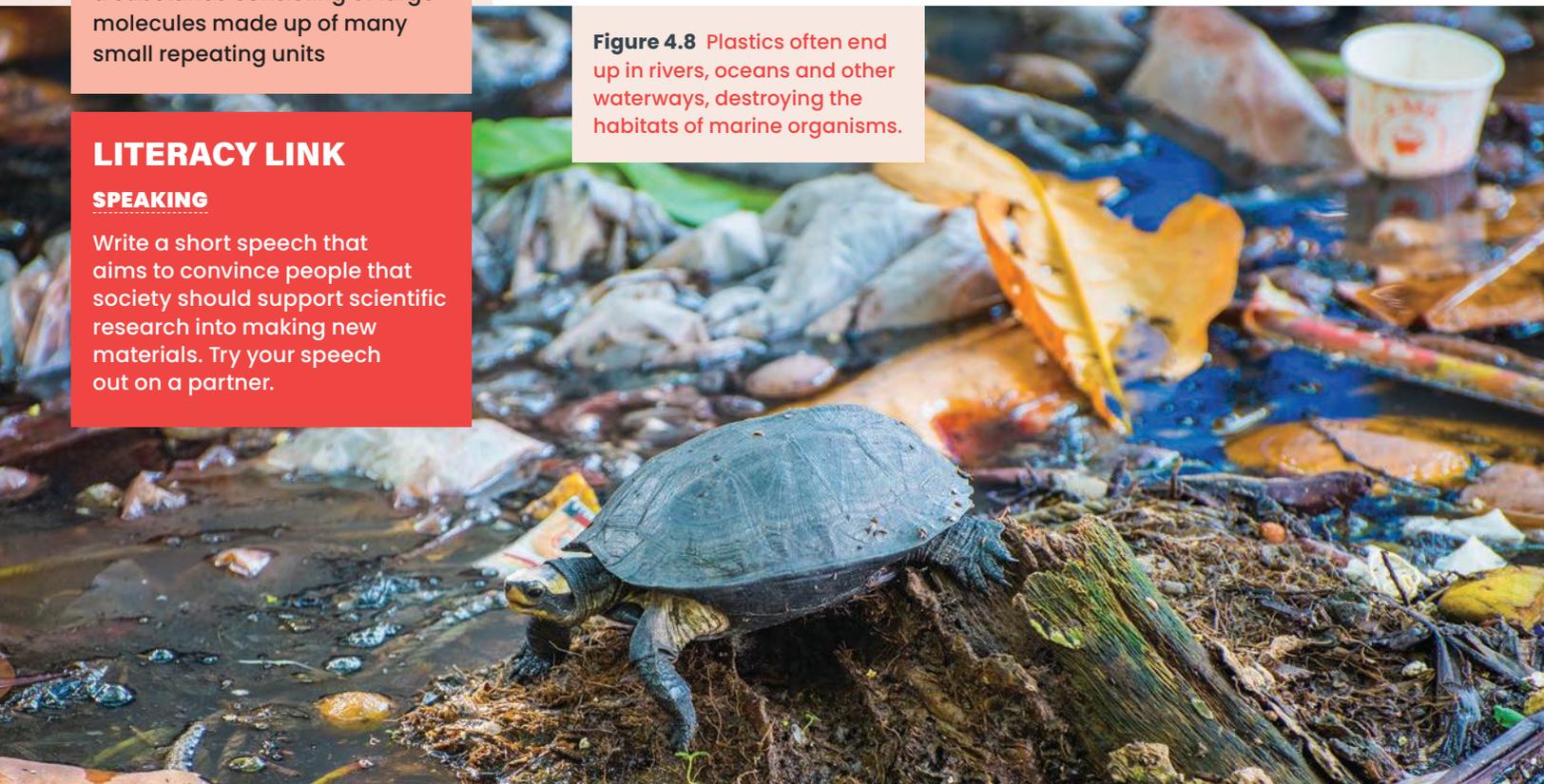
Plastics are materials used in many ways, in millions of different products. They are a kind of **polymer**, which is made up of many tiny, repeating units attached to a 'backbone' of carbon atoms.

Plastics are made from petroleum, a non-renewable resource. The first scientists to make plastics wanted them to last for a long time. This is good when the products are being used, but not when they are no longer needed. Many plastics take thousands of years to fully break down in the environment. When not disposed of properly, plastics cause pollution by cluttering rivers, seas and beaches, killing fish and marine organisms. The production of plastics releases carbon dioxide into the atmosphere, which contributes to global warming.

Because of the huge problems with disposing of plastic, scientists have had to come up with ways of making it more environmentally friendly.

### *Why aren't plastics environmentally friendly?*

**Figure 4.8** Plastics often end up in rivers, oceans and other waterways, destroying the habitats of marine organisms.



## 2 Bioplastics are more environmentally friendly

Bioplastics are a type of plastic invented about 100 years ago. They are made from plant products such as starch and cellulose, which come from corn and sugar cane. The starch is broken down into glucose, which is made into lactic acid. Many molecules of lactic acid are joined to make the polymer polylactic acid (PLA), which is used in bioplastics.

Bioplastics are used in products such as food containers, grocery bags, some cutlery and food packaging. They have many uses in electronics, farming, clothes making and health care.

Many bioplastics are **biodegradable** – they break down quickly in the environment. Bacteria and fungi are quickly able to break down these plastics if they are placed into an industrial composter. The bioplastics absorb water, swell up and break into small pieces that bacteria can easily digest – sometimes in just a few weeks.

Even if not properly composted, bioplastics have less environmental impact than plastics formed from petroleum. If PLA is burned, it doesn't give off toxic fumes. If it ends up in a landfill, it will break down a lot faster than traditional plastics.

*How are bioplastics better for the environment?*

## 3 Scientists are working to improve bioplastics

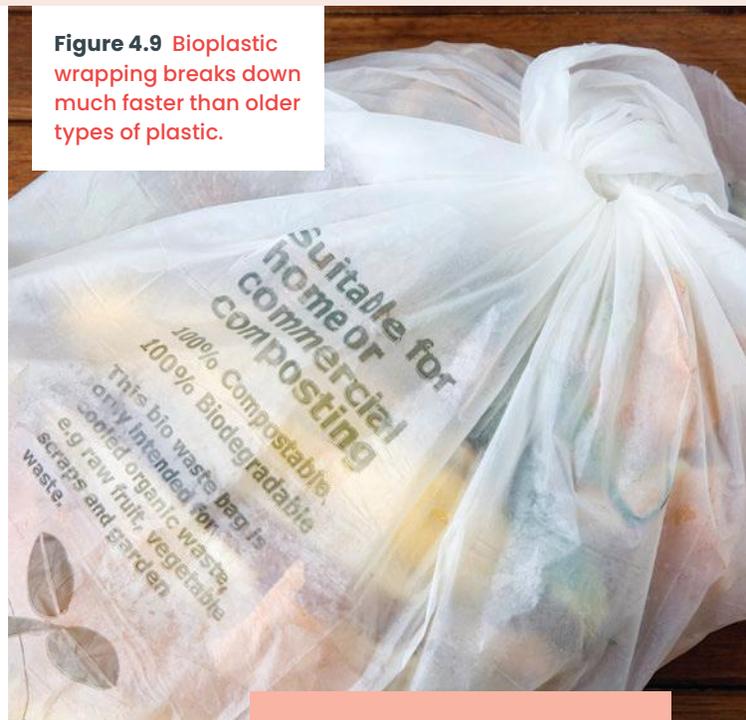
There are many other benefits of bioplastics compared to petroleum plastics. They are cheaper and take less energy to make, and they create far fewer greenhouse gases. They are easier to recycle into other products. However, they still have disadvantages and can be improved.

One disadvantage is that most bioplastics can't be broken down in a backyard compost heap. They need to be processed in special industrial composters. Australia does not have a recycling system that uses these composters, so bioplastics all end up in landfill.

Another issue is that bioplastics are made from plants such as corn. Using these plants for making plastics means that they can't be used as food. It also means that any chemicals used on those plants to kill pests or help them grow can make their way into the bioplastic. This can have unpredictable effects on both the bioplastic and the people who come into contact with it.

*What are the positives and negatives of bioplastics?*

**Figure 4.9** Bioplastic wrapping breaks down much faster than older types of plastic.



### CHECKPOINT 4.4

- 1 Making plastics and polymers from fossil fuels is not sustainable. Explain why.
- 2 What are the benefits of supporting scientists in their research of new materials?
- 3 Explain how bioplastics are different from ordinary plastics.
- 4 PLA is a bioplastic that is biodegradable. Explain how it is created and why it is biodegradable.
- 5 Identify three advantages and three disadvantages of bioplastics.

### ETHICAL CAPABILITY

- 6 Consider the use of traditional plastics. Discuss some of the ethical considerations (what is right and wrong) of their continued manufacture and use.

### SUCCESS CRITERIA

- I can describe using examples how science and technology have contributed to the manufacture of new materials, including plastics.

# 4.5

## SCIENTIFIC COLLABORATION IN AUSTRALIA

### LEARNING INTENTION

At the end of this lesson I will be able to describe how scientific knowledge can develop through collaboration and connecting ideas across the disciplines and practice of science.

### KEY TERMS

**collaboration**  
working cooperatively together

**hydrophilic**  
water-attracting

**hydrophobic**  
water-repelling

**nuclear medicine**  
the branch of medicine to do with the use of radioactive substances in research, diagnosis and treatment

### LITERACY LINK

#### WRITING

Create a one-page flyer or brochure that illustrates the work of the CSIRO in Australia. Include examples of their projects and the kinds of scientists that work there.

### NUMERACY LINK

#### GRAPHING

At a conference of 1000 scientists, 200 work at ANSTO, 500 work at CSIRO and the rest work for universities.

Draw a pie chart to show who attended the conference.

In movies and television shows, inventors and scientists seem to create and discover great things on their own. In real life, almost all scientific advances are the result of **collaboration** – groups of scientists and researchers working together.

Working with scientists from other countries, or with specialists from different scientific fields, is the best way for Australia's scientists to create new things and improve their understanding of the natural world and the universe.

## 1 ANSTO is Australia's national nuclear research organisation

The Australian Nuclear Science and Technology Organisation (ANSTO) is Australia's national nuclear research and development organisation. It produces and uses nuclear radiation for medicine, science, industry, business and agriculture. ANSTO collaborates with international scientists.

The Open Pool Australian Lightwater (OPAL) reactor is a research reactor at Lucas Heights in Sydney. OPAL is used to make **nuclear medicines** as well as for research. It can create neutron beams – streams of high-energy particles – that are used to solve problems in many different fields of science.

**Figure 4.10**  
OPAL is one of the world's most effective research reactors.



ANSTO's other major Sydney facility is the National Research Cyclotron. This machine shoots particles along a spiral path, accelerating them to very high speeds. Cyclotrons and particle accelerators are used to analyse different materials, helping to advance knowledge in areas such as water management and climate science.

Another ANSTO facility is the Australian Synchrotron in Melbourne. This huge machine creates light many times brighter than the Sun. This light can be used to see the otherwise invisible structure and composition of materials, with a level of detail not possible in other laboratories.

*What does ANSTO stand for?*

## 2 CSIRO is Australia's national science organisation

CSIRO is the Commonwealth Scientific and Industrial Research Organisation. This government group partners with thousands of companies, universities and other organisations to develop new technologies. CSIRO's scientific breakthroughs and inventions benefit billions of people around the world each day, in fields such as health, manufacturing, mining, agriculture and sport.

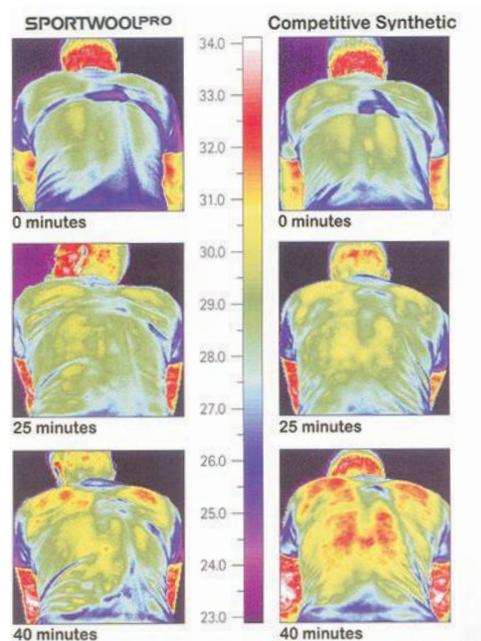
Wearing the right type of clothing helps elite athletes to improve their performance. To help Australia's sportspeople compete, CSIRO scientists produced a fabric that enables athletes to stay dry during exercise. They developed Sportwool, a two-layer wool fabric.

Sportwool consists of a layer of superfine wool on the inside, next to the skin, and a layer of tough polyester on the outside. Sportwool is worn by Australia's cricket and Olympic cycling teams.

Because of this design, Sportwool is **hydrophobic** on the inside and **hydrophilic** on the outside. Sweat moves quickly from the inside of the garment to the outside, keeping the wearer dry. On the outside, the sweat spreads, which increases evaporation and helps keep the wearer cool. The fabric is very light, provides protection from ultraviolet light and doesn't retain any smells.

Sportwool is just one of thousands of inventions that have come out of CSIRO's collaborations. Because of CSIRO's work with other nations and organisations, Australian scientists play a major role in research and invention all around the world.

### How does Sportwool keep athletes dry?



**Figure 4.11** Sportwool fibre has wool on the inside and polyester on the outside.

### INVESTIGATION 4.5

#### Suitability of sports fabrics

**KEY SKILL**  
Evaluating results for reliability and validity

► Go to page 148



### CHECKPOINT 4.5

- 1 Describe ways that ANSTO scientists work collaboratively.
- 2 Briefly describe the work of CSIRO.
- 3 Give evidence from the text that CSIRO collaborates with other organisations.
- 4 Explain how ANSTO helps us.
- 5 Justify why Sportwool is the best fabric to use for the Australian cricket uniform.
- 6 Your school probably produces a very large amount of waste (rubbish) every day.
  - a Imagine you are tasked with solving the problem of waste at your school. Think of three ways you could reduce the amount of waste.
  - b Compare your ideas with two other students. What other ideas did they come up with? In what ways is collaboration more powerful than working on your own?

### RESEARCH

- 7 Another example of scientists working together collaboratively is the Human Genome Project. Research the *what*, *where*, *who*, *when*, *why* and *how* of the Human Genome Project.

### SUCCESS CRITERIA

- I can explain what collaboration is and why it's so important in science.
- I can give examples of when scientists have worked collaboratively.

# VISUAL SUMMARY

**Chemical change**  
a change in properties with  
a new substance formed

**Physical change**  
a change in appearance with  
no new substance formed

- Chemical changes**
- burning wood
  - an egg cooking
  - rusting iron
  - a banana rotting
  - fireworks
  - cookies baking



- Physical changes**
- salt and sand being mixed
  - paper being cut
  - evaporation
  - a ruler breaking
  - salt being dissolved in water



Chemical changes can occur in nature.  
Photosynthesis is a chemical reaction in plants.

Rust (iron oxide) is produced when  
iron reacts with oxygen in the air.

Reactants



**CARBON DIOXIDE**      **WATER**

LIGHT  
→

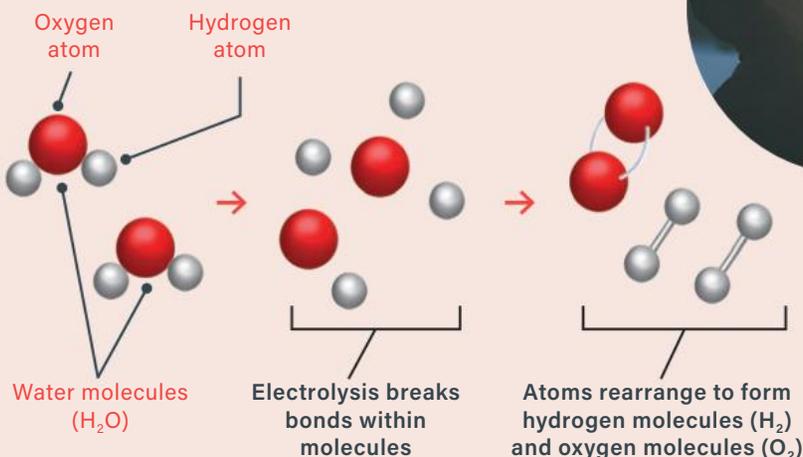
Products



**GLUCOSE**      **OXYGEN**



Particles split or join during a chemical change.



Substances do not  
change during a  
physical change.



Scientific research has led to the  
creation of new materials, such  
as **bioplastics**, that have much  
less impact on the environment.

## ★ FINAL CHALLENGE ★

- 1 Explain the difference between a physical and a chemical change.
- 2 Explain what the reactants and products in a reaction are.
- 3 What are four signs or observations that a chemical change has occurred?

Level 1



50xp



- 4 Describe two examples of a physical change and two examples of a chemical change happening in our daily lives. In each case, explain how it is a physical change or a chemical change.
- 5 Outline the differences between photosynthesis and cellular respiration.
- 6 What is corrosion? How does it occur and what is the result of corrosion?

Level 2



100xp



- 7 Explain the particle theory of matter in your own words.
- 8 Model an equation showing what happens to particles in a chemical change, then describe in words what happens.

Level 3



150xp



- 9 Collaboration in science is extremely important. Suggest why.
- 10 Explain how bioplastics are made and list the advantages and disadvantages of using bioplastics.
- 11 Photosynthesis and respiration are an example of opposite chemical changes. Name a pair of opposite physical changes, and explain why they are opposites.

Level 4



200xp



- 12 Plastics are useful but not environmentally friendly. Support or reject this statement by providing evidence from the text as well as your own opinions.
- 13 Name two Australian organisations that collaborate with other scientists and explain how their work has helped Australians and other people around the world.

Level 5



300xp





# WATER AS A RESOURCE

How can we determine what our most valuable resource is?

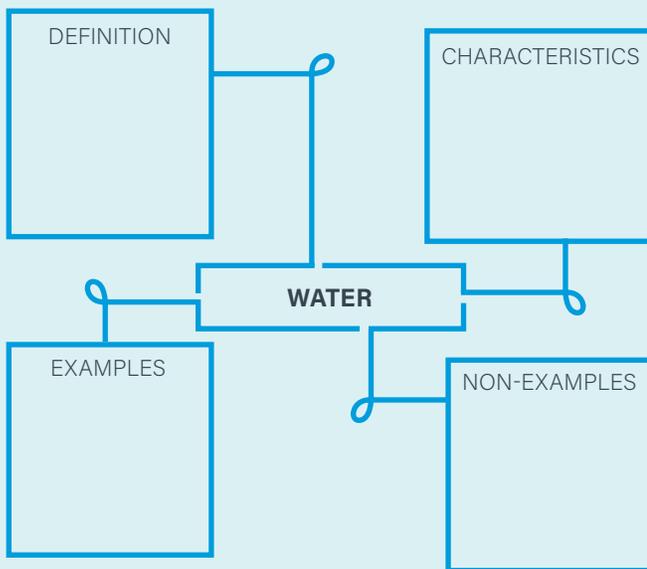


About 70% of Earth’s surface is covered with water, and the oceans contain more than 96% of all the water on Earth. Where is the rest? In lakes, rivers, ice, underground, in the air ... even in living things. Scientists call this the hydrosphere (Earth’s water sphere).

The water cycle model is used to explain how water constantly moves through all of these places. Only about 2.5% of all of the water on Earth is fresh water, and even less is located where humans can easily access it. Hydrologists are scientists who study the water cycle and help make sure that we use this precious resource sustainably.

## 1 FRAYER MODEL

Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *The water cycle* and *Greywater*.

## 2 LEARNING LINKS

Brainstorm everything you already know about water as a resource.



### 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 as many disadvantages of the water cycle as you can think of. Then list some ways to correct these disadvantages.



**MUSIC SMART:** Write a jingle to encourage people to reduce their water use. Use the tune of a song you know already.



#### FORCED RELATIONSHIPS:

Develop a solution to the problem of running out of fresh water that uses a robot, an earthquake and a box of cereal.

### 5 THE DRIEST!

Deserts are regions that receive, on average, less than 200 mm of precipitation (rain, hail, sleet or snow) per year. Some of the driest places on Earth are the McMurdo Dry Valleys in Antarctica. These valleys are unlike other places in Antarctica, because weather patterns prevent moisture laden air from passing over the valleys. Scientists think these valleys might be the closest thing on Earth to the planet Mars, so they are being investigated to help the search for extraterrestrial life.



# 5.1

## WATER IN THE WORLD

### LEARNING INTENTION

At the end of this lesson I will understand that water is an important resource that cycles through the environment.



Most of the water on Earth is salt water.

Only a very small percentage is fresh water, and even less of this water is easily accessible by humans and other living things. Fresh water is an important resource – we use it to drink, to grow our food, and in industry. Water is also a very important part of living systems.

**Figure 5.1** Earth may be called the blue planet, but only about 2.5% of its water is fresh water, and most of that is frozen or underground.

### KEY TERMS

#### adhesion

the 'sticking' of molecules to other substances

#### cohesion

the 'sticking' of molecules to each other

#### ecosystem

a system of living things and their environment

### LITERACY LINK

#### VOCABULARY

Synonyms are words that mean the same thing; for example, *big* and *large*. Choose three words from this lesson and think of a synonym for each.

### NUMERACY LINK

#### GRAPHING

The human body is about 65% water.

Draw a pie chart to demonstrate how much 65% is.

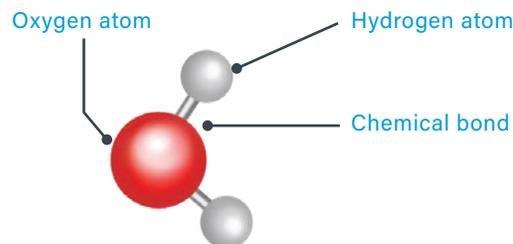
## 1 The chemical formula for water is H<sub>2</sub>O

Water is the only substance found naturally on Earth in the solid, liquid and gas states. A water molecule has the chemical formula H<sub>2</sub>O. This means it is a compound made up of two hydrogen atoms and one oxygen atom, chemically bonded together.

The shape of the water molecule gives it special properties that are important for life. Water molecules are attracted to each other and will 'stick' together – this is called **cohesion**. Water molecules can also 'stick' to other substances – this is called **adhesion**. These properties help water travel from the roots of trees up to the leaves, and through the human body.

### *What is the chemical formula for water?*

**Figure 5.2** A water molecule is made up of two hydrogen atoms bonded to an oxygen atom.



## 2 The human body is made mostly of water

The human body is about 65% water. Water can be found throughout the tissues and cells of your body, as well as in liquids such as blood.

The water inside your body is important for giving your cells structure. It allows all of the important chemical reactions that keep you alive to take place. Humans can only survive for about three days without fresh water.

### *What percentage of the human body is water?*

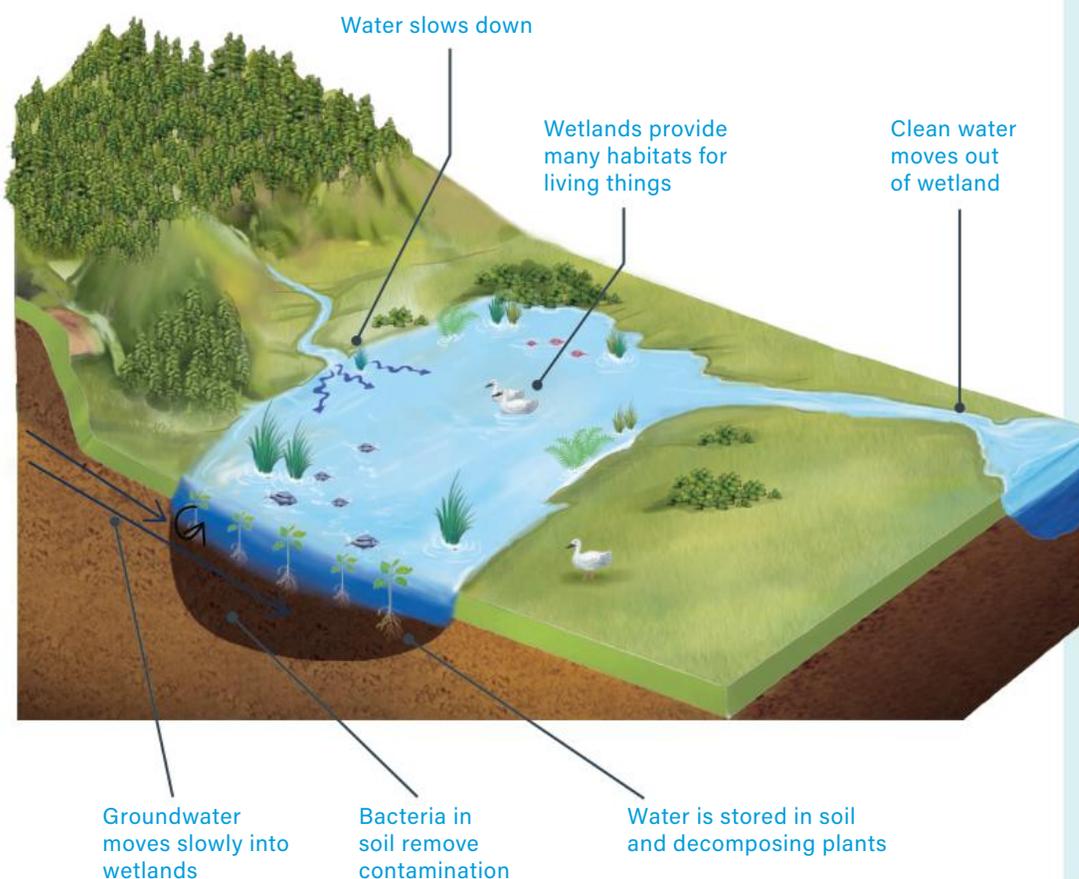
### 3 Water is vital to agriculture and ecosystems

Fresh water is an important agricultural resource. It's used to water crops and to support livestock. Without enough water supplies, farmers are unable to produce enough food or other resources such as cotton and wool.

Fresh water is also an essential part of natural **ecosystems** – without it, they wouldn't exist. Not only does water allow plants to grow, but the collection of rain water in waterways and wetlands creates habitats for other organisms. Even deserts rely on water, which may come from occasional rains or underground reservoirs.

#### *How is water an important part of an ecosystem?*

**Figure 5.3** Wetlands are important for many of the functions of an ecosystem. They allow water to be naturally cleaned and stored.



#### INVESTIGATION 5.1A

Investigating cohesion of water

##### KEY SKILL

Evaluating results for reliability and validity

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#### INVESTIGATION 5.1B

Observing capillary action

##### KEY SKILL

Identifying the variables and formulating a hypothesis

► Go to page 150



### CHECKPOINT 5.1

- 1 Which atoms make up a molecule of water?
- 2 Why is water important for farmers?
- 3 What is the difference between cohesion and adhesion?
- 4 Provide an example of how water can be found on Earth in each state of matter.
- 5 Water is very important for living things in ecosystems. Suggest why.
- 6 Using Figure 5.3, predict what would happen to a wetland in a drought.
- 7 Suggest the impact on living things and ecosystems in the case of:
  - a a drought
  - b a flood.

### CONNECTING IDEAS

- 8 Humans have a huge impact on the natural environment and resources including water. Identify at least five ways that humans impact the quality and quantity of available water.

### SUCCESS CRITERIA

- I can explain why water is an important resource.
- I can describe various uses of water.

# 5.2

## THE WATER CYCLE

### LEARNING INTENTION

At the end of this lesson I will be able to explain the water cycle in terms of the processes involved.

### KEY TERMS

#### condensation

changing from a gas to a liquid

#### evaporation

changing from a liquid to a gas

#### groundwater

water within soil and rocks in the ground

#### precipitation

water falling from clouds as a solid (e.g. hail) or liquid (e.g. rain)

#### transpiration

how water in the soil travels through plants

#### water vapour

the gas state of water

### LITERACY LINK

#### READING

Summarise the water cycle in a postcard to your teacher. Include all the most important aspects.

### NUMERACY LINK

#### UNITS

1 millilitre takes up 1 cubic centimetre of volume. What would be the volume of 1 litre? How many litres would there be in 1 cubic metre?

Every molecule of water on Earth cycles through the atmosphere, rocks of the crust and living things as part of the water cycle.

The water cycle is driven by energy from the Sun, which enables liquid water to evaporate into the atmosphere. Once in the atmosphere, the wind moves it around the planet. It then condenses back to water and falls again.

### 1 Liquid water evaporates into the atmosphere

Water in oceans, lakes and rivers and on the surface of the land gains energy from the Sun. This energy causes the liquid water to **evaporate** and move into the atmosphere as **water vapour**.

Plants can also help in the process of evaporation through a process called **transpiration**. Liquid water moves from the soil into plant roots up to the leaves. The water in the leaves then evaporates.

*How does water in the ocean move into the atmosphere?*

### 2 Water vapour condenses into clouds

As water vapour rises in the atmosphere it starts to cool. As it cools, it **condenses** around tiny solid particles, such as ash and dust, that are small enough to stay up in the atmosphere. These form liquid water droplets. These gather together to form clouds. Movement of air in the atmosphere moves the clouds around.

*What happens to water vapour in the atmosphere?*

### 3 Water falls to Earth as precipitation

When liquid water droplets in clouds become too heavy to stay in the atmosphere, they fall to Earth as **precipitation**. Rain is when the water falls as a liquid. If the atmosphere is cold enough, water can fall as a solid such as snow or hail.

*What is precipitation?*

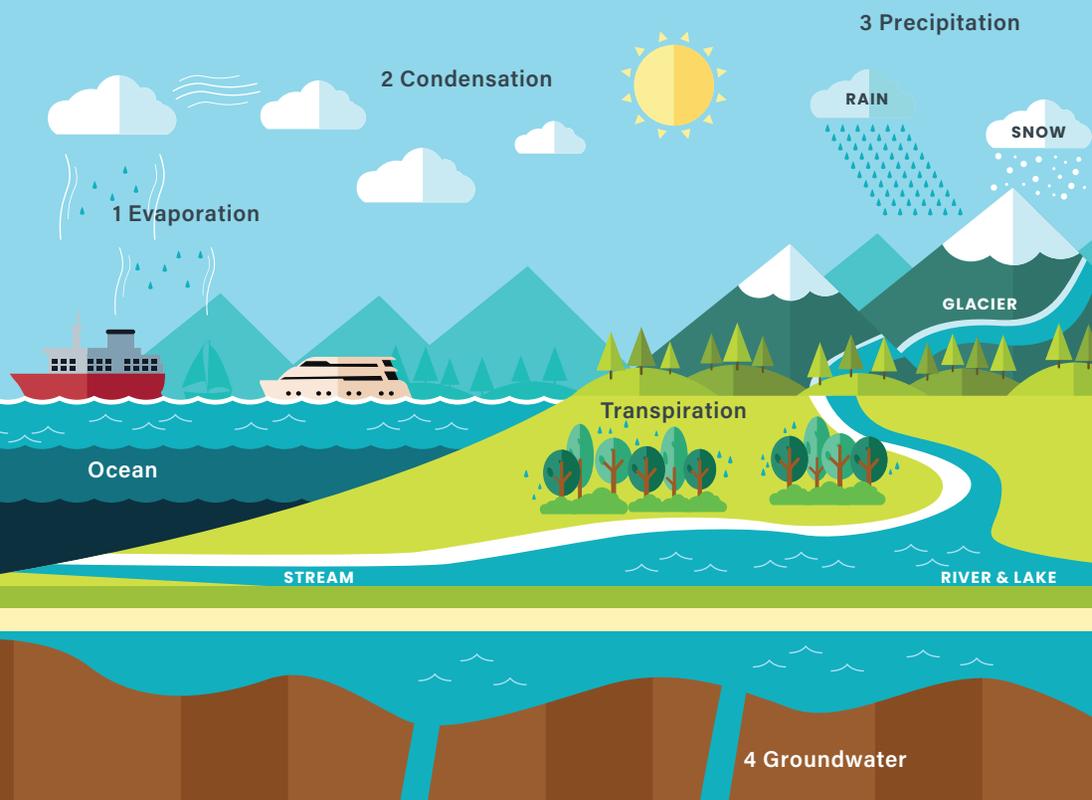
## 4 Water runs over or into the land

When liquid water reaches the land, it runs over the surface to waterways, or it moves through the soil. If it isn't absorbed by plants, it keeps moving through the soil to the rock below and becomes part of the water underground.

**Groundwater** is contained within soil and in cracks and pores in rocks underground. Groundwater can slowly move back to the surface through springs, or make its way into oceans and lakes.

### What is groundwater?

**Figure 5.4** During the water cycle, water moves through the environment and it also changes between solid, liquid and gas.



## 5 Ice melts slowly over time

Water can be stored for long periods of time as ice. This ice can be found in glaciers on mountains and ice sheets at Earth's poles. It can also be found in frozen soil called permafrost. The ice melts slowly over time, adding liquid water to waterways or groundwater.

### How does ice affect the water cycle?

### INVESTIGATION 5.2

Modelling the water cycle

KEY SKILL  
Referencing sources  
of information



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### CHECKPOINT 5.2

- Where in the water cycle do the following events occur?
  - Water changes from a liquid to a gas.
  - Water changes from a gas to a liquid.
  - Water changes from a liquid to a solid.
  - Water changes from a solid to a liquid.
- In what state is most of the water in clouds?
- What is the difference between evaporation and transpiration?
- Would you expect to find a higher rate of transpiration in a desert or a rainforest? Justify your response.
- Would you expect to have a higher rate of evaporation on a cloudy day or a sunny day? Justify your response.
- Describe what could happen to rainwater that falls onto a grassy hill.

### ETHICAL CAPABILITY

- Dams are often built to provide water sources for major towns and cities. Consider how the construction of a dam may alter the water cycle in a local area. Discuss some ethical issues (what is right and wrong) regarding the construction of dams.

### SUCCESS CRITERIA

- I can describe how water moves through the water cycle.
- I can identify when water changes state in the water cycle.

# 5.3

## MANAGING WATER USE

### LEARNING INTENTION

At the end of this lesson I will be able to describe how human management of water impacts on the water cycle.

### KEY TERMS

#### blackwater

water from toilets, urinals or other sources that has come in contact with human waste

#### dam

a wall built across a waterway so that water collects on one side of it

#### greywater

water from washing, laundry or other sources that has not come in contact with human waste

#### run-off

water that runs off the surface of the land into waterways such as rivers

### LITERACY LINK

#### WRITING

Write a 'Letter to the Editor' encouraging people to use water in a sustainable way.

### NUMERACY LINK

#### MEASUREMENT

Ask your teacher for 100 mL of water. Weigh the water (not including the mass of the container). What do you notice?

Fresh water is a precious resource that must be managed and used sustainably.

Scientists use their knowledge of the water cycle and ecosystems to find the best ways to manage water supplies and to limit the impact of human activities on the water cycle.

## 1 Dams supply towns and farms with water

A **dam** is a wall built across a waterway to allow water to collect behind it. Dams are built to store water to supply water to cities, towns and farms.

To work out the best place to build a dam, scientists and engineers calculate the amount of **run-off** in the area. The dam is placed at the spot in the waterway where the run-off will fill it most effectively.

A dam on a river limits the natural flow of water downstream. Water is often released from dams to make sure that the downstream waterways remain healthy.

### *Why are dams built?*

## 2 Stormwater systems link cities to natural waterways

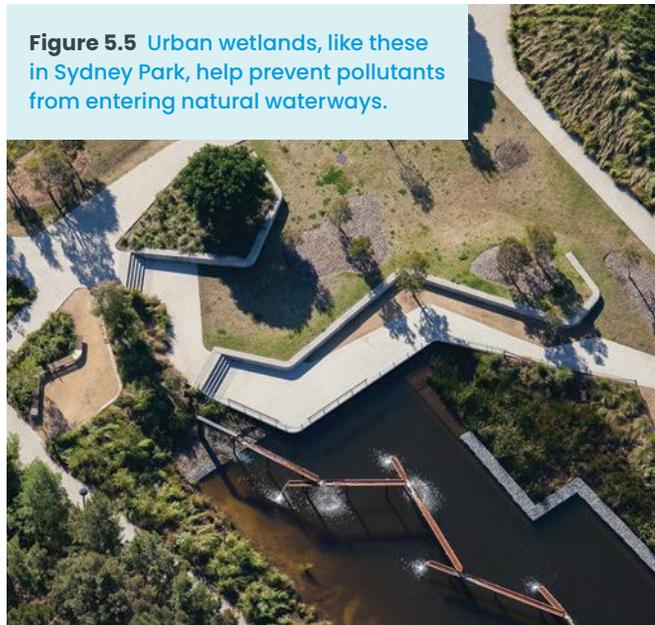
Many materials, such as concrete and road bitumen, prevent rainwater from soaking into the ground. This water runs off into stormwater systems, which eventually link to natural waterways such as rivers and the ocean.

When stormwater runs over hard surfaces, it can pick up pollutants and may take these into natural waterways. To prevent this, some city councils now make wetlands in stormwater systems. These constructed wetlands allow natural processes to take place, including the removal of pollutants, evaporation and the formation of new wetland ecosystems. This means fewer pollutants are deposited into natural waterways.

Scientists regularly test the quality of water in urban areas. This helps them to identify sources of pollution and to make sure natural waterways remain healthy.

### *What happens to rainwater that falls in urban areas?*

**Figure 5.5** Urban wetlands, like these in Sydney Park, help prevent pollutants from entering natural waterways.



### 3 Recycling greywater and blackwater

Currently, nearly all homes in Australia use fresh drinking water to water the garden and flush the toilet. That seems like a big waste of precious water!

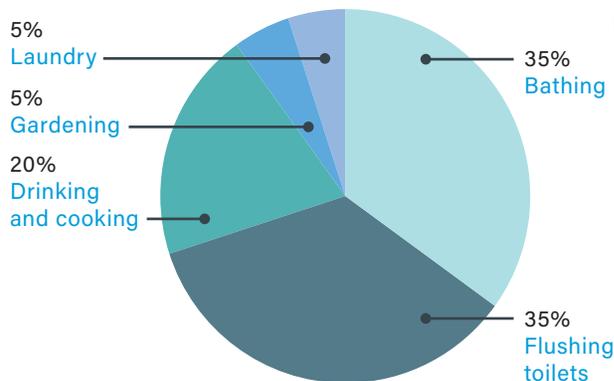
**Greywater** and **blackwater** are the two types of wastewater created in the home. Greywater is from areas like the laundry, showers, sinks and basins. Blackwater is water that comes from or has been mixed with waste or water from the toilet.

Obviously you wouldn't want to re-use blackwater in your washing machine or shower, but if it is treated chemically it can be safe to use in other areas of the home, such as in the garden. Greywater, on the other hand, can be treated and used in the house for things like flushing the toilet.

*What is the difference between greywater and blackwater?*



**Figure 5.6** Chemically treated blackwater can be safely used to water the garden.



**Figure 5.7** The largest proportion of water used in the home is for flushing toilets and bathing.

#### INVESTIGATION 5.3

Testing water quality

**KEY SKILL**  
Drawing conclusions consistent with evidence

► Go to page 152



#### CHECKPOINT 5.3

- 1 Suggest how a dam may impact the river system downstream from it.
- 2 Why do scientists regularly conduct water quality testing?
- 3 What is stormwater?
- 4 Where does the water in stormwater systems flow to?
- 5 Explain why it is important to know about how the water cycle operates in the local area before a dam is constructed.
- 6 Describe some advantages and disadvantages of using greywater and blackwater in the home.
- 7 How do hard surfaces in urban areas affect the water cycle?

#### CONTEMPORARY ISSUES

- 8 The use of recycled water in homes is controversial. Not everyone wants to use greywater or blackwater. What is your opinion? Defend your opinion with some facts.

#### SUCCESS CRITERIA

- I can describe three different ways that human management of water impacts on the water cycle.
- I can discuss key considerations in regards to the recycling of greywater and blackwater.

# 5.4

## INDIGENOUS AUSTRALIAN WATER MANAGEMENT

### LEARNING INTENTION

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

### KEY TERMS

**collaboration**  
working cooperatively together

**cultural significance**  
importance to a particular culture

### LITERACY LINK

#### SPEAKING

Find out more about one of these Dreaming stories.

- Tiddalik the Frog
- The Rainbow Serpent
- Baiame and the Fish Traps

Without using any prompts, tell the story to a partner.

### NUMERACY LINK

#### CALCULATION

Aboriginal and Torres Strait Islander peoples have lived in Australia for approximately 65 000 years. Europeans settled in Australia about 230 years ago. Express the amount of time that Europeans have lived in Australia as a percentage of the time that Indigenous peoples have lived in Australia.

For tens of thousands of years, Australian Aboriginal and Torres Strait Islander peoples have used their knowledge of water sources to survive in times of drought, during travel and to find food. Water is also an important part of Aboriginal and Torres Strait Islander cultures and traditions.

Governments and science organisations are starting to learn how Indigenous knowledge can improve the way they manage water.

## 1 Observing the land can lead you to water

Imagine you're standing in a desert, with no visible water. If you look carefully, you might see a group of ghost gums in the distance, tracks from different animals all leading in the same direction, or a trail of ants coming from one direction and suddenly disappearing into the sand. These are all signs that water is nearby.

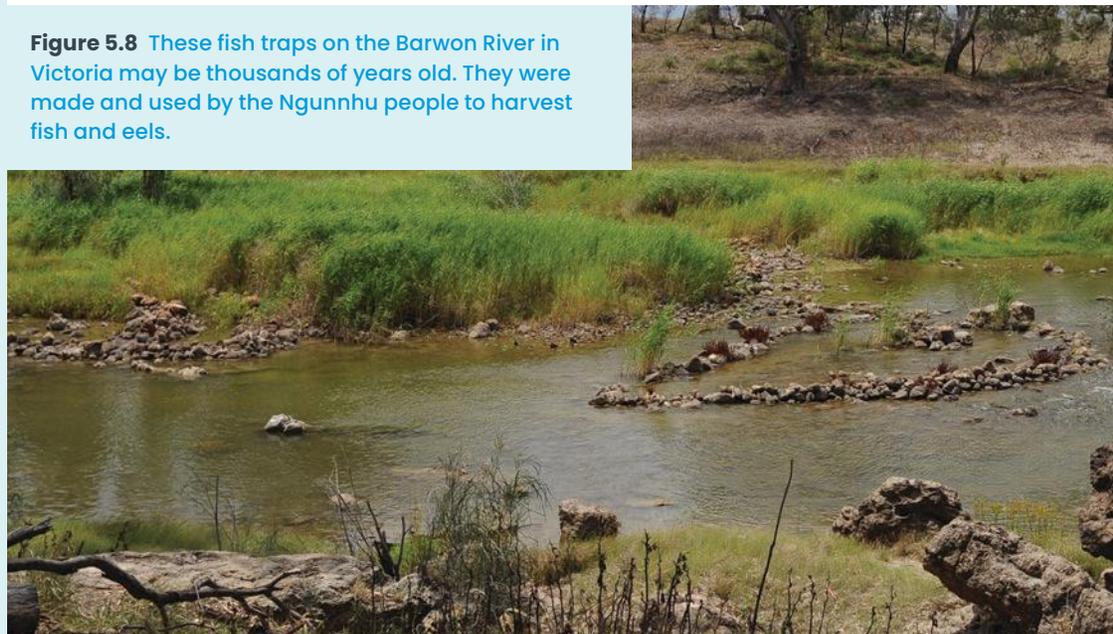
Indigenous Australians have closely observed their environment over many thousands of years, including working out ways to find water sources.

*What are some clues that could suggest a water source is nearby?*

## 2 Water is a resource and is part of Indigenous culture

Water and waterways are highly valued by Indigenous Australians. They provide drinking water, habitats for food plants and animals, and can also be places of **cultural significance**. For these reasons, the careful use of water is part of Indigenous Australian culture and tradition.

**Figure 5.8** These fish traps on the Barwon River in Victoria may be thousands of years old. They were made and used by the Ngunnhu people to harvest fish and eels.



Indigenous Australians have used their knowledge of the seasons and weather observations to predict when the rainy season will arrive and end, so that they could prepare. Traditionally, this might mean moving to a different place, or being ready to harvest plants and animals that flourish after the seasonal rains. They covered wells that they dug into aquifers to prevent water evaporating or being polluted by animals.

Indigenous Australian cultural knowledge about water has been passed on through many generations in stories, songs, dance and art. Many places related to water have been and are still protected.

### Why is water important in Indigenous Australian culture and tradition?

## 3 Scientists are collaborating with Indigenous communities

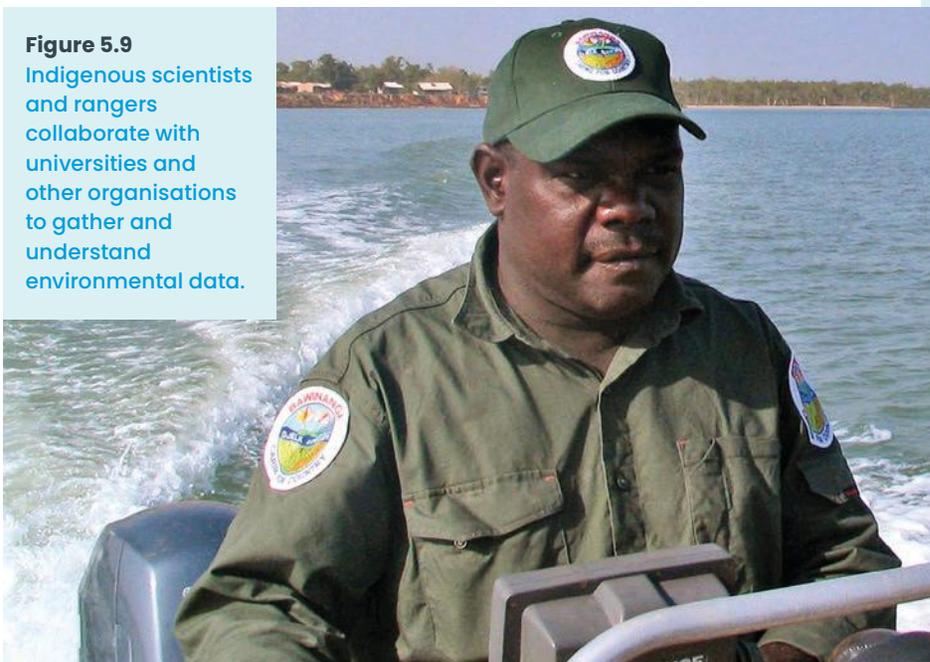
Scientists from universities and other organisations have partnered with Indigenous Australian scientists, rangers and communities to share knowledge. This **collaboration** helps to make sure that water resources are valued, managed and maintained for the future.

Indigenous and non-Indigenous scientists gather data about water quality and meet with local Indigenous Australians who are skilled at making detailed observations. These may be observations of changes to the landscape, waterways and wildlife each season or over several years.

By using all of the information, scientists and others can predict how human activities may affect water supplies, ecosystems and culture. They can then propose ways to prevent or minimise harmful effects.

### How is information from Indigenous Australians being used to manage waterways?

**Figure 5.9**  
Indigenous scientists and rangers collaborate with universities and other organisations to gather and understand environmental data.



## CHECKPOINT 5.4

- 1 Identify three observations that you could use in a desert to find hidden water.
- 2 How have Indigenous Australians protected wells dug into aquifers?
- 3 Why is it traditionally important for Indigenous Australians to be able to predict when rain would arrive?
- 4 What types of observations can support scientific data about water quality?
- 5 Why do you think ghost gums are an important indicator that there is water in the desert? Where is this water located?
- 6 Explain why linking observations of landscapes, waterways and wildlife to water quality data is important for managing Australian water resources.

## RESEARCH

- 7 The D'harawal people from the Sydney and Shoalhaven region traditionally recognise six seasons throughout the year. They have related observations of their environment to weather patterns and resource availability. Research the six seasons and their features.

## SUCCESS CRITERIA

- I can describe at least two water management practices carried out by Aboriginal and Torres Strait Islander peoples.

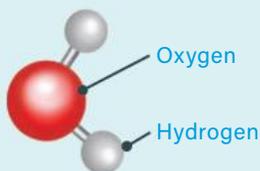
# VISUAL SUMMARY

## The water cycle

- 1 **Evaporation:** water in locations like the ocean, lakes and rivers evaporates and rises into the atmosphere.
- 2 **Condensation:** water in the atmosphere cools and condenses.
- 3 **Precipitation:** water falls to Earth as rain and snow.
- 4 **Transpiration:** once it reaches Earth's surface, water runs over or into the ground.



The chemical formula for **water** is



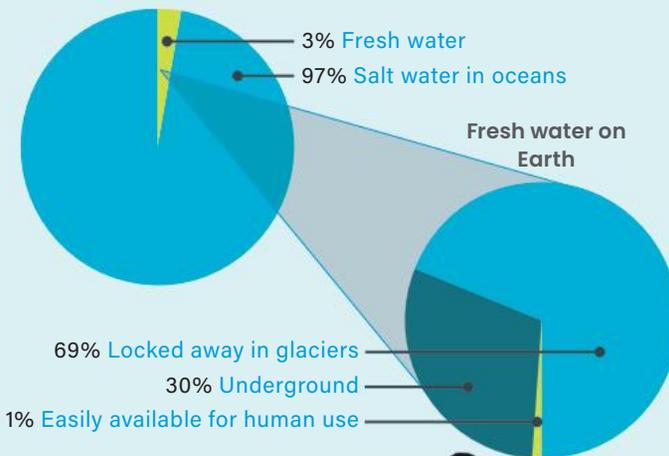
**Greywater** is water from washing, laundry or other sources that has not come in contact with human waste. Treated greywater is safe for household uses such as flushing the toilet.

**Blackwater** is water from toilets, urinals or other sources that has come in contact with human waste. Treated blackwater is safe for use in the garden.



The careful management and use of water is a community and scientific priority.

## All water on Earth



Collaboration is key to successful water management.

Indigenous and non-indigenous scientists, rangers and community leaders collaborate to share water management strategies.

## ★ FINAL CHALLENGE ★

- 1 State the chemical formula for water.
- 2 Identify the physical changes that water goes through as part of the water cycle.
- 3 Identify why water is important:
  - a for the human body
  - b for a farmer
  - c for an ecosystem.

### Level 1



50xp



- 4 Create a flow chart to show how the major processes of the water cycle link together.
- 5 Explain what stormwater is in your own words.
- 6 How is Aboriginal and Torres Strait Islander peoples' traditional knowledge being used in decisions about water management?

### Level 2



100xp



- 7 Explain in your own words what greywater and blackwater are.
- 8 Explain why it would be beneficial to include information from local Indigenous people in a study of rainfall and river flows in your local area.

### Level 3



150xp



- 9 Identify and explain three ways that human action can have a negative impact on the water cycle.
- 10 Identify and explain a possible negative consequence of stormwater running directly into natural waterways.

### Level 4



200xp



- 11 Design a water audit at your home or your school using these steps:
  - a Find out how much water your home or school uses in total over a year or a month.
  - b Identify how this water is used in your home/school.
  - c Propose ways that the water use could be decreased or used more sustainably.

### Level 5



300xp





# EARTH AND THE ROCK CYCLE

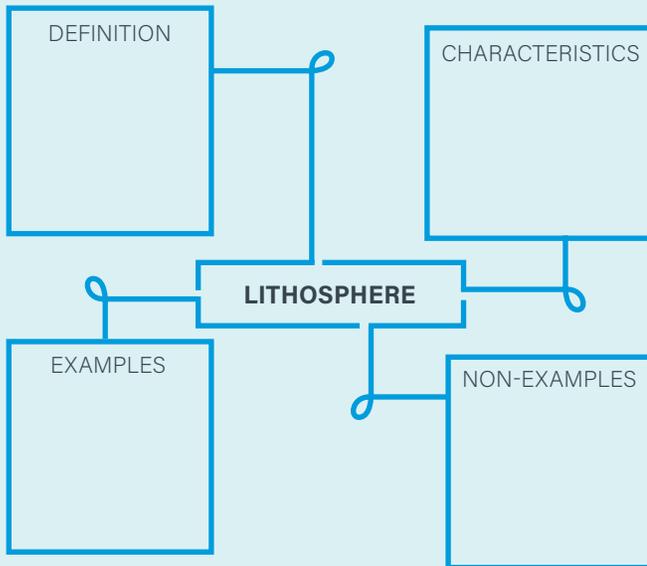
How can we determine what our most valuable resource is?



Have you ever dug a hole and wondered what would happen if you just kept digging? Perhaps you have imagined what the area that you live in was like millions of years ago. Geologists are scientists who study Earth. By making careful observations of the rocks on Earth's surface and gathering a range of other evidence, geologists have been able to work out the structure of the inside of Earth and how that and the landscape around us have changed over time.

## 1 FRAYER MODEL

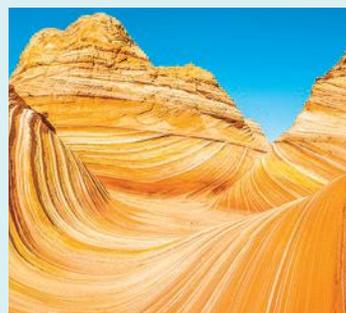
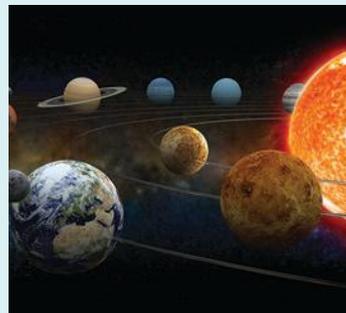
Copy and complete the below chart in your workbook.



Complete two additional charts for the key terms *The rock cycle* and *Minerals*.

## 2 LEARNING LINKS

Brainstorm everything you already know about Earth and the rock cycle.



### 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



**ALPHABET:** Think of a word about geology (hint: to do with rocks, fossils and Earth) for each letter of the alphabet.



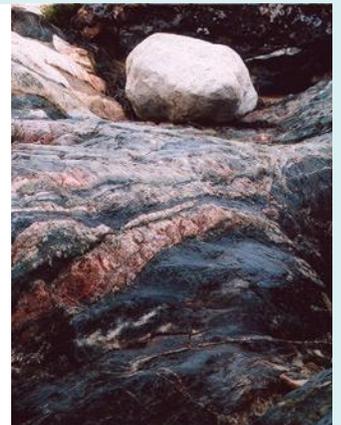
**WHAT IF ...** the outer core of Earth was solid instead of liquid?



**FIVE QUESTIONS:** Write five questions that have the answer 'fossils'.

### 5 THE OLDEST!

The oldest rock in Earth's crust is a metamorphic rock known as the Acasta Gneiss. It is approximately 3.96 billion years old. The rock was originally granite, formed when molten rock solidified about 4.2 billion years ago. About 3.9 billion years ago, this rock was pushed down several kilometres underneath the surface. The heat and pressure changed (metamorphosed) the original rock into the gneiss. Movement of Earth's crust later brought the rock back up to the surface.



# 6.1

## EARTH'S STRUCTURE

### LEARNING INTENTION

At the end of this lesson I will be able to describe Earth's structure in terms of the core, mantle, crust and lithosphere.

### KEY TERMS

#### asthenosphere

the thin zone of the mantle just beneath the lithosphere

#### core

Earth's central layer, made up of a liquid outer core and a solid inner core

#### crust

Earth's thin outer layer

#### density

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

#### lithosphere

Earth's rigid outer zone (crust and upper mantle), made up of tectonic plates

#### mantle

Earth's middle layer, made up of an upper mantle and a lower mantle

#### seismic wave

a wave of energy caused by an earthquake or explosion

### NUMERACY LINK

#### UNITS

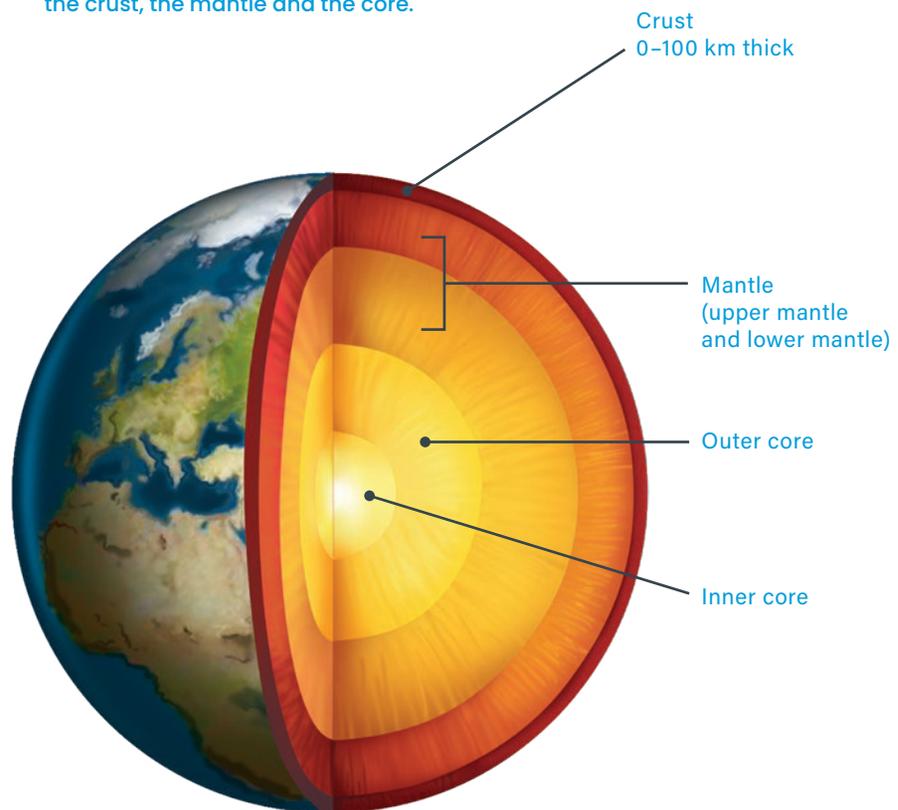
A section of the continental crust is 34 km thick.

Convert 34 km to metres.

When Earth formed approximately 4.5 billion years ago it was a ball of molten (melted) rock. As it gradually cooled, this molten rock separated into three main layers: the core, the mantle and the crust.

The most dense metallic elements moved to the centre to form Earth's core. Elements of medium **density** formed the mantle around the core, and the least dense elements moved to the surface to form its crust.

**Figure 6.1** Earth's main layers are the crust, the mantle and the core.



## 1 Earth's core is solid on the inside, liquid on the outside

Earth's centre is the **core**, made up of a liquid outer core and a solid inner core. Scientists used information from **seismic waves** generated by earthquakes to determine this. The core is made up of a mixture of metals, mostly nickel and iron. Because it is so hot, the outer core is made of liquid metal. The pressure in the inner core is so immense that the atoms are forced together to form a solid.

*What is Earth's core made up of?*

## 2 The mantle sits between Earth's core and the crust

Earth's thickest layer is the **mantle**. It lies between the core and the crust. Even though the mantle is made of solid rock, the very high temperatures and pressure enable the rock to flow very slowly over time. This process is similar to what you might see when you put a blob of silly putty on the edge of a desk. The processes in the mantle cause a lot of the change and movement on Earth's surface. The mantle can be thought of as two parts: the upper mantle and the lower mantle.

*Are most rocks in the mantle solid or liquid?*

## 3 The crust is Earth's thin outer layer

The **crust** is Earth's hard outer layer, and its thinnest layer. If Earth were an apple, the crust would be thinner than the apple's skin. The crust is made of a variety of rocks. There are two different types of crust: continental crust and oceanic crust.

The continental crust forms the continents and the shallow seas around the continents. It covers about 40% of Earth's surface. It is 10–100 km thick.

The oceanic crust is formed in Earth's ocean basins. It covers about 60% of Earth's surface, and is 5–7 km thick.

*What is Earth's crust made of?*

## 4 Earth's lithosphere is the rocky outer zone

The **lithosphere** is Earth's rigid, rocky outer zone. It includes the crust and the upper mantle. The lithosphere is made up of tectonic plates that 'float' and move around on a zone called the **asthenosphere**. There are 15 major tectonic plates and some smaller ones.

The asthenosphere is a thin zone of the mantle that sits just beneath the lithosphere. Rocks here are almost at their melting point (about 1300°C), so they flow more than they do in other parts of the mantle. This allows the tectonic plates of the lithosphere to move and act on each other, which can cause earthquakes and volcanoes at Earth's surface.

*Which two layers of Earth make up the lithosphere?*

**Figure 6.2** Volcanoes are openings in Earth's crust.

### INVESTIGATION 6.1

Modelling Earth's structure

KEY SKILL  
Writing a research question

► Go to page 154



### CHECKPOINT 6.1

- Identify Earth's three main layers.
  - Describe each layer in five words or less.
- Identify Earth's thickest and thinnest layers.
- Identify the two types of crust.
- Explain why the mantle is able to move.
- If you started digging directly through Earth in Sydney, you would emerge in the Atlantic Ocean near the Azores Islands. List, in order, the layers of Earth that you would travel through.
- Distinguish between the lithosphere and the asthenosphere.
- Describe how the relationship between the lithosphere and the asthenosphere causes earthquakes and volcanoes.
- Earth's core has a liquid outer core and a solid inner core. Suggest why.

### CONNECTING IDEAS

- Turn back to the See-Know-Wonder image at the start of this chapter. Redraw it and label Earth's layers. (Hint: The image shows the upper and lower mantles separately.)

### SUCCESS CRITERIA

- I can name the three main layers of Earth.
- I can describe each layer.
- I can draw and label a cross-section of Earth.

# 6.2

## MINERALS

### LEARNING INTENTION

At the end of this lesson I will be able to recognise that rocks are a collection of different minerals that can be identified based on physical and chemical properties.

### KEY TERMS

#### crystal

a solid substance made up of very ordered microscopic parts

#### mineral

a naturally occurring inorganic (non-living) substance

#### physical property

a characteristic that can be seen or measured (e.g. colour, shape, hardness)

### LITERACY LINK

#### WRITING

Write a brief list of instructions for using a Mohs testing kit to test the hardness of an unknown substance.

### NUMERACY LINK

#### MEASUREMENT

Use the Mohs scale in Table 6.1 to estimate the hardness of three objects in the classroom. If possible, test your estimations with a Mohs testing kit.

All rocks are made up of minerals. **Minerals** are the building blocks of rocks. Identifying the minerals that make up a particular rock can be very useful for geologists. The types and amounts of minerals in a rock can suggest how the rock was formed and help geologists to classify it.

Identifying rocks that contain useful mineral resources means that the minerals can be mined and used.

## 1 Minerals are made up of elements

Minerals are inorganic (non-living) substances that are found in nature. Each mineral contains one or more of the 98 naturally occurring elements within Earth. Elements are pure substances, made of only one type of atom. Most minerals are compounds, made up of two or more elements. Quartz is made up of silicon and oxygen ( $\text{SiO}_2$ ). Some minerals are pure substances, made of only one element. These are called native elements.

*Why are minerals described as inorganic?*

## 2 Minerals have specific physical properties

Geologists identify different minerals by observing and measuring their different **physical properties**. Because each mineral has a different chemical make-up, it will have a unique set of properties, including hardness, lustre, streak and crystal shape.

### Lustre

Lustre refers to how light reflects off the surface of a mineral. Some minerals have a metallic lustre – they look shiny, like polished metal. Others have a non-metallic lustre – they look dull and earthy.

**Figure 6.3** Some minerals, such as pyrite, have a metallic lustre. Others, such as jade, have a non-metallic lustre.



Pyrite



Jade

## Hardness

Talc is a mineral so soft that you can scratch it with your fingernail. Diamond is also a mineral but is one of the hardest substances known. German geologist Friedrich Mohs developed a scale in 1812 to compare the hardness of minerals. His scale ranks minerals from 1 (very soft) to 10 (very hard). Hard minerals, with a larger number on the scale, will scratch softer minerals, with a smaller number on the scale. Scratching a crystal of an unknown mineral with a known mineral from a Mohs testing kit can determine the unknown mineral's hardness.

Table 6.1 Mohs scale of relative hardness

Index mineral	Hardness	Everyday material
Talc	1	
Gypsum	2	
Calcite	3	
Fluorite	4	Fingernail (2.5)
Apatite	5	Copper coin (3.5)
Orthoclase	6	Wire nail (4.5)
Quartz	7	Glass and knife blade (5.5)
Topaz	8	Streak plate (6.5)
Corundum	9	
Diamond	10	

## Colour and streak

Colour is not usually a reliable way to identify a mineral because the mineral may be many different colours, or the same colour as another mineral.

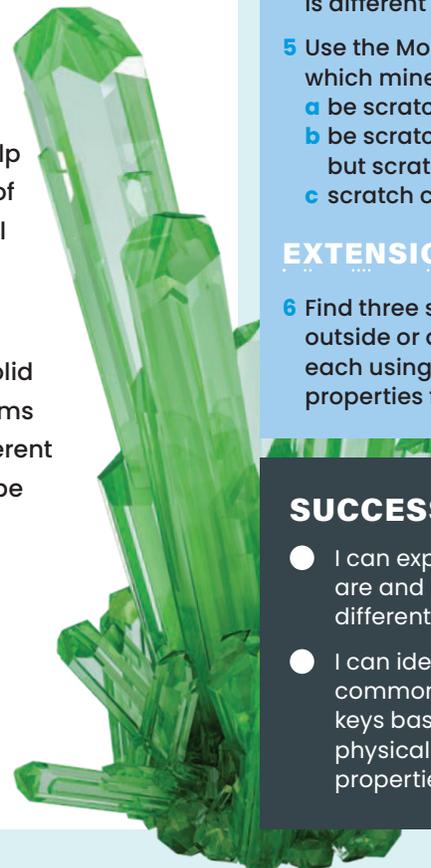
Geologists will often use the streak of the mineral to help identify it. The streak is the colour of the powdered form of a mineral. The powder is made by scratching the mineral on an unglazed white tile.

## Crystal shape

Minerals usually have a crystal structure. **Crystals** are solid substances that have a regular shape because their atoms are bonded together in a regular, repeating pattern. Different minerals have different chemical make-ups, which can be seen in the shape of their crystals.

### What are five physical properties used to identify minerals?

Figure 6.4 Crystal shape can be used to identify minerals.



### INVESTIGATION 6.2A

Observing minerals



#### KEY SKILL

Identifying and managing relevant risks

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### INVESTIGATION 6.2B

Extracting copper

#### KEY SKILL

Representing and recording data using a table

► Go to page 157

## CHECKPOINT 6.2

- Copy and complete. Minerals are the \_\_\_\_\_ of rocks. They are \_\_\_\_\_ occurring substances. A native \_\_\_\_\_ is a mineral that contains only one type of \_\_\_\_\_.
- Identify the main properties used to identify minerals.
- What type of mineral is a gold nugget? Justify your response.
- Explain how a native element is different to other minerals.
- Use the Mohs scale to identify which mineral(s) can:
  - be scratched by apatite
  - be scratched by topaz, but scratch orthoclase
  - scratch corundum.

## EXTENSION

- Find three small rocks outside or at home. Describe each using the five physical properties from this lesson.

## SUCCESS CRITERIA

- I can explain what minerals are and how they are different to rocks.
- I can identify a range of common rock types using keys based on observable physical and chemical properties.

# 6.3

## THE ROCK CYCLE

### LEARNING INTENTION

At the end of this lesson I will be able to describe how different rocks are formed by a variety of naturally occurring processes using forces and energy.

### KEY TERMS

#### igneous rock

rock formed by the cooling of molten rock

#### metamorphic rock

rock formed from another rock that has been changed by heat and pressure

#### sediment

small particles of rocks such as clay, sand and pebbles

#### sedimentary rock

rock formed by sediments that have been pressed together

### LITERACY LINK

#### VOCABULARY

Explain how the meanings of the words *igneous*, *sedimentary* and *metamorphic* give clues to how each of these rocks is formed.

### NUMERACY LINK

#### GRAPHING

The Earth's crust contains 46.6% oxygen, 27.7% silicon, 8.1% aluminium, 5.0% iron and 12.6% of other elements. Display this information in a pie chart.

Rocks are constantly changing and being recycled. As the tectonic plates of the lithosphere move and act on each other, rocks can be pulled under Earth's surface or forced upwards.

Rocks beneath the surface can change due to extreme heat and pressure. Rocks at the surface can change due to natural processes such as weathering (rocks breaking down into smaller particles) and erosion (rocks moved to new locations).

## 1 There are three main types of rock

Geologists classify rocks into three main types based on how they were formed.

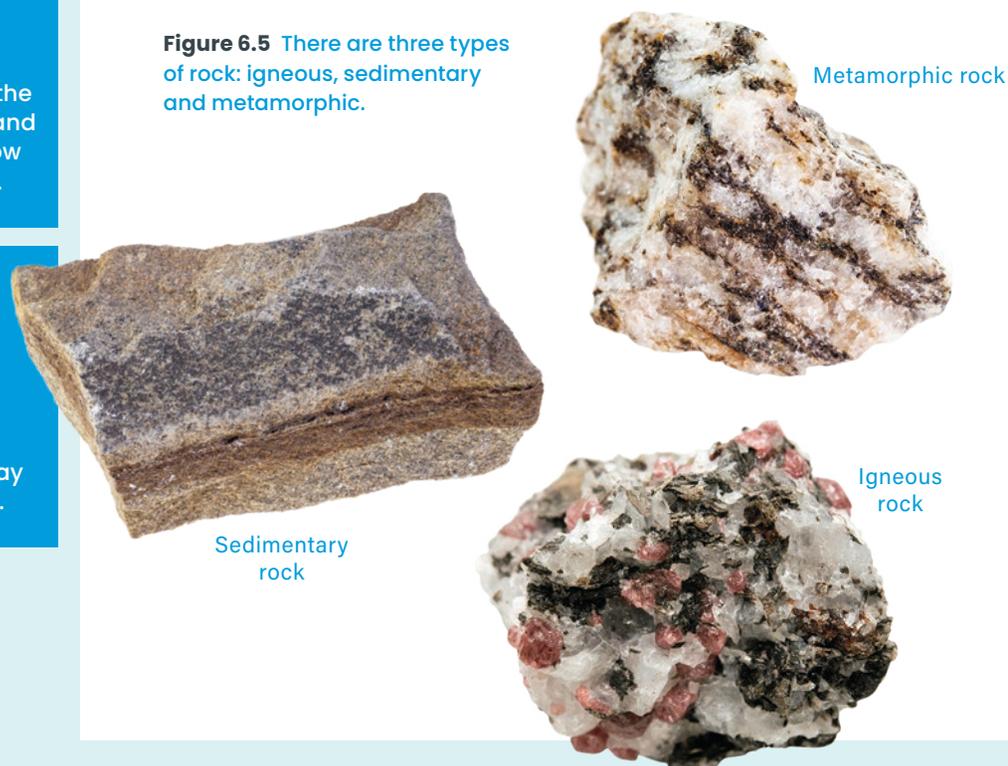
**Igneous rocks** are made by the cooling of molten (melted) rock, either on the surface or within Earth's crust. 'Igneous' comes from the Latin word *ignis* which means 'of fire'. The minerals in the rock can be seen as individual crystals.

**Sedimentary rocks** are made up of **sediments** such as clay, sand, pebbles, shells and other pieces of material. The sediment is usually deposited in layers by wind, water or gravity. Over time the sediment is buried and squashed, and the particles in it are stuck together to form rock. The minerals in the rock are within the sediments and may not be easily seen.

**Metamorphic rocks** form when other rocks change (metamorphose) because of high temperatures and pressure within Earth's crust. The minerals in the rock can be seen as individual crystals.

### What are the three main types of rock?

Figure 6.5 There are three types of rock: igneous, sedimentary and metamorphic.



## 2 Rocks can change over time

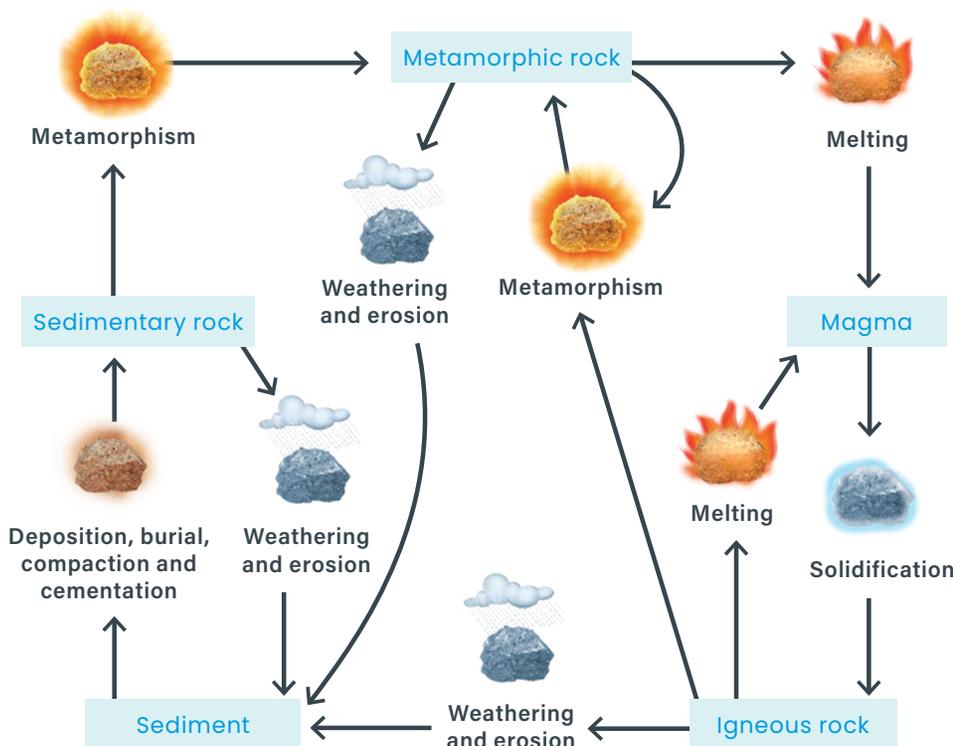
The three main rock types – igneous, sedimentary and metamorphic – are all related, because they can form from one another. Forces within Earth bring rocks to the surface or sink them back down deep within the crust. The rock cycle is a model used to show how different processes can form the three different types of rock. Because some of these processes take millions, sometimes billions, of years and often occur only in certain environments, it is very likely that a rock will not undergo all possible processes in the life of the planet.

These are some common processes that act on rocks:

- *weathering*: Rocks break down into smaller pieces called sediment.
- *erosion*: Sediment moves from one place to another.
- *deposition*: Sediment settles in one place.
- *burial and compaction*: As more sediment is deposited, the sediments below it are buried and squashed together.
- *cementation*: Sediments are chemically glued together into rock.
- *metamorphism*: Rocks change due to heat and pressure.
- *melting*: Rock melts to magma due to high temperatures.
- *solidification*: Molten rock cools and hardens.

### What does the rock cycle describe?

**Figure 6.6** The rock cycle shows how different, naturally occurring processes in Earth form different types of rock.



### INVESTIGATION 6.3

#### Modelling the rock cycle

**KEY SKILL**  
Identifying and managing relevant risks

▶ Go to page 158



### CHECKPOINT 6.3

- 1 Describe the rock cycle in your own words.
- 2 Identify the rock type(s) that are made up of crystals.
- 3 How is an igneous rock similar and how is it different to a sedimentary rock?
- 4 Are sediments formed above or below Earth's surface? Give evidence from the text in your answer.
- 5 What must happen to a sedimentary rock before it can become an igneous rock?
- 6 What must happen to a metamorphic rock before it can become a sedimentary rock?
- 7 Identify the processes that could happen to a rock if it is buried deep under Earth's surface.
- 8 Identify the processes that can only happen to a rock if it is on Earth's surface.

### CONNECTING IDEAS

- 9 Explain the role that forces and energy play in the formation of rocks and minerals.

### SUCCESS CRITERIA

- I can identify the three types of rock.
- I can describe how each type of rock is created.
- I can explain what the rock cycle is.

# 6.4

## IGNEOUS ROCKS

### LEARNING INTENTION

At the end of this lesson I will be able to describe what igneous rocks are and explain how they are formed.

### KEY TERMS

**extrusive igneous rock**  
igneous rock formed at Earth's surface

**intrusive igneous rock**  
igneous rock formed under Earth's surface

**lava**  
molten (melted) rock at Earth's surface

**magma**  
molten (melted) rock under Earth's surface

**solidify**  
become a solid

### LITERACY LINK

#### VOCABULARY

Think of alternative terms for: *molten*, *solidify* and *cool*.

### NUMERACY LINK

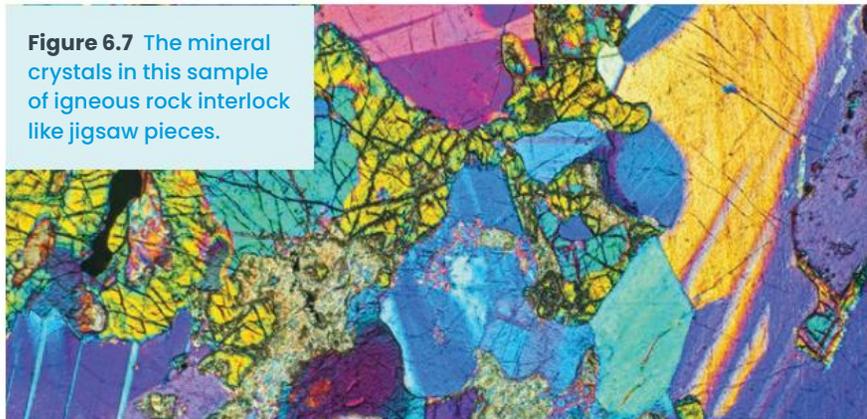
#### UNITS

There are approximately 60 volcanic eruptions on Earth each year. On average, how often is there an eruption somewhere on Earth?

Igneous rocks form when molten rock cools and becomes hard or solid. Most igneous rocks contain interlocking crystals (connected like a jigsaw) of the minerals that were in the molten rock.

The size of the crystals in igneous rocks depends on the time that the molten rock took to cool. Small crystals form in rocks that have cooled quickly. Large crystals form in rocks that have cooled slowly.

**Figure 6.7** The mineral crystals in this sample of igneous rock interlock like jigsaw pieces.



## 1 Rocks can melt to form magma

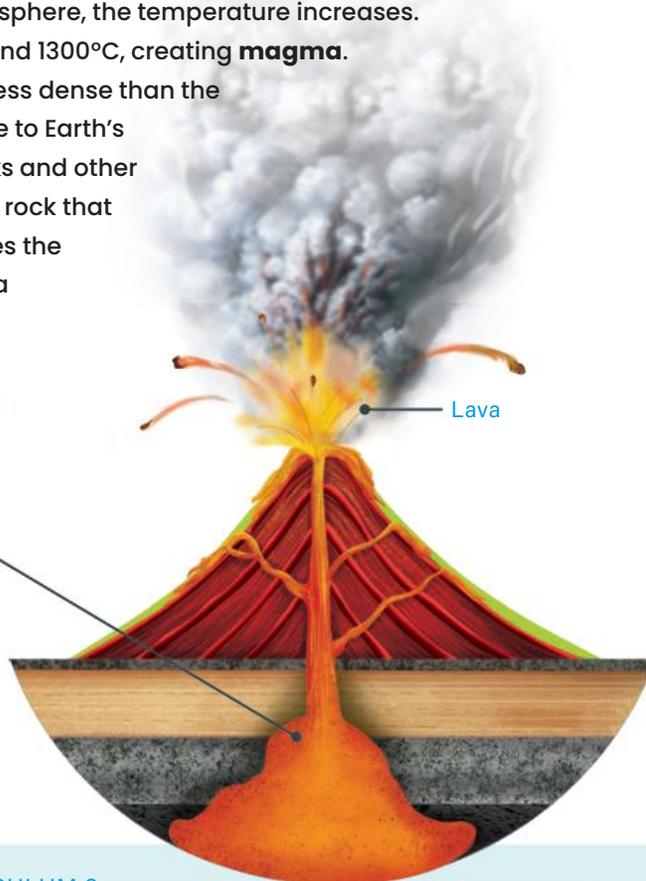
What happens to chocolate when it is heated? It melts! The same thing happens to rocks. As rocks are pulled deep below Earth's surface, towards the base of the lithosphere, the temperature increases. Rocks melt between 700°C and 1300°C, creating **magma**.

Magma is a liquid, so it is less dense than the surrounding rock and will rise to Earth's surface through faults, cracks and other weak spots, also melting the rock that it passes through. If it reaches the surface and erupts through a volcano it is called **lava**.

*How is magma different to lava?*

Magma

Lava



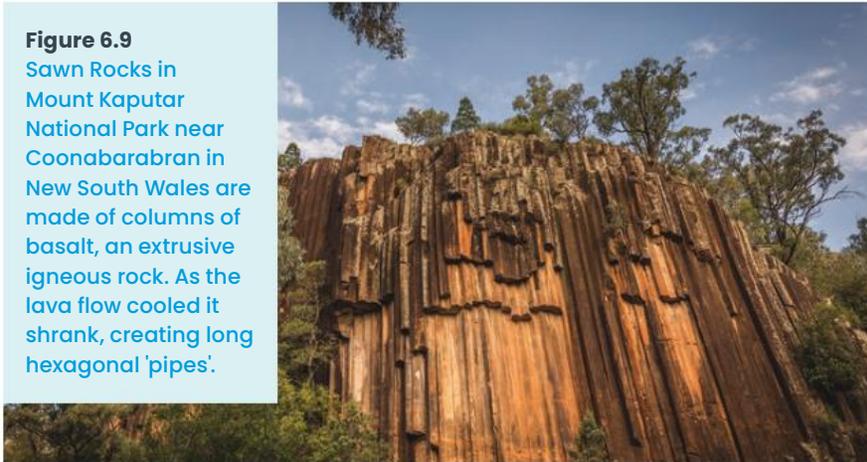
**Figure 6.8** Magma collects in a chamber of a volcano before making its way to the surface to erupt as lava.

## 2 Molten rock cools to form igneous rock

What happens to melted chocolate when it cools down? It **solidifies!** When molten rock cools and solidifies, the minerals form crystals that interlock like a jigsaw to form igneous rocks.

Rocks formed when lava cools on or near Earth's surface are **extrusive igneous rocks**. The magma has been extruded from (pushed out of) the crust. When magma reaches Earth's surface as lava, it will cool down very quickly; even faster if it is under water. Extrusive igneous rocks have very small crystals, so small that they are often not visible with the naked eye. This is because they did not have very long to form before the lava solidified.

**Figure 6.9**  
Sawn Rocks in Mount Kaputar National Park near Coonabarabran in New South Wales are made of columns of basalt, an extrusive igneous rock. As the lava flow cooled it shrank, creating long hexagonal 'pipes'.



When magma cools under the surface, it forms **intrusive igneous rocks**. The magma has intruded on the rocks that were originally there. Magma under the surface cools very slowly, which means the crystals have more time to grow. The crystals in intrusive igneous rocks, such as quartz and granite, are much larger than those in extrusive igneous rocks and can be seen with the naked eye.

*What is the difference between extrusive and intrusive igneous rocks?*

## 3 Crystal sizes tell us where an igneous rock was formed

The size of crystals (known as rock texture) in igneous rocks can tell geologists whether those crystals formed on the surface due to an erupting volcano, or deep underground. The bigger the crystals, the deeper the region where they formed. Geologists also look at the types of minerals that make up a rock to work out how and where the magma was formed.

*Would a rock that formed on the surface contain large or small crystals?*

### INVESTIGATION 6.4A

Cooling rate and crystal size

#### KEY SKILL

Identifying the independent and dependent variables

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### INVESTIGATION 6.4B

Observing igneous rocks

#### KEY SKILL

Explaining results using scientific knowledge

► Go to page 162

## CHECKPOINT 6.4

- Copy and complete.  
Molten rock below Earth's surface is known as \_\_\_\_\_.  
Molten rock at the surface is known as \_\_\_\_\_.
- Copy and complete.  
Igneous rocks that have cooled quickly have \_\_\_\_\_ crystals. Igneous rocks that have cooled slowly have \_\_\_\_\_ crystals.
- Identify two key characteristics that could be used to classify a rock as an igneous rock.
- Explain what is meant when magma is referred to as 'less dense than solid rock'.

## EXTENSION

- When magma loses gas as it moves to Earth's surface, gas bubbles may be preserved as the lava solidifies. This creates igneous rocks containing many air bubbles. Draw a diagram to illustrate this process.

## SUCCESS CRITERIA

- I can describe what igneous rocks are and how they form.
- I can explain the difference between extrusive and intrusive igneous rocks.
- I can state the relationship between cooling and crystal size.

# 6.5

## METAMORPHIC ROCKS

### LEARNING INTENTION

At the end of this lesson I will be able to describe what metamorphic rocks are and explain how they are formed.

### KEY TERMS

#### contact metamorphism

the process of change that happens to a rock over small areas, often near volcanoes

#### metamorphism

the process of change that happens to a rock because of heat, pressure or both

#### regional metamorphism

the process of change that happens to rock over large areas

#### tectonic plate

a plate made up of the mantle and crust of the lithosphere

### LITERACY LINK

#### WRITING

Come up with an analogy to explain regional metamorphism and contact metamorphism.

### NUMERACY LINK

#### GRAPHING

A survey of the rocks in a particular area estimated that there were 4.5 tonnes of shale, 6.7 tonnes of slate and 3.2 tonnes of phyllite. Draw a bar chart to represent this data.

*Metamorphosis* means 'change'. Like a caterpillar changing into a butterfly, a metamorphic rock has changed its form.

Metamorphic rocks form from other rocks that have been changed by heat, pressure or both.

## 1 Rocks are changed by heat and pressure

Metamorphic rocks are formed from rocks that have been put under heat or pressure, or both heat and pressure. This process is called **metamorphism**. It happens when Earth's **tectonic plates** push together, move apart or slide past each other, burying rocks and making them very hot and putting them under pressure. As rocks are heated and put under pressure, the minerals inside them will rearrange. Some may even form new minerals by chemically reacting with each other or with fluids passing through the rocks.

Metamorphosis results in rocks that have crystals. Sometimes these crystals have rearranged into layers.

*How are metamorphic rocks formed?*

## 2 Rocks can be squashed, folded or 'cooked'

Rocks can be metamorphosed in two major processes.

**Regional metamorphism** happens over large areas, often when two tectonic plates push together. This puts rocks under much higher temperatures and pressures, and they may squash and fold. As they are pushed deeper and deeper they will keep changing. The amount of metamorphism depends where the rocks are. Rocks that have been formed by regional metamorphism will have their crystals arranged in layers.

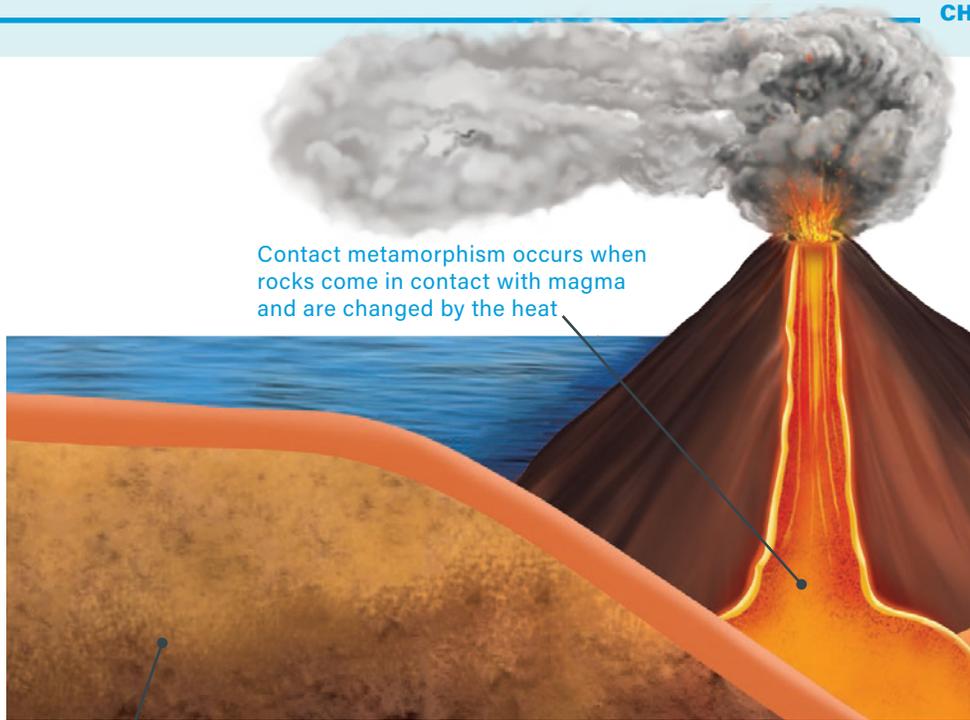
**Contact metamorphism** happens when a body of rising magma meets rock, increasing the temperature of the rock and 'cooking' it, forming new crystals. It happens in a small, local area, often around volcanoes. The crystals in rocks formed by contact metamorphism will not be in layers.

*How could you tell if a rock was formed by regional metamorphism or contact metamorphism?*



**Figure 6.10**

These heavily folded and metamorphosed rocks at Narooma in New South Wales formed due to intense pressure when the Pacific tectonic plate first started colliding with the east coast of Australia.



Contact metamorphism occurs when rocks come in contact with magma and are changed by the heat

Regional metamorphism occurs when rocks are changed by the immense pressure caused when two plates converge

**Figure 6.11** Metamorphic rocks are formed through either regional metamorphism (changed by pressure) or contact metamorphism (changed by heat).

**INVESTIGATION 6.5A**

Modelling contact metamorphism



**KEY SKILL**

Identifying and managing relevant risks

▶ Go to page 163

**INVESTIGATION 6.5B**

Observing metamorphic rocks

**KEY SKILL**

Drawing conclusions consistent with evidence

▶ Go to page 164

**CHECKPOINT 6.5**

- Copy and complete.  
Metamorphic rocks are formed when \_\_\_\_\_ have been \_\_\_\_\_ due to \_\_\_\_\_, \_\_\_\_\_ or both.
- Identify two key characteristics that could be used to classify a rock as a metamorphic rock.
- Identify two locations on Earth where metamorphism could occur, and use evidence from the text to justify your answer.
- Describe how heat and pressure cause the changes in metamorphic rocks.
- Is it possible for metamorphic rocks to form on Earth's surface? Justify your response.

**CONNECTING IDEAS**

- Compare and contrast the features and formation of metamorphic and igneous rocks. In what ways are they similar and different?

**SUCCESS CRITERIA**

- I can describe what metamorphic rocks are and how they form.
- I can explain the difference between regional and contact metamorphism.

**3 Metamorphism can be an ongoing process**

A rock can undergo different amounts of change, depending on what happens to it. Even metamorphic rocks can undergo more metamorphism! As rocks are buried deeper and deeper they will keep changing as the temperature and pressure increase. Think about what happens when you bake chocolate chip cookies. A cool oven and a short period of cooking time will result in soft, doughy cookies, and the chocolate chips keep their shape. A hot oven and a longer period of cooking time will result in hard cookies with chocolate that melts and then resets.

Geologists compare the types of minerals in metamorphic rocks to work out where and how the rocks formed. This can help them to understand more about how Earth's tectonic plates move and act on each other.

*What increases as rocks are buried deeper in Earth?*

**Figure 6.12** Shale is a sedimentary rock formed by layers of very small sediments. As it is buried deeper and deeper, it will change into different types of rock. Slate is a metamorphic rock formed from shale at quite low temperatures and pressures. If it gets buried more and more it will change into phyllite, schist and, finally, gneiss.

Shale → Slate → Phyllite → Schist → Gneiss



# 6.6

## SEDIMENTARY ROCKS

### LEARNING INTENTION

At the end of this lesson I will be able to describe what sedimentary rocks are and explain how they are formed.

### KEY TERMS

**chemical sedimentary rock**  
sedimentary rock formed from layers of mineral crystals that have crystallised from water

**clastic sedimentary rock**  
sedimentary rock formed from sediments cemented together

**organic sedimentary rock**  
sedimentary rock formed from the remains of plants or animals

### LITERACY LINK

#### READING

Underline or copy out as many nouns (names of a person, place or thing) as you can find in this section.

### NUMERACY LINK

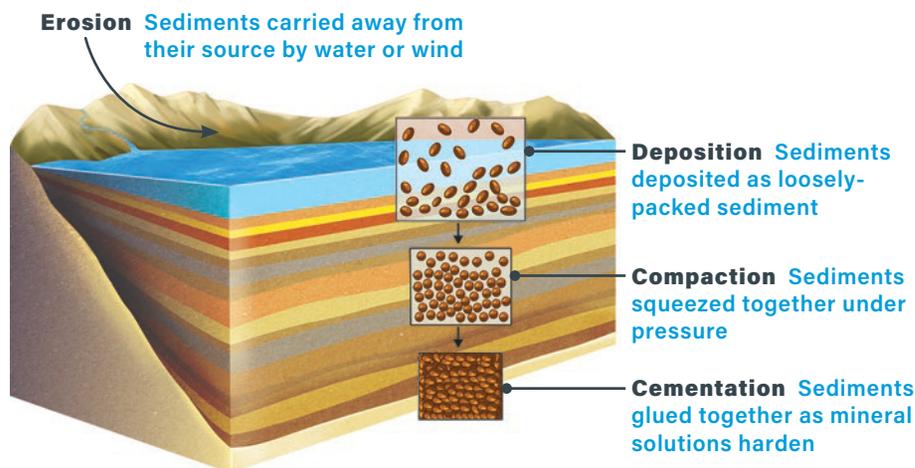
#### CALCULATION

Sedimentary rock makes up 5% of Earth's crust. If the crust in a particular place is 42 km thick, how much of this (in kilometres) will be sedimentary rock?

Sedimentary rocks are made of sediments such as clay, sand, pebbles, shells and other fragments of material. This is often deposited in layers by wind, water or gravity. These are gradually buried, compacted and cemented together into rock.

Sedimentary rocks can be classified into three main types based on how they were formed.

**Figure 6.13** Sedimentary rocks are formed when sediments are eroded, deposited, compacted and cemented together.



## 1 Clastic sedimentary rocks are made up of layers 'glued' together

**Clastic sedimentary rocks** are made up of sediments (clasts) formed by the weathering of other rocks. Wind, water, ice and gravity deposit these clasts into layers. As the layers build up, pressure on the sediments increases and they are compacted together. Chemicals in the groundwater that moves between the sediments will then cement the layers together, forming a hard rock. Clastic sedimentary rocks are classified by the size of their sediments.

*What are clastic sedimentary rocks made of?*

## 2 Pressure can create rocks from organic remains

**Organic sedimentary rocks** are formed from the remains of plants and animals. These remains have been deposited together, buried and compacted. Coal, limestone and chalk are examples of organic sedimentary rocks.

Coal is formed from the remains of ancient swamps. The plant and animal remains do not decompose. Instead, when they are buried the increasing pressure compacts and cements the remains and changes them into coal.

Limestone is made of the remains of ancient coral reefs. The shells of the corals, shellfish and other marine animals made of a mineral called calcium carbonate were buried, compacted and cemented together.

**Figure 6.14** Limestone often contains lots of fossils.



Chalk is a type of limestone formed from the compacted remains of billions of microscopic marine organisms that had shells made of calcium carbonate. As the organisms died, their shells were deposited on the bottom of the ocean. Over time these built up, were buried, compacted and cemented together.

### What are organic sedimentary rocks made of?

## 3 Crystals can form rocks after evaporation

**Chemical sedimentary rocks** are formed when water that contains dissolved minerals evaporates, allowing the mineral crystals to grow. Halite (rock salt) is formed in this way. Some limestones can also be formed in this way: water evaporates and leaves behind crystals of calcium carbonate.

### How are chemical sedimentary rocks created?



**Figure 6.15** Halite is a chemical sedimentary rock that is formed when water containing salt evaporates, allowing salt crystals to form.



- 1 Water evaporates.
- 2 Crystals sink.
- 3 Evaporation continues.
- 4 Salt crystals form and grow.
- 5 Halite remains.



### INVESTIGATION 6.6A

#### Modelling the formation of sandstone

KEY SKILL  
Writing a research question

► Go to page 165



### INVESTIGATION 6.6B

Observing sedimentary rocks

KEY SKILL  
Identifying and managing relevant risks

► Go to page 166

## CHECKPOINT 6.6

- 1 Identify at least three types of sediments that can make up sedimentary rocks.
- 2 Identify the three main types of sedimentary rocks and provide an example for each.
- 3 Outline the difference between organic and chemical sedimentary rocks.
- 4 Explain why compaction and cementation are important steps in the formation of sedimentary rocks. What could happen if they did not occur?
- 5 Which kind of sedimentary rock would be best at preserving fossils? Give evidence to support your answer.

## RESEARCH

- 6 Conglomerate, mudstone and sandstone are types of sedimentary rock. Research what sediments they are made from and the environments they are formed in.

## SUCCESS CRITERIA

- I can describe what sedimentary rocks are and how they form.
- I can explain the difference between clastic, chemical and organic sedimentary rocks.

# 6.7

## THE FORMATION OF LANDFORMS

### LEARNING INTENTION

At the end of this lesson I will be able to relate the formation of a range of landforms to physical and chemical weathering, erosion and deposition.

### KEY TERMS

#### deposition

a process in which sediment is left in a new place

#### erosion

a process in which sediments are moved from one place to another

#### landform

a natural feature of Earth's surface

#### weathering

a process in which rocks are worn down into smaller particles

### LITERACY LINK

#### SPEAKING

Working with a partner, look up frost wedging while your partner looks up wind abrasion. Explain the processes you have learned about to each other.

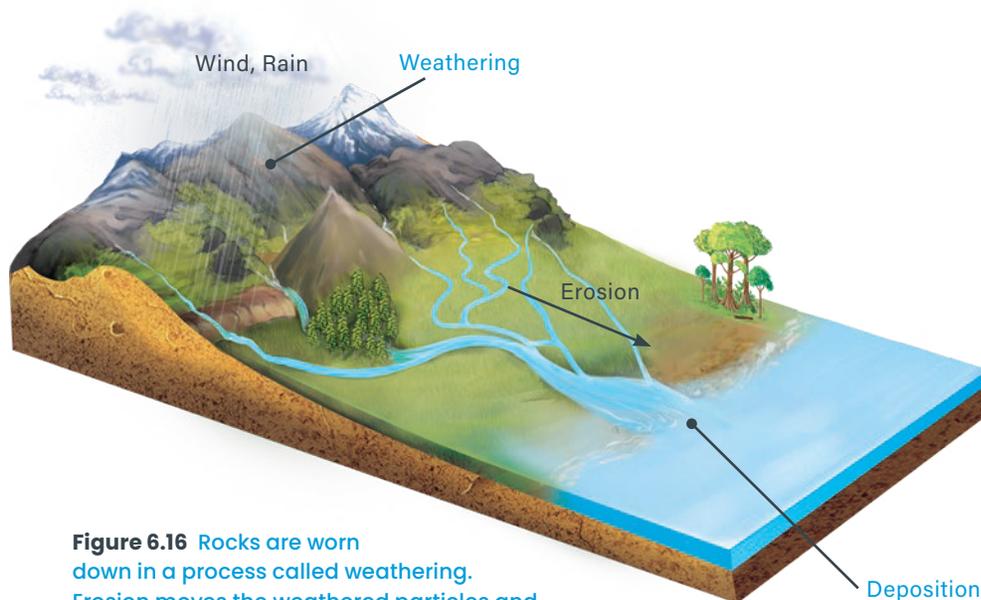
### NUMERACY LINK

#### MEASUREMENT

The large rock on the right of Figure 6.17 is known as Arbol de Piedra. The image is shown at a 1:233 scale. Measure and calculate the height of the Arbol de Piedra in real life, then check online to see if you are correct.

Igneous and metamorphic rocks are formed by changes in Earth's crust. Rocks on Earth's surface also change. Wind, water and changes in temperature can act on these rocks, wearing them down into smaller parts called sediments and depositing them in new locations.

Over a long time, these processes will make and change **landforms** such as mountains, riverbeds, deserts and coastlines, changing the face of Earth.



**Figure 6.16** Rocks are worn down in a process called weathering. Erosion moves the weathered particles and deposition drops the material at a new place. These processes change landforms and form new ones.

## 1 Rocks are worn away by weathering

**Weathering** is the process in which rocks are worn down into sediments such as pebbles, sand and clay. There are two main ways this can happen.

*Physical weathering* breaks rocks into smaller particles through processes that do not change the chemical make-up of the minerals. This can happen when rocks expand, shrink and crack due to temperature changes, or if they are worn down by the actions of wind or water.

**Figure 6.17** Frost wedging (left) and wind abrasion (right) are both types of physical weathering.



*Chemical weathering* breaks rocks into smaller particles through chemical reactions that change the minerals in the rocks. This can happen when rocks contact chemicals in the air or water. The new minerals will often separate from the original rock to form sediments.

### How can weathering produce sediment?

## 2 Erosion moves sediment

**Erosion** is the movement of sediment from one place to another. The sediments can be transported by wind, water, ice or gravity – these are called the agents of erosion.

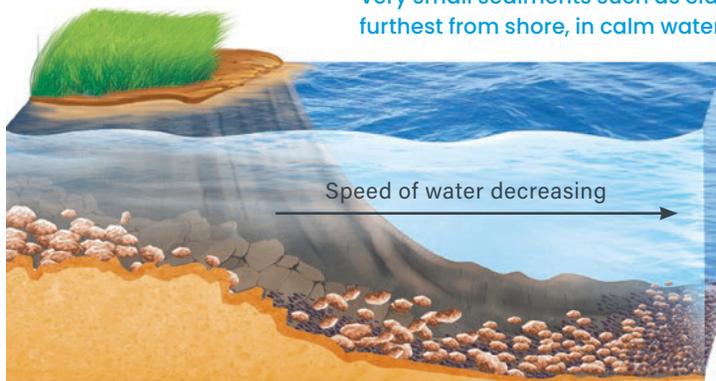
### What are the four agents of erosion?

## 3 Deposition drops sediment in new areas

**Deposition** happens when erosion deposits (drops) sediments in a new place. Often this happens when there is no longer enough energy in the wind or water to carry them any further. If these sediments are not eroded they may eventually be compacted and cemented together to form new sedimentary rocks.

### What is deposition?

**Figure 6.18** As the water in a river slows down (for example, where it meets the sea), the larger sediments it is carrying will be deposited first. Very small sediments such as clay will settle furthest from shore, in calm water.



## 4 Uluru was formed by sedimentary processes

Uluru is made of layers of very hard sandstone. This sandstone was formed when a nearby ancient mountain range similar to the modern Himalayas was weathered, eroded and deposited in a valley more than 500 million years ago. Over time, this sediment was buried under more sediment, compacted and cemented together, forming very hard rock. As tectonic plates pushed together, these rocks were folded and pushed up to the surface again. The softer rock weathered and was eroded, leaving only the hard rock of Uluru at the surface. It is just the tip of a large section of rock that may reach as far as 5 km below the surface.

### How did sedimentary processes form Uluru?

### INVESTIGATION 6.7A

Modelling weathering due to temperature change

#### KEY SKILL

Identifying and managing relevant risks

► Go to page 167

### INVESTIGATION 6.7B

Modelling weathering due to acid rain (Teacher demonstration)

► Go to page 168



## CHECKPOINT 6.7

- Are these examples of erosion, weathering or deposition?
  - transporting sediment or rock to a different location
  - large rocks breaking down into smaller rocks
  - sediments, rocks and soil being added to a landform
  - a stream carrying sediment
  - a landform breaking apart
  - mud flowing from one place to another
- Explain the difference between physical and chemical weathering.
- In February 1983, after a record drought, a massive dust storm hit Melbourne. Use your knowledge of weathering, erosion and deposition to explain what happened.
- Very small sediments carried by a river will be deposited where the river meets a large body of water. Suggest why.

## CONNECTING IDEAS

- How were weathering, erosion and deposition important in the formation of Uluru?

## SUCCESS CRITERIA

- I can describe erosion, deposition and chemical and physical weathering.
- I can explain how erosion, deposition and weathering create landforms over time.

# 6.8

## FOSSILS

### LEARNING INTENTION

At the end of this lesson I will be able to describe how fossils form.

### KEY TERMS

#### cast

an object created when sediment or minerals fill a mould

#### fossil

the preserved remains or traces of once-living things

#### fossilisation

the process of a fossil forming

#### mould

a hollow impression formed by an imprint of an organism, or when the original bone or shell has dissolved

#### palaeontologist

a scientist who studies fossils

### LITERACY LINK

#### LISTENING

Find an image online of a dinosaur. Describe your dinosaur to a partner, while they attempt to draw it from your description. Then swap roles and try to draw a different dinosaur described by your partner.

### NUMERACY LINK

#### CALCULATION

Life has existed on Earth for about 4.1 billion (4 100 000 000) years. Early humans first appeared about 2.5 million (2 500 000) years ago. Calculate 2.5 million as a percentage of 4.1 billion.

**Fossils** are the preserved remains or traces of once-living things. Fossils can be complete or part skeletons, shells and tree trunks, or traces that an animal existed such as footprints, burrows, and even poo.

Fossils and the rocks that they are in can help **palaeontologists**, who study fossils, to reconstruct information about past living things and the environments that they lived in.

## 1 Fossils form in sediment

The process that results in a fossil is called **fossilisation**, and it is rare. Usually when an organism dies it decomposes or is eaten. Soft parts decay or are eaten quickly, and even hard parts such as bones and shells will eventually be eaten or weather away if they are left exposed.

For a fossil to form, a series of events that preserves an organism needs to happen.

### *How do fossils form?*

Figure 6.19 The fossilisation process can be summarised in four steps.



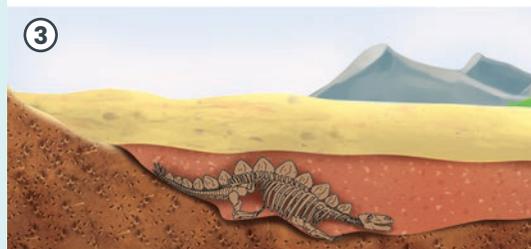
①

The organism dies and its remains are in an environment, such as under water, where they will be quickly buried by sediment.



②

The remains continue to be buried under more layers of sediment. These layers compact, and minerals in the groundwater cement them together into sedimentary rock.



③

Groundwater minerals can also dissolve and replace the minerals in the bones of the organism, often making them harder than the original bone.



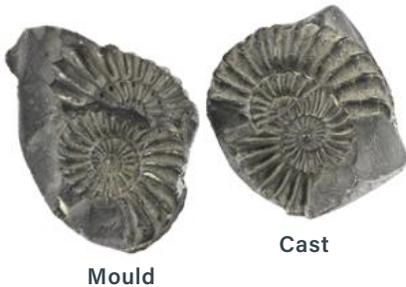
④

Movement of tectonic plates bring the fossil layer closer to the surface, and weathering and erosion or digging can expose them.

## 2 Impressions of dead organisms can be moulds or casts

A **mould** is a hollow impression formed by an imprint of an organism, or when the original bone or shell has dissolved. A **cast** is created when sediment or minerals fill the mould.

*What is the difference between a mould and a cast?*



**Figure 6.20** The hollow imprint, called a mould, left by a dead organism, can be filled with sediment or minerals to become a cast.

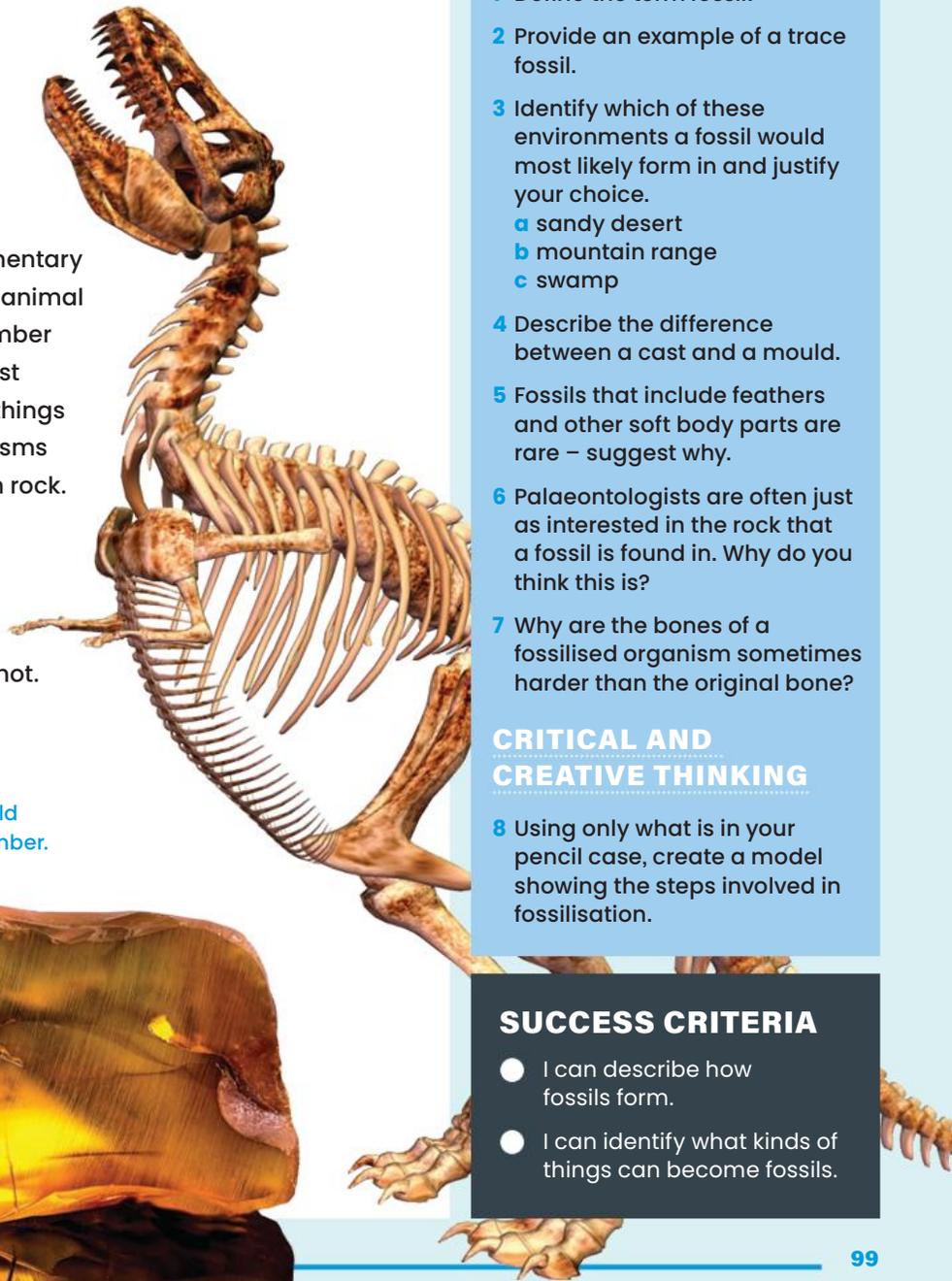
## 3 Fossils can be found in other places

Most fossils are usually found in sedimentary rocks, although sometimes plant and animal remains can be found preserved in amber (fossilised tree sap), tar and permafrost (ground that is always frozen). These things often preserve the soft parts of organisms that would not usually be preserved in rock.

Footprints and burrows can also be preserved by fossilisation. These are called trace fossils. They can show palaeontologists how animals moved and lived, in a way that skeletons cannot.

*What is a trace fossil?*

**Figure 6.21** This 100-million-year-old mosquito has been preserved in amber.



### INVESTIGATION 6.8

Making 'fossils'

KEY SKILL  
Explaining results  
using scientific  
knowledge

► Go to page 169



### CHECKPOINT 6.8

- 1 Define the term *fossil*.
- 2 Provide an example of a trace fossil.
- 3 Identify which of these environments a fossil would most likely form in and justify your choice.
  - a sandy desert
  - b mountain range
  - c swamp
- 4 Describe the difference between a cast and a mould.
- 5 Fossils that include feathers and other soft body parts are rare – suggest why.
- 6 Palaeontologists are often just as interested in the rock that a fossil is found in. Why do you think this is?
- 7 Why are the bones of a fossilised organism sometimes harder than the original bone?

### CRITICAL AND CREATIVE THINKING

- 8 Using only what is in your pencil case, create a model showing the steps involved in fossilisation.

### SUCCESS CRITERIA

- I can describe how fossils form.
- I can identify what kinds of things can become fossils.

# 6.9

## GEOLOGICAL HISTORY

### LEARNING INTENTION

At the end of this lesson I will be able to explain how geological history can be interpreted from a sequence of sedimentary layers.

### KEY TERMS

**conglomerate rock**  
sedimentary rock made of large, rounded pebbles and fragments cemented together

**geological history**  
how Earth has changed over time

**relative age**  
which rocks are younger and which rocks are older when compared with one another

**sequence**  
the order of something

### LITERACY LINK

#### WRITING

Mars rovers have discovered conglomerate rocks on Mars that look very similar to Earth's conglomerate rocks. Write a letter to a friend explaining the significance of this discovery.

### NUMERACY LINK

#### DATA

Gregor collects six rock samples and estimates their ages (in millions of years) as follows: 100, 130, 90, 120, 85, 115. Display this data in a table and calculate the mean and median.

It is possible that the place where you are right now was underwater or near active volcanoes millions of years ago.

We can't go back in time, but geologists can piece together the **geological history** of different locations by investigating the **sequence** of rocks found in the area.

### 1 The youngest rocks are at the top

When sedimentary layers are deposited, younger ones are deposited on top of older ones. Unless something unusual has happened, the oldest rocks in a cliff face will be at the bottom and the youngest rocks will be at the top. Knowing this, geologists are able to work out the **relative age** of the layers. Finding the same layers in different areas means they must have been deposited at the same time.

*Where would you expect to find the oldest rocks in a cliff face?*



**Figure 6.22** The majestic rock formations found in the Grampians National Park in the west of Victoria were formed after millions of years of sedimentation, thousands of meters deep. The Aboriginal name for the Grampians is Gariwerd and the area is pivotal in many ancient stories, with rock art dating back more than 20 000 years.

## 2 Different rocks are deposited in different environments

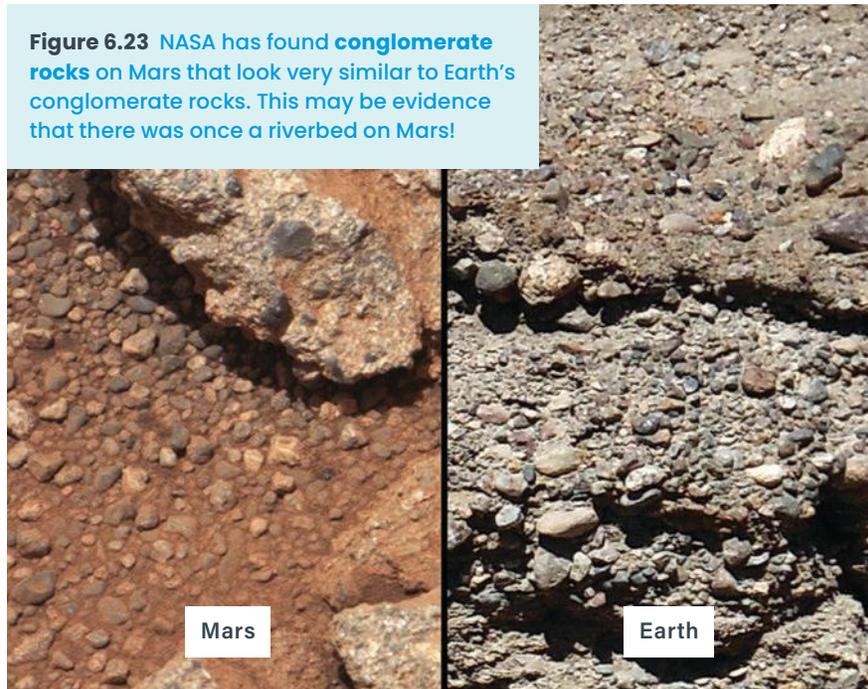
If you are looking at a cliff face and observe different types of sedimentary rock, you can work out its geological history. This is because different rocks are deposited in different environments. Fossils in the rocks can also be used to provide more information, and can be used to work out how old the rocks are. The presence of igneous rocks might mean that a volcanic eruption occurred.

### *What can the presence of different rock types tell us?*

**Table 6.2 Sedimentary rock types and environments of formation**

Rock type	Sediment size	Environment when formed
Limestone	Very small Often fossils of reef organisms	Warm shallow seas
Siltstone and mudstone	Extremely small	Deep, calm water off the continental shelf
Sandstone	Small	Beaches and just offshore from land Deserts
Conglomerate	Large	Rivers

**Figure 6.23** NASA has found **conglomerate rocks** on Mars that look very similar to Earth's conglomerate rocks. This may be evidence that there was once a riverbed on Mars!



1 cm

1 cm

### CHECKPOINT 6.9

- Copy and complete.  
Generally, the youngest layers of rocks are found on the \_\_\_\_\_ and the oldest rock layers are found on the \_\_\_\_\_.
- You observe a rock that contains limestone with fossils of coral. What must the environment have been like when that limestone formed?
- You observe a cliff face that has a layer of limestone at the bottom and a layer of mudstone on top. Has the sea level risen or fallen during the period that the rocks were deposited?
- You observe a cliff face that has a layer of limestone at the bottom and a layer of sandstone on top. Has the sea level risen or fallen during the period that the rocks were deposited?
- You observe a layer of conglomerate in a cliff face. What can you tell about the environment at the time that this layer was deposited?

### CONNECTING IDEAS

- Geologists can use several different techniques to date rocks. Brainstorm other methods scientists have used to determine the age of Earth.

### SUCCESS CRITERIA

- I can explain how different layers of sediment can show geological history.
- I can identify in a sequence of sedimentary rocks where the youngest and oldest rocks can be found.

# VISUAL SUMMARY

## What mineral is that?



Check the hardness of a mineral and score it using Moh's scale.



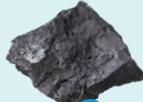
Check a mineral's lustre – is it dull or shiny?



Scratch the mineral to check the colour of the streak.



Check the structure of its crystals.

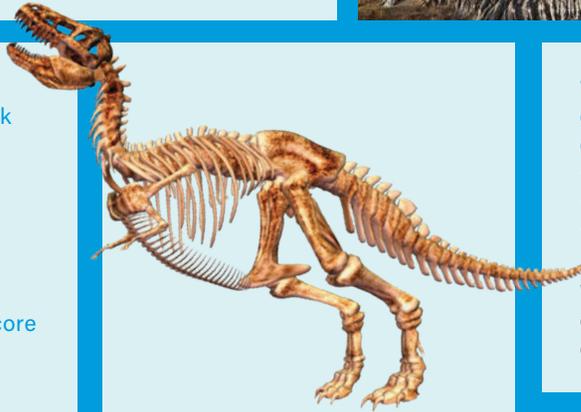
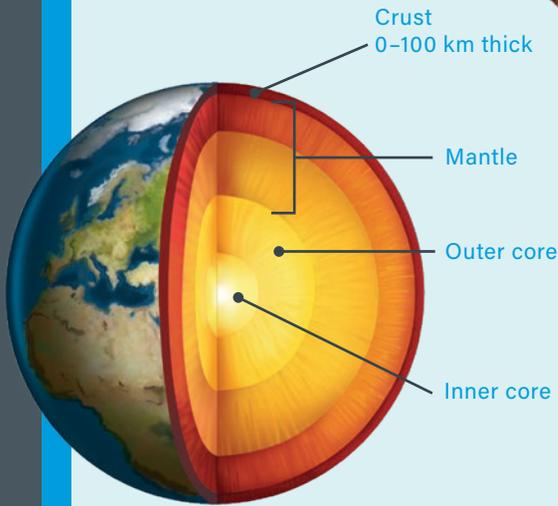


Check the colour, but this is not very reliable.

**Physical weathering** ▶  
Rock breaks down but does not change its chemical make-up.



◀ **Chemical weathering**  
Rock breaks down through chemical reactions that change the minerals in the rocks.



**Fossils**  
form when a dead organism is quickly covered by sediment. Many layers are added, then they compact and cement into sedimentary rock.

The layers of sedimentary rock give us clues to the history of the area.

- Did it used to be underwater?
- Did ancient animals live here?
- Was it part of a vast mountain range?

We can study the type and size of the rocks to answer many of these questions.

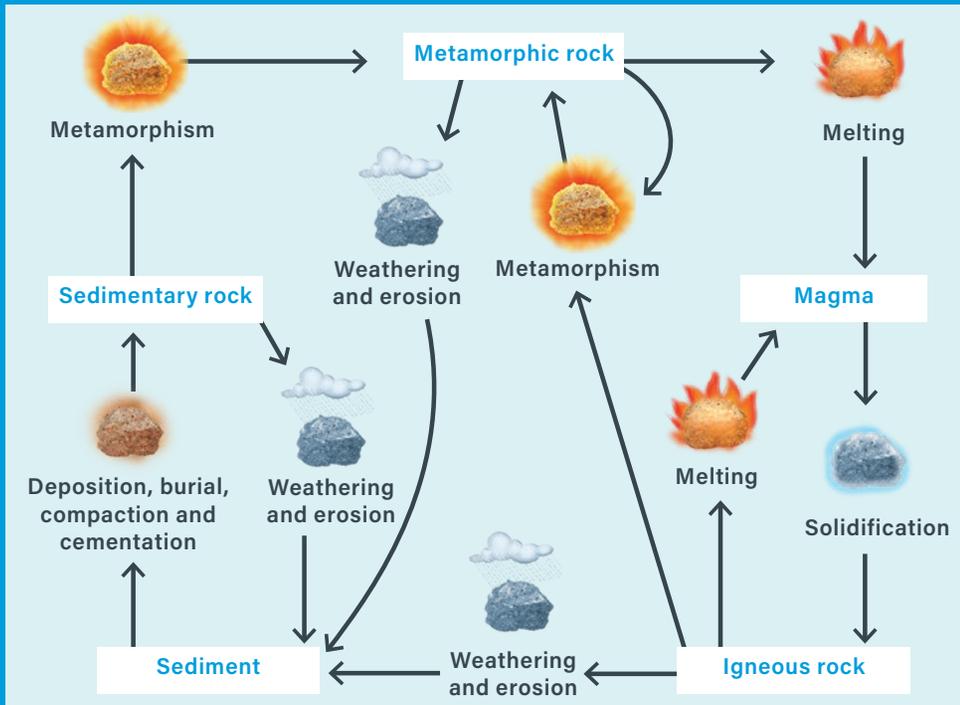
**Igneous rocks** form when molten rocks cool and solidify.



**Sedimentary rocks** form when sediment such as clay, sand and shells are buried and eventually compact, joining together.



**Metamorphic rocks** form from other rocks that have been changed by heat and/or pressure.



## ★ FINAL CHALLENGE ★

- 1 Describe each of Earth's three main layers.
- 2 Which type of rock forms when molten rock cools and solidifies?
- 3 Identify the three types of rocks.

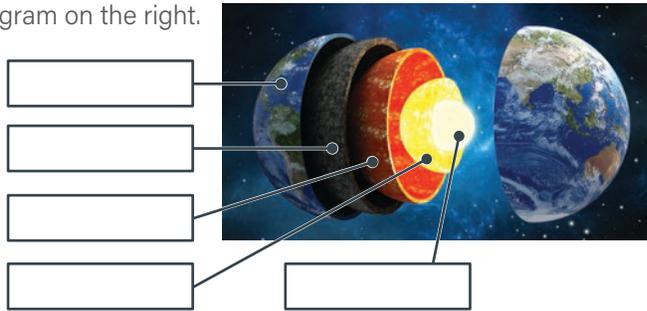
**Level 1**



50xp



- 4 Label each part of the diagram on the right.
- 5 Describe the rock cycle in your own words.
- 6 Explain why fossils are so rare.



**Level 2**



100xp



- 7 Explain how you would classify an unknown rock based on observable properties.
- 8 If you were asked to grow a very large crystal, how would you go about doing this? Give evidence to support your answer.
- 9 Streak is a better way to identify minerals than colour. Suggest why.
- 10 Explain how the sedimentary layers within a cliff face can be used to learn about geological history.

**Level 3**



150xp



- 11 You are presented with two samples of different white minerals. Outline what you would do to tell the difference between the two.
- 12 Explain how sedimentary, metamorphic and igneous rocks are related using an annotated flow chart.
- 13 Metamorphism can be likened to baking a cake. Suggest why.

**Level 4**



200xp



- 14 Using your understanding of the processes of deposition, compaction and cementation, explain the steps required for a skeleton to become a fossil.
- 15 Create a Venn diagram to identify the similarities and differences between the three rock types – igneous, sedimentary and metamorphic.

**Level 5**



300xp





# ENERGY

Why is the behaviour of energy so important to life on Earth?

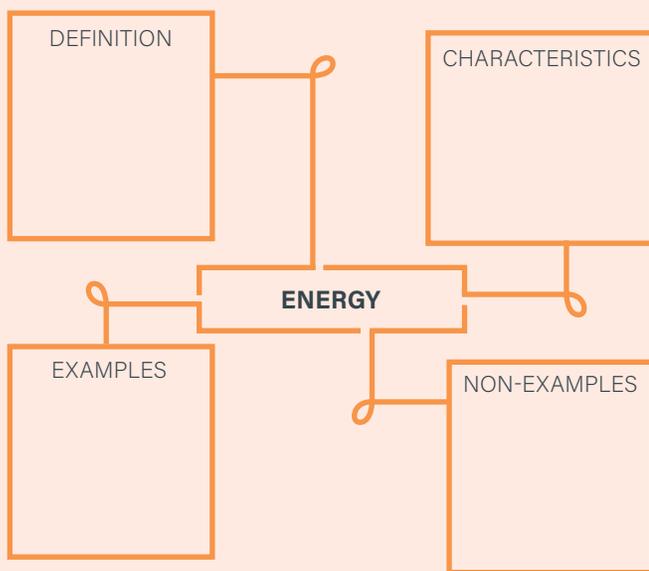


In physics, energy is the ability to do work, but what does this actually mean? Work might be moving something against a force, such as gravity. When you do something against gravity, even just stand up, you use energy.

Energy is closely related to mass. More mass equals more energy. Energy never disappears or runs out, it just moves or changes into a different kind of energy, over and over again, forever!

## 1 FRAYER MODEL

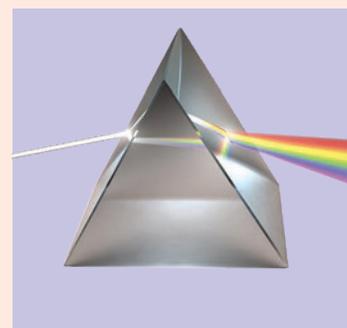
Copy and complete the below chart in your workbook.

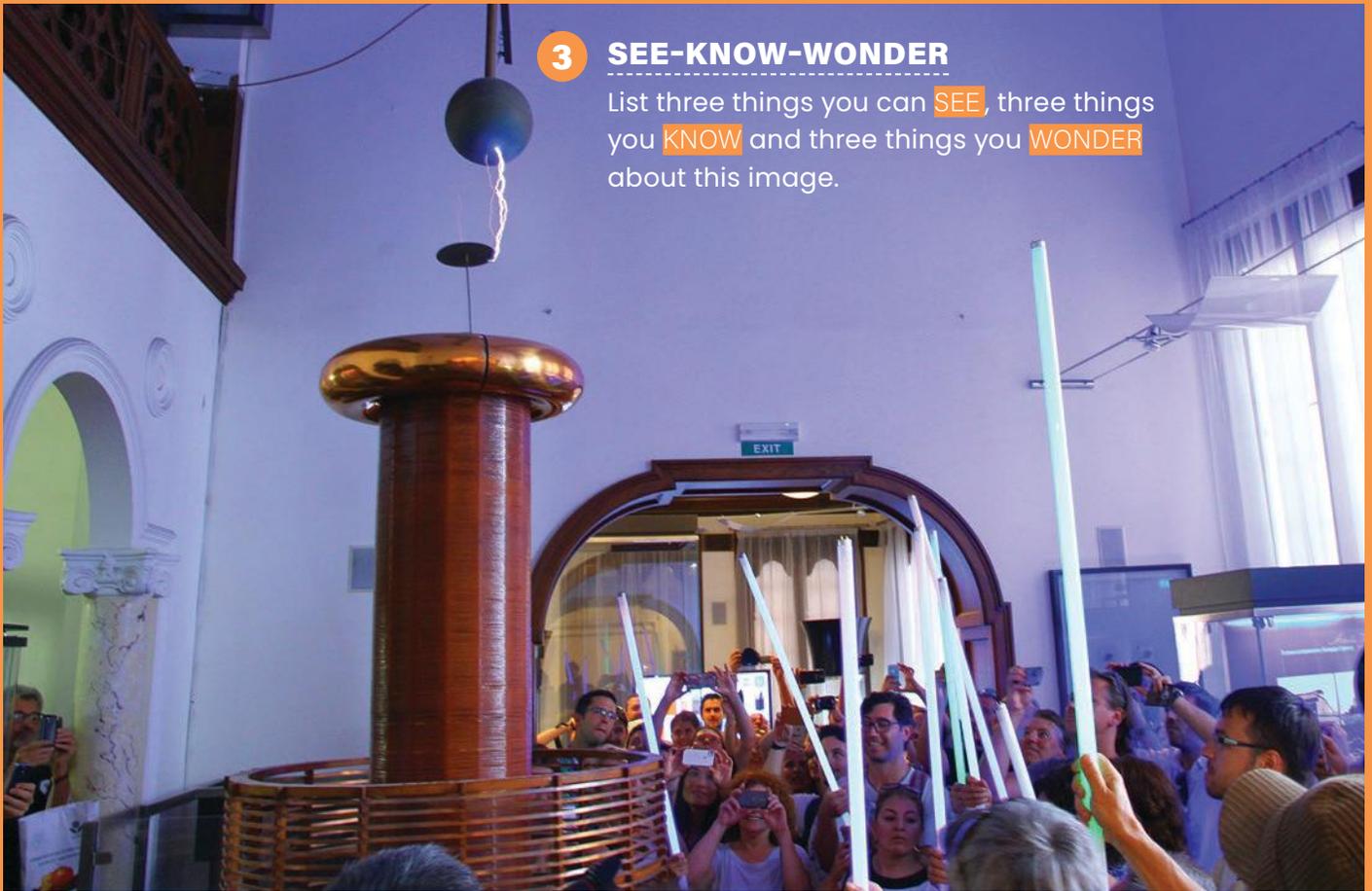


Complete two additional charts for the key terms *Light* and *Sound*.

## 2 LEARNING LINKS

Brainstorm everything you already know about energy.





### 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



**ALPHABET:** Compile a list of words from A to Z that are about energy.



**COMMONALITY:** List the things that a circuit and a rollercoaster have in common.

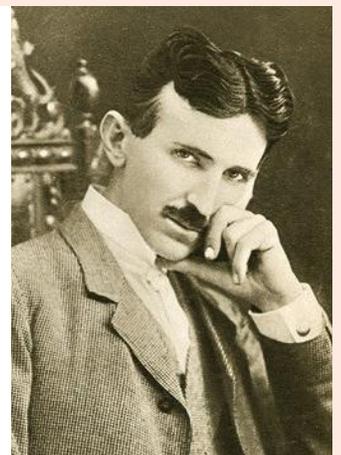


**VARIATIONS:** How many ways can you think of to make light?

### 5 THE MOST INVENTIVE!

Nikola Tesla was a very famous and fascinating scientist. Tesla invented the remote control, and worked on alternating current (which provides the electricity in your house) and the modern car motor. Tesla also had plans to provide free wireless electricity to the world – something that's still not possible today.

Tesla was a fierce rival of American inventor Thomas Edison. The two men even created rival electricity modes. Tesla was an incredible scientist but he lacked social skills, so many of his inventions were misunderstood or thought to be hoaxes.



# 7.1

## KINETIC AND POTENTIAL ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to recognise that energy appears in different forms, including movement (kinetic energy) and potential energy.

### KEY TERMS

#### motion

the change in position of an object over time

#### transfer

to move from one place or object to another

#### transform

to change from one type to another

### LITERACY LINK

#### SPEAKING

Explain to a partner what kinetic energy is and how it can be increased. Then listen carefully as they explain gravitational potential energy to you.

### NUMERACY LINK

#### UNITS

The speeds in Figure 7.1 are given in kilometres per hour (km/h). Convert them to metres per second (m/s) by dividing each by 3.6.

The rollercoaster you're riding slowly starts to climb up the track. The clicking gears mark each metre you rise. By the time you reach the highest point, your heart is really pumping. There's only a moment when you're still, before you rush down the other side, in the grip of gravity. Down and back up again, over and over until finally the ride comes to a stop.

What just happened, and can you do it again?

## 1 A moving object has kinetic energy

The kinetic energy of an object such as a rollercoaster is the energy that it has because of its **motion**. The amount of energy in a moving object depends on its mass and its speed.

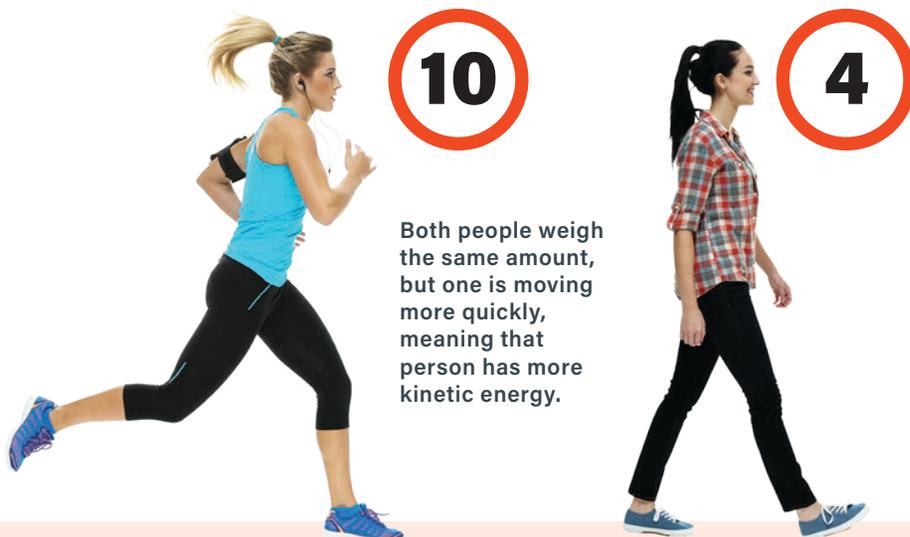
Kinetic energy can be **transferred** from one object to another and **transformed** into other kinds of energy.

*What type of energy do moving objects have?*



**Figure 7.1** The greater the mass of a moving object, the greater its kinetic energy. The greater the speed of an object, the greater its kinetic energy.

The bicycle and the truck are travelling at the same speed, but the truck is heavier, so it has more kinetic energy.



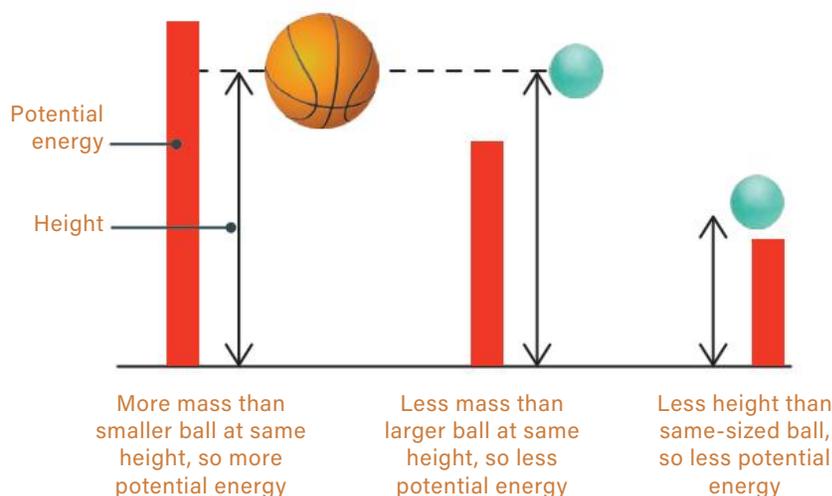
Both people weigh the same amount, but one is moving more quickly, meaning that person has more kinetic energy.

## 2 Potential energy is stored until release

Potential energy is stored energy that can be used to do work. This work might be hammering a nail, shooting an arrow or cooking dinner. The natural state of objects is to have the lowest energy. There are different ways that energy can be stored and released to do work.

Gravitational potential energy is the energy an object has because of its position or height. An object lifted high has the potential to do work. When the mass falls because of gravity, the object moves and gains speed as it falls. This is gravitational potential energy being transformed into kinetic energy.

**Figure 7.2** The greater the height of an object, the more gravitational potential energy it has. The greater the mass, the more gravitational potential energy.



Elastic potential energy can be stored up in an object, such as a spring or an elastic band. If you pull back on an elastic band, you have stored up some energy in the elastic. When you let it go, it returns to its original shape. The stored energy is transformed into kinetic energy. The stronger the elastic band or spring, the greater the elastic potential energy. Also, the more the elastic is stretched or the spring is compressed, the greater the potential energy.

Chemical potential energy is stored in the bonds between atoms in molecules. Chemical reactions break the bonds and release the energy holding them together. One very common chemical reaction is fire. Heat and light energy are released when the bonds between the atoms that make up wood are broken and rearranged.

*What are some ways that energy can be stored?*

### INVESTIGATION 7.1

#### Rolling balls

**KEY SKILL**  
Identifying the variables and formulating a hypothesis

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### CHECKPOINT 7.1

- 1 Explain the difference between kinetic and potential energy.
- 2 Identify which of these objects have kinetic energy.
  - a a cup
  - a bouncing ball
  - a stretched elastic band
- 3 When does an aeroplane have more kinetic energy – sitting on the runway, taking off or in flight?
- 4 A truck, a car and a motorcycle are all travelling at 60 km/h. Which has the most kinetic energy? Suggest why.
- 5 Explain the difference between gravitational, chemical and elastic potential energy.
- 6 A boy is launching balls of paper towards a target using an elastic band slingshot. The problem is that he can't reach the target, no matter how far he pulls the elastic band back. Use your knowledge from this lesson to offer him some advice.

### RESEARCH

- 7 Research and compare the amount of potential energy stored in stretching an elastic band (elastic potential) compared to in a litre of petrol (chemical potential).

### SUCCESS CRITERIA

- I can explain what kinetic energy is.
- I can explain what potential energy is, including naming some types of potential energy.

# 7.2

## HEAT ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to describe the transfer of heat energy by conduction, convection and radiation.

### KEY TERMS

#### conduction

the transfer of heat from one place to another in solids

#### conductor

a material that is good at transferring heat or electricity

#### convection

the transfer of heat from one place to another in gases and liquids

#### insulator

a material that is poor at transferring heat or electricity

#### matter

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

#### radiation

the transfer of heat that doesn't require contact with matter

### LITERACY LINK

#### VOCABULARY

*Insulator and conductor are antonyms (words that are opposite in meaning to each other). Find antonyms for three more words from this lesson.*

You're cooking a fantastic soup for your family when you burn your hand on a pot handle! How could it burn you when the handle wasn't in contact with the heat source? Next, you open the pot lid and suddenly your glasses are fogged with steam. This is not going well!

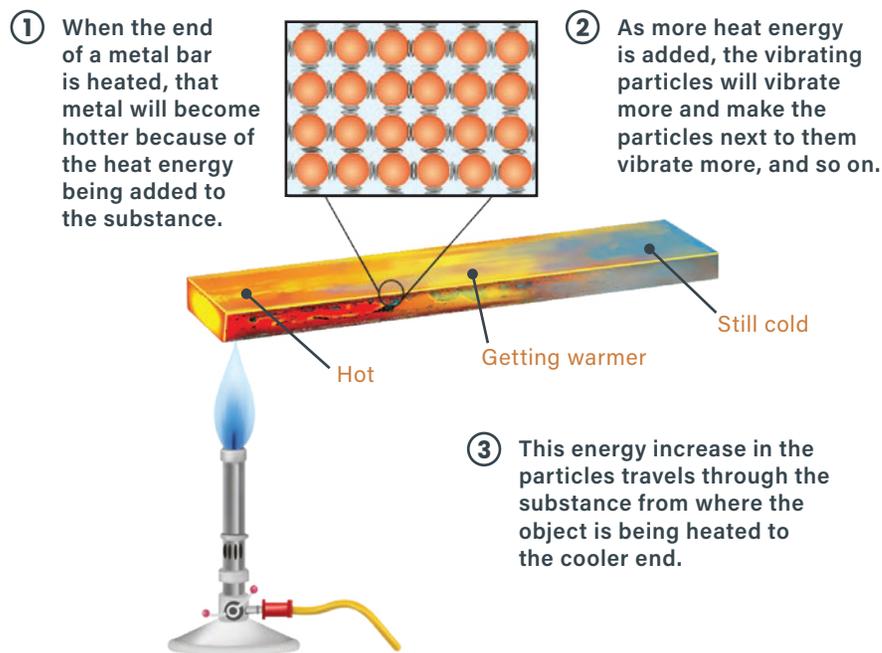
Heat can be transferred in three ways: **conduction** (through solids), **convection** (through liquids and gases) and **radiation** (through a vacuum).

## 1 Heat is conducted through solid objects

Heat is transferred through solids by conduction. In a solid, all the particles in the material are vibrating in place. The amount of energy of a substance has to do with how much its particles are vibrating.

When a solid is heated, it gains energy and the particles vibrate more. As more particles vibrate, the heat moves through the solid.

**Figure 7.3** Objects will even out in temperature to reach their lowest energy state. Hotter areas will cool and cooler areas will heat until an even temperature is reached.



Some solids transfer heat better than others. Substances that transfer heat well are called **conductors**. Metals are usually good conductors of heat energy.

Substances that don't transfer heat well are called heat **insulators**. Substances that are good heat insulators include plastics, glass, foam, rubber, gases and water.

*How does heat energy move through solids?*

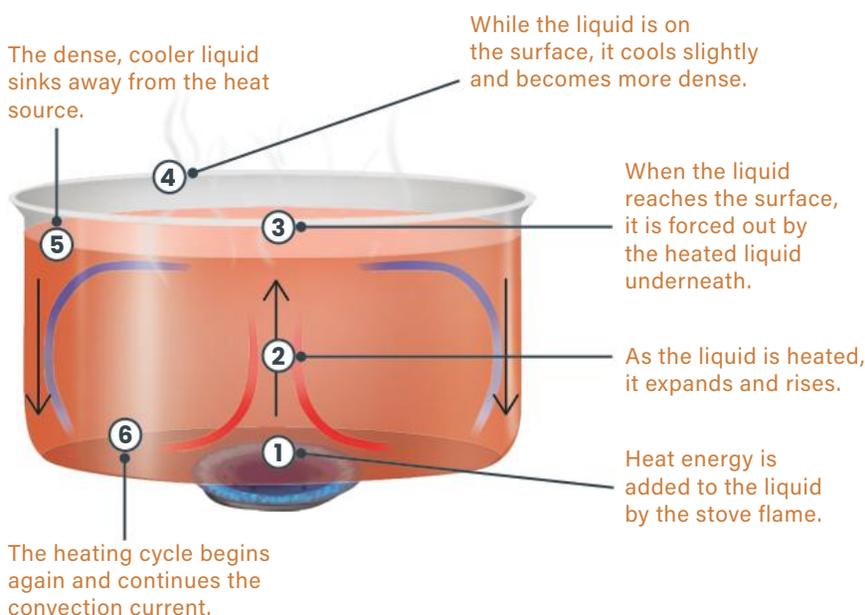
## 2 Convection currents move heat through liquids and gases

Liquids and gases don't conduct heat. The particles in liquids and gases can flow past each other and don't just vibrate in place. Heat is transferred through liquids and gases by convection.

When you add heat energy to a liquid or gas, groups of heated particles move upwards in a convection current. Colder particles move down towards the heat source, and then join the convection current as they warm up. This continuing movement of warm particles through the convection current eventually warms the entire mass of gas or liquid.

### How does heat energy move through liquids and gases?

**Figure 7.4** You can see convection currents in a pot of soup cooking on a stove.



## 3 Heat radiates through a vacuum

Heat energy can also transfer from one place to another without **matter**, by radiation. This is how the heat of the Sun travels through the vacuum of space to reach Earth.

Many different types of energy can be transferred by radiation. Heat energy, or infrared radiation, causes objects to heat up when placed near a fire or left outside on a hot day.

### What is radiation?

#### INVESTIGATION 7.2A

Conduction – heat energy transfer in a solid

##### KEY SKILL

Explaining results using scientific knowledge

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#### INVESTIGATION 7.2B

Convection – heat energy transfer in a liquid

##### KEY SKILL

Identifying and managing relevant risks

► Go to page 172

#### INVESTIGATION 7.2C

Radiation and colour

##### KEY SKILL

Identifying limitations to the method and suggesting improvements

► Go to page 173



### CHECKPOINT 7.2

- Copy and complete.
  - When hot coffee is stirred with a spoon, the spoon gets hot due to \_\_\_\_\_.
  - Warm air over the beach rises while cooler, dense air from the ocean rushes in due to \_\_\_\_\_.
  - You try to sit on a rock in the evening after a warm day, but you can't sit on it because of \_\_\_\_\_.
- Explain the difference between conduction, convection and radiation using a combination of text and diagrams.

### CRITICAL AND CREATIVE THINKING

- The cold water in your plastic bottle always warms up too quickly. How could you fix this with items readily available to you?

### SUCCESS CRITERIA

- I can describe and draw basic diagrams of convection, conduction and radiation.

# 7.3

## TRANSFERRING AND TRANSFORMING ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to investigate some energy transformations that occur in devices.

### KEY TERMS

#### system

a set of simple things that work together as a more complex whole

#### transfer

to move from one place or object to another

#### transform

to change from one type to another

### LITERACY LINK

#### WRITING

Write a step-by-step account of the energy transformations involved in ten-pin bowling.

### NUMERACY LINK

#### DATA

Doug measured the gravitational potential energy of a ball held in the air to be 5 J. He dropped the ball 3 times, and recorded the kinetic energy just before it hit the ground. His measurements were 4.7 J, 4.8 J and 4.5 J.

What could Doug conclude from this? Why?

All energy on Earth comes originally from the Sun. Nuclear reactions in atoms power our Sun, and this energy is transformed into light and heat. The Sun then radiates an enormous amount of light and heat energy into space in all directions.

Only a small amount of this energy reaches Earth, but it is then stored, released, **transferred** and **transformed** over and over again.

## 1 Energy causes change in systems in many ways

Energy transfer and transformations cause change in **systems**.

These changes are happening all the time in the world around us.

Energy transfers happen when one object passes energy to another object. An example is when you throw a ball – the kinetic energy of your hand transfers to the ball when you let it go.

Energy transformations happen when one form of energy is changed to another form of energy in the same object. This also causes change in that system. An example is when the gravitational potential energy of a ball changes into kinetic energy as it falls and gains speed.

### *What causes change in systems?*

Table 7.1 Examples of different forms of energy

Energy form	Description
Gravitational potential energy	The potential of an object to do work because of its relative position above the ground
Elastic potential energy	The energy stored in an object when it is stretched or deformed
Chemical potential energy	The energy stored in the bonds between atoms, released as heat, sound or light during chemical reactions such as burning
Nuclear potential energy	The energy stored in the nucleus of atoms. It may be released quickly as a nuclear explosion or controlled slowly in a nuclear reaction
Kinetic energy	The energy that an object has because of its movement
Heat energy	The motion of atoms and molecules in a substance or object
Light energy	A form of electromagnetic radiation emitted by hot objects. It is usually visible light
Sound energy	The vibration of particles that can be detected by the ear
Electrical energy	The energy generated by moving electrons

## 2 Devices can be used to transfer and transform energy

How did you get to school today? Maybe you were driven in a car or bus; maybe you rode a bicycle or walked. However you arrived, you used a transformation of energy to get you there. Chemical potential energy (the petrol in the car or the food you ate) was converted into kinetic energy (causing the motion of the car or your legs).

We use many devices every day to transform energy. For example, televisions transform electrical energy into light and sound energy, and kettles transform electrical energy into heat energy.

*What type of energy does a television transform?*

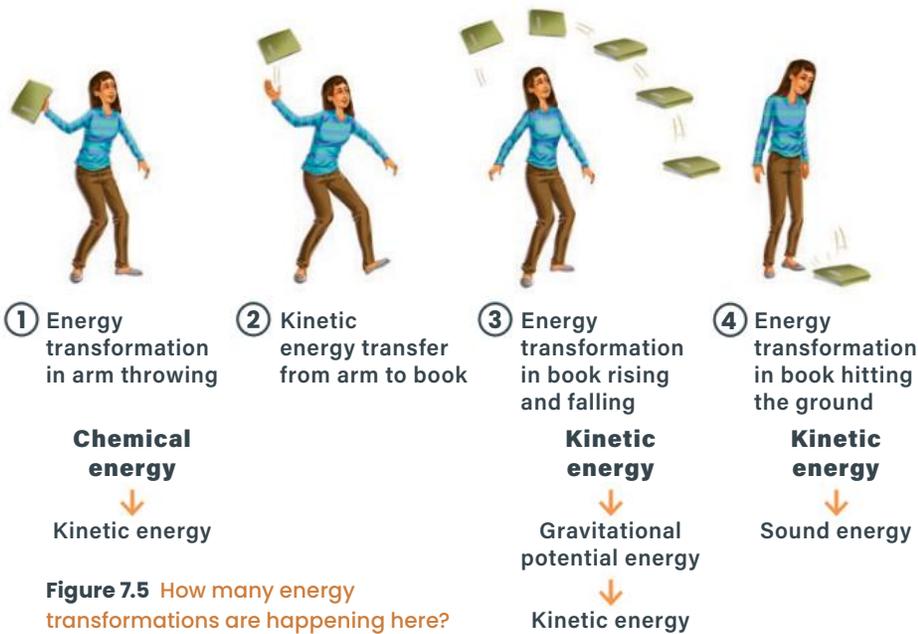
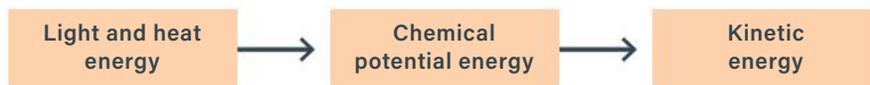


Figure 7.5 How many energy transformations are happening here?

## 3 Flowcharts can be used to represent energy transformations

An apple is able to grow because of light and heat energy from the Sun, which it transforms and stores as chemical potential energy. You eat food (such as apples) to give you energy to perform tasks (such as walking). Your body transforms the chemical potential energy in the apple into kinetic energy when you walk.

There are several energy transformations going on here, and we can display them using a flow chart. Flow charts make it clear to see where the energy has come from, what it is doing, and where it has ended up.



*Why is a flow chart useful to show energy transformations?*

### CHECKPOINT 7.3

- Identify the following as either a transfer or transformation of energy.
  - kicking a ball
  - lighting a candle
  - hitting a drum
  - a light bulb turning on
- Identify what situation could result in the following transformations of energy.
  - chemical potential energy → heat and light energy
  - electrical energy → sound energy
  - chemical potential energy → heat and kinetic energy
  - gravitational potential energy → kinetic and sound energy
  - electrical energy → heat and light energy
- Consider these two columns of words. What could the titles of each column be? Explain your reasoning in sentences.

Title 1	Title 2
Coal	Movement
Natural gas	Heat
Wood	Nuclear
Food	Light
Wind	Electrical
Uranium	Chemical

### RESEARCH

- Historically, most cars have burned petrol as their source of energy. However, scientists are working to design cars that are powered by alternative energy sources. Research three cars that use different types of energy (including electric and solar) and find out how they work.

### SUCCESS CRITERIA

- I can describe the difference between the transfer and transformation of energy.
- I can give at least one example of an everyday energy transformation.

# 7.4

## WAVES TRANSFER ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to use the wave model to describe the measured properties of sound, wavelength and frequency.

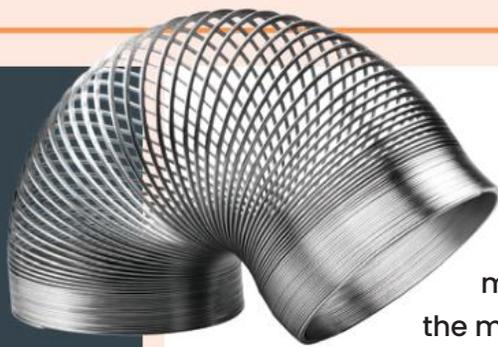


Figure 7.6 Slinkies are a fun way to observe waves.

A wave is a disturbance that travels through a substance. Waves are energy moving from one place to another without the movement of matter. Sound, light, surf and earthquakes are all examples of waves. If you have ever played with a slinky, you have probably observed waves and noticed how you can change their size and frequency. You can make waves in a slinky that go up and down like ocean waves, or back and forth like sound waves.

### 1 Waves are energy carriers

Waves are moving energy. Some waves, called mechanical waves, require matter to move through. Energy is transferred from one place to another when a wave moves through a substance. Sound is a mechanical wave because it requires particles (such as air particles) for the sound to move through. Sound cannot travel through space because it is a **vacuum**, an area free of matter, and there is no medium for it to pass through. However, electromagnetic waves, such as light, can travel through a vacuum. This is how the heat and light from the Sun pass through empty space to reach Earth.

A wave has three properties: amplitude, frequency and wavelength.

- **Amplitude** is the distance from the peak (top) or trough (bottom) of a wave to the middle of its position. A wave with a high amplitude carries more energy than a wave with a low amplitude. In a sound wave, a high amplitude results in a louder sound.
- **Frequency** is the number of waves that pass a point every second. Frequency is measured in hertz (Hz). High-frequency waves carry more energy than low-frequency waves. In a sound wave, a higher frequency causes a higher pitch.

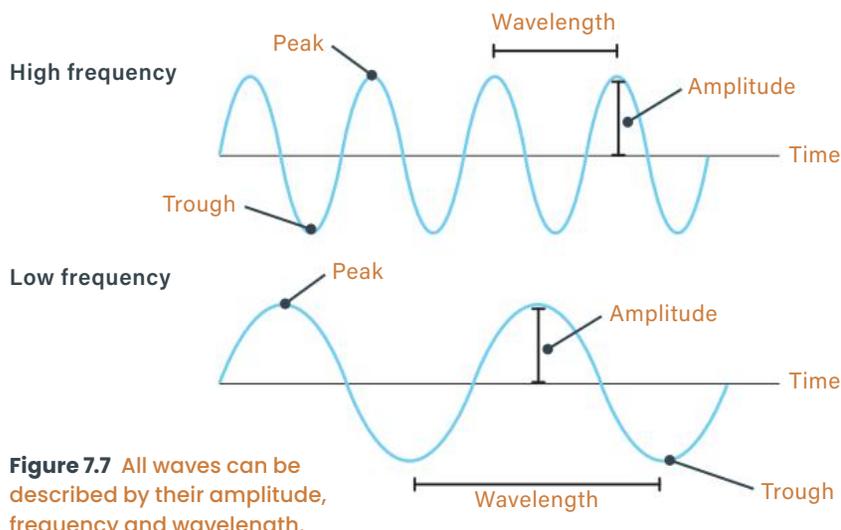


Figure 7.7 All waves can be described by their amplitude, frequency and wavelength.

### KEY TERMS

#### amplitude

the height of a wave measured from its midpoint

#### frequency

the number of waves passing a point every second

#### longitudinal

running lengthwise rather than across

#### transverse

running across rather than lengthwise

#### vacuum

empty space

#### wavelength

the distance from the peak of one wave to the next

### NUMERACY LINK

#### CALCULATION

Speed of a wave (m/s) = wavelength (m) × frequency (Hz)

The speed of sound is 340 m/s. If the frequency of a guitar string is 490 Hz, calculate the wavelength.

- **Wavelength** is the distance from the peak of one wave to the next. Wavelength is measured in metres (m), centimetres (cm) or similar units. A wave with a shorter wavelength carries more energy than a wave with a longer wavelength.

### What are three properties of waves?

## 2 Longitudinal waves vibrate in the same direction that they move

A **longitudinal** wave is a mechanical wave in which the particles of the medium vibrate in the same direction as the wave. Sound waves, tsunamis and earthquakes are longitudinal waves.

A longitudinal wave is made up of different regions called compressions and rarefactions. A compression is where the particles are bunched up. A rarefaction is where the particles are stretched apart. The wavelength is the distance from one compression to the next.

When sound waves travel through a medium, they make the particles of the material vibrate in the direction of the wave. The denser the material, the faster the sound travels. This is why sound travels better through water than it does through air.

### What is a longitudinal wave?

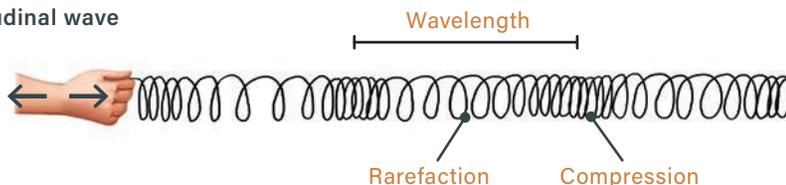
## 3 Transverse waves vibrate at right angles to their movement

**Transverse** waves vibrate at right angles to their direction of motion. In other words, they vibrate 'up and down' rather than 'back and forth'. You can produce transverse waves in a rope by moving the ends of the rope up and down.

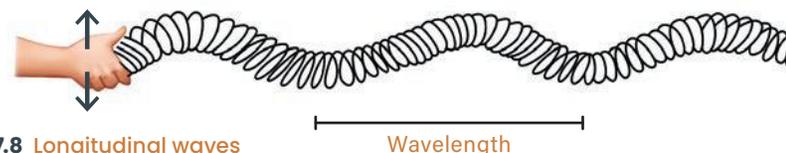
The strings in musical instruments, ocean waves and light are all types of transverse waves. Transverse waves may or may not require a medium to move through.

### What is a transverse wave?

Longitudinal wave



Transverse wave



**Figure 7.8** Longitudinal waves and transverse waves vibrate in different directions.

### INVESTIGATION 7.4

#### Waves in a slinky

KEY SKILL  
Writing a research question

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### CHECKPOINT 7.4

- 1 Draw and label a:
  - a longitudinal wave
  - transverse wave.
- 2 Explain the following terms.
  - wavelength
  - frequency
  - amplitude
- 3 Describe how amplitude, frequency or wavelength can affect how much energy is transferred by a wave.
- 4 Describe the different regions of a longitudinal wave.
- 5 Give some examples of longitudinal and transverse waves.
- 6 A 'Mexican wave' at a sporting event is an example of a transverse wave. Explain why.
- 7 If you heard a very loud sound that has a very low pitch, what would this tell you about the amplitude and frequency of the sound wave?

### INQUIRY

- 8 Using knowledge from this lesson, suggest why earthquakes are hard to detect before they occur.

### SUCCESS CRITERIA

- I can identify at least two situations where waves transfer energy.
- I can use the wave model to discuss key features of waves.

# 7.5

## SOUND ENERGY

### LEARNING INTENTION

At the end of this lesson I will be able to explain the effect of changing amplitude and frequency of a sound wave and describe how sound travels through different mediums.

### KEY TERM

**sonar**  
sound navigation and ranging

### LITERACY LINK

#### WRITING

Write a brief guide on how a musical instrument of your choice creates sound, and how the sound's pitch and volume can be adjusted. Use correct scientific terminology.

### NUMERACY LINK

#### GRAPHING

Use the data in Table 7.2 to construct a column graph comparing the speed of sound in air, lead, gold and glass.

Sound energy is transmitted through materials as longitudinal waves. The particles of the material vibrate as the sound travels through it. The more compact the material, the faster the sound travels. Sound cannot travel at all in a vacuum.

**Table 7.2** The speed of sound in different materials

Material	Speed of sound (m/s)
Rubber	60
Air (20°C)	343
Air (40°C)	355
Lead	1210
Gold	3240
Glass	4540

**Figure 7.9** Every sound wave has an amplitude, frequency and wavelength.



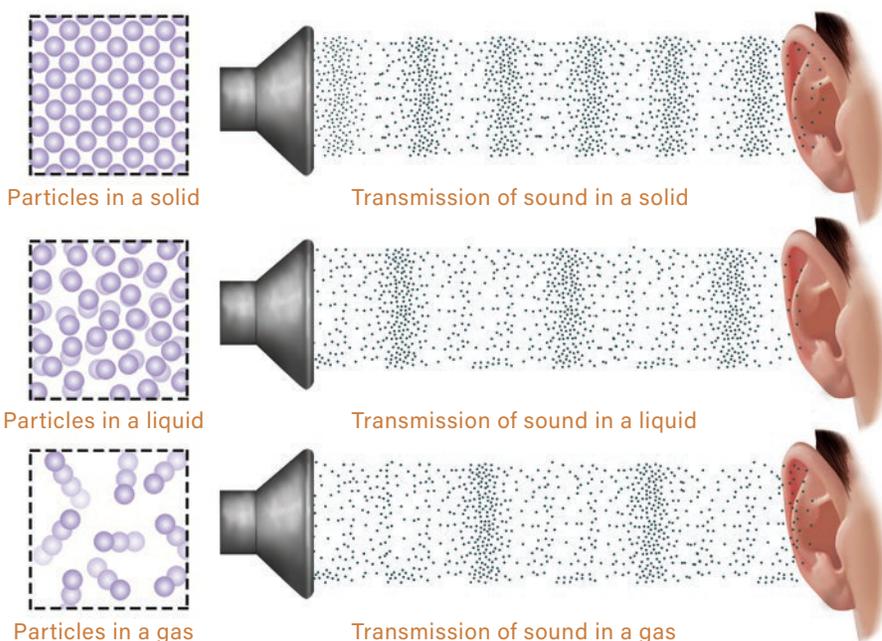
## 1 Sound travels quickly through many solids

Sound wave transmission relies on particles vibrating in different materials. Sounds travel very quickly through most solids.

If you put your ear on a metal rail, you could hear the sound of someone tapping on it before you could hear it through the air. This is because solid particles are bunched up, and sound wave vibrations are carried very quickly along the solid particles.

Sound travels faster through denser solids, such as metals, than through less dense solids, such as rubber.

### How do sounds travel through solids?



**Figure 7.10**  
Sound travels fastest through solids and slowest through gases because of how densely the particles are packed.

## 2 Sound also travels through liquids and gases

Sounds travel through liquids, such as water. Particles in liquids are more spread out than particles in a solid, so sound waves move more slowly through liquids. Dolphins use sound waves in water to navigate, and submarines use their **sonar** systems in a similar way.

Gas particles are very spread out, so sound waves travel the slowest through gases, such as air. It takes longer for vibrations to be passed from particle to particle. Heat can increase the vibrations of particles so sound travels faster through hot air than through cold air.

*How do sounds travel through liquids and gases?*

## 3 Musical instruments create specific sounds

Sound always requires vibration. When you clap your hands, your hands vibrate causing the air particles around them to vibrate, and these vibrations move through the air to your ears.

The differences in sounds we hear can be explained by the wave model.

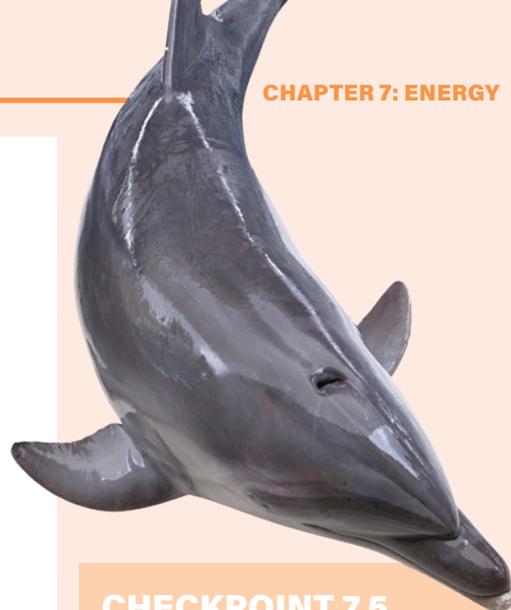
- Amplitude: the greater the amplitude of a sound, the louder it is.
- Frequency: the greater the frequency of a sound, the higher pitched it is.

Musical instruments can be used to generate sounds of a particular frequency and amplitude, through the use of vibration. When a guitar string is plucked, the string vibrates, which creates the sound. The volume can be altered by how hard the string is plucked (amplitude), and different notes can be generated depending on where the string is held down (frequency). Almost all musical instruments create sound in this way, whether they have strings or not. Vibrations are caused by playing the instrument, different notes are produced by altering the frequency and different volumes are produced by adjusting the amplitude of the waves.

*What happens to a sound if the amplitude is increased?*

**Figure 7.11**

A guitarist alters the frequency of the sounds by pressing down with their fingers on the neck of the guitar.



### CHECKPOINT 7.5

- 1 Explain why sound requires a medium to pass through.
- 2 Explain why sounds travel faster through solids than through liquids and gases.
- 3 Suggest why sounds travel the slowest in gases.
- 4 Describe the effect of changing the amplitude and frequency of a sound wave.
- 5 How are air particles made to vibrate using:
  - a a drum?
  - a trumpet?
- 6 A guitarist plays a particular note on a guitar. The guitarist then decreases the amplitude and increases the frequency. What effect will this have on the sound?

### STUDENT VOICE AND AGENCY

- 7 Design an experiment that aims to determine which of your classmates has the best hearing.

### SUCCESS CRITERIA

- I can describe how sounds travel in different mediums by using the particle model.
- I can explain why sound travels at different speeds in different mediums.
- I can explain the effect of changing the frequency and amplitude of a sound wave.

# 7.6

## THE ELECTRO-MAGNETIC SPECTRUM

### LEARNING INTENTION

At the end of this lesson I will be able to describe the different types of radiation in the larger spectrum of radiation, including the spread and order of colours in the visible spectrum.

### KEY TERMS

#### electromagnetic spectrum

all the different electromagnetic waves

#### gamma ray

radiation emitted by radioactive materials

#### infrared light

an electromagnetic wave with longer wavelength than red light

#### reflect

to send back sound or light without absorbing it

#### X-ray

a high-energy ray that can penetrate materials

### NUMERACY LINK

#### UNITS

The wavelengths on the electromagnetic spectrum are measured in nanometres, where there are 1 billion nanometres in 1 metre. How many nanometres are there in 1 millimetre?

Have you ever wondered about the invisible waves around us? We use microwaves not just to heat up food, but also for mobile phone communication and satellite technology. We turn on our TVs using remote controls that use infrared rays. We apply sunscreen to protect us from UV rays that can burn us. Watching TV or listening to the radio uses radio waves. If you break your arm, you will get an X-ray. If you have a CT scan, you will be exposed to gamma rays, which help doctors to diagnose your medical conditions. You can see everything around you because of visible light rays **reflecting** from objects and reaching your eyes.

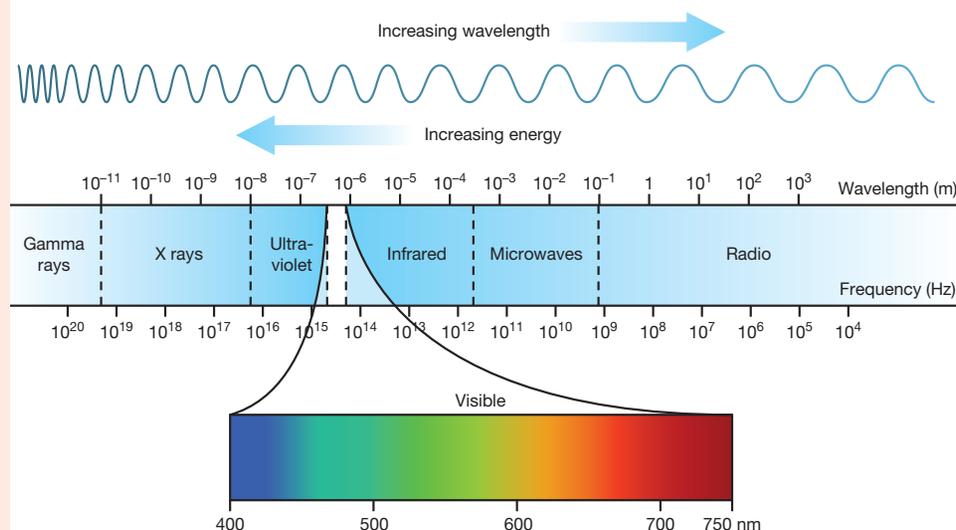
## 1 Electromagnetic radiation travels in waves

Electromagnetic waves originate from the Sun and other stars, and travel through the vacuum of space in different forms. The range of all the different types of electromagnetic radiation is called the **electromagnetic spectrum**. Electromagnetic waves are transverse waves made up of moving magnetic fields and electric fields travelling together. All electromagnetic waves are similar to each other. They all travel at 300 000 km/s – the speed of light.

Electromagnetic waves differ in wavelength and frequency. As wavelength increases, frequency decreases and the energy decreases. As wavelength decreases, frequency increases and the energy increases. In order of increasing energy, electromagnetic waves include radio waves, microwaves, infrared waves, visible light waves, ultraviolet (UV) waves, X-rays and gamma rays.

### What is the electromagnetic spectrum?

**Figure 7.12** The electromagnetic spectrum. Frequency is measured in hertz (Hz), which equals one cycle per second.



## 2 Gamma rays, X-rays and UV waves are high-energy rays

**Gamma rays** can penetrate materials such as lead and concrete. They are dangerous, because they can damage the cells in your body. Gamma rays are used in industry for detecting cracks in metal structures and underground pipes. They are also used for sterilising medical equipment, radiation therapy for the treatment of cancer, and CT scans.

**X-rays** are high-frequency rays that are produced when high-energy electrons hit a metal surface. You cannot see X-rays directly, but they affect photographic film. Denser materials absorb more X-rays than less dense materials do. X-rays are used to produce images of bones. Soft tissue, such as skin and organs, cannot absorb the high-energy rays, and the beam passes through them. X-rays are also used to kill cancer cells, and in the transport industry to check baggage.

Ultraviolet means 'beyond violet'. This is the part of the electromagnetic spectrum that has shorter wavelengths and higher frequencies than violet rays. You cannot see UV light, but insects such as bees can. UV light is used often in forensic science, to detect blood or other substances, as well as checking signatures for forgeries.

### What is ultraviolet light?

## 3 Visible light, infrared light, radio waves and microwaves are low-energy rays

Light is sometimes called visible light because it is the only part of the spectrum that we can see. Our eyes contain special cells that detect only this type of electromagnetic radiation. As seen in Figure 7.12, the colour of light we see depends on its wavelength.

**Infrared light** has a lower frequency and longer wavelength than red light. People give off infrared light in the form of heat. Infrared light is used in electrical heaters, short-range communications (i.e. remote controls), and thermal imaging cameras, which can detect people in the dark.

Microwaves have shorter wavelengths than radio waves, and are given off by mobile phones. Microwaves are used in telecommunications; for example, with satellite telephone towers. Shorter microwaves are used in cooking food.

Radio waves are used for broadcasting television and radio, and in communications and satellite transmissions. The radio waves are produced by vibrating electrons, which cause antennas to vibrate. This is then converted into images on the TV, or sound on the radio.

### How are radio waves produced?



**Figure 7.13** Bees can see UV light, which means they can see patterns on flowers that humans can't.

### CHECKPOINT 7.6

- 1 Explain what is meant by electromagnetic radiation and the electromagnetic spectrum.
- 2 Identify one source of electromagnetic waves.
- 3 Define *electromagnetic waves*.
- 4 What is the relationship between wavelength and frequency?
- 5 Identify a high-energy wave and a low-energy wave in the electromagnetic spectrum
- 6 Describe one property and one use for:
  - a gamma rays
  - b X-rays
  - c UV light
  - d infrared light
  - e visible light
  - f microwaves
  - g radio waves.

### RESEARCH

- 7 Research one medical technique that uses electromagnetic radiation for either treatment or diagnostic purposes.

### SUCCESS CRITERIA

- I can identify the different waves of the electromagnetic spectrum, including their wavelengths and properties.
- I can relate the properties of different waves of the electromagnetic spectrum to their everyday uses.

# 7.7

## ABSORPTION, REFLECTION AND REFRACTION

### LEARNING INTENTION

At the end of this lesson I will be able to describe the occurrence and some applications of absorption, reflection and refraction in everyday situations.

### KEY TERMS

#### angle of incidence

the angle at which light hits a surface

#### angle of reflection

the angle at which light reflects from a surface

#### opaque

doesn't allow any light to pass through

#### refract

to bend (light)

#### translucent

allows some light to pass through

#### transparent

allows light to pass through

### LITERACY LINK

#### READING

Using your own words, write a list of dot points to summarise the properties of light described in this lesson.

Light waves travel very fast, and can pass through transparent objects such as glass, but will usually refract (or bend) as they do. They can also bounce off mirrors or scatter when they strike rough materials. Why does light behave in such a manner? Why does it bounce or bend, and where does the light energy go? What is light energy transformed into when it hits rough surfaces?

Figure 7.14 Light can be reflected.



## 1 Light is an electromagnetic wave

Light is an electromagnetic wave made up of alternating magnetic and electric fields. Light travels extremely fast, at 300 000 km/s. Light can also be reflected, absorbed or refracted when it strikes a surface.

**Transparent** materials (such as cling wrap) allow light to pass through, and you can see a clear image through them. **Translucent** materials (such as wax paper) allow only some light to pass through, so you see a blurred image. **Opaque** materials (such as aluminium foil and cardboard) either reflect or absorb light, but do not allow any light to pass through.

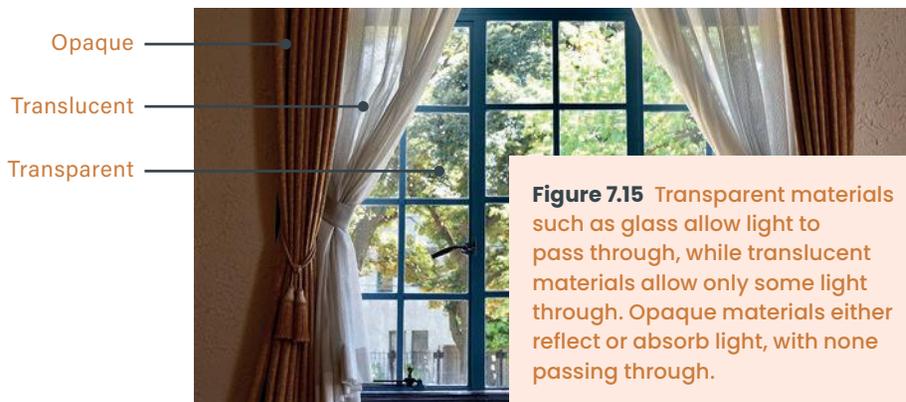


Figure 7.15 Transparent materials such as glass allow light to pass through, while translucent materials allow only some light through. Opaque materials either reflect or absorb light, with none passing through.

*What happens to light when it strikes a surface?*

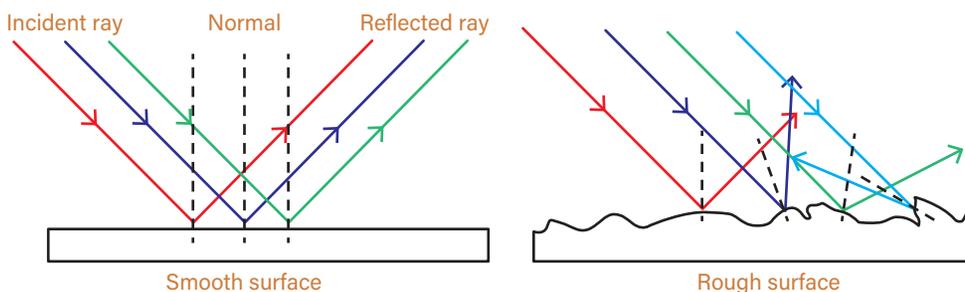
## 2 Light can be reflected and absorbed

When light hits a smooth shiny surface such as water or a mirror, it reflects off at the same angle (**angle of reflection**) as the angle at which it strikes the surface (**angle of incidence**). This is known as the law of reflection. Complete reflection results in a clear image.

Opaque materials that have very rough surfaces, such as brick and concrete, do not reflect light in a regular way. The light striking these surfaces still obeys the law of reflection, but because the surface is so irregular the light scatters in all directions. Also, some of the light is absorbed by the material and converted into heat.

### When is light reflected?

**Figure 7.16** When light hits a smooth surface such as water, it is reflected back at the same angle. When light is refracted, it bends towards the normal (perpendicular) line.

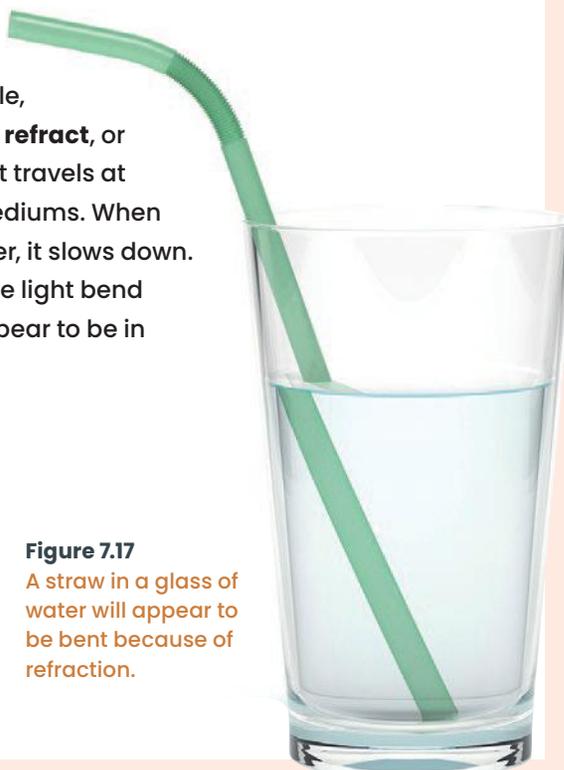


## 3 Light bends when it travels through different mediums

When light passes from one medium to another (for example, from air to water), it will usually **refract**, or bend. This occurs because light travels at different speeds in different mediums. When the light moves from air to water, it slows down. This change in speed makes the light bend inwards, causing objects to appear to be in a different position.

### Why does light refract?

**Figure 7.17**  
A straw in a glass of water will appear to be bent because of refraction.



### INVESTIGATION 7.7A

The law of reflection

KEY SKILL  
Writing a research question

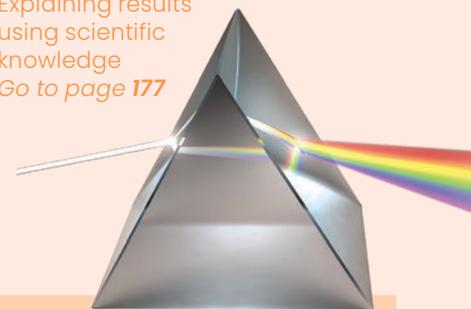
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### INVESTIGATION 7.7B

Refraction

KEY SKILL  
Explaining results using scientific knowledge

► Go to page 177



## CHECKPOINT 7.7

- 1 Explain the difference between reflection, refraction and absorption.
- 2 Identify three things that can happen when light hits different materials.
- 3 What happens to light when it hits a:
  - a smooth surface?
  - b rough surface?
- 4 Identify everyday examples of light reflecting and light absorbing.
- 5 Why does light refract? Give an example of this.
- 6 Name a surface that can reflect, refract and absorb light. Explain your answer.

## CONNECTING IDEAS

- 7 Working with a partner, brainstorm everyday situations where you have observed reflection and refraction.

## SUCCESS CRITERIA

- I can describe reflection, refraction and absorption.
- I can identify everyday examples of reflection, refraction and absorption.

# 7.8

## LENSES

### LEARNING INTENTION

At the end of this lesson I will be able to describe some applications of lenses, including vision correction.

### KEY TERMS

**concave**  
curving inwards

**convex**  
curving outwards

**lens**  
a specially shaped piece of glass used to enlarge or shrink images

**retina**  
the part of the eye that images are focused onto

### LITERACY LINK

#### SPEAKING

With a partner, role play a young child visiting an optometrist (eye doctor). The person playing the optometrist should explain to the child why they need glasses in an age-appropriate way.

### NUMERACY LINK

#### CALCULATION

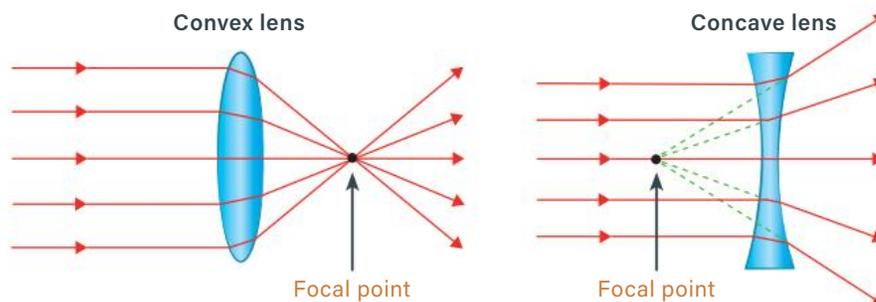
A lens system in a telescope makes things appear 200 times larger than they are. If the moon appears to be 2 cm wide with the naked eye, how large will it appear to be in telescope?

Human beings have been using lenses in various ways for thousands of years. Ancient societies used polished crystals or glassware filled with water to manipulate the light coming through. Glass lenses were first used in the Middle Ages.

## 1 Convex and concave lenses make objects look bigger and smaller

**Lenses** are very useful for bending light. **Convex** lenses (which bulge in the middle) make light rays meet at a point (converge). **Concave** lenses (which curve inwards) make light rays spread out (diverge).

If you look at an object with a concave lens it will look smaller than it is, while a convex lens is used for magnification. The amount that the lens curves determines its focal point – the point that rays meet at (convex lens) or appear to come from (concave lens).

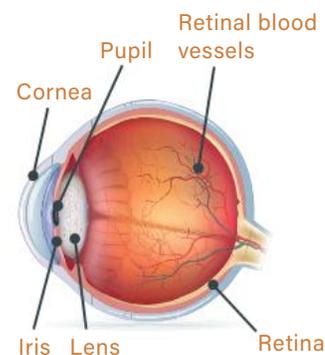


**Figure 7.18** A convex lens makes light rays converge at a single point, the focal point. A concave lens makes rays diverge.

*What is the difference between concave and convex lenses?*

## 2 The human eye

The human eye is an incredibly precise instrument for detecting light. Light passes into your eye through the cornea, which helps focus the light and produce a clearer image. The iris opens and closes to allow different amounts of light through the pupil. The light then passes through the lens, which focuses the image onto the **retina**, the innermost layer of tissue in the eye. The retina then translates the light it is seeing into signals your brain can understand, so you are able to see things. If the lens doesn't focus the light exactly on the retina, your vision will be blurry and you will probably require corrective lenses.



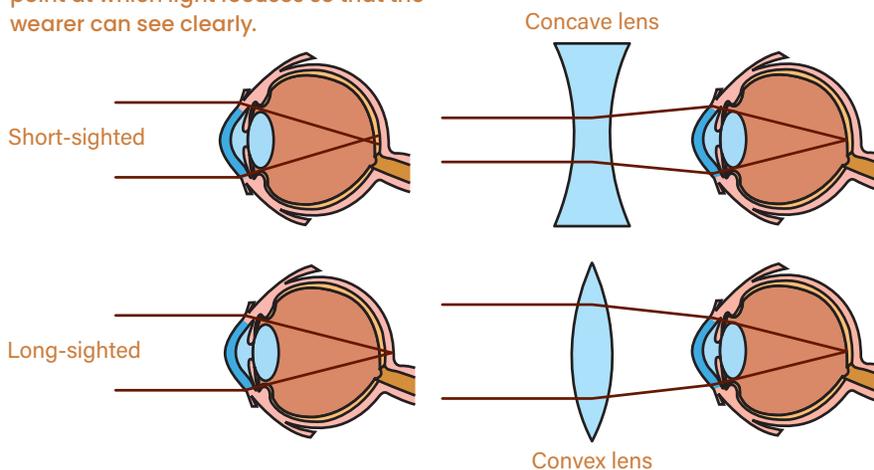
**Figure 7.19** The lens of the eye focuses light on the retina, which then translates the light into signals the brain can understand.

*Where is light focused in the eye?*

### 3 Glasses and contact lenses

To correct vision problems, humans are often prescribed glasses or contact lenses. Both of these work in the same way – they are an additional lens that sits in front of the lens in your eye, shaped so that the light going through them ends up focused perfectly on the retina. People who are short-sighted (cannot see long distances) wear glasses with concave lenses. People who are long-sighted (cannot focus on close objects) wear glasses with convex lenses.

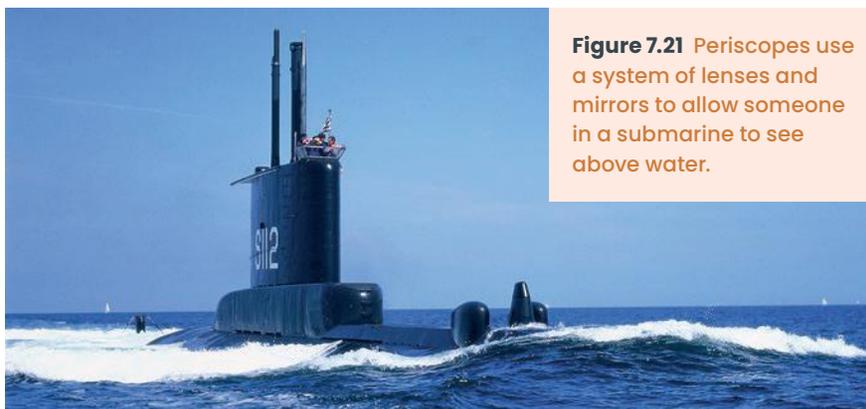
**Figure 7.20** Corrective lenses adjust the point at which light focuses so that the wearer can see clearly.



*What is the function of a corrective lens?*

### 4 Other applications of lenses

Depending on the shape of the lens, light can be focused in many different ways. A magnifying glass uses a convex lens to make objects look bigger than they really are. Telescopes and microscopes both use a series of lenses to increase the size of an image and to make it look sharp and clear. Periscopes, as used by submarines, use a system of mirrors and lenses to produce a clear image of the scene above the water.



**Figure 7.21** Periscopes use a system of lenses and mirrors to allow someone in a submarine to see above water.

*What are three instruments people use that use lenses to focus light?*

#### INVESTIGATION 7.8

Concave and convex lenses



#### KEY SKILL

Identifying the independent, dependent and controlled variables

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#### CHECKPOINT 7.8

1 Which light interaction is most important in the use of lenses – absorption, reflection or refraction? Explain your answer.

2 What is a focal point?

3 Copy and complete.

Eye part	Function
Cornea	
Iris	
Pupil	
Lens	
Retina	

4 Leslie can see distant objects well, but close objects look blurry. Will she need convex or concave lenses? Explain.

5 Draw a diagram showing how a magnifying glass can make objects appear larger.

#### CONNECTING IDEAS

6 Laser eye surgery is becoming more and more popular. This involves a doctor using a laser to change the shape of the cornea. Explain how this could work to improve the vision of a short-sighted and a long-sighted person.

#### SUCCESS CRITERIA

- I can explain the difference between a concave and a convex lens.
- I can explain why some people require corrective lenses.
- I can name some other applications of lenses.

# VISUAL SUMMARY

Energy transfers and transformations happen every day, such as when fire transforms chemical energy into heat energy.



**Energy**  
A non-moving object has potential energy that transforms into kinetic energy when it moves.



The amount of energy in a moving object depends on its mass and speed.



Particles vibrate as sound travels through matter. Sound travels faster through denser substances.

**Conduction**

the transfer of heat from one place to another in solids



**Convection**

the transfer of heat from one place to another in liquids and gases

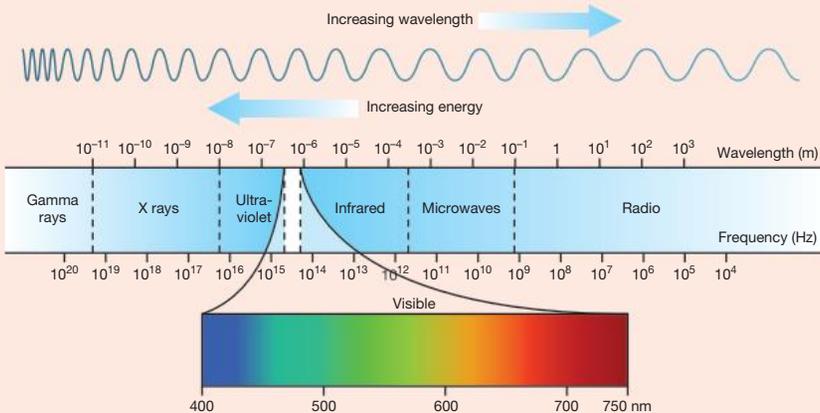


**Radiation**

the transfer of heat from one place to another that does not rely on any contact between the heat source and the heated object



The **electromagnetic spectrum** includes all the different types of electromagnetic radiation, from radio waves to gamma rays.



Light energy is the only part of the electromagnetic spectrum that we can see.

## ★ FINAL CHALLENGE ★

- 1 Petrol contains chemical potential energy. What is the main type of energy that this is converted to when used by a car?
- 2 What two types of energy does Earth receive from the Sun?
- 3 What is the difference between transferring and transforming energy?

Level 1



50xp



- 4 Give an example of an object that you have encountered today that contains:
  - a gravitational potential energy
  - b chemical potential energy
  - c elastic potential energy.
- 5 Compare and contrast longitudinal and transverse waves.

Level 2



100xp



- 6 Copy and complete the following sentence, choosing the correct words from the underlined options.  
For an object to have maximum kinetic energy, it must have a large/small mass and a high/low speed.
- 7 Using the particle model, explain the transmission of sound in different mediums.

Level 3



150xp



- 8 Draw a diagram of a pot of water being heated on a stove. Label where conduction, convection and radiation are occurring.
- 9 Provide some everyday examples of reflection, refraction and absorption.
- 10 Draw a flow chart showing the energy transformations that occur when a battery-powered torch is turned on.

Level 4



200xp



- 11 Do you think solids can experience convection? Explain your answer.
- 12 Describe the relationship between the wavelength and the energy of an electromagnetic wave. Give an example of a high- and low-energy wave in your answer.
- 13 With the aid of a diagram, show how a lens can correct a vision problem.

Level 5



300xp



# SKILLS AND INVESTIGATIONS

## SCIENCE SKILLS

Collecting and using data

Questioning, predicting and planning

Writing investigation reports

## INVESTIGATIONS

### BIOLOGICAL SCIENCES

- 1.1 Examining cells under a microscope
- 1.3 Photosynthesis and respiration
- 1.4A Cellular respiration in yeast
- 1.4B Energy from food
- 1.7A Observing unicellular organisms
- 1.7B Observing specialised cells in multicellular organisms
- 2.3 Water transport in plants
- 2.4 Dissecting a sheep's heart
- 2.7 Dissecting a flower

### CHEMICAL SCIENCES

- 3.1 Comparing metals and non-metals
- 3.3 Separating a mixture
- 3.5 Properties of compounds
- 4.1 Physical and chemical changes (Teacher demonstration)
- 4.2A Corrosion of iron
- 4.2B Preventing corrosion
- 4.3 Burning steel wool (Teacher demonstration)
- 4.5 Suitability of sports fabrics

### EARTH AND SPACE SCIENCES

- 5.1A Investigating cohesion of water
- 5.1B Observing capillary action
- 5.2 Modelling the water cycle
- 5.3 Testing water quality
- 6.1 Modelling Earth's structure
- 6.2A Observing minerals
- 6.2B Extracting copper
- 6.3 Modelling the rock cycle
- 6.4A Cooling rate and crystal size
- 6.4B Observing igneous rocks
- 6.5A Modelling contact metamorphism
- 6.5B Observing metamorphic rocks
- 6.6A Modelling the formation of sandstone
- 6.6B Observing sedimentary rocks
- 6.7A Modelling weathering due to temperature change
- 6.7B Modelling weathering due to acid rain (Teacher demonstration)
- 6.8 Making 'fossils'

### PHYSICAL SCIENCES

- 7.1 Rolling balls
- 7.2A Conduction – heat energy transfer in a solid
- 7.2B Convection – heat energy transfer in a liquid
- 7.2C Radiation and colour
- 7.4 Waves in a slinky
- 7.7A The law of reflection
- 7.7B Refraction
- 7.8 Concave and convex lenses

# KEY SKILLS

Identifying and managing relevant risks	Investigation 1.1 Investigation 1.7A Investigation 2.4 Investigation 2.7 Investigation 4.2A Investigation 6.2A Investigation 6.3 Investigation 6.5A Investigation 6.6B Investigation 6.7A Investigation 7.2B
Representing and recording data using a table	Investigation 1.3 Investigation 6.2B
Representing data	Investigation 1.4A
Identifying the independent and dependent variables	Investigation 1.4B Investigation 6.4A
Writing a research question	Investigation 1.7B Investigation 3.3 Investigation 6.1 Investigation 6.6A Investigation 7.4 Investigation 7.7A
Identifying the controlled variables	Investigation 2.3
Explaining results using scientific knowledge	Investigation 3.1 Investigation 3.5 Investigation 6.4B Investigation 6.8 Investigation 7.2A Investigation 7.7B
Identifying the independent, dependent and controlled variables	Investigation 4.2B Investigation 7.8
Evaluating results for reliability and validity	Investigation 4.5 Investigation 5.1A
Identifying the variables and formulating a hypothesis	Investigation 5.1B Investigation 7.1
Referencing sources of information	Investigation 5.2
Drawing conclusions consistent with evidence	Investigation 5.3 Investigation 6.5B
Identifying limitations to the method and suggesting improvements	Investigation 7.2C

## 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 fall time of the parachutes in the investigation about parachute size (Table 1), you would add 0.72, 0.98 and 1.43, then divide by 3.

The mean would be  $(0.72 + 0.98 + 1.43) \div 3 = 1.04$  s

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 page 128), 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?*

### 3 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).

Clear descriptions in titles

Table has a number and title

TABLE 1: EFFECT OF PARACHUTE SIZE ON TIME TAKEN TO FALL

	Side length of parachute (cm)	Time taken to fall (s)
Parachute 1	10	0.72
Parachute 2	20	0.98
Parachute 3	30	1.43

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?

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

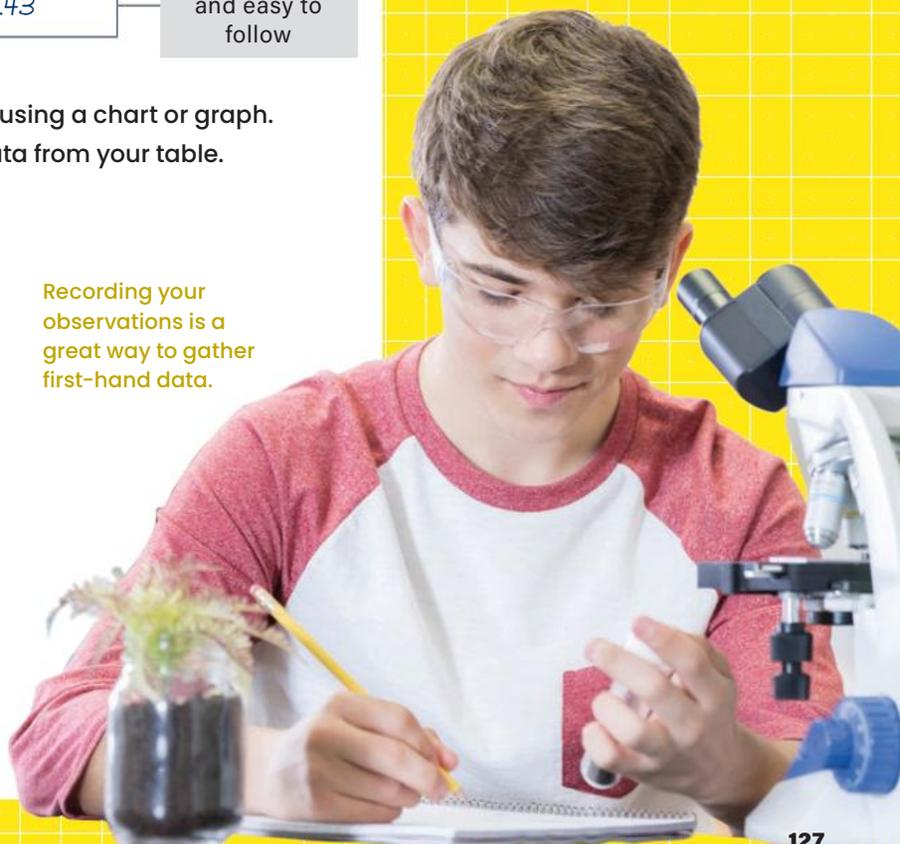


Recording your observations is a great way to gather first-hand data.

### 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.



# 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 an 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.



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.

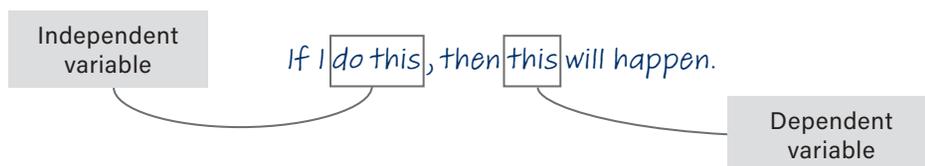
Let's say you decide to put three plants in three different amounts of sunlight to see which plant grows the most. You would make sure the plants were the same size, health and species, and only change the amount of sunlight the plant is getting – this is the independent variable. The dependent variable 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?

## 3 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).

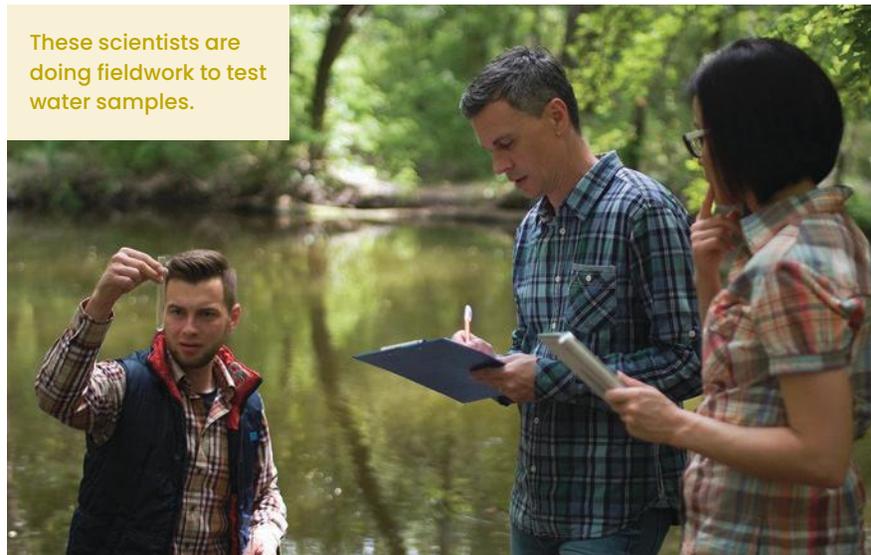
You use the independent and dependent variables when writing a hypothesis, so the first step is always to identify these. The general rule to use when writing a hypothesis is:



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?

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.

# WRITING INVESTIGATION REPORTS

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

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

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

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

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

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.

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.

### HOW DOES THE SIZE OF A PARACHUTE AFFECT THE TIME IT TAKES TO FALL?

#### AIM

To investigate how changing the size of a parachute affects the time it takes to fall

- Independent variable: size of the parachute (in centimetres)
- Dependent variable: time taken to fall (in seconds)
- Controlled variables: mass of plasticine, height from which parachute is dropped, length of string connecting parachute to plasticine, shape of parachute

#### HYPOTHESIS

If the size of a parachute is increased, then it will take longer to fall.

#### MATERIALS

- 1 black bin bag
- plasticine
- ruler
- string or cotton
- stopwatch

#### METHOD

- 1 Three squares (with side lengths of 10 cm, 20 cm and 30 cm) were cut from the bin bag to make three different-sized parachutes.
- 2 The corners of the 10 cm square were tied to a small ball of plasticine using the string.
- 3 The middle of the parachute was held up high and released. The time between the parachute being released and hitting the ground was timed.
- 4 Steps 2 and 3 were repeated for the 20 cm and 30 cm parachutes.

## RESULTS

TABLE 1: EFFECT OF PARACHUTE SIZE ON TIME TAKEN TO FALL

	Side length of parachute (cm)	Time taken to fall (s)
Parachute 1	10	0.72
Parachute 2	20	0.98
Parachute 3	30	1.43

## DISCUSSION

As the results in Table 1 show, the parachute that took the longest to fall was the 30 cm parachute. This parachute took 1.43 s to fall, compared to the 10 cm parachute which took 0.72 s to fall.

The results make sense because a large parachute encounters more air resistance than a smaller parachute, and so it would be expected to slow down more.

One error that may have occurred is the timing of each drop. As the times were short, the accuracy of these measurements depended on the reflexes of the person timing the drop. There also may have been an error in the height that each parachute was dropped from, as these were estimated but not measured. This experiment could be improved by measuring the drop height and keeping it consistent, as well as performing each drop multiple times and averaging them out. This would reduce errors in timekeeping.

## CONCLUSION

The results of this investigation show that the size of the parachute does affect how long it takes to reach the ground. The investigation supported the hypothesis that a large parachute will fall more slowly than a small parachute. This is due to the amount of air resistance encountered by the parachute.

## REFERENCES

BBC Bitesize, 2020. *Could You Use An Umbrella To Parachute?* [online] Available at: <https://www.bbc.co.uk/bitesize/clips/zhynvow> [Accessed 21 May 2020]

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

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

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

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 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.

## Investigation 1.1

# Examining cells under a microscope



## 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 cells in a slide of onion tissue under a microscope

### MATERIALS

- onion
- light microscope
- microscope slides and coverslips
- chopping board and knife
- tweezers
- dropper bottle of dilute iodine solution
- paper towel
- blunt dissecting needle or sharp pencil

### METHOD

- 1 Watch your teacher demonstrate how to create a microscope slide.
- 2 Place 1 drop of iodine solution in the centre of the microscope slide.
- 3 Using the knife and chopping board, cut a small piece from an onion ring.
- 4 Using your fingernails or tweezers, carefully peel the membrane away from the inner curve of the onion piece.
- 5 Place this membrane on the drop of iodine on your slide, trying not to let it curl up. Place a second drop of iodine solution on top of the onion membrane.
- 6 Use the blunt dissecting needle (or a sharp pencil) to carefully and slowly lower a coverslip over the onion membrane as shown.
- 7 Use a corner of a paper towel to gently soak up any extra liquid that squeezes out from under the coverslip.
- 8 Examine your slide under the microscope. Record your observations.

### QUESTIONS

- 1 What features of the onion cells could be seen?
- 2 Suggest why other organelles could not be seen.
- 3 What was the role of the iodine in this investigation?
- 4 Name two differences between a plant and animal cell.

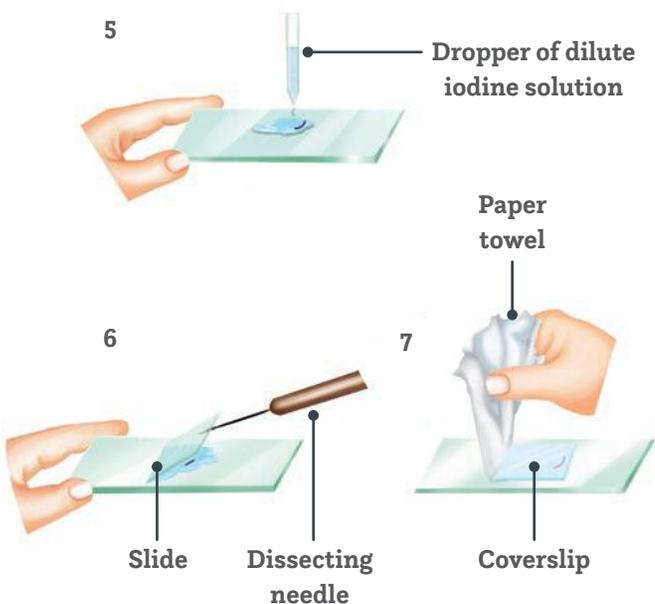
### CONCLUSION

Copy and complete:

'The results show that: *(respond to the aim)*'.



**TAKE CAUTION USING THE KNIFE. IF YOU CUT YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND SEEK FIRST AID.**



## Investigation 1.3

# Photosynthesis and respiration



30 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 the process of photosynthesis in plants

## MATERIALS

- disposable gloves
- safety glasses
- water weeds
- bromothymol blue solution
- colour scale for bromothymol blue pH
- measuring cylinder
- conical flask
- straws
- 3 test tubes with stoppers
- test-tube rack
- aluminium foil
- sun lamp

## METHOD

- 1 Pour 75 mL of bromothymol blue into the flask. Record the colour of the solution.
- 2 Using a straw, slowly blow into the flask until the solution just turns yellow.
- 3 Check the colour of your solution against the colour scale. Record the colour and the pH value.
- 4 Pour an equal amount of the solution into three test tubes. Label them A, B and C.
- 5 Put a 5 cm water weed in tube A and stopper the tube. Do the same with tube B, then wrap it in aluminium foil so that no light can enter. Stopper tube C without adding anything to it.
- 6 Place the tubes upright in the rack, and place the rack about 20 cm from the sun lamp. Turn on the lamp, making sure the light reaches all three tubes equally, and leave them for 24 hours.
- 7 After removing the water weeds and foil, compare the solutions in all three tubes to the colour scale. Record your observations for each tube.

## QUESTIONS

- 1 Why was tube C left empty except for the solution?
- 2 What happened in each test tube?

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



**TAKE CAUTION WHEN USING BROMOTHYMOL BLUE. USE HAND AND EYE PROTECTION. NEVER CONSUME ANYTHING IN THE SCIENCE LABORATORY.**

## Investigation 1.4A

# Cellular respiration in yeast



## 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 data into a chart or a 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 temperature that is most suitable for yeast respiration

### MATERIALS

- 3 × 500 mL water bottles (empty)
- yeast
- sugar
- hot and cold water
- ice
- filter funnel
- thermometer
- 3 balloons
- matches
- teaspoon



**TAKE CAUTION USING MATCHES. NEVER LIGHT A MATCH UNLESS INSTRUCTED.**

### METHOD

- 1 Copy the results table into your notebook, adding a title.
- 2 Add 2 teaspoons of yeast and 5 teaspoons of sugar to each empty bottle using a filter funnel.
- 3 Prepare water of approximately 10°C, 35°C and 60°C using ice, tap water and hot water from a kettle. Add 100 mL of 10°C water to one bottle, 35°C water to the second bottle and 60°C water to the third.
- 4 Replace the lids and shake each bottle to mix the contents, and mark the level of the mixture in each bottle. Remove the lids again.
- 5 While you hold each bottle, have a classmate stretch a balloon over the mouth of each.
- 6 Measure the distance the yeast mixture rises every 5 minutes for 30 minutes. Record your observations in your table.
- 7 Remove the balloon that has expanded to the largest size, and hold it so that the gas does not escape.
- 8 Release the gas to a lighted match and record what happens.

### QUESTIONS

- 1 Which temperature created the most yeast activity? Use your results to justify your answer.
- 2 Which temperature created the least yeast activity? Use your results to justify your answer.
- 3 What was used as a reactant in respiration, and what product was formed?
- 4 Describe the effect of the gas on the lit match.

### CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'

## RESULTS TABLE 11.4A

Temperature	Yeast activity (cm) every 5 min					Observations
10°C						
35°C						
60°C						

## Investigation 1.4B



# Energy from food



30 min



Level 2



## 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 which foods release the most energy when burnt

### MATERIALS

- piece of bread
- selection of other foods (e.g. pasta, cheese, potato, apple, broccoli, carrot, meat, fish)
- test tube
- water
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- retort stand with bosshead and clamp
- thermometer
- wooden handle with sharp metallic end (probe), or tongs
- measuring cylinder



**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.**

### METHOD

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Cut all the food to the same size.
- 3 Add 5 mL of water to a test tube and secure the test tube upright using the retort stand, bosshead and clamp.
- 4 Put a thermometer inside the test tube and measure the initial temperature.
- 5 Hold the piece of bread with the probe or tongs.
- 6 Set up the Bunsen burner on the heatproof mat, with the tripod and gauze mat. Light the Bunsen burner and heat the bread over the flame until it ignites.
- 7 Put the burning bread under the test tube of water and note the highest temperature the water reaches. Record this in your table, along with the total change in temperature.
- 8 Repeat steps 3–7 with other foods.

### QUESTIONS

- 1 Which food produced the highest temperature and energy change?
- 2 Explain why this food might have generated more heat when burned.

### DISCUSSION

- 1 Identify three errors that may have resulted in inaccurate results in this experiment.
- 2 Suggest improvements to the method that would address each of these errors.

### CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'

### RESULTS TABLE 11.4B

Food item	Initial temperature (°C)	Highest temperature (°C)	Change in temperature (°C)
Piece of bread			

## Investigation 1.7A

# Observing unicellular organisms



## 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 unicellular organisms in pond water using a microscope

### MATERIALS

- pond water
- light microscope
- microscope slides
- coverslip
- dropper
- paper towel

### METHOD

- 1 On a clean microscope slide, place 1 or 2 drops (depending on the size of the drop) of pond water.
- 2 Gently add a coverslip and wipe away any extra water.
- 3 Put the prepared slide on the microscope and clip it down using the stage clips.
- 4 Observe your slide under low magnification. Record your observations.
- 5 Increase the magnification to high and observe the sample again. Record your observations.
- 6 Draw what you saw under low and high power.

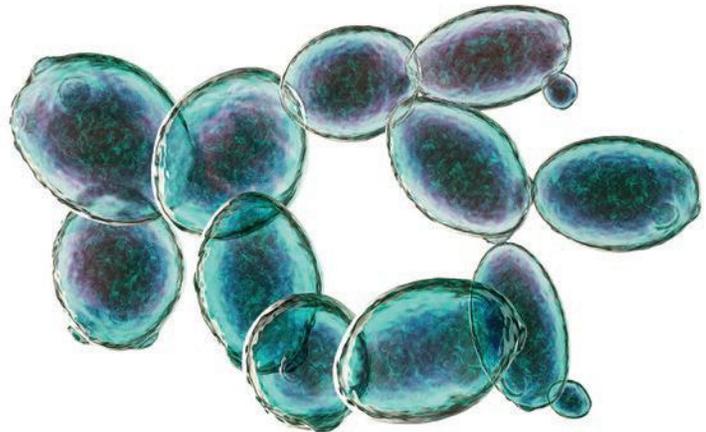
### QUESTIONS

- 1 Why was a microscope necessary to view these organisms?
- 2 How many organisms did you see under low magnification?
- 3 What happened when you increased the magnification of the field of view to high?
- 4 Describe the movement of the organisms. Were they moving fast or slow?
- 5 Tally how many of each organism you saw. Draw a column graph representing the number of organisms in a drop of pond water.

### CONCLUSION

Copy and complete:

'The results show that: *(respond to the aim)*'.



## Investigation 1.7B

# Observing specialised cells in multicellular organisms



## 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 specialised cells found in multicellular organisms

### MATERIALS

- microscope or bioviewer
- prepared microscope or bioviewer slides of plant and animal cells

### METHOD

- 1 Your teacher will prepare and distribute slides of plant and animal cells.
- 2 Place each prepared slide on the stage of the microscope and clip it in place.
- 3 Observe each slide under low power and then under high power.
- 4 Record your observations. Draw your observations and label any cell features that you see.

### QUESTIONS

- 1 Were all the cells you drew similar in structure? How were the cells different?
- 2 Suggest the functions of the cells you studied.
- 3 Looking at the structure of the cells, which of these cells are plant cells and which of them are animal cells?

### CONCLUSION

Copy and complete:

'The results show that: (respond to the aim)'.



## Investigation 2.3

# Water transport in plants



30 min



Level 1



## KEY SKILL

### IDENTIFYING THE CONTROLLED VARIABLES

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.

**Hint #2:** Some examples of controlled variables are listed on page 128.

## AIM

To investigate how water is transported in plants

## MATERIALS

- 3 celery sticks with leaves attached
- food colouring
- 3 × 200 mL beakers
- knife
- magnifying glass
- water
- gloves
- marker pen

## METHOD

- 1 Label the beakers A, B and C. Add 100 mL of water to beakers A and B and leave beaker C empty. Add enough food colouring to beaker A to get an intense, dark colour.
- 2 Cut 2 cm off the bottom of each stick of celery.
- 3 Place one celery stick in each beaker (cut end down), then leave them to stand overnight.
- 4 The next day, observe the leaves of the three celery sticks and record your observations.
- 5 Wearing gloves, remove the celery that was in the coloured water and slice it crosswise and lengthwise. Using the magnifying glass, observe the pathway of the food colouring.
- 6 Draw what you see in your notebook.

## QUESTIONS

- 1 What was the purpose of beakers B and C?
- 2 Explain what happened to the celery in beaker A in terms of the plant's water transport system.
- 3 What result did you obtain in beaker C? Why do you think this happened?
- 4 Describe how water is transported in plants, using observations or diagrams from your investigation to support your answer.

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



**TAKE CAUTION USING THE KNIFE.  
IF YOU CUT YOURSELF, TELL YOUR  
TEACHER IMMEDIATELY AND  
SEEK FIRST AID.**

## Investigation 2.4

# Dissecting a sheep's heart



45 min



Level 3



## 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 physical features of a sheep's heart

## MATERIALS

- 1 whole sheep's heart
- magnifying glass
- dissecting board
- dissecting kit
- disposable gloves
- safety glasses
- paper towel

## METHOD

- 1 In groups of 3 or 4, observe the external features of the heart and record your observations.
- 2 Locate the right side of the heart – it will feel softer than the left side. Cut it open using a scalpel to expose the right atrium and ventricle. Record your observations.
- 3 Cut open the left side of the heart in the same way. Record your observations and draw a diagram at each stage of the dissection.
- 4 Locate the tendons holding the heart valves. Use the probe to open the valves on both sides. Record your observations.
- 5 Find the large artery that leaves the left ventricle. Push the probe up the artery and record your observations.

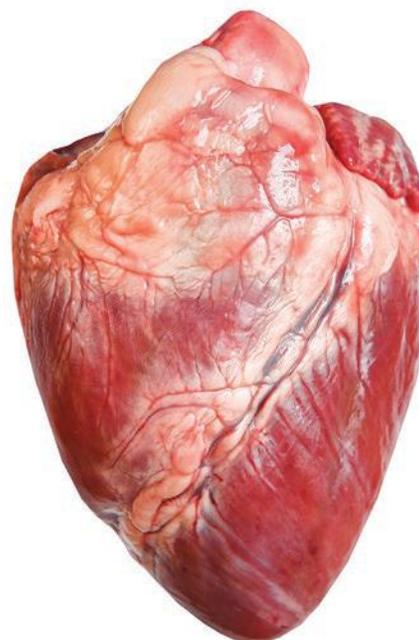
## QUESTIONS

- 1 Suggest why there would be a difference in the thickness of the left and right ventricle walls.
- 2 What function do the tendons have in the heart?
- 3 Describe the large artery coming out of the left ventricle. What function does this artery have?

## 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 2.7

# Dissecting a flower



## 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 physical features of flowering plants

### MATERIALS

- 1 large, whole flower
- magnifying glass
- dissecting board
- dissecting kit
- disposable gloves
- safety glasses

### METHOD

- 1 In groups of 3 or 4, observe the external features of the flower and record your observations.
- 2 Locate both parts of the stamen on your plant (the anther and filament). Record your observations.
- 3 Locate all three parts of the pistil on your plant (stigma, style and ovary). Cut open the ovary and count the number of eggs inside, using the magnifying glass to help you count. Record your observations.

### QUESTIONS

- 1 Why is it important for the anthers to be towards the top of the flower?
- 2 How many eggs were inside the plant's ovary? How could you tell they were eggs?
- 3 Explain how pollen would normally move from the male to female organs of the flower.

### 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 3.1

# Comparing metals and non-metals



**KEY SKILL**

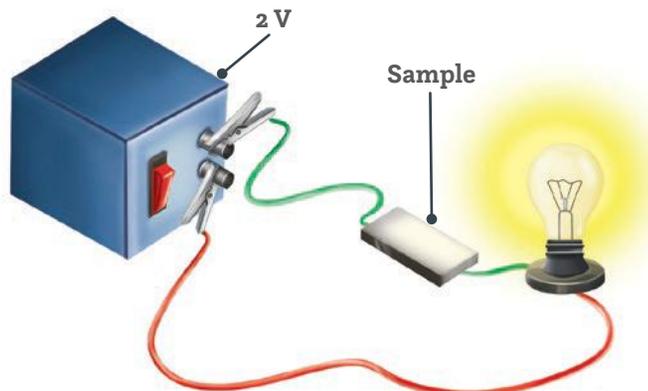
**EXPLAINING RESULTS USING SCIENTIFIC KNOWLEDGE**

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 properties of metals and non-metals



**ELECTRICITY IS A HAZARD. TAKE CAUTION.**

**MATERIALS**

- selection of metals and non-metals (e.g. sulfur, aluminium, iron, magnesium, carbon, plastic, wood, polystyrene)
- power supply
- light bulb
- 3 connecting wires
- alligator clips
- steel sewing needle

**METHOD**

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Choose one of the samples and record your observations of its appearance (colour, shininess etc.)
- 3 Try to bend the sample to test for malleability.
- 4 Scratch the sample using the steel needle. Is the sample shiny underneath?
- 5 Connect the electric circuit as shown. Switch the power supply on to 2 V. Observe whether the light bulb turns on. If so, the sample conducts electricity.

**QUESTIONS**

- 1 What properties did all of the metals have in common?
- 2 Were there any properties common to both metals and non-metals?
- 3 Predict the properties of tungsten (metal) and iodine (non-metal).

**CONCLUSION**

Copy and complete:  
 'The results show that: (respond to the aim).'

**RESULTS** TABLE I3.1

Sample	Metal or non-metal?	Appearance	Malleable?	Shiny?	Conducts electricity?

## Investigation 3.3

# Separating a mixture



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 process of separating a mixture of salt and water

## MATERIALS

- 15 g of table salt
- 100 mL of water
- evaporating dish
- Bunsen burner
- heatproof mat
- tripod
- pipeclay triangle
- matches
- 150 mL beaker
- 100 mL measuring cylinder
- 10 mL measuring cylinder

## METHOD

- 1 Combine the water and salt in the 150 mL beaker. Stir until all of the salt is dissolved.
- 2 Pour 10 mL of the salt solution into an evaporating dish.
- 3 Set up the apparatus as shown.
- 4 Heat the salt water solution for a few minutes until the water has all evaporated.
- 5 Observe the salt remaining in the dish. Record your observations.

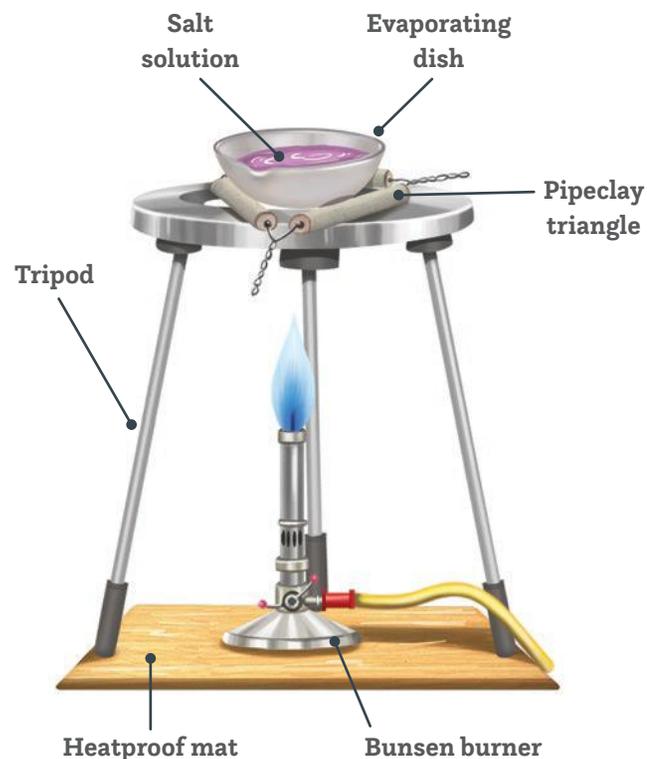
## QUESTIONS

- 1 Compare the appearance of the salt at the end of the investigation to the salt at the beginning. How is it different?
- 2 What happened to the water during the experiment?
- 3 How does this investigation show that salt water is a mixture?
- 4 Can you think of any other ways to separate a mixture of salt and water?

## 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 3.5

# Properties of compounds



## 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 the properties of a compound differ from those of the elements it is made of

## MATERIALS

- 5 cm magnesium ribbon
- crucible and lid
- Bunsen burner
- heatproof mat
- tripod
- pipeclay triangle
- matches
- brass (crucible) tongs

## METHOD

- 1 Look closely at the magnesium ribbon. Record your observations (e.g. colour, shininess, feel).
- 2 Place the magnesium ribbon inside the crucible and put the lid on. Set up the apparatus as shown.
- 3 Using the Bunsen burner, heat the crucible containing the magnesium. Using tongs, lift the lid every 5 – 10 seconds to ensure enough air is in the crucible. *Do not look directly at the magnesium.*
- 4 The heated magnesium will combine with oxygen in the air to create magnesium oxide, a compound. After the magnesium has finished reacting, observe the magnesium oxide. Record your observations about its properties.

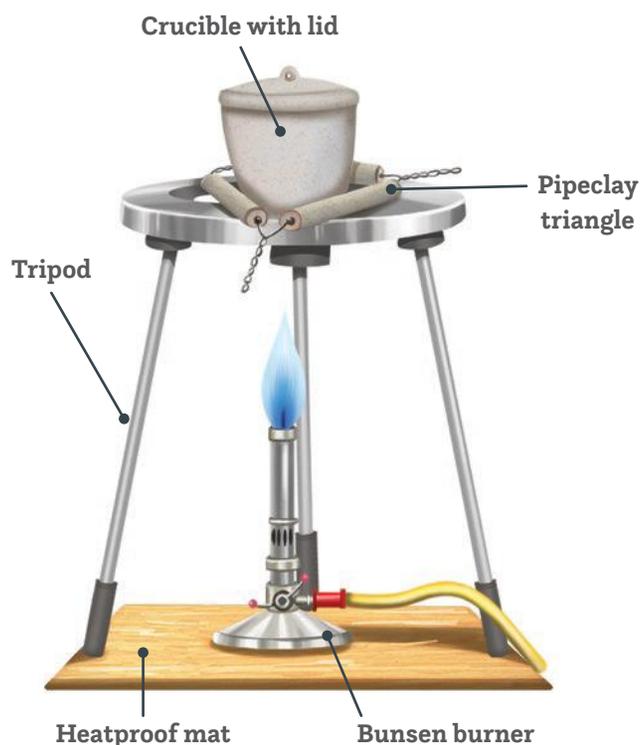
## QUESTIONS

- 1 How did the appearance of the magnesium differ to that of the magnesium oxide?
- 2 What was the purpose of lifting the crucible lid occasionally?
- 3 Where did the oxygen in the magnesium oxide come from?

## 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.**

**MAGNESIUM RIBBON IS A HAZARD. IT IS FLAMMABLE AND REACTIVE. TAKE EXTREME CAUTION. NEVER LOOK DIRECTLY AT THE BURNING MAGNESIUM RIBBON.**

## Investigation 4.1

# Physical and chemical changes

### TEACHER DEMONSTRATION



#### AIM

To investigate physical and chemical changes

#### MATERIALS

- Alka-Seltzer tablet
- vinegar
- bicarbonate of soda
- magnet
- mixture of sand and iron filings
- Petri dish
- 3 popsticks
- 5 cm magnesium ribbon
- 1 mol/L hydrochloric acid
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- matches
- evaporating basin
- 3 test tubes
- 3 × 10 mL measuring cylinder
- brass tongs
- water
- teaspoon

#### METHOD

- 1 Copy the results table into your notebook, adding a title.
- 2 Your teacher will set up the Bunsen burner on the heatproof mat, with the tripod and gauze mat.
- 3 They will use the Bunsen burner to burn the popsticks above the evaporating basin.
- 4 Observe as they add 1 teaspoon of bicarbonate of soda to a test tube and pour 5 mL of vinegar into it.
- 5 Your teacher will pass the magnet back and forth over the mixture of sand and iron filings (in the sealed Petri dish).

- 6 Your teacher will add one quarter of an Alka-Seltzer tablet to 5 mL of water in another test tube.
- 7 Your teacher will add the piece of magnesium ribbon to 5 mL of acid in a test-tube, using brass tongs. Observe closely. They will touch the bottom of the outside of the test tube.
- 8 Record all of your observations in your table. Explain why you categorised changes as physical or chemical.

#### QUESTIONS

- 1 What is the difference between a physical change and a chemical change?
- 2 From your results, list four properties you observed that indicated that the change was a chemical change.
- 3 Which change can be easily reversed, physical or chemical? Why?
- 4 What happens in all chemical changes?

#### CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.

**RESULTS** TABLE I4.1

Substances	Observations	Type of change	Explanation
Popsticks and fire			
Baking soda and vinegar			
Magnet, sand and iron			
Alka-Seltzer and water			
Magnesium and acid			

## Investigation 4.2A

# Corrosion of iron



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 identify the conditions that cause iron to rust (corrode)

## MATERIALS

- 5 iron nails
- vegetable oil
- 10 mL of salt water solution
- distilled water
- tap water
- 5 test tubes
- 5 test-tube stoppers
- test-tube rack
- safety glasses

## METHOD

- 1 Set the test tubes in the test-tube rack.
- 2 Place nails and liquids in the test tubes as shown. The fifth test tube will not contain any liquid, only the nail and air.
- 3 Stopper all the test tubes.
- 4 Observe the test tubes for signs of rusting over the next week. Record your observations.

## QUESTIONS

- 1 Rank the test tubes from containing the least rust to the most rust.
- 2 Suggest why some of the nails showed more signs of corrosion than others.

## DISCUSSION

- 1 How could you make this investigation more reliable?

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



Oil

Salt solution

Distilled  
water

Tap water

Air



**CHEMICALS OR SALT SOLUTION MAY GET INTO YOUR EYES. WEAR SAFETY GLASSES THROUGHOUT THE LESSON TO PREVENT THIS.**

## Investigation 4.2B

# Preventing corrosion



## 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 which materials can prevent or slow corrosion

## MATERIALS

- butcher paper
- 5 iron nails
- oil
- petroleum jelly
- paint
- anti-rust spray
- 5 test tubes
- water
- test-tube rack



## METHOD

- 1 Line your bench with some paper to protect the surface.
- 2 Prepare the nails so that you have one nail covered with oil, one nail covered with petroleum jelly, one painted nail, one nail sprayed with anti-rust spray and one nail left untreated.
- 3 Add each nail to a test tube. Fill each test tube with water so that the nail is covered.
- 4 Leave the test tubes in the test-tube rack for 2 days. Record your observations and determine which method best protected the nails from corrosion.

## QUESTIONS

- 1 What was the purpose of putting the untreated nail in a test tube of water?
- 2 Which method prevented corrosion the best?
- 3 What other corrosion prevention substances could you potentially test?
- 4 List some ways of preventing rust.

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'

## Investigation 4.3

# Burning steel wool

## TEACHER DEMONSTRATION



### AIM

To investigate what occurs when steel wool is burnt

### MATERIALS

- steel wool pad, cleaned with acetone
- watchglass
- brass tongs
- evaporating basin
- electronic balance
- 9 V battery

### METHOD

- 1 Your teacher will place some of the steel wool in the watchglass on the electronic balance. Record the total mass in your notebook.
- 2 Your teacher will place the steel wool in the evaporating basin. Record the total mass in your notebook.
- 3 Your teacher will touch the battery terminals to the steel wool, causing it to burn. This will continue until all of the wool is completely burned into ash or powder.
- 4 Record the current mass of the evaporating dish and steel wool. Calculate the current mass of the steel wool alone.

### QUESTIONS

- 1 Does burning steel wool cause a physical or chemical change? Justify your answer.
- 2 What happened to the mass of the steel wool?
- 3 Use the particle theory to explain what happened to the steel wool.

### CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.



Investigation 4.5

# Suitability of sports fabrics



**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 which fabric is most suitable for sports clothing

**MATERIALS**

- 4 different types of fabric (cotton, polyester, nylon, spandex)
- 2 retort stands with bossheads and clamps
- 500 mL beaker
- long piece of string
- 4 stopwatches
- pegs
- warm water
- teaspoon
- salt
- fan

**METHOD**

- 1 Copy the results table into your notebook, adding a title.
- 2 Mix 500 mL of warm water and 1 teaspoon of salt together in a 500 mL beaker and leave aside.
- 3 Cut the four types of fabric into equal sized pieces.
- 4 Place the retort stands over a sink and tie a string from one retort stand to another.
- 5 Put the fan on, facing the retort stands.
- 6 Cover the prepared fabrics with salt water, take them out one at a time and peg them to the string, which serves as a clothesline.
- 7 Have four students time how long each fabric takes to dry. Record the times in your table and calculate an average time for each fabric.

**QUESTIONS**

- 1 Why do you think salt water instead of tap water was used in this investigation?
- 2 Why is it important for a sports person to wear clothing made from the right type of fabric?
- 3 Which fabric dried the fastest? Why do you think this was so?
- 4 Research the fast-drying fabric and write the properties that make it suitable for making clothes for sports people.

**CONCLUSION**

Copy and complete:  
 'The results show that: (respond to the aim).'

**RESULTS** TABLE I4.5

Fabric	Time (min) (student 1)	Time (min) (student 2)	Time (min) (student 3)	Time (min) (student 4)	Average time (min)
Cotton					
Polyester					
Nylon					
Spandex					

## Investigation 5.1A

# Investigating cohesion of water

**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 cohesion in water using a 5-cent coin

**MATERIALS**

- 5-cent coin
- small amount of water in a 50 mL beaker
- pipette or eyedropper

**RESULTS**

TABLE 15.1A

Trial	Number of drops before overflow	Average
1		
2		
3		
4		

**METHOD**

- 1 Copy the results table into your notebook, adding a title.
- 2 Use the pipette or eyedropper to practise making water drops of the same size.
- 3 Predict how many drops of water you will be able to fit onto the coin before it overflows. Record this in your notebook.
- 4 Carefully place one water drop on to the coin.
- 5 Keep adding water drops, counting how many you can fit on the coin before it overflows.
- 6 Dry the coin and repeat this process another three times.
- 7 Add up all four trial results and divide by four to calculate the average result.

**QUESTIONS**

- 1 Compare your prediction to your average result. Are they different? If so, why?
- 2 Compare your average result to others in your class. What might be the cause of differences, if any?
- 3 Would you expect to be able to fit the same number of drops of soapy water onto the coin? Design a procedure to test your hypothesis.
- 4 Research to find out more about the surface tension of water. How is this related to the cohesion between the water molecules?

**CONCLUSION**

Copy and complete:

'The results show that: (respond to the aim).'



Investigation **5.1B**



# Observing capillary action

**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 on page 129 to help you.*

**AIM**

To investigate whether the thickness of a straw affects the movement of water by capillary action

**MATERIALS**

- 250 mL beaker
- food colouring
- water
- 3 clear straws or tubes of different widths, including one capillary tube (very thin tubing)
- marker pen
- ruler
- stopwatch

**METHOD**

- 1 Copy the results table into your notebook, adding a title.
- 2 Half fill the beaker with water and add some food colouring so the water is a dark colour.
- 3 Arrange the straws so that their ends line up. Use the marker pen to draw a line across all of them about one-third of the way along.
- 4 Carefully hold the straws in the beaker of water, lining up the marker line with the top of the water. The straws should not touch the bottom of the beaker.
- 5 Start timing with the stopwatch. Hold the straws in place for 60 seconds.
- 6 Quickly and carefully mark where the water level inside the straws rises to.
- 7 Remove the straws from the beaker and measure the difference between the original water level and the final water level. Record this in your table.
- 8 Repeat steps 4–7 another two times.

**QUESTIONS**

- 1 Describe the trend shown in your results.
- 2 Explain why you observed this trend. (You may need to do some research.)
- 3 Explain how both the cohesion and adhesion of water molecules allow water to travel up the straw. You may like to use a diagram to support your explanation.
- 4 Capillary action allows plants to transport water from their roots to their leaves through special transport vessels called xylem. Based on your results, do you think large trees would have narrow or wide xylem? Justify your response.

**CONCLUSION**

Copy and complete:  
 ‘The results show that: (respond to the aim)’.

**RESULTS** TABLE I5.1B

Trial	Straw/tube width (mm)	First distance (mm)	Second distance (mm)	Third distance (mm)
1				
2				
3				

## Investigation 5.2

# Modelling the water cycle



30 min



Level 2



## 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 such as 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, the processes in the water cycle

## MATERIALS

- large clear plastic bowl or container
- modelling clay
- cling film
- elastic band
- heat lamp
- water
- small pebble
- food colouring
- camera (optional)



## METHOD

- 1 Use the modelling clay to form an 'island' that will sit in the middle of the container. Make a small depression in the top of the island that will represent a freshwater lake – do not make it too deep.
- 2 Add water to the container so that it comes about a quarter of the way up your island. Add some food colouring to colour the water.
- 3 Carefully cover the top of the container with cling film, securing it around the edges with an elastic band so that no water vapour can escape.
- 4 Place the pebble on the cling film, in the centre above your island.
- 5 Place the heat lamp over the container and switch it on. Leave it for a period of time and record your observations in your notebook. You may like to photograph your model to support what you have written.

## QUESTIONS

- 1 Identify the part of the model that simulated evaporation.
- 2 Identify the part of the model that simulated condensation.
- 3 Identify the part of the model that simulated precipitation.
- 4 Compare the colour of the water in the 'lake' with that in the 'ocean'. Explain any differences.
- 5 Explain why water is considered to be a renewable resource.
- 6 This model does not include all parts of the water cycle. Which parts were not included? Suggest ways that the model could be altered to include them.

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



**TAKE CAUTION USING THE HEAT LAMP. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.**

## Investigation 5.3

# Testing water quality

## 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 the quality of different water sources

## MATERIALS

- water samples from different areas (e.g. dams, different points along a river)
- distilled water
- test tubes
- test-tube rack
- pipettes
- universal indicator and chart
- 0.1 mol/L silver nitrate in a dropper bottle
- 5% ammonia solution in a dropper bottle
- nitrate test strips

## METHOD

Copy the results table into your notebook, adding a title and rows as needed.

### PART 1:

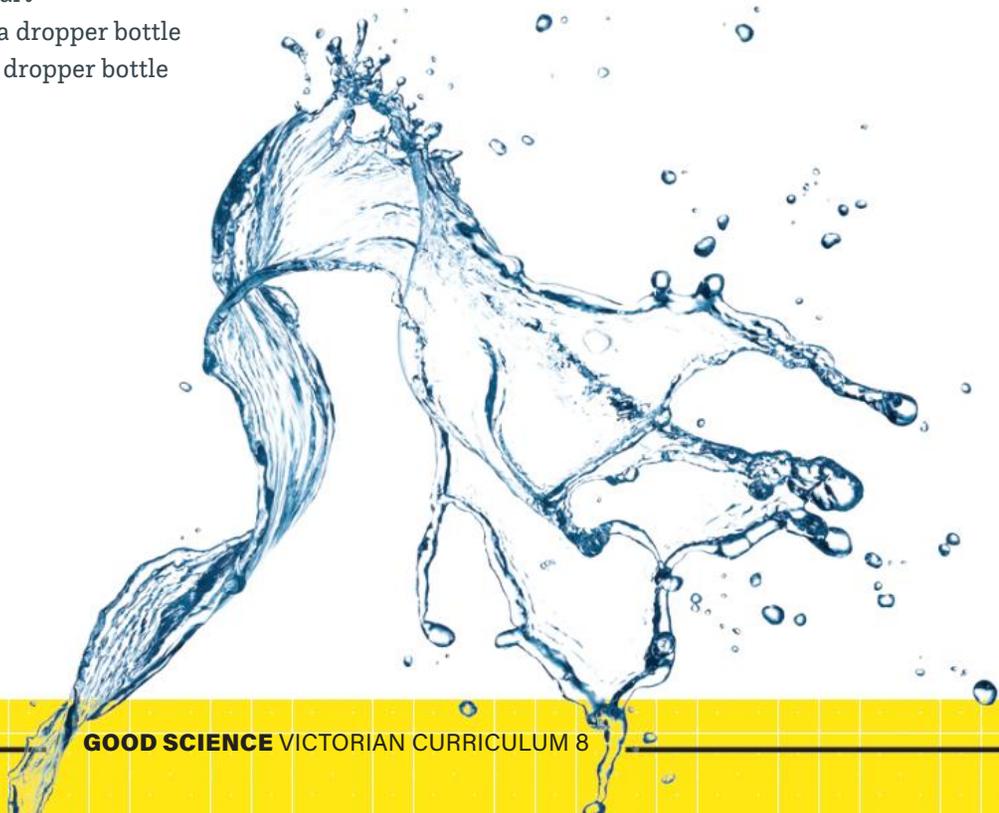
#### TESTING FOR PH

- 1 Use the pipette to add 2 cm of each water sample, including distilled water, into separate test tubes.
- 2 Add 1 drop of universal indicator to each sample.
- 3 Use the universal indicator chart to identify the pH of each sample. Record this in the results table.
- 4 Dispose of the water in the test tubes as per your teacher's directions.

### PART 2:

#### TESTING FOR SALINITY

- 1 Add 2 cm of each water sample, including distilled water, into separate test tubes.
- 2 Carefully add 1 drop of silver nitrate to each test tube and swirl to mix.
- 3 If salt is present in the water it will turn white and cloudy; the more salt, the cloudier it will be. Record your observations in your table.
- 4 Dispose of the water in the test tubes as per your teacher's directions.





**PART 3:**

**TESTING FOR NITRATES  
(NUTRIENTS IN FERTILISERS)**

- 1 Add 2 cm of each water sample, including distilled water, into separate test tubes.
- 2 Carefully dip the reactive end of a nitrate strip in each water sample for the time shown on the directions.
- 3 Use the colour chart to determine if nitrates are present in your water sample. Record your observations in your table.
- 4 Dispose of the water in the test tubes as per your teacher's directions.

**PART 4:**

**TESTING FOR COPPER**

- 1 Add 2 cm of each water sample, including distilled water, into separate test tubes.
- 2 Carefully add 5 drops of 5% ammonia to each test tube.
- 3 If copper is present in the water, a light blue colour will appear. Record your observations in your table.
- 4 Dispose of the water in the test tubes as per your teacher's directions.

**QUESTIONS**

- 1 What was the purpose of testing distilled water?
- 2 Identify which tests were qualitative and which were quantitative.
- 3 Compare the results for each location.
- 4 Find out what different pH values can indicate about a water supply. Can you propose any reasons for the results you may have obtained?
- 5 Find out what the presence of salt, nitrates and copper might indicate about the water supply. Can you propose any reasons for the results you may have obtained?

**CONCLUSION**

Copy and complete:

'The results show that: (*respond to the aim*)'.



**SILVER NITRATE AND AMMONIA ARE TOXIC. TAKE CAUTION. NEVER CONSUME ANYTHING IN THE SCIENCE LABORATORY. WASH YOUR SKIN IF IT COMES IN CONTACT WITH THESE SUBSTANCES.**

**RESULTS**    **TABLE 15.3**

Sample	pH	Salinity	Nitrates	Copper

Investigation 6.1

# Modelling Earth's structure

**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 demonstrate how liquids of different densities interact and use their properties to model the different layers of the Earth

**MATERIALS**

- 5 solutions of different densities (e.g. water, dishwashing detergent, vegetable oil, honey, light corn syrup) (100 mL of each)
- measuring cylinders (one each of 5, 10, 25 and 100 mL)
- 5 × 100 mL beakers
- electronic balance

**METHOD**

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Use the electronic balance to find the mass of 10 mL of each liquid.
- 3 Use your knowledge of density to work out which liquid will represent each of Earth's layers. Check your order with your teacher. Add this to your table. (Hint: the densest solution will represent the inner core, while the least dense will represent the crust.)
- 4 Use the 25 mL measuring cylinder to measure 19 mL of liquid to represent the inner core. Pour this into the 100 mL measuring cylinder. Clean the 25 mL measuring cylinder.
- 5 Measure 35 mL of the liquid for the outer core. Carefully pour this into the 100 mL measuring cylinder so that it forms a layer on top of the first liquid. (Hint: Hold the measuring cylinder at an angle.) Clean the measuring cylinders you used.
- 6 Measure 42 mL of the liquid for the lower mantle. Carefully layer this into the 100 mL measuring cylinder.
- 7 Measure 3 mL of the liquid for the upper mantle. Carefully layer this into the 100 mL measuring cylinder.
- 8 Measure 1 mL of the liquid for the crust. Carefully layer this into the 100 mL measuring cylinder.

**RESULTS** TABLE I6.1

Name of solution	Mass of 10 mL (g)	Density (g/mL)	Earth layer represented	Volume required for scale model (mL)



30 min



Level 1

## QUESTIONS

- 1 Draw and label a diagram of your model.
- 2 How much thicker is the mantle than the inner core?
- 3 How much thicker is the lithosphere than the asthenosphere?
- 4 Explain how the model you have created represents Earth's layers and the density of the substances in each layer.
- 5 Models do not always accurately reflect what they are trying to show. Identify and explain one way that your model does not accurately reflect Earth's layering.

## DISCUSSION

- 1 How could errors in measuring the density of the liquids have impacted this investigation?
- 2 What could you do to improve your method so that these errors are less likely to happen?

## CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.



Investigation 6.2A

# Observing minerals



**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 properties of some common minerals

**MATERIALS**

- selection of mineral samples (mineral kit)
- hand lens
- streak plate/unglazed white ceramic tile
- copper coin
- nail
- glass file/knife blade

**METHOD**

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Complete steps 3–7 for each mineral sample.
- 3 **Lustre:** Determine if the mineral has a metallic or non-metallic lustre.
- 4 **Colour:** Describe the colour of the mineral.
- 5 **Streak:** Scratch the mineral along the streak plate. Describe the colour of the powder that is left on the plate. (Note: If your mineral has a measurement of more than 6.5 it will not make a streak. In this case write 'N/A' ('not applicable') in your table.)
- 6 **Hardness:** Use your fingernail, copper coin, nail, glass file/knife blade and the streak plate along with Table 6.1 on page 87 to determine the approximate hardness of the mineral.

**QUESTIONS**

- 1 Which mineral was the softest and which was the hardest?
- 2 Which property do you think was the easiest to test? Why?
- 3 Is there one property that you could use on its own to tell the difference between each of the mineral samples you tested? Justify your response.
- 4 Explain why we observe both the colour and the streak of minerals.

**CONCLUSION**

Copy and complete:

'The results show that: *(respond to the aim)*'.



**RESULTS TABLE I6.2A**

Mineral name	Lustre	Colour	Streak	Hardness

## Investigation 6.2B

# Extracting copper



## 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 how chemical reactions are used to extract copper from a copper ore

## MATERIALS

- 5 g of malachite or copper sulfate crystals
- zinc metal strip
- distilled water
- 100 mL beaker
- stirring rod

## METHOD

- 1 Carefully stir to dissolve 5 g of malachite or copper sulfate crystals in 50 mL of distilled water.
- 2 Add the zinc metal strip to the beaker so that it is covered by the solution.
- 3 Write the heading 'Start of the investigation' in your notebook and record your observations about the colour of the solution, colour of the zinc strip and any other observations.
- 4 Leave the beaker and solution overnight.
- 5 Write the heading 'End of the investigation' in your notebook and record your observations about the colour of the solution, colour of the zinc strip and any other observations.
- 6 Include drawings or photos of the initial beaker and the beaker after 24 hours.
- 7 Describe the colour change to the solution in the beaker.
- 8 Describe the colour change to the zinc strip.

## QUESTIONS

- 1 Describe the changes to both the zinc and the solution.
- 2 Research to find out the chemical reaction that occurred in this investigation. Write it as a word equation.
- 3 Where were the copper atoms located at the start of the investigation?
- 4 Where were the copper atoms located at the end of the investigation?
- 5 What does the investigation demonstrate about how chemical reactions can be used to extract minerals from ores?
- 6 What observations might you make to tell you that not all of the copper had been extracted from the solution?
- 7 How could you improve the method to extract all of the copper from the solution?

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim)'.



## Investigation 6.3

# Modelling the rock cycle

## 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 model the processes of the rock cycle using wax crayons

## MATERIALS

- 2–4 wax crayons of different colours, cut into halves
- water
- butter knife or plastic knife
- cutting mat
- mortar and pestle
- rolling pin
- crucible and lid
- Bunsen burner
- heatproof mat
- tripod
- pipeclay triangle
- matches
- brass (crucible) tongs
- kettle
- camera (optional)

## METHOD

- 1 Use the camera to take photographs of each step of this process.
- 2 Use the knife to cut up the crayons into very small pieces. Keep the colours separate for now.
- 3 Layer the different colours of crayon in the mortar.
- 4 Use the pestle to gently push down on your crayon layers so that they stick together.
- 5 Carefully take the crayon layers out of the mortar and place them on the cutting mat.
- 6 Use the rolling pin to further press down and combine the crayon layers.
- 7 Use the knife to carefully cut a section of the crayon layers that will fit into the crucible.
- 8 Set up the Bunsen burner, heat proof mat, tripod and pipeclay triangle.
- 9 Carefully place the crucible without its lid on the pipeclay triangle.
- 10 Light the Bunsen burner and turn to a blue flame.
- 11 Observe how the wax changes. Once all of the wax has melted, turn off the Bunsen burner.
- 12 Remove the crucible with the tongs and allow the melted wax to cool.





## QUESTIONS

- 1 What do the original crayons represent in this model?
- 2 Identify the rock cycle processes that are modelled by steps 2, 3, 4, 6, 11 and 12.
- 3 Using the processes outlined in Figure 6.6 (page 89), along with the photos you took, create your own rock cycle diagram.

## DISCUSSION

- 1 Identify the steps in the method that pose a safety risk. What did you do to reduce the risks?
- 2 Evaluate the method for its effectiveness in modelling the rock cycle. Could you make improvements? How could you improve the method?

## CONCLUSION

Copy and complete:

'The results show that: *(respond to the aim)*'.



**HOT LIQUID, WAX AND STEAM ARE HAZARDS. TAKE EXTREME CAUTION. IF YOU SCALD (BURN) YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.**

## Investigation 6.4A

# Cooling rate and crystal size

## 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 how cooling rate affects crystal size

## MATERIALS

- saturated copper sulfate or alum solution
- solid copper sulfate or alum
- 3 test tubes
- 3 × 250 mL beakers
- 100 mL beaker
- ice
- cotton wool
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- matches
- spatula
- stirring rod
- magnifying glass

## METHOD

- 1 Copy the results table into your notebook, adding a title.
- 2 Place a test tube in each of the three 250 mL beakers. Surround one with ice up to the top of the beaker, one with cotton wool up to the top of the beaker and leave the other surrounded by air.
- 3 Set up the Bunsen burner, heat proof mat, tripod and gauze mat.
- 4 Add about 40 mL of saturated copper sulfate (or alum) solution to the 100 mL beaker.
- 5 Heat this solution using the Bunsen burner.
- 6 Add one spatula full of solid copper sulfate (or alum) to the solution at a time, stirring with the stirring rod until it dissolves. Keep adding solid until it no longer dissolves.
- 7 Carefully remove the solution from the Bunsen burner, pouring one third into each test tube.
- 8 Plug the top of each test tube with some cotton wool. Leave the test tubes to cool overnight.
- 9 Use the magnifying glass to help you observe the size of the crystals in each test tube and complete the results table.

**RESULTS** TABLE I6.4A

Beaker	Observations	Relative size of crystals (e.g. small, large)	Relative speed of cooling (e.g. slow, fast)
control			
ice			
cotton wool			



30 min



Level 2



## QUESTIONS

- 1 Which tube cooled fastest?
- 2 Describe the relationship that you observed between the rate of cooling and the size of the crystals formed. Was this expected? Why/Why not?
- 3 Which test tube represented the formation of an intrusive igneous rock? Justify your choice.
- 4 Which test tube represented the formation of an extrusive igneous rock? Justify your choice.
- 5 Molten rock can cool slower in some places than others. Suggest why.
- 6 Draw a labelled scientific diagram, with a scale showing the size and shape of the crystals that formed in each test tube.
- 7 With reference to the scientific method, explain why it was important to plug all three test tubes with cotton wool.

## 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 **6.4B**

# Observing igneous rocks



**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 observe key characteristics of some igneous rocks

**MATERIALS**

- selection of igneous rocks (e.g. basalt, granite, pumice, rhyolite, gabbro, obsidian)
- magnifying glass

**METHOD**

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Carefully observe each sample with the magnifying glass, and record your observations in your results table.

**QUESTIONS**

- 1 Identify the extrusive igneous rocks. What feature enabled you to identify them?
- 2 Identify the intrusive igneous rocks. What feature enabled you to identify them?
- 3 You are walking through the bush and find a rock outcrop. What observations do you need to make to confirm that it is an igneous rock?

**CONCLUSION**

Copy and complete:

'The results show that: (respond to the aim).'

**RESULTS** TABLE I6.4B

Rock name	Approximate % of light and % dark minerals	Crystal size	Other observations	Rate of cooling



## Investigation 6.5A

# Modelling contact metamorphism



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, using a model, the process of contact metamorphism using hot water and egg white

## MATERIALS

- raw egg white
- salt
- water
- 100 mL beaker
- spatula
- Petri dish
- Bunsen burner
- heatproof mat
- tripod
- gauze mat
- matches
- beaker tongs
- camera (optional)

## METHOD

- 1 Place the egg white in the Petri dish, making sure there is enough to cover the base of the dish.
- 2 Half fill the beaker with water and add a spatula full of salt.
- 3 Set up the Bunsen burner on the heatproof mat, with the tripod and gauze mat. Bring the water to the boil.
- 4 When the water is boiling, use beaker tongs to carefully remove the beaker from the tripod and place it in the centre of the Petri dish.
- 5 Observe what happens over 10 minutes. Record your observations. You may like to use photos to support your observations.

## QUESTIONS

- 1 Describe the change that happened to the egg white.
- 2 What caused the change to the egg white?
- 3 This investigation modelled contact metamorphism.
  - a Explain what the egg white represented in this process.
  - b Explain what the beaker of hot water represented in this process.
- 4 Explain how the change to the egg white is similar to the changes to rocks that have undergone contact metamorphism.
- 5 Do you think that metamorphic rocks could be easily changed back into their original form? Justify your response.

## CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.



**BOILING WATER, STEAM AND OPEN FLAME ARE HAZARDS. TAKE CAUTION. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.**

**IF YOU ARE ALLERGIC TO EGG WHITE, TELL YOUR TEACHER BEFORE PROCEEDING WITH THIS INVESTIGATION.**

**NEVER EAT ANYTHING IN THE SCIENCE LABORATORY.**

Investigation **6.5B**

# Observing metamorphic rocks



**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 observe some samples of metamorphic rocks

**MATERIALS**

- selection of metamorphic rocks (e.g. quartzite, marble, slate, gneiss)
- magnifying glass

**METHOD**

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Carefully observe each rock sample with the magnifying glass, and record your observations in your table.

**QUESTIONS**

- 1 Use your knowledge of metamorphic rocks to identify each sample as being formed by either contact or regional metamorphism.
- 2 What feature did you use to be able to identify the formation type of each sample?
- 3 You are walking through the bush and find a rock outcrop. What observations do you need to make to confirm that it is a metamorphic rock?

**CONCLUSION**

Copy and complete:  
 'The results show that: (respond to the aim).'

**RESULTS** TABLE I6.5B

Rock name	Size of crystals (mm)	Crystals in layers? (yes/no)	Other observations (e.g. colour)



## Investigation 6.6A

# Modelling the formation of sandstone



## 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, the formation of sandstone

### MATERIALS

- separate samples of sands of different colours, with dry plaster of Paris mixed in
- water
- 2 clear disposable plastic cups
- spatula or spoon

### METHOD

- 1 Place a layer of sand of one colour into one of the plastic cups.

- 2 Use the spatula or spoon to moisten (but not saturate) the sand with water.
- 3 Press the base of the second cup in to compress the layer.
- 4 Repeat steps 1–3 for sands of different colours.
- 5 Allow your 'sandstone' to dry before removing it from the plastic cup.

### QUESTIONS

- 1 Identify the steps in the procedure that represent deposition, compaction and cementation.
- 2 Compare your 'sandstone' to a real sample of sandstone. What are the similarities? What are the differences?
- 3 What did the investigation demonstrate about the formation of sandstone?
- 4 What are the safety risks in this investigation?
- 5 What safety advice could you offer to address the safety risks?

### CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.



Investigation **6.6B**

# Observing sedimentary rocks



**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 observe samples of sedimentary rocks

**MATERIALS**

- selection of sedimentary rocks (e.g. sandstone, conglomerate, mudstone, shale, limestone)
- magnifying glass

**METHOD**

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Carefully observe each rock sample with the magnifying glass, and record your observations in your table.

**QUESTIONS**

- 1 Which rock contained the largest sediments?
- 2 Which rock contained the smallest sediments?
- 3 Large sediments are deposited in high-energy environments and small sediments are deposited in low-energy environments. Identify the rock that was deposited in the:
  - a highest energy environment
  - b lowest energy environment.
- 4 Explain why some of your samples did not have obvious layers, even though they are still sedimentary rocks.
- 5 You are walking through the bush and find a rock outcrop. What observations do you need to make to confirm that it is a sedimentary rock?

**CONCLUSION**

Copy and complete:  
 'The results show that: *(respond to the aim)*'.

**RESULTS** TABLE I6.6B

Rock name	Size of sediments (mm)	Obvious layers present? (yes/no)	Other observations (e.g. colour, presence of fossils)



## Investigation 6.7A

# Modelling weathering due to temperature change

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 how extreme temperature can weather rocks

### MATERIALS

- piece of granite (approx. 20 × 20 × 20 mm)
- piece of quartzite (approx. 20 × 20 × 20 mm)
- 250 mL beaker
- water
- Bunsen burner
- heatproof mat
- matches
- brass tongs
- paper towel

### METHOD

- 1 Half fill the beaker with tap water.
- 2 Set up the Bunsen burner on the heatproof mat.
- 3 Using the tongs, heat the granite sample in the blue flame for 2 minutes.
- 4 Quickly put the sample in the beaker of water so it is covered. (This is called quenching.)
- 5 Record your observations.
- 6 Retrieve the sample from the water and pat dry with the paper towel.
- 7 Repeat steps 3–6 another four times.
- 8 Repeat the method for the quartzite sample.

### QUESTIONS

- 1 Describe what happened to the granite sample after heating and quenching once. How did this change during the repetitions?
- 2 Describe what happened to the quartzite sample after heating and quenching once. How did this change during the repetitions?
- 3 What natural process is this investigation representing? Describe an environment where it might happen.
- 4 Granite is an igneous rock made of at least three different minerals, and quartzite is a metamorphic rock made of one mineral. Consider how this may affect how quickly they weather.
- 5 Is this investigation representing chemical or physical weathering?

### CONCLUSION

Copy and complete:

'The results show that: (respond to the aim)'.



**OPEN FLAME IS A HAZARD. TAKE CAUTION. DO NOT TOUCH THE HOT GRANITE - IT WILL BE EXTREMELY HOT.**

**FIRST AID: TELL YOUR TEACHER IMMEDIATELY ABOUT ANY INJURIES. TREAT BURNS OR SCALDS BY PLACING THE SKIN UNDER COLD RUNNING WATER FOR 20 MINUTES.**

Investigation **6.7B**

# Modelling weathering due to acid rain

**TEACHER DEMONSTRATION**

30 min

**AIM**

To investigate how acid can react with rocks and chemically weather them

**MATERIALS**

- small (less than  $1 \times 1 \times 1$  cm) pieces of each of limestone, sandstone and granite
- 1 mol/L hydrochloric acid
- 3 test tubes
- test-tube rack
- camera (optional)

**METHOD**

- 1 Your teacher will place one piece of each type of rock in three separate test tubes in the test tube rack.
- 2 They will then add hydrochloric acid to the test tubes to cover the rocks.
- 3 Record any initial observations.
- 4 The samples will be left until the end of the lesson or overnight before you consider them again to make final observations. You may like to include photos and drawings in your results and observations.

**QUESTIONS**

- 1 What evidence was there that chemical weathering happened?
- 2 Were your observations the same for all rock types?
- 3 Would you expect to observe the same reactions if you added water instead of acid? Justify your response.
- 4 Acid rain happens when pollution causes rain to be very acidic. What might you expect to happen to monuments and buildings made of limestone that are exposed to acid rain?

**CONCLUSION**

Copy and complete:

'The results show that: (*respond to the aim*)'.



## Investigation 6.8

# Making 'fossils'



## 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 model the formation of a fossil

## MATERIALS

- shell or other item
- plasticine
- plaster of Paris
- popstick
- plastic cup
- water
- plastic container (e.g. take-away food container)
- camera (optional)

## METHOD

- 1 Carefully add water to the plaster of Paris in a plastic cup and mix with a popstick until it is the same consistency as toothpaste.
- 2 Press the plasticine into the base of the plastic container and smooth the top.
- 3 Press the shell or other item into the plasticine to make an imprint, then remove it.
- 4 Carefully add a 1–2 cm layer of plaster of Paris on top of the plasticine. Tap the container down to remove any air bubbles.
- 5 Leave the plaster to dry.
- 6 Carefully separate the plaster from the plasticine.
- 7 Record your observations. You may like to photograph the plaster and the plasticine to support your observations.

## QUESTIONS

- 1 Identify which of the plasticine and plaster is the mould and which is the cast. Propose a procedure you could carry out that would swap the two.
- 2 Use the terms *deposition*, *compaction* and *cementation* to compare the method you followed to the process of fossilisation.

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



# Investigation 7.1



## Rolling balls

### 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 on page 129 to help you.

### AIM

To investigate the relationship between gravitational potential energy and kinetic energy

### MATERIALS

- balls or marbles with different masses
- electronic balance
- inclined plane
- ruler or tape measure
- milk carton or small, empty box

### METHOD

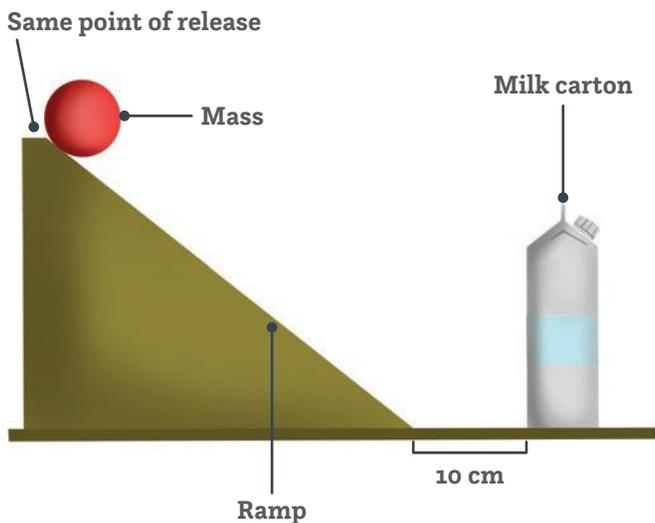
- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Set up the ramp and the box or milk carton as shown.
- 3 Record the mass of each ball.
- 4 Roll each ball down the inclined plane. Measure the distance that it moves the carton when the ball hits it.
- 5 Repeat the test five times with each ball.
- 6 Calculate the average of the five trials.

### QUESTIONS

- 1 Which ball had the most gravitational potential energy?
- 2 What variable contributed to this?
- 3 What is the other variable that contributes to gravitational potential energy?
- 4 Design an experiment that would investigate the variable you identified in question 3 and its relationship to gravitational potential energy.

### CONCLUSION

Copy and complete:  
 'The results show that: (respond to the aim).'



**RESULTS** TABLE I7.1

Ball mass (g)	Distance (cm) (trial 1)	Distance (cm) (trial 2)	Distance (cm) (trial 3)	Distance (cm) (trial 4)	Distance (cm) (trial 5)	Average distance (cm)

## Investigation 7.2A

# Conduction – heat energy transfer in a solid

20 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 how heat energy is conducted in a solid

## MATERIALS

- metal bar
- wax beads
- retort stand with bosshead and clamp
- Bunsen burner
- matches
- tray



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.

## METHOD

- 1 Set up the apparatus as shown.
- 2 Light the Bunsen burner.
- 3 Observe the metal bar and wax beads, and record your observations.

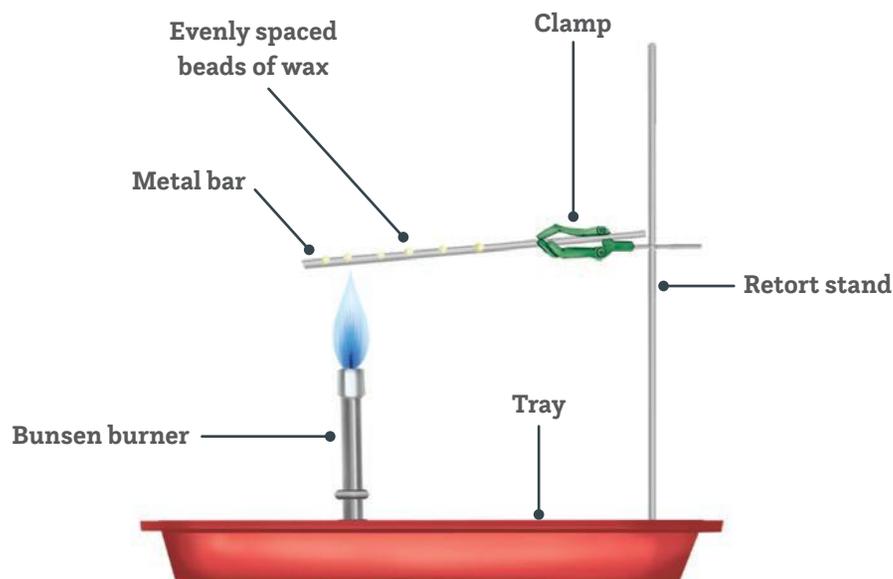
## QUESTIONS

- 1 Explain how heat is conducted in a solid, using your observations from this investigation.
- 2 Design an experiment to demonstrate that heat energy is transferred through different metals at different rates.
- 3 Design an experiment to determine which materials are good at conducting heat energy.

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



## Investigation 7.2B

# Convection – heat energy transfer in a liquid



## 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 heat energy is transferred in a liquid

## MATERIALS

- 2 L beaker
- small conical flask
- cold water
- hot water
- red food colouring
- string or long-handled tongs

## METHOD

- 1 Add cold water to the beaker until it is 3 cm from the top.
- 2 Tie the string around the neck of the conical flask.
- 3 Place a few drops of red food colouring into the conical flask, then fill it almost to the top with hot water.
- 4 Using the string or the long-handled tongs, carefully lower the small conical flask into the beaker. Take care not to spill the hot water or disturb the flask too much.
- 5 Record your observations.

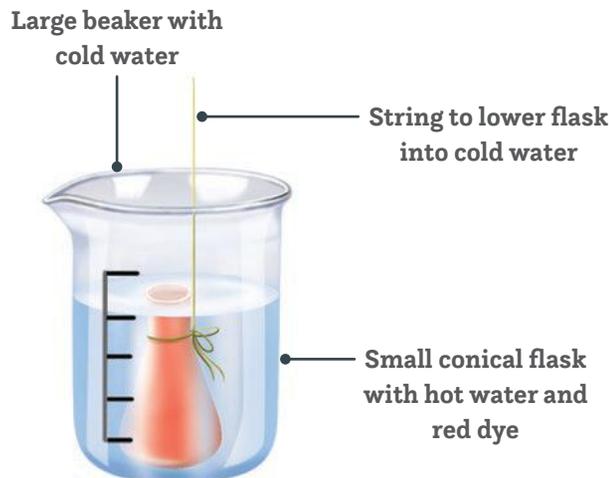
## QUESTIONS

- 1 Draw a diagram that shows the movement of the hot water in the cold.
- 2 Explain how convection works in a liquid, using your observations from this investigation.

## CONCLUSION

Copy and complete:

'The results show that: (*respond to the aim*)'.



## Investigation 7.2C

# Radiation and colour



## 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 relationship between colour and transfer of radiant heat energy

## MATERIALS

- 6 test tubes
- test-tube rack
- 5 pieces of coloured paper (black, white, red, blue and green)
- 6 thermometers
- scissors
- tape
- water
- heat source (sunlight or a heat lamp)

## METHOD

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Cut the paper to size and wrap one colour around each test tube, securing with tape. Leave one test tube uncovered as a control.
- 3 Fill each test tube with the same volume of water and place in the test-tube rack.
- 4 Place a thermometer in each test tube and allow enough time for the temperature to stabilise.
- 5 Record this initial temperature in your table at time 0 minutes.
- 6 Leave the test tubes in sunlight, or near the heat lamp, and record the temperature for each colour every 5 minutes for half an hour.

## QUESTIONS

- 1 Which colours transmitted the most radiant heat energy?
- 2 Which colours transmitted the least amount of radiant heat energy?
- 3 Explain what radiant heat energy is, in your own words.

## CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'



**TAKE CAUTION USING THE HEAT LAMP. IF YOU BURN YOURSELF, TELL YOUR TEACHER IMMEDIATELY AND PLACE THE BURNT AREA UNDER COLD RUNNING WATER FOR 20 MINUTES.**

RESULTS TABLE I7.2C

Time (min)	Temperature (°C)					
	Control	Black paper	White paper	Red paper	Blue paper	Green paper

## Investigation 7.4

# Waves in a slinky

### 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 movement of waves in a slinky and to calculate the frequency of waves

#### MATERIALS

- slinky
- stopwatch
- masking tape
- metre ruler

#### METHOD

- 1 Copy the results table into your notebook, adding a title.
- 2 With a partner, stretch the slinky along the ground and mark the length with masking tape.
- 3 Measure this distance with the ruler.
- 4 Produce small transverse (up and down) waves. Use the stopwatch and count how many waves are produced in 10 seconds. Then calculate the frequency in hertz (Hz).

$$\text{Frequency (Hz)} = \frac{\text{number of waves}}{\text{time}}$$

- 5 Produce large transverse (up and down) waves. Use the stopwatch and count how many waves are produced in 10 seconds.
- 6 Produce small longitudinal waves (back-and-forth). Use the stopwatch and count how many waves are produced in 10 seconds.
- 7 Produce large longitudinal waves (back-and-forth). Use the stopwatch and count how many waves are produced in 10 seconds.
- 8 Repeat steps 4–7 twice and average your three results for each.
- 9 Record all your measurements in your results table.

### RESULTS TABLE I7.4

Wave	Small waves (number of waves per second) (Hz)				Large waves (number of waves per second) (Hz)			
	Trial 1	Trial 2	Trial 3	Average	Trial 1	Trial 2	Trial 3	Average
Longitudinal								
Transverse								

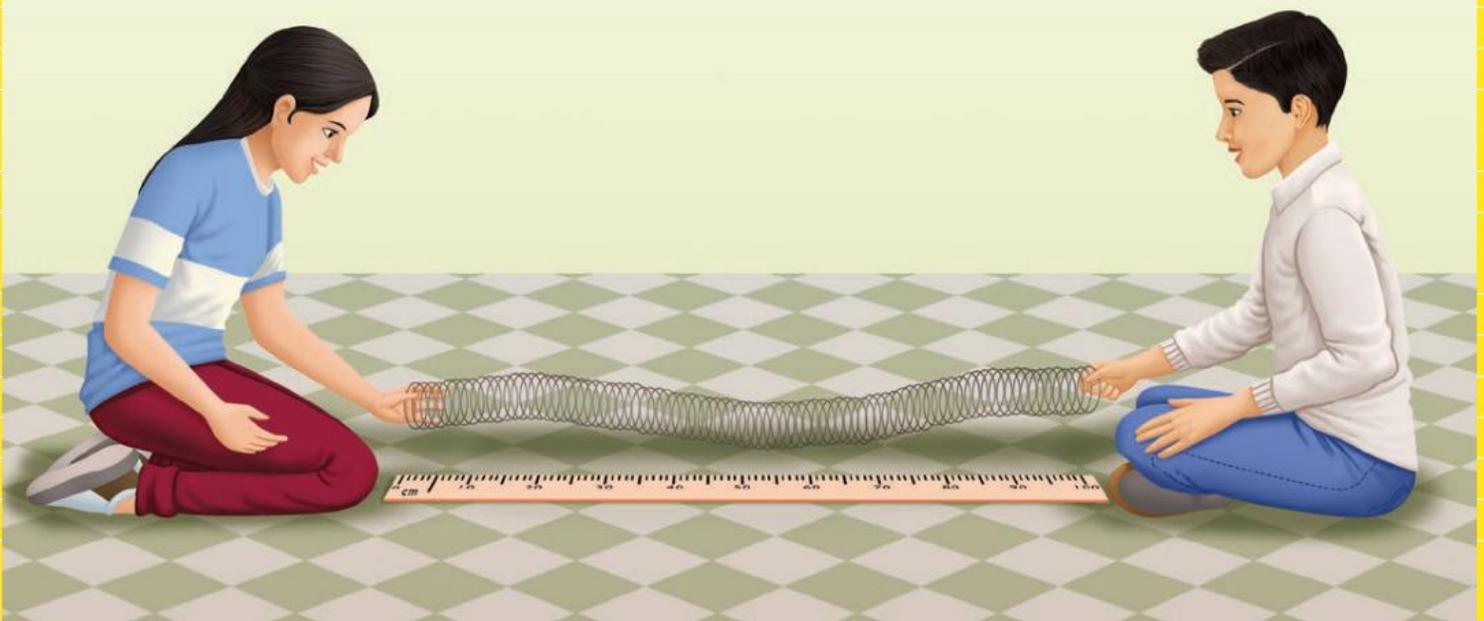


## QUESTIONS

- 1 List the independent, dependent and controlled variables.
- 2 Which wave is faster?
- 3 Draw and label the two types of waves investigated.
- 4 Explain the difference between longitudinal and transverse waves.
- 5 Describe how frequency is calculated.

## CONCLUSION

The two waves investigated are \_\_\_\_\_ and \_\_\_\_\_. The \_\_\_\_\_ wave produced by the slinky has an up-and-down motion and the \_\_\_\_\_ wave produced by the slinky has a back-and-forth motion. The average frequency calculated for the longitudinal wave is \_\_\_\_\_ per second (Hz) and the average frequency calculated for the transverse wave is \_\_\_\_\_ waves per second (Hz).



## Investigation 7.7A

# The law of reflection



### 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.

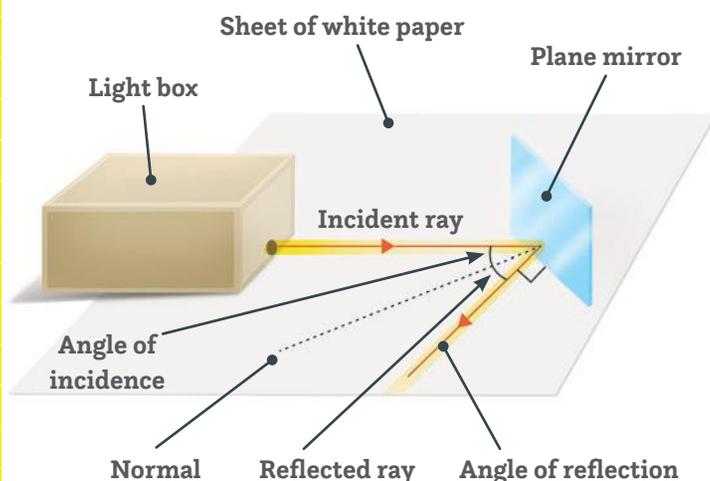
**Hint #2:** Your research question can also be used as a title for an experiment report.

#### AIM

To investigate the law of reflection

#### MATERIALS

- plane mirror
- concave and convex mirrors
- light box and power supply
- single slit plate
- protractor
- pencil
- sheet of white paper



### RESULTS TABLE I7.7A

Ray	Angle of incidence (degrees)	Angle of reflection (degrees)
1		
2		
3		

#### METHOD

- 1 Copy the results table into your notebook, adding a title. Write the headings *Concave mirror diagram* and *Convex mirror diagram* on the paper.
- 2 Set up your equipment, using the plane (flat) mirror, as shown in the diagram. Trace the mirror and the incident and reflected rays of light onto the paper.
- 3 Measure the angles that the incident ray (incoming ray) and reflected ray make to the normal. Record your results in the results table.
- 4 Repeat your experiment using at least three different angles of incidence.
- 5 Predict what will happen when rays of light strike a curved mirror. Will they be spread out (diverged) or brought together (converged)? Test your predictions with a concave mirror and a convex mirror.

#### QUESTIONS

- 1 Briefly describe the law of reflection.
- 2 Do your results support the law of reflection?
- 3 Compare what happened when light hit a concave mirror and a convex mirror.

#### CONCLUSION

Copy and complete.

'The results show that: (*respond to the aim*)'.

Investigation 7.7B

# Refraction



**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 observe refraction of light using different lenses

**MATERIALS**

- rectangular prism
- concave and convex lenses
- light box and power supply
- single slit plate
- pencil
- sheet of white paper

**METHOD**

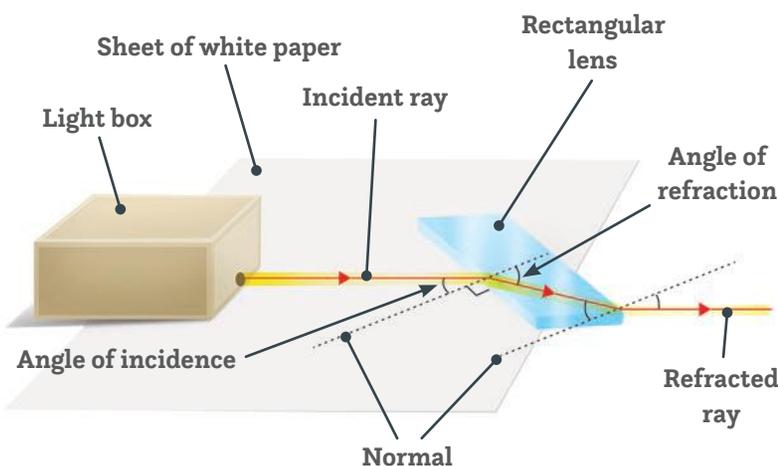
- 1 Copy the results table into your notebook, adding a title. Write the headings *Concave lens diagram* and *Convex lens diagram* on the paper.
- 2 Set up your equipment as shown in the diagram.
- 3 Direct a single ray of light to the centre of the prism.
- 4 Use the pencil to trace the path of the ray as it is refracted through the lens and out of the prism.
- 5 Remove the prism and use the protractor to measure the angle of incidence and angle of refraction. Record your results.
- 6 Repeat steps 3–5 using three angles of light from a light box with a concave lens and then with a convex lens. Trace the path of rays using your pencil.

**QUESTIONS**

- 1 Compare the angle of light before it enters the rectangular prism and after it exits. Is there a difference? Explain why.
- 2 Compare what happened when light hit a concave lens and a convex lens.

**CONCLUSION**

Copy and complete.  
 'The results show that: (respond to the aim).'



**RESULTS** TABLE I7.7B

Ray	Angle of incidence (degrees)	Angle of refraction (degrees)
Light entering glass from air		
Light entering air from glass		

## Investigation 7.8

# Concave and convex lenses

### 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 how changing the arrangement of lenses affects an image projected on a screen

### MATERIALS

- light box (that can produce 3 parallel beams of light)
- convex lens
- concave lens
- ruler
- piece of white card to use as a screen

### METHOD

- 1 Copy the results table into your notebook, adding a title and rows as needed.
- 2 Set up the lightbox so that it is 10 cm away from the screen. Turn on the light box so that there are three beams showing on the screen. Using your ruler, measure the width of the image (the distance between the far left and far right beams).
- 3 Place the convex lens 2 cm away from the light box, between it and the screen. Observe the beams on the screen. Measure and record the distance between the far left and far right beams.
- 4 Repeat step 3 with the convex lens at distances of 4 cm, 6 cm, and 8 cm away from the light box.
- 5 Repeat steps 3 and 4 using the concave lens instead of the convex lens.

- 6 Place both lenses between the light box and the screen, so that the light passes through each lens. Move the lenses until you have projected an image on the screen that is exactly twice as wide as the original beams. Record the distance of each lens from the light box.
- 7 Repeat step 6, but move the lenses until you have projected an image that is exactly half as wide as the original beams. Record the distance of each lens from the light box.

**RESULTS** TABLE I7.8

Lens type	Distance from light box (cm)	Width of image (cm)
None		
Convex	2	
Convex	4	

### QUESTIONS

- 1 Describe what happened to the projected image as the convex lens moved further away from the light box.
- 2 Describe what happened to the projected image as the concave lens moved further away from the light box.
- 3 Using your results, can you estimate the focal length of the convex lens? Explain your answer.
- 4 When using both lenses together, which lens was closest to the lightbox when forming:
  - a the larger image?
  - b the smaller image?
- 5 Explain why the lenses were arranged in this way.
- 6 Explain how this experiment could be used to model:
  - a eyeglasses
  - b a telescope.

### CONCLUSION

Copy and complete:

'The results show that: (respond to the aim).'

# GLOSSARY

**adhesion** the 'sticking' of molecules to other substances

**aerobic respiration** how living organisms produce energy using oxygen

**amplitude** the height of a wave measured from its midpoint

**angle of incidence** the angle at which light hits a surface

**angle of reflection** the angle at which light reflects from a surface

**asthenosphere** the thin zone of the mantle just beneath the lithosphere

**atom** the smallest unit of an element

**binary fission** a process where very simple cells divide into identical halves

**biodegradable** able to be broken down by natural processes; for example, by bacteria

**blackwater** water from toilets, urinals or other sources that has come in contact with human waste

**blood vessel** a tube such as a vein or artery that carries blood in the body

**body system** a group of organs working together

**brittle** not able to be bent; will break if stressed

**cancer** the uncontrolled growth of cells in some part of the body, which then spreads to other body parts

**cartilage** connective tissue that holds bones together

**cast** an object created when sediment or minerals fill a mould

**cell** the smallest functional unit of an organism

**cell membrane** a thin layer around a cell that controls the substances going in and out

**cell wall** a stiff layer around a plant or fungal cell that supports the cell

**chemical bond** a force that holds atoms together

**chemical change** a change in properties, with a new substance formed

**chemical formula** a group of chemical symbols showing the number of atoms of each element in a compound

**chemical sedimentary rock** sedimentary rock formed from layers of mineral crystals that have crystallised from water

**chemical symbol** a symbol of one or two letters used to represent an element

**chemist** a scientist who studies elements and compounds

**chlorophyll** the green pigment in chloroplasts that enables photosynthesis

**chloroplast** a small organelle that allows plants to make food

**chromosome** a thread-like molecule of genetic information in the nucleus of a cell

**clastic sedimentary rock** sedimentary rock formed from sediments cemented together

**cohesion** the 'sticking' of molecules to each other

**collaboration** working cooperatively together

**compound** a substance containing atoms of two or more elements bonded together in a fixed ratio

**concave** curving inwards

**condensation** changing from a gas to a liquid

**conduction** the transfer of heat from one place to another in solids

**conductor** a material that is good at transferring heat or electricity

**conglomerate rock** sedimentary rock made of large, rounded pebbles and fragments cemented together

**contact metamorphism** the process of change that happens to a rock over small areas, often near volcanoes

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

**controversial** creating public disagreement and debate

**convection** the transfer of heat from one place to another in gases and liquids

**convex** curving outwards

**core** Earth's central layer, made up of a liquid outer core and a solid inner core

**corrosion** the breaking down or destruction of a substance, especially a metal, through a chemical reaction

**crust** Earth's thin outer layer

**crystal** a solid substance made up of very ordered microscopic parts

**cultural significance** importance to a particular culture

**cytoplasm** a jelly-like fluid in which the other parts of a cell sit

**dam** a wall built across a waterway so that water collects on one side of it

**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

**deposition** a process in which sediment is left in a new place

**differentiate** to change to have a particular function

**differentiated cell** a cell that has specialised functions

**digestion** the physical and chemical processes that break down food in the body

**ecosystem** a system of living things and their environment

**electrolysis** passing electricity through a substance to break it up

**electromagnetic spectrum** all the different electromagnetic waves

**electron** a negatively charged particle that moves around the nucleus of an atom

**element** a substance made up of only one type of atom

**embryo** an early stage of development of an unborn baby

**enzyme** a chemical that speeds up a reaction (e.g. digestion of food)

**epidermis** the outer layer of cells

**erosion** a process in which sediments are moved from one place to another

**ethical** relating to principles about what people think is 'wrong' and 'right'

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

**evaporation** changing from a liquid to a gas

**excretion** the elimination of cellular waste from the body

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

**extrusive igneous rock** igneous rock formed at Earth's surface

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

**fertilise** to join a sperm with an ovum

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

**foetus** a later stage of development of an unborn baby

**fossil** the preserved remains or traces of once-living things

**fossil fuel** a natural fuel formed over millions of years from the remains of living things

**fossilisation** the process of a fossil forming

**frequency** the number of waves passing a point every second

**gamma ray** radiation emitted by radioactive materials

**geological history** how Earth has changed over time

**glucose** a type of sugar that is the energy source for cells

**greywater** water from washing, laundry or other sources that has not come in contact with human waste

**groundwater** water within soil and rocks in the ground

**hormone** a chemical substance produced by the body that controls the activity of certain cells or organs

**humane** compassionate and sympathetic

**hydrophilic** water-attracting

**hydrophobic** water-repelling

**hypothesis** a scientific statement that can be tested

**igneous rock** rock formed by the cooling of molten rock

**independent variable** the thing that is purposely changed during an investigation

**inference** an educated judgement based on observations

**infrared light** an electromagnetic wave with longer wavelength than red light

**insulator** a material that is poor at transferring heat or electricity

**intrusive igneous rock** igneous rock formed under Earth's surface

**landform** a natural feature of Earth's surface

**lattice** a three-dimensional shape made up of a repeating pattern of atoms

**lava** molten (melted) rock at Earth's surface

**lens** a specially shaped piece of glass used to enlarge or shrink images

**lithosphere** Earth's rigid outer zone (crust and upper mantle), made up of tectonic plates

**longitudinal** running lengthwise rather than across

**magma** molten (melted) rock under Earth's surface

**malleable** able to be bent and shaped

**mantle** Earth's middle layer, made up of an upper mantle and a lower mantle

**mass** the amount of matter in a physical body

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

**meiosis** complex cell division, where new cells are not identical to the original cell

**metamorphic rock** rock formed from another rock that has been changed by heat and pressure

**metamorphism** the process of change that happens to a rock because of heat, pressure or both

**microscope** an instrument used to look at objects too small to see with the naked eye

**mineral** a naturally occurring inorganic (non-living) substance

**mitochondria** the organelles where respiration happens

**mitosis** simple cell division, where new cells are identical to the original cell

**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

**molecule** two or more atoms chemically bonded together

**motion** the change in position of an object over time

**mould** a hollow impression formed by an imprint of an organism, or when the original bone or shell has dissolved

**multicellular** made of more than one cell

**neutron** a neutrally charged particle found in the nucleus of an atom

**Nobel Prizes** world-famous awards given each year for academic, cultural and scientific advances

**nuclear medicine** the branch of medicine to do with the use of radioactive substances in research, diagnosis and treatment

**nucleus (atom)** the centre of an atom, which contains protons and neutrons

**nucleus (cell)** the control centre of a cell; DNA is found inside the nucleus

**observation** something you see and know to be true

**opaque** doesn't allow any light to pass through

**organ** a group of tissues with a specific function

**organelle** a cell structure that has a membrane around it (usually)

**organic sedimentary rock** sedimentary rock formed from the remains of plants or animals

**palaeontologist** a scientist who studies fossils

- periodic table** a table of all known elements and their chemical symbols
- photosynthesis** the chemical reaction, powered by sunlight, that plants use to change carbon dioxide and water into sugars and oxygen
- physical change** a change in appearance, with no new substances formed
- physical property** a characteristic that can be seen or measured (e.g. colour, shape, hardness)
- pistil** the female reproductive organs of a flower (stigma, style and ovary)
- pollen** the fine, powdery substance in the flowers of plants, which contains male sex cells
- pollination** the movement of pollen from the male part of the plant (anther) to the female part (stigma)
- polymer** a substance consisting of large molecules made up of many small repeating units
- precipitation** water falling from clouds as a solid (e.g. hail) or liquid (e.g. rain)
- prediction** a statement about the future based on observation and evidence
- primary data** first-hand data, from your own investigation
- product** a substance formed during a chemical reaction
- prokaryote** an organism without a nucleus or structures inside its cell(s)
- proton** a positively charged particle found in the nucleus of an atom
- protozoan** a unicellular eukaryote that moves and feeds on organic matter
- qualitative** written descriptions and observations
- quantitative** numerical information and data
- radiation** the transfer of heat that doesn't require contact with matter
- reactant** a substance that takes part in a chemical reaction
- reflect** to send back sound or light without absorbing it
- refract** to bend (light)
- regional metamorphism** the process of change that happens to rock over large areas
- relative age** which rocks are younger and which rocks are older when compared with one another
- reliable** provides consistent results when repeated
- research** to gather data and information in an organised way to inform a hypothesis or an investigation
- respiration** a chemical reaction that converts glucose to energy
- retina** the part of the eye that images are focused onto
- reversible** can be taken back to its previous state
- run-off** water that runs off the surface of the land into waterways such as rivers
- secondary data** second-hand data, from someone else
- sediment** small particles of rocks such as clay, sand and pebbles
- sedimentary rock** rock formed by sediments that have been pressed together
- seismic wave** a wave of energy caused by an earthquake or explosion
- sequence** the order of something
- solidify** become a solid
- sonar** sound navigation and ranging
- stamen** the male reproductive organs of a flower (anther and filament)
- stem cell** a cell that can produce a different type of cell and divide to make more cells
- stomata** pores on the surface of a leaf; the site of gas exchange in plants
- substance** matter that has a fixed chemical make-up
- system** a set of simple things that work together as a more complex whole
- tectonic plate** a plate made up of the mantle and crust of the lithosphere
- tendon** connective tissue that connects muscle to bone
- theory** an explanation that can be supported or disproved using evidence
- tissue** a group of cells with a similar structure and function
- transfer** to move from one place or object to another
- transform** to change from one type to another
- translucent** allows some light to pass through
- transparent** allows light to pass through
- transpiration** how water in the soil travels through plants
- transverse** running across rather than lengthwise
- unicellular** made of one cell
- vacuum** empty space
- valid** measures what is intended to be measured
- vascular tissue** the tissue that transports fluids and nutrients through a plant
- water vapour** the gas state of water
- wavelength** the distance from the peak of one wave to the next
- weathering** a process in which rocks are worn down into smaller particles
- X-ray** a high-energy ray that can penetrate materials
- zygote** the first single cell of new life

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