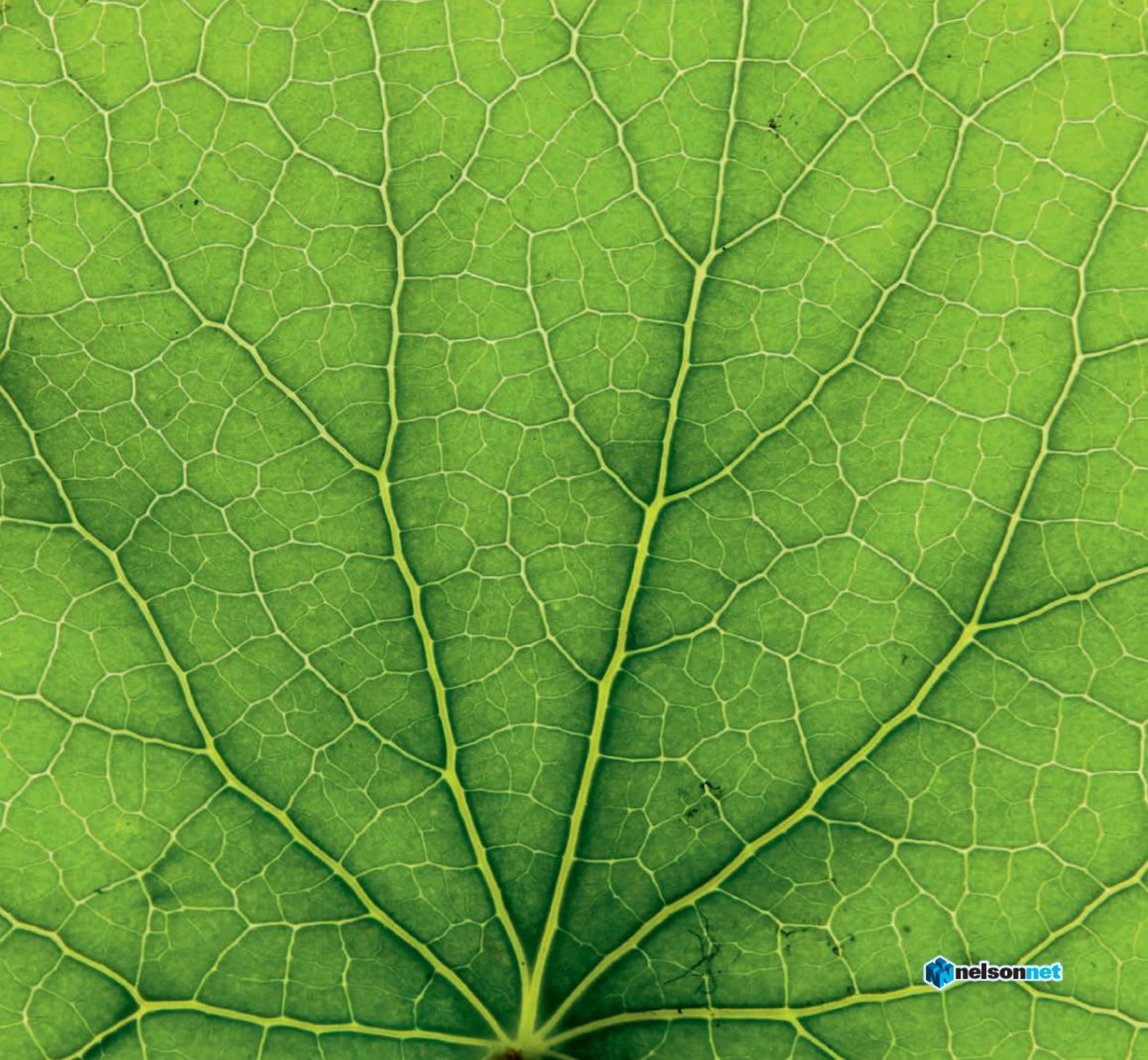
nelson iscience 8

for the Australian Curriculum • NSW Stage 4

Robert FARR • Anna DAVIS • Elizabeth MCKENNA • Rebecca SMYTH • Katrina WALKER



Key

atomic number
Symbol
element name

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H hydrogen																	2 He helium
2	3 Li lithium	4 Be beryllium											5 B boron	6 C carbon	7 N nitrogen	8 O oxygen	9 F fluorine	10 Ne neon
3	11 Na sodium	12 Mg magnesium											13 Al aluminium	14 Si silicon	15 P phosphorus	16 S sulfur	17 Cl chlorine	18 Ar argon
4	19 K potassium	20 Ca calcium	21 Sc scandium	22 Ti titanium	23 V vanadium	24 Cr chromium	25 Mn manganese	26 Fe iron	27 Co cobalt	28 Ni nickel	29 Cu copper	30 Zn zinc	31 Ga gallium	32 Ge germanium	33 As arsenic	34 Se selenium	35 Br bromine	36 Kr krypton
5	37 Rb rubidium	38 Sr stronium	39 Y yttrium	40 Zr zirconium	41 Nb niobium	42 Mo molybdenum	43 Tc technetium	44 Ru ruthenium	45 Rh rhodium	46 Pd palladium	47 Ag silver	48 Cd cadmium	49 In indium	50 Sn tin	51 Sb antimony	52 Te tellurium	53 I iodine	54 Xe xenon
6	55 Cs caesium	56 Ba barium	57–71 lanthanides	72 Hf hafnium	73 Ta tantalum	74 W tungsten	75 Re rhenium	76 Os osmium	77 Ir iridium	78 Pt platinum	79 Au gold	80 Hg mercury	81 Tl thallium	82 Pb lead	83 Bi bismuth	84 Po polonium	85 At astatine	86 Rn radon
7	87 Fr francium	88 Ra radium	89–103 actinides	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium		114 Fl flerovium		116 Lv livermorium		

57 La lanthanium	58 Ce cerium	59 Pr praseodymium	60 Nd neodymium	61 Pm promethium	62 Sm samarium	63 Eu europium	64 Gd gadolinium	65 Tb terbium	66 Dy dysprosium	67 Ho holmium	68 Er erbium	69 Tm thulium	70 Yb ytterbium	71 Lu lutetium
89 Ac actinium	90 Th thorium	91 Pa protactinium	92 U uranium	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

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iscience8

for the **Australian Curriculum • NSW Stage 4**

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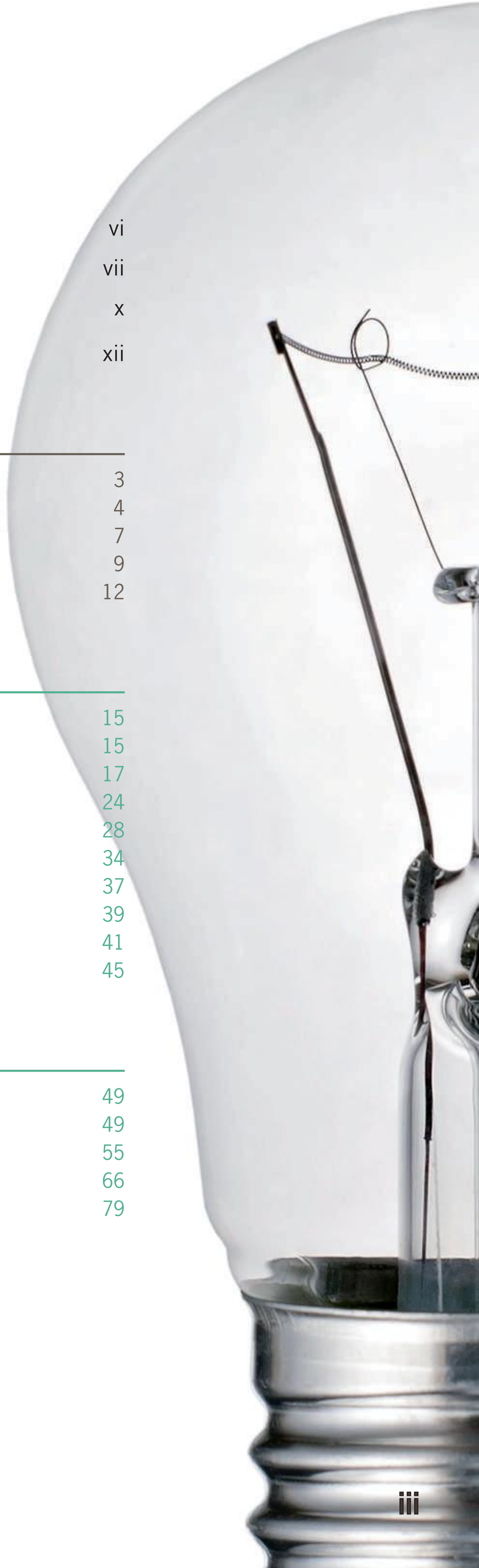


4 Ecosystems

5 Elements

6 Chemical changes

7 Forms of energy

8 Electricity

9 Managing Earth's resources

Introduction

The New South Wales Syllabus for the Australian Curriculum – Science provides the opportunity to immerse students in the wonder and awe of science. It emphasises that science is a creative and collaborative human endeavour that helps students make sense of their world. Having an understanding of science assists students to be effective and successful members of society, especially in this rapidly changing technological world. More than this, the new syllabus enables students to gain practical and thinking skills that they can benefit from throughout their lives.

The authors of the *Nelson iScience for NSW* series have embraced the New South Wales Syllabus for the Australian Curriculum – Science and produced a truly 21st-century science resource for students. *Nelson iScience for NSW* provides a resource that fully integrates the strands and aims of the new syllabus into the fascinating story of Science.

Nelson iScience for NSW combines higher-order thinking tools and ICT to promote innovative and creative problem-solving and approaches to learning science. It builds on the collaborative nature of learning by enabling students to learn with and from one another by sharing their work, ideas and thoughts through the vast capabilities of ICT.

Nelson iScience for NSW has adopted a differentiated practical approach to the learning of Science, providing many opportunities for hands-on and minds-on activities. Many of these activities challenge students, assisting them in organising their thoughts and understandings. Many others require students to unpack information and ideas and repackage or manipulate them to show their understanding. The series provides each student with many and diverse opportunities to excel.

Whether students continue with the study of Science or not, they are sure to learn lifelong and valuable lessons and skills that are transferrable from the *Nelson iScience for NSW* series.

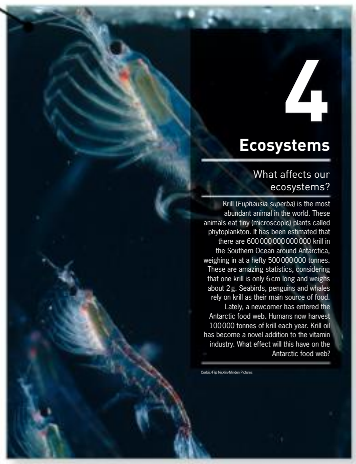
How to use *Nelson iScience for NSW*

The *Nelson iScience for NSW* series has been authored by practising teachers from across Australia to meet the requirements of the New South Wales Syllabus for the Australian Curriculum – Science. The *Nelson iScience* series integrates the three strands of the Australian Curriculum, integrating the depth and full scope of the NSW syllabus.

Nelson iScience for NSW has been designed for use by the students of the 21st century. It seamlessly while integrates the use of ICT in the science classroom to research, analyse, record, collaborate and present material. Higher-order thinking skills are developed and reinforced throughout the series, providing students with strategies to manipulate information and ideas to tackle issues and assist with problem-solving.

The *Nelson iScience for NSW* series has a clear, uncluttered and easy-to-follow design.

Each chapter begins with a chapter opening page that features a unit question based around one of the overarching ideas of the NSW Syllabus for the Australian Curriculum – Science. The chapter question is designed to ignite student curiosity. It also provides a framework on which teachers build students' knowledge. Each idea is further developed in subsequent chapters, showing that these key aspects of science bridge scientific knowledge and understanding across all levels and disciplines of science.


4

Ecosystems

What affects our ecosystems?

Krill (*Euphausia superba*) is the most abundant animal in the world. These animals eat tiny (microscopic) plants called phytoplankton. It has been estimated that there are 600 000 000 000 000 krill in the Southern Ocean around Antarctica, weighing in at a hefty 500 000 000 tonnes. These are amazing statistics, considering that one krill is only 6 cm long and weighs about 2 g. Seabirds, penguins and whales rely on krill as their main source of food. Lately, a newcomer has entered the Antarctic food web. Humans now harvest 100 000 tonnes of krill each year. Krill oil has become a novel addition to the vitamin industry. What effect will this have on the Antarctic food web?

Corbis/Flip Nicklin/Minden Pictures

Students are challenged to think about What do you already know about …? at the start of each chapter. This is designed to determine what understandings and skills each student brings into each topic, and enables teachers to customise the chapter to build on their students' current knowledge and skills.

The culminating assessment task is presented towards the beginning of each chapter so that students can plan their time to complete the task. The culminating assessment task is designed to assess the understandings and skills presented in each chapter. Each culminating assessment task is accompanied by an assessment rubric so that students are aware of the criteria on which they will be assessed.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Chapter 4 • Ecosystems

Living world – Stage 4

Key knowledge

- Food chains and food webs exist in all ecosystems.
- Ecosystems are made up of different interactions between producers, consumers and decomposers. These interactions can be represented by food webs and food chains.
- Human activities such as overfishing or land clearing can disrupt interactions in food webs and impact the health of an ecosystem.
- Australian plants and animals have special adaptations to survive and reproduce in environments such as deserts or tropical forests.
- Resource management knowledge from Aboriginal and Torres Strait Islanders can be applied to help better care for Australia's ecosystems.
- Technology and scientific research, along with other private and government agencies, work together to develop and manage ecosystems after natural disasters and human impact, including development in agricultural and horticultural processes.

ACTIVITY SHEET
CAT with rubric: Food webs in your environment

CULMINATING ASSESSMENT TASK

Food webs in your environment

Urban environments have food webs too. **Investigate** the plants and animals living around your school, neighbourhood or another location selected by your teacher. **Demonstrate** the feeding relationships, using photographs or drawings, and **construct** at least one food chain. **Synthesise** your food chain with others from the class to **construct** a local food web.

What do you already know about ecosystems?

WORKSPACE
What do you already know about ecosystems?

Figure 4.1 Australian ecosystems: **a** Great Barrier Reef **b** Simpson Desert **c** Daintree Rainforest **d** Murray River red gum forest

climate
the weather conditions found in a region over a period of time

biotic
any living part of the ecosystem, such as plants, animals, micro-organisms

abiotic
any non-living factor, such as salinity, pH, humidity, wind, soil

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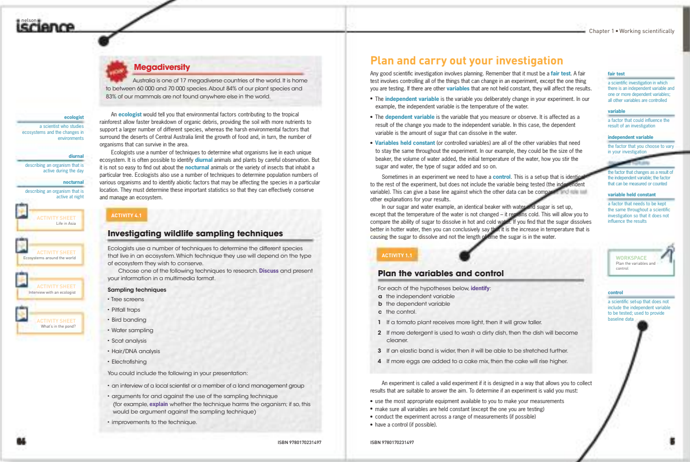
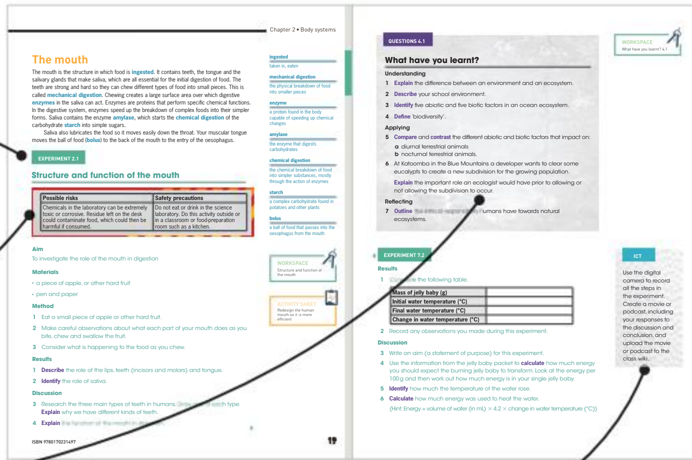


WOW! boxes provide interesting and engaging information related to the content of the chapter.

ACTIVITY 1.1

Activity boxes occur throughout each chapter, providing practical minds-on or hands-on activities to reinforce student learning. Activity boxes build and reinforce valuable skills related to the science inquiry skills strand. Many activities are suitable for homework or extension exercises.

Glossary terms are conveniently located in the margins as students meet new scientific words.



EXPERIMENT 4.1

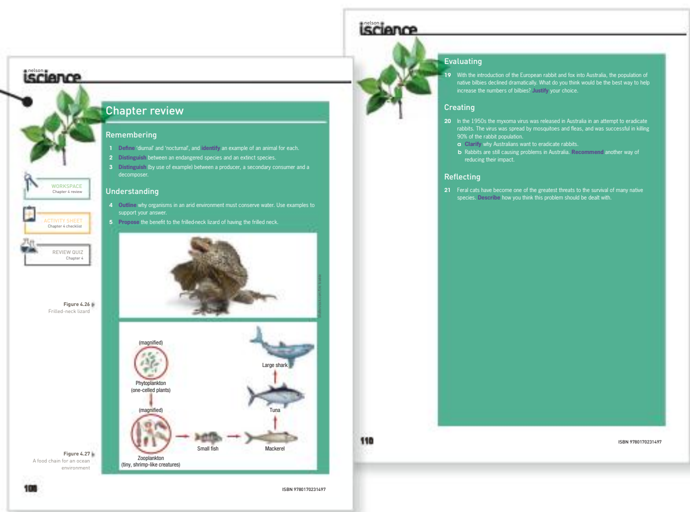
Experiments allow students to follow procedures, collect data, perform guided experiments and analyse results. Experiment – Investigations challenge students to test their own hypotheses by designing and performing their own experiments. Safety audit boxes alert teachers and students to some of the risks associated with completing the experiment. Experiments build and reinforce valuable skills related to the Science inquiry skills strand.

QUESTIONS 4.1

What have you learnt? boxes break the chapter content into smaller chunks. They allow students to review and assess their learning. Questions are categorised according to Bloom's Revised Taxonomy, designed to extend each student's thinking and understanding.

ICT

ICT boxes throughout the chapters give optional suggestions on how ICT applications can be used to assist with the delivery or presentation of content and student learning.



The end-of-chapter review consists of an interactive autocorrecting review quiz, a chapter checklist to assist students with revising for a test, and a set of end-of-chapter review questions. These questions, similar to other questions throughout the chapters, are categorised according to Bloom's Revised Taxonomy to extend each student's thinking and understanding.

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NelsonNet is your protected portal to the premium digital resources for Nelson textbooks located at www.nelsonnet.com.au. Once your registration is complete, you will have access to exciting and stimulating digital resources that supplement and complement each chapter. They include the following.

WORKSPACES are provided throughout each chapter. These are spaces in which students can complete the work required within the chapter. Workspaces can be either printed out or filled in on-screen and submitted electronically to the teacher.

ACTIVITY SHEETS provide extra activities, literacy exercises, questions and more that can be used either within class or as homework and extension material. Activity sheets can be either printed out or filled in on-screen and submitted electronically to the teacher.

INTERACTIVES provide learning objects that the student can interact with and use at their own pace to reinforce their learning.

ANIMATIONS provide students with animated illustrations from the student text.

WEBLINKS link students to websites on the Internet.

VIDEOS direct students to video clips to aid with learning and understanding.

REVIEW QUIZZES appear at the end of each chapter. Each quiz contains 10 multiple-choice items and is interactive and autocorrecting.

WORKSPACE

ACTIVITY SHEET

INTERACTIVES

ANIMATIONS

WEBLINKS

VIDEO

REVIEW QUIZZES

Nelson iScience for NSW NelsonNetBook

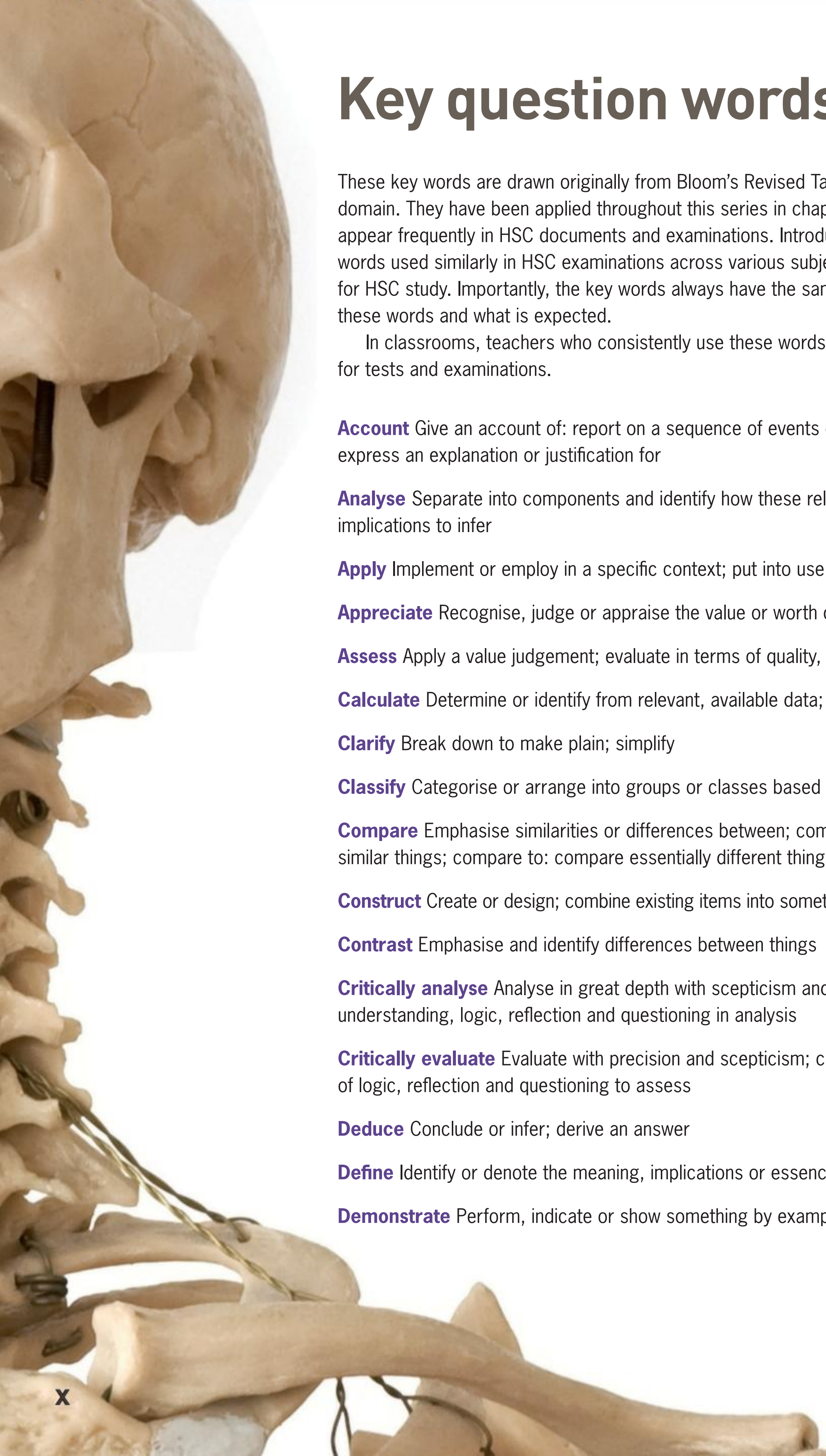
NelsonNetBook is a web-based downloadable ebook for secondary schools, friendly to interactive whiteboards and computers. Optional ICT functionality enables class groups and individuals to add highlights, annotations, audio clips and weblinks. Visit the NelsonNet portal at www.nelsonnet.com.au to find out more, to register or to log in if already registered.

NelsonNetBook allows both teachers and students to personalise the book and for teachers to share their enriched version with groups of students, or a group of teachers, in the school. Alternatively, students can simply use the resource independently without being in a group. The creation and membership of the groups is entirely in the hands of the teacher, and the shared environment is protected through individual access codes and school registration.

The NelsonNetBook becomes central to everything the students do. It loads onto the screen with toolbars down the side and along the bottom (can be interchanged as per the user's preference). The icons on the toolbars correspond to editing features, such as highlighting, note-taking, inserting weblinks, bookmarking, inserting video links and inserting worksheets, as well as for more personalised activities.

Nelson iScience for NSW teacher companion site

The teacher will have access to assessment material and detailed curriculum grids that map in detail the chapters to the science curriculum strands, teaching plans for each chapter and a pdf of the student book.



Key question words

These key words are drawn originally from Bloom's Revised Taxonomy for the cognitive learning domain. They have been applied throughout this series in chapter questions. Many of these appear frequently in HSC documents and examinations. Introducing students to specific key words used similarly in HSC examinations across various subjects helps them to better prepare for HSC study. Importantly, the key words always have the same meaning. Students understand these words and what is expected.

In classrooms, teachers who consistently use these words will better prepare their students for tests and examinations.

Account Give an account of: report on a sequence of events or transactions; account for: express an explanation or justification for

Analyse Separate into components and identify how these relate to each other; use implications to infer

Apply Implement or employ in a specific context; put into use

Appreciate Recognise, judge or appraise the value or worth of

Assess Apply a value judgement; evaluate in terms of quality, size, results or outcomes

Calculate Determine or identify from relevant, available data; score or quantify

Clarify Break down to make plain; simplify

Classify Categorise or arrange into groups or classes based on similar features

Compare Emphasise similarities or differences between; compare with: compare essentially similar things; compare to: compare essentially different things

Construct Create or design; combine existing items into something new; build arguments or plans

Contrast Emphasise and identify differences between things

Critically analyse Analyse in great depth with scepticism and objectivity; use knowledge and understanding, logic, reflection and questioning in analysis

Critically evaluate Evaluate with precision and scepticism; carefully consider; apply elements of logic, reflection and questioning to assess

Deduce Conclude or infer; derive an answer

Define Identify or denote the meaning, implications or essence of

Demonstrate Perform, indicate or show something by example

Describe State attributes and characteristics; answer 'what?'

Design Create or build something for a purpose; come up with a plan for a purpose

Discuss Engage in conversation about; consider issues and problems; describe; argue for and/or against

Distinguish Make distinct from; note how things differ

Evaluate Apply criteria, reasons or evidence to judge or identify the value of

Examine Inspect or investigate in great depth; take stock of

Explain Give reasons for; demonstrate relationships between; show cause and effect; answer 'why?' and 'how?'

Extract Select a relevant and appropriate part of the whole

Extrapolate Predict, infer and conclude from given information

Identify Name, label or recognise

Illustrate Use examples to make plain, simplify or prove

Interpret Define; translate or make sense of something

Investigate Scrutinise, question and explore thoroughly

Justify Provide proof for an argument or conclusion

List Arrange items, words or names one after the other, sometimes in a specific order

Modify Make small changes to something, especially to improve

Outline Summarise the main characteristics of; describe in general terms

Predict Use available information to anticipate a possible outcome

Propose Recommend an action; present an idea or point of view for consideration

Recall Draw on remembered facts

Recommend Approve or advocate for

Recount Give a detailed account of a sequence of events; retell as a narrative

Relate Identify and describe the links between two or more things, or people

Show Make something evident in a clear way, possibly using examples

Summarise State only the essential details; provide a succinct overview of

Synthesise Draw together knowledge and information into a harmonious whole

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1

Working scientifically

Where do maggots come from? Of course, you know they come from eggs laid by flies; however, in the 17th century, people thought maggots arose from meat. Italian scientist Francesco Redi used the scientific method to prove that living maggots could not come from non-living substances such as meat. Can you imagine how he designed this simple controlled experiment?

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Working scientifically – Stage 4

Key knowledge

- Science inquiry skills (observing, questioning, inferring and predicting) are required to investigate problems.
- Planning an experiment requires the student to consider a problem to be investigated, the equipment required, the method to follow, and how the data is to be collected and analysed.
- Independent, dependent and controlled variables are elements of fair testing.
- A scientific report is made up of a number of elements such as an aim, hypothesis, materials, method, results, discussion and conclusion.
- A safety audit is used to minimise risks when conducting an experiment.
- Following a method correctly improves the likelihood that the results collected will represent what is being tested.
- Qualitative data is information that is collected that does not have a numerical value.
- Quantitative data is numerical information that can be collected using equipment such as stopwatches, rulers, or thermometers.
- The reliability of an experiment can be improved by repeating the experiment a number of times.
- The validity of an experiment can be improved by ensuring all elements of a fair test are followed and the correct equipment is used.
- Diagrams, tables and graphs can be used to organise information in an experiment.
- Scientific experiments require modifications when problems are encountered.
- Scientific ideas can be communicated in a variety of ways.

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What do you already know about working scientifically?

Chris and Jess were rolling up hundreds of old newspapers and using elastic bands to secure them at each end. But the elastic bands kept breaking. They decided to test which elastic band stretches the greatest distance. After formulating a method, they carried out their experiment and then wrote it up, as shown below.

Aim

I want to use the elastic band that stretches the most and is the strongest.

Materials

One thick red elastic band approximately 10 cm long, one thin light brown one approximately 5 cm long; one dark brown elastic band 5 cm long (but with a thickness in between the other two); a tape measure

Method

We have a hook screwed into our back fence, 30 cm above the ground. We decided to hook the elastic bands (one at a time) onto the hook and then stretch the band parallel to the ground as far as we can, until just before breaking. Jess then tries to use the tape measure to measure the distance each elastic band has stretched. She didn't find it easy. We recorded the distance each rubber band had stretched in cm.

Results

Type of elastic band	Red	Light brown	Dark brown
Distance the band stretched	25 cm	10.1 cm	13.7 cm

Conclusion

The red elastic band is best to hold the newspapers.

There are problems with Chris and Jess's experiment and the way they have written their scientific report.

1 **Identify** any headings that are missing from their scientific report.

2 The aim is not written correctly for what they are trying to test.

- **a** **Identify** two things wrong with their aim.
- **b** Rewrite the aim for their intended experiment.

3
- **a** **Identify** the independent and dependent variables for their intended experiment.
- **b** **Identify** the variables they should have held constant to make this a fair test.

4 **Construct** their table as it should appear.

WORKSPACE
What do you already know about working scientifically?

ISBN 9780170231497

1.1 The scientific method

In *iScience 7* you learnt many new science skills. You learnt how to use and draw scientific equipment properly. You learnt the difference between observations, predictions and inferences. You became better at following a set procedure when carrying out experiments and you may have even planned investigations to solve problems or questions. You will continue to use these skills throughout the rest of your science schooling, so it is important that you consistently revise these ideas.

scientific method

a set of rules that enables scientists to plan and conduct experiments in a consistent and repeatable way

As you have already learnt, any good experiment must follow the **scientific method**. If it doesn't, you cannot be sure that the results you obtain from your experiments will allow you to answer the question you are proposing. Below are the basic steps of the scientific method that you learnt in *iScience 7*.

When following the scientific method you:

- ask a question
- formulate a hypothesis
- plan and carry out your investigation
- collect and analyse your data
- draw conclusions and evaluate your investigation.

Ask a question

When you think of something you want to test you often ask yourself a question. This question often begins with what, why, how, which, who or where. For example:

- How does the temperature of water affect how much sugar dissolves?
- Which type of soil allows the best drainage?
- Where can I place a plant seedling so that it grows the fastest?

Not all questions can be tested in the school laboratory. 'Why do birds sing?' is a question, but it is not a question that can be easily answered by performing an experiment.

Formulate a hypothesis

hypothesis

an educated guess or prediction that can be tested in a scientific way, usually written in the form: 'If . . . then . . .'

After you have posed a question, you make an educated guess (a prediction) about what you think might happen. This is called a **hypothesis**. A hypothesis needs to be able to be tested in a scientific way. The hypothesis is written as a statement, often using 'if . . ., then . . .'

'*If* the temperature of the water is increased, *then* more sugar will dissolve in the water.' Alternatively it can be written as: 'A greater mass of sugar will dissolve in a set volume of water, *if* the water is at a higher temperature.' One seems more scientific than the other, but both hypotheses talk about the effect on the sugar (more will dissolve), the dependent variable, because of the change that you make to the water (increasing the temperature), the independent variable.

refute

to show to be false; to disprove

As we saw in *iScience 7*, Chapter 2, it is not possible to 'prove' a hypothesis. The results of an experiment will either support or **refute** your hypothesis. Either way, a hypothesis is just a statement explaining what you *think* might happen. It does not matter if it is incorrect, only that it is relevant to your aim and written correctly.

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Plan and carry out your investigation

Any good scientific investigation involves planning. Remember that it must be a **fair test**. A fair test involves controlling all of the things that can change in an experiment, except the one thing you are testing. If there are other **variables** that are not held constant, they will affect the results.

- The **independent variable** is the variable you deliberately change in your experiment. In our example, the independent variable is the temperature of the water.
- The **dependent variable** is the variable that you measure or observe. It is affected as a result of the change you made to the independent variable. In this case, the dependent variable is the amount of sugar that can dissolve in the water.
- **Variables held constant** (or controlled variables) are all of the other variables that need to stay the same throughout the experiment. In our example, they could be the size of the beaker, the volume of water added, the initial temperature of the water, how you stir the sugar and water, the type of sugar added and so on.

Sometimes in an experiment we need to have a **control**. This is a set-up that is identical to the rest of the experiment, but does not include the variable being tested (the independent variable). This can give a base line against which the other data can be compared and rule out other explanations for your results.

In our sugar and water example, an identical beaker with water and sugar is set up, except that the temperature of the water is not changed – it remains cold. This will allow you to compare the ability of sugar to dissolve in hot and cold water. If you find that the sugar dissolves better in hotter water, then you can conclusively say that it is the increase in temperature that is causing the sugar to dissolve and not the length of time the sugar is in the water.

fair test
a scientific investigation in which there is an independent variable and one or more dependent variables; all other variables are controlled

variable
a factor that could influence the result of an investigation

independent variable
the factor that you choose to vary in your investigation

dependent variable
the factor that changes as a result of the independent variable; the factor that can be measured or counted

variable held constant
a factor that needs to be kept the same throughout a scientific investigation so that it does not influence the results

ACTIVITY 1.1

Plan the variables and control

For each of the hypotheses below, **identify**:

a the independent variable
b the dependent variable
c the control.

1. If a tomato plant receives more light, then it will grow taller.
2. If more detergent is used to wash a dirty dish, then the dish will become cleaner.
3. If an elastic band is wider, then it will be able to be stretched further.
4. If more eggs are added to a cake mix, then the cake will rise higher.

WORKSPACE
Plan the variables and control

control
a scientific set-up that does not include the independent variable to be tested; used to provide baseline data

An experiment is called a valid experiment if it is designed in a way that allows you to collect results that are suitable to answer the aim. To determine if an experiment is valid you must:

- use the most appropriate equipment available to you to make your measurements
- make sure all variables are held constant (except the one you are testing)
- conduct the experiment across a range of measurements (if possible)
- have a control (if possible).

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In our example of testing the amount of sugar that dissolves at different temperatures, a way we could make it a more valid experiment would be to use a temperature probe rather than a thermometer (as it is more accurate), and add the sugar to water samples at five different temperatures (20°C, 40°C, 60°C, 80°C, 100°C) rather than just two.

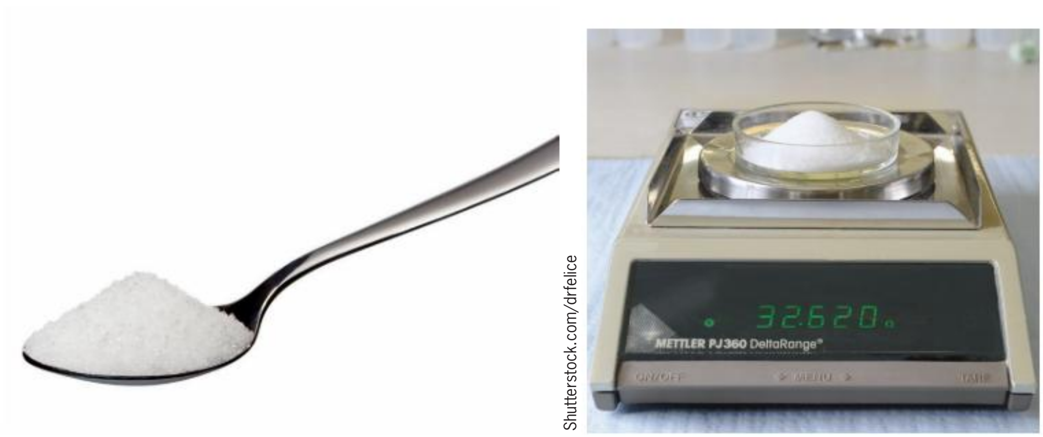
To check the reliability of your investigation, repeat it. If you get results that are very similar or the same, you can be fairly sure this was not due to luck or accident. If the results are the same, it is a reliable investigation. If the results are very different, it isn't reliable. This means there must be some part of the experiment that is not controlled properly.

Repetition is an important part of the scientific method. If a scientific finding is to be taken seriously, other scientists must be able to follow the same method and achieve the same results.

Collect and analyse your data

Before you start an experiment you need to think about the data you will collect. In the sugar–water example, you will be adding a set amount of sugar to the water. Will you use 'number of teaspoons' or will you use an electronic balance? How will you measure the temperature of the water at each stage? Will you use a thermometer, or a temperature probe? Will you repeat the experiment? If so how many times? How will you record or display this data? Will you write it down, video it or both?

When you have collected all your data, what are you going to do with it? Will you list the data in a table? How are you going to analyse it or work out what it is telling you? Will you graph the data? How are you going to work out if your data is accurate?



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Mark Fergus Photography

Figure 1.1 Which is more accurate: the teaspoon or the electronic balance?

Draw conclusions and evaluate your investigation

Once you have worked out what your data is telling you, you need to look back at your aim. Does the data support or refute the aim?

You also need to look back at your experimental method. Did you encounter any problems, limitations or faults that would need fixing if you were to carry out this investigation again? It is important to remember that limitations to a method are not the same as mistakes that you might make, such as spilling some of the sugar or reading the thermometer incorrectly. Each time you carry out an experiment it is assumed that you have followed the method correctly.

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EXPERIMENT 1.1

Planning a fair test: how does the height of a ramp affect how far a toy car travels?

WORKSPACE
Planning a fair test: how does the height of a ramp affect how far a toy car travels?

Your challenge

Working in a group of two or three, plan a fair test to find out if the vertical height of a ramp affects how far a toy car travels. Make sure that you plan to test at least three different ramp heights.

This might help

Reread the section on the scientific method (pages 4–6).

- **Identify** your question.
- Write this as an aim.
- What do you think will happen in the experiment? Write this as a hypothesis.
- **Identify** the equipment you will need.
- **Describe** any risks involved with this experiment. **Identify** how you will manage (control) these risks to stay safe.
- **Identify** your independent and dependent variables.
- **Identify** the variables that need to be held constant in order for this to be a fair test.
- **Describe** how you will collect your results and what measuring equipment you will use.
- **Describe** how you could best display and **analyse** your results.

You do not need to carry out this experiment yet.

1.2 Writing a scientific report

A scientific report is a systematic way of displaying what you have done and what you have found. It follows a specific set of elements in a particular order. Your scientific report should always follow the order of title, aim, hypothesis, materials, method, results, discussion and conclusion. It should also be written in a way that would allow others to understand exactly what you were trying to test, what you did, and what you found out.

Title

The title of your report needs to reflect what your investigation is about.

Aim

The aim states the purpose of your investigation. It is expressed in general terms and often begins: 'To investigate . . .' or 'To determine . . .'

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Hypothesis

The hypothesis is more specific than the aim. It is a prediction of what you think might happen. It is a statement that might or might not be true, and is often written in the form: 'If . . ., then . . .' Your investigation will test the hypothesis by collecting data to support or refute it.

Materials

This is a list of the equipment and materials you will need to carry out your investigation. It should include numbers and/or quantities such as 'three 250 mL beakers' or '2.5 grams of salt'.

Method

The method is a set of step-by-step numbered instructions that show exactly what you will do to carry out your investigation. Remember that other people should be able to repeat your investigation using these instructions. Your method should also be impersonal, i.e. not use terms such as I or we.

Results

The results section is extremely important. Results show what you have found in your investigation. The results section can include tables that you have created to display your data or information. Remember that the independent variable should be in the first column of your table. The results section can also include graphs and any calculations you have made when analysing your data. Remember that, when drawing a graph you need to give it a title, and that the independent variable is always on the *x*-axis. Be sure to label your graph appropriately. If your graph includes numerical data, you should use an appropriate scale. In the results section, do not make conclusions about what you think has happened.

Discussion

This is where your results are summarised, described and analysed. Any problems encountered during the investigation are discussed here, as well as possible ways to improve the experiment. However, the discussion relates only to the results that you obtained in the investigation. Do not discuss what should have happened or what you would have liked to happen.

Conclusion

The conclusion is a clear statement of what your investigation found. A conclusion is usually a statement that answers your aim. Never restate your results in your conclusion.

Extra information in a scientific report

A risk assessment or safety audit is often also done before an experiment. This is where you identify any possible safety risks, and assess how you are going to manage them. Although it is not a general heading in a scientific report, it is often useful to write it (and place it) after you have written your method, as this is often when you will determine where any risks will occur. A risk assessment should always be written before you carry out your experiment. If you are using any chemicals in an experiment, it is

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important that you read the labels on the bottles to identify any possible risks and add these to your risk assessment.

A diagram is often useful to show the way the equipment is set up and can reduce the length of your method and make it easier for others to follow. It is usually placed after the method.

1.3 Example of a scientific report

The effect of vegetable oil temperature on the time taken for a ball bearing to fall

Possible risks	Safety precautions
Hot water and glassware can cause burns.	Do not fill the beaker with water. Remove hot glassware using heat mitts where necessary
Electronic hotplates can cause burns.	Ensure you keep hands away from the hotplate and turn it off when not in use.

Aim

To investigate the effect of temperature of vegetable oil on the time taken for a ball bearing to fall through it

Hypothesis

The higher the temperature of the vegetable oil, the less time it will take for the ball bearing to fall.

Materials

- 9 × 50 mL measuring cylinders
- 3 × 500 mL beakers
- fridge
- electronic hotplate
- water
- vegetable oil (at room temperature)
- 9 small ball bearings (the same size and mass)
- stopwatch
- 3 thermometers

Method

1 Fill each measuring cylinder with 50 mL of vegetable oil.

2 Place 3 measuring cylinders in the fridge and leave 3 more at room temperature. You will work with the remaining 3 in the next step.

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3 Half fill the 3 beakers with warm water and place them on the hotplate. When the water reaches about 70°C (measured using the thermometer), turn off the hotplate, and place the remaining 3 measuring cylinders of oil into the beakers of hot water.

4 Use a thermometer to record the temperature of the oil in one measuring cylinder.

5 When the oil temperature reaches 55°C, drop a ball bearing into the oil and use the stopwatch to time how long it takes to reach the bottom from the surface of the oil, in seconds (to the nearest half of a second).

6 Repeat step **5** with each of the other two 'hot water' cylinders, then average your results.

7 Repeat steps **4–6** for the measuring cylinders at room temperature and in the fridge.

8 Tabulate your results.

9 Graph temperature versus average time for your results.

Results

Table 1.1

A table to show the time taken for a ball bearing to drop through 50 mL of vegetable oil at three different temperatures

Temperature (°C)	Time taken for a ball bearing to fall through 50 mL (s)			
	Trial 1	Trial 2	Trial 3	Average
5	81.0	79.5	80.0	80.0
20	8.0	8.5	9.0	8.5
55	1.5	2.0	2.0	2.0

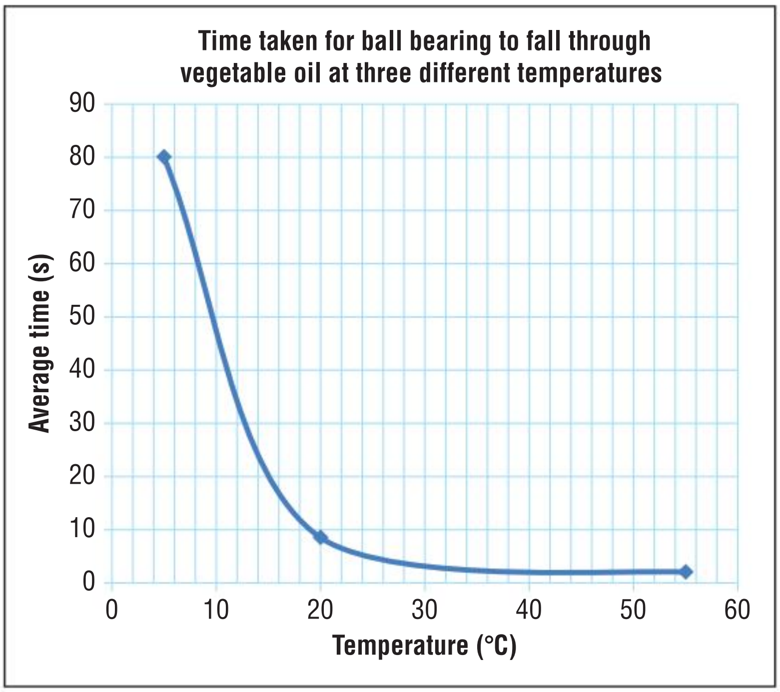

Figure 1.2
Time taken for ball bearing to fall through vegetable oil at three different temperatures

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The ball bearing fell faster the higher the temperature of the oil. It took approximately 10 times longer to fall at 5°C than at 20°C.

Discussion

There was a clear trend with the effect of temperature on the speed of the falling ball bearing. The colder temperature appears to do something to make the ball bearing fall more slowly. At hotter temperatures, the oil seems runnier and that helps the ball bearing drop faster.

The experiment was repeated three times for each temperature and the results collected were fairly close (within a suitable margin of error). Reliability could be improved if we repeated it more times.

A temperature probe with a data logger could have been used instead of a thermometer to collect more accurate results. A greater range of temperatures could have been tested (at least two more) to achieve a better trend.

The main thing affecting the validity was keeping all other variables constant. The temperature of the oil could have changed during the three trials, leading to inaccurate results. Three different measuring cylinders were used with each temperature, meaning the total volume of oil in each could have been slightly different. But mostly, validity is affected by human error with the stopwatch. At 55°C the time was very quick – 1.5–2 seconds – which is hard to measure accurately with a stopwatch. However, the results show that the data was fairly close, which means the experiment was fairly valid.

Conclusion

As the temperature of vegetable oil increases, the time taken for a ball bearing to fall decreases.

ACTIVITY SHEET
Spot the errors

EXPERIMENT 1.2

Performing an experiment and writing up a scientific report

1. Go back to Experiment 1.1 on page 7. Read through your plan again and make any modifications you think necessary.
2. Write a risk assessment for your experiment.
3. Carry out your experiment.
4. Collect your results and then write a scientific report with all of the correct headings, using the example of the vegetable oil investigation as a reference.

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WORKSPACE
Chapter 1 review

ACTIVITY SHEET
Chapter 1 checklist

REVIEW QUIZ
Chapter 1

Chapter review

Understanding

1 **Describe** the difference between an aim and a hypothesis.

2 **Identify** the important elements (headings) of a scientific report, in order.

3 **Define** the following terms or phrases as they relate to the scientific method:
- a independent variable
- b dependent variable
- c variables held constant
- d control
- e reliable results
- f valid results.

4 **Describe** the difference between what you display or write in 'results' and what you write in 'discussion'.

Applying

5 a Suppose that in the vegetable oil and temperature investigation you used ball bearings of different sizes for each temperature. **Explain** what effect this might have on the investigation.

b **Describe** how your results for the vegetable oil and temperature investigation would have been affected if the three cold oil samples had been placed in three different fridges. **Compare** your answer with that for an experiment in which 9 measuring cylinders were placed equally in three different fridges.

6 **Describe** a method you could follow to test this aim: 'To investigate the absorption of oil by different materials'.

Analysing

7 From the vegetable oil and temperature investigation, can you say conclusively that the time taken for a ball bearing to drop through any type of oil will take longer? **Justify** your answer.

8 Ethan said that because more sugar dissolves in hot water, it must boil faster. Olivia stated that this is not necessarily true. **Assess** their statements and **explain** how you could determine whether Ethan or Olivia (or both) was correct.

Evaluating

9 'If scientists had not come up with the scientific method, we would not know what we know about the world.' **Evaluate** this statement.

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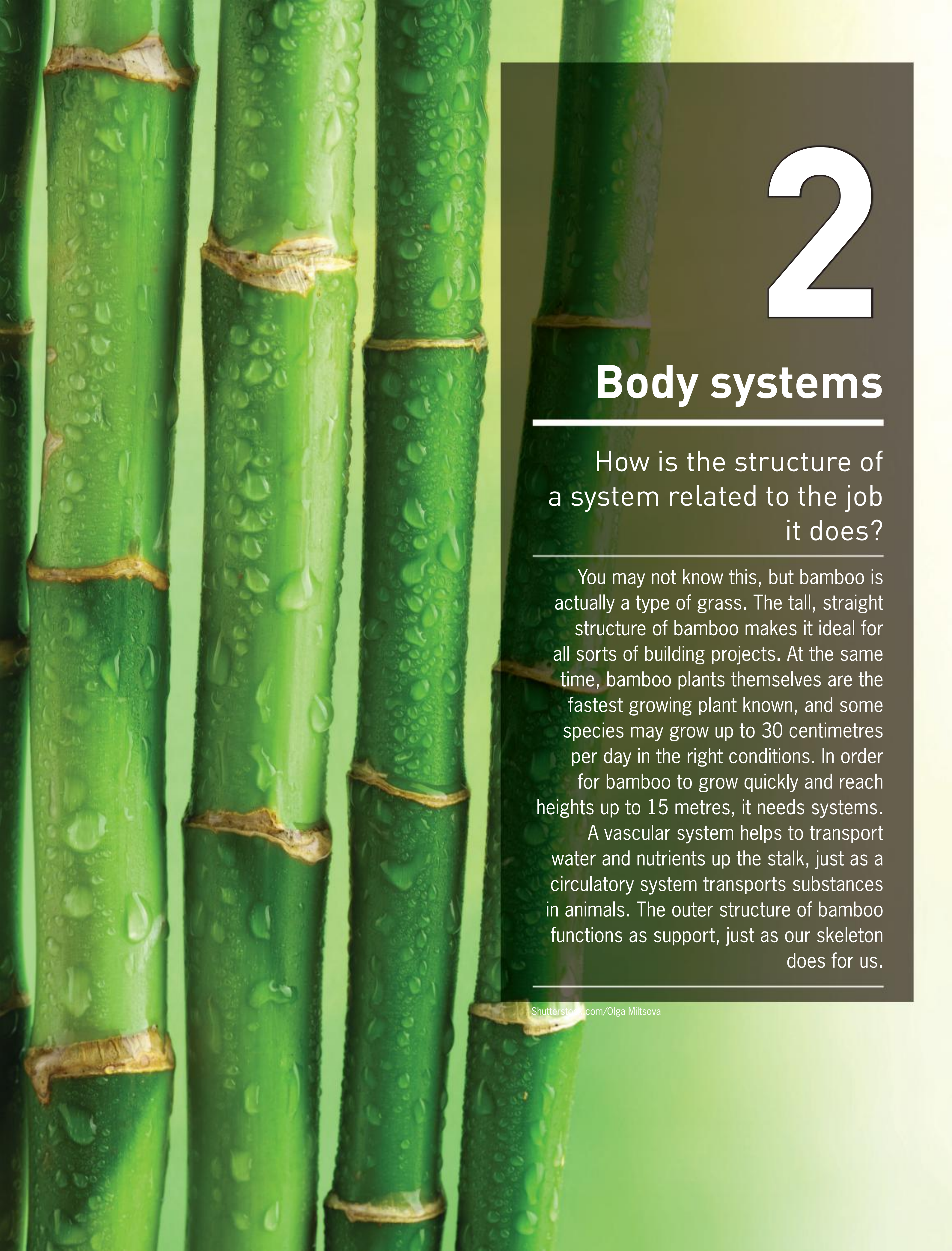

2

Body systems

How is the structure of a system related to the job it does?

You may not know this, but bamboo is actually a type of grass. The tall, straight structure of bamboo makes it ideal for all sorts of building projects. At the same time, bamboo plants themselves are the fastest growing plant known, and some species may grow up to 30 centimetres per day in the right conditions. In order for bamboo to grow quickly and reach heights up to 15 metres, it needs systems. A vascular system helps to transport water and nutrients up the stalk, just as a circulatory system transports substances in animals. The outer structure of bamboo functions as support, just as our skeleton does for us.

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Living world – Stage 4

Key knowledge

- Organs and systems are made from different types of tissues, which are made from different types of cells.
- Multicellular organisms require the interaction of specialised tissues, organs and systems to sustain life.
- In plants, the root system provides water and minerals to the plant.
- In plants, the shoot system provides carbon dioxide and chlorophyll for photosynthesis, and allows transport of substances within the plant.
- The digestive system in animals breaks food down into particles small enough that they can enter cells.
- The circulatory system in animals transports nutrients and wastes between different parts of the body.
- The excretory system in animals removes toxic products formed in the body, including carbon dioxide and urea.
- The skeletal system allows animals to move.
- The respiratory system provides animals with oxygen and removes carbon dioxide, to maintain respiration.
- The structures of body systems have adaptations that allow them to perform their functions efficiently.
- Scientific advances have helped us to better understand and better treat contemporary health issues.
- Different members of society may make different decisions about how to apply scientific knowledge to health issues such as organ donation.

ACTIVITY SHEET
CAT with rubric:
System storybook

CULMINATING ASSESSMENT TASK

System storybook

Create a storybook of the structure and function of one of the systems studied in this chapter. Imagine you are one input into that system and **describe** your journey as you travel through the system. Consider the order, structure and function of the main organs in the system. **Outline** what happens to you as you pass through each organ. **Outline** the outputs from the system.

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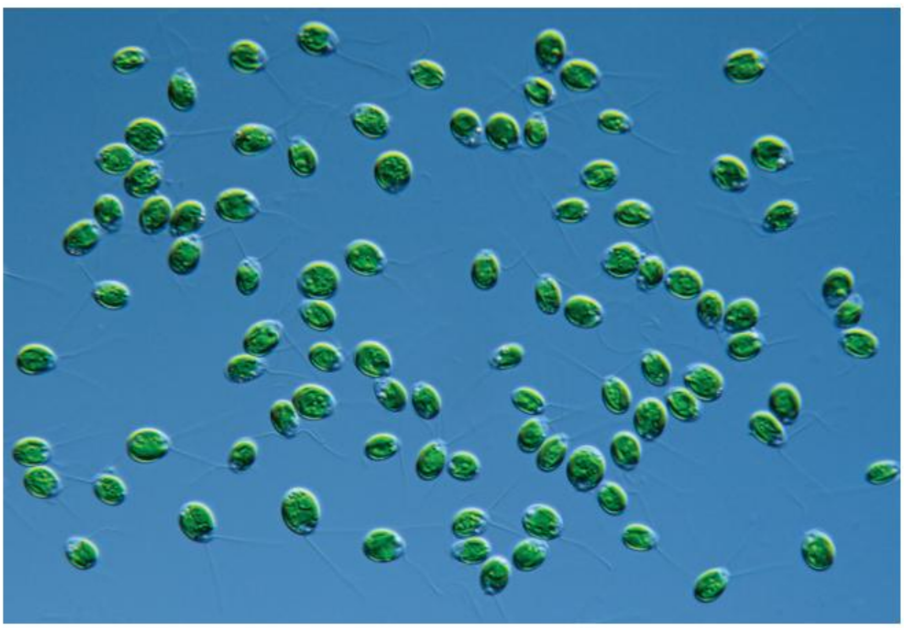
What do you already know about body systems?

1 Work in groups of three or four.
2 Together, brainstorm a list of all the organs of the body you can name.
3 Now, **identify** their function, location and approximate size.
4 Using only butcher's paper, coloured markers and sticky tape, devise a method to visually record all of the information everyone in your group knows about organs in the body.
5 Try to name the body system into which each of these organs fits.
6 **Identify** any organs of whose location you were unsure.
7 **Identify** any organs that could belong in more than one system.
8 Make a digital image of your work to refer to later.

2.1 Too big for diffusion

In *iScience 7 for NSW* you learnt that cells rely on diffusion to obtain their requirements and get rid of their wastes. This is an ideal arrangement for unicellular organisms, such as bacteria and protists. They are small and their entire surface area (cell membrane) is exposed to the outside environment. Oxygen from the air and nutrients from the water in which they live easily diffuse in.

Multicellular organisms are made up of hundreds, millions or often trillions of cells. Imagine a big ball of one trillion cells. How would the cell right in the middle of the ball obtain oxygen or nutrients? It couldn't, if it relied only on diffusion, and so it would die. The only way for the cell in the middle of the ball to survive is if the oxygen and nutrients are brought to it and its wastes are removed. This is what your respiratory, digestive, circulatory and excretory systems do. They use a system of 'pipes' to connect all the cells, bring them their requirements and remove their wastes. Together, these pipes make up some of our body systems.



Corbis/Wim van Egmond/Visuals Unlimited

Figure 2.1 Unicellular organisms can easily obtain their requirements and get rid of waste by diffusion.

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Body basics

The cell is the basic unit of all living things. A collection of cells that perform a similar function is called a **tissue**. For example, your skin cells form skin tissue. A collection of different tissues that perform a particular function is called an **organ**. For example, your heart is an organ made up of a variety of different sorts of tissues, such as muscle, fat and blood vessel tissues. A number of organs grouped together to carry out a specific job is called a **system**.

tissue
a collection of cells that have similar structure and function

organ
a collection of tissues, similar or different, that combine to perform a specific function

system
a group of organs that work together to perform a specific function

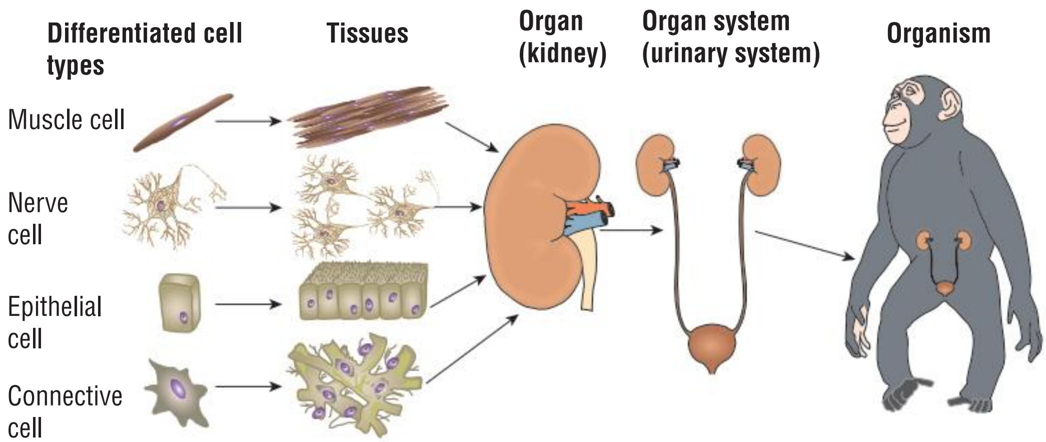

Figure 2.2 Cells, tissues, organs, systems and organisms

In this chapter, we are going to investigate how different body systems work. We will relate the structure of them to their function, and we will look at their inputs, processing and outputs.

ACTIVITY SHEET
Cells to systems

WORKSPACE
What have you learnt? 2.1

QUESTIONS 2.1

What have you learnt?

Understanding

1 **Define** 'tissue', 'organ' and 'organ system'.

2 **Describe** how cells, tissues, organs and systems are related to each other.

Applying

3 **Explain** why being multicellular means you need body systems.

Creating

4 Begin a chapter mind map. In the centre, draw an image of the human body. Draw five branches radiating out of the image. Label one branch as the digestive system, and the others as the respiratory, circulatory, excretory and skeletal systems. **Identify** any organs in each of these systems. As you proceed through this chapter, add new words and images.

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2.2 The digestive system

Inputs – nutritional requirements

We eat food to provide energy and nutrients so the body can function. The foods we eat can be classified into three main groups – **carbohydrates**, **proteins** and **fats** – which are large, complex molecules. The body cannot use the energy stored within these foods or access their nutrients in this complex form. They are too large to enter cells. The digestive system breaks these molecules down into smaller pieces: sugars, amino acids and fatty acids and glycerol, respectively. These are small enough to pass through the pores in the cell membranes and be used by the cells. Some uses are listed in Table 2.1.

carbohydrates
a complex food group found in starchy foods such as rice, potatoes and pasta

proteins
a complex food group found in foods such as meat, fish, soy beans and cheese

fats
a complex food group found in foods such as butter and cream


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Figure 2.3
This meal has plenty of carbohydrates in the bun, proteins in the meat and fat in the chips. Your body cannot use this meal in this form – it needs to be broken down.

ACTIVITY SHEET
What's in my pantry?

Table 2.1
Complex forms of food and the simpler forms they are broken down into by the digestive system

Complex form	Simple form	Where the food group is found	Use in body
Carbohydrates	Simple sugars such as glucose	Pasta, rice, bread and potatoes	Energy sources and stores
Protein	Amino acids	Meat, cheese, fish, soy beans	Can be structural as in muscle, or functional such as enzymes and hormones
Fats	Fatty acids and glycerol	Butter, oil	Energy stores, hormones, cell membranes and many organelles

Analogies can be used to represent difficult ideas. An **analogy** uses something you already know about to explain a new concept. The easiest way to think about complex foods is by thinking of a beaded necklace. The finished necklace represents the complex form. The beads are the smaller, simple form. The beads are all connected and the whole necklace is quite large. If the string is broken, all the loose beads will fall off. This breaking up of the necklace represents digestion. Each 'bead' is then much smaller than the whole 'necklace', and is small enough to enter a cell.

analogy
using something that you already know about to explain a new concept

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VIDEO
Investigating proteins using the Australian synchrotron

The cell then builds its own 'necklace' from the 'beads', usually a necklace that is very different from the original one, as the cell has different needs.

Figure 2.4 **a** Individual beads represent the simple form. **b** Beads on a string represent the complex form.

Digestion

The digestive system is essentially a long, muscular tube with different sections in which various processes occur. All the processes act to break down the food from a complex form to a simple form. This is the role of digestion.

ANIMATION
Digestive system

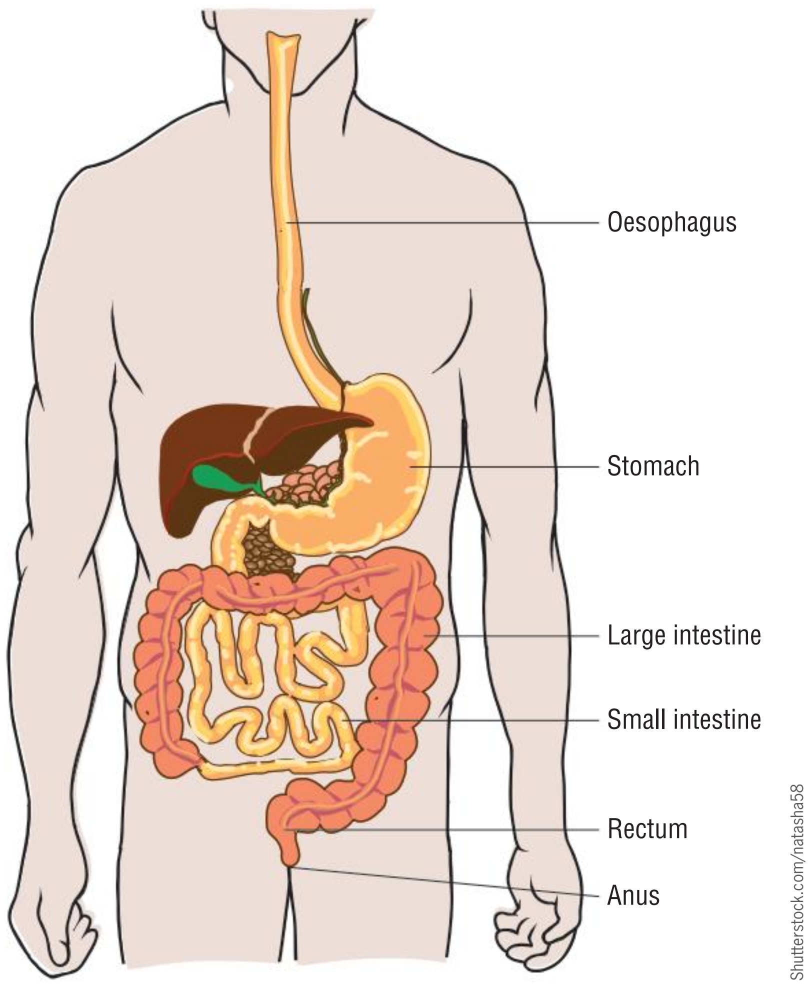

Figure 2.5 The organs of the digestive system

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The mouth

The mouth is the structure in which food is **ingested**. It contains teeth, the tongue and the salivary glands that make saliva, which are all essential for the initial digestion of food. The teeth are strong and hard so they can chew different types of food into small pieces. This is called **mechanical digestion**. Chewing creates a large surface area over which digestive **enzymes** in the saliva can act. Enzymes are proteins that perform specific chemical functions. In the digestive system, enzymes speed up the breakdown of complex foods into their simpler forms. Saliva contains the enzyme **amylase**, which starts the **chemical digestion** of the carbohydrate **starch** into simple sugars.

Saliva also lubricates the food so it moves easily down the throat. Your muscular tongue moves the ball of food (**bolus**) to the back of the mouth to the entry of the oesophagus.

ingested
taken in, eaten

mechanical digestion
the physical breakdown of food into smaller pieces

enzyme
a protein found in the body capable of speeding up chemical changes

amylase
the enzyme that digests carbohydrates

chemical digestion
the chemical breakdown of food into simpler substances, mostly through the action of enzymes

starch
a complex carbohydrate found in potatoes and other plants

bolus
a ball of food that passes into the oesophagus from the mouth

EXPERIMENT 2.1

Structure and function of the mouth

Possible risks	Safety precautions
Chemicals in the laboratory can be extremely toxic or corrosive. Residue left on the desk could contaminate food, which could then be harmful if consumed.	Do not eat or drink in the science laboratory. Do this activity outside or in a classroom or food-preparation room such as a kitchen.

Aim

To investigate the role of the mouth in digestion

Materials

- a piece of apple, or other hard fruit
- pen and paper

Method

1 Eat a small piece of apple or other hard fruit.

2 Make careful observations about what each part of your mouth does as you bite, chew and swallow the fruit.

3 Consider what is happening to the food as you chew.

Results

1 **Describe** the role of the lips, teeth (incisors and molars) and tongue.

2 **Identify** the role of saliva.

Discussion

3 Research the three main types of teeth in humans. Draw one of each type. **Explain** why we have different kinds of teeth.

4 **Explain** the function of the mouth in digestion.

WORKSPACE
Structure and function of the mouth

ACTIVITY SHEET
Redesign the human mouth so it is more efficient

ISBN 9780170231497

EXPERIMENT 2.1

5 **Justify** this statement: 'The mouth is well structured to carry out the role that it does.'

Extension

6 **Compare** the mouth, and in particular the teeth, of a lion, piranha and human. Use a graphic tool to visually represent the similarities and differences.

7 **Explain** three main reasons for differences in the structure and function of the mouth in different species.

8 **Justify** or refute this statement: 'All organisms have a mouth.'

peristalsis
a progressive wave of contraction and relaxation of the digestive tract

sphincter
a ring of muscle that can close off a tube

heartburn
a burning of the oesophagus caused by rising stomach acid

hydrochloric acid
the acid found in the stomach to help digest food

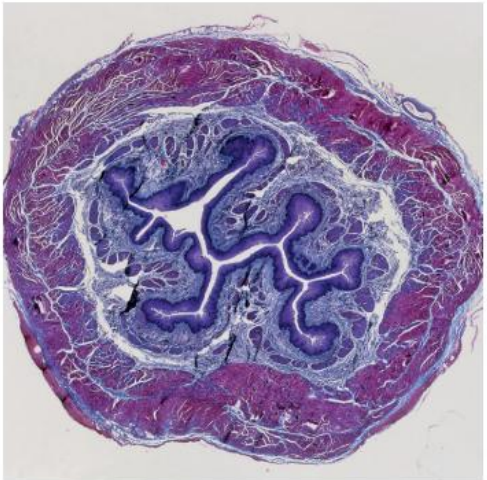


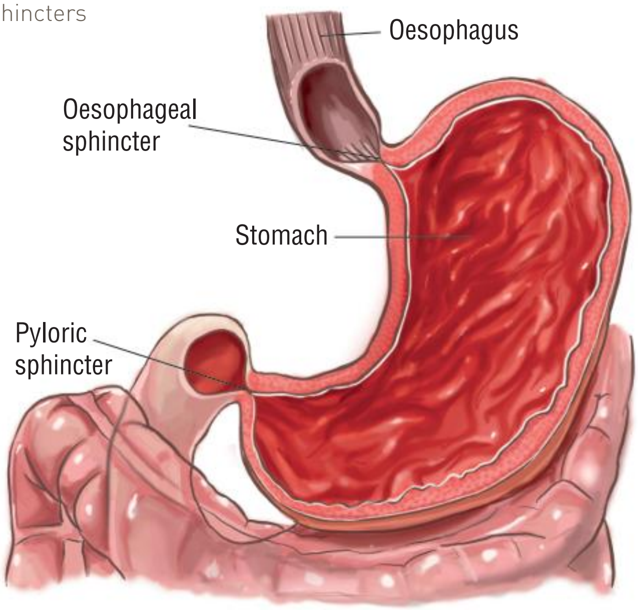
Figure 2.6 Cross-section of the oesophagus, showing its muscles

Getty Images/Pasieka/SPL

The oesophagus

The oesophagus is a long, muscular tube that transfers food from the mouth to the stomach. The muscles in the oesophagus contract and relax in waves so that food is pushed along it. This is known as **peristalsis**. It allows you to swallow even while upside-down. The thick layer of muscle is stained pink in Figure 2.6. At the end of the oesophagus is a special ring-like muscle, or **sphincter**, which opens and closes the entrance to the stomach. This sphincter prevents the acidic contents of the stomach from flowing back up into the oesophagus and burning the oesophagus wall – a condition known as **heartburn**.

Figure 2.7 The stomach and sphincters



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The stomach

The stomach is a muscular sac at the end of the oesophagus. When empty, the stomach has a capacity of approximately 50 mL, but when full it can stretch up to 3 L – that is, to 60 times its normal size! The stomach wall has many folds in it that allow it to expand.

The stomach wall contains glands that secrete protein-digesting enzymes. **Hydrochloric acid** is also secreted to kill any pathogens you may have ingested and to help with the digestion of proteins.

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The wall of the stomach is highly muscular. It is responsible for churning the food within the stomach, another form of mechanical digestion. The mixture of food, acid and enzymes formed in the stomach is called **chyme**.

chyme
partially digested food that passes from the stomach to the small intestine

WOW!

Small but long

The small intestine is only small in diameter. It is about 6 m long in humans, and is so highly folded with villi that its total surface area, if we could iron it out flat, would cover a tennis court!

ACTIVITY SHEET
The importance of surface area

The small intestine

Chyme is released in small amounts from the stomach to the small intestine through another sphincter. This sphincter opens and closes the entrance to the **duodenum**, the first section of the small intestine.

If the small intestine was uncurled and laid out straight, it would stretch for about 6 m. The length is important to ensure that the chyme has enough time to be fully digested. Peristalsis continues in the small intestine, churning the chyme and mixing it with intestinal **secretions**. These secretions include enzymes that further digest proteins, fats and carbohydrates.

Most simple nutrients, such as glucose, amino acids and fatty acids, as well as water, are absorbed by the small intestine. Magnification of the wall of the small intestine shows it to be made up of **villi** (singular 'villus'). Villi increase the surface area of the small intestine. Blood vessels project into the villi, bringing the circulatory system close to the digested nutrients.

Digestive products that have not yet been absorbed continue along the digestive tract to the large intestine.

duodenum
the first part of the small intestine

secretion
a liquid produced by a cell that assists in a bodily function

villi
small finger-like projections on the cells of the small intestine that increase surface area

ACTIVITY SHEET
Villi under the microscope

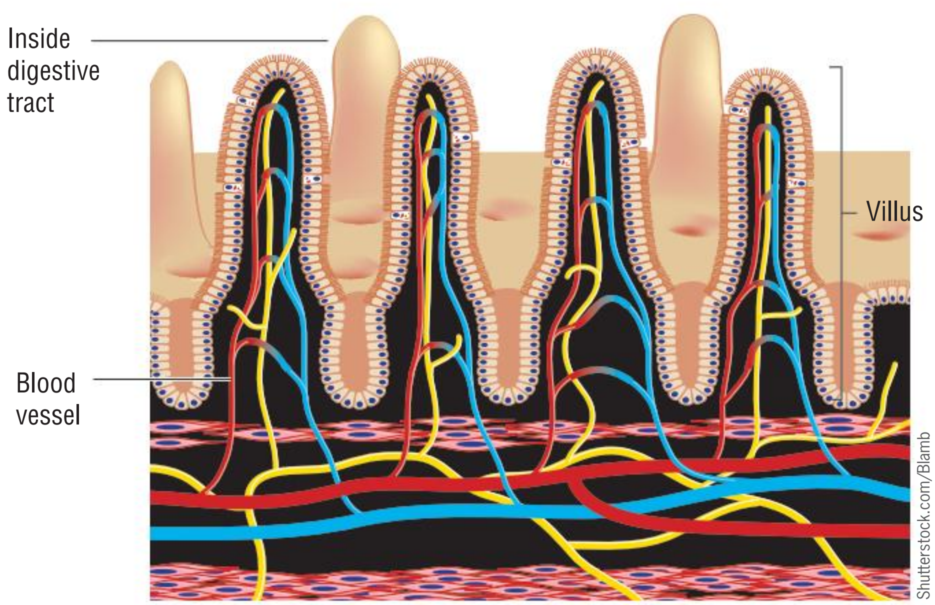

Figure 2.8 Structure of villi in the small intestine

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WEBLINK
Peristalsis

ACTIVITY SHEET
Digestion flowchart

WOW!

Helicobacter pylori

In 2005, two Australians won the Nobel Prize in Physiology or Medicine. Barry Marshall and Robin Warren were awarded the prize for their work on peptic ulcer disease. An ulcer occurs when the stomach lining becomes inflamed. Dr Marshall was so determined to convince the world that bacteria – not stress – caused ulcers that he drank a batch of the bacterium *Helicobacter pylori*. Five days later he was vomiting, and he had severe stomach inflammation for about two weeks. Once he started taking antibiotics he quickly recovered.

The large intestine

The large intestine is a wider muscular tube only 1.5 m in length. The main function of the large intestine is the absorption of water, vitamins and minerals from digested food into the capillaries of the circulatory system. Bacteria live in this part of the digestive system and can digest food within the tract, producing some essential vitamins (vitamins K and B_{12}) and gas.

At the end of the large intestine is the rectum. It acts as a storage place that can stretch to hold **faeces** – undigested material. The human digestive system cannot break down the cellulose cell walls of plants. This cellulose is commonly referred to as the 'roughage' or fibre in your diet and makes up part of the faeces. When the rectum has stretched sufficiently, it moves the faeces out of the body through the anus.

The anus is the opening at the end of the digestive tract through which faeces leave the body. When a **bowel motion** occurs, the anal sphincter – which is a specialised muscle that is normally closed – opens to allow waste to be **egested**.

INTERACTIVE
In digestion

ACTIVITY SHEET
Digestion rap

faeces
undigested waste material

bowel motion
the process of egesting faeces through the anus

egest
to pass out of the body

carnivorous
meat-eating

How do we compare?

Your digestive system is suited to your regular diet. The digestive systems of other animals are also suited to their diets. Koalas do not eat fruit salad and dingoes do not eat leaves. How do their digestive systems differ from yours?

Koalas have a very restricted diet. They only eat the leaves of certain eucalypt trees. These leaves are very tough and hard to digest. They are low in protein and energy and they contain poisons. Koalas have wide grinding teeth to crush the leaves. Between the small and large intestines koalas have a caecum (pronounced 'see-com'). It contains cellulose-digesting micro-organisms that break down the cell walls of the eucalypt leaves. This releases the nutrients within the cells for use by the koala. It also renders the poisons harmless.

Dingoes are **carnivorous**. Their teeth are those of a hunter, adapted to tearing meat rather than chewing. Dingoes have a long small intestine and a very reduced caecum and large intestine. Their digestive system is adapted to digesting fats and proteins, rather than cellulose.

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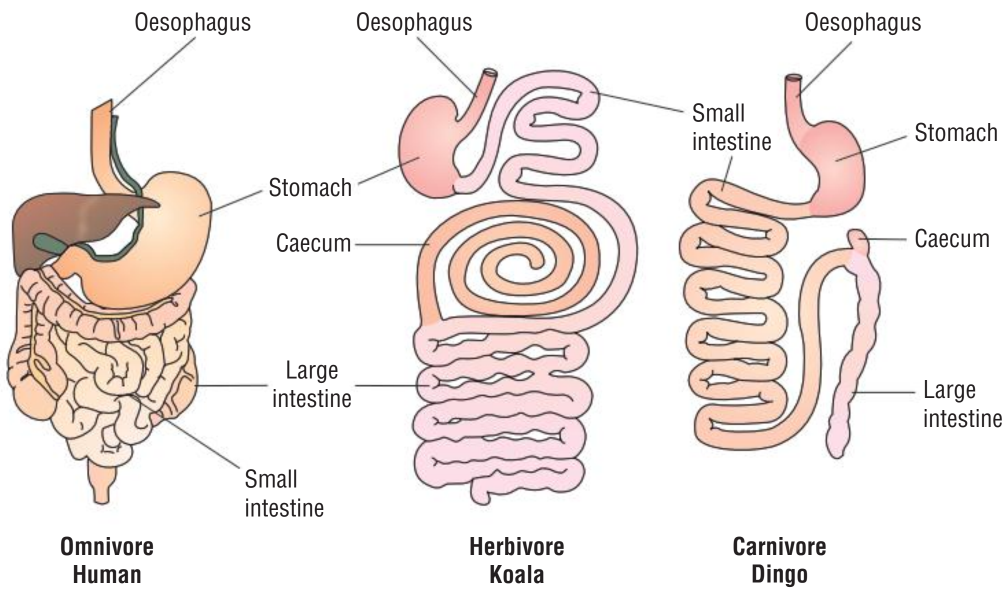

Figure 2.9 The digestive systems of omnivores, herbivores and carnivores are adapted to suit their diets.

QUESTIONS 2.2

What have you learnt?

Understanding

1 **Describe** the role of the digestive system.

2 **Identify** what enzymes are and what they do.

3 **Describe** the difference between mechanical digestion and chemical digestion. Give an example of each from the human digestive system.

4 **Identify** where water is absorbed along the digestive tract.

5 **Identify** the role of a sphincter. **Explain** how its structure is suited to its function.

Applying

6 **Explain** why it is important for our body that complex foods are broken down into their simpler forms by the digestive system.

WORKSPACE
What have you learnt? 2.2

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QUESTIONS 2.2

7 **Construct** a table.
   a In the first column of the table, place the following organs in their correct order from mouth to anus: mouth, stomach, rectum, oesophagus, duodenum, caecum, anus.
   b In the second column of the table, **describe** the function of each of these organs.

8 **Compare** and **contrast** the oesophagus and duodenum.

9 **Explain** why peristalsis occurs in the digestive tract.

Analysing

10 **Investigate** the three different types of digestive enzymes in the human body (carbohydrases, proteases and lipases). **Identify** where they are produced, where they act, what they act on and what is produced as a result of their actions. **Construct** a table for your results.

11 **Investigate** Barry Marshall's scientific career. **Describe** the events that led him to the discovery that most peptic ulcers are caused by *Helicobacter pylori*.

12 **Contrast** the digestive systems of the koala and dingo with your digestive system. **Explain** why they are different.

Creating

13 Return to your mind map and add any new information you have learnt.

2.3 The respiratory system

WEBLINK
The muscles of breathing

Our cells require oxygen. Cells use oxygen in the process of cellular respiration. Recall from *iScience 7 for NSW* that respiration is not breathing! In cellular respiration glucose, one of the products of digestion, is broken down in the presence of oxygen to release energy for use by the cell. Carbon dioxide is a waste product of this reaction.

$$\text{Glucose} + \text{oxygen} \longrightarrow \text{water} + \text{carbon dioxide} + \text{energy}$$

The role of the respiratory system is to bring oxygen into the body and to remove the waste carbon dioxide, so that respiration can occur. Oxygen and carbon dioxide are some of the inputs and outputs of respiration.

Breathing – inputs and outputs

inhalation
breathing in

exhalation
breathing out

diaphragm
a sheet of muscle under the lungs that assists with inhalation and exhalation

Breathing, or ventilation, is the process by which air enters the body through the mouth and nasal passages. As the air enters the body, it is warmed and moistened.

On **inhalation**, or breathing in, air rushes into the lungs, bringing oxygen as an input. On **exhalation**, or breathing out, air is forced out of the lungs, removing carbon dioxide as an output. Muscles in the chest and the **diaphragm** are responsible for increasing and decreasing the size of the chest cavity so that air rushes in and out.

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The trachea and bronchi

Air passes into the windpipe or **trachea**. The trachea is a long tube running from the back of the nasal passage to the **bronchi**. It has rings of **cartilage** around it that keep the tube open and allow air to travel along it. The trachea branches into two bronchi, one going to each lung. The bronchi take the air deep into both lungs.

trachea

a tube that runs from the back of the throat to the bronchi

bronchi

tubes that branch off the trachea to the left and right lung

cartilage

stiff yet flexible connective tissue found, for example, in joints between bones and around the bronchial tubes

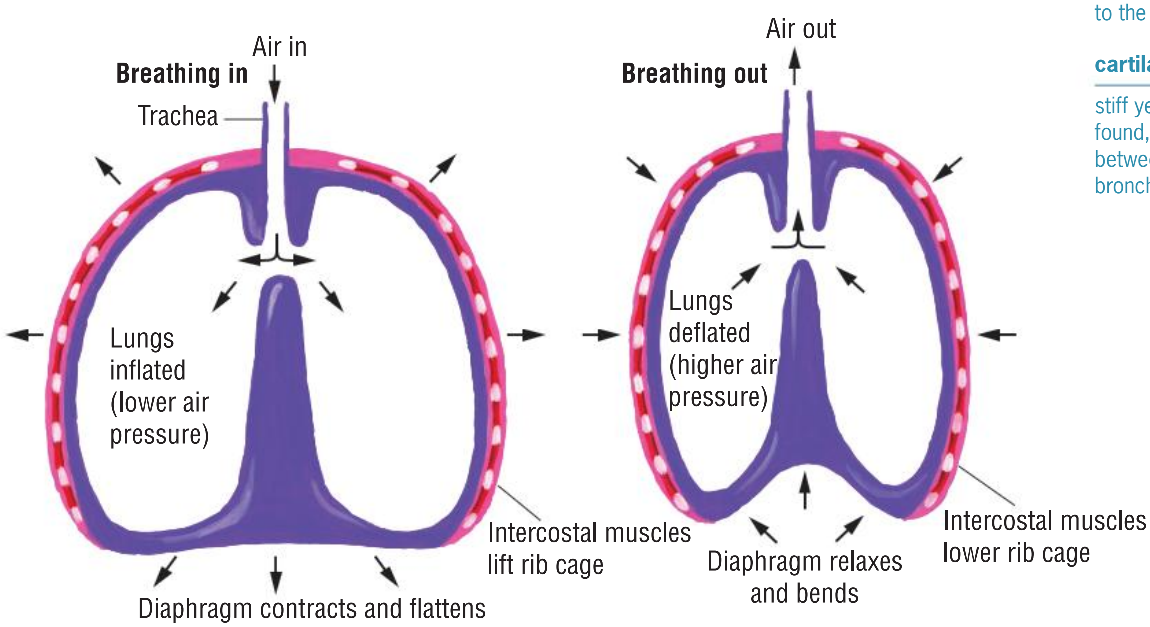

Figure 2.10
Breathing in and out involves muscles lifting and lowering the rib cage.

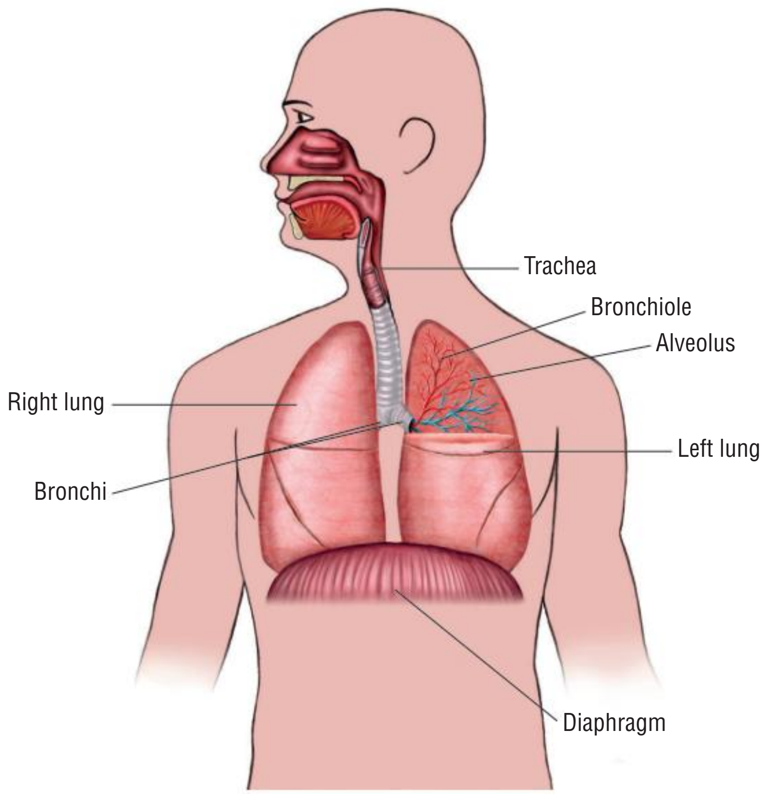

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Figure 2.11
Structure of the respiratory system

ANIMATION
Structure of the respiratory system

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The lungs

bronchiole
a smaller tube made when the bronchi divide

alveoli
air sacs at the end of the bronchioles in the lungs

capillaries
minute blood vessels located in between the smallest arteries and smallest veins

The bronchi branch into **bronchioles**, smaller tubes that continue branching into even smaller tubes until they end in **alveoli** (singular 'alveolus') deep within the lungs. The alveoli are tiny sac-like structures surrounded by **capillaries**. The oxygen in the air within the alveoli dissolves in the moist surface and moves across the alveoli and capillary surfaces to enter the bloodstream. The alveoli and capillary surfaces are known together as the respiratory surface. Waste carbon dioxide in the bloodstream moves the opposite way, from the blood to the air inside the alveoli. From here it travels back up the bronchioles, bronchi and trachea and is breathed out when you exhale.

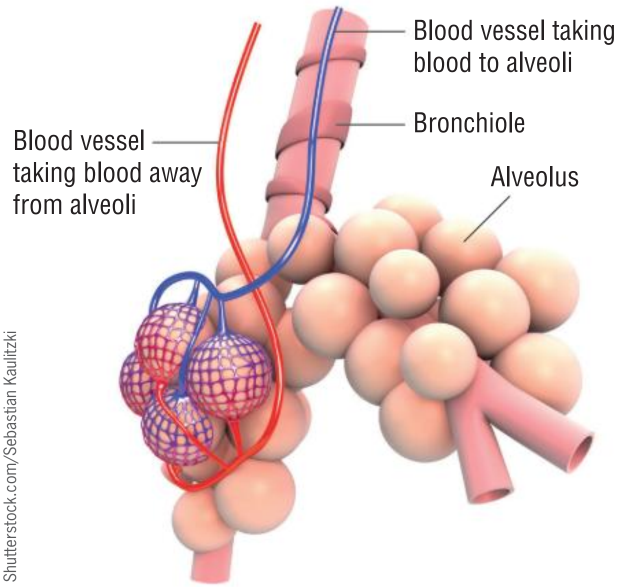

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Figure 2.12 Alveoli

WEBLINK
How the respiratory system works

ICT

Use **www.gliffy.com** to draw a flowchart to **show** the path of air after it enters the nose or mouth.

WORKSPACE
Making a model lung

WOW!

How big is that?

If the whole surface of the alveoli in a human was laid out flat, it would cover approximately 140 m^2 or half a tennis court. This large size enables you to get enough oxygen to function efficiently.

EXPERIMENT 2.2

Making a model lung

Possible risks	Safety precautions
Scissors or the sharp cut edge of the plastic bottle can cut you.	Cut away from yourself, and have someone help by holding the bottle. Do not hold the bottle by the cut edge.

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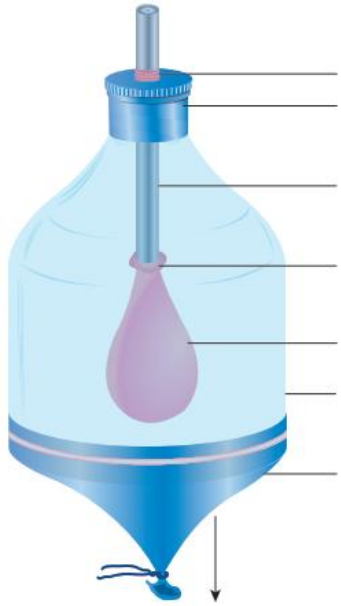

Figure 2.13
A model lung

Aim

To model how the diaphragm controls inhalation and exhalation

Materials

- 1 L plastic soft-drink bottle with lid
- scissors
- hole punch
- drinking straw
- 2 balloons
- 2 rubber bands
- Plasticine

Method

1 Cut away the bottom of the bottle using scissors, and discard the base.

2 Punch a hole in the lid of the bottle and insert the straw.

3 Use Plasticine to seal around the straw so it is airtight.

4 Use a rubber band to attach one of the balloons to the end of the straw inside the bottle.

5 Cut off the bottom of the second balloon and stretch the top part of the balloon over the base of the bottle, as shown in the diagram.

6 Secure this second balloon with a rubber band.

7 Put the lid, with the straw and balloon attached, back on the bottle.

Results

1 Pull down on the balloon on the bottom and observe what happens to the balloon inside the bottle. Release the stretched balloon and observe what happens.

2 Record your findings.

Discussion

3 **Identify** the part(s) of the human respiratory system represented by:

   a the bottle

   b the bottom balloon

   c the inside balloon

   d the straw.

4 **Evaluate** your model lungs as a representation of a real respiratory system. Look at its benefits and drawbacks.

5 **Explain** how the diaphragm controls inhalation and exhalation.

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VIDEO
Measuring gases in breathing

The air in there

Inhaled air and exhaled air have different percentages of oxygen and carbon dioxide. The approximate composition of inhaled air and exhaled air is shown in Table 2.2.

Table 2.2
The approximate composition of inhaled and exhaled air

	Nitrogen (%)	Oxygen (%)	Carbon dioxide (%)
Normal air (inhaled)	78	21	0.04
Exhaled air	78	14	4.4

WORKSPACE
What have you learnt? 2.3

QUESTIONS 2.3

What have you learnt?

Understanding

1 **Identify** the features of the lungs that make them well suited to the job they do.

2 **Explain** why air is warmed and moistened before it enters the lungs.

3 Draw the journey of an oxygen particle from the air to the bloodstream inside a capillary.

4 a **Compare** the composition of exhaled air and inhaled air as outlined in Table 2.2.
  b **Explain** why the composition of exhaled air is different from that of inhaled air.
  c **Explain** why the percentage of nitrogen in inhaled air and exhaled air does not change.

Applying

5 **Explain** why a large surface area is important in the respiratory system. **Identify** one other body system where a large surface area is important.

Creating

6 Return to your mind map and add any new information to your respiratory system branch.

2.4 The circulatory system

The circulatory system links all the systems of the body. It transports oxygen and the products of digestion directly to cells. It also takes away waste products such as carbon dioxide. These are removed from the body by the lungs and kidneys. The circulatory system is made up of the heart, blood vessels and blood.

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The heart

The heart is a muscular pump about the size of your fist. It is located in the centre of your chest, slightly tilted towards the left side of your body. The heart normally pumps without needing instruction. Heart cells in a test tube will beat. To ensure the whole heart contracts at the same time, the heart has pacemaker cells that determine its beating rate, like a bandleader who keeps the marching band in time.

ACTIVITY 2.1

Appreciate your heart

Open and close the fist of your right hand. Do this once a second for a minute. How does your hand feel? Can you do this for another minute? How does your hand feel now? For how long can you keep doing this?

When you are at rest your heart pumps approximately 60 times a minute, every minute of every day. How strong must it be to keep doing this?

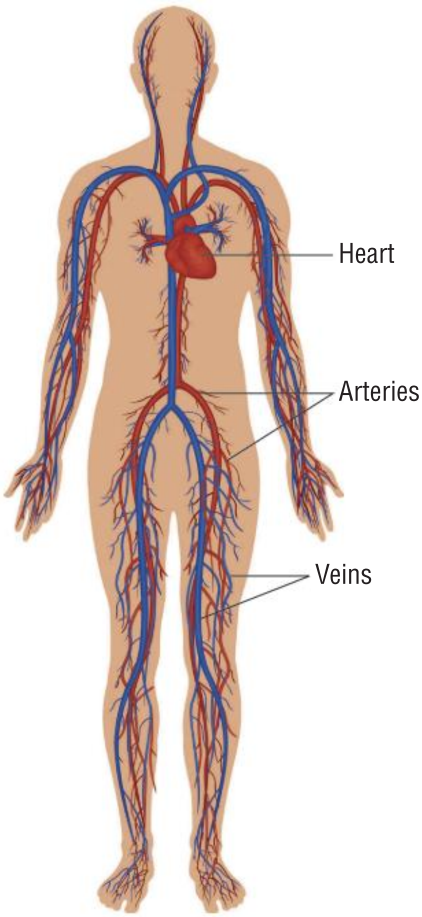

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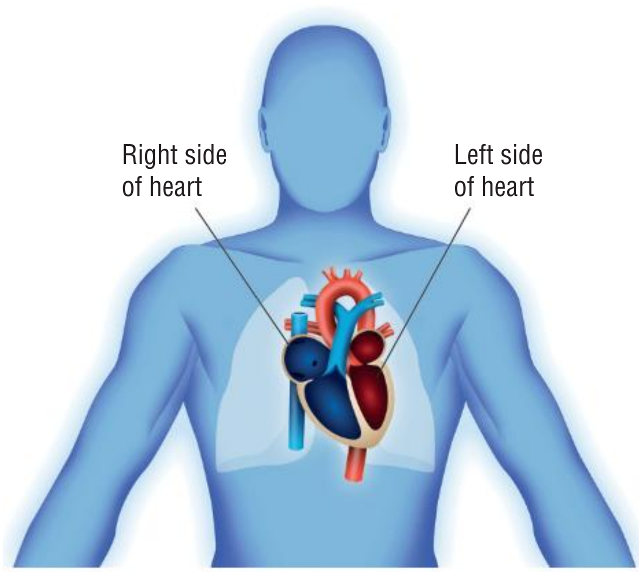
Figure 2.14 The human circulatory system – veins (coloured blue) transport blood to the heart and arteries (coloured red) transport blood from the heart. They are connected by capillaries.

It is normal to speak about the left and right side of your heart. The right side of the heart is on the right side of your body. In books we draw it as if we were looking at a person, front on (see Figure 2.15). The labels refer to their left and their right.



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ANIMATION
The structure of the human heart

Figure 2.15 Left and right sides of the heart

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chamber

one of the compartments making up the normal structure of the heart

atria

two upper chambers in the heart that receive blood from veins

ventricle

the two lower chambers in the heart that pump blood to either the lungs or the rest of the body

vena cava

a large vein bringing blood to the heart from all parts of the body

valve

a structure in the heart and veins that prevents the backflow of blood

pulmonary artery

a blood vessel that takes blood from the heart to the lungs

pulmonary vein

a blood vessel that returns blood from the lungs to the heart

aorta

a large artery that takes blood from the left side of the heart to the rest of the body

The heart is divided into four sections or **chambers**. Blood vessels enter and leave the heart. The two chambers at the top of the heart are the **atria** (singular 'atrium'). The two chambers at the bottom of the heart are the **ventricles**. The walls of the atria and ventricles have different thicknesses. The atria have relatively thin muscular outside walls, while the ventricles have outside walls that are very muscular and thick.

Blood first enters the heart through the right atrium. Blood that has travelled around the whole body enters from a large, thin-walled blood vessel called the **vena cava** into the right atrium. The blood that enters here is low in oxygen (coloured blue in Figure 2.16) because the oxygen has been used for respiration by the tissues in the body. It is also under very low pressure. Once in the heart, the blood moves from the right atrium, through a one-way **valve**, into the lower chamber, the right ventricle. From here, the blood is pumped through another one-way valve, into the **pulmonary artery** to travel to the lungs.

In the lungs, waste carbon dioxide is removed from the blood and exhaled and oxygen is added to it from the inhaled air. The oxygenated blood returns from the lungs in the **pulmonary vein** and enters the left atrium. Blood then moves through another one-way valve into the left ventricle. From here it is pumped through yet another valve and into the **aorta**, the vessel in which it begins its journey around the body.

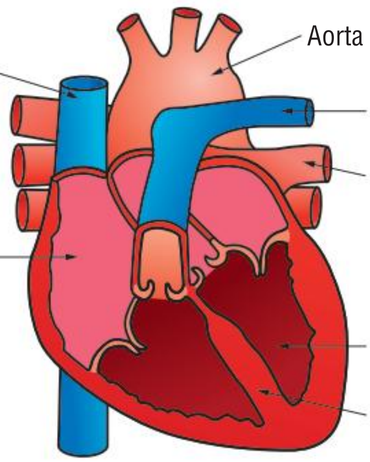

Figure 2.16 The structure of the human heart

septum

the dividing wall between the left and right hand sides of the heart

Look at Figure 2.16. You will notice that the wall of the left ventricle is very thick and muscular. This is so it can pump the blood hard enough to travel all the way around the body.

Blood in the right side of the heart never mixes with blood on the left side of the heart. A wall down the middle of the heart keeps the two sides separate. This wall is called the **septum**.

ACTIVITY SHEET
Ventricular septal defect

congenital

born with

WOW!

Hole in the heart

Some heart diseases are caused by lifestyle, but some are **congenital,** meaning you are born with them. Some babies are born with a 'hole in the heart'. If the hole occurs in the septum between the two atria it is called an atrial septal defect (ASD). If it occurs between the two ventricles, it is called a ventricular septal defect (VSD). If the hole is small, then it does not usually require surgery as it often closes on its own.

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Valves

A valve makes sure any liquid flows in the right direction. The heart contains valves that make sure that blood only flows in the right direction. There are four valves in the human heart, one at the exit of each chamber. Heart valves are made of flaps of skin that only open in one direction. If blood tried to flow backwards, the valve would snap shut, preventing the flow in that direction.

ICT

Use Gliffy to draw a flowchart to **demonstrate** your understanding of the flow of blood from the vena cava to the aorta.

WEBLINK
Function of the heart valves

ACTIVITY SHEET
Sheep heart dissection

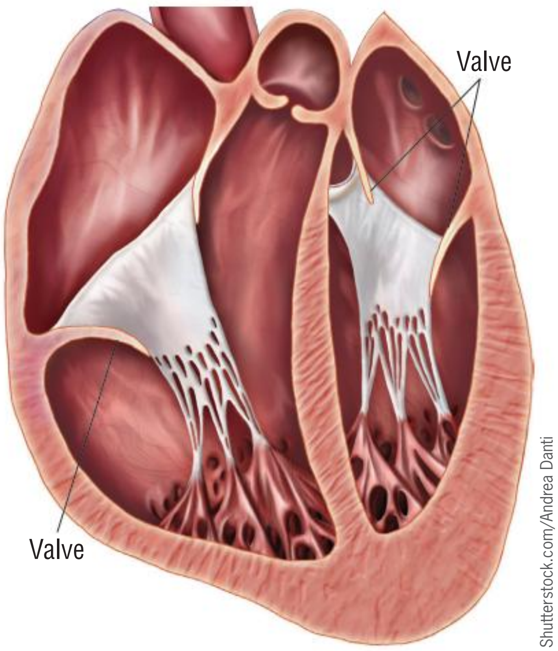

Figure 2.17
The valves of the heart

The blood vessels

The major types of blood vessels are:

1 **arteries** – the vessels that carry blood away from the heart
2 **veins** – the vessels that carry blood to the heart
3 capillaries – the very small vessels that intertwine with your tissues. It is here that oxygen and carbon dioxide move between the blood and tissues.

artery
a blood vessel that carries blood away from the heart

vein
a blood vessel that carries blood to the heart

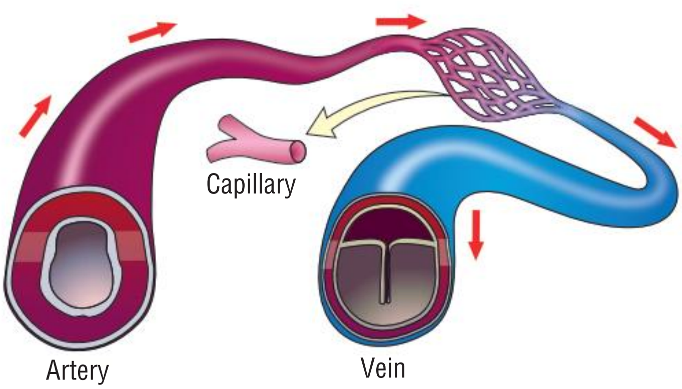

Figure 2.18
Major types of blood vessels

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The oxygenated blood on the left side of the heart leaves the heart through the aorta – a very large, thick-walled artery. From here, the blood moves into smaller and smaller arteries. It finally enters very fine blood vessels called capillaries. These are the major exchange sites for the blood and occur in every tissue of the body. No cell is more than 1 mm away from a capillary. Oxygen is taken up from the blood in the capillaries into the cells for use in cellular respiration. The waste product of cellular respiration, carbon dioxide, is taken from the cells into the blood. This blood eventually makes its way back through veins to the right atrium of the heart. It enters the heart through the vena cava and the whole process starts again.

ACTIVITY SHEET
Heart structure: compare and contrast

WEBLINK
The Heart House: how the heart works

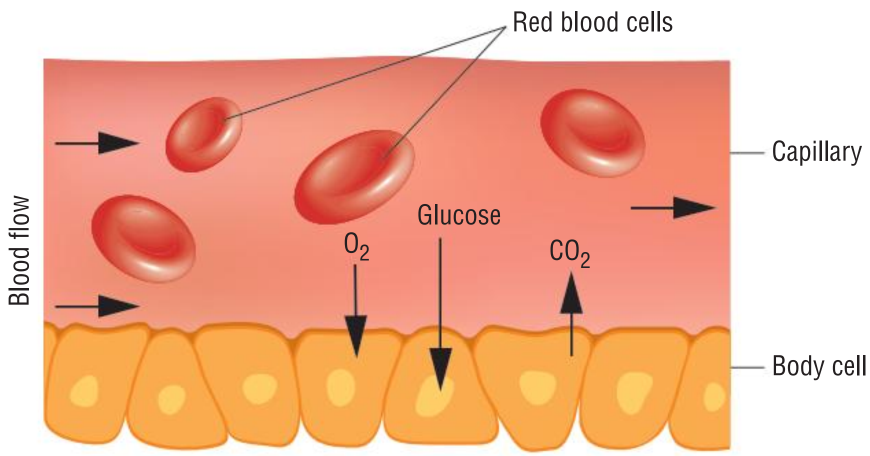

Figure 2.19 Exchange of materials in the capillary

Arteries and veins have very different structures to accommodate the different pressures of blood flowing through them. Arteries need to cope with high-pressure blood that is being pumped from the heart, so they have thick, muscular walls. Their expansion and contraction gives you your pulse.

Veins contain blood that is returning to the heart and is at lower pressure. Veins have very thin walls. They are able to stretch and blood can sometimes pool in them, rather than continuing to flow. As many veins flow up from the feet to the heart, they contain one-way valves to stop the blood from rushing back to your feet. The action of the muscles contracting and relaxing pushes the blood along. You have no pulse in your veins.

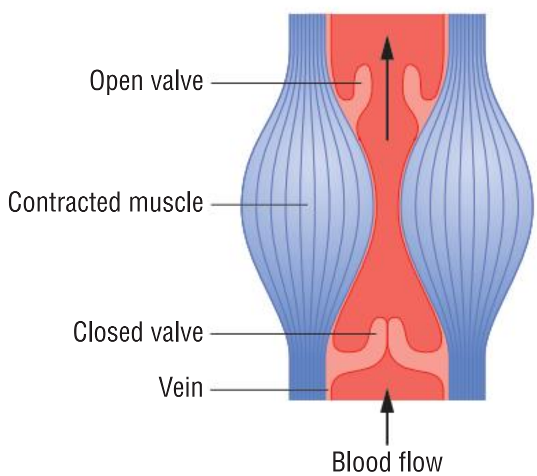

Figure 2.20 Valves in the vein

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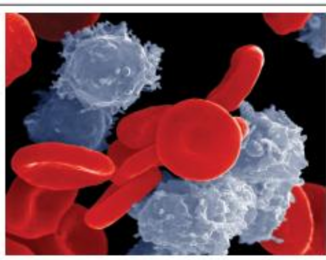
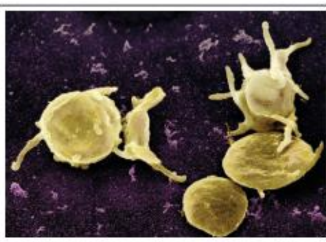
The blood

Blood is a tissue. It contains different types of cells and cell products, as described in Table 2.3. Blood is the transport fluid that links all your organs together. There is approximately 5 L of blood in your body. The blood is confined to the blood vessels, unless an injury opens a blood vessel.

Table 2.3 Blood composition

Constituent	Appearance	Features	Function
Plasma	 Shutterstock.com/Bork	Makes up more than 50% of the blood volume Consists of 90% water with dissolved proteins, glucose, minerals, **hormones** and carbon dioxide	Carrier of blood cells and nutrients
Red blood cells	 Shutterstock.com/Sebastian Kaulitzki	Make up just less than 50% of the blood volume Have no nucleus and a limited life span of 3–4 months Made in the bone marrow	Carry oxygen bound to **haemoglobin**
White blood cells	 Corbis/Visuals Unlimited	Make up less than 1% of the blood volume Made in the bone marrow	Defend the body as part of the **immune system**
Platelets	 Getty Images/SPL	Cell fragments Survive about a week	Blood clotting

plasma
the watery component of the blood in which the cells are suspended

hormone
a chemical messenger

red blood cell
a blood cell that carries oxygen

haemoglobin
the component of red blood cells that binds with oxygen

white blood cell
a blood cell that is part of the immune system

immune system
the system that fights diseases

platelets
fragments of cells that act in blood clotting

ACTIVITY SHEET
Blood donation

ISBN 9780170231497

WORKSPACE
What have you learnt? 2.4

QUESTIONS 2.4

What have you learnt?

Understanding

1 **Identify** three components that make up the circulatory system.

2 **Compare** and **contrast** the structure of the atria and the ventricles.

3 Match the blood constituent to its function.

Constituent	Function
Plasma	Immune functions
Red blood cells	Fluid medium
White blood cells	Blood clotting
Platelets	Carries oxygen bound to haemoglobin

4 **Identify** three differences between red and white blood cells.

5 **Outline** the role of the blood.

Applying

6 Reread the section on the muscular walls of the atria and ventricles. **Account** for the differences in thickness of each.

7 **Predict** what would happen if the valves in your heart were two-way valves.

Creating

8 Return to your mind map and add new information to your circulatory system branch.

2.5 The skeletal system

tendon
the tissue that attaches muscle to bone

ligament
the tissue that connects bones to bones

The organs in the skeletal system include all the bones in your body, the **tendons**, **ligaments** and cartilage that interact with them, as well as your teeth.

The skeletal system has many roles. It supports our bodies and allows us to move by interacting with muscles. Bones of the skeleton protect vital organs such as the brain, spinal cord, heart and lungs. Bones also make blood cells and they store minerals.

Getty Images/George Stubbs

Figure 2.21 The human skeleton

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The bones

Bones are living tissue, and have cells, blood vessels and nerves in them. Most bones are made of a dense hard outer case of compact bone, with lightweight porous spongy bone inside. The centre contains the marrow, which makes our red and white blood cells. The outer part stores calcium and phosphorus and provides the strength and support necessary to hold up and move our bodies.

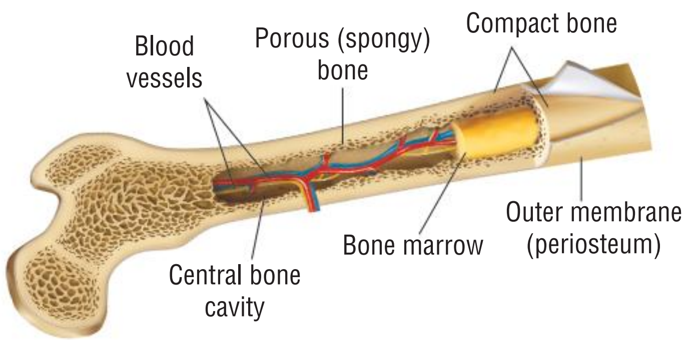

Figure 2.22
Bone

WORKSPACE
Bending bones

EXPERIMENT 2.3

Bending bones

Vinegar can leach out the minerals that make bones hard. Without these minerals the bones reveal their other properties.

Possible risks	Safety precautions
Vinegar can burn your eyes.	Wear safety glasses and do not touch your eyes. If you spill any vinegar clean it up immediately.

Aim

To investigate the consistency of bone without its minerals

Materials

- 2 identical chicken bones
- 2 rubber bands
- 2 cups
- plastic to cover cups
- 200 mL vinegar
- 200 mL water

Method

1 Label the cups 'water' and 'vinegar'.
2 Try to bend each chicken bone. Record your results in a table.
3 Place a chicken bone in each cup.

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EXPERIMENT 2.3

4 Cover the bone in the water cup with 200 mL of water. Cover the bone in the vinegar cup with 200 mL of vinegar.

5 Cover each cup with plastic and secure it with a rubber band.

6 Allow the bones to sit for at least five days in the water or vinegar.

Results

1 On the sixth day remove the bones and **compare** their flexibility.

Discussion

2 **Describe** how the bone that was soaked in vinegar feels.

3 **Compare** it with the bone soaked in water and the bones before they were soaked.

4 **Explain** the role of the bone that was soaked in water, in this experiment.

5 Research the disease rickets. **Describe** the cause and symptoms and **relate** them to what you learnt in this experiment.

The tendons

Tendons are tough fibrous tissues that connect muscles to bones. Perhaps the best known is the Achilles tendon, which joins the calf muscle to the heel bone. When a muscle contracts it pulls on a tendon which pulls on a bone. This allows us to move.

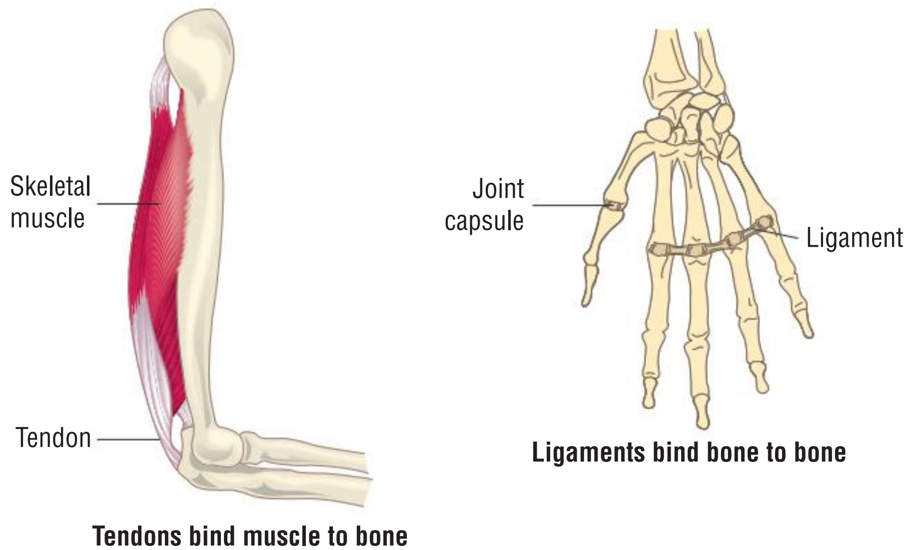

Figure 2.23 Tendons and ligaments

The ligaments

Bones are held to other bones by fibres called ligaments. Where two bones meet we have joints, such as our elbows, knuckles and shoulder. These allow us to bend our bodies. To prevent the bones from grinding against each other in a joint, we have cartilage covering the two ends, forming a smooth, slippery surface.

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2.6 The excretory system

The excretory system is responsible for removing wastes from inside your body. It deals with outputs. Note that faeces are not considered to be excreted, as they were never inside your body cells; they were moving through a tube through your body. This is analogous to driving through the Sydney Harbour Tunnel: you don't get wet because you aren't actually in the harbour.

Bodily wastes include carbon dioxide, urine and small amounts of salts and water.

The main organs responsible for excretion are the kidneys, but the lungs, the liver and the skin also play a role.

The kidneys

When we eat too much protein our bodies use the amino acids released as an energy source. This leaves a waste product called **urea**, which is carried around in our blood. Our kidneys remove urea from our blood to make urine. Excretion of wastes through urine is so important that the urinary system is often called a system of its own.

Blood enters the kidney from the renal artery, a branch from the aorta. It is filtered through structures called **nephrons**. Cells are too large to enter nephrons but substances such as water, salts, glucose and urea do enter nephrons. The kidney then reabsorbs the nutrients such as glucose and most of the salts and water, and leaves the urea behind to form urine. The process is a bit like cleaning your room. You pile everything into the middle except the really big things like the bed and desk. These represent the cells. Then you pick through all the smaller things in the middle of the room and put away the ones you want; your clothes, iPod, chocolate bars etc. These represent glucose, water, amino acids and other nutrients. What's left in the middle at the end is the waste, which you throw away.

The urine that has been made in the kidney travels down the **ureter** to be stored in the **bladder**. When the bladder is full, we expel the urine through the **urethra**.

urea

waste from protein breakdown, found in urine

nephron

the functional unit of the kidney

ureter

the tube from the kidney to the bladder

bladder

the sac that collects urine for excretion

urethra

the tube that carries urine from the bladder to the outside of the body

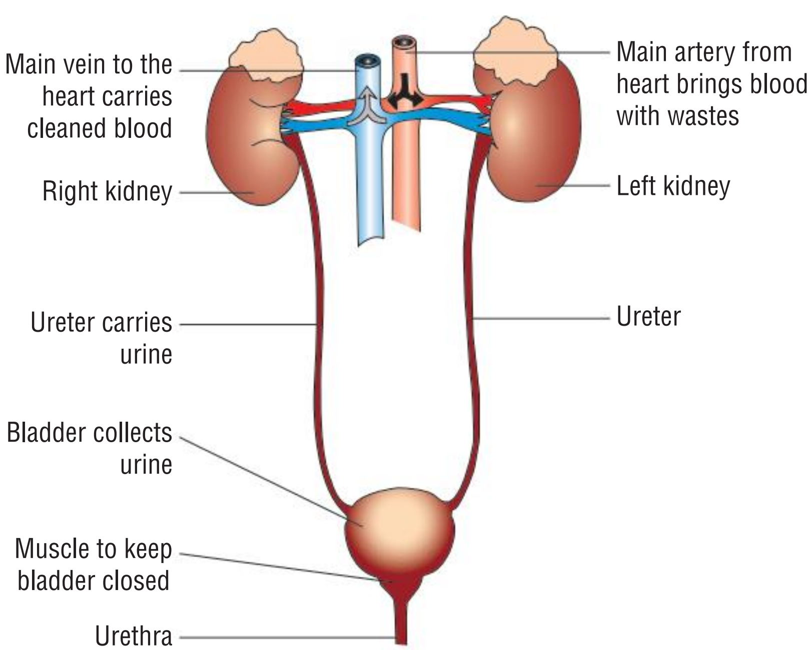

Figure 2.24
The urinary system

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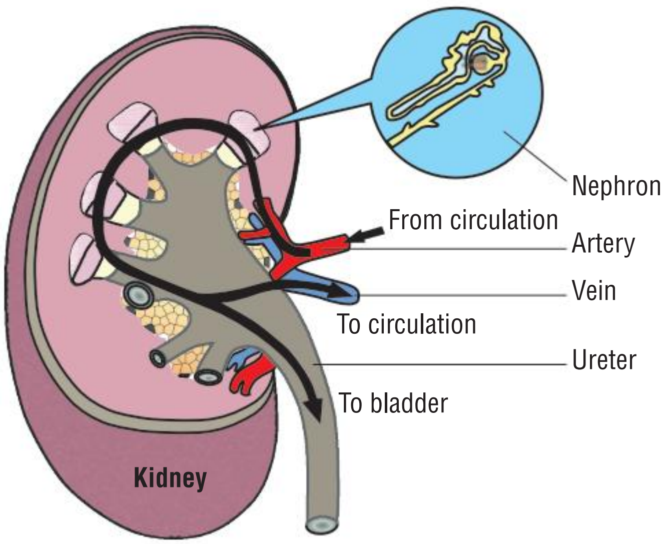

Figure 2.25 The kidney and a nephron

The lungs

You learnt about the structure of the lungs in the respiratory system. When lungs remove carbon dioxide they are acting as part of the excretory system.

WORKSPACE
Excreting carbon dioxide

EXPERIMENT 2.4

Excreting carbon dioxide

Carbon dioxide is colourless and odourless, but we can detect its presence by using limewater. Limewater is colourless, but turns milky in the presence of carbon dioxide.

Possible risks	Safety precautions
Broken glassware can cut you.	Do not touch broken glass. Use a dustpan and brush to clean up any broken glassware and inform your teacher immediately.
Limewater can cause skin and eye irritation with prolonged exposure.	Avoid touching limewater. Wash hands after use. Wear safety glasses when using it.

Aim

To demonstrate that exhaled breath contains carbon dioxide

Materials

- 250 mL conical flask
- 100 mL fresh limewater, not shaken
- drinking straw

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EXPERIMENT 2.4

Method

1 Carefully pour 100 mL of limewater into the conical flask, without disturbing any sediment on the bottom.

2 Blow one long slow breath through the straw into the limewater, making bubbles. Keep breathing out until you notice a change. If necessary, take another breath and exhale again into the limewater.

Results

1 Record your observations of the limewater.

Discussion

2 There was no control for this experiment. **Propose** a suitable control.

3 **Explain** where the carbon dioxide in your breath came from.

The liver

The liver removes toxic substances from the blood and makes them soluble so your kidneys can filter them out.

The skin

Have you ever eaten so much garlic that you can smell it on your skin the next day? By sweating, your body removes salts, water, urea and some other compounds, including those in garlic.

2.7 Organ transplantation

Many of our organs are essential for survival. When something goes wrong with our essential organs often the only hope is a transplant. However, transplant surgery is complex and the donated organ must come from another person. We have two kidneys, so we can donate a kidney and survive with just one. However, this is not true for our heart. Donor hearts must come from healthy people who have died, generally car accident victims.

To make matters more complicated, donor organs must be the same as or similar to the receiver's tissue type. Unless the donor is an identical twin a perfect match is never possible. The closest match possible is made, and the receiver must take **immunosuppressant** drugs for the rest of their life to prevent their body rejecting the donated organ.

Australian organ donation rates are some of lowest in the developed world and more people die waiting for an organ donation than are saved by one. The government has made an organ donor register so you can indicate your desire to donate any needed organs.

ACTIVITY SHEET
Organ transplantation

immunosuppressant
a drug that stops the body attacking a transplanted organ

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WEBLINK
Australian Organ Donor Register

ACTIVITY 2.2

Would you donate a kidney?

Choose one of the following and write a short essay discussing your point of view. Or you may divide into groups and debate the issue.

A Would you donate a kidney to a family member? To a friend? To a stranger? **Discuss** and **justify** your answer.

B Should parents be able to decide whether or not their children's organs or tissues are to be donated after death? **Discuss** and **justify** your answer.

C **Explain** what you think might be some reasons why organ donation rates are relatively low in Australia. **Propose** some possible solutions.

D As there is a limited supply of organs available for those in need, what criteria should we use to decide who will receive an organ? Should alcoholics get new liver tissue? Does age matter? **Critically analyse** this problem and **discuss** your point of view.

WORKSPACE
What have you learnt? 2.5

QUESTIONS 2.5

What have you learnt?

Understanding

1 **Outline** three roles of the skeletal system.

2 **Identify** three different organs in the skeletal system.

3 **Identify** three different organs in the excretory system.

Applying

4 **Explain** the difference between tendons and ligaments.

5 **Describe** the role of cartilage in the body.

6 Go back to your mind map and add your new understandings to it.

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2.8 Plant systems

Plants, like animals, are made up of systems of organs. A plant has two systems – the **root system** and the **shoot system**. These two systems function, as do animal systems, to provide the plant with the requirements necessary for it to survive.

root system
the part of a plant that is below ground; it absorbs water and nutrients from the soil

shoot system
the leaves and stems of a plant

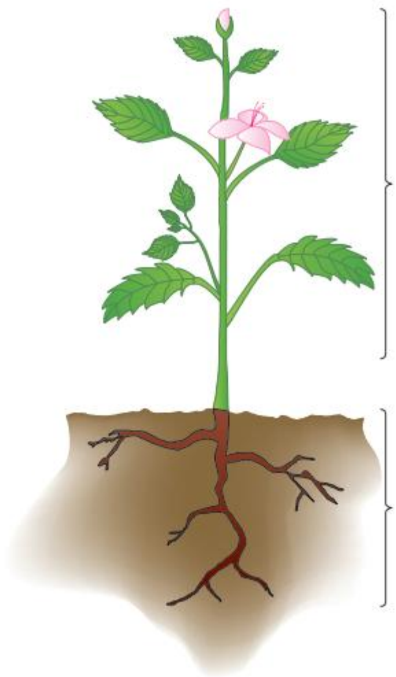


Figure 2.26
A plant is made up of systems.

Root system

The root system is the part of the plant that is below ground. Its organs include the roots and any extensions of the roots such as tubers and rhizomes (see Chapter 3).

The root

The main functions of the roots are to anchor the plant in the soil, and to absorb water and minerals for use by the plant. The surface area for absorption of water is greatly increased by the elongated root hair cells (Figure 2.27).

Getty Images/Adam Hart-Davis/SPL

Figure 2.27
Root hair cells greatly increase the surface area for absorption of water.

Shoot system

The shoot system is the part of the plant that is above ground. The organs in this system include leaves, stems and flowers.

The leaf

The leaves are the major organs of **photosynthesis**.

Photosynthesis is the chemical reaction in green plants that enables them to produce their own simple sugar, glucose, using energy from the Sun. The plant's organs are structured so they allow the plant to gain the inputs required for photosynthesis (carbon dioxide and water) and then transport the product (glucose) around the plant so it can be used by cells for respiration.

The chemical equation for photosynthesis is:

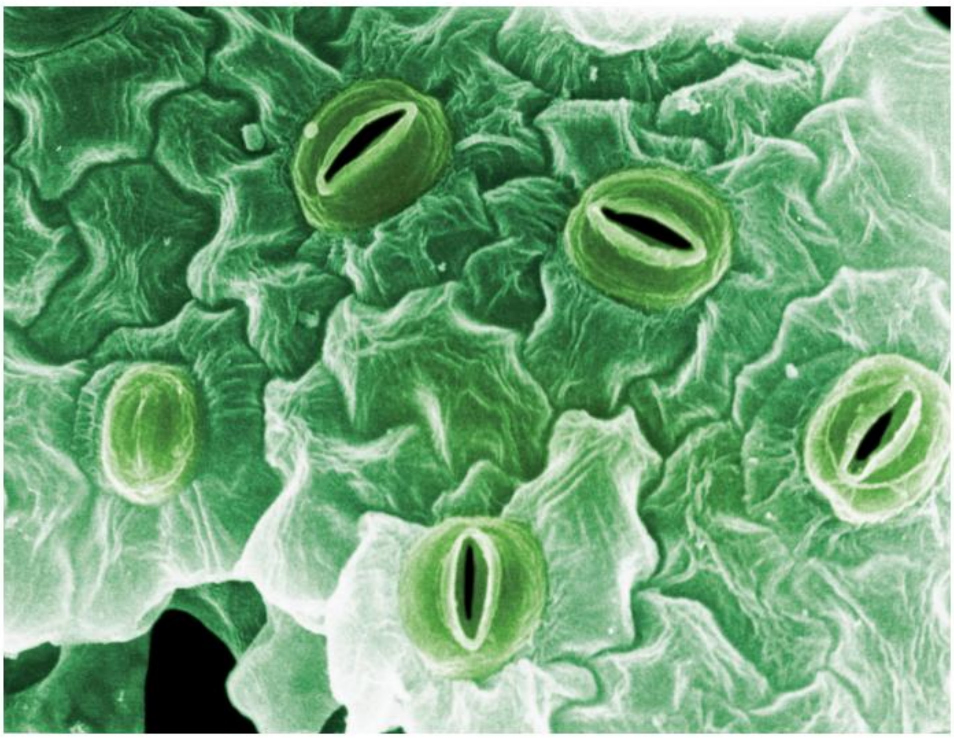
$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{glucose} + \text{oxygen}$$

Pores in the leaf surface, called **stomata** (singular 'stoma'), open and close to allow entry of carbon dioxide into the leaf. Around the edge of stomata are specialised cells called **guard cells**.

photosynthesis
the process that uses the energy from the Sun to provide nutrition for plants

stomata
tiny pores on the leaf surface that allow gas exchange for photosynthesis; water is lost through stomata

guard cells
cells that surround a stoma, allowing it to open and close



Corbis/Dr. Gerald Van Dyke/Visuals Unlimited

Figure 2.28 Stomata allow the entry into and exit of gases from a leaf.

ACTIVITY SHEET
Looking at stomata

ACTIVITY 2.3

Mnemonic

Create a mnemonic (a tool to help you remember) that you can use to recall the word equation for photosynthesis. Upload your mnemonic to the class wiki.

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The stem

The water required for photosynthesis is transported in the stems from the root system to the leaves by specialised **xylem** cells. Xylem cells are tubular in shape, stacked one on top of another. The end walls of the xylem cells break down to form one long continuous tube running from the roots of the plant to the leaves.

The glucose produced by photosynthesis in the leaf can either be used immediately by the cell for cellular respiration, or be transported away to be stored for later use. Storage of excess glucose as starch occurs in the root system and leaves of the plant. Excess glucose is transported from the leaves to the roots by specialised **phloem** cells. Phloem cells are tubular in shape, like xylem cells, but their end walls are perforated like a sieve. The liquid inside the phloem can move in two directions, from the leaves to the roots for storage, and from the roots to the leaves when glucose is in short supply.

xylem
the water transport system in plants

phloem
the nutrient transport system in plants

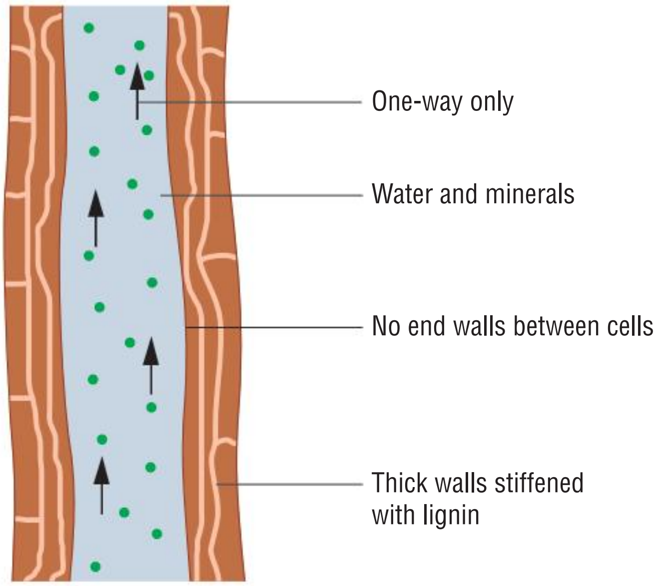

Figure 2.29 Xylem cells transport water from the roots to the leaves.

VIDEO
Water uptake by plants

ACTIVITY SHEET
Looking at xylem

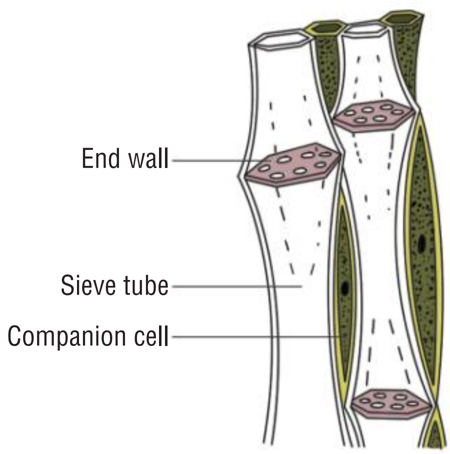

Figure 2.30 (left) Spirals of lignin supporting xylem tubes

Figure 2.31 (right) Phloem cells showing perforated sieve plates

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WEBLINK
Crossword

ACTIVITY 2.4

Plant systems

Use a graphic organiser of your choice to display the key ideas about plant systems. Upload your work to the class wiki. Include the reason for your choice of graphic organiser.

WORKSPACE
What have you learnt? 2.6

QUESTIONS 2.6

What have you learnt?

Understanding

1 **Identify** the two systems that make up a plant.

2 **Identify** the requirements for photosynthesis. **Describe** how plants get these requirements.

3 **Identify** the products of photosynthesis. Write a word equation for photosynthesis.

4 **Identify** uses in plants for the products of photosynthesis.

Applying

5 **Compare** and **contrast** each of the following pairs:

a root hair cells and small intestinal villi
b xylem cells and human veins
c xylem cells and phloem cells.

Creating

6 **Explain** how an increased surface area is achieved in both the human body and in plants. Draw a labelled diagram of the structures.

Reflecting

7 **Explain** why having a large surface area is so important.

8 Repeat the 'What do you already know about body systems?' activity. **Compare** your two drawings. **Identify** what you have learnt in this chapter in your workspace.

ICT

Create a crossword by using words from the glossary terms throughout this chapter. Swap crosswords with a partner and complete them.

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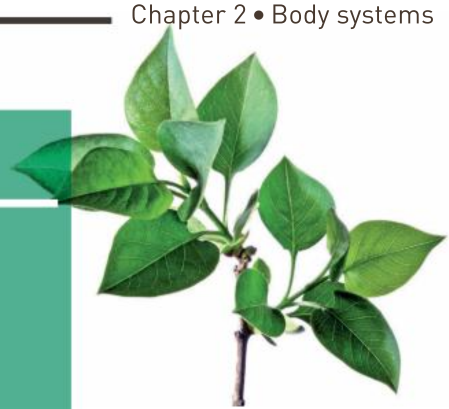

Chapter review

Remembering

1 **Identify** the three major food groups and their simple components.

2 **Define** these terms.
- a Ingestion
- b Digestion
- c Absorption
- d Egestion

Understanding

3 'All arteries contain blood that is high in oxygen.' This is not a true statement. **Identify** the artery that is the exception.

4 Body systems usually work together to achieve a function. **Describe** the main function of the combined circulatory and respiratory systems.

5 **Construct** a table to **identify** the components of the excretory system and the substances they excrete.

6 The structures of the trachea and bronchi are well suited to their function.
- a **Identify** their function.
- b **Explain** how their structure suits their function.

7 Label the indicated parts on the following diagram of a heart.

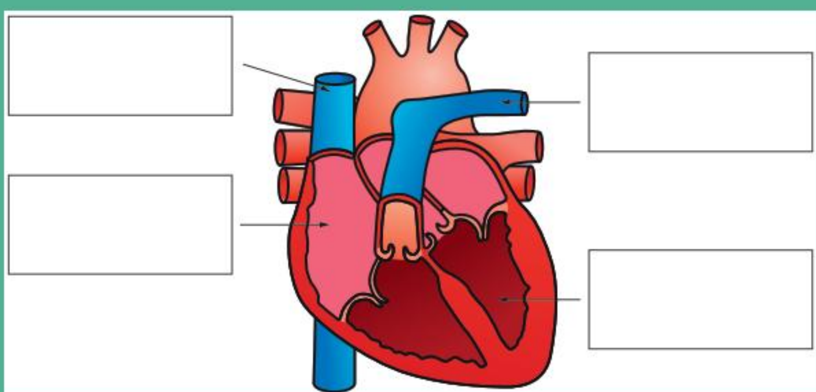

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Figure 2.32 The heart

Applying

8 **Identify** three features of the small intestine that make it suited to its role of absorption.

9 **Describe** how the structure of the mouth is suited to the functions it performs.

10 a **Identify** the role of capillaries.
- b **Explain** how their structure is suited to their function.

11 The skeletal system is often referred to as the musculoskeletal system. **Justify** the claim that the muscular and skeletal systems could be considered one system.

WORKSPACE
Chapter 2 review

ACTIVITY SHEET
Chapter 2 checklist

REVIEW QUIZ
Chapter 2

ISBN 9780170231497

12 **Describe** the function of respiration.

13 'Without a skeletal system we could not move. But without a skeletal system we also would not survive.' **Justify** this statement by referring to two different roles of the skeletal system.

14 Draw input, processing, output (IPO) diagrams for the:
 a digestive system
 b respiratory system.

Analysing

15 **Explain** the difference between breathing and respiration.

16 **Compare** the structure and function of the trachea and the aorta.

17 a **Explain** how a large surface area for water absorption is achieved by a plant.
 b **Identify** the structure in humans that does a similar job.

18 **Compare** the equations for respiration and photosynthesis.

Evaluating

19 'Circulatory system transplants are unlikely to happen.' **Justify** this statement.

Creating

20 Kidneys are the most common organ transplants. **Propose** reasons why kidney transplants are so much more common and successful than heart or lung transplants.

Reflecting

21 'The digestive, respiratory, circulatory, skeletal and excretory systems all work together to support respiration and therefore life.' **Justify** this statement, making specific reference to the role of each system in humans.

Extension

22 Giant insects will only ever be science fiction, and never fact. **Investigate** the circulatory and respiratory systems of the insect and use your information to **explain** why. Investigating grasshoppers would be a good start.

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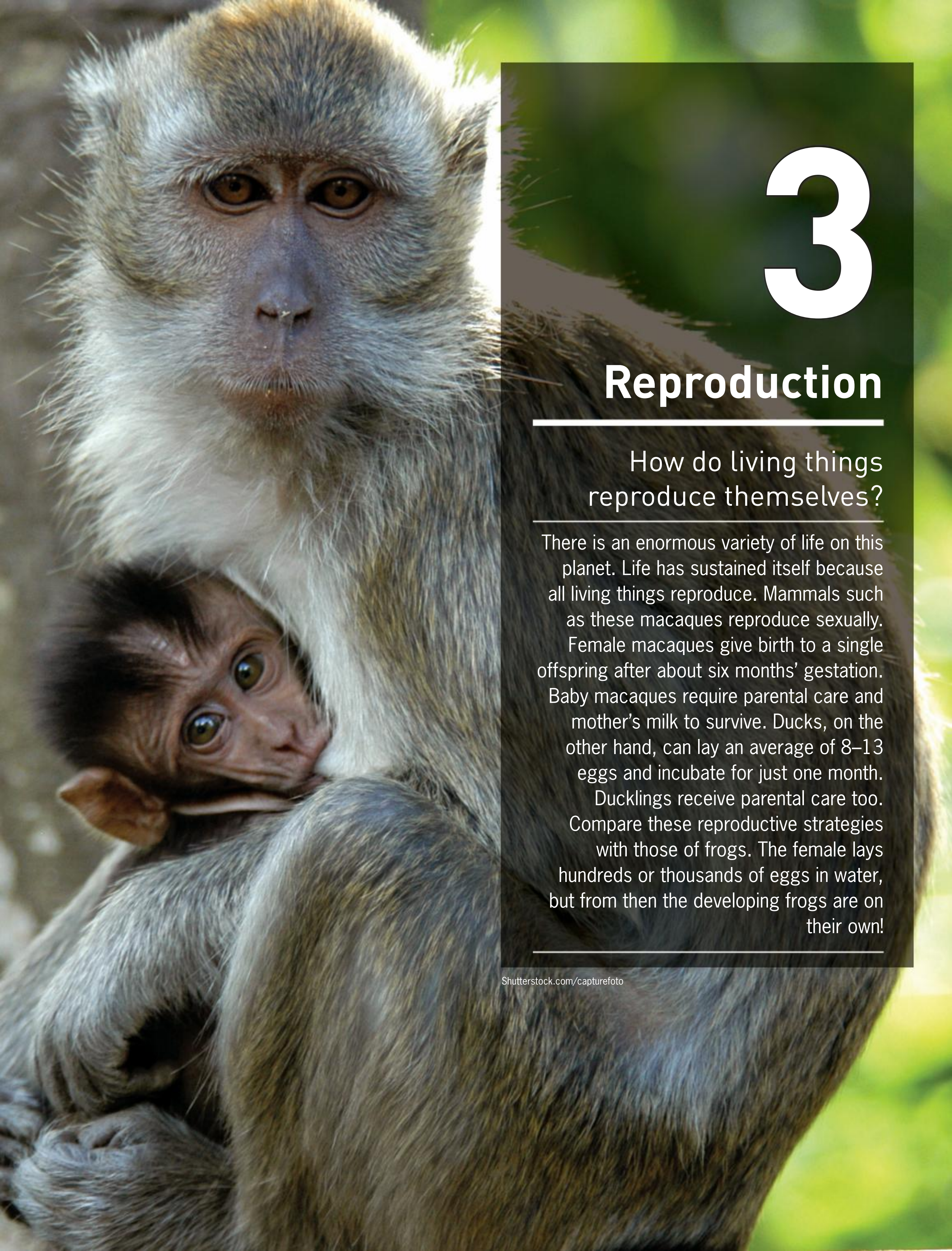

3

Reproduction

How do living things reproduce themselves?

There is an enormous variety of life on this planet. Life has sustained itself because all living things reproduce. Mammals such as these macaques reproduce sexually. Female macaques give birth to a single offspring after about six months' gestation. Baby macaques require parental care and mother's milk to survive. Ducks, on the other hand, can lay an average of 8–13 eggs and incubate for just one month. Ducklings receive parental care too. Compare these reproductive strategies with those of frogs. The female lays hundreds or thousands of eggs in water, but from then the developing frogs are on their own!

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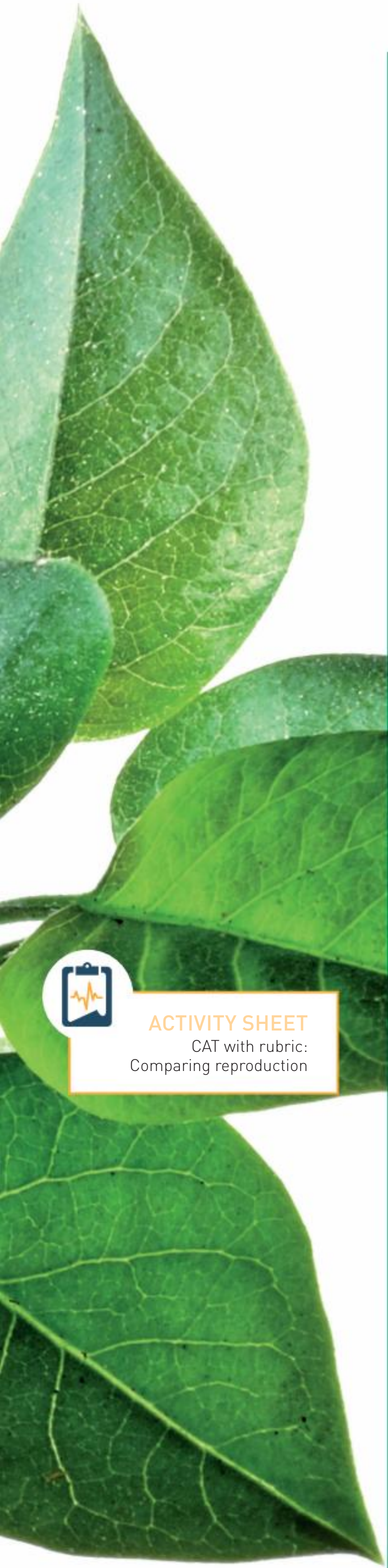

Living world – Stage 4

Key knowledge

- Organisms grow and repair themselves using cell division.
- Some organisms reproduce using cell division.
- Reproduction in multicellular organisms relies on specialised organ systems.
- Flowers are organs of sexual reproduction in flowering plants.
- The structure of organs in the human reproductive system is closely related to their function.
- In vitro fertilisation can help overcome fertility problems in humans.
- Different members of society may make different decisions about whether or not to apply reproductive technologies.

ACTIVITY SHEET
CAT with rubric: Comparing reproduction

CULMINATING ASSESSMENT TASK

Comparing reproduction

Choose one of the following topics:

- **Compare** an animal that undergoes external fertilisation with an animal that undergoes internal fertilisation.
- **Compare** an animal that undergoes internal fertilisation with a flowering plant's reproductive processes.

Prepare a presentation that includes a labelled diagram of the reproductive system of a male and a female of each of your chosen organisms. You will **identify** where gametes are produced, **describe** how and where fertilisation occurs and where development of the growing offspring occurs, **describe** the main reproductive structures involved in these processes, and **summarise** your findings.

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What do you already know about reproduction?

1 Work in groups of two. Use scissors to cut out the words from the word list below in your workspace. With your partner, paste the words where you think they are most meaningful on the plant and animal Venn diagram in the workspace. **Discuss** your reasons for the position of the words with your partner.

2 Join with another group and share your diagrams.

3 **Compare** your positioning of the words with that of the other group.

4 **Identify** any words you did not know where to place.

5 **Identify** at least three questions you have about these words.

Anther	Penis	Testes	Mitosis
Cuttings	Sperm	Embryo	Pollen
Filament	Gamete	Style	Stigma
Nectar	Ovary	Vagina	Fallopian tubes
Eggs	Pollination	Fertilisation	Uterus
Ovule	Fruit		

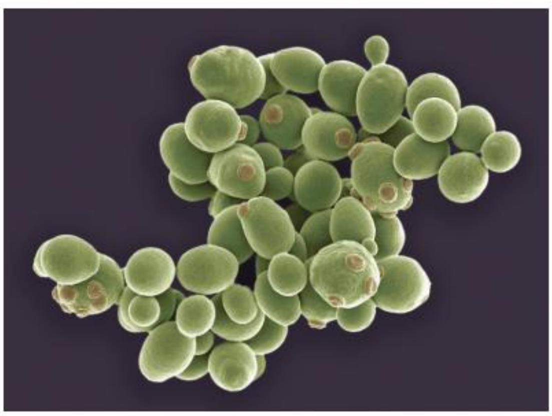
WORKSPACE
What do you already know about reproduction?

3.1 Asexual reproduction

The role of cell division

Reproduction is the making of new individuals from existing ones. It can occur either asexually or sexually. Recall from *iScience 7* that living things grow by the process of cell division involving mitosis. The cells enlarge, copy their DNA and divide it evenly, and then the cells divide. This makes new cells, so the organism grows. Lost cells, such as skin and blood cells, are also replaced this way.

Many plants and some animals can even reproduce in this way. Their cells divide and the new cells grow separately instead of adding to the parent organism. In this case, a new plant or animal forms, and the parent survives too. The organism has **replicated** or reproduced itself. The yeast cells in Figure 3.1 have been produced in this way.



Corbis/Steve Gschmeissner/Science Photo Library

Figure 3.1 New yeast cells grow by budding off from parent cells.

reproduction
the making of new individuals (offspring) from existing ones (parents)

replicated
made a copy

ACTIVITY SHEET
Experiment: Growing plants from existing plants

ISBN 9780170231497

Asexual reproduction in plants

The making of new organisms by mitosis and cell division is called **asexual reproduction** or **cloning**. When plants reproduce in this way, it is also known as **vegetative propagation**. In this case, the process typically involves particular organs such as tubers, rhizomes, bulbs and runners (for the first three, see Figures 3.2–3.4).

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Figure 3.2 (left) This potato is producing a new plant from a tuber.
Figure 3.3 (middle) Rhizomes, such as this ginger plant, give rise to new plants.
Figure 3.4 (right) Tulips grow from bulbs.

asexual reproduction
the production of offspring from one parent

cloning
producing offspring that are genetically identical to the parent

vegetative propagation
a form of asexual reproduction in plants

WOW! Traditional Aboriginal diet

In the past, Australian Aborigines living traditionally off the land included many roots, tubers and bulbs such as yams, native onions, yam daisy and the wild potato in their diet. They also ate wild nuts, including the pandanus nut and the fruit and nuts of the bunya bunya tree.

New plants produced asexually have only one parent. The new plants are genetically identical to the parent plant. They have the same genetic make-up (DNA) and will look and function in a similar way.

Many of the plants you consume for food are grown asexually. A farmer or scientist may spend a very long time breeding an orange tree that produces fruit of high quality. In order to keep this desirable characteristic in the new plants, it is best to produce them by asexual reproduction. In this way, the new plants will all produce equally good fruit because they are clones of the parent.

ACTIVITY SHEET
Science career – botanist

WORKSPACE
Vegetative reproduction

EXPERIMENT 3.1

Vegetative reproduction

Possible risks	Safety precautions
Potting mix contains live bacteria and fungal spores, which may cause infection.	Keep potting mix damp at all times. Do not inhale the dust from the potting mix. Wear a face mask. Do not handle potting mix with bare hands: wear strong gloves. Wash your hands thoroughly after use.
Plants and fungi can cause allergic reactions.	If you are allergic to any of the plants or soil microbes in this experiment, inform your teacher immediately. Do not handle plant specimens or soil.

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EXPERIMENT 3.1

Aim

To investigate the processes involved in vegetative reproduction

Materials

- pieces of potato with an eye, all from the same potato
- clove of garlic from the same bulb as everyone else's
- cuttings of geranium, frangipani or begonia, from the same plant
- pieces of ginger, about 5 cm long, from the same rhizome
- 4 pots (about 10 cm diameter and 15 cm high) with drainage holes in the bottom. If you are using a frangipani cutting, you will need a larger pot.
- hormone powder for the cuttings (optional)
- coarse gravel or stones
- potting mix
- gardening gloves
- face mask
- large tray to stand pots in and catch excess water
- digital camera (optional)

Method

1 Read the instructions for this activity. **Predict** what you think will happen to the plant in each pot. Record your predictions in a table in your workspace.

2 Label the pots with your name, the date and the type of plant.

3 Place about 3 cm depth of gravel over the bottom of each pot. This provides drainage so that your plants don't drown.

4 Wearing gloves and a mask, fill each pot to about 4 cm from the top with potting mix.

5 Place a piece of potato onto the soil in pot 1. Its eye should be facing up.

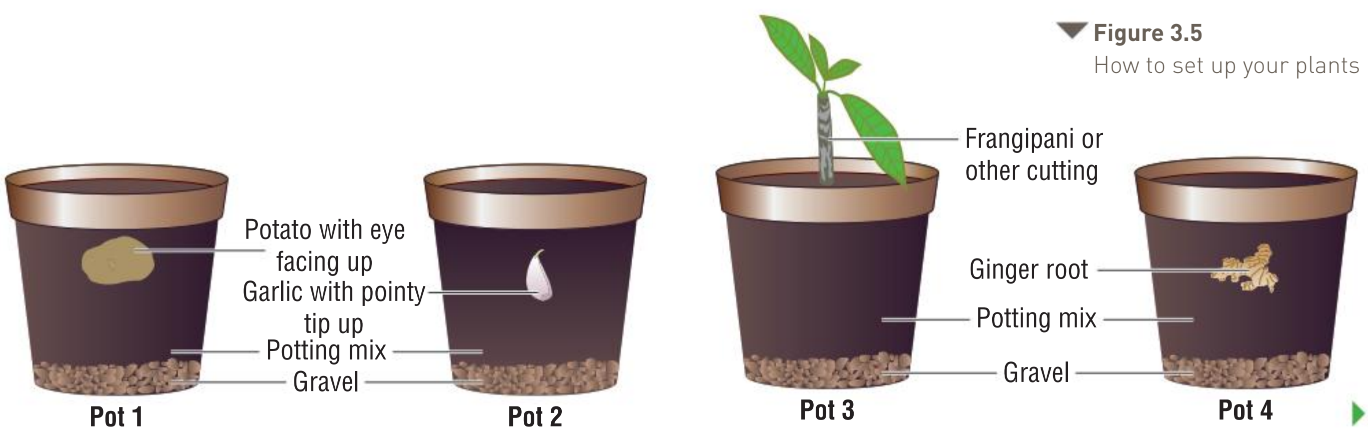

Figure 3.5 How to set up your plants

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EXPERIMENT 3.1

6 Cover the potato with 1–2 cm of soil and press down firmly.

7 Place one clove of garlic onto the soil in pot 2. Its base should be facing down, and its pointy tip should be facing up.

8 Push the garlic clove firmly into the soil. Cover it with soil so that its tip is just under the surface. Press the soil firmly.

9 Use a pencil to push a hole into the centre of the soil in pot 3. Into this hole, place your cutting. If you are using frangipani, you will need a bigger pot and a bigger hole. Press the soil firmly around the cutting to ensure it stands straight.

10 Place the piece of ginger root onto the soil in pot 4. Cover it with about 2 cm of soil and press down firmly.

11 Place all the pots into the tray and put them in a warm sunny position, away from drafts and heaters.

12 Water all the pots well. Make sure water comes out of the drainage holes. Do not leave them standing in deep pools (more than 1 cm) of water.

13 Water the plants daily for the first three days, then reduce to every 2–3 days, and finally every week.

ICT

You can load your photographs onto Smilebox to make a working collage of your plant's growth.

WEBLINK
Smilebox

WEBLINK
Sea-star regeneration

Results

1 Measure the height of your plants every week to see how much they have grown. Record your measurements in the table with your original predictions.

2 Use a digital camera to record the growth of your plants each week.

3 **Compare** your results with those of the rest of the class.

Discussion

4 **Describe** how the leaves of the potato plants differed in shape from each other.

5 **Describe** how the leaves of the garlic plants differed in shape from each other.

6 **Describe** how the leaves and flowers of the chosen cutting were different from each other. Did you expect them to be? **Explain** your answer.

7 **Calculate** how many potato plants the class grew from the one original potato.

8 **Compare** your results with your predictions.

9 **Identify** three careers for which knowledge of asexual reproduction in plants might be useful.

Extension

10 **Explain** why recording the height of the plants would not always be a valid measurement of growth.

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Asexual reproduction in animals

Plants produce clones readily. Some plants only reproduce asexually. The disadvantage of asexual reproduction is that it gives no genetic variation. All the clones are the same. This can be desirable if the environment is unchanging, but in a changing environment it can be a disadvantage.

Many animals can also reproduce asexually. New starfish (sea stars) can grow from the arm of a parent starfish as long as part of the centre of the starfish is attached to the arm. A simple water animal called the hydra reproduces asexually by simply budding new offspring (Figure 3.6).

A more complicated form of asexual reproduction known as **parthenogenesis** also occurs in a wide range of animals, including bees, wasps, scorpions and crayfish. This involves unfertilised eggs growing into adults. If no males are present, parthenogenesis has also been known to occur in hammerhead sharks, komodo dragons, geckoes and turkeys.

parthenogenesis
when a new individual grows from an unfertilised egg

Figure 3.6 (Left) Hydra parent buds to produce new offspring.

Figure 3.7 (Right) Komodo dragons have been known to reproduce by parthenogenesis, when males are absent.

Getty Images/Tom Branch

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QUESTIONS 3.1

What have you learnt?

Understanding

1 **Outline** the major differences between asexual and sexual reproduction.

2 **Identify** whether the following statements are true or false. If the statements are false, rewrite them in the workspace to make them true.

- **a** Plants grown asexually are clones.
- **b** All plants grown asexually from the same parent are identical to each other.
- **c** Plants grown asexually have two parent plants.

WORKSPACE
What have you learnt? 3.1

ISBN 9780170231497

QUESTIONS 3.1

d Asexual reproduction can only be performed from tubers, bulbs and rhizomes.
e Animals cannot reproduce asexually.

3 Match the plant organs with their descriptions.

Tuber	A fleshy underground stem that sprouts roots and shoots
Rhizome	An underground bud that can grow new plants
Bulb	A stem that grows over the ground to form new plants
Cutting	A starchy underground swelling that can sprout roots and shoots
Runner	A branch removed from a plant that can sprout roots and grow new leaves

4 **Classify** each vegetable as a tuber, rhizome or bulb.
a Garlic
b Sweet potato
c Ginger
d Onion
e Turmeric

Applying

5 Look at Figure 3.8. It contains at least 10 different vegetables (some of which are fruit!).


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Figure 3.8 Vegetables and fruit

a **Identify** those that are bulbs, tubers or rhizomes or something else (such as fruit or seed pods).
b **Identify** one other vegetable and **describe** how it can be grown by asexual reproduction.

Creating

6 **Explain** why asexual reproduction is suited to an unchanging environment. **Predict** what could happen if a new disease enters that environment.

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3.2 Sexual reproduction in plants

Many organisms reproduce sexually. This means the offspring receive genetic material from two parents – a male and a female.

Sexual reproduction produces offspring that are different from their parents. They may have different-coloured flowers or different-shaped leaves. This type of variety can be advantageous if the environment changes. If all the plants were the same, then they could all die if a change such as drought occurs in the environment. If the plants are different, some may be better suited to drier conditions. These will then survive to produce new offspring that are also suited to dry conditions. In this way, the species survives.

sexual reproduction
the formation of genetically different offspring from a male and a female parent

Getty Images/Cordelia Molloy/SPL

Figure 3.9
Resurrection plants cope in dry conditions by 'dying' and then coming back to life when it rains. This characteristic is passed from parent to offspring.

Sexual reproduction involves specialised cells called **gametes** or sex cells. Gametes are produced by a cell division process involving **meiosis** (pronounced 'my-o-sis'). The daughter cells produced by the male and female parents after meiosis have one copy of each parent cell's genetic information. Most cells have two copies. The aim of sexual reproduction is to bring the two gametes together. The resulting cell will have a full copy of genetic information.

gametes
sex cells – sperm in males and ova in females; contain half the amount of genetic material of other cells

meiosis
a form of cell division that produces gametes

Parts of a flower

Flowers are a common organ in plants used for sexual reproduction. Flowers can differ in many ways – size, colour, smell and sex. Some flowers have both male and female parts. Other species have plants with only male flowers or only female flowers. Others, such as the zucchini, have both male flowers and female flowers on the same plant (Figure 3.10). The role of the flower in sexual reproduction is to produce gametes, bring the gametes together and then disperse the resulting **seeds**.

seed
a protective covering for a plant embryo, usually with a rich reserve of starch or oil for a food supply

Getty Images/Peter Anderson

Figure 3.10
Separate male (top) and female (bottom) flowers of the zucchini plant

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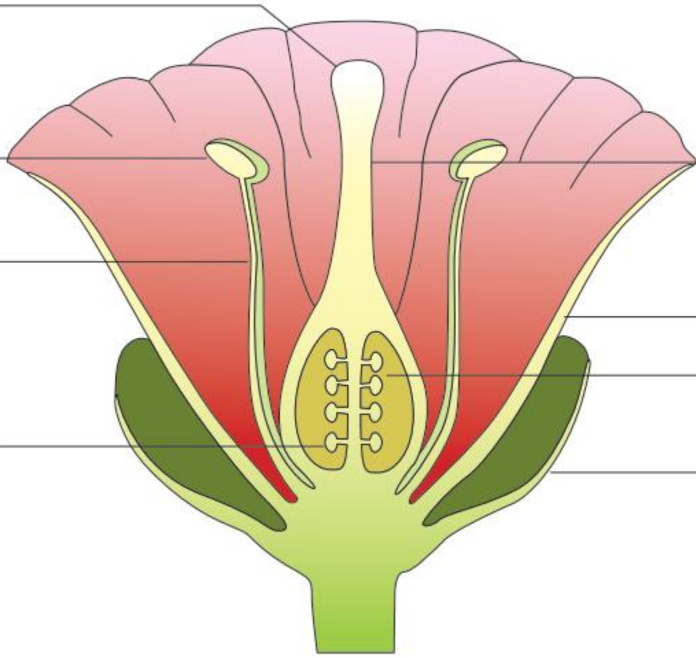

Figure 3.11 Anatomy of a flower

stamen
the male part of a flower

filament
a long stalk that displays the anther in a flower

anther
a sac on the end of a filament that produces pollen

pollen
grains produced in anthers that contain male sex cells

carpel
the female part of a flower

stigma
the part of the carpel that captures the pollen

style
the stalk that holds the stigma in position

ovary
the part that produces and protects the ova

ovum
a female gamete

The entire male part of the flower is called the **stamen**. Each stamen is made up of a long stalk called a **filament**. Sacs on the ends of the filaments are called **anthers**. This is where **pollen** is made. Pollen grains contain male gametes or sperm cells. The filaments display the anthers so the pollen can be easily removed by wind, insects, birds or small mammals.

The female parts of the plant are the **carpels**, which are made of the **stigma**, **style**, **ovary** and **ovum** (plural ova). The stigma sits on the end of the style. The style holds the stigma in a position so it has easy access to pollen. It is long and sticky to catch the pollen. The ovary is deep within the flower, protecting the ova.

Figure 3.12 Ovaries of a hibiscus flower

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EXPERIMENT 3.2

Flower dissection

Potential risks	Safety precautions
Scalpels are sharp and can make serious cuts.	Take great care when using a scalpel. Always cut away from yourself. Carry the scalpel in a tray with the point facing down. Never run when carrying it. Always use a cutting board. Place the scalpel in the middle of the board, so that it doesn't fall off the edge. Report any cuts to your teacher immediately.
Pollen can stain hands, clothes and anything it touches.	Avoid touching it or wear gloves. Wash your hands thoroughly at the end of this activity.
Pollen can cause allergic reactions.	If you are allergic to pollen or to any plant used, inform your teacher immediately and do not do this activity.

Aim

To investigate the number of male and female parts in a flower

Materials

- flower (such as hibiscus)
- cutting board
- scalpel
- forceps
- magnifying glass, microscope, slides and coverslips or a digital handheld microscope (if available)
- coloured pencils and plain paper
- digital camera (optional)

Method

1 Place your flower on the cutting board and draw or photograph it from the top and from the side.

2 Label your drawing or download your photo into your workspace and label all the parts you can see. Look for the petals, **sepals**, anthers, filaments, stigma and style (see Figure 3.11).

3 Remove one petal from your flower. Examine it under the magnifying glass or microscope. **Describe** its texture.

4 Remove one stamen and examine it under the magnifying glass or microscope. Draw or photograph it and label the anther and filament.

WORKSPACE
Flower dissection

WEBLINK
What does pollen look like?

WEBLINK
Flower structure

WEBLINK
Flower anatomy

ACTIVITY SHEET
Flower anatomy

sepal
a modified leaf that protects the developing flower bud

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EXPERIMENT 3.2

5 Rub the anther onto a piece of paper. What happens to the paper? If you used your fingers for this, make sure you wash them. Use a hand lens, magnifying glass or microscope to observe the pollen.

6 Touch the top of the stigma with your finger. How does it feel? Why do you think it feels this way?

7 Use the scalpel to carefully cut the flower in half vertically.

Results

1 Draw or photograph the cut flower and label it. Remember the rules of biological drawing.

2 Count the number of male parts. How many stamens are on your flower?

3 Count the number of female parts. How many carpels are there?

4 Measure the length of the stamens and the carpels. Record their lengths.

5 Cut the carpel open if you haven't already. Look at it using the microscope or digital handheld microscope. Can you see the ovules inside? (These contain the ova.) Draw what you see, or take a photo.

Discussion

6 **Compare** the number of male parts and female parts in your flower.

7 **Explain** the difference in number of male and female parts in your flower.

8 Were the male parts longer or shorter than the female parts? **Explain** why this might be.

Pollination

pollination
the transfer of pollen from the anther to the stigma

nectar
a sweet substance secreted by flowers to attract insects and birds

nectaries
glands at the base of a flower that produce and secrete nectar

Pollination is the transfer of pollen from the anthers of a flower to the stigma of the same or another flower.

Animals such as birds, insects and even small mammals can carry pollen between plants. Plants have evolved to make **nectar** to attract the animals. Nectar is a rich sugary liquid formed by glands called **nectaries** at the base of flower petals. The plant may also advertise itself with brightly coloured petals and sweet perfumes to attract the animals' attention.

Getty Images/Tatiana Gerus

Figure 3.13 Grevillea flowers – the flowers at the bottom have drops of nectar

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Animals eat the nectar to provide them with energy (see Chapter 2). As an animal enters the flower, it brushes past the anthers. The pollen on the anthers sticks to the animal. After it has fed on one flower, the animal moves to another, taking the pollen with it. When the animal feeds on a new flower, the pollen can come off and stick to the sticky female stigma of the new flower. The animal effectively carries the pollen between the plants. This allows pollination of one plant by another plant.

Some plants use wind instead of animals to carry their pollen. Grasses are one example. They do not need to have colourful flowers or scents. Other plants disperse their pollen on water currents.

Once the pollen is on the stigma, it still has to get from the stigma to the ova in the ovary. To do this, the pollen grows a **pollen tube** down through the style to the ovary. The sperm from inside the pollen can finally travel to the ovary and fertilise the ova.

Fertilisation produces one cell called a **zygote**. This is a fertilised egg. In this case, one cell (a sperm) plus one cell (an egg) make one cell (a zygote). This cell grows and divides into an **embryo** surrounded by a nutrient-rich starch reserve in a protective coat – a seed.

WEBLINK
Pollination

WEBLINK
Growth of a pollen tube

pollen tube
a tube that grows from the pollen grain, down through the style to the ovary, transporting sperm cells to the ova

zygote
a cell formed as a result of the fusion of a sperm and an ovum

embryo
the early stage of development after zygote stage

Seed dispersal

A seed contains a store of food, often starch, protein or oil. This gives the new plant an energy source (see Chapter 2). It uses this energy source to grow its first leaves and roots. Once it has grown leaves, the plant can photosynthesise to produce its nutrients.

It is the starch or oil that makes seeds appealing as food to humans and other animals. Rice, wheat, oats, peas, beans and many of the spices such as pepper, mustard and cardamom are all seeds.

It is not advantageous to the parent plants if their seeds grow too close to them. The new plants can't compete with the parent plant for nutrients, light and water, and won't benefit from competing with each other. Plants have many ways of dispersing their seeds. One way is to package them in something sweet, colourful and nutritious, such as a fruit. Animals will eat the fruit and the seeds. They will digest the fruit, but the seeds' hard coat protects them. The animals then release the seeds, with a dollop of fresh fertiliser, some distance from the parent plant. Tomatoes, cucumbers, pumpkins, apples, oranges and pears are all fruits.

Other plants have different methods of seed dispersal. Dandelions have very light seeds with a parachute. These seeds can be carried very long distances by wind. Coconuts produce seeds that can float. This is how they managed to cross oceans to colonise desert islands.

ACTIVITY SHEET
Eating seeds

Figure 3.14
Fruits are just fancy packaging for seeds.

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WEBLINK
Fruit development

Some seeds have burrs on them to stick onto animals' fur (Figure 3.15). The animal can carry the seeds a long way before they remove them by grooming. Clover and many grasses have these annoying types of seeds.


Getty Images/Scott Camazine

Figure 3.15 These seeds have been dispersed by sticking to the dog's fur.

WOW!

The invention of Velcro

In 1948, Swiss mountaineer George de Mestral took his dog for a walk. He and his dog returned covered in plant burrs. He removed a burr and ran to his microscope to investigate why it was able to stick to his clothes so effectively. On seeing the hook-like structures he developed the idea for Velcro!


Getty Images/Clouds Hill Imaging Ltd/SPL

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EXPERIMENT 3.3

Looking at seeds

WORKSPACE
Looking at seeds

Possible risks	Safety precautions
You may have allergies to seeds or plants.	Inform your teacher and do not touch the plants.

Aim

To investigate different seeds and their dispersal methods

Materials

- seeds from different trees, grasses and weeds
- stereomicroscope or digital microscope
- camera that attaches to microscope (optional)

Method

1 Place each seed under the microscope.

Results

1 Draw or photograph each seed.

2 Record your results in a table.

Discussion

3 **Identify** any structures that will improve the seeds' chances of being dispersed. **Explain** how they do this.

Germination

When conditions are right, the seed will **germinate**. The seed begins germination by absorbing water and swelling. The seed's protective coat breaks and it sends out a root and a shoot.

The newly germinated seed is very vulnerable to dehydration. Consequently, seeds only germinate when conditions are good for survival. Most seeds germinate after rain. The water causes them to swell and so the protective coat breaks. This means they won't germinate when it's too dry for them to survive.

Seeds usually need specific temperatures (which are different for each type of plant) to germinate. Adequate oxygen from the air spaces in the soil is also needed. Some seeds also need light or dark to germinate.

germination
when a plant emerges from a seed

Shutterstock.com/Beata Becla

Figure 3.16
A germinating seed of a mung bean

WORKSPACE
Germination of seeds

EXPERIMENT 3.4

Germination of seeds

Possible risks	Safety precautions
Mould may grow in your Petri dish, which can cause infection or allergic reactions.	Do not touch the mould or inhale its spores. Dispose of the Petri dish in a plastic bag in the rubbish. Wash your hands thoroughly at the end of the activity.

Aim

To investigate whether the root or the shoot appears first when a seed germinates

When a seed germinates, it sprouts a root and a shoot. **Predict** which you think will appear first. Write your prediction in your workspace. **Justify** your prediction.

Materials

- about 10 seeds from the same type of plant
- cotton wool
- Petri dish or a saucer
- beaker

Method

1 Line the Petri dish or saucer with cotton wool.

2 Add enough water to wet the cotton wool. Do not cover it in water.

3 Add the 10 seeds, spacing them evenly over the Petri dish. Make sure some are upside down and some are not. Cover the base of the Petri dish with an inverted beaker to give the seedlings room to grow.

4 Place them in a warm place out of direct sunlight.

5 Check your seeds every day. Ensure that they stay moist, but not wet.

Results

1 Count the number of seeds that have germinated each day. Note whether the germinated seeds have a root, a shoot or both.

2 Measure the length of each root and shoot every day. Record this in a table.

3 Graph your results. Remember the guidelines for drawing graphs. You could record your data in an Excel spreadsheet and use this to graph the data.

Discussion

4 Did all the seeds germinate at the same time? **Identify** how much variation was present.

5 **Compare** where the shoot and the root grew from.

6 **Identify** which grew first: the root or the shoot.

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EXPERIMENT 3.4

7 Use your graph to determine which grew fastest: the shoot or the root.

8 **Explain** why a plant needs roots.

9 **Identify** whether a plant would need roots before or after it grows shoots. **Explain** your answer.

10 **Compare** your results with your prediction.

WEBLINK
Sprouting seeds

EXPERIMENT 3.5

What conditions are best for germination?

WORKSPACE
What conditions are best for germination?

Potential risks	Safety precautions
Potting mix contains live bacteria and fungal spores, which may cause infection.	Do not inhale the dust from the potting mix. Wear a face mask. Do not handle potting mix with bare hands: wear strong gloves. Wash your hands thoroughly after use.
Plants and fungi can cause allergic reactions.	If you are allergic to any of the plants or soil microbes in this experiment, inform your teacher immediately. Do not handle plant specimens or soil.

Aim

To find out the optimum conditions for germination of a particular type of seed

Materials and method

Go to the interactive 'Fair test' and try a number of experiments. Then plan your own experiment according to fair-testing principles. Extra equipment can be supplied when you have given your teacher your plan.

INTERACTIVE
Fair test

1 **Identify** any other risks you need to manage during this investigation. Add these to the safety audit in the workspace.

2 **Predict** what you think will be the outcome of this experiment.

3 You will be using fair-testing principles to plan your experiment. To do this, you need to think about all the variables, such as:

- volume of water
- type of potting mix
- intensity of light
- concentration of fertiliser
- volume of potting mix
- temperature.

Choose one independent variable. **Identify** your controlled variables.

4 **Explain** how you will measure germination (the dependent variable).

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EXPERIMENT 3.5

Results

1 Use a spreadsheet such as Excel or draw a table for your results. Include a column for the different trials. Add a column for the number of seeds planted in each trial and a column for the number of seeds germinated in each trial. **Calculate** the success rate as a percentage using the formula:

$$\frac{\text{number of seeds germinated}}{\text{number of seeds planted}} \times 100 = \text{success rate (\%)}$$

Put this number in your last column.

ACTIVITY SHEET
Student investigation: Germination after a bushfire

ACTIVITY SHEET
Wordfind revision

Discussion

2 **Describe** the conditions that were optimal for germination of your seeds. **Justify** your descriptions with the germination success rates you calculated.

3 **Identify** the variables other students tested.

4 **Describe** their results.

5 **Explain** why you grew more than one seed in each test.

6 'All seeds germinate under the same conditions.' Use your results to **analyse** this statement.

7 From your results and those of other groups, **propose** a conclusion about the types of conditions that can affect seed germination.

8 **Explain** why your investigation was a fair test. **Identify** any difficulties you experienced. **Describe** how you could change your procedure to overcome these difficulties.

Extension

9 Read the planting instructions on the seed packet. **Compare** these with what you found in your experiment. Rewrite the planting instructions to make them more accurate if necessary.

WORKSPACE
What have you learnt? 3.2

QUESTIONS 3.2

What have you learnt?

Remembering

1 On the diagram of a flower in your workspace, **identify** the male parts by colouring them blue and the female parts by colouring them red. Label all the parts indicated.

2 **Identify** three different animals that assist in the pollination of plants.

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QUESTIONS 3.2

Understanding

3 **Identify** three features present in flowers that encourage animals to assist with transferring pollen.

4 **Describe** the features you would expect to see on wind- or water-pollinated plants and **explain** their role.

Applying

5 **Explain** why rain is an important factor in helping seeds to germinate.

6 **Explain** why oxygen availability plays a role in the germination of plants.

7 We usually plant seeds underneath soil. However, some seeds need light to germinate. **Predict** what role light would play in the timing of germination.

8 **Explain** how the structure of the following flower parts is suited to their function.

a Anthers
b Stigma
c Petals

9 **Outline** the advantages of sexual reproduction compared to asexual reproduction in plants.

10 Farmers must plant crops when there is a good chance of most seeds germinating and surviving. Research what time of the year this is for two different crops grown in Australia. **Compare** the time for two very different regions of Australia.

Analysing

11 A scientist is investigating whether seedlings are affected by the amount of salt in the water. She decides to grow five groups of 10 seedlings and give each group a different amount of salt. She then measures the growth of each seedling to determine how the salt affects growth.

a **Identify** the dependent and independent variable in this investigation.
b **Identify** three variables that would have been controlled during this investigation.
c One group of plants received water with no salt. **Explain** the purpose of this group.
d **Explain** why the scientist grew 10 seedlings in each group.

Evaluating

12 'A flower is well structured for the role it performs.' **Identify** the role that a flower performs. **Justify** this statement by giving five reasons to support it.

Creating

13 View the video in the weblink 'Flower Power'. Use a graphic organiser of your choice to record the ideas shown in this video.

WEBLINK
Flower Power

ISBN 9780170231497

3.3 Sexual reproduction in animals

Just as in plants, sexual reproduction in animals requires the production of gametes and their fusion to form a zygote. In many animals the growing young develop inside a parent, which requires specific organs. In mammals, such as pigs, the zygote formed after fertilisation grows and develops into an embryo (Figure 3.17) and later, a foetus.


Science Photo Library/Daniel Sambraus

Figure 3.17 A pig embryo

Gametes

Gametes produced by male animals are called sperm. Sperm cells are far too small for you to see. They have a head and a tail, and they swim through fluid – much like a tadpole (Figure 3.18).

Gametes made by females are called eggs or ova. Egg cells can be very different sizes. A human egg cell is about the size of a grain of sugar. A chicken egg is much larger, and an ostrich egg is bigger still, about 15 cm long. It is the equivalent of two dozen chickens' eggs!


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Figure 3.18 Human egg and sperm

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External fertilisation

When the egg and sperm of the same species meet, fertilisation takes place. But, as you learnt for plants, it's not always easy to get them to meet. Animals have many different structural and behavioural adaptations to ensure that their eggs and sperm do meet. Some species are much more successful than others.

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Figure 3.19 Frogs increase the chance of external fertilisation by bringing their gametes close to each other.

For water-based animals, such as fish, amphibians and coral, fertilisation occurs outside or external to the body. The gametes (eggs and sperm) are simply released into the water. The frogs in Figure 3.19 will need to wait until they are in water before releasing eggs and sperm. The eggs and sperm are not in danger of dehydration, and water currents can help carry them to each other. The numbers of individuals in each species is evidence of the success of this process.

External fertilisation has many advantages. There are fewer risks than with internal fertilisation. It doesn't require specific organs to sustain an embryo, and parenting or nurturing of the young is generally not done at all. It doesn't even require the organisms to meet, although often they do. Some species perform external fertilisation in close proximity. For example, male frogs clasp onto female frogs, and they release eggs and sperm simultaneously. This increases the chance of fertilisation.

external fertilisation
fertilisation that occurs outside of the body

External fertilisation also has many disadvantages. Egg and sperm of the same species need to meet. Floods can wash the eggs out to sea, where they die. Droughts can cause waterways to dry up and eggs to dehydrate. Ultraviolet light from the Sun can damage the eggs. Other animals can eat the eggs. Survival rates of offspring are low because generally they are not protected or nurtured by their parents. For this reason, females release huge numbers of eggs. This helps to ensure enough will be fertilised to ensure survival of the species.

WOW!

Coral spawning

Coral carry out synchronised spawning to overcome the problem of predation. All the coral in the entire reef release their gametes into the sea at the same time – on one night of the year. The sea becomes cloudy with coral gametes, and predators have a feeding frenzy! But so many gametes are released that the predators can't eat them all. Enough gametes survive to meet and produce offspring and the coral survives.

WEBLINK
Coral spawning

ACTIVITY 3.1

Pluses and minuses

As a class, brainstorm the advantages (pluses) and the disadvantages (minuses) of external fertilisation. Record these in the plus minus table in the workspace.

WORKSPACE
Pluses and minuses

ISBN 9780170231497

Internal fertilisation

Fertilisation in humans takes place inside the female body. This is also the case for most land animals, including mammals, birds, reptiles and land-based invertebrates such as insects.

Internal fertilisation is necessary for animals that live on land because the gametes would dehydrate in the air. It has other benefits too. It gives a much higher chance of successful fertilisation as the eggs and sperm are confined inside the mother's body. It also significantly improves the survival rate for the offspring, which are protected from predation while inside their mother's body. In many mammals, the developing embryo is fed by its mother, via the **placenta**, until it is born. In reptiles and birds, the embryo is nourished by a food supply inside the egg.

internal fertilisation
fertilisation that occurs inside the body

placenta
the organ that connects the developing embryo or foetus to the wall of the uterus, and allows gases, wastes and nutrients to be exchanged

For internal fertilisation to be achieved, sexual intercourse, a process by which the male and female gametes meet inside the female's body, must occur. However, sexual intercourse can be very dangerous. Often males fight to the death over breeding rights. The act of intercourse itself makes the animal vulnerable and at risk of passing on disease. Additionally, females are more vulnerable when pregnant, and risk injury or death during childbirth.

WOW!

Giant eggs

Reptiles and birds have much bigger eggs than mammals, as the egg must contain nutrients to feed the baby until it hatches. The biggest egg ever known held about 4 litres, the equivalent of 100 chicken eggs. It was the egg of the elephant bird *Aepyornis maximus*. This is probably as large as an egg can get. As the egg gets bigger, the shell must get thicker. But the shell cannot get too thick or the chick could never get out! Today the largest egg is the ostrich egg.

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The human male reproductive system

The organs and structures of the male reproductive system are involved with sperm production and storage, and with the transfer of sperm to the female (Figure 3.20).

Sperm is produced in the **testes** (singular testis). The testes are made up of small thin tubes. If all the tubes in the testes were laid out, they would stretch 500 m. Newly made sperm move to the **epididymis**, a structure above the testes that stores the sperm until they mature. The testes and epididymis are held in the scrotum, which hangs outside the main part of the body.

Mature sperm travel from the epididymis in a small tube called the **vas deferens** (Latin for 'carrying away vessel'). As the sperm travel along the vas deferens, fluid from the **seminal vesicle** and **prostate gland** is added. The resulting fluid is known as **semen**.

testes
the part of the male reproductive system that produces the sperm

epididymis
the part of the male reproductive system that stores the sperm

vas deferens
the tube that carries the sperm from the epididymis to where it joins with the urethra

seminal vesicle
the gland that produces about 70% of the semen

prostate gland
the gland that produces about 30% of the semen

semen
the fluid added to sperm, contains nutrients and provides a medium for the sperm to swim in

ISBN 9780170231497

The vas deferens joins up with the urethra. The urethra is the tube that empties urine from the bladder, but during intercourse it carries semen. The urethra opens at the end of the penis. During sexual activity, the tissue of the penis fills will blood and the penis becomes erect, allowing intercourse.

ACTIVITY SHEET
Structure and function of the male reproductive system

ANIMATION
Structures of the male reproductive system

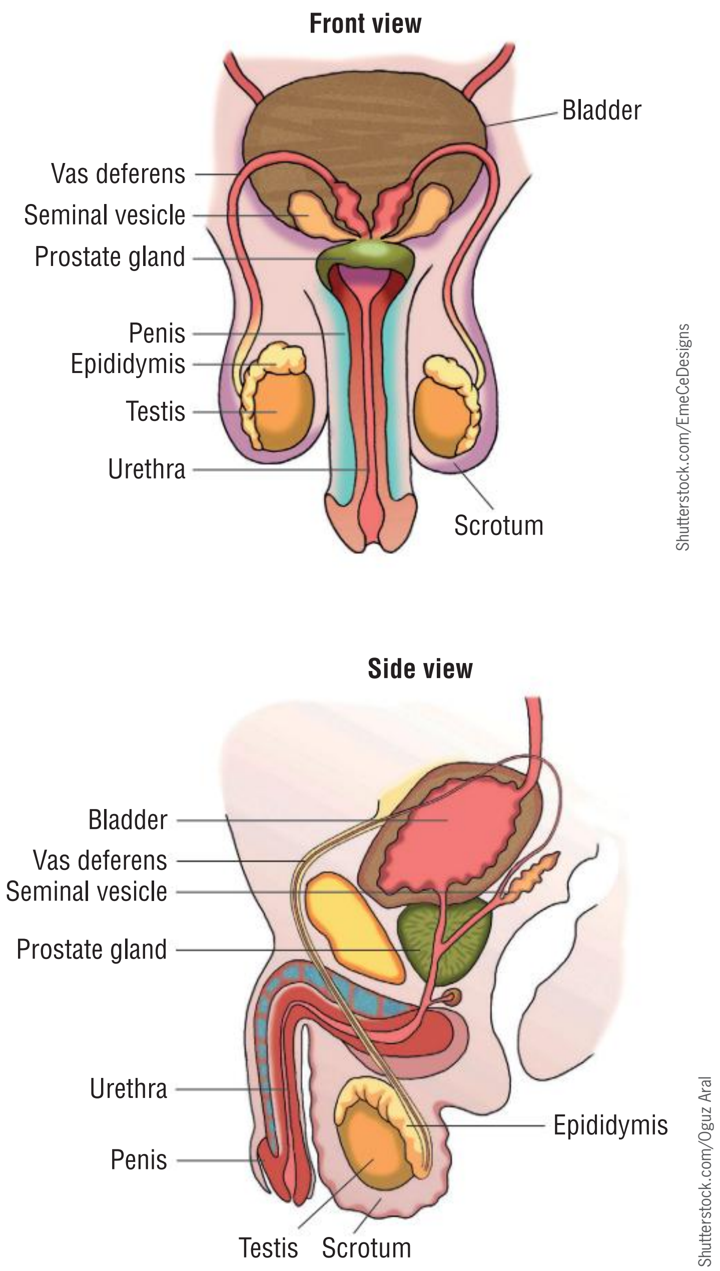

Figure 3.20
Male reproductive system

The human female reproductive system

The organs and structures of the female reproductive system are involved with receiving the sperm, ova production and fertilisation, and caring for the young until birth.

Ova are produced in the ovaries. A female baby is born with all the ova she will ever produce. Once a girl reaches **puberty**, the ova will progressively mature and be released from the ovary. This is known as **ovulation** and occurs every 28 days. The mature ovum travels down the **fallopian tube** (also known as an oviduct). If sexual intercourse has occurred in the previous 5 days or so,

puberty
sexual maturation in humans

ovulation
the release of an ovum from the ovary

fallopian tube
the tube that carries ova to the uterus; can be the site of fertilisation if sperm is present

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cervix
the narrow region at the lower end of the uterus and top of the vagina

vagina
the tube leading from the uterus to outside the body; acts as the birth canal

menstruation
the monthly shedding of the lining of the uterus in sexually mature females

and there are live sperm in the fallopian tube, fertilisation will occur here. If there are no sperm in the fallopian tube, the ovum will continue down and move into the uterus (also known as the womb).

The walls of the uterus contain many blood vessels and glands. These act to prepare the uterus wall for pregnancy. If no pregnancy occurs, the lining of the uterus breaks down. The ovum moves with the lining through the **cervix** (the opening of the uterus) and to the outside through the **vagina**. This is the process of **menstruation** (periods). Menstruation occurs every month if a female is not pregnant.

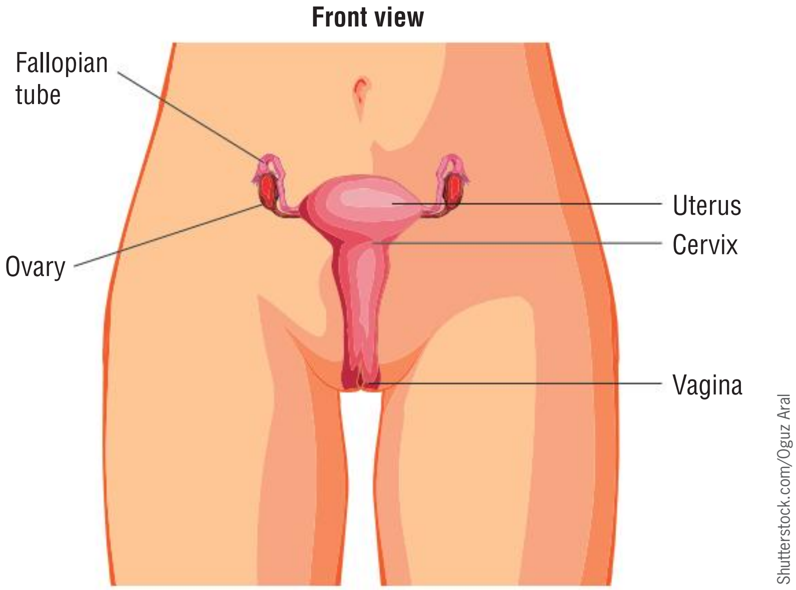
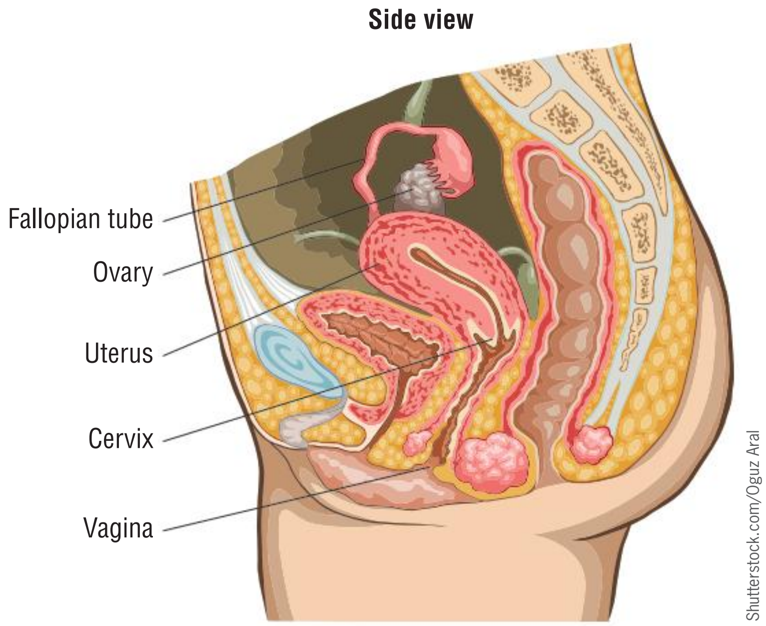


Figure 3.21 Female reproductive system



ANIMATION
Structures of the female reproductive system

ACTIVITY SHEET
Structure and function of the female reproductive system

ISBN 9780170231497

ACTIVITY 3.2

Menstrual cycle

Create a visual representation of the 28-day cycle that a woman goes through. Include ovulation and menstruation in the cycle.

ICT

Upload your visual representation to the class wiki.

Bringing the egg and sperm together

During sexual intercourse, the erect penis is placed inside the vagina, into which the man **ejaculates**. This involves muscular **contractions** that move the semen out through his urethra, into the woman's vagina.

The sperm then swim up through the woman's uterus to the fallopian tubes to meet an egg. This is when fertilisation occurs.

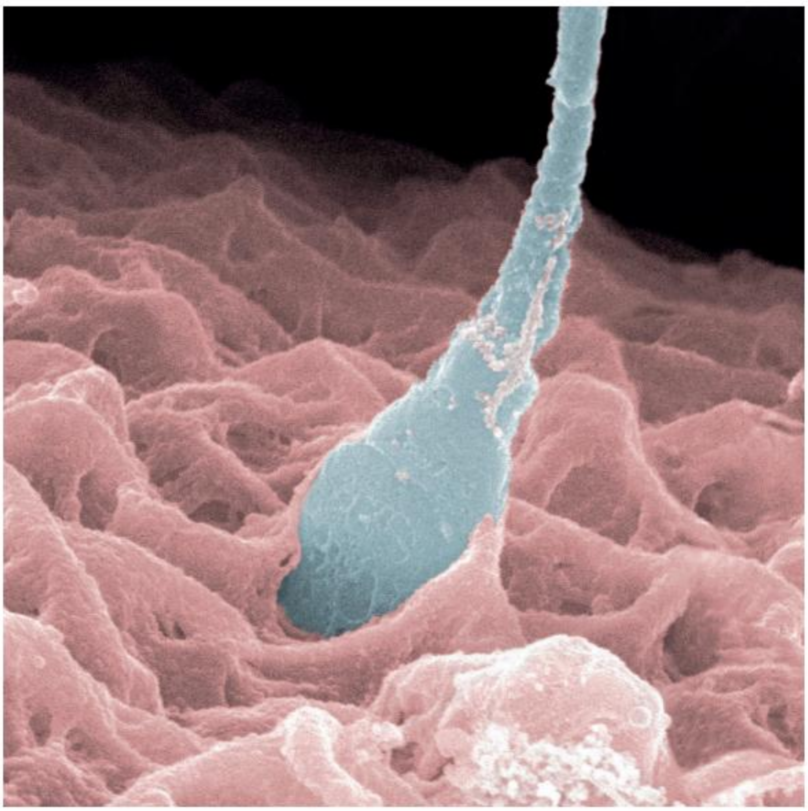
Of the 400 million or so sperm that are released, most die. Only a few hundred reach the egg. These release enzymes that dissolve the ovum's protective coat. Once a sperm enters the ovum, a protective chemical barrier develops around the egg to prevent any more sperm from entering. Hence, only one sperm can enter the egg. This is fertilisation and is shown in Figure 3.22. The head of the sperm fuses with the egg to form a zygote. The tail of the sperm stays outside.

ejaculate

to release sperm and semen from the penis

contraction

tightening and relaxing of muscles



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WEBLINK
Crossword

Figure 3.22
The moment of fertilisation

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ICT

Create a crossword by using words from the glossary terms in this chapter so far. Upload your crossword to the class wiki. Download someone else's crossword and complete this.

WOW!

Risky business

For male praying mantises and spiders, sex – the mechanism for internal fertilisation – can be extremely risky. Often the female will eat the male or at least bite his head off after mating!

Shutterstock.com/Dr. Morley Read

In vitro fertilisation

'In vitro' means 'in glass'. **In vitro fertilisation (IVF)** techniques have been developed over the last 40 years to overcome **infertility** in males or females. Infertility can occur as a result of blocked fallopian tubes, age, or low sperm count as well as many other reasons. The first IVF pregnancy was achieved by a team working at Monash University in Victoria in 1973. Although this pregnancy lasted only a few days, it was a small but necessary step. The first IVF live birth occurred 5 years later in the United Kingdom when Louise Brown was born.

in vitro fertilisation (IVF)
fertilisation that occurs artificially in a glass Petri dish in a laboratory

infertility
inability to reproduce

Getty Images/Gamma-Keystone via Getty Images

Figure 3.23 The first IVF baby is born.

ISBN 9780170231497

During the IVF process, eggs are 'harvested' from the woman's ovaries. The eggs are placed in a glass Petri dish along with collected semen. The ratio of sperm to eggs is about 75 000:1. When fertilisation of one or more eggs is achieved (this can take up to 18 hours), they are placed into the uterus of the mother. Here, the fertilised egg or eggs go through the pregnancy cycle. The number of live births resulting from IVF treatment depends on the age of the mother. Younger mothers (21 years or less) have a higher success rate than older mothers (38 years or older). Millions of babies worldwide have now been born through IVF treatment.

QUESTIONS 3.3

What have you learnt?

WORKSPACE
What have you learnt? 3.3

Remembering

1 **Define** 'sexual reproduction'.

2 **Identify** what the human male and female gametes are called.

3 **Describe** the two main types of fertilisation in animals.

Understanding

4 **Identify** the organs in sequence that the male's gametes pass through to get outside the body.

5 **Identify** the organs in sequence that the female's gametes pass through if pregnancy does not occur.

6 **Identify** where fertilisation usually occurs in humans.

7 **Define** 'menstruation'. **Identify** how often it occurs.

8 **Recount** the steps in the IVF process.

Applying

9 **Explain** how gametes differ from other cells in the human body.

10 **Explain** how organisms overcome the disadvantages of external fertilisation.

11 There is a greater chance of multiple births (such as twins or triplets) for women undergoing IVF treatment. **Explain** which step in the IVF process enables this to happen.

Creating

12 **Describe** the reasons people have for undergoing IVF. **Assess** whether these reasons are valid.

Evaluating

13 Complete a plus minus table for internal fertilisation. **Compare** this with the plus minus table you completed for external fertilisation (Activity 3.1, page 67). Based on your comparison, **evaluate** which is the more reliable type of fertilisation.

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WORKSPACE
Designer babies

ACTIVITY 3.3

Designer babies

1 **Define** 'designer babies'.
2 **Identify** the positives and negatives of this concept.
3 Conduct a class debate on whether or not parents should be able to choose the characteristics of their baby.

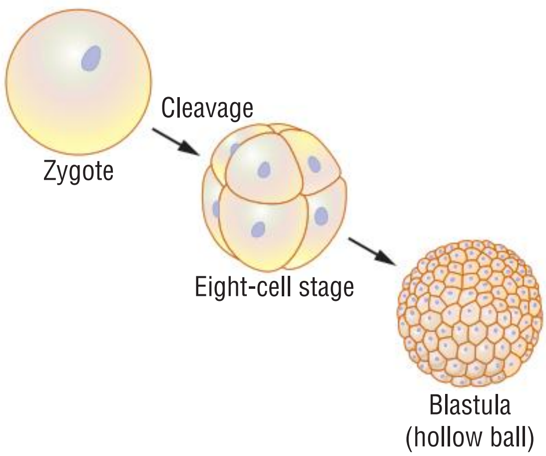

Figure 3.24
Division of the zygote

foetus
the stage of embryonic development after 11 weeks' gestation

Pregnancy

In humans, as soon as the egg is fertilised it immediately begins to divide. This division involves mitosis.

The ball of cells grown from the fertilised egg moves to the uterus and attaches to the uterus wall. It grows the placenta, which holds it to the thickened lining of the uterus. The placenta has a rich blood supply to support the developing embryo. Hormones are released to maintain the lining of the uterus and prevent menstruation. Technically, this is the start of pregnancy; however, pregnancy is timed from the first day of the woman's last period. For the first two weeks of 'pregnancy' the woman isn't actually pregnant!

After a while, the cells start to specialise and an embryo develops. After five weeks, a functioning brain, heart and spinal cord develop, and so does a tail! The tail is reabsorbed later. Internal organs are already starting to develop.

In week six, eyes, nose and ears start to form. Buds appear from the body and slowly develop into arms and legs, with fingers and toes forming soon afterwards. You can see these in Figure 3.25. After two months, the embryo is developed enough to be called a **foetus**. It starts moving, although this can't be felt by the mother yet. Already, its fingerprints are forming!

Getty Images/Dr G. Moscoso/SPL

Figure 3.25
A six-week-old foetus

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The developing foetus obtains all of its requirements through the umbilical cord, which carries the foetus's blood to the placenta. The placenta grows from some of the first cells of the developing embryo. The placenta is close enough to the mother's blood for nutrients and wastes to diffuse across it, although the blood of the mother and baby never actually mix. The foetus gains requirements such as nutrients and oxygen and excretes waste via the placenta. The mother removes these wastes through her kidneys or lungs.

By the end of the third month, the foetus has fingernails and bones. It weighs about the same as two grapes.

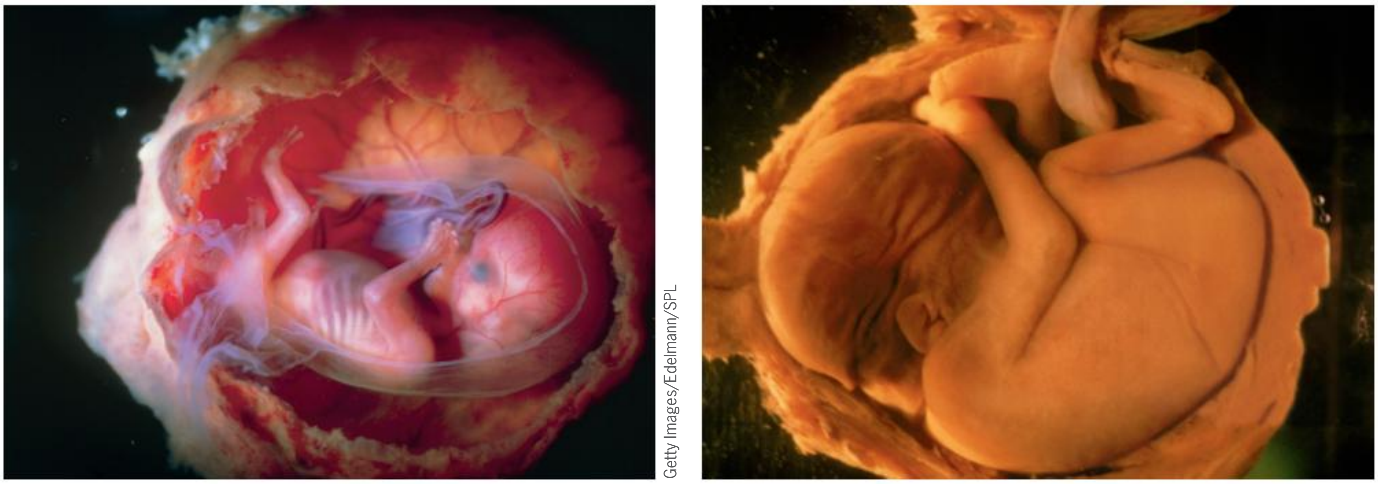
In the fourth month, the foetus starts to grow hair and its internal organs develop further. The foetus weighs about 110 g, similar to a small apple. This is when the mother first feels her baby moving. The baby's reproductive organs are developing and its sex can be determined.

In the fifth month, the internal organs develop very rapidly. The baby can weigh up to half a kilogram. This is when most women 'start to show'.

In the sixth month, the baby's eyelashes grow. Babies born at this stage can survive. However, they need a lot of medical help, and generally have health problems all their life.

Figure 3.26
a A four-month-old foetus;
b a six-month-old foetus

a **b**



Getty Images/Edelmann/SPL

Getty Images/Biophoto Association

After seven months, the foetus's eyes open and close. If the baby is born after seven months' **gestation**, it can generally survive, but it still requires medical assistance.

After eight months' gestation, the baby has a good chance of survival once born. Most of its organs are well developed. The last organs to develop are the lungs. These aren't used until the baby is born. It exchanges oxygen and carbon dioxide through the placenta until then, and is surrounded by fluid in the **amniotic sac**. It is only near the end of the ninth month that the lungs can cope with air.

After a little over nine months, the baby is ready to be born. Most babies weigh 3–3.5 kg when born.

Human babies are nowhere near as well developed as many other mammalian babies. Horses walk and run within an hour of being born – human babies take about a year to do this! But the baby can't stay inside the mother any longer or its head will be too big to get out through her pelvis.

gestation

the period of time a foetus/embryo spends developing inside its mother; begins with fertilisation and ends at birth

amniotic sac

a sac containing fluid in which the embryo or foetus develops

ACTIVITY SHEET
Science career–obstetrician

ISBN 9780170231497

WEBLINK
My growing baby

WEBLINK
Watch the baby grow

ACTIVITY 3.4

Growth of the foetus

Aim

To model the size and mass of a human foetus during its development in the womb

Materials

- graph paper or Excel spreadsheet

Method

1. Use the information given in Table 3.1 to create a graph of foetal development. Include time (in weeks) along the *x* axis and body length (in millimetres) along the *y* axis. Plot these points with an x. You can either draw this by hand or graph it electronically using Excel.
2. On the same grid, use the right-hand axis to plot body mass (in grams) against the time (in weeks). Plot these points with an open circle. Remember to put a title on your graph that reflects both sets of information. Include a key so you know which data is body mass and which data is body length. Draw a line of best fit for each set of data.

Table 3.1
Body length and body mass of a developing foetus

Age of embryo or foetus (weeks)	Body length (mm)	Body mass (g)
1–2	0	0
3	0.3	0
4	0.4	0.1
5	0.5	0.3
6	4	0.5
7	8	0.7
8	13	1
9	18	2
10	30	3
12	80	25
16	150	80
19	200	40
23	280	725
27	380	1200
31	430	2000
35	480	3000
39	530	3500

ACTIVITY SHEET
Modelling growth of a baby

ISBN 9780170231497

ACTIVITY 3.4

Discussion

1 **Explain** what the two different lines on the graphs tell you.
2 **Identify** which happens first: the increase in length or the increase in body mass.
3 **Identify** the weeks between which the embryo or foetus increased most in body length.
4 **Identify** the weeks between which growth in body mass was slowest.
5 **Identify** the month in which the foetus reaches a mass of 1 kg.
6 **Explain** which you think would be a better indicator of growth: body length or body mass.
7 By the end of pregnancy, the body mass of the foetus is increasing more than the body length is. **Explain** this.

Birth

When the baby is fully developed, hormones are released to bring on **labour**. Labour is a series of contractions of the muscular uterus. The contractions help move the baby into the right position for birth, open the cervix and eventually push the baby out through the vagina. During labour, the fluid-filled amniotic sac that surrounds the baby bursts and the fluid flows out through the vagina. This is known as the **breaking of the waters**.

Babies are normally born head first – the safest and easiest position. They generally turn upside down in the uterus a few weeks before birth. If they don't, this is called a **breech birth**. This can be more dangerous but many breech births occur naturally, with no problems.

After the baby is born, the placenta is delivered. This is called the afterbirth.

labour
muscular contractions that prepare for birth

breaking of the waters
the release of amniotic fluid (waters) when the amniotic sac breaks open just prior to birth

breech birth
when a baby is born buttocks or feet first, rather than head first

antibody
a protein that fights infection in our body

immune system
the body system that fights infection and disease

iStockphoto/1joe

Figure 3.27
A newborn baby only minutes old receiving a checkup from nurses.

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Survival of newborns

Mammals, including humans, feed their young on milk. This is produced in mammary glands, or breasts. It is controlled by hormones released during pregnancy and birth.

As well as feeding the baby, breast milk provides the baby with **antibodies** from the mother. Antibodies are proteins that fight infection or disease. A baby's **immune system** is not developed and so many diseases can kill babies quickly. If the baby is breastfed, the antibodies from the mother can prevent the baby from becoming sick.

WORKSPACE
What have you learnt? 3.4

ICT

Write down all the words from this chapter that were new to you. Copy this list and go to Tagxedo (see the weblink below). Create a new word cloud, paste the list of words that you generated and choose a shape, colour and font, to create a word cloud of your new words.

WEBLINK
Tagxedo

QUESTIONS 3.4

What have you learnt?

Understanding

1 **Identify** how long a normal human pregnancy lasts.

Applying

2 **Describe** the function of the placenta. **Explain** how its structure is suited to its function.

3 **Explain** why a human female reproductive system is ideally suited to the internal development of a zygote to a foetus.

Creating

4 **Construct** a table to clearly **show** the stages in development from a zygote to a fully developed foetus. **Explain** why the organs develop in the order that they do.

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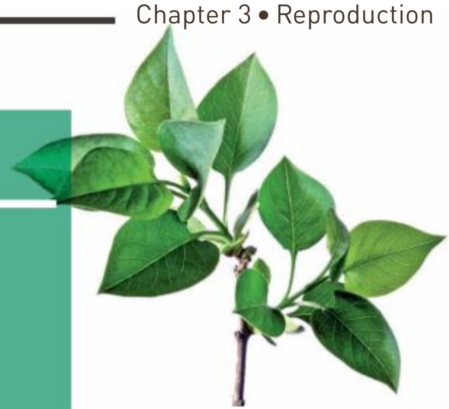

Chapter review

Remembering

1 **Define** 'fertilisation'.

Understanding

2 **Distinguish** between:
 a pollen and sperm
 b pollination and fertilisation
 c pollination and seed dispersal
 d a seed and a fruit
 e a gamete and a zygote
 f an embryo and a foetus.

Applying

3 **Explain** why many plants make sweet, colourful and nutritious fruit.

4 **Explain** why plants grow by making new cells rather than by just increasing the size of the cells they have.

5 **Explain** why it is important for seeds to be dispersed far from the parent plant.

6 **Contrast** human eggs and human sperm. **Identify** three differences.

7 **Outline** the role of the umbilical cord.

8 **Describe** where the placenta comes from, and where it goes.

9 **Propose** a reason why organisms that undergo external fertilisation can have more offspring than those that undergo internal fertilisation.

10 **Describe** why mammals have small eggs, and birds, reptiles, fish and amphibians have large ones.

11 Many different science careers require an understanding of plant reproduction. Choose one of the following and **explain** how they would benefit from an understanding of plant reproduction.
- Farmer (growing crops such as wheat, rice, canola or barley)
- Botanist
- Horticulturalist

12 Put the following events into order to reflect the start of a new life:

embryo development, fertilisation, birth, gamete production, foetus development, delivery of afterbirth, waters breaking, intercourse

13 A man can produce at least 500 million sperm every day. Can a woman produce 500 million eggs every day? **Explain** the limitations of the female reproductive system in light of this information.

WORKSPACE
Chapter 3 review

ACTIVITY SHEET
Chapter 3 checklist

REVIEW QUIZ
Chapter 3

ISBN 9780170231497

Analysing

14 **Explain** why the wall of the uterus is made of thick muscle.

15 **Describe** the differences you would expect between plants grown from seeds and the same type of plant grown from cuttings.

16 Many species of plants can fertilise themselves but many other species don't.
  a **Explain** why it would be beneficial for a plant to be able to fertilise itself.
  b **Explain** why many species do not fertilise themselves.

17 The eggs we eat come from female chickens. People who keep chickens for eggs generally do not have a rooster. **Explain** why these chicken eggs won't hatch.

Evaluating

18 **Compare** and **contrast** two methods of reproduction. **Assess** which one of the two methods you think is the most efficient at producing offspring.

19 **Suggest** why plants have different methods of reproducing.

20 **Describe** what would happen if plants stopped reproducing.

Creating

VIDEO
Conserving fish stocks

21 Barramundi are excellent fish for eating. Barramundi are unusual because they start life as males, and when they reach 80–100 cm long they turn into females. In some places in Australia, barramundi that are less than 50–60 cm in length when caught must be put back in the water. **Explain** why this size limit could cause problems for barramundi populations. Queensland has a size limit of 120 cm. **Explain** how this can help avoid the problem you described.

22 Watch the video 'Conserving fish stocks'.

Given what you have learnt about reproduction, **propose** a solution to the problem of unsustainable fishing.

23 **Explain** the difference between a marsupial and a placental mammal. Where do you think a platypus fits in?

Reflecting

24 Return to the questions that you wrote in 'What do you already know about reproduction?' on page 49. Write answers to these questions. If you cannot answer your questions, how might you go about finding out the answers?

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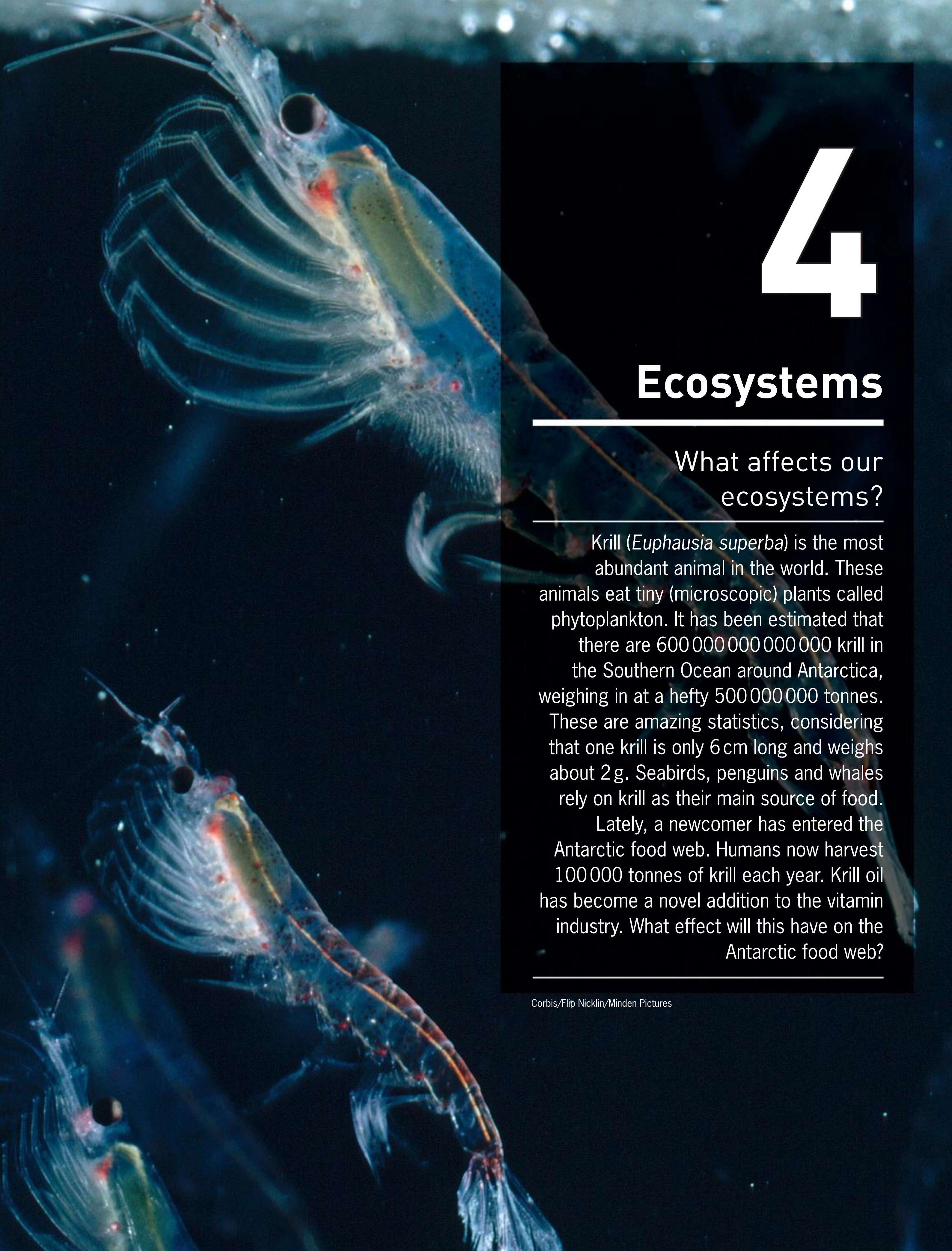

4

Ecosystems

What affects our ecosystems?

Krill (*Euphausia superba*) is the most abundant animal in the world. These animals eat tiny (microscopic) plants called phytoplankton. It has been estimated that there are 600 000 000 000 000 krill in the Southern Ocean around Antarctica, weighing in at a hefty 500 000 000 tonnes. These are amazing statistics, considering that one krill is only 6 cm long and weighs about 2 g. Seabirds, penguins and whales rely on krill as their main source of food. Lately, a newcomer has entered the Antarctic food web. Humans now harvest 100 000 tonnes of krill each year. Krill oil has become a novel addition to the vitamin industry. What effect will this have on the Antarctic food web?

Corbis/Flip Nicklin/Minden Pictures

Living world – Stage 4

Key knowledge

- Food chains and food webs exist in all ecosystems.
- Ecosystems are made up of different interactions between producers, consumers and decomposers. These interactions can be represented by food webs and food chains.
- Human activities such as overfishing or land clearing can disrupt interactions in food webs and impact the health of an ecosystem.
- Australian plants and animals have special adaptations to survive and reproduce in environments such as deserts or tropical forests.
- Resource management knowledge from Aboriginal and Torres Strait Islanders can be applied to help better care for Australia's ecosystems.
- Technology and scientific research, along with other private and government agencies, work together to develop and manage ecosystems after natural disasters and human impact, including development in agricultural and horticultural processes.

ACTIVITY SHEET
CAT with rubric: Food webs in your environment

CULMINATING ASSESSMENT TASK

Food webs in your environment

Urban environments have food webs too. **Investigate** the plants and animals living around your school, neighbourhood or another location selected by your teacher. **Demonstrate** the feeding relationships, using photographs or drawings, and **construct** at least one food chain. **Synthesise** your food chain with others from the class to **construct** a local food web.

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What do you already know about ecosystems?

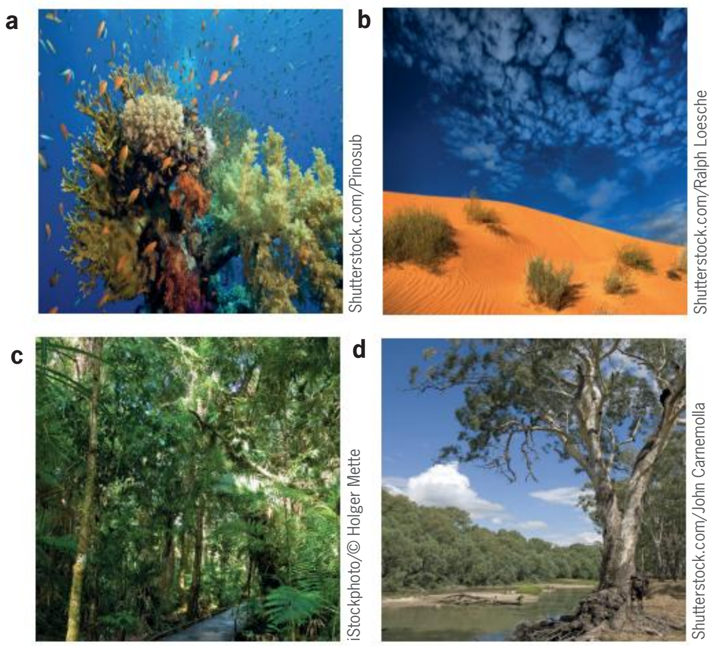

Figure 4.1 Australian ecosystems: **a** Great Barrier Reef **b** Simpson Desert **c** Daintree Rainforest **d** Murray River red gum forest

1 Write three different definitions for the word 'ecosystem'. The audiences for your definitions are:

a a primary school student
b an adult
c a visiting scientist you hope to impress with your knowledge.

2 What do you already know about the different ecosystems found in Australia? Write the heading 'Australian ecosystems' and brainstorm a list of related terms. Here are some questions that might help you get started:

- What types of animals are found in Australia? Are they found across the whole country or only in one area?
- What types of plants are found in Australia? Are coastal plants different from forest plants?
- What type of weather is typical in Australia?
- What type of **climate** does the Northern Territory have in summer? What type of climate does Tasmania have in winter?
- What type of soil does Australia have? Does it change as you move from Victoria to Western Australia?
- What types of aquatic animals are found in Australian waters?

3 Once you have completed your brainstorm, use green to highlight all the terms that represent **biotic** (living factors), such as 'echidnas' and 'grass'. Then use orange to highlight all the terms that represent **abiotic** (non-living factors), such as 'humidity' and 'rocks'.

4 Choose two of the factors you highlighted green and **describe** how their characteristics help them survive in their natural environment.

WORKSPACE
What do you already know about ecosystems?

climate
the weather conditions found in a region over a period of time

biotic
any living part of the ecosystem, such as plants, animals, micro-organisms

abiotic
any non-living factor, such as salinity, pH, humidity, wind, soil

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4.1 What is an ecosystem?

Australia has many different types of **environments**. These range from hot, humid environments in tropical Queensland to the cold, snowy environments of the Victorian alpine region and the hot, dry environments of Central Australia. An environment is the set of conditions within a given area. These can include temperature, amount of light, types of **predators** and prey, rainfall, the **pH** of soil, the **salinity** (saltiness) of water or soil, and the number of different **species** living in the area. Environmental factors can be separated into two groups: biotic and abiotic.

An **ecosystem** includes all the biotic and abiotic environmental factors of an area and how they interact with one another. The relationship that each **organism** has with the environment is unique. Indigenous Australians explain the relationships between organisms and the Sun through Dreamtime stories. Use the weblink to read 'Earth dying, Earth reborn'. This story explains Aboriginal understanding of the complex ecosystem. It describes organisms such as grasses and trees requiring the Sun's energy to grow, and insects to pollinate them. It says that reptiles, which are **ectotherms**, require the Sun's warmth to be able to move, and that different water systems have diverse fish and water life. Through stories such as these, Indigenous Australians explain the seasons and the importance of night, in order to rest for future journeys.

environment
a unique set of non-living and living factors (conditions) for a particular area and time

predator
an animal that preys on other animals

pH
the acidic or alkaline nature of a substance

salinity
the concentration of salt found in soil or a body of water

species
a group of individuals having common characteristics, capable of interbreeding and producing fertile offspring

ecosystem
a community of organisms interacting with one another and with their environment

organism
a living thing

ectotherm
an organism that cannot maintain its internal body temperature; a cold-blooded organism

WEBLINK
Earth dying, Earth reborn

ACTIVITY SHEET
Venn diagram – living and non-living factors

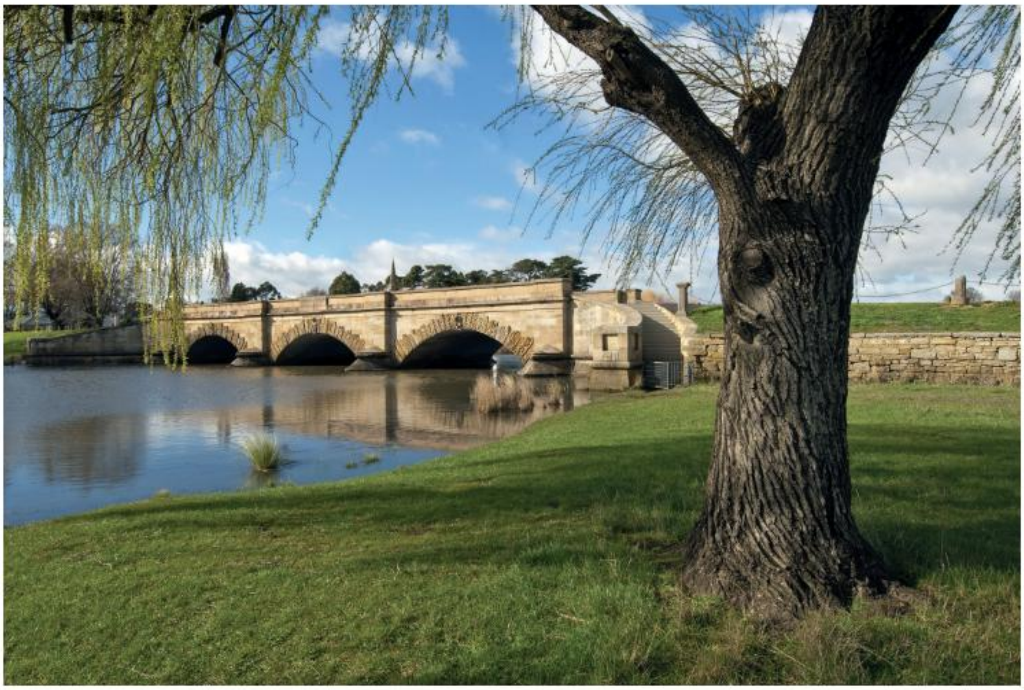
Shutterstock.com/David Lade

Figure 4.2 Identify the living and non-living factors can you see in the picture.

Biodiversity

Australia's ecosystems change in dramatic ways. Each ecosystem has its own different plants, animals and micro-organisms. The variety of living organisms in a particular area is known as its **biodiversity**. The biodiversity of the tropical rainforests of Queensland is considerably greater than that of the **arid** deserts of Central Australia. Why might this be the case?

biodiversity
the variety of different living organisms found in a particular area

arid
describes a region characterised by a severe lack of water available to support organisms

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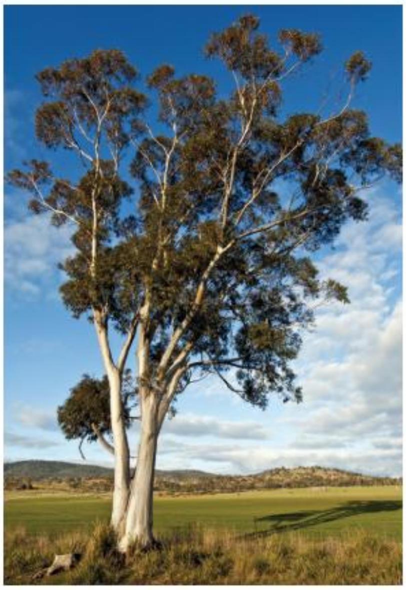
a

iStockphoto/© Ron Masessa

b

Shutterstock.com/Jordan Tan

c



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d

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f

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g

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h

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Figure 4.3 Australia's biodiversity: **a** Green sea turtle **b** Kangaroo paw **c** Eucalyptus tree **d** Dugong **e** Emu **f** Koala **g** Eastern grey kangaroo **h** Thorny devil

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Megadiversity

WOW!

Australia is one of 17 megadiverse countries of the world. It is home to between 60 000 and 70 000 species. About 84% of our plant species and 83% of our mammals are not found anywhere else in the world.

ecologist

a scientist who studies ecosystems and the changes in environments

diurnal

describing an organism that is active during the day

nocturnal

describing an organism that is active at night

An **ecologist** would tell you that environmental factors contributing to the tropical rainforest allow faster breakdown of organic debris, providing the soil with more nutrients to support a larger number of different species, whereas the harsh environmental factors that surround the deserts of Central Australia limit the growth of food and, in turn, the number of organisms that can survive in the area.

Ecologists use a number of techniques to determine what organisms live in each unique ecosystem. It is often possible to identify **diurnal** animals and plants by careful observation. But it is not so easy to find out about the **nocturnal** animals or the variety of insects that inhabit a particular tree. Ecologists also use a number of techniques to determine population numbers of various organisms and to identify abiotic factors that may be affecting the species in a particular location. They must determine these important statistics so that they can effectively conserve and manage an ecosystem.

ACTIVITY SHEET
Life in Asia

ACTIVITY SHEET
Ecosystems around the world

ACTIVITY SHEET
Interview with an ecologist

ACTIVITY SHEET
What's in the pond?

ACTIVITY 4.1

Investigating wildlife sampling techniques

Ecologists use a number of techniques to determine the different species that live in an ecosystem. Which technique they use will depend on the type of ecosystem they wish to conserve.

Choose one of the following techniques to research. **Discuss** and present your information in a multimedia format.

Sampling techniques

- Tree screens
- Pitfall traps
- Bird banding
- Water sampling
- Scat analysis
- Hair/DNA analysis
- Electrofishing

You could include the following in your presentation:

- an interview of a local scientist or a member of a land management group
- arguments for and against the use of the sampling technique (for example, **explain** whether the technique harms the organism; if so, this would be argument against the sampling technique)
- improvements to the technique.

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QUESTIONS 4.1

What have you learnt?

Understanding

1 **Explain** the difference between an environment and an ecosystem.

2 **Describe** your school environment.

3 **Identify** five abiotic and five biotic factors in an ocean ecosystem.

4 **Define** 'biodiversity'.

Applying

5 **Compare** and **contrast** the different abiotic and biotic factors that impact on:
   a diurnal terrestrial animals
   b nocturnal terrestrial animals.

6 At Katoomba in the Blue Mountains a developer wants to clear some eucalypts to create a new subdivision for the growing population.

   Explain the important role an ecologist would have prior to allowing or not allowing the subdivision to occur.

Reflecting

7 **Outline** the ethical responsibility humans have towards natural ecosystems.

WORKSPACE
What have you learnt? 4.1

4.2 Adaptations for survival

A feature that increases an organism's chance of survival is known as an **adaptation**. There are three different types of adaptation:

- behavioural adaptations, such as an animal seeking shade in the middle of the day
- structural adaptations, such as an animal having strong front legs and sharp claws for digging burrows
- functional adaptations, such as an animal being able to reduce its **metabolic rate** to allow it to **hibernate** in winter.

Adaptations are not specific to animals; plants also exhibit a variety of adaptations that help them to survive and reproduce in their environment.

adaptation
a characteristic of an organism that improves the organism's chance of survival

metabolic rate
the amount of energy released in chemical reactions occurring in the body

hibernate
to remain dormant for an extended period of time, generally over winter

Plant adaptations

As plants are unable to move and escape the heat, they need more specific adaptations to save water. Some plants have specialised roots, leaves or stomata.

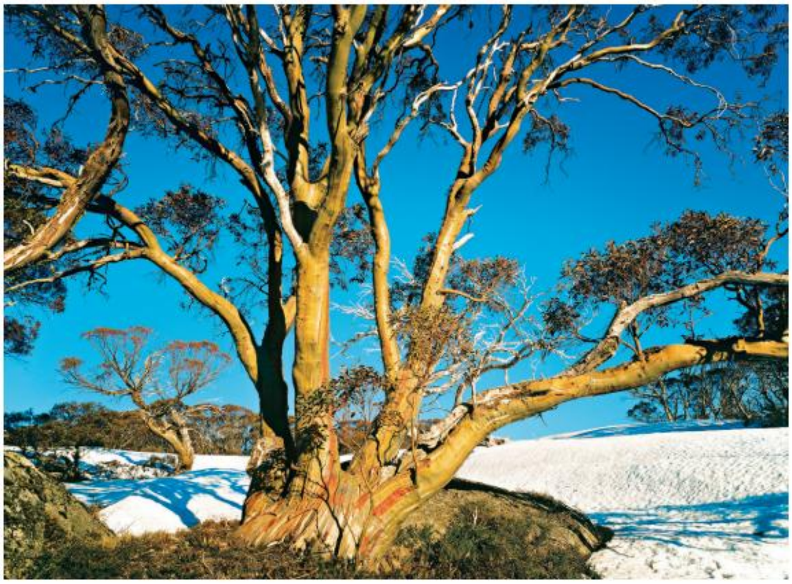
ISBN 9780170231497

Figure 4.4
A tap root

Eucalyptus trees

Eucalyptus trees, such as the river red gum (*Eucalyptus camaldulensis*) which is found all across Australia, have a specialised root structure that allows them to obtain water from sources deep underground. The river red gum has a tap root that can grow vertically downwards for up to 10 m to find water. Interestingly, studies in western New South Wales suggest that this figure may be conservative and the roots can penetrate much deeper.

Snow gums (*Eucalyptus pauciflora*) are found in the NSW and Victorian alpine regions. These trees have special adaptations to reduce the water lost through their stomata. Like desert plants, the leaves of plants of the alpine region have special coatings, such as hair or wax, or are folded to restrict air flow and, in turn, water loss. The snow gum has a narrow leaf, which reduces the surface area exposed to the sun's heat, and its waxy coating reflects UV light. It is vital that they reduce their water loss while the water is locked up as ice and wait for warmer temperatures. The shape of the leaf also helps it to shed snow.



Corbis/Steve Parish Publishing/Steve Parish Publishing

FloraPhoto/Colin Bower

Figure 4.5 (left)
Snow gum

Figure 4.6 (right)
Hairy styleworts

ephemeral
having a short life cycle

Styleworts

The hairy stylewort or *Levenhookia dubia* is a plant that exhibits a behavioural adaptation. This particular species of stylewort is found in the sandy soils of NSW, South Australia, Victoria and Western Australia. This plant is also known as an **ephemeral** plant. An ephemeral plant is known for its short life cycle. Generally ephemeral plants will grow, flower and disperse in 6–8 weeks. *L. dubia* will lie dormant over the summer and winter seasons and only flower after the wet season has started (September to October) to give it the best chance to reproduce.

Banksias

In 1770 Sir Joseph Banks travelled to Australia on the *Endeavour*, and it was at Botany Bay that he collected the first banksia specimen. Banksias, in particular *Banksia quercifolia*, have a unique adaptation to reduce water loss. On the underside of their leaves they have fewer stomata and the stomata are sunken into the leaf cuticle. This creates a local humid environment around each stoma, which reduces the amount of water vapour lost through these microscopic pores.

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Animal adaptations

Animals of arid environments also show various adaptations for survival. They can have a small body size, use burrows, remain inactive during the heat of the day, or travel long distances to escape heat or find water.

The kangaroo

The red kangaroo (*Macropus rufus*) is one of 50 native species of kangaroos in Australia and the largest. Its most common natural **habitat** is the sparse outback of north-western NSW, where it can be very hot. The kangaroo must be able to keep its body temperature down. In the heat of the day, the kangaroo will seek the shade of a tree and remain inactive until dusk, when it will feed. This behaviour lowers its metabolic rate and therefore reduces the amount of heat produced by the body. The kangaroo will also lick its front limbs. As the wind blows over the moisture from its saliva, evaporation occurs and cools the body further.

habitat

the place where an organism lives, which has a unique set of non-living and living factors (conditions) for a particular area and time

Figure 4.7
The red kangaroo

Corbis/Jami Tarris

Spinifex hopping mouse

The tiny spinifex hopping mouse (*Notomys alexis*), found in Alice Springs, has a number of adaptations to cope with the hot environment. For example, its small body size is a structural adaptation that reduces the area of the body that is exposed to the sun, and therefore reduces the amount of water lost through perspiration. Another structural adaptation is its large ears. They allow excess body heat to be lost, and so help the mouse to maintain a stable body temperature. In periods of long dry weather, the mouse can go without drinking, as its kidneys retain every drop of water from its waste, so that none is lost to the environment; this is a type of functional adaptation. The mouse also displays behavioural adaptations. For example, during the heat of the day it hides in a deep, humid burrow and feeds at night when temperatures are cooler. The spinifex hopping mouse has also been known to migrate up to 15 km towards rain.

Corbis/D. Parer & E. Parer-Cook/Auscape/Minden Pictures

Figure 4.8
Spinifex hopping mouse

The mountain pygmy possum

The mountain pygmy possum (*Burramys parvus*) weighs approximately 45 g and has a body that is about 11 cm long. It is the largest pygmy possum of the five native species. This **endangered** little possum was thought to be extinct until it was discovered in 1966 at Mt Higginbotham, Victoria. In order to survive the harsh cold winters of the alpine region, the mountain pygmy possum collects and stores food in rock crevices where it will live for the winter. An amazing functional adaptation is that the possum falls into a state of **torpor**, reducing its metabolic rate by up to 98% during its hibernation. Due to its small body size, at the start of winter the hungry possum will wake after a couple of days to feed on its food store, but during the height of winter it will stay in a state of torpor for up to 3 weeks.

endangered

a species threatened with becoming extinct

torpor

a state of hibernation in which the metabolic rate of an organism is lowered in order to reduce its energy consumption

Newspix/News Ltd/Town Jay

Figure 4.9
Mountain pygmy possum

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ACTIVITY 4.2

Identifying animal adaptations

Carefully observe the images below of animals in their natural environment.

a

Auscape/ © Dave Watts

b

Shutterstock.com/clearviewstock

c

iStockphoto/© susan flashman

d

Corbis/Paul Evans/ Auscape/Minden Pictures

e

Corbis/Shin Yoshino/Minden Pictures

Figure 4.10 Animal adaptations

WEBLINK
Australian animals – Perth Zoo

WEBLINK
Ga:Ni king of the lizards

1 **Identify** some of the adaptations each animal possesses to survive.

Go to the Australian animals – Perth Zoo weblink to learn more about each animal and the environment in which it lives.

2 The story of Ga:Ni king of the lizards on the weblink explains how the frilled-neck lizard got its black belly. **Explain** the benefit of the lizard having a black stomach.

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EXPERIMENT 4.1

Field trip: investigating adaptations

Introduction

Animals and plants have a range of adaptations to help them survive in different environments. On this field trip you will be taken to various places, such as a zoo and botanical gardens, to observe different plants and animals. You are to sketch, take photographs and make observations of a range of plants and animals to **analyse** their adaptations.

Aim

To investigate a range of plant and animal adaptations

Materials

- range of plants and animals
- camera
- pencils
- paper

Method

1 Choose three different animals to observe.

2 Record their appearance by sketching them or taking photographs.

3 Record a description of their environment.

4 Choose three different plants to observe.

5 Repeat steps 2 and 3.

Results

Display your results in an easy-to-interpret way.

Discussion

1 For each organism, **discuss** in a paragraph how the adaptation relates to its survival in its environment.

2 **Identify** three different ways in which the investigation could be improved.

Conclusion

3 **Summarise** what you have learnt and **relate** it back to the aim.

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WORKSPACE
What have you learnt? 4.2

QUESTIONS 4.2

What have you learnt?

Understanding

1 **Define** 'adaptation'.

2 **Describe** the difference between structural, functional and behavioural adaptations. Provide an example of each.

3 Briefly **explain** two adaptations that will help animals survive in an arid environment.

4 Unlike animals, plants cannot simply pull up their roots and go in search of water. **Identify** and **explain** how the snow gum overcomes the lack of water in the winter.

Applying

5 Choose a native plant or animal in your state. **Identify** an adaptive feature of the organism and **justify** why it is required in the environment in which the organism lives.

Analysing

6 **Compare** the two foxes in Figure 4.11. **Deduce** why one fox has such large ears and a thin coat, yet the other has small ears and a thick coat.

a

Getty Images/Ronald Wittek

b

Getty Images/Konrad Wothe

Figure 4.11 a Arctic fox, b Fennec fox of North Africa

Reflecting

7 Write down one concept that you feel you haven't mastered during this section. **Explain** how you would go about finding more information to gain a better understanding. Write down three questions about the concept and find their answers.

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4.3 Relationships in ecosystems

Every ecosystem is unique, but there are some processes that are the same in every ecosystem. One of these is energy flow. This process allows an ecosystem to function and survive. **Energy flow** is the movement of usable energy through an ecosystem.

energy flow
the movement of chemical energy through an ecosystem

chlorophyll
green pigment in plants that absorbs the Sun's energy during photosynthesis

autotroph
an organism that produces its own sugar through photosynthesis; also known as a producer

heterotroph
an organism that must consume other organisms to gain chemical energy; also known as a consumer

cellular respiration
a series of chemical reactions that break down sugar into chemical energy

Energy flow

The energy source for all ecosystems is the Sun. Light energy from the Sun reaches the Earth's surface and plants trap some of this energy using the **chlorophyll** in their leaves. In a process known as photosynthesis, plants use this light energy to convert simple materials into a form of sugar that they can use to grow. The sugar contains energy. Because plants can produce their own energy source, they are called **autotrophs**. When other organisms eat plants, some of this energy-rich sugar is passed on to them. Organisms that get their energy from consuming other organisms are known as **heterotrophs**.

Photosynthesis – the beginning

Photosynthesis is a series of chemical reactions in which water (taken up by the roots of plants) and carbon dioxide (from the air) are converted into oxygen and sugar (glucose). Radiant energy (from the Sun) is used for this process and some of it ends up stored as chemical energy in the sugar. Plants can break down this sugar (by **cellular respiration**) to release the stored energy and use it for living and for growth.

Heterotrophs also need energy for survival. They obtain this energy by eating plants or other animals. For example, photosynthesis will occur in grass to produce glucose, a type of sugar. A portion of the sugar is used when the grass grows, and the rest is stored in the plant. If a kangaroo eats the grass, the stored sugar is transferred to the kangaroo. The kangaroo then uses the sugar and other nutrients in the grass to grow, power its muscles, nourish its joey, and so on.

Cellular respiration

Cellular respiration is the series of reactions that occur in an organism's cells to release energy from the energy-rich sugar glucose. Organisms need this energy to stay alive, grow, move and carry out all their vital bodily functions. When the glucose is broken down by cellular respiration, oxygen is consumed and carbon dioxide and water are produced as waste products. All living things undergo cellular respiration.

ANIMATION
Photosynthesis

WEBLINK
Linking photosynthesis to cellular respiration

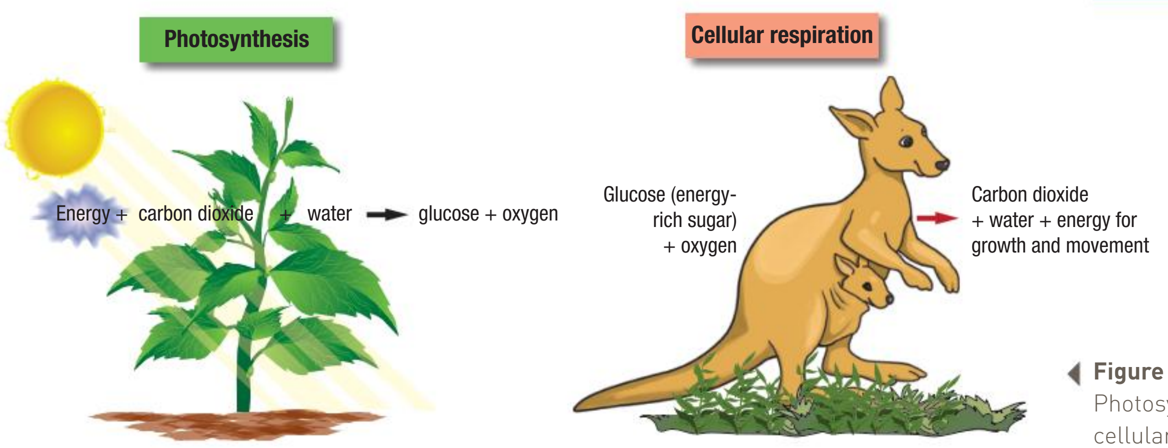

Figure 4.12 Photosynthesis (left), cellular respiration (right)

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WORKSPACE
Student investigation: determining water loss in plants

EXPERIMENT 4.2

Student investigation: determining water loss in plants

You have learnt that photosynthesis uses energy from the Sun to convert carbon dioxide and water into glucose. This energy can be stored or used by the plant to grow. A plant obtains the water required for this process through its roots and loses water from its leaves, through the stomata. At times it can be a challenge for a plant to maintain its water balance in different environments.

Your challenge

In groups, **design** an investigation that will link plant adaptations to the amount of water lost through the stomata. **Investigate** two or more different plant species to determine whether their adaptive features reduce their water loss.

Refer back to Chapter 1 to revise the steps for conducting a scientific investigation. Make sure you conduct all the steps when completing this investigation.

Materials, method and results

1 **Predict** what might happen in this investigation. Use your prediction to formulate a hypothesis.

2 **Identify** how you could measure the amount of water a plant (or plant cutting) loses. What data will you collect? Will it be qualitative or quantitative or both?

3 **Clarify** the variables in this investigation. How will you control all the variables except the one you want to test? What will be your independent and dependant variables?

4 Determine for how long you will conduct the experiment. How often will you record your results?

5 How will you **analyse** and display your results?

Discussion

1 **Explain** what you discovered about the amount of water lost through the leaves.

2 **Clarify** whether the amount of water lost varies for the different plant species that you used.

3 Using the results, **assess** whether the adaptive features work effectively to reduce water loss.

4 **Discuss** whether the results support or disprove your hypothesis.

5 **Identify** any experimental limitations that could have affected the results.

6 **Outline** how you could improve the method in this investigation.

Conclusion

7 Write a paragraph, referring back to your aim, to **summarise** your findings.

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Food chains and food webs

A **food chain** shows how energy flows from one organism to another in an ecosystem. There are four classifications of organisms in a food chain. Plants are always at the bottom of the food chain because they produce their own simple sugars. They are known as **producers**. Above the producers are three levels of **consumers** – primary, secondary and tertiary. They are called consumers because they consume other organisms to obtain their energy.

- Primary consumers feed only on plants (the producers). These organisms are also called **herbivores**. A grasshopper is a primary consumer. (See Figure 4.13.)
- A secondary consumer feeds on herbivores. It may eat plants and animals (making it an **omnivore**) or animals only (making it a **carnivore**). Our example continues with a brown snake eating the grasshopper.
- Tertiary consumers feed on secondary consumers. Our example continues with a wedge-tailed eagle feeding on the brown snake.

Eventually, individual organisms of the populations contributing to the food chain die and become food for **micro-organisms**, such as bacteria and fungi. These micro-organisms break down dead plants and animals and are known as **decomposers**.

food chain
a linear diagram that shows the way energy is transferred from producer to consumer

producer
an organism that produces its own chemical energy through photosynthesis; also known as an autotroph

consumer
an organism that must consume other organisms to gain chemical energy; also known as a heterotroph

herbivore
an organism that feeds solely on plants

omnivore
an organism that consumes both plants and animals

carnivore
an organism that feeds solely on animals

Figure 4.13
An Australian food chain

micro-organism
an organism that is too small to be seen with the naked eye, such as a bacterium

decomposer
a micro-organism, such as fungi and bacteria, that breaks down dead matter

ACTIVITY 4.3

Role-play: creating a food chain

1. Your teacher will give each student an arrow and a picture of an animal or plant. The plants and animals come from a range of environments.
2. Find other students who have a species that lives in the same environment as your plant or animal.
3. **Construct** a food chain, with each student holding their picture and using their arrow to **show** the direction of energy flow.
4. **Demonstrate** the food chain you created by drawing it.

ICT

Use a digital camera to take an image of your completed food chain. Upload your image to the class wiki. Comment on other students' food chains.

Food webs

An ecosystem has a variety of organisms. Most feed on more than one plant or consumer. Therefore scientists create many different food chains to show the flow of energy. A food web looks at the bigger picture of energy flow through an ecosystem. It is created by linking different food chains together. Figure 4.14 shows a typical Australian food web.

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food web
a group of interlinked food chains that gives an overall picture of how energy is transferred through an ecosystem

Food webs also help scientists predict what could happen if one of the organisms in the food web was disrupted in some way. What might happen to the consumers in Figure 4.14 if a drought caused much of the native grass to die? The primary consumers, such as the wallaby or wombat, might no longer have enough food. They might move to a new area, or some individuals might die of dehydration and starvation. In turn, the secondary consumers would have smaller numbers of primary consumers to prey on, limiting their food supply. This would cause some individuals of the kookaburra and red-bellied black snake populations to die of starvation. In this way, the impact of the drought flows throughout the ecosystem.

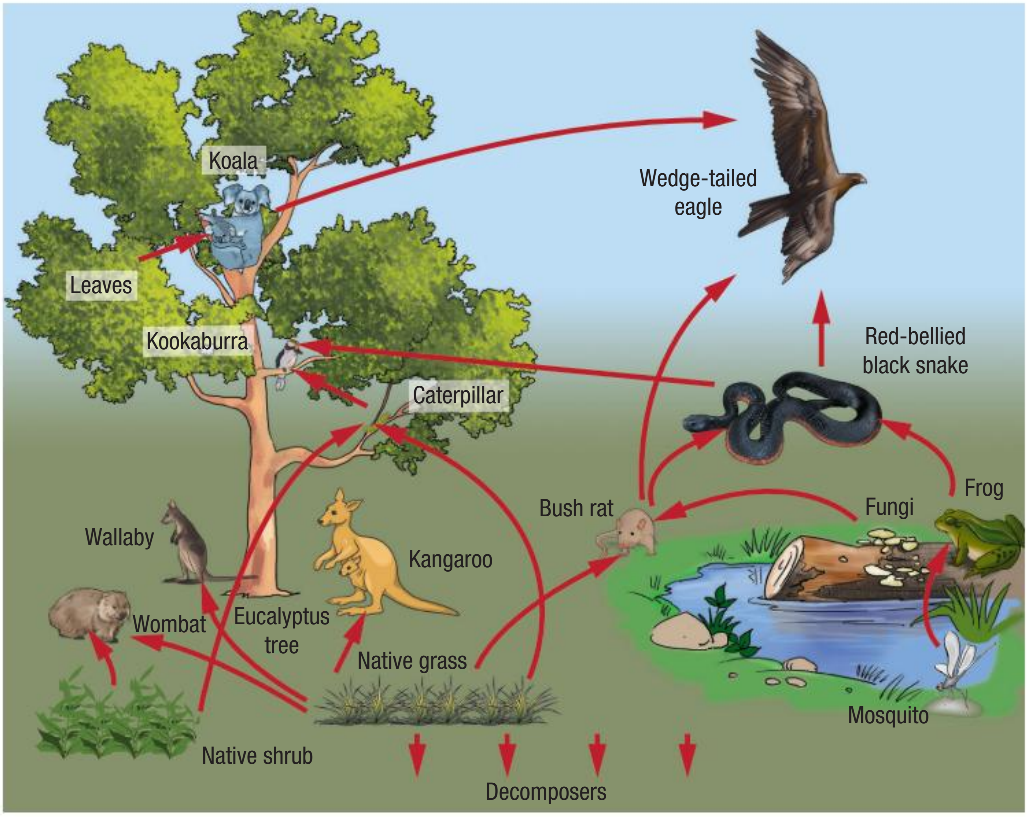

Figure 4.14 An Australian food web

WORKSPACE
What have you learnt? 4.3

WEBLINK
Identifying parts of a food web

ACTIVITY SHEET
Creating a food web

QUESTIONS 4.3

What have you learnt?

Understanding

1 **Demonstrate** what a food chain is using an example containing at least four organisms.
2 **Identify** what a food web is made up of.
3 **Explain** why producers are always at the bottom of a food chain or web.
4 **Discuss** the importance of cellular respiration and why organisms need it.
5 **Explain** the difference between a food chain and a food web.

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ACTIVITY SHEET
Be a critic

QUESTIONS 4.3

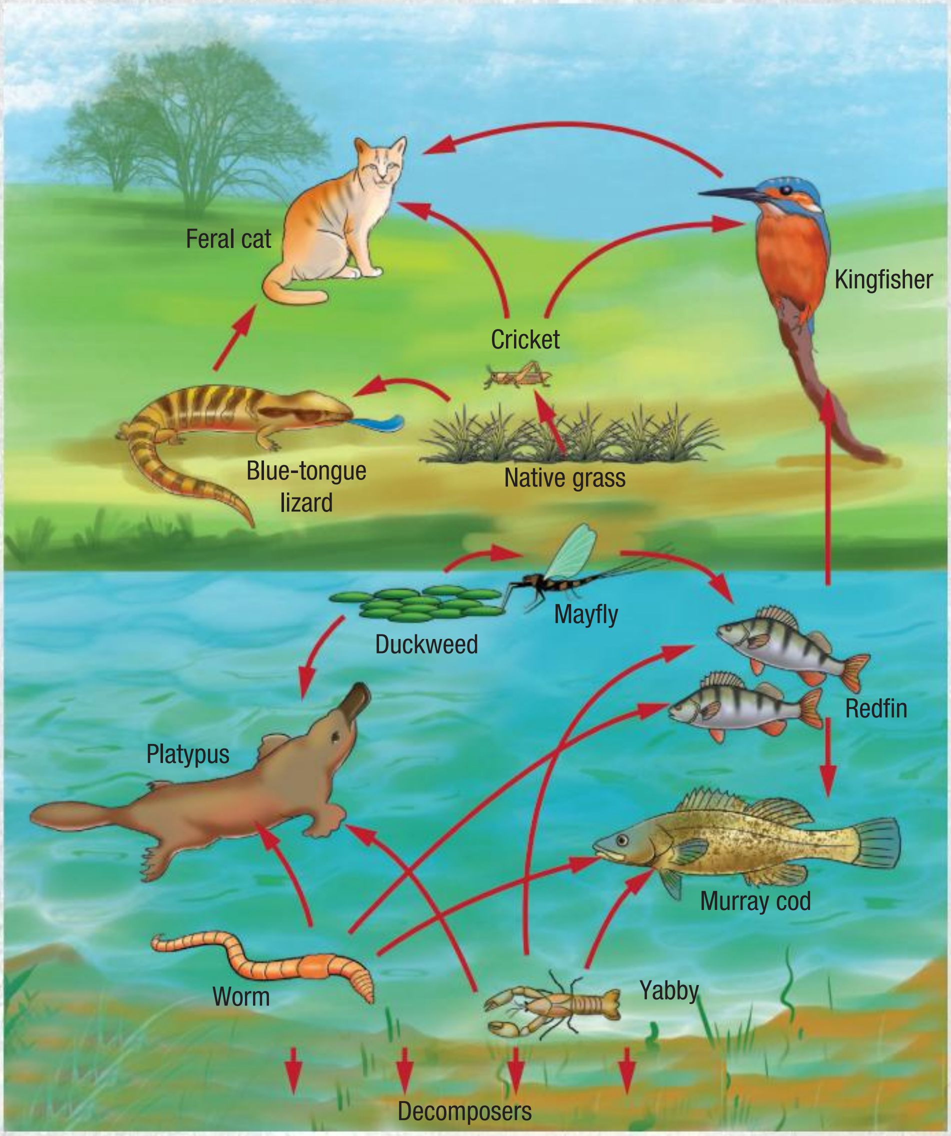

Figure 4.15 A typical Australian food web

Applying

6 Use Figure 4.15 to answer the following questions.

a **Clarify** which organisms are producers and which are consumers.
b **Identify** an example of a herbivore, an omnivore and a carnivore.
c **Explain** the difference between an autotroph and a heterotroph, and **identify** an example of each.
d A food web shows the links between various food chains. **Describe** three food chains that are found in this food web.
e **Propose** what effect the feral cat has on the food web.
f **Explain** what might happen if the European rabbit was introduced into this community.

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QUESTIONS 4.3

Figure 4.16 Three different food chains

7 Use Figure 4.16 to complete the following food chains:

a ____________ → ____________ → bird

b Leaves → ____________

c ____________ → rabbit

8 **Identify** how the food chains in Figure 4.16 represent energy flow.

9 **Describe** the process of photosynthesis, including the simple materials that are used and produced.

Analysing

10 **Explain** how a food web is like a river.

Evaluating

11 'Photosynthesis is necessary for the survival of all organisms on Earth.' **Justify** this statement.

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4.4 Managing ecosystems after natural or human impact

Over time, people have realised that our actions have damaged our native ecosystems. Unsustainable practices such as **deforestation** and environmental pollution have caused a number of species to become threatened. Natural disasters such as bushfire, drought, floods and cyclones have also put various populations at risk due to ecosystem destruction. In order to conserve an ecosystem, it is important that ecologists actively and effectively manage it. The Aboriginal and Torres Strait Islanders have cared for and managed our precious ecosystems for thousands of years. Species population numbers and entire ecosystems are managed through knowledge from Indigenous peoples. Scientific studies of specific habitats and populations, using technological advances such as computer modelling coupled with procedures and policies, such as breeding programs and fishing quotas, are put in place when species become threatened by natural or human impact.

deforestation

the removal of naturally occurring forest by logging or burning

ACTIVITY SHEET
Population analysis

ACTIVITY SHEET
Research task: sustainable care and management

ACTIVITY SHEET
Science careers

ACTIVITY 4.4

Research task: sustainable care and management

Working in pairs, you are to **investigate** how the knowledge of Aboriginal and Torres Strait Islanders about the care of waterways or sustainable management of the environment is used to inform scientific decisions to care for Country and Place. Use the activity sheet to complete the task.

WEBLINK
Save the Cassowary campaign

Shutterstock.com/Meister Photos

Figure 4.17
Mission beach cassowary

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Managing ecosystems after a natural disaster

Biological monitoring

Ecologists will investigate areas of interest and monitor how species are progressing. They may:

- assess population size, making sure the numbers are not becoming too low
- identify threats to species' survival, such as pollution and invasive species
- determine whether a species needs to be relocated to a new site to survive.

From their investigations, they will recommend management plans to address any problems.

Relocation of species

ACTIVITY SHEET
Barrow Island relocation

WEBLINK
The helmeted honeyeater

Worldwide, many species are on the brink of extinction as their local ecosystems shrink and they are affected by competition and predation from introduced species. In 2006, cyclone Larry caused major destruction to the Queensland coast. Regarded as one of the most violent cyclones to hit Queensland, it not only affected state infrastructure, agriculture and residences, it also directly claimed the lives of 35% of cassowary (*Casuarius casuarius johnsonii*) populations. As the cassowary is a threatened species, the Queensland Parks and Wildlife Service quickly decided to put in place a relocation program. On 2 February 2011, cyclone Yasi caused mass devastation to the Queensland coast. The 300 km/h winds once again shattered the natural habitat of the cassowary. It is not known how many birds were lost during this cyclone. Ecologists are trying to manage and conserve the species' population by education, and by providing aerial food drops and food shelters in protected areas. There are four main guidelines for the successful relocation of species to new sites where they may have a better chance of survival.

1. Selection of site: The new habitat must have similar qualities to the species' natural environment and must provide similar foods.
2. Selection of individuals: Relocation is stressful for organisms, so only those in good physical condition are chosen for relocation. The number of organisms to be relocated must be carefully determined.
3. Time of relocation: The time of the year must be carefully chosen to support the survival of the organisms. Ecologists look at food availability, temperature and mating season.
4. Post-monitoring: Ecologists monitor the organisms over an extended period of time to watch their progress.

Figure 4.18 An orange-bellied parrot is reintroduced back into its natural environment.

Ian Stych, courtesy of Melbourne Zoo

Captive breeding programs

The populations of the critically endangered helmeted honeyeater (*Lichenostomus melanops cassidix*) have declined throughout the 1900s. It was estimated that there were approximately 270 birds in 1963 and as few as 40–44 adults in 1984. The decline in bird numbers is a result of habitat removal, predation by feral cats, and bushfires. In 1989 a recovery program was put in place to help increase their numbers. In 1991, the Healesville Sanctuary, east of Melbourne, had 28 captive individuals for its breeding program. Now helmeted honeyeaters are regularly released into the wild.

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Many zoos have captive breeding programs. The orange-bellied parrot is being bred in captivity at three zoos across three states. The most important use of a captive breeding program is to help prevent an endangered species from becoming extinct. In a captive breeding program, animals are protected from disease and predators so that they have a better chance to build up a healthy population. To reproduce successfully, a population needs animals with a range of ages and which are not too closely related to one another. If the population becomes large enough, some animals may be reintroduced into the natural environment (Figure 4.18).

Controlled burns

Controlled burning (Figure 4.19) is carried out in New South Wales by the NSW National Parks and Wildlife Service and the NSW Rural Fire Service. The aim of controlled burning is to reduce organic fuel to prevent the rapid spread of bushfire that might affect homes, livestock, human lives and native plants and animals. However, a number of Australian species of plant have adapted to fire, and require the intense heat and smoke to release and germinate their seeds. It is suggested by scientists that controlled burning encourages biodiversity and the regeneration of fire-adapted species, and will help fire-fighters manage and understand the behaviour of wild bushfires.


Newspix/News Ltd/Clive Hyde

Figure 4.19
Controlled burning

WOW!

Fighting back with trees

Since 1997 Greenfleet, a not-for-profit group, has planted about 7.5 million (7 500 000) native trees at more than 350 sites across Australia. Planting trees helps to restore native species of plants and animals, absorb greenhouse gases, reduce salinity and erosion, and improve water quality in rivers and streams.

WEBLINK
Thirsty koala, a Black Saturday victim

Managing ecosystems after human impact

Humans impact on ecosystems in a number of ways. Global warming (heating of the Earth's atmosphere), deforestation (removal of forests) and pollution are just some of these impacts.

ICT

Use Google maps to locate the Alligator River region of the Kakadu National Park. In which state or territory does it occur? What is the closest capital city?


Corbis/John Carnemolla

Figure 4.20
Ranger uranium mine

ISBN 9780170231497

Mining

Scientists are continually monitoring the impact of mining and processing of uranium **ores** on the Alligator River region of the Kakadu National Park.

They study the Madela Creek tributary, close to the Ranger uranium mine, to ensure that the local aquatic environment is not affected by waste from the mine and have undertaken monitoring of the South Alligator River near the Coronation Hill prospect, to determine any short-term effects on the local ecosystem and its species. In studies such as these, scientists compare population numbers of **macroinvertebrates** and fish communities with those from previous studies. Management plans must be put in place to prevent any long-term damage to the organisms and the ecosystem.

ore
a rock from which metal can be extracted

macroinvertebrate
an invertebrate large enough to be seen without a microscope

Land-clearing

Deforestation is the removal of naturally occurring forest. Trees are cut down to:

- clear land for agriculture, housing, roads or mining
- provide timber for building materials, furniture and paper-making
- provide fuel for heating and cooking.

Land-clearing also occurs through the burning of trees. This releases huge amounts of carbon dioxide into the atmosphere and destroys the local habitat for native animals. In the past, forests and bushland were burnt to clear land for farms, cities and towns. Today, bushfires can result from acts of nature such as lightning strikes and from **arson**. On Black Saturday (7 February 2009), about 400 fires were burning across the state of Victoria. Caused by arson, lightning strikes and fallen power lines, the fires resulted in a major loss of life and habitat for people and animals.

arson
the deliberate lighting of a fire to cause damage

Loss of habitat, whether from land clearing or fire, often leads to reduced survival rates or the local extinction of species.

Clearing land for agriculture can cause the underground watertable (Chapter 7) to rise closer to the surface, bringing dissolved salts up with it. The water evaporates, leaving solid salt behind. The increased salinity causes trees to die, reduces the productivity of the land and results in a decrease in the number of species of plants and animals.

Internationally, Australia is playing a leading role in decreasing deforestation. Australia's International Forest Carbon Initiative is aimed at slowing deforestation in developing countries such as Indonesia.

Figure 4.21
Deforestation can lead to loss of habitat for local species and increased salinity of the soil.

WOW!

The high cost of salt

Salty land in Australia is on the rise. More than 1 million hectares of Western Australia is salt-damaged, with more than 400 000 hectares of South Australia affected and up to 80% of irrigated land in New South Wales under threat. Salinity costs Victoria an estimated \$50 million per year, and is expected to cost Western Australia up to \$400 million and the loss of about 450 plant species by 2050.

ISBN 9780170231497

ACTIVITY 4.5

Forces driving deforestation

In a group or as a class, brainstorm all the forces (reasons) that are driving the deforestation of land across Australia. For each force, **identify** those that affect Australia's economy. Suggest ways to manage their impact on our land and our economy.

At home, Australia is improving sustainable logging practices and we are gradually reducing the amount of deforestation compared with regrowth, to ensure natural habitat is available. However, the amount of land-clearing in Queensland continues to be a concern, in spite of reforms introduced by the state government.

Water pollution

Our precious water resources are continually being threatened by pollution. Pollutants can enter our waterways through runoff from roads, farms, sewage and other waste water from cities and towns. Many industries use water to remove their waste. Pollutants that can enter into our water systems include:

- heavy metals such as lead and mercury, which can affect the cell function in animals
- nitrates and phosphates from fertilisers and sewage, which increase the level of nutrients in the water, promoting the growth of algae and reducing the levels of oxygen
- petrochemical products, such as household cleaning agents, which are toxic to marine life.

As more scientific data on the impact of agricultural pollutants on local ecosystems becomes available, Australia is requiring that industries treat or recycle waste water. Correct and effective use of fertilisers, herbicides and pesticides not only helps healthy crop cultivation but it also prevents damage to sensitive aquatic ecosystems.

Figure 4.22 (left) Increased algal growth on the Murray River is a sign that there are high levels of nitrates and phosphates in the water system.

Figure 4.23 (right) Healthy crop cultivation

AAP Image/Supplied by Minister Phil Costa's Office

Shutterstock.com/Zeljko Radojko

ISBN 9780170231497

Hard rubbish in water systems = the Great Pacific Garbage Patch

WOW!

The Pacific Ocean is home to the Great Pacific Garbage Patch. This is an area in which swirling ocean currents have caused rubbish to accumulate. Some estimates say the patch is twice the size of France, to a depth of about 10 m, and getting bigger. The rubbish weighs about 3 million tonnes.

Patrick AVENTURIER/Gamma-Rapho via Getty Images

Introduced species

Australia was colonised by the English, who arrived in Port Jackson in 1788. Early settlers brought with them food plants, such as wheat and corn, and animals, such as cows, sheep, goats and rabbits, with which they started our agricultural industry. To create gardens, they planted roses, blackberry bushes and ivy. For sport, they deliberately released rabbits, foxes and European carp into the wild. They even imported blackbirds and sparrows so that people would feel more at home. Unfortunately, people did not understand the consequences that their actions would have on the native plant and animal species of Australia.

WORKSPACE
Introduced species

ACTIVITY 4.6

Introduced species

Use Google to search for a timeline to find out when cane toads were first introduced into Australia. Where did they come from, and why were they released in Queensland?

Getty Images/Minden/Mitsuaki Iwago

Getty Images/Jason Edwards

Figure 4.24 The rabbit and the cane toad were both introduced into Australia.

ISBN 9780170231497

An **introduced species** is one that has either arrived accidentally or been deliberately brought to an area. Sometimes the local conditions are not favourable to the introduced species and it struggles to survive. However, some introduced species thrive in their new environment because they are free from the predators and diseases that kept their numbers in check in their native environment.

introduced species

a species that has arrived accidentally or has been deliberately brought to an area

If the new environmental conditions are favourable, introduced species will reproduce quickly, increasing their population size. As their numbers increase, they start to compete with native species for food and shelter. This can cause a decrease in the population of native species, which may become endangered or even extinct.

Overall, the impact of introduced species can be extremely detrimental to a local ecosystem. Tables 4.1 and 4.2 give examples of deliberate and accidental introductions of species to Australia. Perhaps the most well-known example is the rabbit. Rabbits arrived with the First Fleet in 1788 and were kept as pets and as a source of food. However, it was the deliberate introduction in 1859 of rabbits for sport that probably led to the devastating rabbit plague in 1890. The rabbit population reached 600 million before it was partly controlled by the release of the myxoma virus in 1950. Further scientific research into ways of controlling rabbit populations resulted in the identification of the calicivirus in 1984. This virus is also known as viral haemorrhagic disease, due to the symptoms it causes in rabbits. Both the myxoma virus and the calicivirus are used to decrease the wild populations of European rabbits to manage agricultural land.

In north Queensland in the early 1900s, the native cane beetle was destroying sugar cane crops. In 1935, the cane toad was deliberately introduced from South America as a method of **biological control** of the cane beetle. However, the cane toad did not reduce the population of cane beetles. Instead, it adjusted quickly to the tropical environment, eating almost anything and spreading disease. Birds and animals that tried to eat the cane toad were poisoned by its toxins. The rapid increase in cane toad numbers led to the decline of native frogs, reptiles and birds in Queensland. The cane toad reached the Northern Territory in 1974 and Western Australia in 2009, and toads are now a threat to native species in New South Wales.

biological control

the control of pests by deliberately introducing one of their natural predators or diseases

To avoid such problems in the future, a strict procedure has been put in place. Biosecurity Australia, an agency within the Commonwealth Department of Agriculture, Fisheries and Forestry, investigates the risk management of proposed biological controls. Extensive experimentation and modelling is conducted by scientists to ensure that the biological control will not have a negative impact on local ecosystems and crops and this information is then provided to the Australian Quarantine and Inspection Service.


Auscape/ © Densey Clyne

Figure 4.25
The caterpillar of the *Cactoblastis* moth feeds on the prickly pear.

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A successful example of biological control in Australia is the use of a moth species to reduce the number of prickly pear plants (*Opuntia stricta*). The prickly pear was brought to Australia on the First Fleet. By the early 1900s it had infested 25 million hectares of land in New South Wales and Queensland. It was eventually controlled by the *Cactoblastis* moth (*Cactoblastis cactorum*). The moth lays eggs on the plant. As the larvae hatch, they feed on the prickly pear, reducing its spread.

By controlling introduced species such as the European rabbit, cane toad and prickly pear, the native flora and fauna have benefited and farmers have been able to obtain better quality crops and higher yields.

Table 4.1
Intentionally introduced species

Species	Year of introduction	Reason for its introduction
Foxes	1855	Fur trade, sport
European carp	1859	Food source, sport
Rabbits	1859	Sport
Cane toad	1935	Biological control of the cane beetle

Table 4.2
Accidentally introduced species

Species	Location	How it happened
House mouse	Across Australia	Hitchhiking on boats from England to Australia
Red-eared slider tortoise	New South Wales	Released from household aquariums by pet owners
Pacific starfish	Victoria	Dumping of ballast water from international ships

ACTIVITY SHEET
The exotic pet trade

ACTIVITY SHEET
Reflection: Think locally, act globally

ACTIVITY 4.7

Education for the community

Choose one of the following environmental issues, or another issue approved by your teacher:

- Pollution of air, soil or water
- Introduced species
- Deforestation

Create a brochure to educate your local community about:

- the issue
- how it affects local ecosystems and agriculture
- how scientific knowledge is helping agriculturalists to manage the issue
- how the community can take steps to help prevent or lessen its impact.

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QUESTIONS 4.4

What have you learnt?

Understanding

1 **Identify** three different ways in which natural and human impacts can affect an ecosystem.

2 **Summarise** ways in which scientists are involved in researching and protecting endangered species.

3 **Compare** two methods that ecologists could use to help increase the population of a species that is threatened. Provide an example of each.

4 **Recall** the purpose of Biosecurity Australia.

5 Some species have been introduced accidentally into Australia, while others, such as the myxoma virus and the calicivirus, have been introduced deliberately. **Assess** whether the myxoma virus and/or the calicivirus are having a positive impact on agricultural management.

6 **Account** for why farmers have to be careful of what fertilisers, herbicides and pesticides they use to help crop cultivation.

Applying

7 **Identify** three species that have been introduced into Australia. How have these species affected the environment?

8 Research and **discuss** other uses of biological control in Australia. Were they successful? Why or why not?

9 **Outline** five personality traits that would be most important for an ecologist to have.

Evaluating

10 **Discuss** the pros and cons of releasing introduced species into Australia. **Clarify** which side of the argument you agree with, and give reasons why.

Creating

11 You are the environment reporter for the local newspaper. Write a short report (200 words) about a recent bushfire, drought or cyclone in your local area. **Discuss** the effect the event had on the local fauna and flora. **Predict** the long-term effects. **Explain** the solutions that could be put in place to help the ecosystem to recover.

12 Write a letter to a government **proposing** policies that could be put in place to help develop the management of agricultural practices.

WORKSPACE
What have you learnt? 4.4

INTERACTIVE
Crossword – test your understanding

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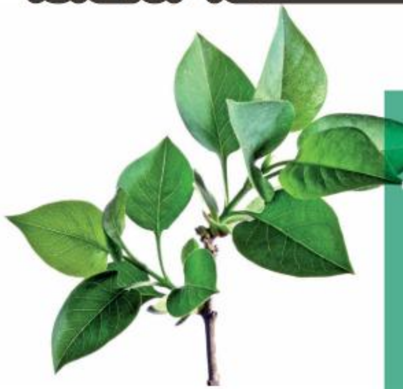

Chapter review

Remembering

1 **Define** 'diurnal' and 'nocturnal', and **identify** an example of an animal for each.

2 **Distinguish** between an endangered species and an extinct species.

3 **Distinguish** (by use of example) between a producer, a secondary consumer and a decomposer.

Understanding

4 **Outline** why organisms in an arid environment must conserve water. Use examples to support your answer.

5 **Propose** the benefit to the frilled-neck lizard of having the frilled neck.

WORKSPACE
Chapter 4 review

ACTIVITY SHEET
Chapter 4 checklist

REVIEW QUIZ
Chapter 4

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Figure 4.26 Frilled-neck lizard

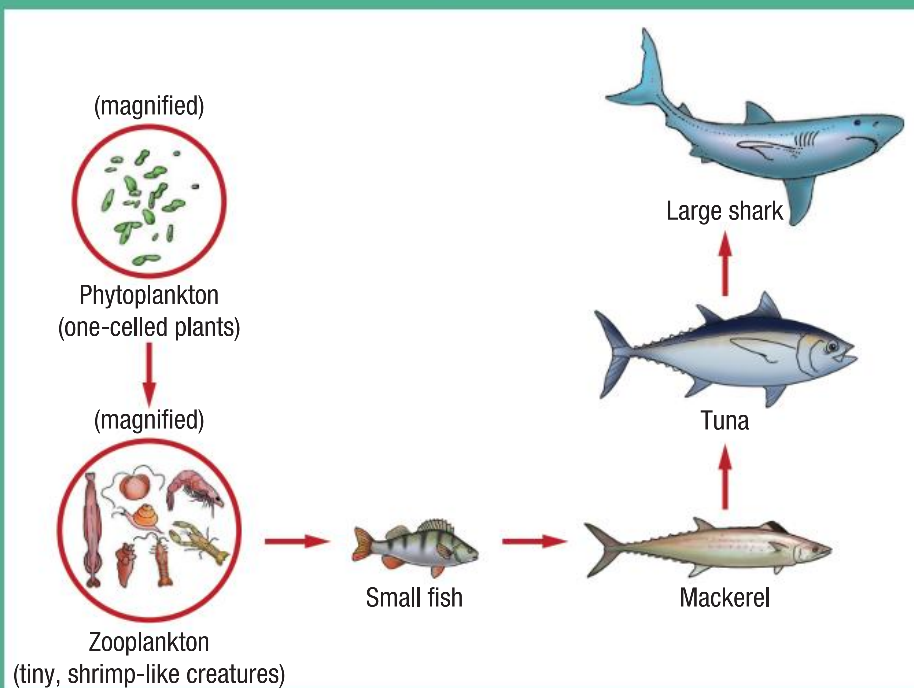

Figure 4.27 A food chain for an ocean environment

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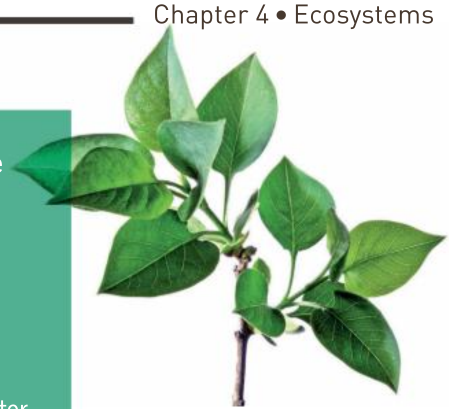

6 Figure 4.27 is a food chain for an ocean environment. **Identify** the producer and the primary, secondary and tertiary consumers.

7 **Describe** how water pollution can affect an ecosystem. **Identify** an example.

8 **Assess** the effect the cane toad has had on the Australian environment.

9 **Describe** the aim of a captive breeding program. Use an example to support your answer.

10 Briefly **describe** two methods that ecologists can use to conserve an ecosystem after natural or human impact.

Applying

11 **Explain** how a scavenger such as the Tasmanian devil fits into a food web.

12 **Construct** a food chain for the following information.

One day, a bird saw a snake with a full belly, lazing in the late-afternoon sunshine. The bird thought, 'Mmm, I'm hungry.' It flew down and caught the snake for dinner. Earlier that day, the snake had been busy catching his own meal. Gliding by the pond, he had noticed a grasshopper nibbling on some grass. When a cheeky frog snapped up the grasshopper with its long, sticky tongue, the snake thought, 'Jackpot!' It slithered quickly to the edge of the pond and caught the frog as it was eating the grasshopper.

13 A farmer discovered that he had a severe snail problem in his cabbage patch. He wanted to know how many snails there were in the patch. The farmer counted four snails in a 1 m^2 area. If the total area was 100 m^2, **calculate** how many snails were in the patch.

14 **Assess** why photosynthesis is such an important process. **Explain** your answer in terms of energy.

Analysing

15 When ecologists monitor a particular species or environment, they collect a number of different samples over an extended period of time. **Discuss** why scientists need to collect many samples when determining the number of individuals of a species in an area.

16 **Identify** some of the positives and negatives of deforestation. **Justify** why they are positive or negative.

17 Countries near the equator have large biodiversity. However, as you move towards the poles, biodiversity decreases. **Explain** why this is the case.

18 Temperature is thought to affect the germination of certain seeds.

a **Design** an experiment to test the effect of temperature on seed germination.

b **Identify** the variables that would need to be controlled.

c **Identify** the control in your experiment.

d **Justify** why it is important to use a control.

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Evaluating

19 With the introduction of the European rabbit and fox into Australia, the population of native bilbies declined dramatically. What do you think would be the best way to help increase the numbers of bilbies? **Justify** your choice.

Creating

20 In the 1950s the myxoma virus was released in Australia in an attempt to eradicate rabbits. The virus was spread by mosquitoes and fleas, and was successful in killing 90% of the rabbit population.

- **a** **Clarify** why Australians want to eradicate rabbits.
- **b** Rabbits are still causing problems in Australia. **Recommend** another way of reducing their impact.

Reflecting

21 Feral cats have become one of the greatest threats to the survival of many native species. **Describe** how you think this problem should be dealt with.

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5 Elements

How does the chemistry of elements affect their use?

Napoleon's massive army of 600 000 men marched against Russia in the cold winter of 1812. His army was previously undefeated. Every single man had tin buttons sewn onto his uniform. Unfortunately, if tin is exposed to the bitter cold, such as that of a Russian winter, it disintegrates into a powder. Is it possible that the men could no longer fight when their uniforms fell to pieces in the freezing cold? Could crumbling tin buttons be the reason for their horrible defeat? We will never know, but we do know that the chemistry of elements and substances dictates how we use them.

Getty Images/FPG Intl.

Chemical world – Stage 4

Key knowledge

- Elements, compounds and mixtures have different arrangements of particles.
- Elements are represented by symbols that are recognised throughout the world.
- Common compounds such as water and carbon dioxide can be identified by name or chemical formulae.
- Elements can be classified as metals or non-metals.
- Metals and non-metals have different physical properties.
- Technology has impacted on our understanding of the structure and properties of elements.
- Elements and compounds have been used by different peoples throughout history to make a variety of helpful items such as weapons and tools.

ACTIVITY SHEET
CAT with rubric: An important element in everyday applications

CULMINATING ASSESSMENT TASK

An important element in everyday applications

Research an element that has useful applications in everyday life as an element, as part of a useful compound, and as a component of a mixture. You will **evaluate** the benefits of these applications and decide whether they outweigh any potential negative effects.

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WORKSPACE
What do you already know about elements?

What do you already know about elements?

Complete the following experiment to find what you already know about elements.

Possible risks	Safety precautions
Some of the substances may be harmful to your skin or eyes.	Wear safety glasses and do not touch any of the chemical substances or remove the seals from the test tubes.
Some chemicals are dangerous.	If a test tube breaks, do not touch the contents. Report it to your teacher immediately.

Aim

To observe a range of substances to note their physical properties

Materials

- labelled test tubes: magnesium (Mg), salt water, salt (NaCl), iron (Fe), oxygen gas (O_2), zinc (Zn), water (H_2O), copper (Cu), copper sulfate ($CuSO_4$), sulfur (S)
- safety glasses

Method and results

1. Observe the substances in the test tubes. **Classify** them according to their state at room temperature and their colour.
2. **Construct** a table to **show** your observations.

Discussion

1. Use a Think, Pair, Share to **compare** your observations. **Identify** similarities and differences.
2. **Classify** the state of the substance that would be made if iron, zinc and magnesium were mixed together. **Justify** your answer.

5.1 The structure of elements

All matter is made up of particles that are so tiny you cannot see them. So why can you see so many substances around you if particles are not visible to our eyes? Salt is a substance made up of tiny identical particles. It is much easier to see a cup of salt than it is to see a grain of salt. This is because there are many more billions of salt particles in one cup than there are in one grain. This makes it more visible, simply because there are more particles. Whether it is a cup or a grain of salt, it is still the same substance because it is made up of the same type of particle. The way a substance looks to us is due entirely to the *type* and *number* of particles that make up the sample.

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Figure 5.1 All of these substances 'contain' chlorine in some way – **a** as the element chlorine gas, **b** in PVC pipe, **c** in sodium chloride (table salt) and **d** in sodium hypochlorite (bleach).

pure substance
a substance made up of the same type of particle

mixture
a substance made up of different types of particles, physically combined

INTERACTIVE
Types of matter: pure substances and mixtures

So far, we have classified matter into two groups: **pure substances** and **mixtures** (see *iScience 7 NSW*, Chapter 6). If all of the particles in a substance are the same, it is called a pure substance. Salt and pure water are examples of pure substances because each of them is made up of only one type of particle.

Mixtures are made up of two or more different types of particles, physically combined; for example, combining sand and water makes a mixture. If the pure substances salt and water are added together, they form a solution. As the different particles making up the salt solution are not chemically 'connected', they can be easily separated. A salt solution can be separated by evaporation, crystallisation or distillation.

Atoms

Imagine a wall made up of identical bricks – all the same size, shape and colour. The smallest unit that makes up the wall is an individual brick. If the brick wall represents the simplest type of pure substance, then each individual, identical brick would represent the smallest particle of that pure substance. In the world of chemistry, this particle is called the atom. An atom is the smallest part of an element that still retains the properties of that element.

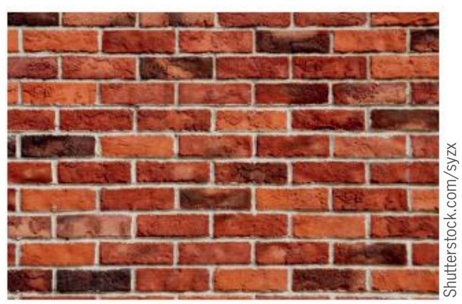

Figure 5.2 A wall made up of individual bricks

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VIDEO
What are atoms?

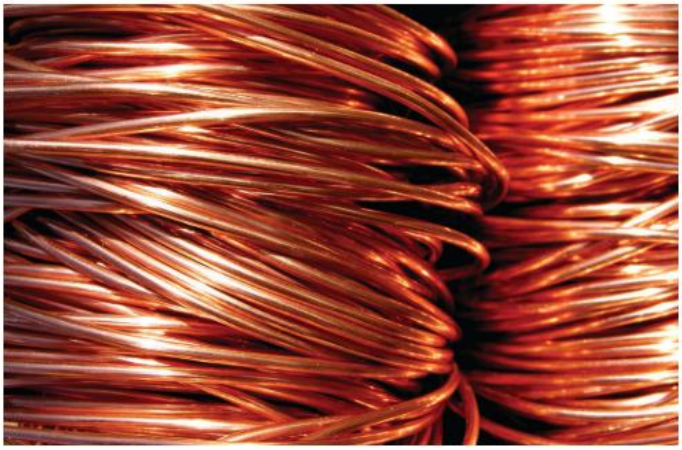
The atom is the smallest particle of matter. The word 'atom' comes from the Greek term *atomos*, meaning 'indivisible'. This means atoms are unable to be broken down any further as they are the simplest form of matter. Sometimes atoms are referred to as the building blocks of matter because everything around you is made up of atoms.

So what makes two different substances that are only made up of atoms so unlike one another?

The pure substances copper and zinc do not look alike. Copper (Figure 5.3) is a shiny orange-brown coloured metal that is solid at room temperature. Zinc (Figure 5.4) is a shiny grey solid metal at room temperature. These two metals look different because copper is made up of copper atoms and zinc is made up of zinc atoms. Copper and zinc atoms are not the same. This means both copper and zinc are pure substances and they are different from one another.

Figure 5.3 (left) The metal copper is a shiny orange-brown solid.

Figure 5.4 (right) The metal zinc is a shiny grey solid.



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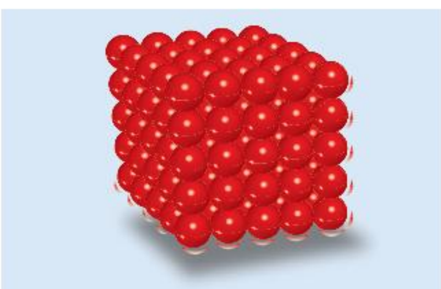
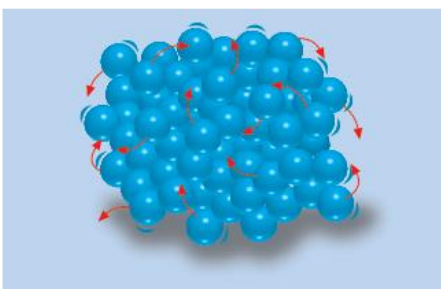
It is hard to imagine what atoms look like because they are so small. Figures 5.5–5.7 represent what three different pure substances would look like if we could magnify them enough to see how the particles would look and how they were arranged. The individual atoms are represented by the small, coloured spheres. The degree of particle vibration in each is shown by the red lines or arrows. Each pure substance in each figure has different coloured spheres. This shows that the atoms of each pure substance are different from each other and so the substances themselves must also be different. Particle diagrams such as these are one way to visualise the type and arrangement of atoms in different substances.

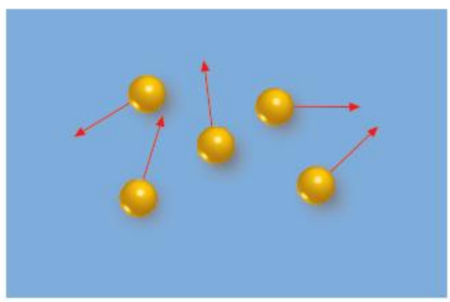
Figure 5.5 (left) A solid pure substance made up of one type of atom

Figure 5.6 (middle) A liquid pure substance made up of one type of atom

Figure 5.7 (right) A gaseous pure substance made up of one type of atom







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Elements

What do we observe when we look at Figures 5.5–5.7? The atoms in Figure 5.5 are all the same colour and size. This is also true for Figures 5.6 and 5.7. This means all three substances are pure, as each of them is made up of only one type of particle – more specifically, the same type of atom.

The illustrations represent a type of pure substance known as an **element**. An element is a pure substance that is made up of only one type of atom. This means that in an element, all of the atoms that make it up are the same. Elements cannot be broken down into simpler substances because they already exist in their most basic form.

element
a pure substance made up of only one type of atom; cannot be broken down into a simpler substance

The metal copper is an element because it is only made up of copper atoms. We can make a piece of copper smaller by cutting it up, but we will just be left with smaller pieces of copper all made up of the same copper atoms. If it were possible to cut a piece of copper until all that we were left with were the individual atoms, they would still be copper atoms and therefore it would still be copper.

Today we officially recognise more than 114 different elements, which have been discovered over time.

Elements can be further classified into three groups – metals, non-metals and metalloids. This is shown in Figure 5.8.

ICT

Recreate the information in Figure 5.8 using an application, such as Gliffy or drawanywhere. Be as creative as you can. Upload your creation to the class wiki

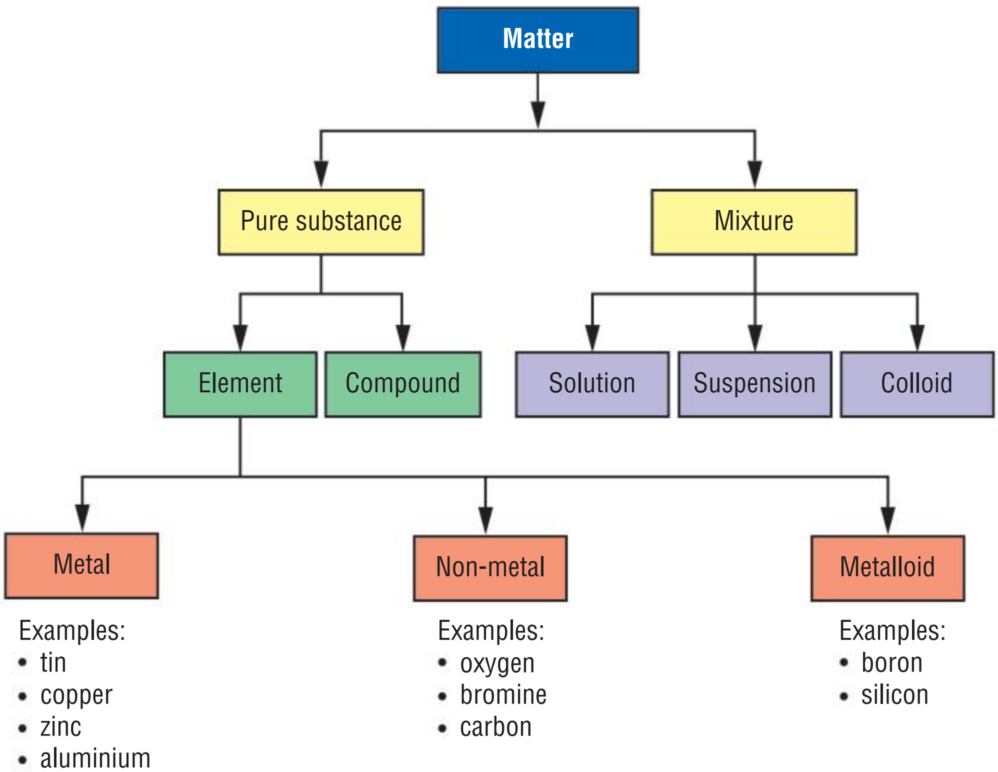

Figure 5.8 The classification of matter

VIDEO
Origin of the Earth's elements

Impact of technology on our understanding of common elements

Thousands of years ago, different philosophies (ideas of people) and cultures used what they called the classical elements to explain the nature of the world around them. The four main classical elements were earth, air, water and fire. These four 'elements' were meant to be in

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perfect balance. Diseases or natural disasters were attributed to one or more elements changing – that is, being out of balance. For example, floods were seen as the element water being out of balance.

The ancient Greek philosopher Aristotle added a fifth element called the quintessence, from the Latin root *quinta essentia*, meaning the 'fifth essence'. He added this because he had observed that the stars, or 'heavens', did not change like the other earthly elements did. He called this fifth element the aether.

Do you like *Harry Potter* novels? If you do, then you will love chemistry! **Alchemy** has been described as a mixture of philosophy and science. At the scientific level, alchemy was an ancient practice of chemistry and scientists (called alchemists) searched for ways to transform 'base' metals such as lead into more precious metals such as gold. In order to do this, they were constantly trying to create an object they called 'the philosopher's stone'. These alchemists held a strong belief that this stone could also be used to create an elixir (medicine) that would cure all diseases and make people immortal (live forever).

Corbis/The Gallery Collection

Figure 5.9
An alchemist working in his 'laboratory'

alchemy
both a philosophy and an ancient practice of science; alchemists attempted to turn base elements into precious metals and to create a substance that would provide immortality

Technology helps ideas

But how did the ancient ideas about the elements develop into our current understanding? As with all scientific development, advances in knowledge mostly arise through scientific research. When scientists investigate a hypothesis, they are trying to expand their knowledge of that idea. Sometimes the results from their experiments will support their current understanding. At other times, new evidence will suggest that their current understanding needs to be changed. This is how scientific theories are refined and improved. With continued advances in technology, scientists will be able to develop new techniques to find out more about atoms and elements. This will challenge our current understanding and certainly lead to new elements being discovered in the years to come.

Different elements have different properties. For example, iron is a solid at room temperature, and chlorine is a gas at room temperature. Scientists have known this for a long time. Other properties have only been able to be measured more recently. Different elements have atoms of different sizes. Scientists have been able to measure the radii of atoms using a special technique called X-ray crystallography. William Lawrence Bragg, who was born in Adelaide, and his father William Henry Bragg completed a lot of research in this area, for which they were awarded the Nobel Prize for Physics in 1915.

More recently, scientists have discovered that very small particles of elements, called **nanoparticles**, have properties that are different from those of large chunks of the same element. For example, a nanoparticle of aluminium is magnetic but the aluminium foil you use at home is not. As scientists understand more about the properties of various elements, they will also be able to see other uses for these elements.

VIDEO
Alchemy and discovering elements

ACTIVITY SHEET
Harry Potter

nanoparticle
a particle that has a diameter of less than one billionth (1×10^{-9}) of a metre

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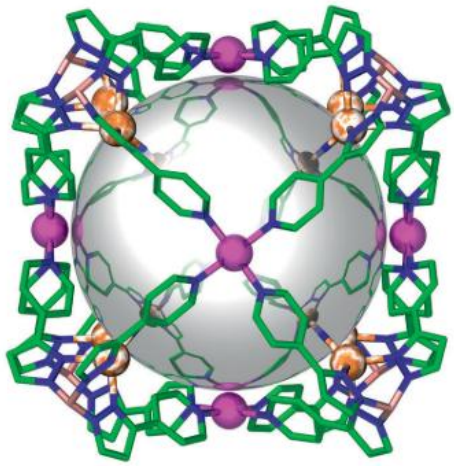
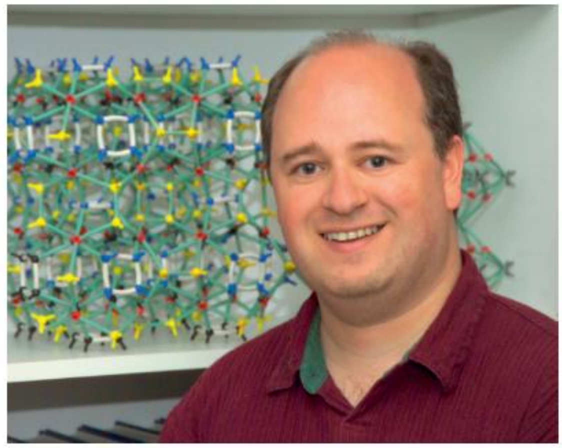


Source: Professor Stuart Batten, Monash University



Source: Professor Stuart Batten, Monash University

Figure 5.10 (left) X-ray crystal structure of a molecule

Figure 5.11 (right) Professor Stuart Batten from Monash University uses X-ray crystallography to understand the structure of molecules.

WORKSPACE
The concept of the element through history

WEBLINK
Timetoast

ICT

You could use Timetoast or similar to create your timeline.

ACTIVITY 5.1

The concept of the element through history

Use the Internet to research how our understanding of the concept of elements has changed throughout history. Use the following list as a guide for your research.

- The classical elements
- The alchemists
- Robert Boyle
- Antoine Lavoisier
- John Dalton

1 For each concept of the elements:
 a **outline** the date the idea was proposed
 b **identify** the person who came up with the idea, if possible
 c **outline** the idea
 d **outline** any experiments that were done that allowed the person to develop their idea.

Assessment

2 Draw a timeline for the information you have gathered in Question **1**, parts **a** and **b**. Combine this with a summary of your information for parts **c** and **d**, and submit your report to your teacher.

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Chemical symbols for the elements

Do you recognise the symbols or signs shown in Figure 5.12?

Figure 5.12
What do these signs or symbols mean to you?

Figure 5.13
Even if you can't read the language, you can recognise that these are all stop signs.

Symbols and signs have been used for centuries. Today, the red octagon is a sign that is used on roads all over the world to represent 'stop'. Even if you do not understand the language that is written in the middle of the octagon, you still know what the sign means (Figure 5.13).

Symbols are also used as abbreviations. This is because it is quicker and easier than writing the full word. The word 'because' can be written as 'b/c'. 'SMS' is an abbreviation for the term 'short message service'.

Science uses **chemical symbols** for the elements for both of these reasons. It is a type of internationally recognised 'shorthand'. There is a chemical symbol for each element that is the same all over the world.

Chemical symbols used for elements are made up of letters of the alphabet. Many of the symbols are the first letter of the element, such as H for hydrogen and C for carbon. Other symbols have two letters such as Ca for calcium and Co for cobalt. This is so the elements carbon, calcium and cobalt are not confused. The first letter of the chemical symbol is always a capital letter. If there is a second letter, it is always lower case. The chemical symbols of some other elements seem to have no relationship to their names, such as Fe for iron and Sn for tin. This is because the names of these elements were derived from another language – Fe is from the Latin *ferrum*. No two chemical symbols are the same.

The chemical symbol represents one atom of an element. For example, the chemical symbol for nitrogen, N, means one atom of the element nitrogen. A **chemical formula** is used if there is more than one atom in a particle of a substance. For example, you may have seen oxygen gas written as O_2. The '2' means two oxygen atoms are chemically joined together. So O_2 is not called the chemical symbol for oxygen gas but the chemical formula for oxygen gas. You will learn more about why this is later in this unit.

Table 5.1 shows the names and chemical symbols for the first 20 elements. It also provides their state at room temperature and whether they are metals, non-metals or metalloids.

chemical symbol
a letter (or letters) of the alphabet used to represent an atom of a specific chemical element

chemical formula
a collection of symbols and numbers that represents the number of atoms in a particle of an element or compound

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WEBLINK
'The Elements' song

ICT

Create a word cloud using the first 20 elements listed in Table 5.1.

WEBLINK
Tagxedo

Table 5.1
The first 20 elements

Atomic number	Chemical element	Chemical symbol	State at room temperature	Metal, non-metal or metalloid
1	Hydrogen	H	Gas	Non-metal
2	Helium	He	Gas	Non-metal
3	Lithium	Li	Solid	Metal
4	Beryllium	Be	Solid	Metal
5	Boron	B	Solid	Metalloid
6	Carbon	C	Solid	Non-metal
7	Nitrogen	N	Gas	Non-metal
8	Oxygen	O	Gas	Non-metal
9	Fluorine	F	Gas	Non-metal
10	Neon	Ne	Gas	Non-metal
11	Sodium	Na	Solid	Metal
12	Magnesium	Mg	Solid	Metal
13	Aluminium	Al	Solid	Metal
14	Silicon	Si	Solid	Metalloid
15	Phosphorus	P	Solid	Non-metal
16	Sulfur	S	Solid	Non-metal
17	Chlorine	Cl	Gas	Non-metal
18	Argon	Ar	Gas	Non-metal
19	Potassium	K	Solid	Metal
20	Calcium	Ca	Solid	Metal

WORKSPACE
What have you learnt? 5.1

WEBLINK
Element flash cards

QUESTIONS 5.1

What have you learnt?

Remembering

1 Play the online game 'Element flash cards'. Click on 'More options, please!' and then click 'First 20 Elements'. In the periodic table on page 23, also select the elements zinc, silver, gold, iron, copper, bromine, iodine, tin, uranium and mercury. Use the flash cards until you have memorised all of their names and symbols.

2 **Identify** the names and chemical symbols for the first 20 elements that are:
   - **a** metals
   - **b** non-metals
   - **c** metalloids.

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QUESTIONS 5.1

Understanding

3 **Propose** a question that has the answer:

- **a** pure substance
- **b** mixture
- **c** atom
- **d** element
- **e** chemical symbol
- **f** chemical formula.

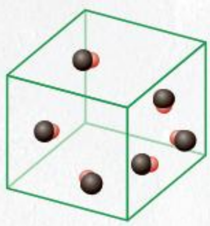
4 Use secondary sources to **identify** three elements for which the properties of nanoparticles of the element are different from those of the bulk element.

Applying

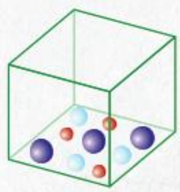
5 The diagrams A–D represent particles of different substances. **Identify** the diagram(s) that represent(s):

- **a** an element
- **b** a mixture of different elements
- **c** a pure substance
- **d** a mixture.

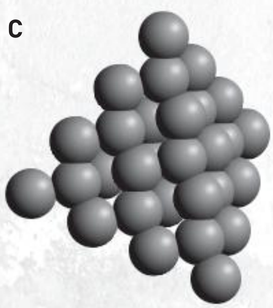
A



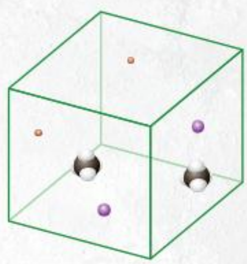
B



C



D



6 Figure 5.14 represents a particle of a pure substance.

- **a** **Identify** the names of the elements that make up a particle of this substance.
- **b** **Identify** how many different types of atom make up a particle of this substance.

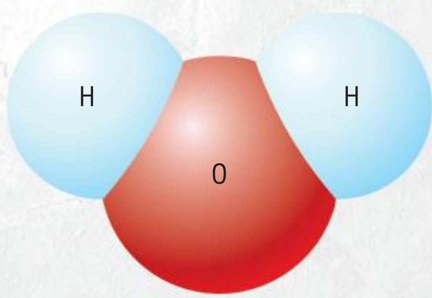


Figure 5.14 A particle of a pure substance called dihydrogen monoxide

ISBN 9780170231497

WEBLINK
The periodic table with photographs

QUESTIONS 5.1

c **Deduce** the number of atoms in total that make up one particle of this substance.
d Can this substance be classified as an element? **Justify** your answer.
e **Identify** the scientifically accepted name for this compound.

7 Table 5.1 has been reproduced for you in your workspace. Use the weblink 'The periodic table with photographs' to find out what the first 20 elements look like. Either add written descriptions or import photographs to your workspace.

Analysing

8 Look at the information provided in Table 5.1 on page 120. Look for patterns in the physical properties of the elements. **Describe** each pattern you have observed.

9 Use the information in Table 5.2 to **identify** the state of elements X, Y and Z at room temperature. **Justify** your answers.

Table 5.2
The melting and boiling points for three mystery elements

Element	Melting point (°C)	Boiling point (°C)
X	–100.98	–34.6
Y	–7.2	58.8
Z	113.5	184.4

Evaluating

10 Sherlock Holmes is a character in a series of novels written by Sir Arthur Conan Doyle. The following phrase was made popular in the Sherlock Holmes films, although it was never actually used in the novels:

Elementary, my dear Watson!

Sherlock Holmes would say this to his partner Dr Watson when questioned how he had worked out basic information that had helped him solve a case.

a **Explain** what Sherlock Holmes meant when he said this to Dr Watson?
b **Evaluate** whether this statement is correctly used in the scientific sense.

Creating

11 **Explain** the concept of an 'atom'. Your audience for this task is an 8-year-old primary school student. You may only use props, language or diagrams that they will understand.

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5.2 The periodic table

The periodic table is a chart that organises most of the known elements and provides a wealth of information. It is made up of a number of rows and columns. The horizontal rows are called **periods** (for example, if you move across from lithium to neon) and the vertical columns are referred to as **groups** (for example, if you move down from fluorine to astatine).

period

a row across the periodic table

group

a column down the periodic table

Figure 5.15
The modern periodic table

Key: atomic number / Symbol / element name

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H hydrogen																	2 He helium
2	3 Li lithium	4 Be beryllium											5 B boron	6 C carbon	7 N nitrogen	8 O oxygen	9 F fluorine	10 Ne neon
3	11 Na sodium	12 Mg magnesium											13 Al aluminium	14 Si silicon	15 P phosphorus	16 S sulfur	17 Cl chlorine	18 Ar argon
4	19 K potassium	20 Ca calcium	21 Sc scandium	22 Ti titanium	23 V vanadium	24 Cr chromium	25 Mn manganese	26 Fe iron	27 Co cobalt	28 Ni nickel	29 Cu copper	30 Zn zinc	31 Ga gallium	32 Ge germanium	33 As arsenic	34 Se selenium	35 Br bromine	36 Kr krypton
5	37 Rb rubidium	38 Sr strontium	39 Y yttrium	40 Zr zirconium	41 Nb niobium	42 Mo molybdenum	43 Tc technetium	44 Ru ruthenium	45 Rh rhodium	46 Pd palladium	47 Ag silver	48 Cd cadmium	49 In indium	50 Sn tin	51 Sb antimony	52 Te tellurium	53 I iodine	54 Xe xenon
6	55 Cs caesium	56 Ba barium	57–71 lanthanides	72 Hf hafnium	73 Ta tantalum	74 W tungsten	75 Re rhenium	76 Os osmium	77 Ir iridium	78 Pt platinum	79 Au gold	80 Hg mercury	81 Tl thallium	82 Pb lead	83 Bi bismuth	84 Po polonium	85 At astatine	86 Rn radon
7	87 Fr francium	88 Ra radium	89–103 actinides	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium		114 Fl flerovium		116 Lv livermorium		

57 La lanthanium	58 Ce cerium	59 Pr praseodymium	60 Nd neodymium	61 Pm promethium	62 Sm samarium	63 Eu europium	64 Gd gadolinium	65 Tb terbium	66 Dy dysprosium	67 Ho holmium	68 Er erbium	69 Tm thulium	70 Yb ytterbium	71 Lu lutetium
89 Ac actinium	90 Th thorium	91 Pa protactinium	92 U uranium	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

The periodic table provides the name and chemical symbol of every element. Every element has an atomic number and you will learn more about this in *iScience 9 NSW*. The periodic table is read by following the atomic numbers from left to right, moving from the top of the periodic table to the bottom.

ACTIVITY 5.2

Online element games

Play one or all of the online element games, such as element hangman, element crosswords, element concentration or element word scrabble. You may need a periodic table to help you.

WEBLINK
Online element games

ISBN 9780170231497

Corbis/Baldwin H. Ward & Kathryn C. Ward

Figure 5.16 Dmitri Mendeleev published the first periodic table.

The periodic table is a strange shape. It seems to be separated into different sections. This is because the elements on the periodic table are not randomly arranged. In 1869, Russian chemist Dmitri Mendeleev classified the 63 known elements of the time and published the first version of the periodic table (Figure 5.17).

Reihen	Gruppo I. — R^2O	Gruppo II. — RO	Gruppo III. — R^2O^3	Gruppo IV. RH^4 RO^2	Gruppo V. RH^3 R^2O^5	Gruppo VI. RH^2 RO^3	Gruppo VII. RH R^2O^7	Gruppo VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,8	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fo=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	So=78	Br=80	
6	Rb=86	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Co=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Ti=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Figure 5.17 Dmitri Mendeleev's periodic table

WORKSPACE
Investigating the elements on the periodic table

VIDEO
Mendeleev and the periodic table

ACTIVITY 5.3

Investigating the elements on the periodic table

Materials

- a periodic table
- access to the Internet

Method

Use the periodic table to answer the following questions in the workspace. You may need to do some extra research on the Internet.

1 **Identify** the names and symbols of elements that are liquids at room temperature. Present your answer in a table.

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ACTIVITY 5.3

2 **Identify** the names and symbols of elements that are gases at room temperature. Present your answer in a table.

3 **Identify** the names and symbols of three elements that have been named after planets.

4 **Identify** the names and symbols of four elements that have been named after famous scientists.

5 **Identify** the names and symbols of two elements that have been named after the countries in which they were discovered.

6 The following symbols of elements are very different from their chemical names in English. **Explain** why these elements have been given these symbols.
   - **a** K (potassium)
   - **b** Fe (iron)
   - **c** Sn (tin)
   - **d** Ag (silver)
   - **e** Au (gold)
   - **f** Pb (lead)
   - **g** Hg (mercury)
   - **h** Na (sodium)

7 The following words or statements have been written using the symbols of some of the elements on the periodic table. For example, the word 'more' is made up of the elements molybdenum (Mo) and rhenium (Re).

   For each word or statement below, **identify** and **list**, in the correct order, the names and symbols of the elements that make it up. (Note: The spaces between words should be ignored.) There may be more than one correct answer for some questions.
   - **a** Chocolate
   - **b** Nasal
   - **c** Prunes
   - **d** Archery
   - **e** Bicycle
   - **f** Niceties
   - **g** Lubrication
   - **h** Heterogeneous
   - **i** International baccalaureate
   - **j** Coffee run
   - **k** Moe's tavern
   - **l** Crack that whip!
   - **m** In space, no one can hear you scream.

8 Use the letters of the elements on the periodic table to make up five of your own words or statements. Swap with another student and try to work theirs out.

ICT

Share your words or statements by loading them onto the class wiki.

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WORKSPACE
What have you learnt? 5.2

QUESTIONS 5.2

What have you learnt?

Remembering

1 **Identify** the elements on the periodic table that begin with the letter 'B'. Tabulate their names and symbols.

Understanding

2 **Explain** why some elements on the periodic table have two letters for their symbol while others only have one letter.

Applying

3 **Compare** (provide similarities and differences) the modern periodic table with the table developed by Mendeleev in 1869.

4 Research examples of the symbols that John Dalton gave to some of the chemical elements. **Compare** these symbols with the ones we use today.

Analysing

5 Go back to the weblink on page 120 and listen to 'The Elements' song again.

- a In groups, watch the animation of this song. **Deduce** the most efficient way to write a list of all the elements mentioned in the song, in order.
  - i Play the song as many times as you need to in order to compile your list.
  - ii How many times did you need to play the song?
  - iii Which group in the class played it the least number of times?
  - iv **Identify** the method they used to record the information most efficiently.
- b When you have a list of the elements in order, check the periodic table to make sure they are all real elements. Write down their chemical symbols next to their names.
- c The last element in the song was darmstadtium, discovered in 2003. Can you find it on the periodic table? Are there any other elements listed after it? **Identify** these elements and write their chemical symbols.
- d **Explain** why these elements are not in the song.
- e **Identify** the organisation responsible for deciding whether new elements should be included on the periodic table.
- f This organisation also finalises the names of newly discovered elements. **Investigate** if there have ever been any issues when naming new elements. What were the elements? What was the issue?
- g Are there any elements that have been discovered but which are not yet on the periodic table? **Explain** why.

Evaluating

6 **Compare** the organisation of a supermarket with that of the periodic table.

7 **Propose** some modern-day consequences if Mendeleev had not devised the periodic table.

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5.3 Classifying elements

The periodic table classifies elements according to similarities in their properties. One of these categories is whether the elements are metals, non-metals or metalloids. Other sets of elements have been given specific names that reflect other similar properties, rather than just being a metal or a non-metal. For example, the elements helium, neon, argon, krypton, xenon and radon are also known as the noble (inert) gases. These elements are called noble gases because they are non-reactive (which is what 'inert' means).

WEBLINK
Interactive periodic table

ACTIVITY 5.4

Classifying elements on the periodic table

In this activity, you will label and classify important parts of the periodic table on your own paper copy. Alternatively, you could complete this electronically, using a spreadsheet or word processing program.

Materials

- paper print-out of the periodic table
- coloured highlighters
- pencil
- pen
- access to a computer and the Internet

Method

Go to the weblink. Use the drop-down menus in the bottom left-hand corner to change the category. Make sure you have the heading just above the menus set to 'Classification'.

1 On your paper copy of the periodic table, use three different coloured highlighters to colour in the elements that are classified in the following categories. Include a key at the bottom of your periodic table. Make sure you set the drop-down menus back to their original positions before you move on to the next category.
   a Select 'Metals' by using just the 'Properties' drop-down menu.
   b Select 'Metalloids' by using the 'Classification' drop-down menu in the second column.
   c Colour the rest of the elements all one colour. These are the non-metals.

2 Set the drop-down menus back to their original positions, and then use the 'Classification' menu in the second column for the categories listed below. Use your pen to label each group or period on your paper copy with the following special names.
   a Noble (inert) gases
   b Halogens
   c Transition metals

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ACTIVITY 5.4

d Lanthanoids
e Actinoids
f Alkali metals
g Alkaline earth metals

3 Set the drop-down menus back to their original positions. Use the 'State at room temperature' drop-down menu to **investigate** the states of the elements at room temperature. In pencil, write 'g' for the gaseous elements and 'l' for the liquid elements. The remaining elements on the periodic table are all solids. You do not need to fill these in.

WORKSPACE
What have you learnt? 5.3

QUESTIONS 5.3

What have you learnt?

Remembering

Use your labelled periodic table to answer the following questions.

1 State the names and symbols of the liquid elements.

2 **Identify** how many elements are gases on the periodic table.

3 **Identify** two metalloids.

Applying

Questions **4–6** refer to the weblink 'Interactive periodic table' on page 127.

4 Click on 'Discovery' at the bottom of the interactive.
   a Drag the cursor to the beginning of the timeline. What is the date? **Identify** the elements that were known at this time.
   b Drag the cursor to find the approximate date that the next element was discovered. What was this element?
   c Drag the cursor to find the approximate date that the first actinoid was discovered. What was the element?
   d **Compare** the total number of elements on the interactive website with the number in your copy of the periodic table. What do you find? Why is this the case?

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QUESTIONS 5.3

5 Click on 'Property ranking' at the bottom of the screen. Then click on the column title 'Percentage mass of the Earth's core' until the arrow in the column heading points up.

a **Identify** the substance that has the greatest abundance in the Earth's core.

b Add up the values for the eight elements that have the greatest abundance in the Earth's core. Does the total equal 100%? **Explain** why or why not.

c Create a sector graph from the percentage values for the eight elements to **show** their abundance in the Earth's core. You will need to add a section for other elements to make the total equal 100%. (Hint: You will need a protractor, a compass and a calculator. Remember that 100% equals 360°, so 1% equals 3.6°.)

Analysing

6 Go back to the experiment on page 113.

a **Identify** the chemical symbols and formula for each chemical substance you observed in the experiment.

b **Identify** the substances that were elements.

c **List** the chemical symbol or formula for every substance. Next to each, **identify** the element or elements each contains.

d Highlight the pure substances that have more than one element in them. **Explain** why these pure substances cannot be called elements. Look back at the classification chart in Figure 5.8, on page 116, and **identify** what these substances must be called.

5.4 Properties and uses of common elements

In a cutlery drawer the knives are in a separate compartment from the spoons and the forks. Utensils are classified in this way according to their uses. Materials can also be classified according to the properties they have in common. Scientists divide properties into two categories: physical and chemical. **Physical properties** are features of a substance that can be observed or examined without changing the actual composition of a substance.

Table 5.3 lists some common physical properties of substances.

The features in Table 5.3 are all called physical properties because they can be observed or measured in some way. Some of the physical properties of common substances are shown in Table 5.4.

physical properties

the properties of a substance that can be observed or examined without changing the composition of the substance

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Table 5.3
Some common physical properties of substances

Physical property	Description
State at room temperature	Whether it is a solid, liquid or gas
Colour	The colour it appears as (for example, blue, red, colourless)
Hardness	Its resistance to a permanent change in shape if a force is applied
Density	The amount of matter (mass) in a given space (volume); often calculated by density = mass/volume
Melting point	The temperature at which it changes state from a solid to a liquid (or from a liquid back to a solid)
Boiling point	The temperature at which it changes state from a liquid to a gas (or from a gas back to a liquid)
Solubility	The amount that can dissolve in a particular volume of solvent (at a particular temperature)
Lustre	How shiny it is (often after sanding with glass paper or steel wool)
Malleability	The ability to be bent or hammered into shapes
Ductility	The ability to be drawn out into wires
Heat conductivity	The ability to transfer heat: good heat conductors transfer heat well; insulators transfer heat poorly
Electrical conductivity	The ability to transfer electricity: good electrical conductors transfer electricity well; insulators transfer electricity poorly

lustre
the shininess of a material

malleability
the ability of a substance to bend or be hammered into different shapes

ductility
the ability of a substance to be drawn into wires

heat conductivity
the ability of a substance to transfer heat: good heat conductors transfer heat well; poor heat conductors (insulators) transfer heat poorly

electrical conductivity
the ability of a substance to transfer electricity: good electrical conductors transfer electricity well; poor electrical conductors (insulators) transfer electricity poorly

Table 5.4
Physical properties of some common substances

Substance	State at room temperature (25°C)	Colour	Melting point (°C)	Boiling point (°C)	Solubility in water at 25°C (g/100 g)	Lustre
Table salt	Solid	White	801	1465	36	Dull
Water	Liquid	Colourless	0	100	—	—
Oxygen	Gas	Colourless	2219	2183	0.004	—
Copper metal	Solid	Orange-brown	1085	2572	Insoluble	Lustrous
Chlorine	Gas	Yellow-green	2101	235	0.64	—

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Physical properties of the chemical elements

In the previous section, you learnt that the chemical elements are classified on the periodic table according to the similarities in their properties. One way you classified the elements was to group them as metals, non-metals or metalloids. This is shown in Figure 5.18. So what physical properties do these groups of chemical elements have in common?

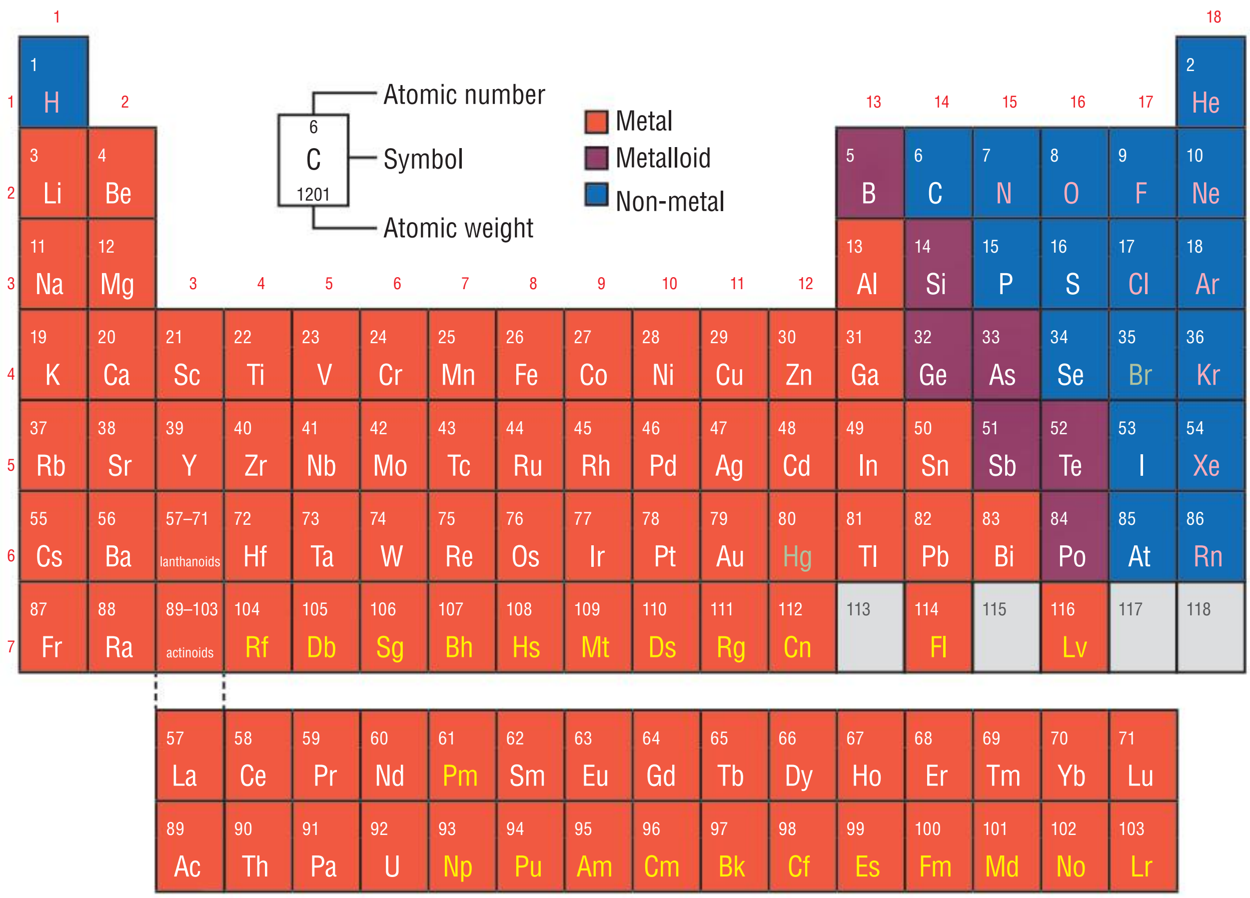

Figure 5.18 Elements on the periodic table can be classified as metal, non-metal or metalloid.

EXPERIMENT 5.1

Physical properties of the elements

WORKSPACE
Physical properties of the elements

Possible risks	Safety precautions
Bunsen burners and hot equipment and metals can burn.	Before touching anything that has been heated, hold your hand over it. If you feel heat coming off it, don't touch it. Always use the tongs to hold the metals when heating. Allow the metals to cool down before you touch them.
Some metals or non-metals cannot be used by students.	Your teacher will demonstrate these for you.

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EXPERIMENT 5.1

Aim

To compare the physical properties of elements

Materials

- small pieces/amounts of different elements, such as a graphite rod, tin, copper, aluminium, iron and zinc (Your teacher will perform any tests on sulfur powder, phosphorus, silicon and oxygen gas.)
- Ingenhousz apparatus, or rods/wires about 15 cm long and of the same diameter of, for example, tin, copper, aluminium, iron and zinc
- heating apparatus
- stopwatch
- glass paper (black sandpaper)
- wax candle
- Bunsen burner
- heat-proof mat
- tongs
- battery or power pack, 1.5 V globe, conductivity wires and alligator clips

Method

1. **Identify** as many physical properties for each element as you can, just by looking at them.
2. Test 1: Try bending the elements you think can be bent.
3. Test 2: Use the glass paper to shine the elements you think can be sanded.
4. Test 3: Use the Ingenhousz apparatus or rods/wire of different metals. One at a time, place some candle wax on one end of each metal rod. Place a heat-proof mat under the end with the wax. Use the blue flame of the Bunsen burner to heat the end of the rod/wire without the wax. Use the stopwatch to time how long it takes for the wax to fall off the end of the rod. Repeat for each different metal.
5. Test 4: Connect a battery in a simple circuit to a light globe (see Figure 5.19). Leave one side of the circuit incomplete. Use each element you are allowed to handle in turn to complete the circuit.
6. Your teacher will perform the above tests for the elements you are unable to handle.

Results

1. **Construct** a table to **compare** the physical properties of each element, both observed and from the results you obtained from the activity.

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EXPERIMENT 5.1

Figure 5.19
A simple circuit

Discussion

2 Using the results of your experiment, **classify** the elements into groups on the basis of how similar their physical properties are.

3 **Identify** any elements that seem to fit into more than one group. **Classify** these elements into the groups with which they seem to have the most similarities, but highlight these elements with a different colour.

4 On the basis of your results, **outline** the physical properties of metals and non-metals.

Table 5.5 summarises some of the physical properties of metals and non-metals.

Table 5.5
Physical properties of metals and non-metals

Physical property	Metals	Non-metals
State at room temperature	Solid (except mercury, which is a liquid)	Mainly gases and solids (bromine is the only liquid non-metal)
Melting and boiling points	Moderate to high	Varied
Lustre (shiny when sanded)	Lustrous	Dull
Malleability (ability to bend)	Malleable	Not malleable
Ductility (able to be drawn into wires)	Ductile	Not ductile
Heat conductivity	Good	Poor
Electrical conductivity	Good	Poor (except graphite)

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INTERACTIVE
The elements: element analyser

ACTIVITY SHEET
The elements: mystery elements

ACTIVITY SHEET
Mystery elements: fill in the gaps

WORKSPACE
The uses of elements are linked to their properties

ACTIVITY 5.5

Physical properties of the elements

Use the interactive 'The elements: element analyser' to **investigate** the physical properties of the elements on the periodic table.

WOW!

Foiled

Major chewing-gum manufacturers have made the switch from aluminium foil wrappers to paper wrappers. This is expected to save more than 850 tonnes of aluminium every year.

ACTIVITY 5.6

The uses of elements are linked to their properties

Complete the following table using information from the Internet and from Table 5.3 on page 130. There may be more than one property that makes the element suitable for the use. Similarly, there may be more than one use that is appropriate for a specific property. The information for copper has been completed for you.

Element	Use for element	Property of element that makes it suitable for this use
Copper	Wiring for electrical circuits in the home	Good conductor of electricity
Carbon (graphite)	Rods in normal dry cell batteries	
Aluminium	Foil used to cover food when placed in the oven	
Copper		Good conductor of heat

Steel is a mixture of iron and carbon. It is mostly iron with between approximately 1% and 4% carbon. Iron is very malleable. Adding carbon to the iron increases the strength of the steel. However, increasing the carbon content in steel also makes the steel more brittle. Other elements are sometimes added to the steel to change its properties. Some elements commonly added to steel are chromium, nickel, tungsten, molybdenum, manganese and sulfur. Different types of steel are used for many different structures, tools and instruments. Some examples are shown in Figure 5.20.

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Figure 5.20
Examples of structures, tools and instruments made from steel include **(a)** a ship's hull, **(b)** the Sydney Harbour Bridge, **(c)** cutlery, **(d)** surgical instruments, **(e)** drill bits and **(f)** staples and paper clips.

ACTIVITY 5.7

Effects of adding different elements to steel

Use the Internet to complete the following table to **summarise** how adding different elements to steel affects its properties.

Element added to steel	Description of how adding this element affects the properties of the steel	Use for the steel
Chromium		
Nickel		
Tungsten		
Molybdenum		
Manganese		
Sulfur		

WORKSPACE
Effects of adding different elements to steel

ISBN 9780170231497

WORKSPACE
What have you learnt? 5.4

QUESTIONS 5.4

What have you learnt?

Remembering

1 **Define** 'physical properties'.
2 **Identify** three physical properties.

Understanding

3 **Outline** the effect of adding carbon to steel.
4 **Outline** the effect of adding chromium to steel.
5 **Identify** a use for the steel with added chromium.

Analysing

6 Use the table of data to answer the questions below.

Substance	Melting point (°C)	Boiling point (°C)	Density (g/cm3)
Octane	–57	125	0.70
Water	0	100	1.00
Copper	1085	2562	8.94
Sugar	186		1.59

a Rank these substances from lowest melting point to highest melting point.
b **Identify** a substance that is more dense than water.
c Using the data in the table, **justify** why copper is a solid at room temperature.

7 An unknown element has the following properties: solid, brittle and a poor conductor of heat. **Identify** whether the element is a metal or non-metal. **Justify** your answer.

5.5 The structure of compounds

compound
a pure substance made up of two or more different atoms chemically bonded together

A chemical element is one type of pure substance. The other type of pure substance is called a **compound**. A compound is a pure substance made up of two or more different types of atoms chemically bonded together. Pure solid table salt, pure liquid water and the gas carbon dioxide are all examples of common naturally occurring compounds.

Salt is one compound that is dissolved in the ocean. We know this because the ocean tastes salty. Water falls to the ground from the clouds when it rains. Carbon dioxide is a gas that exists in our atmosphere and is produced when fossil fuels are burnt. Figures 5.21–5.23 show diagrams for each of these compounds if we were able to magnify them enough to see the arrangement and structure of the particles.

The substances represented in Figures 5.21–5.23 can be classified as pure because the particles of each substance are all the same. But because the particles are made up of different types of atoms chemically combined, they are compounds, not elements. The particles of specific compounds are always exactly the same. One particle of carbon dioxide is always made up of one carbon atom bonded to two oxygen atoms. A particle made up of one carbon atom bonded to one oxygen atom is a completely different compound, and this compound is called carbon monoxide.

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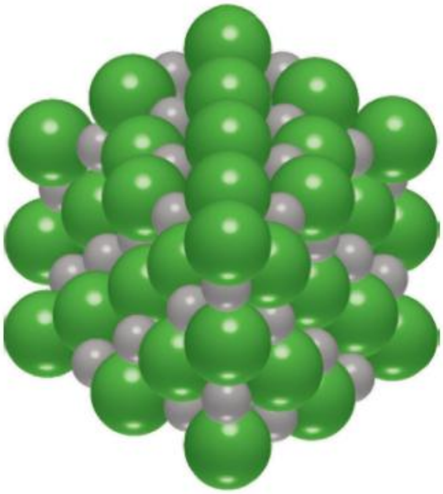

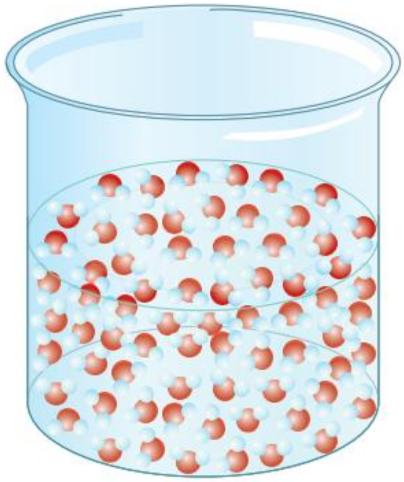

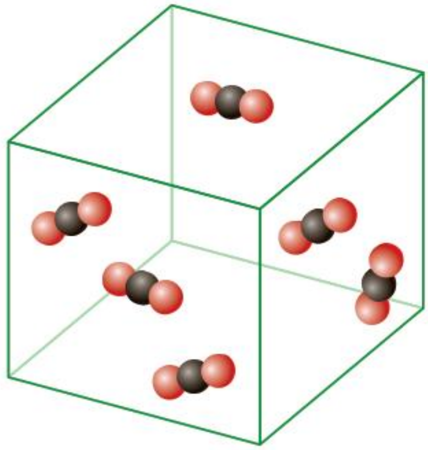

Figure 5.21 (left) Pure solid table salt (sodium chloride)

Figure 5.22 (middle) Pure liquid water

Figure 5.23 (right) Pure carbon dioxide gas

Compounds are different from mixtures. In mixtures, the different particles are only physically combined: they are not chemically 'connected together'. The individual substances that make up a mixture retain their physical properties, such as particle size or boiling point. This makes it possible to separate them by physical separation processes, such as filtration or evaporation.

In compounds, the different elements are chemically 'connected' together to form a new substance that has new physical and chemical properties. This means the properties of a compound are different from the properties of the elements that make it up. This is why compounds cannot be separated into their elements by physical separation processes, such as filtration or evaporation. However, if enough energy is added, compounds can be broken down (decomposed) into simpler substances – the elements that make them up. (Remember what you learnt about the elements hydrogen and oxygen earlier in this unit. Are the properties of the compound water the same as or different from those of hydrogen and oxygen?)

Molecules

Non-metal elements and some compounds consisting of only non-metals are made up of particles called molecules.

Observe the structures in Figure 5.24 on page 138. What do you notice about the diagrams in Figure 5.24? Instead of being represented by a single atom, they all have two or more atoms drawn touching each other. This means that the smallest particle of these pure substances is actually a number of atoms that are chemically bonded. Each illustration represents a particle called a molecule. A molecule is a type of particle in which two or more non-metal atoms are chemically bonded together. The molecules shown in Figure 5.24 tell us the number and types of atoms that make up a particle of a substance. If all of the atoms in the molecule are the same, then it is called a **molecule of an element**. If two or more different types of atoms are bonded together, then it is called a **molecule of a compound**. Molecules can exist separately. This means they do not break down into their individual atoms unless enough energy is provided to pull them apart in a chemical reaction.

Figure 5.24 shows a molecule of oxygen gas. Oxygen atoms do not exist for very long on their own in nature. Instead they 'pair up'. A particle of oxygen gas is always made up of two oxygen atoms chemically connected together. The chemical formula for oxygen gas is O_2. Oxygen gas is still an element because the atoms that make up oxygen molecules are the same. Oxygen, O_2, is the form of oxygen that we breathe in and is used in respiration.

WEBLINK
How is a compound different from a mixture?

ANIMATION
Molecules and compounds

INTERACTIVE
The elements: find the elements

molecule of an element
a particle in which two or more atoms of the same non-metal element are chemically bonded together

molecule of a compound
a particle in which two or more atoms of different non-metal elements are chemically bonded together

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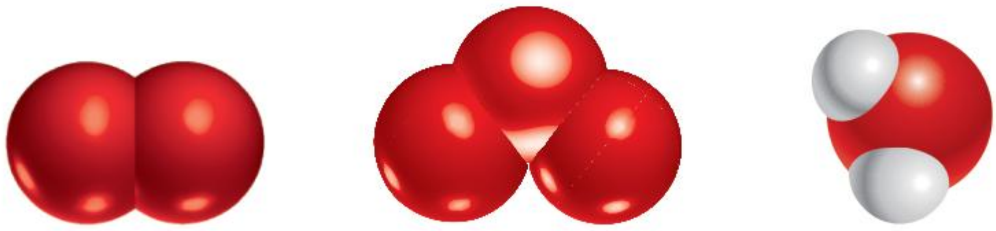
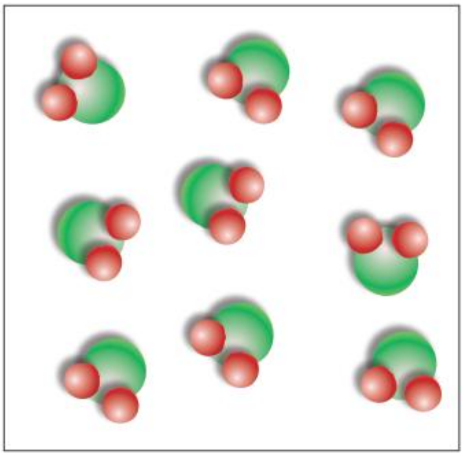
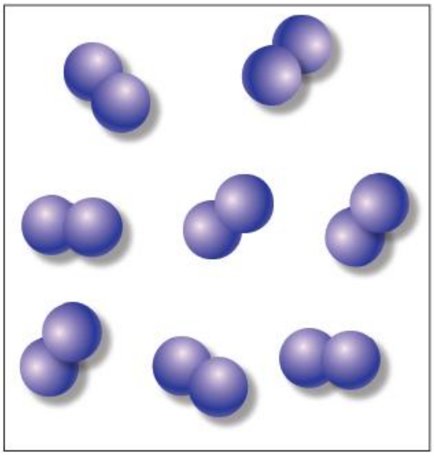


Figure 5.24 Molecules of the non-metal element oxygen as oxygen gas, ozone gas and in a molecule of the compound water

Figure 5.24 also shows a molecule of the gas ozone. It is made up of three oxygen atoms connected together. So the chemical formula for ozone is O_3. Ozone is formed in nature when an oxygen molecule, O_2, combines with an oxygen atom, O, high up in the part of the atmosphere known as the stratosphere. Ozone, O_3, is the form of oxygen that acts as Earth's UV shield. It prevents most of the dangerous UV radiation from reaching Earth's surface.

A molecule of water is also shown in Figure 5.24. This is a compound because there are two different types of atoms connected together. There are two hydrogen atoms and one oxygen atom in a particle of water. So the chemical formula for water is H_2O.





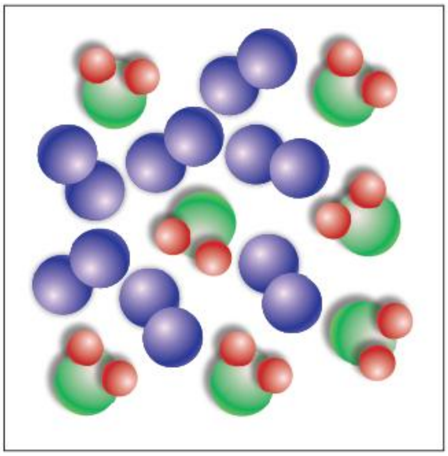


Figure 5.25 (left) This is a pure substance since it is made up of one type of molecule. The molecule has two different types of atoms in it so it is a compound.

Figure 5.26 (middle) This is a pure substance since it is made up of one type of molecule. The molecule has only one type of atom in it so it is an element.

Figure 5.27 (right) This is not a pure substance since it is made up of more than one type of molecule. It is a mixture.

WOW!

Strange names for molecules!

Traumatic acid is a 'wound hormone' found in plants. Its job is to promote repair at a site of trauma on a plant. It is also known as (E)-dodec-2-enedioic acid. Which seems stranger to you?

Moronic acid is a chemical substance that can be isolated from the Chinese sumac plant. It has been shown to have medicinal qualities and is being tested as an anti-HIV drug.

Vomitoxin is a toxin produced by a type of fungus that grows on wheat. The scientific name is deoxynivalenol (DON).

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ACTIVITY 5.8

Representing different types of chemical substances with Lego®

In this activity, each Lego brick represents one atom. If the Lego bricks are the same size and colour, they represent the same type of atom. If the Lego bricks are different, they represent different types of atoms. If two or more Lego bricks are connected together, they represent a molecule. After you have carried out each step, take a photo of your results and upload it into your workspace. Then answer the questions that follow before moving on to the next step.

Materials

- a range of different Lego bricks
- three plastic containers
- digital camera

Method

1 Work in groups of three. Each member chooses a different coloured Lego brick. Use the same number of Lego bricks of your type to build any structure you like.
   - a **Identify** the type of chemical substance represented by the structures you have made.
   - b **Identify** the type of particle making up these substances.
   - c **Compare** the three substances in your group. **Justify** your answer.
   - d Provide an example found in nature of this type of chemical substance.

2 Dismantle your structures and place all of the Lego bricks into one plastic container. Shake the container to mix them around.
   - a **Identify** the type of chemical substance represented here. **Justify** your answer.
   - b **Compare** the structure of this substance to the substances you built in step 1.

3 Each member chooses a different coloured Lego brick. Collect another of the same brick and connect them together. You now have a particle made up of two identical Lego bricks. Make six more individual particles each. Each member places the particles into separate plastic containers.
   - a **Identify** the type of particle made here. **Compare** this particle to the particle used in step 1.
   - b **Identify** the type of chemical substance you have represented. **Justify** your answer.

4 Mix all of your Lego substances from step 3 into one container.
   - a **Identify** the type of substance that it represents.
   - b **Compare** this to the type of substance made in step 2.

5 Each member chooses Lego bricks of two different colours and connects them together. You now have a particle made up of two different Lego bricks. Make six more individual particles each. Each member places the particles into separate plastic containers.

WEBLINK
Elements, compounds and mixtures at the particle level

WEBLINK
Review animation: elements, compounds and mixtures

INTERACTIVE
Types of matter: quiz

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ACTIVITY 5.8

a **Identify** the type of particle made here. **Compare** this particle to the particles made in steps 1 and 3.
b **Identify** the type of chemical substance that this is representing. **Explain** your answer.
c Provide an example found in nature of this type of substance.

6 Mix all of the substances into one container.
a **Identify** the type of substance this represents.
b **Compare** this to the types of substances made in steps 2 and 4.

7 Copy the photographs of all of your results. Arrange these photographs into groups to **classify** them according to their similarities.

WORKSPACE
What have you learnt? 5.5

QUESTIONS 5.5

What have you learnt?

Remembering

1 **Define** the following terms and provide an example of each.
a Compound
b Molecule
c Molecule of an element
d Molecule of a compound

Understanding

2 **Identify** whether the following statements are true or false. If they are false, **explain** why and rewrite them so that they are true.
a All pure substances are elements.
b All elements are pure substances.
c The smallest particle of a mixture is a molecule.
d Mixtures can contain both atoms and molecules physically combined together.
e A compound is made up of atoms that are all the same.

Applying

3 **Identify** which of illustrations A–F are:
a elements
b compounds
c made up of only molecules
d mixtures.
Justify your answers.

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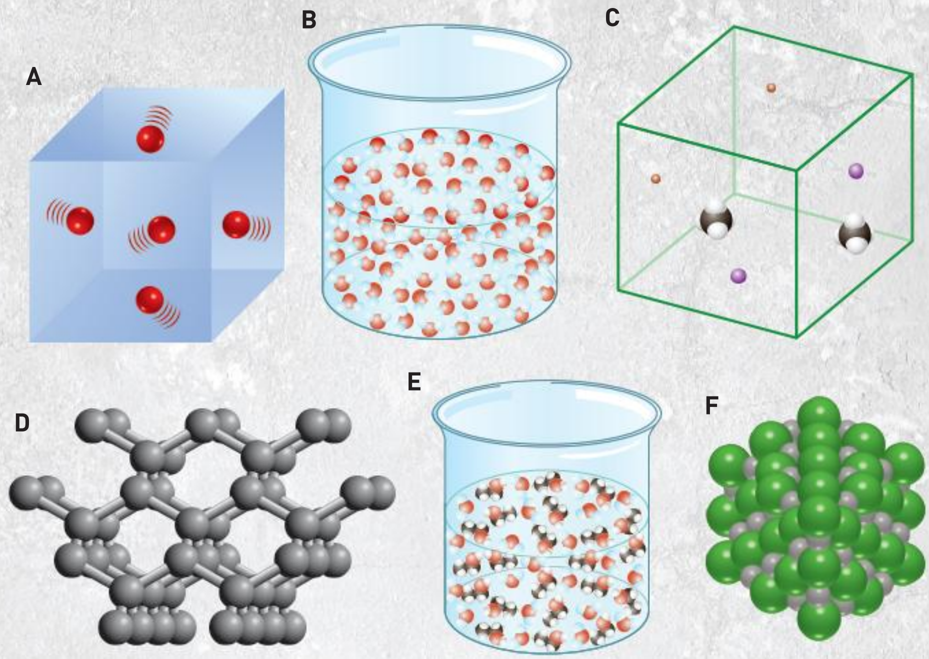
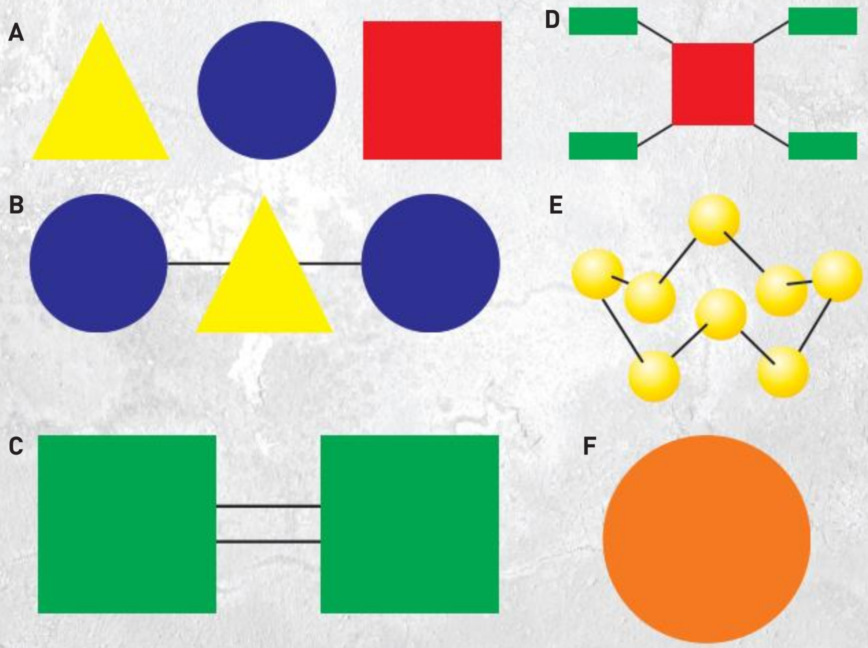
QUESTIONS 5.5



4 In each of the particle diagrams A–F below, the different shapes represent different atoms. The black lines represent chemical bonds holding the atoms together. **Identify** the particle diagrams representing:

- **a** an atom
- **b** a molecule of an element
- **c** a molecule of a compound
- **d** a mixture.

Justify your answers.



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QUESTIONS 5.5

5 Draw particle diagrams from the following descriptions. Use circles for the atoms and place the chemical symbol inside the circles.

a A molecule of an element containing two chlorine atoms

b A molecule of a compound containing a carbon atom in the middle connected to each of four hydrogen atoms around the outside

c A particle of a compound containing one sulfur atom connected to two oxygen atoms

d A mixture containing two different elements and one compound of your choice

5.6 Chemical formulas

WORKSPACE
Why is water written as H_2O?

EXPERIMENT 5.2

Teacher demonstration — why is water written as H_2O?

Possible risks	Safety precautions
Water and your body can conduct electricity. This can be dangerous if you are touching the water and a supply of electricity.	Keep water away from the powerpack. Make sure your hands are dry when turning electrical switches off and on. Your teacher will carry out this activity as a demonstration.

Note: Although safety tells us water should never be around an electrical current, a Hofmann voltameter works by using electricity to break down water into its elements. This is a complicated but common and important process that you will learn in later years of chemistry.

Aim

To decompose water into its elements, hydrogen gas and oxygen gas

Materials

- Hofmann voltameter
- de-ionised water (your teacher may explain why another substance also needs to be added)
- power pack

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EXPERIMENT 5.2

- taper
- non-permanent marker pen, such as whiteboard marker
- matches

Method

1 Your teacher will show you the set-up of the Hofmann voltameter as shown in Figure 5.28. It contains the compound water and is connected safely to an electrical source.

2 Your teacher will mark the level of water in each of the three columns.

3 Turn on the power pack to 12V DC to chemically break down the compound water into its elements.

4 Observe the apparatus over the course of the lesson.

Getty Images/Trevor Clifford Photography/SPL

Figure 5.28 A Hofmann voltameter (containing water) connected to an electrical power source

Results

1 Observe the changes in water level in the three columns. **Outline** what you notice.

2 Observe the two outer columns. **Outline** what you notice at the top of each.

Discussion

3 **Identify** whether the water level in the main centre column changed. **Predict** what is happening.

4 Observe the changes in the level in each of the two outer glass columns. **Identify** whether they are the same, or different.

5 Write a statement to **compare** the water levels in the two outer columns.

6 The chemical formula for water is H_2O. What does this mean? **Analyse** how this is similar to what you can observe in the columns containing gas in the voltameter.

7 Your teacher will perform the appropriate tests on the gases in each column to confirm their identity. What do the results suggest?

Conclusion

8 **Explain** how this activity suggests water is a compound and not an element.

9 **Explain** how this activity supports the chemical formula for water.

Every compound has a chemical formula. It tells us which elements the compound contains. Compounds can be made up of:

- two or more non-metals chemically bonded together
- a metal combined with a non-metal.

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We already know that non-metals bond together to form compounds, and the chemical formula tells us the number of atoms in one particle of that compound. Figure 5.29 illustrates this.

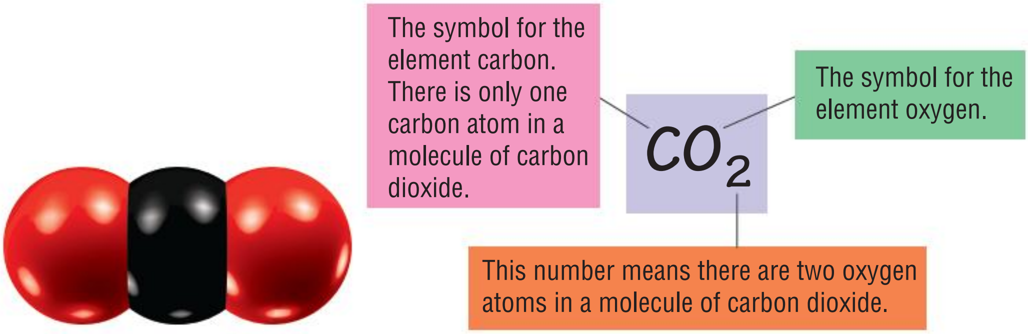

Figure 5.29 A carbon dioxide molecule and the chemical formula for carbon dioxide

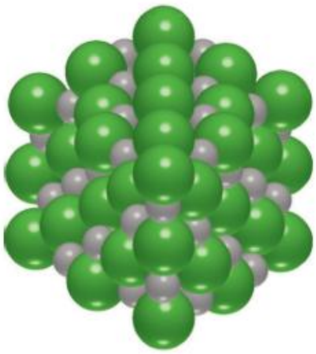

Figure 5.30 The structure of sodium chloride, NaCl

Figure 5.30 shows a compound formed between a metal (sodium) and a non-metal (chlorine). For every one sodium particle, there is one chloride particle. This means that the chemical formula for this compound (sodium chloride) is NaCl.

Table 5.6 Compounds formed between metals and non-metals

Metal	Non-metal	Compound name
Sodium	Chlorine	Sodium chloride
Beryllium	Fluorine	Beryllium fluoride
Potassium	Phosphorus	Potassium phosphide
Aluminium	Sulfur	Aluminium sulfide

ACTIVITY SHEET
Modelling the structure of elements and compounds

WORKSPACE
What have you learnt? 5.6

Notice the metal is named first and the non-metal second. The ending of the non-metal has been changed to '–ide'. This is a general rule when naming many chemical compounds (note the name 'carbon diox*ide*' from the example in Figure 5.29). You will also have noticed some compounds have common names, such as water.

QUESTIONS 5.6

What have you learnt?

Remembering

1 Complete this table by writing the formula of each substance and **classifying** whether it is an element or a compound. The first one has been done for you.

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QUESTIONS 5.6

Name of substance	Composition of substance	Chemical formula	Element or compound
Chlorine gas	Two atoms of chlorine	Cl_2	Element
Methane	One atom of carbon and four atoms of hydrogen		
Ethanol	Two atoms of carbon, six atoms of hydrogen and one atom of oxygen		
Sulfur dioxide	One atom of sulfur and two atoms of oxygen		
Ammonia	One atom of nitrogen and three atoms of hydrogen		
Nitrogen gas	Two atoms of nitrogen		
Glucose	Six atoms of carbon, twelve atoms of hydrogen and six atoms of oxygen		
Hydrochloric acid	One atom of hydrogen and one atom of chlorine		
Sulfuric acid	Two atoms of hydrogen, one atom of sulfur and four atoms of oxygen		

5.7 Historical uses of elements and compounds by different cultures

Our understanding of elements and compounds has developed over thousands of years, with many different cultures and civilisations contributing to our understanding. In fact, some historical time periods have been named after the main substances from which utensils, tools and weapons were made. These historical time periods were known as the Stone Age, the Bronze Age and the Iron Age. The Stone Age was the earliest of these historical time periods. It lasted for several million years and ended in approximately 3000 BCE. During this time, only simple tools made from stone were used.

However, as humans learnt more about their environments and how to work with materials, they developed more sophisticated tools and utensils. The next period was known as the Bronze Age as people developed simple processes that enabled them to make tools and utensils from bronze, which is a mixture of copper and tin. This period was from about 3000 BCE to about 1000 BCE. The people were able to heat copper and tin ores and produce a mixture called bronze. They were able to melt and mould the bronze in wood fires to produce bowls and drinking goblets as well as weapons, such as arrowheads for spears.

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The Iron Age was the last of the three time periods named after the materials from which utensils and weapons were made. It lasted from about 1000 BCE to 1 CE, although the dates varied in different parts of the world. It was known as the Iron Age, but many of the tools and weapons were made from steel.

The earliest known iron work was from the Western Zhou Dynasty of Ancient China.

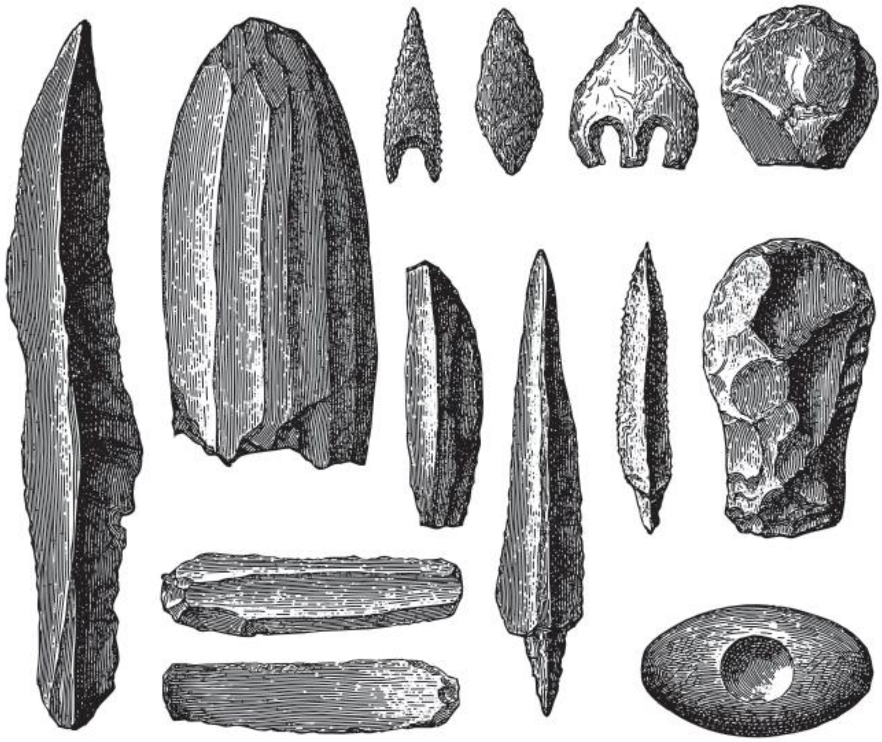

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Figure 5.31 Simple Stone Age tools

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Figure 5.32 Simple bronze hooks and arrowheads

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ACTIVITY 5.9

WORKSPACE
Bronze Age and Iron Age

Bronze Age and Iron Age

Bronze Age

1 Research the Bronze Age and find dates for the start and finish of this age for at least three different cultures or regions of the world. Include at least one from Asia. Create a timeline to **show** this information.

2 **Explain** why the Bronze Age started at different times.

3 **Describe** the conditions that were necessary for bronze to be melted and moulded.

4 **Describe** some of the properties of bronze.

Iron Age

5 **Outline** the roles of the Zhou Dynasty and the Han Dynasty in contributing to our understanding of metallurgy.

6 Research the Iron Age and find dates for the start and finish of this age for at least three different cultures or regions of the world. Create a timeline to **show** this information.

7 **Describe** the conditions that were necessary for iron to be extracted from its ore and melted and moulded.

8 **Justify** why the Bronze Age occurred before the Iron Age.

9 **Describe** some of the properties of iron.

10 **Explain** why the historical period was known as the Iron Age rather than the 'Steel' Age.

11 **Propose** why the people chose to make their weapons and tools from iron rather than bronze.

Various cultures observed their natural environment and recognised that rocks had different coloured crystals in them. They isolated these crystals and ground them to make powders that they used to make pigments. These pigments were used for creating artworks and make-up for various rituals. Historically, Indigenous Australians have used haematite, a red iron oxide ($Fe_2O_3.H_2O$), and white gypsum, calcium sulfate ($CaSO_4.2H_2O$), for rock art. They have also used these to paint their bodies for various ceremonies. Other people, such as the Egyptians, used a black ore known as stibnite (Sb_2S_3), for eye make-up.

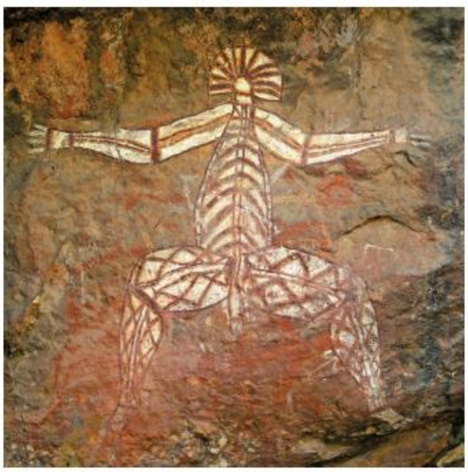

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Figure 5.33 Aboriginal rock art in Kakadu, Northern Territory

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WORKSPACE
Compounds for artwork and make-up

ACTIVITY 5.10

Compounds for artwork and make-up

Below are ores used by different cultures for artwork and/or make-up. Complete the table to list the ores and the elements from which they are made.

Ore	Chemical composition	Names of elements present in the ore	Colour of ore	Use for ore
Haematite	$Fe_2O_3.H_2O$		Red	Aboriginal artwork and make-up
Gypsum	$CaSO_4.2H_2O$			Aboriginal artwork
'White lead'	$(PbCO_3)_2.Pb(OH)_2$			Egyptian face make-up for paler skin colour
Stibnite				Egyptian eye make-up
Orpiment				Egyptian eye make-up
Chrysocolla	$CuSiO_3.H_2O$			Egyptian eye make-up

WORKSPACE
What have you learnt? 5.7

QUESTIONS 5.7

What have you learnt?

Remembering

1 **Define** these terms:
  a conductivity
  b malleable
  c ductile

Understanding

2 Nails are important for holding a building together. Nails are generally made of metal. **Identify** two physical properties that:
  a would be suitable for a nail
  b would not be suitable for a nail.

3 From the periodic table, **identify** two metals and two non-metals. **Compare** the physical properties of these types of elements.

WEBLINK
Memory: elements and their symbols

Applying

4 Aluminium is generally used to make soft-drink cans. **Outline** the physical properties of aluminium that make it suitable for this use.

5 An element is lustrous and it has a moderately high melting point. **Classify** the element as a metal, a metalloid or a non-metal.

Analysing

6 Clays of different colours (known as ochre) have been used as paints by indigenous peoples all over the world, including Australian Aboriginal artists. The ochre is mostly made up of a compound of iron, which we know best as rust. Using this information, **identify** the colours you think would be most common in aboriginal art.

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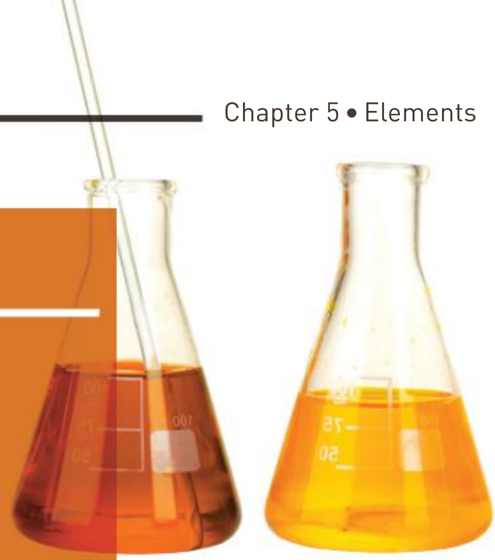

Chapter review

Remembering

1. **Identify** the term given to the smallest unit of matter.
2. **Identify** the smallest particle that makes up a metal.
3. **Identify** the elements present in bronze.

Understanding

4. **Describe** the difference between an atom of an element and a molecule of an element. Use examples to support your answer.
5. **Distinguish** between a pure substance and a mixture.
6. Draw a particle diagram to represent a compound.
7. **Explain** how scientific theories are refined and improved.

Applying

8. Find images of the metals aluminium and zinc. Do they look alike? **Explain** why they are not the same element even though they are the same colour and in the same state at room temperature. Research the physical properties of aluminium and zinc and **outline** how they differ. Use the word 'atom' in your answer.
9. Orpiment is a yellow mineral that was used as a pigment by the Egyptians. It has the formula As_2S_3.
   a. **Identify** the elements present in orpiment.
   b. **Justify** whether you think that using this compound would have any health effects.
10. The chemical formula for the compound ammonia is NH_3. Ammonia is a component of many of the products you can buy to clean windows and mirrors.
    a. **Identify** the elements that make up the compound ammonia.
    b. **Classify** these elements as metals or non-metals.
    c. **Identify** this type of particle.
    d. **Identify** how many atoms in total there are in one particle of NH_3.
    e. **Identify** how many atoms of each element there are in one particle of NH_3.

Analysing

11. **Explain** whether the chemical formulas Co and CO are for the same substance.
12. An element has the following properties: it is a solid at room temperature and is a good conductor of electricity. **Classify** the element as a metal, a metalloid or a non-metal.
13. **Identify** the name of the compound formed between magnesium and chlorine.

WORKSPACE
Chapter 5 review

ACTIVITY SHEET
Chapter 5 checklist

REVIEW QUIZ
Chapter 5

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14 Research and **outline**:

a some uses of ammonia

b what bats have to do with the making of ammonia

c what Fritz Haber had to do with ammonia.

Evaluating

15 **Explain** how Haber's discovery contributed to society. **Justify** whether the Iron Age should be renamed the Steel Age.

Reflecting

16 **Analyse** whether world history would be different if Fritz Haber had not made his discovery.

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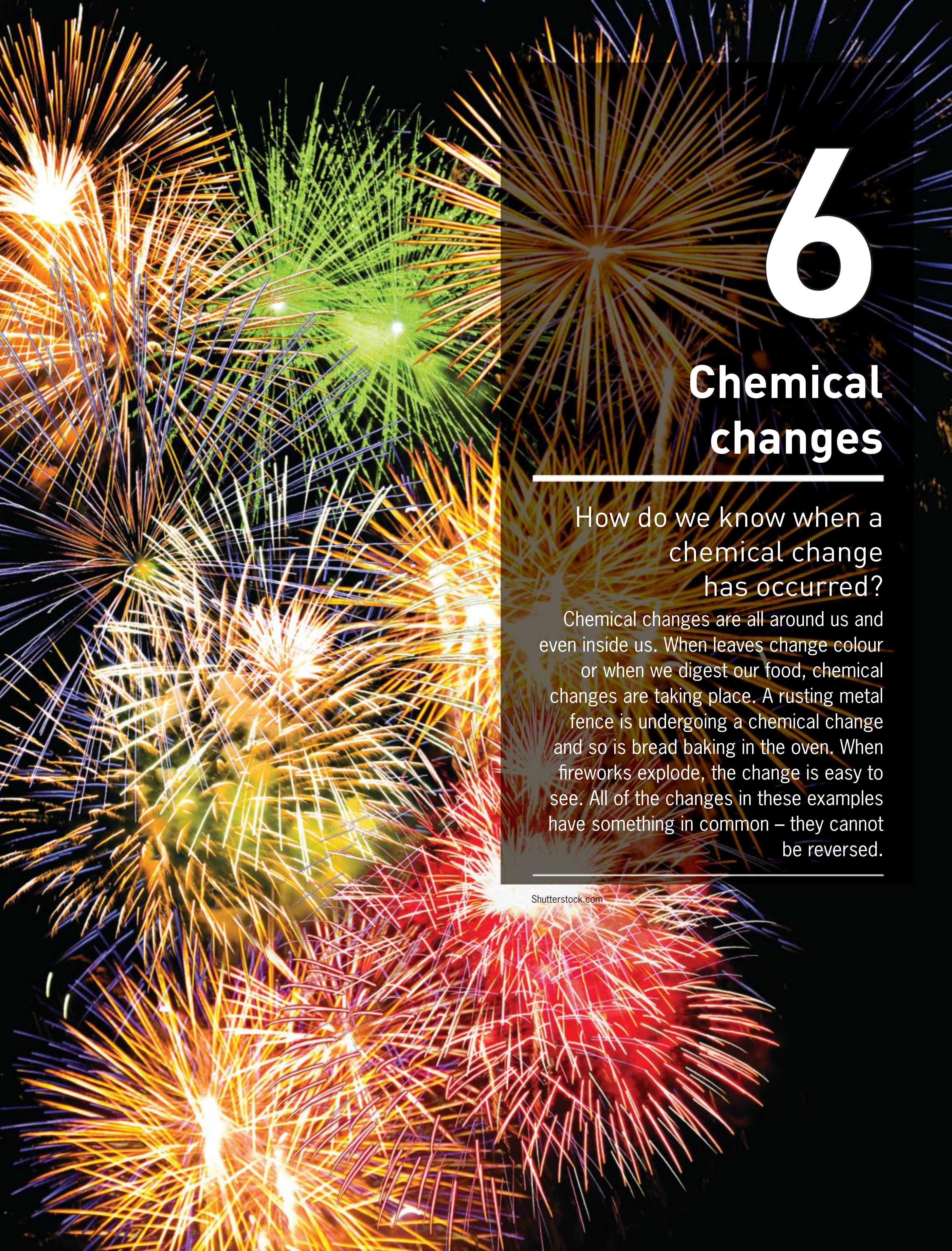

6

Chemical changes

How do we know when a chemical change has occurred?

Chemical changes are all around us and even inside us. When leaves change colour or when we digest our food, chemical changes are taking place. A rusting metal fence is undergoing a chemical change and so is bread baking in the oven. When fireworks explode, the change is easy to see. All of the changes in these examples have something in common – they cannot be reversed.

Chemical world – Stage 4

Key knowledge

- Chemical changes are due to chemical reactions.
- Signs of a chemical reaction include:
  - bubbling
  - a colour change
  - a temperature change
  - a new substance is formed
  - the starting substance disappears.
- New substances are formed as a result of chemical reactions.
- Chemical weathering is an example of a chemical reaction that occurs in rocks.
- Photosynthesis is an example of a chemical reaction that occurs in plants.
- Respiration is an example of a chemical reaction that occurs in both plants and animals.
- Particles move during physical changes.
- Particles rearrange during chemical reactions and cannot easily be reversed.
- Scientific research is important for the development of new materials, such as pharmaceuticals, that we can use in our daily lives.
- Society should be supportive of ethical science that helps improve sustainability and human health.
- Scientists across different disciplines work together to produce new materials.
- Uses of materials can be linked to their chemical properties.

ACTIVITY SHEET
CAT with rubric: Investigating how scientists have created new materials

CULMINATING ASSESSMENT TASK

Investigating how scientists have created new materials

Investigate the production and development of a known material of your choice. **Investigate** the chemical reactions that take place in its production, and **describe** how its properties relate to its uses. **Justify** why your material could be classified as beneficial.

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WORKSPACE
What do you already know about chemical reactions?

What do you already know about chemical reactions?

Complete the following experiment to find what you already know about chemical reactions.

What do you already know about chemical reactions?

Possible risks	Safety precautions
Some of the substances may be harmful to your eyes or skin.	Wear safety glasses and wash your hands after the activity with soap and water.
Glassware can break and broken glassware can cut.	If any glassware breaks, tell your teacher immediately.
Bunsen burners and hot equipment can burn.	Use a heat-proof mat and heat-proof mitts with heating equipment. Wait until equipment cools before removing it from the tripod. Leave the Bunsen burner on the safety flame or off when not in use.

Aim

To predict whether a chemical reaction will occur

Materials

- sugar
- salt
- spatula
- ice cube
- baking soda
- vinegar
- unused tea light candle
- piece of porous pot
- warm and cold water
- 2 test tubes and test-tube rack
- 2 corks
- 50 mL beaker
- watch glass
- heating equipment (Bunsen burner, tripod, heat-proof mat)
- evaporating basin
- tongs
- matches

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Method

1 Work in groups of three. Read through the activity first and then **predict** what you think will happen in each case. State whether you think each experiment will be an example of a chemical reaction or not.

2 Add one small spatula of sugar to a test tube half-filled with warm water. Cork the test tube and shake it carefully from side to side for one minute. Place it in the test-tube rack and observe it after 10 minutes.

3 Place an ice cube on a watch glass and record the mass. Leave the watch glass on the windowsill for the entire experiment. Record the mass again.

4 Light the tea light candle. Leave it burning for 3 minutes (supervised) and then blow it out. Observe any changes, before, during and after.

5 Add one small spatula full of baking soda to 10 mL of vinegar in the 50 mL beaker. Observe.

6 Add one spatula of salt to 25 mL of warm water. Pour the salt solution into the evaporating basin and carefully heat it over the Bunsen burner until there is no water left.

7 Using the tongs, hold a piece of porous pot over the safety flame of the Bunsen burner for 10 seconds.

Results

1 Draw a table using the column headings 'Experiment', 'Observations', 'Chemical reaction'.

2 Record your observations and then place a tick or a cross to indicate whether it represented a chemical reaction or not.

Discussion

3 For those experiments you think were examples of chemical reactions, **explain** your reasoning.

4 For those experiments you did not think were chemical reactions, **explain** your reasoning.

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6.1 Properties of substances and their uses

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Figure 6.1
A takeaway coffee cup keeps the coffee hot.

In the previous chapter, we learnt that physical properties were features of a substance that could be observed or examined without changing the actual composition of that substance. Some examples of physical properties were density, melting point, boiling point and electrical conductivity. Each substance has specific physical properties. For example, water has the following physical properties:

- Density = 1.0 g/cm^3
- Melting point = 0°C
- Boiling point = 100°C
- Electrical conductivity = poor

The properties of a substance can determine what it is used for. For example, a paper coffee cup is able to keep the coffee hot. Air trapped in the double paper wall of the cup acts as a good insulator against the hot coffee. The corrugations in the outer paper wall keep your fingers further away from the hot coffee, allowing you to hold the cup without getting burned.

QUESTIONS 6.1

What have you learnt?

Understanding

1 The following pairs of terms are used to describe materials: strong/weak, elastic/not elastic, transparent/opaque, melts easily/does not melt easily.

a Research the meanings of the words, then choose one word from each pair to **describe** these materials:

i rubber
ii glass
iii iron
iv plastic wrap (also called cling film or cling wrap).

b **Identify** a use for each of the materials in part a. **Explain** how the properties of each make it suitable for the use you identified.

Analysing

2 Below are two items proposed for particular purposes. **Identify** which item you would choose for the purpose given. Take into account the properties of each item and the effect of each item on the environment.

a A paper bag or a plastic bag to carry shopping
b A metal tea strainer or a plastic colander to separate peppercorns, minced garlic and chopped parsley from a salad dressing
c A paper towel or a sponge to wipe up olive oil spilt on a table

WORKSPACE
What have you learnt? 6.1

INTERACTIVE
Life without chemistry

INTERACTIVE
Skateboard race

ISBN 9780170231497

6.2 Physical changes

physical change

occurs when the form of a substance changes, but the kind of substance remains the same; examples are a change of state and dissolving

When a substance undergoes a **physical change**, its appearance changes, but the substance is still the same – no new substance is produced. For example, a physical change occurs when a substance changes state. When ice (solid water) melts, the liquid we are left with is still water. Liquid water has different physical properties from ice – water is a liquid and can be poured, and ice is a solid and cannot be poured. But they are both still the same substance.

When liquid water boils to form gaseous water vapour, its properties change. It is now a gas, and we cannot see it, but it is still water. Physical changes can usually be reversed. The water vapour can easily be changed back to liquid water by cooling it. This is done during the distillation process.

Shutterstock.com/Michael Shake

Figure 6.2 Water vapour is the gas phase of water.

Remember that water has the formula H_2O – it is a compound that has two atoms of hydrogen and one atom of oxygen chemically combined.

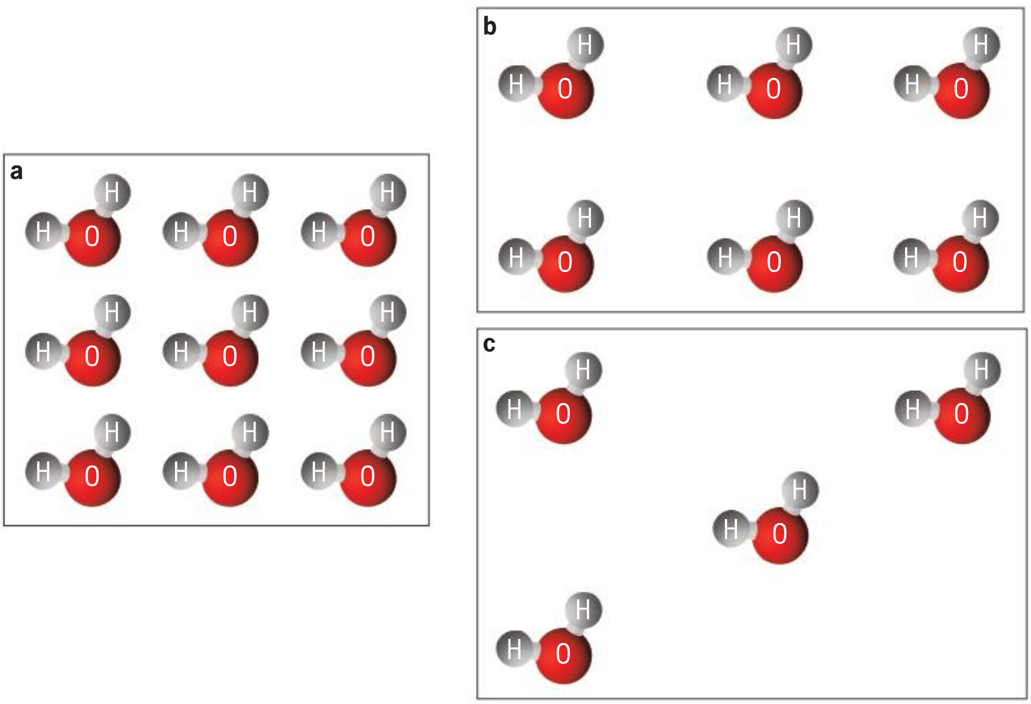

Figure 6.3 Water particles in **a** ice, **b** liquid water and **c** water vapour.

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Figure 6.3 shows water molecules in three states: solid, liquid and gas. Although they are different distances apart, they are still water molecules. They still have two atoms of hydrogen and one atom of oxygen chemically combined. The molecules of water in water vapour are further apart than the water molecules in the water liquid. When the water boils, the water molecules take in energy and move further apart. This is a physical change because no new substance has been formed – there are still water molecules. This is a physical process because it can be reversed. The water molecules in the vapour can be cooled down: energy is taken away from the molecules and they move closer together to form a liquid again.

ACTIVITY 6.1

Modelling particle motion in changes of state

Form groups of three to role play a water molecule. The person in the middle is an oxygen atom and the other two people are hydrogen atoms bonded to the oxygen. Link arms with each other to be bonded together as a molecule.

As a class, model the movement of the H_2O molecules as the change of state is called out by the teacher or a student: 'Melting, Freezing, Boiling, Condensing', etc. Start as ice. You can use Figure 6.3 as a guide. Consider how close you should be to other water molecules as you all change state. In your own group of three, be sure to stick together!

A physical change also occurs when a solute is dissolved in a solvent. If solid salt is dissolved in water, we cannot see the salt, but we know it is still there because the solution tastes salty. If we evaporated the water, we would be left with the original solid salt. This shows there has been no change to the salt itself and so it is a physical change.

QUESTIONS 6.2

What have you learnt?

Understanding

1 Research the physical properties of ethanol. **Compare** the physical properties of ethanol and water.

2 **Distinguish** between a physical property and a physical change.

Applying

3 Look back at your results for the 'What do you already know about chemical reactions?' activity on page 153. **Identify** the experiments that involved physical changes. **Justify** your answer.

WORKSPACE
What have you learnt? 6.2

ISBN 9780170231497

QUESTIONS 6.2

4 Two students were trying to decide the best material for holding soft drink. They compared plastic bottles, glass bottles and aluminium cans. One student thought plastic was the best while the other student decided aluminium was best.

  a **Identify** two properties of glass that make it a less favourable choice.
  b **Identify** the material you think is best for holding soft drink. **Justify** your choice.

5 a **Compare** the physical properties of ice and water.
  b Using the particle model, **explain** why melting ice is an example of a physical change.

Reflecting

6 **Construct** a mind map to organise all the information you have learnt so far. Add to this mind map as you work through this chapter.

6.3 Chemical changes

You have already learnt that the composition of a substance is not altered during a physical change. When liquid water is boiled, it changes state, forming a gas. Liquid water and water vapour have some different physical properties, such as their state at room temperature, but they are both still made up of identical H_2O molecules. The only difference is the amount of energy the molecules contain and how close the particles are to one another. Water vapour can be easily condensed back into liquid water by using distillation equipment in the laboratory.

Burning a piece of coal is a very different story. When coal burns, it produces new substances such as carbon dioxide, soot and a number of gases, including water vapour.

VIDEO
Joining elements: making compounds

Shutterstock.com/Osa

Figure 6.4 Burning wood produces new substances.

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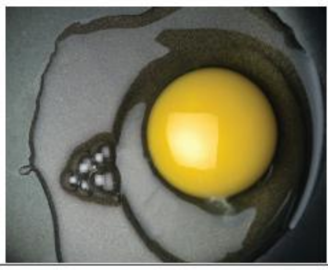
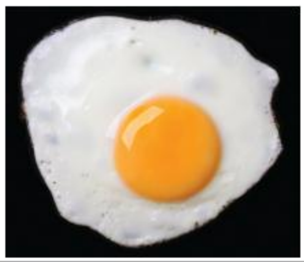
The new substances (called the **products**) have very different physical and **chemical properties** from the original piece of coal (called a **reactant**). The carbon dioxide, and other substances produced, cannot be turned back into coal again. The coal gets 'used up' and so more coal would need to be burned if we wanted to keep a fire going. This is one example of a **chemical reaction**. Another is when simple compounds are formed by the reaction between the elements that make them up. This is shown in the video 'Joining elements'.

In a chemical reaction, one or more substances may react, forming at least one new substance. As the chemical reaction proceeds, the original substance (such as the coal) is used up as the products are formed.

If a chemical reaction has occurred, the chemical make-up (composition) of the products is very different from the chemical make-up of the reactants. Coal is not the same substance as soot, ash or carbon dioxide gas. This means the original substance has undergone a **chemical change**. A chemical change can be difficult to reverse, as the new substances (products) have different physical and chemical properties from the original substances (reactants).

Table 6.1 shows some everyday examples of chemical changes.

Table 6.1
Some everyday chemical changes

 Shutterstock.com/Vince Clements	Raw egg becomes cooked egg.	 Shutterstock.com/Tischenko Irina
 Shutterstock.com/Stephanie Frey	Cake mix becomes cake.	 Shutterstock.com/Mi.Ti.
 Shutterstock.com/greenland	Paper becomes ash.	 Shutterstock.com/ifong
 Shutterstock.com/valdis torms	Steel rusts.	 Shutterstock.com/Stocksnapper

product
a new substance produced in a chemical reaction

chemical properties
the properties that show how a substance reacts when combined with other substances

reactant
a substance used up in a chemical reaction

chemical reaction
occurs when a substance changes to produce a new substance

chemical change
when the chemical make-up of a substance changes, and a new substance or substances are formed

ACTIVITY SHEET
Chemical changes at home

ISBN 9780170231497

Living chemical factories

WOW!

All living things are 'alive' because of the thousands, perhaps millions, of chemical reactions that take place inside them. Plants rely on photosynthesis to produce the compounds necessary for their growth, while animals rely on respiration that occurs in their cells to produce energy.

You are just one big chemical factory – your body continually breaks apart the food you eat and reconstructs the basic components into new substances to make your body's building blocks. Most of these changes go unnoticed until one or more of them gets out of control.

WEBLINK
Making honeycomb

Chemical changes in the kitchen

Cooking involves many chemical changes. Bicarbonate of soda (baking soda) reacts with many liquids, including water and vinegar, releasing carbon dioxide gas. When you put sugar, honey and water into a mixing bowl and then add bicarbonate of soda, a chemical change occurs that produces the confectionary called honeycomb. You know that a chemical change occurs because you can observe the colour changing and test if a gas is being released. Also, the reactants (sugar, honey, water and bicarbonate of soda) look very different from the products (honeycomb and carbon dioxide).

sugar + honey + water + bicarb soda → honeycomb + carbon dioxide

reactants → products

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Getty Images/Danielle Wood

Figure 6.5 The reactants of sugar, water, honey and bicarbonate of soda are very different from the product, honeycomb.

Indicators of a chemical change

Chemical changes occur at the atomic or molecular level of a substance. Atoms can never be created, nor can they just disappear. As you recall, in a physical change, the atoms of molecules stay bonded, but the molecules move around. They can easily undergo physical changes of state. In a chemical change, the atoms that make up the reactants are rearranged in a different way to form a new substance with a different chemical make-up.

In a laboratory, you can collect some hydrogen gas atoms in a cold test tube and these can then combine with the oxygen gas atoms from the air to form a new substance – water. Not

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only is a new substance created, but also the original gas atoms are gone and it is not easy to reverse this. So, this is an example of a chemical change, or chemical reaction.

You cannot see atoms or molecules, so how do you know if a chemical reaction has occurred?

EXPERIMENT 6.1

Indicators of a chemical change

WORKSPACE
Indicators of a chemical change

Possible risks	Safety precautions
Some chemicals are toxic or may burn the skin.	Use in very low concentrations. Use dropper bottles to keep chemicals away from skin. Use very small amounts. Wash hands immediately after use.
Some chemicals may spray into the eyes.	Wear safety glasses.
Burning magnesium can produce a bright light that can damage your eyes if looked at directly.	Your teacher will instruct you to look at the magnesium peripherally as it begins to react and will supervise throughout the experiment.
Bunsen burners and hot equipment can burn.	Use a heat-proof mat with heating equipment. Wait until the equipment cools before removing it from the tripod. Leave the Bunsen burner on the safety flame or off when not in use.

Aim

To identify the indicators of a chemical change

Materials

- iodine solution
- slice of raw potato
- steel wool
- dropper bottle of copper sulfate solution (0.1 mol/L)
- 1 cm piece of magnesium ribbon
- 5 cm piece of magnesium ribbon twisted into a loose coil
- dropper bottle of hydrochloric acid (1.0 mol/L)
- 2 test tubes and a test-tube rack
- watch glass
- heating equipment (Bunsen burner, tripod, heat-proof mat)
- crucible, crucible lid (optional), pipe clay triangle
- two 10 mL measuring cylinders
- small beaker
- 5 mL potassium iodide
- 5 mL lead nitrate

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EXPERIMENT 6.1

Method

1 Tease out a small piece of steel wool and place it in a test tube.

2 Add enough copper sulfate solution to the test tube to cover three-quarters of the steel wool threads. Leave it for the rest of the activity.

3 Place a slice of potato on a watch glass. Place a few drops of iodine solution onto the potato. Make observations after a minute or so.

4 Place the 1 cm piece of magnesium into a test tube and sit the tube in the test-tube rack. Cover the magnesium with the hydrochloric acid. Make observations. After 30 seconds, feel the outside of the test tube.

5 (Teacher supervision) When you are ready to do this, ask your teacher for safety instructions and supervision. Burn the 5 cm coiled piece of magnesium ribbon in the crucible.

6 Add 5 mL of potassium iodide and 5 mL of lead nitrate into a small beaker.

Results

1 Record your observations in an appropriate table.

Discussion

2 **Identify** the chemical changes that occurred in each activity. **Justify** how you knew a chemical reaction was taking place.

3 **Describe** some everyday examples of chemical reactions.

4 Using your observations from this activity, **describe** the evidence you would look for to determine whether a chemical change has taken place.

In some of the tasks in Experiment 6.1, you observed a number of chemical changes all at once. When the hydrochloric acid was added to the magnesium metal, bubbles of gas were given off, the outside of the test tube became warmer and, after a while, the magnesium metal disappeared.

The general indicators of a chemical change are:

1 a colour change occurs

2 the original substance disappears

3 a new substance forms:
- a gas is given off (visible by bubbles or detected by smell)
- a solid forms (called a precipitate) when two solutions are added together

4 there is an energy change:
- the temperature increases or decreases (without being heated or cooled)
- sound energy is given off
- light energy is given off.

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When yeast is added to bread mix, it starts breaking down the sugar in the bread mix to release energy and carbon dioxide. The carbon dioxide gas bubbles that are a product of this reaction are what causes the bread dough to rise.

Figure 6.6
The bubbles in bread are caused by a chemical reaction releasing carbon dioxide gas.

Chemical changes that occur in everyday life

Cooking is one example of a chemical change; however, there are many more that occur every day.

Photosynthesis

Photosynthesis is a very important chemical process that only occurs in plants (see Chapter 4). Plants take in simple particles such as carbon dioxide from the air and water from the soil and use these particles to create glucose as a new substance.

Photosynthesis is an example of a chemical change as new substances are formed. The plant takes in some very small particles, namely, carbon dioxide (CO_2) and water (H_2O), and produces a very large particle called glucose ($C_6H_{12}O_6$). Another particle is also formed, oxygen (O_2). This is a waste product in the photosynthesis process. The plant makes much more oxygen than it needs for itself, so it releases it into the atmosphere.

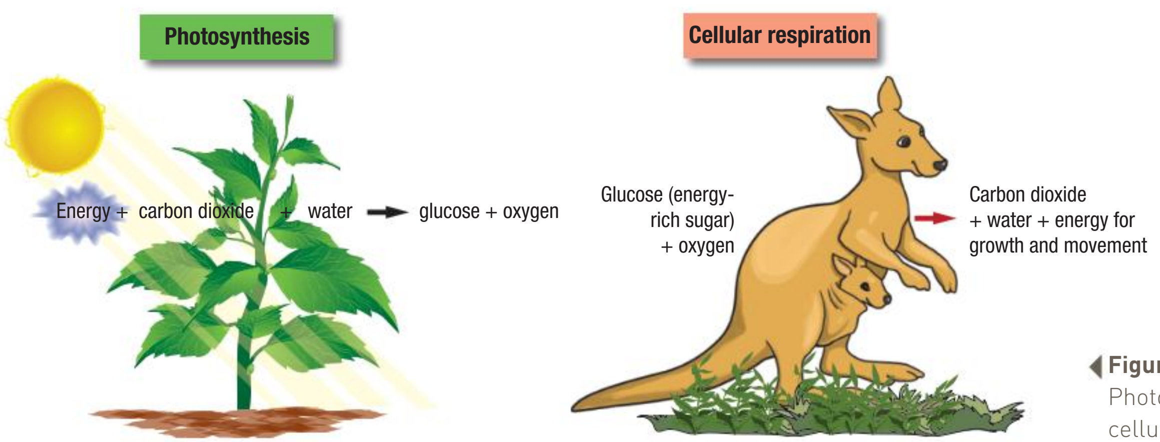

Figure 6.7
Photosynthesis (left) and cellular respiration (right)

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Respiration

Respiration is a very important process that occurs in both plants and animals (see Chapter 4). It is the process that allows us to break down our food and use the energy produced for all of our daily requirements, for example running, thinking and speaking. Oxygen is a very important starting substance for respiration. So, although oxygen was a waste product in photosynthesis, it is essential for the chemical process of respiration to occur. Respiration occurs in the cells of our bodies. It is the process where oxygen reacts with our digested food, especially glucose, to produce the energy we need. It produces carbon dioxide and water. The carbon dioxide is a waste product and our body gets rid of it by breathing it out. Excess water is excreted through our urine or by sweating. So, respiration is also an example of a chemical change, since new substances are formed. It uses glucose and oxygen and produces carbon dioxide and water.

Chemical weathering

weathering
the breakdown of rocks

Weathering is the breakdown of rocks. This can occur either through physical means or chemical means. Physical weathering is sometimes called mechanical weathering. An example of this type of weathering is tree roots growing down into cracks in rocks. As the roots grow they break the rock apart. The formation of caves is due to chemical weathering. This is where the rock reacts with rainwater and forms new substances. Rainwater is a mixture. A number of substances, such as carbon dioxide, are dissolved in the water. This makes the water slightly acidic, so it reacts with some types of rocks to break them down. Limestone ($CaCO_3$) is one rock that undergoes chemical weathering. Jenolan Caves, about three hours west of Sydney, is an example of caves that have been formed by chemical weathering.

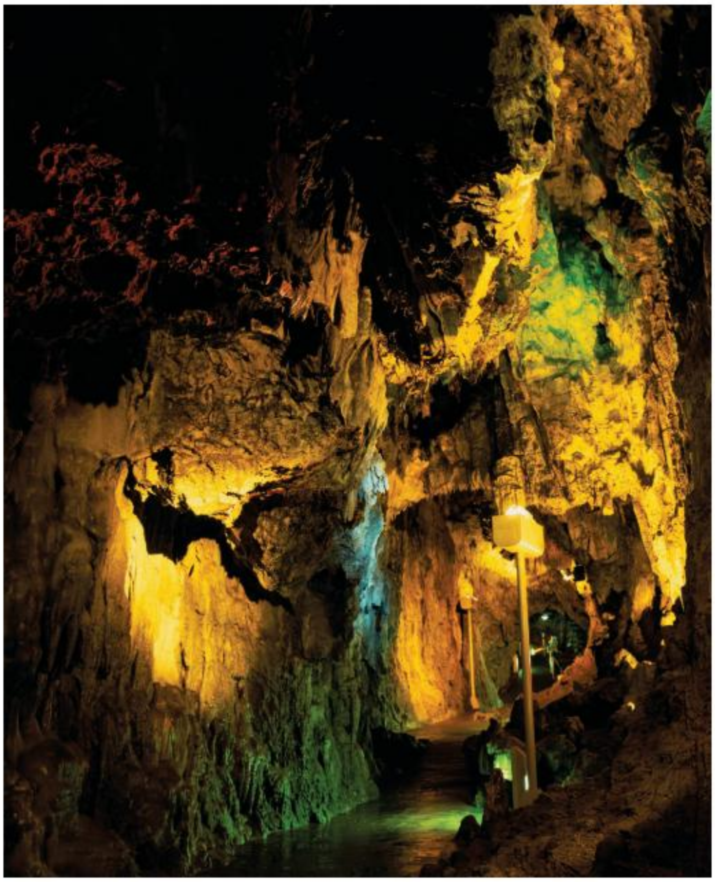

Figure 6.8 Rock formations formed by chemical weathering in Ryusendo caves, Japan

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EXPERIMENT 6.2

Chemical weathering

Possible risks	Safety precautions
Acids are corrosive.	Wash your hands after the experiment and wear safety glasses and a lab coat for protection.

WORKSPACE
Chemical weathering

Aim

To model the process of chemical weathering

Materials

- 5 mL of 2 mol/L hydrochloric acid (HCl)
- small piece of limestone, or a few pieces of marble chips or a piece of chalk
- test tube

Method

1 Place 5 mL of hydrochloric acid into the test tube.

2 Put the small piece of limestone (or the marble chips or the chalk) into the same test tube.

Results

Record your observations.

Discussion

Explain how you can tell that this is a chemical change.

QUESTIONS 6.3

What have you learnt?

WORKSPACE
What have you learnt? 6.3

Remembering

1 **Define** the following terms.

- a Reactant
- b Product
- c Chemical reaction
- d Chemical change

Understanding

2 **Outline** three everyday examples in which chemical changes are occurring. **Explain** why they are chemical changes and not physical ones.

3 **Identify** the tasks from Experiment 6.1 (on page 161) that were examples of chemical reactions. **Outline** the observations that indicated this to you.

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WEBLINK
Diet Coke and Mentos

ACTIVITY SHEET
Diet Coke and Mentos

QUESTIONS 6.3

Applying

4 Two students were performing an experiment. They added two level spatulas of a solid made up of blue crystals into 100 mL of water. The water turned blue, but was transparent. They poured the mixture into an evaporating basin and heated it until no more liquid was left. A blue powder (solid) was left in the evaporating basin. One student claimed it was a chemical reaction while the other said it was not.

- a **Outline** the observations that might lead a student to think it was a chemical reaction.
- b **Outline** the observations that might lead a student to think it was not an example of a chemical reaction.
- c **Identify** which student is correct. **Justify** your answer.

5 **Identify** some observations that suggest a chemical change may be occurring in your body.

Analysing

6 Two mystery substances were added to a conical flask sitting on an electronic balance that had already been zeroed. The mass of the substances were measured every 30 seconds for 4 minutes. The following table represents the data collected.

Time (min)	Mass (g)
0.0	4.00
0.5	3.00
1.0	2.49
1.5	2.00
2.0	1.70
2.5	1.40
3.0	1.40
3.5	1.40
4.0	1.40

- a Plot these results and draw a curve of best fit through your data. You could do this by hand or on a computer.
- b **Calculate** the change in mass over the 4.0 minutes.
- c From your graph, determine the mass remaining after 75 seconds.
- d From your graph, estimate the mass remaining after 5.0 minutes.
- e **Justify** which answer is more accurate: part **c** or **d**.
- f **Outline** how you could improve the reliability of this experiment.
- g **Justify** whether this experiment is an example of a physical change or a chemical reaction.

Evaluating

7 **Justify** why researching new chemical reactions is important.

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6.4 Chemical properties

The features of a substance that determine how it reacts with other substances are called chemical properties. You cannot observe the chemical properties of a substance in the way you can its physical properties. But if two substances have similar chemical properties, you will be able to tell by observing how they each react with the same substance. If they react in a similar way, they will have similar chemical properties.
Chemical properties include:

- **flammability** (the ability to catch fire)
- **toxicity** (the ability to be poisonous)
- the ability to **corrode**
- sensitivity to light (which causes newspaper to turn yellow).

flammability
the ability of a substance to catch fire

toxicity
how poisonous a substance is

corrode
to break down a metallic substance by a chemical reaction with substances in the environment, such as oxygen and water

Paper will easily catch fire but a substance called asbestos does not. However, paper is unlikely to harm you, whereas asbestos is highly toxic and has caused a wide range of diseases, such as lung cancer when the fibres have been inhaled. In fact, the use of asbestos in Australia has been banned since 2003. Paper and asbestos have different chemical properties. Paper is flammable and non-toxic, and asbestos is not flammable but toxic.


Shutterstock.com/Terry Davis

Figure 6.9 Asbestos fibres are highly toxic and cause lung cancer.

Iron (Fe) is a very important metal used in skyscrapers, ships and garden furniture. But when the outer surface of iron is exposed to the air, the atoms react readily with oxygen gas (O_2) (often in the presence of water) to form the compound iron oxide, also known as **rust**. Rust is an orange-brown solid. It is a brittle compound that easily flakes off the surface of the iron. This is a problem because fresh iron atoms are then exposed to the air, causing further corrosion.

rust
a compound produced when iron reacts with oxygen and water in the atmosphere

Rusting (the corrosion of iron) is usually a slow reaction. However, the reaction is accelerated in the presence of salt water. People who live on the coast find that wrought iron balcony railings, fences or gates corrode very quickly.

Studies into the rates of corrosion of different metals have shown that aluminium can resist corrosion much better than other metals.

VIDEO
Corrosion of different metals

ISBN 9780170231497

Figure 6.10 The railings of wrought iron balconies have to be continually treated against rust.

WORKSPACE
Rusting nails

EXPERIMENT 6.3

Rusting nails

Possible risks	Safety precautions
Bunsen burners and hot equipment may burn	Use a heat-proof mat with heating equipment. Wait until the equipment cools before removing it from the tripod. Leave the Bunsen burner on the safety flame or off when not in use.

Iron nails and screws will often rust over time. We can observe the chemical reaction of an iron nail with oxygen (in the presence of water) by observing the changes that occur. This experiment will determine the best conditions for this chemical change to occur. Carry out the following investigation.

Aim

To identify the conditions for rusting of iron to occur

Materials

- 4 iron nails without protective coatings
- 1 iron nail painted with a rust inhibitor
- 5 test tubes, test-tube rack and test-tube holder
- 5 test-tube stoppers
- 3 g of calcium chloride powder
- 1 mL of vegetable oil
- de-ionised water at room temperature

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EXPERIMENT 6.3

- heating equipment (Bunsen burner, tripod, heat-proof mat)
- salty water
- digital camera (optional)

Method

1 Place a nail into test tube 1, half submerge the nail in tap water and then seal the tube with a stopper (oxygen, water).

2 Place a nail into test tube 2, add 3 g of calcium chloride powder and then seal the tube with a stopper (oxygen, no water).

3 Before you add the nail to test tube 3, half-fill the tube with de-ionised water. Carefully heat the water for 30 seconds using the Bunsen burner, moving the test tube in and out of the blue flame so the test tube does not break. Carefully place the nail into the water. Gently pour oil into the test tube so that it sits as a layer on top of the water. Try to avoid mixing any air with the water when you do this. Seal the tube with a stopper (no oxygen, water).

4 Place a nail into test tube 4, half submerge the nail in salt water and then seal the tube with a stopper (oxygen, water, salt).

5 Your teacher will provide you with a nail that has been painted with a rust inhibitor. Place this into test tube 5 and seal it with a stopper (no oxygen, no water).

6 Leave the nails and check on them a number of times throughout the week.

Results

1 Record your results each day for a week, either as a sequence of photos or as comments in a table.

Discussion

2 **Outline** the conditions for the nail that started rusting first.

3 **Identify** the nail that had rusted the most by the end of the experiment. **Explain** why this occurred, by referring to the reaction conditions.

4 **Identify** the nail that remained rust free. **Explain** why this occurred, by referring to the reaction conditions.

5 **Identify** the test tube that was the control in this experiment.

6 **Discuss** whether this experiment was a valid and reliable investigation.

7 **Outline** modifications you could make to improve this experiment.

Student investigation

8 Plan and perform an experiment to test whether nails made from different metals corrode at the same rate.

VIDEO
Rusting investigation (1): set-up

VIDEO
Rusting investigation (2): results

ICT

Create a digital presentation to **show** what happened over the week by using a photo story or VoiceThread. Include your answers to the 'What did you discover?' questions in your digital presentation.

WEBLINK
Voice Thread

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The properties of a substance determine its use

Both the physical and chemical properties of a material will affect how and where it is used. We use gold, silver and platinum for jewellery because they are lustrous and malleable and have relatively high melting points. They are also relatively unreactive, so they will not react with water or the **acids** in our skin.

acid
a chemical that is corrosive, has a sour taste, turns bromothymol blue a yellow colour and has a pH less than 7

We would not use magnesium for jewellery because it would readily react with hot water when taking a shower or doing the dishes! However, its chemical properties did have a use for photographers. Photographers used to burn powdered magnesium to provide enough white light to take a photograph. Cameras now have built-in electronic flashes.


Getty Images/SPL

Figure 6.11 Flashes on cameras used to be made by burning powdered magnesium.


Getty Images/GRAHAME McCONNELL

Figure 6.12 The copper domes on the Queen Victoria Building in Sydney

verdigris
a green patina caused by the reaction of copper with air or sea water over a long period of time

WEBLINK
Copper used in and around the home

Copper is used for electrical wires because it is malleable, ductile and the best conductor of electricity (after silver, which is too expensive to use). Copper's reactivity is also poor and so it will not react with many of the substances in our natural environment. However, it does react with oxygen. Copper shines for a while after being polished but eventually turns a darker, duller colour. This is due to a reaction between the copper atoms in the metal and the oxygen in the air. Copper was a very popular metal for making domes on buildings. Copper metal reacts with air or sea water over a long period of time. The green patina that is produced due to this chemical reaction is called **verdigris**. You may have seen it on copper domes on some of your city's buildings.

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WORKSPACE
What have you learnt? 6.4

QUESTIONS 6.4

What have you learnt?

Remembering

1 a **Define** 'chemical property'.
b **Identify** some examples of chemical properties.

Understanding

2 **Compare** the physical and chemical properties of magnesium metal and argon gas.

3 a **Define** 'corrosion'.
b **Justify** whether this process is a physical or chemical change.

4 **Explain** why steel is so widely used, given that it corrodes easily.

Applying

5 **Describe** how you can use both the physical and chemical properties of a substance to identify it.

6 Use the periodic table and the Internet to **identify** which metals would be best suited to the following uses. **Justify** your choice by referring to the physical and chemical properties of the metal.

Metal	What it is used for	Reason
	Jewellery	
	Food cans	
	Saws and drills	
	Medical hip replacements	
	Ballast in boats	

7 A student made the following observations during an experiment.
- The powder is white and has a sweet smell.
- It has a smooth, slippery feel.
- It fizzes when mixed with vinegar.
- When first heated, it melts and then turns black.

a **Outline** the physical properties of the powder.
b **Outline** the chemical properties of the powder.

Analysing

8 **Compare** physical and chemical properties.

9 Students find three containers in the kitchen cupboard but none of them has a label. On further investigation, the students find three labels: 'Flour', 'Icing sugar' and 'Dishwashing powder'. They decide to use their knowledge of the properties of the three substances to identify them. They know they cannot taste the substances because dishwashing powder is poisonous.
a **Identify** the properties of each of the three substances.
b **Outline** tests the students could conduct to identify each substance.

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6.5 New materials for society

As they learn more about elements and compounds, scientists can develop new materials to meet the demands of a modern world.

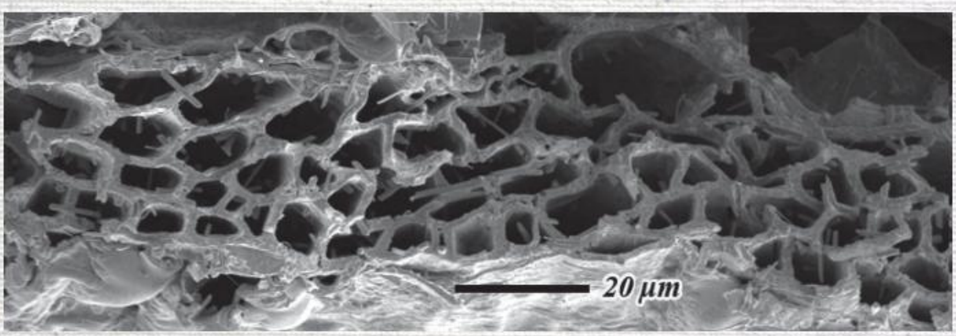
ACTIVITY SHEET
Science career – materials chemist

VIDEO
Investigating new substances using the Australian Synchrotron

WOW! Artificial leaves

Scientists at Shanghai Jiao Tong University in Shanghai, China, have created a material that works a lot like a leaf but produces hydrogen in the presence of sunshine, without polluting the air. This is important because scientists are looking for clean ways to produce hydrogen as a replacement for petrol in cars.

This scanning electron microscope image shows a cross-section of an artificial leaf.



Dr. Zhang Shanghai Jiao-Tong University

Scientific research – making new plastics

Raw materials for plastic manufacture traditionally come from by-products of the petroleum-refining process. Most plastics are composed of the elements carbon and hydrogen. They can also contain oxygen, nitrogen, chlorine or sulfur. Plastics are **non-biodegradable** – they do not break down to become non-toxic materials. They can exist in the soil and oceans for many years.

Most of our plastic bags are disposed of in landfill. Local councils collect garbage weekly and send it to landfill sites throughout the state. Sydney has four major landfill sites; however, these are close to capacity, so the government is looking at other solutions to the garbage problem. Part of the solution is the movement of rubbish to the Woodlawn dump near Goulburn in southern NSW. However, a longer term solution is to decrease the proportion of garbage that must be disposed of in landfill. This requires the development of materials that can be recycled or are **biodegradable**, and break down reasonably quickly in the landfill.

non-biodegradable
not able to be decomposed by the action of living organisms

biodegradable
able to be decomposed by the actions of living organisms

ISBN 9780170231497

WOW!

A sea of plastics

Globally, we produce more than 100 million tonnes of plastic each year, with only about 1% being recycled. Plastics cover almost 40% of the ocean, outnumbering zooplankton 6 to 1. Fish, seabirds and turtles die by the thousands every year from accidental plastic ingestion or entanglement. Scientific research estimates that more than 100,000 marine mammals die in plastic-related incidents annually.

Corbis/Norbert Wu/Science Faction

Figure 6.13 Plastic bags can pose a threat to native animals.

In 2007, Australians used 3.9 billion single-use plastic shopping bags. Many of these plastic bags enter our waterways and pose choking threats to wildlife. Wherever the bags end up, the plastic will persist in the environment.

Scientists have been working on biodegradable plastics, or **bioplastics**. Bioplastics are sometimes referred to as biopolymers. These are made from renewable sources and will break down into carbon and hydrogen by the action of sunlight, water or micro-organisms. Bioplastics can be made from starch, similar to that found in potatoes or corn.

bioplastic or biopolymer
a plastic made from starch derived from plants such as corn and potato

Some micro-organisms can also produce bioplastics. PHB (poly(3-hydroxybutanoate)) is a plastic produced by the micro-organism *Alcaligenes eutrophus*. This plastic has the same physical properties as polypropylene, but it is biodegradable – polypropylene is not. At present, it is still more expensive to produce than polypropylene, but as landfill becomes a greater issue there will be a greater demand for this product. It is used for disposable nappies and for packaging such as bottles and bags.

WEBLINK
Environmentally friendly packaging

ISBN 9780170231497

Scientists working for government agencies and for commercial companies are continually looking for ways to develop new materials that both meet a need for society and are economically viable.

Courtesy of The Honest Company

Figure 6.14 Disposable nappies can be made from PHB, a bioplastic.

WORKSPACE
Properties and uses of bioplastics

ACTIVITY SHEET
Ethical plastic science

ACTIVITY 6.2

Properties and uses of bioplastics

1 **Identify** some properties of PHB.
2 **Explain**, with reference to its properties, why PHB is considered a more useful plastic than other bioplastics.
3 Find a diagram for the chemical structure of polylactic acid.
4 **Identify** the elements present in polylactic acid.
5 **Compare** the elements present in polylactic acid and other plastics made from chemicals produced from fossil fuels.
6 **Outline** some properties of polylactic acid.
7 **Outline** some uses of polylactic acid and **relate** these to its properties.
8 **Outline** some potential uses for polylactic acid.

ISBN 9780170231497

Scientific research – is there a cure for spinal injuries?

Chitosan is a biopolymer made by treating chitin with sodium hydroxide. Chitin is found in the exoskeleton of crustaceans such as lobsters and crabs. It was first produced more than 150 years ago; however, commercial production did not start until the 1970s. Chitosan has many commercial uses in agriculture, water filtration and winemaking. It is used medically to stop bleeding. Both the US army and the UK military have used chitosan products on the battlefields of Iraq and Afghanistan.

However, it is the recently published work on chitosan by a research team at Purdue University in Indiana, USA, that is ground-breaking. Richard Borgens, Riyi Shi and Youngnam Cho are researching ways to repair spinal cord nerve cells and thus allow electrical signals to be transmitted to the brain. They originally used polyethylene glycol, which forms toxic products when it breaks down. So, they are currently experimenting with chitosan. They have done a number of tests in which they have applied chitosan to the injured area of the membrane of a spinal cord. They have then injected a fluorescent dye, which will only enter the spinal cord if the membrane is damaged. They found that no fluorescent dye entered the spinal cord. This indicated that the membrane had been repaired. They also found that no substances leaked out of the spinal cord. So, chitosan repairs membranes of the spinal cord.

The next challenge for the research team was to see if chitosan also restored the ability for electrical signals to be transmitted through the damaged region of the spinal cord and reach the brain. The team found that 30 minutes after injecting chitosan, electrical signals did travel through the damaged region and reach the brain.

ACTIVITY SHEET
Materials repurposed

ACTIVITY 6.3

Chitosan – the power of team work

1. So far, the research team from Purdue University has only conducted tests on guinea pigs. **Explain** why they have conducted the research on guinea pigs rather than on humans.
2. **Outline** some of the issues that need to be considered before this treatment is made widely available.
3. **Identify** the properties of chitosan that make it suitable to be used to repair the spinal cord.
4. **Identify** the qualifications held by each of the members of the team from Purdue University who have conducted research on using chitosan to repair damaged spinal cords.
5. Referring to their qualifications, **outline** the contribution each of these members makes to this research project.
6. **Relate** the medical use of chitosan to the properties of chitosan.
7. **Outline** one other use for chitosan and **relate** it to its properties.
8. **Discuss** whether society should support scientific research.

WORKSPACE
Chitosan – the power of team work

ISBN 9780170231497

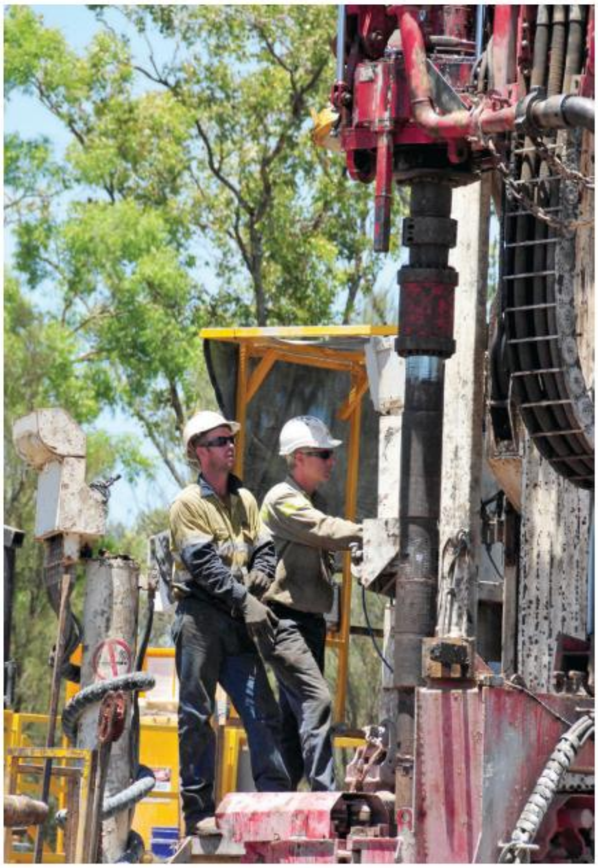
6.6 Coal seam gas – a multidisciplinary case study

Australia, like many other countries, is investing in research to develop appropriate technologies that will allow us to become more self-sufficient in our energy needs while minimising our impact on the environment. At present, approximately 80% of our crude oil and petroleum products are imported from overseas. Roughly 85% our electricity is generated by coal-fired power stations.

Coal seam gas, sometimes referred to as CSG, is a form of natural gas that is extracted from coal seams at depths of 300–1000 m. It is about 96% methane. Coal seam gas can be used as a source of gas to fuel gas appliances such as cooktops, heaters and hot water systems or it can be liquefied and exported to other countries. Australia has large reserves of coal seam gas. There are several companies that have bought the mining rights to large areas of land with the intention of extracting the gas from the coal seams underground. Coal seam gas has traditionally been extracted during the mining of coal; however, companies are now using techniques to extract the CSG without mining the coal.

cleat
a fracture in the coal seam

Coal seam gas is extracted by putting a drill down into the coal seam. The coal seam needs to have cracks in it so that the gas can be released. Water is then pumped out of the coal seam. Once the water is released from the coal, the pressure in the coal seam decreases and the gas starts to flow from the **cleats**. In some cases a mixture of water, sand and a variety of other chemicals are forced down the well at high pressure to assist extraction. This process is called fracking.



Eric Taylor/Bloomberg via Getty Images

Figure 6.15 Coal seam gas workers

ISBN 9780170231497

Newspix/Jono Searle

Figure 6.16 Australians protesting coal seam gas extraction

The issue about whether Australia should have a large coal seam gas industry is complex. People in different parts of Australia and different groups have a variety of views. We need to understand the science of the extraction process and its impact on the environment before informed decisions can be made about this issue.

Much has been written and said about the extraction of coal seam gas and its impact on the environment. However, we must look at the information objectively and weigh it up by analysing the scientific evidence available. We must decide whether the evidence overwhelmingly supports a particular position or whether it is inconclusive or even contradictory. Scientists from many different branches of science, such as geophysicists, hydrologists, ecologists, chemists, mining engineers and chemical engineers, need to work together to pool their knowledge so that they can develop a comprehensive body of knowledge about this issue.

ACTIVITY 6.4

Coal seam gas – a complex issue

1 **Outline** some of the issues that must be addressed to build an effective body of knowledge about coal seam gas mining so that informed decisions can be made.

2 Choose one of these types of scientists: geophysicists, hydrologists, ecologists, chemists, mining engineers and chemical engineers.
  - a **Identify** the qualifications needed for this type of scientist.
  - b **Describe** the role of this type of scientist.
  - c **Explain** how this type of scientist would contribute to gathering evidence about this issue.
  - d Create a vodcast about your type of scientist and upload it to the class wiki.
  - e Watch other vodcasts and create a poster using glogster to **describe** the role of each of these scientists in assisting us to understand the issues related to coal seam gas.

WORKSPACE
Coal seam gas – a complex issue

ICT
Try Vodcast or Glogster.

WEBLINK
Vodcast

WEBLINK
Glogster

ISBN 9780170231497

ACTIVITY 6.4

3 **Identify** other groups that may have specific views about coal seam gas and **outline** their views.

4 Search for five different types of articles that have been published about the issue of coal seam gas extraction. Some possible sources may include media outlets such as television, radio, newspaper (online), letters to the editor, blogs, CSIRO and Geoscience Australia. For each article:
   a **Identify** whether the author of the article has any bias or whether they are objective (unbiased).
   b **Evaluate** whether the article contributes to the discussion about coal seam gas extraction.

WORKSPACE
What have you learnt? 6.5

QUESTIONS 6.5

What have you learnt?

Remembering

1 **Outline** one example of a scientist who has developed a new material.

2 **Identify** the elements that are produced when bioplastics break down.

3 **Outline** how coal seam gas is extracted.

Analysing

4 **Contrast** the terms 'biodegradable' and 'non-biodegradable'.

Evaluating

5 **Evaluate** the need for new plastics.

6 **Discuss** whether society should support scientific research.

Reflecting

7 **Discuss** why we continue to develop new materials.

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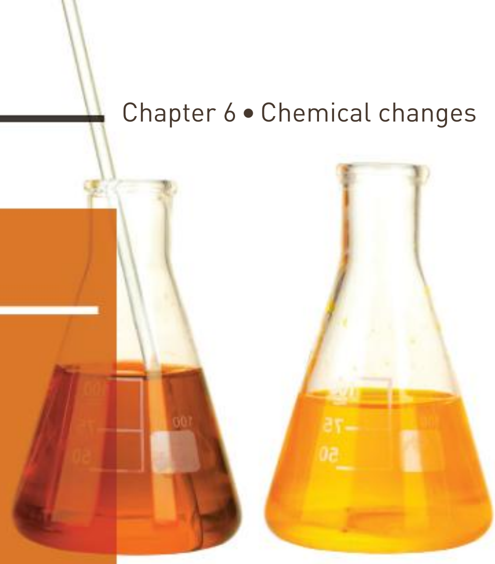

Chapter review

Remembering

1 **Identify** two biopolymers and **outline** their uses.

2 **Recall** the four indicators of chemical change.

Understanding

3 A single piece of paper is easy to tear in half. Try tearing it in half, placing the halves together and then tearing it again. Repeat this with all the paper put together. The paper is getting smaller and smaller but thicker and thicker. **Justify** whether this is a physical or chemical change.

4 In the late 1970s, supermarkets replaced their paper shopping bags with plastic bags. **Identify** the physical properties of plastic that made plastic bags better than paper bags for carrying shopping.

5 **Identify** whether the change of water from a block of ice to liquid water is a physical or chemical change. **Justify** your answer.

6 Use the periodic table to **identify** two metals and two non-metals. **Compare** the chemical and physical properties of these two types of elements.

7 Determine whether the following statements are true or false. For the statements that are false, correct and rewrite them so that they are true.

a Electrical conductivity is a chemical characteristic.

b Oxides, hydroxides and carbonates are bases.

c The definition of an acid, put forward by Lavoisier, has remained the same for hundreds of years because all of the evidence supports this definition.

d Phenolphthalein is an example of a base.

e Using a universal indicator is a more accurate method for measuring pH than using a pH meter.

f During an exothermic reaction, heat is released.

g In an acid–base reaction, the salt formed gets the first part of its name from the acid and the second part of its name from the base.

h Respiration is an endothermic reaction.

i Our mouth, stomach and small intestine all have different chemical environments since they each have a different pH.

j To test for hydrogen gas, a lighted taper is placed over the hydrogen and the gas goes ‘pop’.

Analysing

8 Argon gas is placed between the two sheets of glass in double-glazed windows. **Outline** the properties of argon gas that make it suitable for this use. **Identify** whether these properties are physical or chemical.

WORKSPACE
Chapter 6 review

ACTIVITY SHEET
Chapter 6 checklist

REVIEW QUIZ
Chapter 6

ISBN 9780170231497

9 A substance is labelled as being flammable when it has a good chance of catching fire when exposed to oxygen in the air. **Explain** why being flammable is considered a chemical property rather than a physical one.

10 The rusting of iron occurs when iron and oxygen meet. **Compare** this with the burning of a match.

Applying

11 Substance X has a pH of 4 and substance Y has a pH of 6. Determine much more acidic is substance X than substance Y?

Evaluating

12 **Evaluate** which of the following you think is a better focus for scientific research:
- developing new recyclable plastics
- developing biodegradable plastics.

Justify your answer.

13 Scientific research is an individual task. **Discuss** this statement with reference to a specific scientific issue.

14 Wool has been used for hundreds of years to produce fabric for clothing. It is a natural material, fully biodegradable and non-flammable. Rayon, an artificial silk, was first produced in the 19th century. It was a semi-synthetic material and quite flammable, not a safe chemical property for clothing. In 1894, a safer version of rayon was produced. It was followed by polyester in 1941. **Evaluate** the statement: 'When manufacturing clothing, we cannot improve on nature.'

Reflecting

15 Acid rain is a significant environmental issue. **Discuss** actions that could be taken to minimise the effects of acid rain on our planet.

16 Think about your learning process during this topic. **Recall** concepts you learnt easily. **Identify** the modes of learning from the list below that helped your understanding and rank them from most to least helpful.
- Role play
- Conducting experiments
- Relating new information to everyday life
- Using ICT
- Watching videos
- Discussing
- Doing research activities

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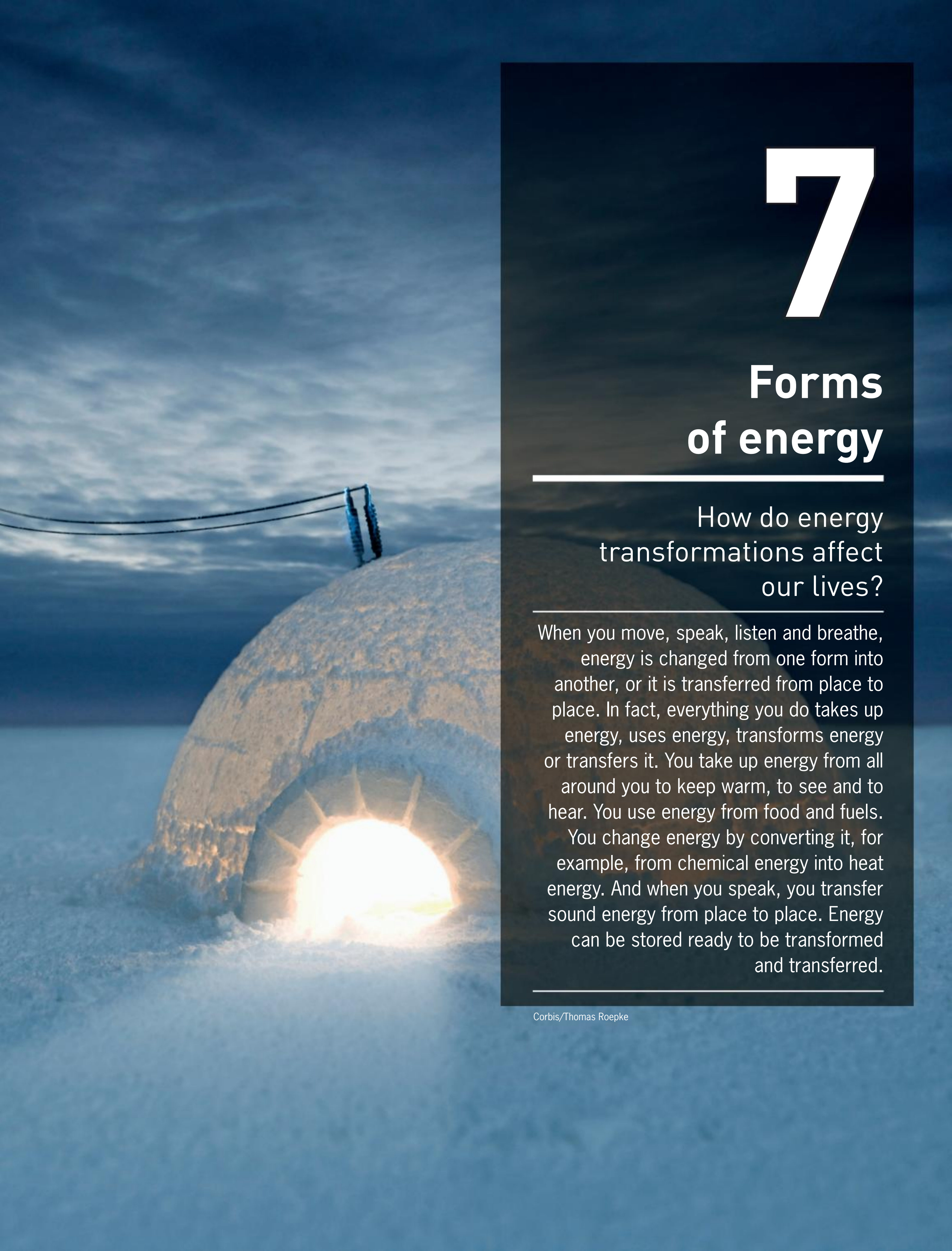

7

Forms of energy

How do energy transformations affect our lives?

When you move, speak, listen and breathe, energy is changed from one form into another, or it is transferred from place to place. In fact, everything you do takes up energy, uses energy, transforms energy or transfers it. You take up energy from all around you to keep warm, to see and to hear. You use energy from food and fuels. You change energy by converting it, for example, from chemical energy into heat energy. And when you speak, you transfer sound energy from place to place. Energy can be stored ready to be transformed and transferred.

Corbis/Thomas Roepke

Physical world – Stage 4

Key knowledge

- Objects can have energy because of their motion (kinetic energy) or because of their properties (potential energy).
- Everyday energy transformations cause changes within systems, including heat, light, sound or motion.
- Scientific knowledge and technological developments have led to finding solutions to contemporary issues by improving devices to increase the efficiency of energy transfers or conversions.

ACTIVITY SHEET
CAT with rubric: Energy

CULMINATING ASSESSMENT TASK

Energy

Prepare a set of flowcharts or Sankey diagrams to **outline** energy transfers and transformations for at least three situations. The main energy transfers and transformations should be different for each situation.

For these situations, **demonstrate** an understanding of energy transfer, transformation, loss and conservation.

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What do you already know about energy?

Create a Prezi presentation to **show** your understanding of energy. Collect as many different images as you can that illustrate the meaning of the word 'energy'. For each illustration, write a description of the form of energy shown. Select and arrange two or three of the illustrations so they **show** energy going from place to place (energy transfer). Select and arrange another two or three illustrations to **show** energy being changed from one form to another (energy transformation).

Present this to the class or a small group.

ICT

Your presentation could be an electronic presentation. You could use Prezi, Open Office Impress, Keynote, PowerPoint, Publisher brochures or a web page.

7.1 Energy is energy!

Energy is a fundamental concept in science. It is hard to define what energy is, so we define energy by what it does. For example, when energy is transferred or transformed, work can be done.

Energy can appear in many different forms. It can be transferred in the same form from place to place, but it is still energy. **Energy transfer** occurs when light from the Sun comes to us across space from millions of kilometres away. When the **light energy** reflects off surfaces, you can see things. But seeing requires an **energy transformation**. The light is changed into a form that your brain can use – electrical energy and **chemical energy**.

Energy is a little like money. For example, Australian dollars and Indonesian rupiah are different forms of money. When we carry Australian dollars from home to the shops, we transfer money from place to place. When we change it from dollars to rupiah, we transform it. Similarly, energy can move from place to place, but it is still energy. Just as money allows you to buy something, energy provides the ability to do something – heat water, produce light, make a car move and so on.

energy transfer
the movement of a single form of energy from place to place or from one body to another

light energy
energy transferred as radiation; energy detected by eyes or photometer

energy transformation
the change of one form of energy into another form of energy

chemical energy
energy stored in chemicals and released when the chemicals react

ACTIVITY SHEET
Energy simile

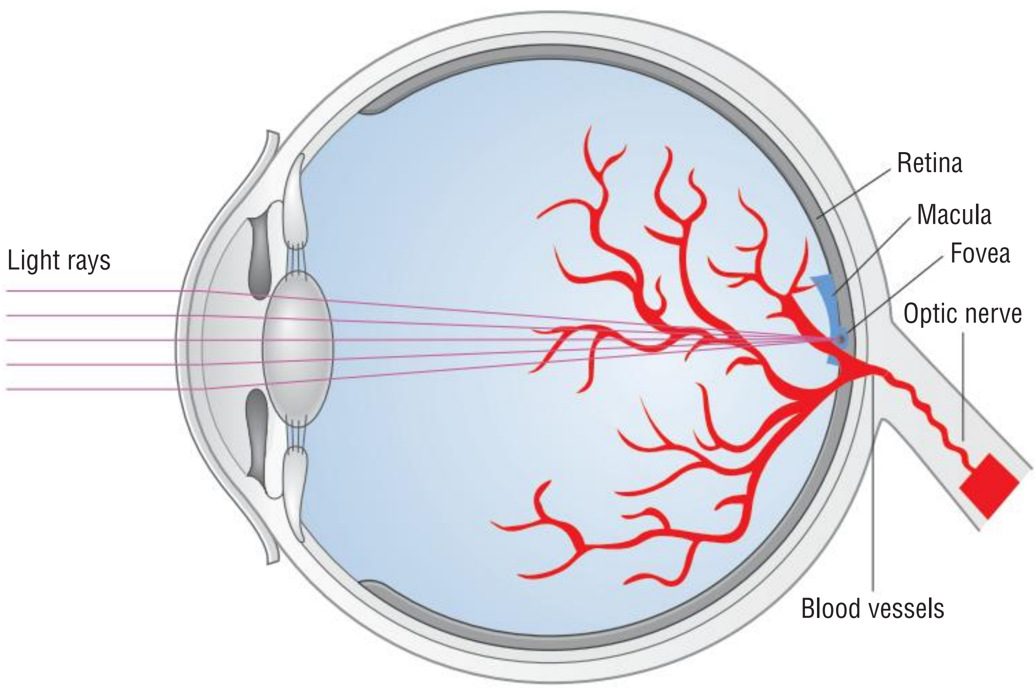

Figure 7.1 Sunlight energy travels across space to your eyes. It is transformed into electrical and chemical energy. The energy is transformed by the retina and travels along the optic nerve.

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Forms of energy

heat energy
thermal energy of an object due to the energy of each of its particles; energy measured by a thermometer

sound energy
energy transferred by a vibrating source; energy measured by a sound-level meter

gravitational potential energy
energy associated with the position of an object above the ground

elastic energy
energy stored in springs and elastic materials

Energy comes in different forms. A form of energy is given a name because of where it comes from, or because of the way we experience it (Figure 7.2). However, it is still just energy. Solar energy comes to us from the Sun as light energy and **heat energy**. **Sound energy** comes from a variety of sources, but it is always experienced by our ears or a sound-measuring device. **Gravitational potential energy** is ready to be released when things fall down. Chemical energy is transformed when two or more chemicals react to form a new substance, such as when fireworks explode. Like chemical energy, **elastic energy** can be stored in springs for later use, which is what we do with wind-up toys and pogo sticks.

Figure 7.2 Fireworks are a spectacular example of chemical energy.

ACTIVITY SHEET
Energy in the kitchen

Classifying forms of energy

kinetic energy
energy of an object due to its motion

potential energy
energy that is stored; energy ready to be transformed

Forms of energy can be sorted into two main categories: **kinetic energy** and **potential energy**. Table 7.1 shows some forms of energy and their relationship to these two basic forms of energy. There are two other important forms of energy – nuclear and mass–energy – but these are a bit too complicated for the time being!

Table 7.1 Energy forms

Basic form of energy	Meaning	Forms	Examples
Kinetic energy	Energy of moving things	Mechanical, thermal (heat), sound, light, chemical	Moving truck, hotplate, speaker, globe, burning fireworks
Potential energy	Energy stored in things	Gravitational, elastic, electrical, chemical	High-diver, stretched spring, battery, petrol

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Kinetic energy

Kinetic energy is energy of movement, so large objects such as moving cars have kinetic energy. Very tiny particles, such as atoms and electrons in chemicals, also move, so they too have kinetic energy. Light moves, but it is a bit different from the usual particles with which we are familiar, so it is a special form of kinetic energy.

Examples of kinetic energy include people running, moving pistons in engines, cars travelling along roads and machines at work.

Inside every material, there are billions of extremely small particles – atoms and molecules – all moving about and hitting each other. The amount of their movement is a measure of the temperature. Heat energy, therefore, is a form of kinetic energy because of the movement of these tiny particles.

Sound energy is also kinetic energy. The air particles through which the sound travels moves backwards and forwards as the energy is transferred from place to place.

Heat and sound are such important types of energy that they are usually classed as separate categories of energy.

Moving vehicles possess kinetic energy. Vehicles can be stopped in a controlled manner using brakes, which can convert the kinetic energy into heat, light and sound energy. A vehicle that is out of control will do 'work' by damaging whatever it crashes into, such as a brick wall or a tree. Larger vehicles such as trucks possess more kinetic energy due to their larger mass, and so when they crash they cause more damage. An important aspect of kinetic energy and vehicles is that the same vehicle travelling at 100 km per hour has not twice but four times the kinetic energy it has when travelling at 50 km per hour. This is why speed is such an important factor in road crashes.

Potential energy

Potential energy is energy stored ready to make things happen. If a boulder on a mountain is dislodged, it converts its gravitational potential energy into kinetic energy. Chemicals store electrical energy, which can be redistributed to produce kinetic energy (heat and light). Springs store potential energy when they are squashed or stretched.

Examples are fireworks chemicals, water used at a hydroelectric power station and squashed springs.

When fireworks explode they produce heat and light. The chemical energy stored within and between the reacting chemicals is released as heat and light.

If you lift something up above the ground, it has gravitational potential energy. When it is released it turns that stored, potential energy into kinetic energy. Think of a hydroelectric power station. Water is released from high up the hill. When it is released, it rushes downhill and crashes into a turbine, which spins to produce electricity. If you spend energy pushing your bike and walking up a hill, you have gained potential energy. Jump on the bike and ride it back down the hill and your potential energy is converted back into kinetic energy – but hopefully not too much!

When you stretch or squash a material such as a spring, the energy you used is stored in the material so it has not been lost. It is then possible to release this **elastic potential energy** later.

elastic potential energy

energy stored in an elastic band or spring that is ready to be transformed when the elastic band or spring is released

ISBN 9780170231497

WORKSPACE
Think, pair, share – energy

ACTIVITY 7.1

Think, pair, share – energy

Imagine you had to explain potential or kinetic energy to a primary school student. How would you do this? Try to think of a creative way to do this rather than just a verbal explanation.

1 **Think** of your ideas and record them.

2 **Pair** up with a classmate and combine your ideas. Choose one idea and prepare a 3-minute explanation.

3 **Share** your explanation with the class or another group.

WOW!

Piezoelectricity

Between 1880 and 1882, brothers Pierre and Jacques Curie (at right) showed that some crystals, now known as piezoelectric crystals, produced an electrical effect when squeezed.

© Photos 12/Alamy

Shutterstock.com/marekuliasz

Piezoelectricity is an example of the transformation of energy from mechanical to elastic to electrical energy. Piezoelectricity is used in igniters for gas appliances.

piezoelectricity
electricity that is produced when certain crystals are squeezed or distorted

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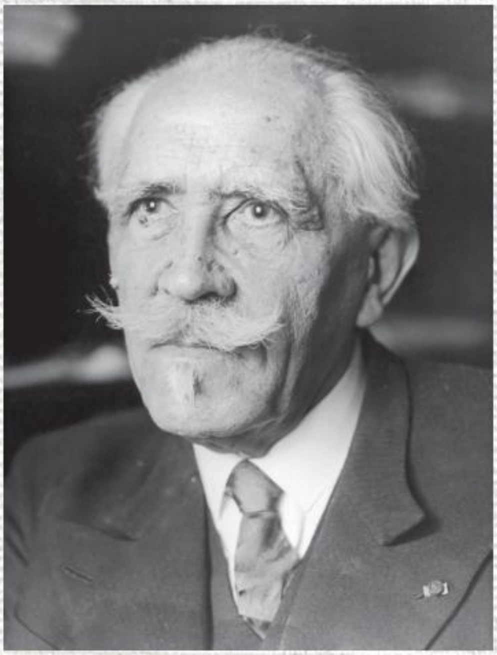
In 1917, French physicist Paul Langevin used piezoelectricity to develop sonar depth sounders to detect submarines. Piezoelectricity is also used in hi-tech telecommunications, smoke alarms and remote controls. There is a developing interest in piezoelectric applications in nanotechnology.



Keystone-France/Gamma-Keystone via Getty Images

QUESTIONS 7.1

What have you learnt?

WORKSPACE
What have you learnt? 7.1

Understanding

1 Write five questions that could only have 'energy' as their answer.

2 **Define** the following terms and give an example for each.
- a Energy transfer
- b Energy transformation

3 **Identify** the two main categories of energy. How do they differ?

4 **Identify** forms of energy that fall under each of these main categories.

Applying

5 Look around you now. **List** all the different forms of energy you can **identify**.

6 **Identify** the forms of energy that would be in a:
- a coiled spring
- b block of chocolate
- c lamp
- d box on top of a wardrobe
- e see-saw.

ISBN 9780170231497

QUESTIONS 7.1

Creating

7 Oliver asked you why the metal saucepan got hot when it was placed on the hotplate. **Propose** an answer you would give him in terms of particles and heat energy.

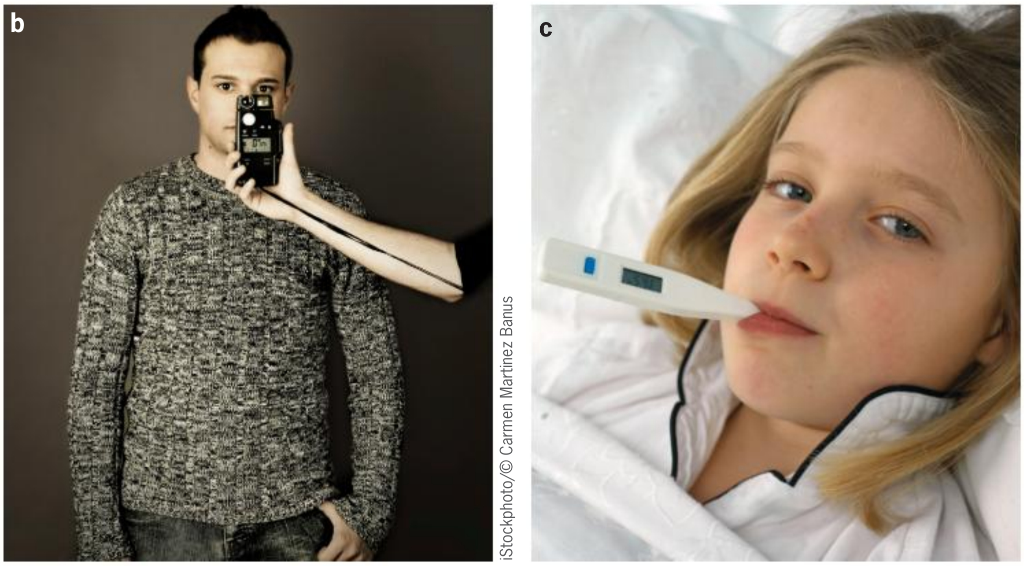
7.2 Measuring energy

You only know about energy when you experience it directly or observe it being transformed. Your body is your first way of knowing about energy. You use your senses to see light, hear sound and feel heat. You would not know about the energy from the Sun if it never came in your direction. This is also true for sound energy and heat energy.

How much light do we see? How much sound do we hear? To find out, you need to use accurate measuring devices. Your body systems are not very accurate measuring instruments. For example, if you put warm hands in very cold water, the very cold water feels very hot. But if your hands are quite cold to start with, then the very cold water actually feels warm. Thus, when you feel heat, your body senses cannot tell you the actual temperature of the water. For this reason, you need to use measuring devices, such as thermometers for heat, which will always give you the same measurement for the same amount of energy.

a

iStockphoto/© Ana Abejon



b

iStockphoto/© Carmen Martinez Banus

c

iStockphoto/© Kameel

Figure 7.3 Measuring instruments for **(a)** sound, **(b)** light and **(c)** heat

ISBN 9780170231497

Qualitative and quantitative measurements of energy

You can describe energy transfer or transformation in words or you can measure it, using numbers. From Year 7, you will remember that a descriptive measurement or observation is a **qualitative measurement**. Often, we make qualitative measurements with our bodies. For example, you might describe the water in the shower qualitatively as being cold, warm or hot.

A **quantitative measurement** is a description that uses numbers to represent the actual quantity of energy. You could say that the air has a quantitative temperature, measured on a thermometer, of 5°C, 25°C or 45°C. Qualitatively, temperatures of about these values are cold, warm and very hot respectively.

The quantitative unit of temperature measurement is degrees Celsius (°C), which can be related to the quantitative measure of energy.

qualitative measurement

any information that can be gathered that is not numerical

quantitative measurement

any information that can be measured numerically

ACTIVITY 7.2

Celsius or Fahrenheit?

Most countries measure temperature using the Celsius scale, and others use the Fahrenheit scale. In a small group, research to find:

- six countries that use the Celsius scale
- six countries that use the Fahrenheit scale
- where the name 'Fahrenheit' originated.

Find out the freezing point and boiling point temperatures for each scale. Vote on which scale you think makes more sense.

ACTIVITY SHEET
Student investigation: Heat absorption

The unit used for measuring energy is the **joule (J)**. It is named after English physicist James Prescott Joule. Joule performed a very famous, very accurate experiment that showed that the amount of energy in one form is exactly the same as the amount of energy that appears in another form. This led him to propose the **law of conservation of energy**.

joule (J)

the unit of measurement for energy

law of conservation of energy

a fundamental law of physics, which states that when energy is transferred or transformed, the total amount of energy remains the same

How much is a joule of energy?

One joule is a small unit of energy. A small bar of chocolate weighing 100 grams held 1 metre above the ground has about 1 joule (1 J) of gravitational potential energy. When you drop it, this is transformed to 1 J of kinetic energy just before it hits the ground.

It takes more than 1000 J to raise the temperature of a cup of water (250 mL) by 1°C. To boil it from room temperature (about 20°C) would take 83 600 J. Because the joule is so small, we often use multiples such as the kilojoule (kJ), which is 1000 J. Hence, 83 600 J is the same as 83.6 kJ. The energy available from food is often measured in kilojoules. A megajoule (MJ) is 1 million joules (1 000 000 J).

So, 1000 J = 1 kJ and 1000 kJ = 1 MJ.

ACTIVITY SHEET
James Prescott Joule

ISBN 9780170231497

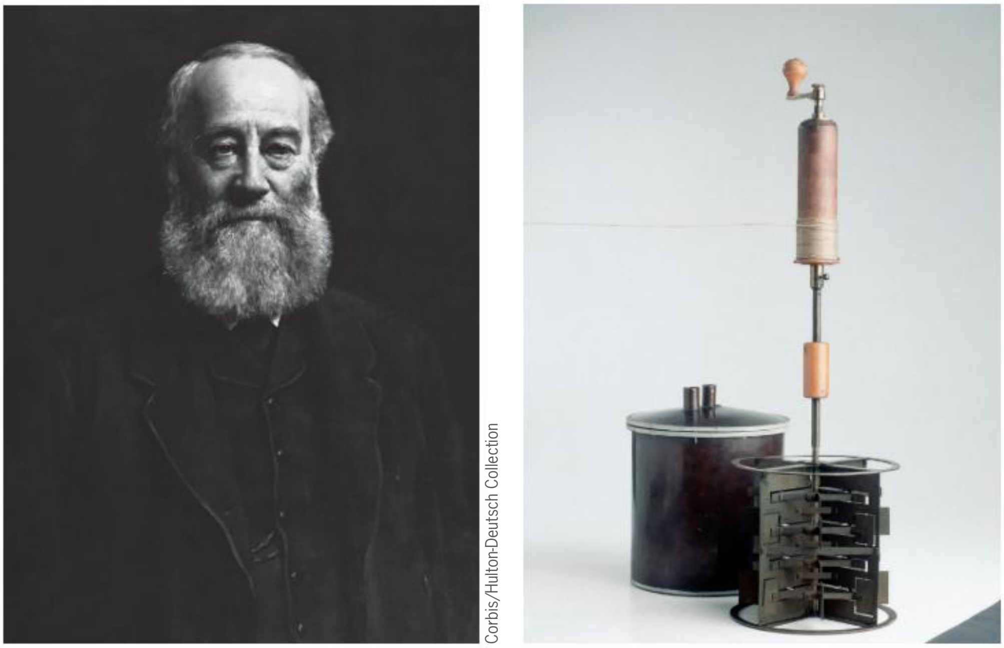


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Figure 7.4 **a** James Prescott Joule (1818–89) proposed the law of conservation of energy; **b** Joule's apparatus for measuring energy.

Law of conservation of energy

The law of conservation of energy states:

> When energy is transferred from place to place or transformed from one type of energy to another, the total amount of energy remains the same.

It often seems that some energy is 'lost' when you transfer or transform energy. This is because you are usually interested only in a small part of what is actually happening. For example, when hydroelectric energy is produced, gravitational energy is transformed to kinetic energy when the water rushes down a pipe before hitting the turbine blades. Some of the energy makes the air move (sound energy). Some is affected by friction against the sides of the pipe, which produces heat that cannot be used. The amount of energy at the turbine is less than the amount we started with. Even more is 'lost' inside the turbine due to friction and related heating and noise. The energy we started with is not all available at the end. There was a loss of useful energy, but none of the energy was destroyed – it just was not available for our purposes!

WOW!

James Prescott Joule

James Prescott Joule's experiment, which led to the law of conservation of energy, showed how energy can be transformed from one type to another. A falling weight was attached by a string to a paddle-wheel in an insulated beaker containing water (see Figure 7.4b). The water increased in temperature by an amount he predicted. This is similar to using an egg beater to heat a bowl of water and measuring how hot the water gets!

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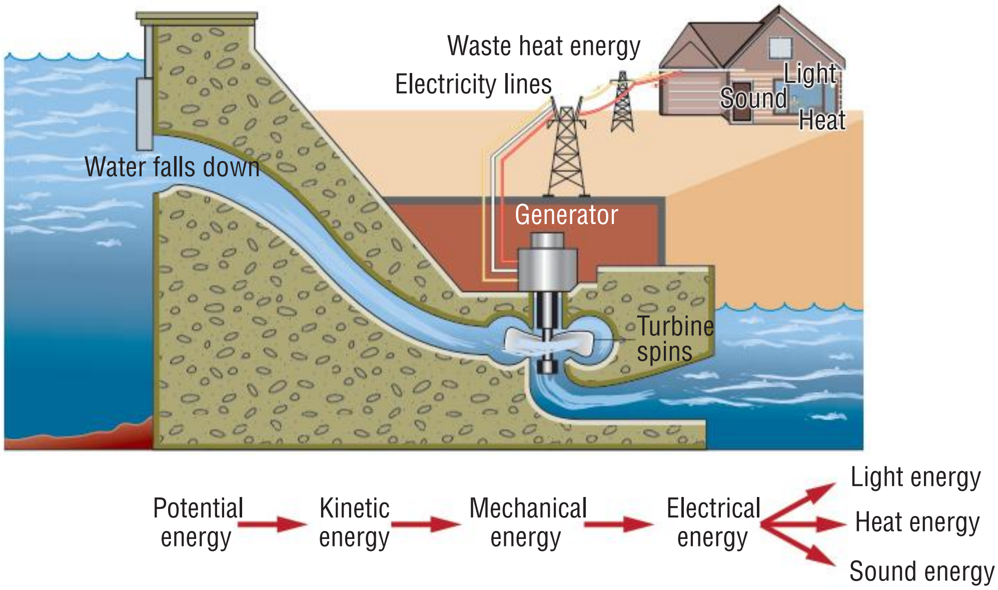

Figure 7.5 Energy transformations in the production of hydroelectricity. Some energy is used for other purposes.

ANIMATION Energy transformation in a hydroelectric plant

ANIMATION Conservation of energy

Representing energy transformations

The energy transformations leading to the production of hydroelectricity in Figure 7.5 can be illustrated in a flowchart or a Sankey diagram. In a flowchart, you identify the transformations and put them in order. You use arrows to show the direction of the energy transformations:

Gravitational potential energy ⟶ kinetic energy ⟶ electrical energy

ACTIVITY SHEET Energy transformations

A **Sankey diagram** is like a flowchart in which the width of the arrows shows increases or decreases in energy. Generally, the amount of energy available to be transformed for the intended purpose decreases. In this example, the Sankey diagram would look like Figure 7.6a.

It is also possible to include arrows on a Sankey diagram that point away from the main line to show the energy transfers and transformations that cause the decrease in useful energy (Figure 7.6b).

Sankey diagram
a type of flowchart that uses arrows of various sizes to indicate the amount of energy moving through a system

ACTIVITY SHEET Measuring gravitational potential energy

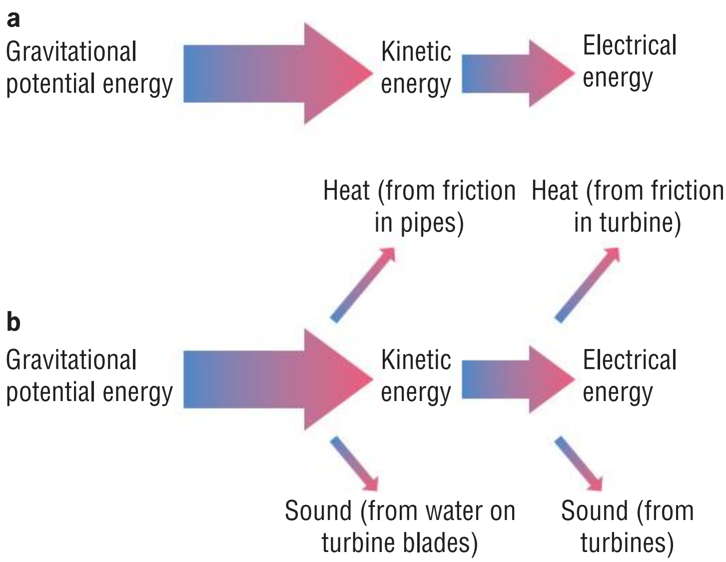

Figure 7.6 Energy transformations in the production of hydroelectricity can be represented in a Sankey diagram. The arrows show **(a)** the change in the amount of energy or **(b)** the energy transformations.

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WORKSPACE
Transforming gravitational potential energy

EXPERIMENT 7.1

Transforming gravitational potential energy

Anything above the ground has gravitational potential energy that can be transformed to kinetic energy.

Materials

- kinematics cart (or toy car or truck)
- plank of wood (approximately 2 m long)
- some bricks to make a ramp
- metre ruler
- motion sensor and data logger
- digital camera (optional)

Planning

1. Read the method carefully.
2. Plan what you will do.
3. Sketch a diagram or take a photo of the equipment in place to do the activity.
4. Draw a table for your results.
5. Decide on the columns you will need for your data table. Consider using 'Starting height' and 'Final speed' as the headings and use appropriate units.

Method

1. Use the bricks and plank to make a ramp with the highest point 60 cm above the ground.
2. Place the kinematics cart at the top of the ramp.
3. Set up the motion sensor and data logger to record the speed of the cart as it rolls down the ramp. Take digital images to record your experiment. If your school does not have a motion data logger available, **calculate** the final speed by doubling the distance the cart travels down the ramp (in metres) and then dividing this by the time taken (in seconds). This will give you the final speed in metres per second.
4. Measure the vertical height of the cart above the ground and record it in your data table.
5. Start the data logger and release the cart.
6. Record the motion until the cart reaches the ground.
7. Record the final speed of the cart just as it reaches the ground.
8. Repeat the measurement three times. **Calculate** the average speed. Repeat steps 4 to 8 for five more heights.

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EXPERIMENT 7.1

9 Using your data table, plot a graph to **show** how the final speed is affected by the starting height.

Results and discussion

1 **Identify** which form of energy is represented by the:

a height above the ground

b speed of the cart.

2 **Describe** what happened to the speed when the release height was at its:

a highest

b lowest.

Give your answers both qualitatively and quantitatively.

3 **Construct** a Sankey diagram to **show** the main energy transformation for the cart.

4 **Describe** any evidence you noticed of other energy transformations that might affect this activity.

Conclusion

5 **Describe** how the height above the ground is related to energy transfers in this activity.

Extension

6 Test different surfaces to see what effect they have on energy transformations in this activity. You could put different surfaces on the ramp, or you could put different surfaces on the ground for the cart to run on to. **Discuss** your ideas with your teacher.

QUESTIONS 7.2

What have you learnt?

Understanding

1 **Recall** the ways our body experiences energy.

2 **Describe** how energy transfer is different from energy transformation.

3 **Identify** the unit used to measure:

a temperature

b energy.

4 **Define** the unit 'joule'.

WORKSPACE
What have you learnt? 7.2

ISBN 9780170231497

QUESTIONS 7.2

Applying

5 When you see things, light energy is transformed to electrical energy and chemical energy. **Summarise** this energy transformation sequence as a:

a flowchart

b Sankey diagram.

6 **Explain** why we need accurate measuring instruments to find out about energy.

Analysing

7 **Identify** an example of money transfer. How is this similar to energy transfer?

8 A wind generator produces electrical energy. Moving air – the wind – causes a fan to turn and electrical energy to be produced. **Construct** a Sankey diagram to **show** this series of three energy transformations.

Reflecting

9 Go back to the Prezi presentation you created for the 'What do you already know?' activity, and think about your descriptions and links. What needs to be changed? Add new forms of energy, such as kinetic and potential energy. Decide which forms of energy are defined in terms of where they come from or how they are experienced. Ask yourself about the way your senses are used to observe energy. Think about why instruments are needed to measure energy.

10 Use a graphic organiser such as a mind map to **outline** the connections between the major concepts covered in this chapter so far.

7.3 Chemical energy

Chemicals are arrangements of particles that store energy in the bonds that hold them together. In many chemical reactions, some of that energy is released, for example, as heat. A particular type of chemical energy has become a very important aspect of our society. Electrochemical reactions occur inside batteries. Chemical reactions convert the chemical energy into electrical energy. By choosing certain chemicals, these reactions can be reversed, so we now have rechargeable batteries. Only a few decades ago rechargeable batteries were very rare, but they are now found in so many everyday devices that we would be at a loss without them. Glow sticks are examples of chemical reactions that turn chemical energy directly into light energy, although the light produced is not as intense as the light from torches and light globes.

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Energy from food

Food is made of chemicals such as sugars, carbohydrates, fats and oils. During cellular respiration, the digested products from these chemicals combine with oxygen to transform chemical energy into other forms of energy so that you can live. If these energy transformations stopped, you would stop! Your body would not get the heat energy it needs to keep warm without these energy transformations.

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Figure 7.7
The energy available to our bodies from foods is shown on packets in kilojoules.

ACTIVITY SHEET
How good is my lunch?

ACTIVITY SHEET
Food labels

ACTIVITY SHEET
Science career – nutritionist

Foods that contain fats and sugars can be used to transform the most chemical energy. Foods with a lot of fibre and water transform the least. A 13-year-old person needs to transform about 10 million joules (10 MJ) of energy each day. A slice of white bread can transform about 300 000 J (300 kJ) of energy. If you eat a 250 g bag of jelly babies, your body will transform more than one-third of the recommended daily energy consumption for a 13 year old. Many low fat foods have had the fat in them replaced with sugars, so that they can be made to transform nearly as much energy when they are eaten as the original 'fatty' version. Fast food outlets in New South Wales have been made to publish the energy that would be transformed when the foods are eaten. This has been done to make people aware of how much energy their bodies will transform. The extra energy that is not used in moving or producing heat will be stored by the body as fat.

When you ask, 'How much energy is in my food?' or, even worse, 'How many kilojoules are in my food?', you are making a technical mistake. Notice that we have been careful to talk about transformation of energy from food chemicals. When you say, 'What is the energy content of my food?', you really mean, 'How much energy will be transformed by the chemical processes in my body if I eat this food?' There are always at least two chemicals involved in transforming energy in your body: the food chemical and the oxygen you have breathed in through your respiratory system.

You will recall from Chapter 4 that plants are able to make food for us by converting light energy from the Sun into chemical energy, which is then stored in the plant material. This process is called photosynthesis and it occurs in all green plants. When we eat our vegetables and fruit, the energy we are able to get from the food came originally from the Sun.

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WORKSPACE
Releasing energy from a jelly baby

EXPERIMENT 7.2

Releasing energy from a jelly baby

Possible risks	Safety precautions
The jelly baby will get very hot.	Make sure you use a long probe and keep your fingers away from the jelly baby and the flame. Keep everything over the heat-proof mat. If the jelly baby falls off the probe, then leave it to cool down before cleaning it up.
Bunsen burners and hot equipment can burn.	Make sure you follow the rules for using a Bunsen burner.

A jelly baby is mostly made of sugar, which is a chemical. When sugar is heated, it will burn by combining with the chemical oxygen in the air. In the process, a new chemical, which also requires energy to stick together, is produced. Much of the chemical energy available in the sugar and in the oxygen is transformed into heat energy that can be used to raise the temperature of water.

Materials

- heating equipment (Bunsen burner, heat-proof mat)
- electronic scales
- long metal probe
- at least one jelly baby per group
- retort stand, boss-head and clamp
- test tube
- thermometer (or a temperature probe and data logger if available)
- digital camera (optional)

Method

1. Place the jelly baby on the scales and record its mass.
2. Place the jelly baby on the end of the metal probe. Make sure the probe goes all the way from the jelly baby's feet to its head. It is all right if the probe comes out the top of the jelly baby's head.
3. Half-fill the test tube with water and clamp it about 20 cm above the bench.
4. Place the thermometer in the water and record its initial temperature.
5. Light the Bunsen burner and hold the jelly baby in a blue flame.
6. Once the jelly baby is alight, remove it from the flame and hold it under the test tube. If the jelly baby goes out, return it to the Bunsen burner flame to re-light it.
7. Keep heating the water until the jelly baby is no longer able to burn.
8. Once the jelly baby has completely cooled down, place it back on the scales to record its final mass.

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EXPERIMENT 7.2

Results

1 Complete the following table.

Mass of jelly baby (g)	
Initial water temperature (°C)	
Final water temperature (°C)	
Change in water temperature (°C)	

2 Record any observations you made during this experiment.

Discussion

3 Write an aim (a statement of purpose) for this experiment.

4 Use the information from the jelly baby packet to **calculate** how much energy you should expect the burning jelly baby to transform. Look at the energy per 100 g and then work out how much energy is in your single jelly baby.

5 **Identify** how much the temperature of the water rose.

6 **Calculate** how much energy was used to heat the water.

(Hint: Energy = volume of water (in mL) × 4.2 × change in water temperature (°C))

7 **Compare** the amount of energy transferred to the water with the amount of energy you expected to be transformed by the burning jelly baby. **Calculate** the percentage of the expected energy transformation that was actually transferred to the water.

8 Was all the jelly baby transformed to energy to heat the water? If not, what happened to the energy? **Justify** your answer. (Hint: Could you see the flame? Was any jelly baby left over?)

9 **Identify** some of the problems or difficulties you found in achieving the purpose of this experiment.

10 **Discuss** if you think this a good process for finding the amount of energy that can be transformed by any foods. (Hint: How would you find the energy available for the transformation of energy from orange juice?)

Conclusion

11 Write your own conclusion. In your conclusion:

a **show** how you achieved the purpose of the experiment

b make sure you mention what you found about energy transformations and energy transfers

c **explain** how the law of conservation of energy helps you understand what happened to the energy available from the food and oxygen.

Extension

12 **Propose** ways to improve the amount of energy that can be transferred from the burning jelly baby to the water. If your teacher is satisfied that your ideas are safe and sensible, repeat the experiment with your improvements in place.

ICT

Use the digital camera to record all the steps in the experiment. Create a movie or podcast, including your responses to the discussion and conclusion, and upload the movie or podcast to the class wiki.

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WORKSPACE
What have you learnt? 7.3

QUESTIONS 7.3

What have you learnt?

Understanding

1 The following is a list of forms of energy:

kinetic energy, chemical energy, gravitational energy, elastic energy, electrical energy, heat energy, solar energy, sound energy, light energy, hydroelectric energy

Use the list to **construct** energy chains that **show** energy transfers and transformations associated with:

- a producing hydroelectricity
- b riding a pogo stick
- c exploding fireworks.

2 **Recall** at least three things that use energy stored in springs.

Applying

3 **Identify** three examples of energy stored in your house ready to be transformed when required. Try to find different storage types rather than just different examples of the same type. **Explain** why these are examples of stored energy.

4 Fuels are chemicals that can be transformed to produce electrical energy. **Identify** at least four fuels that are used for this purpose. **Explain** why these fuels are all examples of both chemical energy and stored energy.

5 Look at the food you have eaten, or will eat, for lunch today.

- a **Identify** what high-energy foods you have taken to school.
- b **Identify** the low-energy foods you have taken to school.
- c Which would you say is the healthiest of your foods? **Justify** your decision by identifying the criteria you used to decide this.

Analysing

6 Athletes often eat a lot of bread and pasta the night before they compete. However, on the day they compete they usually eat fresh fruit. **Explain** why they do that. (Hint: 'High GI' foods release their energy very quickly. 'Low GI' foods release their energy over a much longer time.)

7 The energy content of a mango is 60 kJ per 100 g while the energy content of a boiled egg is 330 kJ per egg. Use 'energy transformation' in a sentence to **define** 'energy content of food'. **Calculate** how much mango you would need to eat to get the same amount of energy as from an egg.

Reflecting

8 **Identify** five energy resources you use at home. Which is the one you use most? Is this the energy resource you use most at school?

9 Use an Internet search engine to find an image of a healthy food pyramid. Where are the high GI foods? the low GI foods?

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7.4 Elastic potential energy

A bungee jumper, with gravitational potential energy, jumps off a bridge over a river valley. The gravitational potential energy is transformed into kinetic energy during the fall. At some point, this kinetic energy needs to be removed from the jumper or there will be a catastrophic ending! The bungee rope is made of a spring-like material. The spring extends and stores the kinetic energy. When an archer fires an arrow, the arrow is given its kinetic energy when the elastic potential energy stored in the bow is released. Wind-up toys work by storing energy in a circular spring and then releasing it gradually.

The energy transformations can be drawn in flowchart form:

Gravitational potential energy ⟶ kinetic energy ⟶ elastic potential energy

Another example of elastic potential energy is when a person jumps on a trampoline. When they land, their kinetic energy is converted into the stored elastic potential energy in the stretched springs of the trampoline, which then release this energy to give the jumper back their kinetic energy, this time going up.

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ACTIVITY SHEET
Rubber band car

Figure 7.8
In a bungee jump, gravitational potential energy is converted into kinetic energy. Then the spring rope stores it as elastic potential energy.

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WORKSPACE
What have you learnt? 7.4

QUESTIONS 7.4

What have you learnt?

Understanding

1 **Explain** why a stretched rubber band is said to contain elastic potential energy.

2 **Identify** three examples not mentioned above of where elastic potential energy could be found.

Applying

3 A friend walks up to you with a plastic ruler bent between both their hands. **Explain** how you could find out if the ruler has elastic potential energy or not.

Analysing

4 **Explain** what would happen to a bungee cord if someone tried to store more elastic potential energy in the cord than it was designed for.

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Chapter review

Remembering

1 **Explain** the difference between kinetic energy and gravitational potential energy.

Understanding

2 By referring to a filament light globe, **describe** the meaning of:
  a energy transfer
  b energy transformation.

3 **Discuss** why chemical energy can be regarded as potential energy while heat can be regarded as kinetic energy.

4 When you eat, the chemical energy is transformed partly into heat energy. Your body needs this heat, but you often produce more than is necessary, so you transfer it to the surrounding air. **Show** this information by constructing a:
  a flowchart
  b Sankey diagram.

Applying

5 A personal trainer encourages clients to 'lose kilojoules'. **Explain** why is this is wrong.

6 When it is moving, a car transforms chemical energy into mechanical energy. A lot of waste heat is produced. **Describe** this by drawing a Sankey diagram.

7 Complete a five whys on this question: 'Why is it important to learn about early inventions and scientific discoveries?'

Analysing

8 One litre of petrol is capable of transforming 36 000 J of energy. However, in a car, only 1200 J of this energy is able to be used to make the car go. **Calculate** the efficiency of this energy transformation.

9 Waste heat is a serious problem for all energy transformation processes. **Explain** how waste heat from one process is, or could be, used in another process.

10 When a gas is compressed its temperature rises.
  a Use your knowledge of particles to **explain** why this happens.
  b **Identify** why this is important for the four-stroke petrol engine.

Evaluating

11 For any one form of energy discussed in this chapter, **evaluate** how important it is for us in our everyday lives.

WORKSPACE
Chapter 7 review

ACTIVITY SHEET
Chapter 7 checklist

REVIEW QUIZ
Chapter 7

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Creating

12 Create a wordle using all the glossary terms in this chapter. The terms that you think are the most important need to be larger than the other terms. Share your wordle with the class by uploading it to the class wiki.

Reflecting

13 **Outline** the factors that you think contribute to a successful scientific discovery or invention.

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8

Electricity

The first use of electric street lights in Australia was in 1888 in Tamworth. Within a few decades, our society became totally reliant on electricity not only for comfort but for our every need. Electrical circuits are now everywhere – in our homes, streets, cars, schools and even in devices we have in our pockets. How did everything change so quickly? Just how important is electricity? Could we live without it? This chapter will show you how we make use of electricity safely and in ways our forebears could not have imagined.

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ACTIVITY SHEET
CAT with rubric: Electric circuit room model

Physical world – Stage 4

Key knowledge

- Electricity is a useful form of energy.
- Electrical energy results from a conversion of another form of energy, such as non-renewable coal or renewable hydroelectric power.
- Electrical energy can be transformed into other forms of energy, such as light energy, sound energy or heat energy.
- Electrical energy can be transferred in simple circuits, such as series or parallel circuits.
- Electrical circuits can be drawn using symbols for components such as the battery, switch and resistor.

CULMINATING ASSESSMENT TASK

Electric circuit room model

Construct a model of a room in your house using a cardboard box or similar that has at least:

- a battery as a power source or connecting wires that can connect to a power pack at school
- connecting wires and a switch in the circuit
- two small 12 V globes that are both controlled by the same switch.

Draw a circuit diagram to **describe** all the pathways for electricity in your model of the room. **Explain** how your model is similar to a room in your home and how it is different.

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What do you already know about electricity?

Work with a partner. State all the electrical appliances and devices you think you use in one day while your partner **proposes** how your day might be different if you did not have each of these electrical items.

8.1 What is electricity?

The earliest civilisations observed electricity when they saw lightning and used flint stones to make sparks to start fires. For thousands of years stories were made to explain what lightning is. We now know that lightning is caused by a huge build up of **static electricity** in thunderstorm clouds where hailstones exist. When the static charge can no longer be held within the cloud a spark will jump to a nearby cloud or to the ground, producing a brilliant flash of light. A lightning bolt can travel as far as 20 kilometres and produces temperatures as high as 30 000°C. You can tell roughly how far away lightning is by counting the seconds between seeing the lightning flash and hearing the thunder and dividing the number of seconds by three. This number is the distance in kilometres. Surf lifesavers are instructed to close a beach if the time taken to hear thunder is any less than 30 seconds after they see the lightning. The safest way to stand if you are caught outdoors in a thunderstorm without nearby shelter is to crouch down low and stand on one leg only – try it, it's not easy! This way, any current through the ground will not travel up one leg and down the other, and crouching low minimises the risk of getting hit directly by lightning. As the air near the spark expands at supersonic speeds, it sends out a shockwave that we hear as thunder.

static electricity
electric charge that remains in the same place

WEBLINK
Make your own lightning

© Ern Mainka/Alamy

Figure 8.1
Lightning is an awe-inspiring example of electricity.

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electrical current
electric charges that move or flow through a conductor

It was only in fairly recent times that the true nature of electricity and **electrical current** was discovered. Even before electricity was fully understood we began to use it for our benefit, first with electric lights and then in other appliances such as motors, radios and televisions. Many important investigations and observations were made along the way.

WOW!

Struck by bad luck!

People can survive lightning strikes, as did the man pictured at the right.


US Dept of Health and Human Services

Roy Cleveland Sullivan (1912–1983), a park ranger from Virginia, USA, is listed in the Guinness Book of World Records as the person who has survived more lightning strikes than any other person. Known as the 'human lightning rod', Sullivan was first struck by lightning as a child and then lived through seven recorded strikes over a 35-year period. He endured burns down his legs, toes and chest, his shoes burnt off and his hair caught on fire a number of times. Even his wife was struck once when she was outside with him! Lightning can have several million volts and thousands of amps of current, so Sullivan is either very unlucky, or very lucky, depending on your view.

The history of electricity and early scientists

Several scientists who made important observations about the nature of electricity have become household names. No one scientist 'discovered' electricity. Rather, the knowledge gained over many years has allowed us to gradually better understand what electricity and, more specifically, electrical current really is.

Galvani

Italian doctor and physicist Luigi Galvani (1737–98) studied and taught anatomy – the structure of the bodies of living things. He believed that electricity was somehow stored within muscles and tissues in living things. Galvani based these beliefs on his observations of the dissected legs of dead frogs. When he touched the frog's legs with a charged rod, the leg twitched. Galvani found that this also occurred when the frog's legs were attached to an iron nail and the spinal cord attached to a brass hook. This led Galvani to publish his findings that referred to 'animal electricity' in which he spoke of the brain as being the source of this fluid that could be conducted to the muscles and tissues of living things. Although Galvani was not correct in believing the brain stores electricity, he was correct in saying that nerves conduct electricity and that muscles move as a result of receiving electricity. Today we still refer to certain chemical reactions that produce electricity as galvanic cells, in Galvani's honour.

WEBLINK
Ten milestones in electricity

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Figure 8.2 Over 200 years ago Galvani believed electricity came from animals.

WORKSPACE
Ethics in Science class

ACTIVITY 8.1

Ethics in Science class

In groups of four, discuss the following scenario:

At a new school, your class is asked to amputate the legs of a recently living frog in order to recreate Galvani's experiment.

- What would you do? **Discuss**. **Outline** your reasons.
- **Evaluate** whether or not it is ethical for secondary students to experiment with animals, dead or alive.

Volta

Physics professor Alessandra Volta (1745–1827) believed that electricity was made by the joining of two pieces of different metals. In 1800, he invented the first **battery** by constructing a pile of alternating discs of zinc and copper separated by cloth soaked in salt water, which could deliver a constant flow of electricity. This device became known as 'Volta's pile' and uses the same principle as the batteries we use today. The unit of electrical energy, the **volt (V)**, is named after him.

battery
a series of electrochemical cells designed to deliver electrical energy to a circuit

volt (V)
the unit of electrical potential; a measure of how much energy a quantity of electricity contains

What is a 'battery'?

A typical AA or AAA 'battery' is not a battery at all, but a single cell (galvanic cell). The word 'battery' really only applies to a combination of more than one galvanic cell. A 12 volt car battery, for example, is made from six galvanic cells, each producing 2 volts.

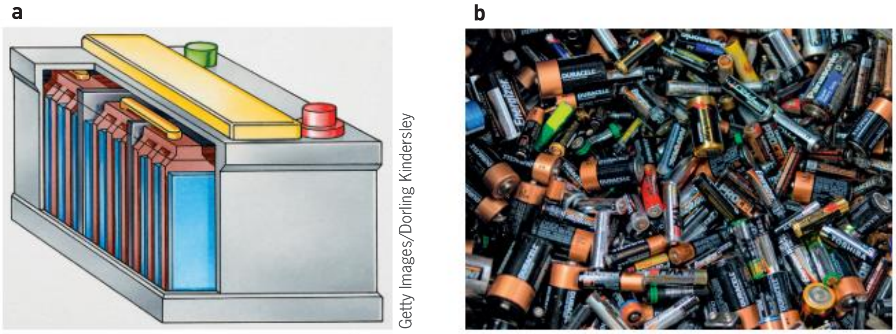

Figure 8.3
a A car battery is made up of six cells wired together.
b Volta is credited with making the first 'battery', now common household items.

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WORKSPACE
Making a simple battery

EXPERIMENT 8.1

Making a simple battery

Possible risks	Safety precautions
An electric shock could occur to someone touching the battery.	Do not combine more than two of these batteries so that the voltage remains within safe limits.

Aim

To construct a simple battery and measure its electric output

Materials

- 5 pieces of flat copper sheets, each about 2 cm square
- 5 pieces of flat zinc sheets, each about 2 cm square
- 10 pieces of thin cardboard or thick filter paper, each about 2 cm square
- salty water
- a voltmeter, either digital or analogue
- connecting wires if needed
- fine sandpaper

Method

1 Soak the pieces of cardboard or filter paper in the salty water for several minutes.

2 Clean each piece of metal using fine sandpaper.

3 Stack the pieces of metal one on top of the other, alternating between the copper and the zinc, and placing a piece of the soaked cardboard or paper between each pair of the sheets of metal, as shown in Figure 8.4.

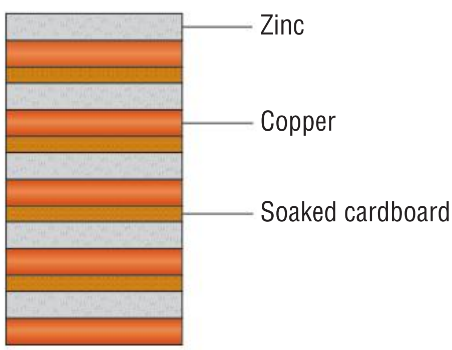

Figure 8.4 Experimental set-up

4 Ensure a firm contact is made between each piece of metal and soaked cardboard or paper by gently pressing on the pile.

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EXPERIMENT 8.1

5 Hold one of the leads from the voltmeter to the piece of metal sheet at the bottom of the pile and the other lead to the sheet of metal at the top of the pile.

6 Adjust the voltmeter scale so that a reading of the voltage can be taken.

Results

1 Record the reading on the voltmeter.

Discussion

2 **Explain** why you think it was necessary to press down on the pile before taking the voltage measurement.

3 **Outline** why you think the pieces of cardboard or paper were soaked in salty water rather than fresh water.

Extension

4 You can try to join your pile with another pile from a different group in your class to make a larger pile. **Predict** what the reading on the voltmeter will be and then measure the voltage of this larger pile. **Explain** your results.

Benjamin Franklin

American scientist and inventor Benjamin Franklin (1706–90) undertook investigations and made many observations about the nature of electricity. In his most famous experiment he flew a kite in a thunderstorm, hoping that it would be hit by lightning. During the storm Franklin sheltered under an open shed and attached a key to the end of the kite's string. A spark jumped from the key to his hand, luckily not killing him. This showed Franklin that lightning was indeed made from electricity. Until then no one could be sure what lightning actually was.

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Figure 8.5
Benjamin Franklin flew a kite in a thunderstorm to find out about the nature of lightning.

ACTIVITY 8.2

Benjamin Franklin

Research one of the other inventions patented by Benjamin Franklin. Write a newspaper article in which you **outline** its use for society.

ISBN 9780170231497

Electricity sure can kill!

WOW!

A person may be electrocuted by as little as 30 volts, especially if they are in water or have wet skin, but it is quite common for people to survive being hit by lightning with up to 100 million volts! It's the current through the heart that kills – not the voltage of the electricity!

WEBLINK
How lightning forms

Electricity today

It is now known that electricity, or **electric current**, is the flow of **electrons** (Figure 8.6). You will recall from *iScience 7 for NSW* that electrons are the negative particles found in all atoms. In Year 7 you also learnt about static electricity, in which the electrons move from one material to another, creating a build up of electric charge. Electric charge can only flow through materials that are known as **conductors**, such as metals and salty water. However, if the charges have nowhere to go, they begin to bunch up together very quickly. They repel any more charges trying to approach them. This prevents the flow from continuing and the electric current will stop.

electric current
the flow of electricity, such as the movement of electrons through a wire

electron
the negative particle in an atom that can move through a conductor

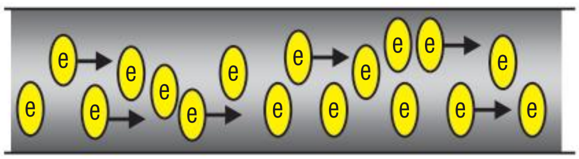

Figure 8.6 Electric current is a flow of electrons.

This occurs so quickly that, in effect, there will not be a current at all unless there is an **electric circuit** for the electrons to flow around, coming back to pass their original position in a continuous loop. Such electric circuits are rather like a water pipe that goes around in a loop. A pump is needed to make the water go around, but as long as the pump works, the water can keep going around. A blockage at any point in this pipe will cause the water to stop flowing everywhere in the pipe. It is important to understand that the electrons never get 'used up' or lost on their way around a circuit – they just turn their energy into other forms.

Voltage is the term we use to describe how much energy the electrons have that can be transformed into other forms of energy. Imagine if you were in a shopping centre and had to follow a looped pathway that leads through a sports store and back out again to where you receive an

conductor
a material that allows electric current to flow through it, such as metals and salt water

electric circuit
a pathway for electric current that leads back to the same starting point

voltage
a measurement of the energy contained in the electrons

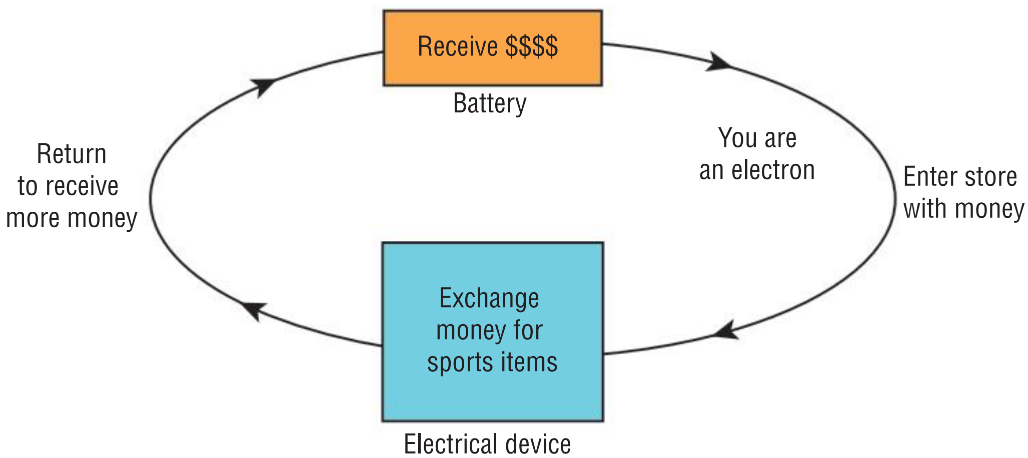

Figure 8.7 An analogy for voltage in an electric circuit – spending money is given to you by the 'battery' and you exchange the money for items you can buy in a 'shop'.

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amount of money (the battery). The amount of money you receive is like the voltage of the circuit. The items you buy in the store in exchange for the money you give the salesperson represents the different forms of energy being produced in the device wired into the electric circuit.

The dangers of electricity

You have probably noticed that appliances you use around the home have at least two metal prongs on the plugs that go into a power point. Some have a third prong, which is used as a safety device in case a fault develops in the appliance. If a fault occurs in the wires in the appliance, this third prong connects the body of the appliance to an **earth wire** so that if a person touches the appliance they will not receive the full current, which might otherwise kill them. The other two prongs conduct electricity into and out of the appliance. If there was only one wire, the electric current could not flow and the appliance would not work.

Wet skin allows electricity to enter your body more easily, increasing your chances of receiving a deadly shock if you do touch a live wire. This is why they say electricity and water do not mix! Rushing in and touching a person who has been electrocuted and is still touching the live wire may result in the rescuer being killed too. The first thing you must do is disconnect the power supply. Don't even touch the victim until you are sure the power supply is turned off.

earth wire

a wire, coloured yellow and green, that connects all three-pronged appliances to the earth so that harmful currents do not pass through a person

iStockphoto/© Tom Brown

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Figure 8.8
Power plugs can have two or three prongs, depending on the type of appliance used.

WEBLINK
More about how electricity can kill

WEBLINK
Using electricity safely in the home

Ian Waldie/Bloomberg via Getty Images

Figure 8.9
Electricity can be dangerous.

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WORKSPACE
What have you learnt? 8.1

QUESTIONS 8.1

What have you learnt?

Remembering

1 **Define** 'current'.

2 **Define** 'volt'.

3 **Recall** the term for a material, such as a metal rod, through which electric current can easily flow.

Understanding

4 **Outline** why Galvani thought electricity was stored in the muscles and tissues of animals.

5 **Describe** how Volta made the first battery.

6 **Compare** Galvani's and Volta's views about where electricity comes from.

7 **Recall** why Benjamin Franklin flew a kite in a thunderstorm. **Describe** what happened.

Applying

8 Carefully **examine** the power plugs of several different appliances around your home. **Describe** the differences you observe between the ones that have two prongs on the plug and the ones that have three prongs.

9 Lightning is a giant spark carrying a huge current of electricity from the cloud to the ground or to other clouds. **Explain** why it is considered too dangerous to continue surfing at the beach or other outdoor activities during a thunderstorm.

10 **Investigate** the principles behind a defibrillator and **outline** what it does.

Analysing

11 Begin a mind map to **summarise** the key concepts so far.

12 How advanced a country is compared to other countries is sometimes measured by the average amount of electricity consumed by each person.

a Research the amount of electricity used by at least three other countries and **compare** it to Australia's electricity usage.

b **Discuss** why the amount of electricity used can be linked to how advanced the country is.

Reflecting

13 Using the analogy about voltage and getting money to spend in a shop, **describe** what would happen if you were given more money to spend before you entered the shop every time. **Relate** this to increasing the voltage in an electric circuit.

ISBN 9780170231497

8.2 What is so good about electricity?

Electricity by itself can be used to make sparks or to electrocute people. It is what we do with electricity that makes it so useful to us. It is a very valuable way of getting energy from one point to another and has become a tool that our modern society has come to rely on totally.

Generating energy

Everything we use that runs on electricity needs a supply of energy. That energy comes from the electricity. To **generate** the energy that is contained in electricity, we build large power stations that burn coal or use water falling down mountainsides through huge pipes. Coal-fired power stations use the heat energy from burning coal to turn water into steam under enormous pressure. This steam is directed into turbines, which work like windmills that in turn rotate generators to produce the electricity. One turbine can produce enough electricity to power three million televisions at once.

CSIRO ScienceImage/James Porteous

Figure 8.10 White Bay power station, near the centre of Sydney, is no longer used.

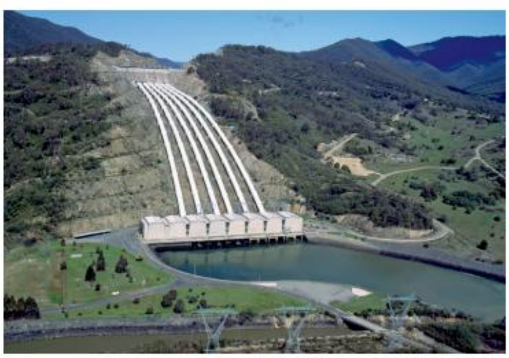
generate

to make or produce

WEBLINK
Energy transformations in a hydro power station

The release of the gravitational potential energy of water as it flows down a mountainside produces kinetic energy. The fast-flowing water is then directed through turbines, to generate electricity. The Snowy Mountains Hydro-Electric power scheme, one of the largest engineering feats ever undertaken anywhere in the world, produces electricity for periods of peak demand in New South Wales and Victoria. As the flowing water can be easily controlled by opening and closing valves, hydro-electric power stations are ideal for short-term electricity generation. Coal-fired power stations run day and night, whether electricity is needed or not, as it is too hard to turn them off and back on again.

Building these huge structures within a city such as Sydney would be impractical. Coal-fired power stations that used the coal found deep underneath Sydney's inner suburbs such as Balmain, Glebe and White Bay contributed to the city's air pollution problem. They also became too expensive to operate. Some have been pulled down and replaced with houses and apartments. The huge amount of electricity needed by the city now mainly comes from power stations on the Central Coast, near Lithgow and in the Hunter Valley near Muswellbrook. These power stations use so much coal that they are built next to where the coal is mined. The Snowy Mountains Hydro-Electric Scheme contributes to our electricity needs during periods of high demand, mainly in the early evening.



National Archives Australia [A6135:K17/10/91/19]

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Figure 8.11 (left) Hydro-electric power is generated when stored water falls down mountains, such as in the Snowy Mountains Hydro-Electric Scheme.

Figure 8.12 (right) Lake Jindabyne in the Snowy Mountains is part of the Snowy Mountains Hydro-Electric Scheme.

ISBN 9780170231497

WORKSPACE
Generating electrical energy

EXPERIMENT 8.2

Generating electrical energy

Aim

To spend energy to produce electrical energy

Materials

- a hand-held electrical generator with a small globe

Method

1 Turn the handle of the generator to make the globe light up.

2 Observe how hard it is to turn the handle when it is being turned faster.

3 Observe the brightness of the globe when the speed of the generator is varied.

Results

1 Record your observations and your comments.

Discussion

2 **Analyse** the relationship between how brightly the globe glows and the amount of energy you need to use to turn the handle of the generator.

3 **Apply** your findings to real energy uses. **Outline** two real-world uses of generators. **Propose** a new use for human-powered generators.

Conclusion

4 Write a brief conclusion to this activity.

Energy transformations and electrical devices

As mentioned earlier, electricity by itself is not much use for anything. It is really only useful when the energy contained in the electricity is converted into a desired form of energy. Such desired forms of energy include light, heat, sound or kinetic (motion) energy. Look around you right now – how many different appliances and devices that use electricity can you see? The more you look, the more you will notice!

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ACTIVITY 8.3

Transforming energy

Make observations of devices that transform electrical energy into other forms of energy.

Select a program you are familiar with, such as Prezi, in which you can construct diagrams easily.

Look around your laboratory or classroom and, if your teacher allows, around your school, for devices and appliances that use electricity as their source of energy.

Construct a diagram or flowchart to **show** what form (or forms) of energy is produced from the electrical energy used by each of these devices or appliances.

1 Present your final diagram to your group or to the class.

2 Does every device or appliance you found only produce one form of energy from the electrical energy it consumes? If not, **describe** the efficiency of each of the devices or appliances; i.e. how good it is at producing the desired form of energy.

WORKSPACE
Transforming energy

WEBLINK
Prezi

QUESTIONS 8.2

What have you learnt?

Understanding

1 **Recall** four electrical devices or appliances you use daily. **Classify** them according to the form of energy that is produced.

2 **Recount** the energy transformations involved when a hand-powered generator powers a light globe.

Applying

3 **Investigate** why electricians will always touch a bare wire in a house with the back of their hand rather than with the front, even though the power to that wire is turned off.

Analysing

4 **Discuss** why it can be said that 'electrical energy is a very versatile form of energy'.

WORKSPACE
What have you learnt? 8.2

ISBN 9780170231497

QUESTIONS 8.2

Evaluating

5 **Discuss** with a partner some of the ways in which electricity has benefited and helped improve our society.

Creating

6 **Construct** and present a diagram that summarises the main stages in the process of transforming energy stored in coal into electrical energy that occurs in power stations.

8.3 How electricity is represented

ammeter
a device used to measure how much electric current is flowing

voltmeter
a device used to measure the voltage across another device in a circuit

Once electrical current began to be used, a standard method for drawing the wiring used and what connections were made began to evolve. Rather than having to draw everything individually, symbols were adopted to represent things such as switches, globes, batteries, **ammeters**, **voltmeters** and resistors, to name a few. Today, there is a world standard for symbols and the way in which electrical wiring is drawn in diagrams so that anyone can look at the diagram and work out what is happening. Some of the symbols used are shown in Figure 8.13. Even though the electricity is invisible, the wires and components are not!

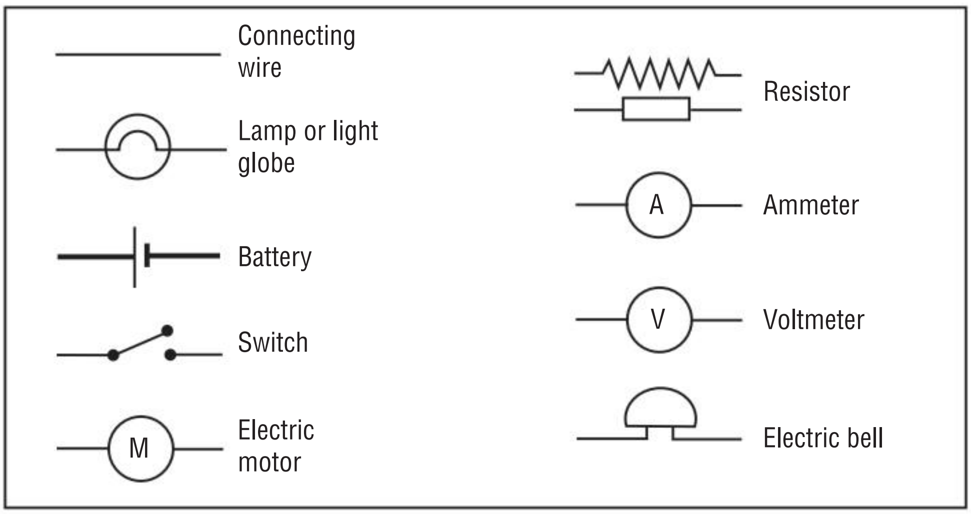

Figure 8.13 The symbols used for some common components found in electric circuits.

Circuit diagrams

circuit diagram
a simplified drawing showing the pathways for electricity and the devices connected

A diagram that shows all the pathways for electricity and the devices used is called a **circuit diagram**. Circuit diagrams can appear to be very complicated, such as the one shown in Figure 8.14, which is the electronic wiring diagram for a small part of a television.

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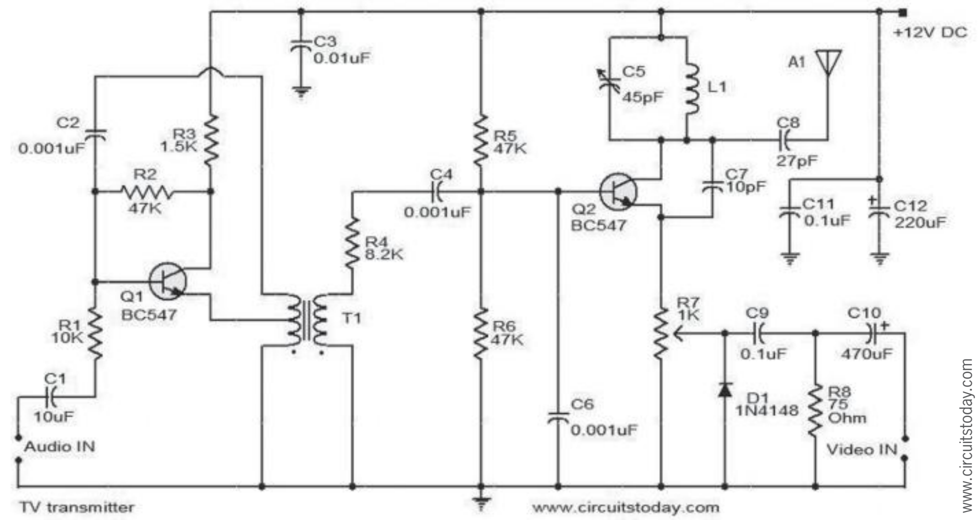

Figure 8.14 The circuit diagram for a small part of a television

The circuit diagrams that we will be working with are a lot simpler than these. All the circuit diagrams you will use will have the symbols for a number of things in common. These are:

1. a source of electrical energy, usually a battery or a power pack (which is often shown as a battery anyway as it makes very little difference to the result)
2. connecting wires that show the 'road map' for the electricity to flow
3. a device that will transform the electrical energy into a useful form of energy, such as a globe, motor, bell or length of heating (resistance) wire
4. perhaps an extra device, such as a meter or a switch.

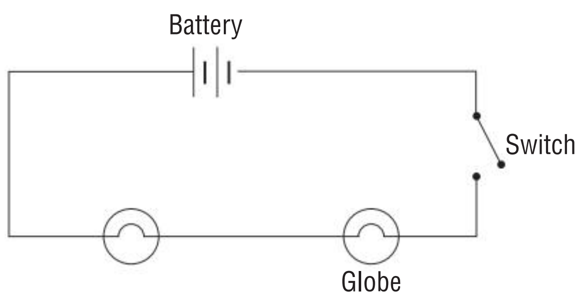

Figure 8.15 This simple circuit diagram shows a battery, a switch and two globes.

Constructing electric circuits from circuit diagrams

When you are asked to construct an electric circuit using a circuit diagram as a plan, it is important to follow the diagram closely and to check that all the connections have been made correctly before the power is turned on or the battery is connected. An incorrectly wired electric circuit may provide a direct pathway for electricity to flow from one terminal of the battery or power pack to the other without passing through any device. This is called a **short circuit** and it can damage the battery or power pack by overloading it or make the wires become very hot.

WEBLINK
The background to circuits and circuit diagrams

short circuit
a circuit consisting of a wire that directly connects the two sides of a battery or power pack with no device in between

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WORKSPACE
Constructing a simple circuit

EXPERIMENT 8.3

Constructing a simple circuit

Possible risks	Safety precautions
A short circuit – that is, connecting the terminals of the power pack or battery directly to each other – will cause the wires to become very hot.	Always check your connections before turning the power on. If in doubt, ask your teacher first and always follow the teacher's instructions.
Globes become very hot after they have been on even for only a few seconds.	Take care not to touch the globes while they are on or for a while afterwards.

Aim

To construct a simple electric circuit using a circuit diagram

Materials

- power supply, such as a 12 volt power pack
- globes
- 3 connecting wires

Method

1. Carefully **examine** the circuit diagram in Figure 8.16.
2. Connect the wires from the power supply to the globe and the switch as shown in Figure 8.16.

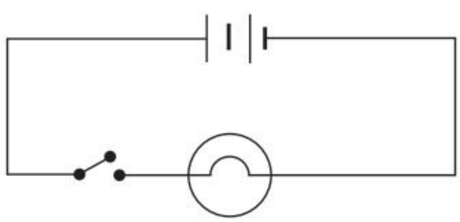

Figure 8.16 A simple circuit diagram

3. Use the 12 volt DC setting on the power supply. Your teacher will show you this, as there are many different types of power supplies in schools.
4. When you have checked your circuit, push the contacts of the switch together. Observe what happens.

Results

1. Record your observations.
2. Draw and label a circuit diagram of your circuit.

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EXPERIMENT 8.3

Discussion

1 **Explain** why, when the switch is not on, electric current cannot flow through the globe.

2 **Predict** what would happen if you:

a added another globe

b added another switch

c doubled the length of the wire

d moved the switch to the other side of the globe.

Conclusion

3 Write a short statement to **describe** how the electric current moves around this circuit to make the globe glow.

Further investigation

4 Before packing up your apparatus, **investigate** how you could connect a second globe so that both globes are controlled by the same switch. Draw your modification as a circuit diagram.

Extension

5 Observe and **describe** the effect on the brightness of the globe of turning the voltage down. **Discuss** how this affects the rate at which energy is being transformed by the globe.

Analysing energy in circuit diagrams

You may have noticed by now that circuit diagrams must have a pathway for the electric current to leave one side of the power supply and return to the other to complete the circuit. This means that anything connected to the electric circuit must have two wires so that the electric current can flow through it. But what happens to the electricity as it flows through a globe? Where does the light come from? **Incandescent** light globes (which are being phased out of general use as they are not efficient) have a very thin wire that becomes very hot, so hot in fact that it glows due to the heat. A normal wire would melt at such high temperatures, so a special metal element called **tungsten** is used. The heat and light energy comes from the electrical energy provided by the battery or the power supply. An energy transformation is taking place. The electrical energy is being transported through the wires from the power source to the globe.

If there are two globes in the circuit, then the energy from the power source will be shared between the two globes.

incandescent

giving off light due to the object being very hot

tungsten

a metal element with the highest melting point of all elements

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World's smallest wire

WOW!

Scientists working at the University of New South Wales have made a wire that conducts electricity which is 1/10 000th of the width of a human hair – only four atoms wide. This will help make a future generation of 'quantum computers' possible. Such computers would be thousands of times faster than modern computers and much smaller.

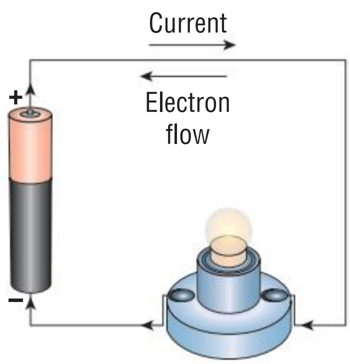

Figure 8.17 Electrons actually move in a direction opposite to what we call the current.

Which way does electricity really flow?

Early scientists believed that electricity was some kind of positively charged fluid that flowed through wires. Even though we now know electric current is due to the flow of negatively charged particles, it has not changed the fact that all electrical wiring diagrams are written as if electricity was a flow of positive charge! In the end, it makes no difference to how things work.

WORKSPACE
Types of energy transformations

EXPERIMENT 8.4

Types of energy transformations

Possible risks	Safety precautions
Globes become very hot after they have been on even for only a few seconds.	Take care not to touch the globes while they are on or for a while afterwards.

Aim

To observe different types of energy transformations using simple electric circuits

Materials

- power pack (or battery)
- 3 connecting wires
- switch
- globe
- 12 volt electric bell
- small 12 volt electric motor

Method

1 Using the circuit diagram shown in Figure 8.16 on page 218, connect a globe to a power source.

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EXPERIMENT 8.4

2 Taking care not to touch the globe, observe the heat it generates when the switch is closed by placing your hand just above the globe while it is on.

3 When the globe has cooled, disconnect the globe and connect the electric bell. Observe and record the forms of energy generated when the bell is on. Note: You will need to use the AC connections from the power pack for the bell – a battery will not work nor will the DC connections.

4 Finally, connect the electric motor to the power source and again observe all of the forms of energy generated when the switch is closed.

Results and discussion

1 Record your observations in a table with the column headings 'Device', 'Energy type(s) produced' and 'Comments'. **Identify** the types of energy produced. In the 'Comments' column, **describe** how efficient the device is in producing the type of energy for which it is designed.

Conclusion

2 Write a concluding statement about energy transformations in simple circuits.

QUESTIONS 8.3

What have you learnt?

Understanding

1 **Recall** the different types of energy that have been observed being produced from electrical energy.

2 **Recount** how electricity flows through a simple circuit.

Applying

3 **Explain** why the direction of the flow of electrons around a circuit is opposite to the direction of the assumed flow of positive fluid that electricity was once thought to be.

4 **Explain** why it is important to consider the efficiency of a device.

5 A small incandescent light globe is normally placed inside a chicken hatching cage. **Explain** the purpose of this, using the words 'energy' and 'transformation'.

Analysing

6 **Discuss** whether there is any 'missing' energy when an electric bell is operating.

Creating

7 **Summarise** your knowledge of circuit diagrams and transformation of energy by drawing and labelling a simple circuit diagram for a device that produces heat, light and sound energy.

WORKSPACE
What have you learnt? 8.3

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8.4 Series circuits

When two or more devices are connected end-to-end so that all the electric current that flows through the first device must also then flow through the second device, we say that the two devices are wired in 'series'. Series connections are useful in special applications such as Christmas tree lights, where one globe has a built-in switch that turns on and off to make the lights flash. Other globes are connected in series with this one so that they all flash on and off together. There are, however, problems with having many globes connected in series, as Experiment 8.5 will show.


Shutterstock.com/Fotomicar

Figure 8.18 Series connections are useful for holiday decorations.

WORKSPACE
Globes in series

EXPERIMENT 8.5

Globes in series

Aim

To investigate what happens when several globes are connected in series

Materials

- power pack or battery
- 3 globes, preferably identical
- switch
- 5 connecting wires

Method

1 **Identify** the safety hazards of constructing an electric circuit and **explain** how you will control these hazards.

2 Connect a globe and a switch to a power pack or battery as shown in Figure 8.16 on page 218.

3 Close the switch and observe the brightness of the globe.

4 Next, add another globe into the circuit in series with the first globe. One extra connecting wire will be needed to do this correctly. Your circuit should now be the same as the circuit diagram in Figure 8.15 on page 217.

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EXPERIMENT 8.5

5 Close the switch and record your observations about the brightness of the two globes compared to when only one globe was used.

6 Now add the third globe into the circuit, in series with the other two globes. Again, close the switch and record your observations of the brightness of the three globes.

Results

1 Record your observations in a table.

Discussion

2 **Explain** why you think the brightness of the globes changes the way it does when extra globes are added to the circuit.

3 **Describe** how the circuit with the three globes is similar to a string of flashing Christmas tree lights.

Further investigation

4 Before packing away your apparatus, **investigate** and **describe** what happens to the other two globes if one globe is disconnected or taken out of its socket.

5 **Investigate** if there is a way to control each globe separately or independently using extra switches while the globes are connected in series.

6 One group connects a single globe in a circuit with the voltage set to 4 volts, while another group connects three globes in series with the power pack set to 12 volts. **Compare** the brightness of all the globes.

QUESTIONS 8.4

What have you learnt?

Understanding

1 **Explain** why it is not possible to make globes go on and off individually if they are connected in series.

2 Draw a circuit diagram that has a battery, a switch, a globe and a bell all connected in series.

Applying

3 Use your observation from Experiment 8.5 to **discuss** whether wiring the globes of a car's headlights in series would be a good idea.

4 Research the use of series circuits and **describe** any other application of series connection you find.

Analysing

5 Using your observations from Experiment 8.5, estimate the voltage that each globe experiences when three globes are connected in series and the powerpack is set to 12 volts.

WORKSPACE
What have you learnt? 8.4

ISBN 9780170231497

8.5 Parallel circuits

load
the total amount of electricity being used at that time

circuit breaker
a device that acts like a switch and will turn off if it detects an unsafe load on the circuit

Parallel circuits are found in many applications where more than one appliance or device requires electrical energy at the same time. It is quite common for several appliances, such as the television, DVD player, computer and phone chargers, to all be plugged into the same circuit and in use at the same time. Connecting more appliances would not normally make any difference to the other appliances or devices already plugged in unless the total **load** on the circuit was too much. If this happens the **circuit breaker** cuts the power to the circuit to protect the wires from overheating and possibly causing a fire.

Figure 8.19 A household circuit breaker

Getty Images/Science Photo Library

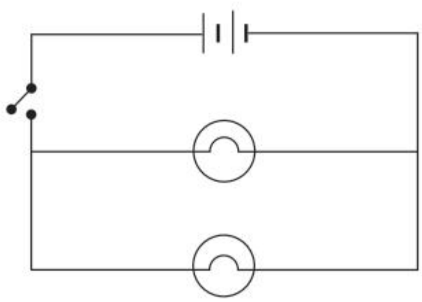

Figure 8.20 A circuit diagram showing two globes in parallel

In Experiment 8.6 you will be able to compare the behaviour of globes in parallel with that of the globes in series, which you investigated in Experiment 8.5.

WORKSPACE
Globes in parallel

EXPERIMENT 8.6

Globes in parallel

Aim

To observe what happens when globes are connected in a parallel circuit

Materials

- power pack or battery
- 3 globes, preferably identical
- switch
- 7 connecting wires

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EXPERIMENT 8.6

Method

1 Connect one globe into the circuit with the switch, as shown in Figure 8.16 on page 218. Observe how bright the globe glows when the switch is closed.

2 Connect an extra globe in parallel with the first globe, as shown in Figure 8.20. To do this, connect a wire to each side of the second globe and then 'piggyback' the other ends of these two wires onto either side of the first globe.

3 Close the switch and observe both globes.

4 Add a third globe in parallel with the other two globes by following the procedure in step 2. Piggyback this globe onto the second globe. Draw a circuit diagram of your circuit.

5 Close the switch and observe all three globes.

6 **Investigate** what happens to the other globes when one globe is taken out of its socket.

Results

1 **Compare** the brightness of the globes in steps 1, 3 and 5.

Discussion

2 **Describe** how the power being provided by the power source changes as extra globes are connected to this parallel circuit.

3 **Discuss** with others in your group whether household lights that have more than one globe have the globes wired in series or in parallel with each other. Record your conclusions.

Conclusion

4 Write a brief conclusion for this investigation.

Extension

5 Before packing away your apparatus, **investigate** how extra switches could be wired into the circuit with three globes so that each globe is controlled by a separate switch. Draw the circuit diagram for the circuit you construct.

QUESTIONS 8.5

What have you learnt?

Understanding

1 **Define** the terms 'series' and 'parallel' when they are used to describe connections in circuits.

WORKSPACE
What have you learnt? 8.5

ISBN 9780170231497

QUESTIONS 8.5

Applying

2 There is a limit to how much power any powerpack can deliver to a circuit. **Explain** why it would not be possible to connect a very large number of globes in parallel using just one powerpack.

3 **Discuss** whether the taps in your home or connected to the main water supply from the street are connected in series or in parallel.

4 **Recall** the advantages of connecting globes in a chandelier in parallel.

5 Using a circuit diagram, **describe** how it would be possible to connect two globes in parallel as well as two globes in series in the same circuit.

8.6 The story of the light globe

Before the invention of fire, nights were always very dark. An advance on the primitive camp fire came with the invention of candles and oil lamps. Up until the 1880s, all streets were lit by gas lanterns that had to be lit individually each evening and turned off again by hand each morning. Tamworth, in New South Wales, was the first city in the southern hemisphere to use electric street lighting in 1888. A power station was built in Tamworth to supply the electricity needed.

The beginning – the first light globe

American inventor Thomas Edison (1847–1931) patented many of his inventions, including the first practical incandescent light globe. More than 1000 patents were registered by Edison, but he is remembered mainly for his invention of the first commercial electric light globe. A glass bulb enclosed a thin piece of carbonised bamboo which gave off light when an electric current was passed through it.

This idea was nothing new, as Alessandro Volta had demonstrated the first electric light back in 1800. However, Edison's light bulb lasted much longer than any other and was practical in that it did not need a large amount of electric power for it to operate.

For the next 130 years or so, the improved incandescent light globe was used as the main source of light in almost every house that had electricity. As has been seen in the experiments in this chapter, incandescent light globes produce more heat energy than light energy, making them quite wasteful and inefficient.

ACTIVITY SHEET
My day without electricity

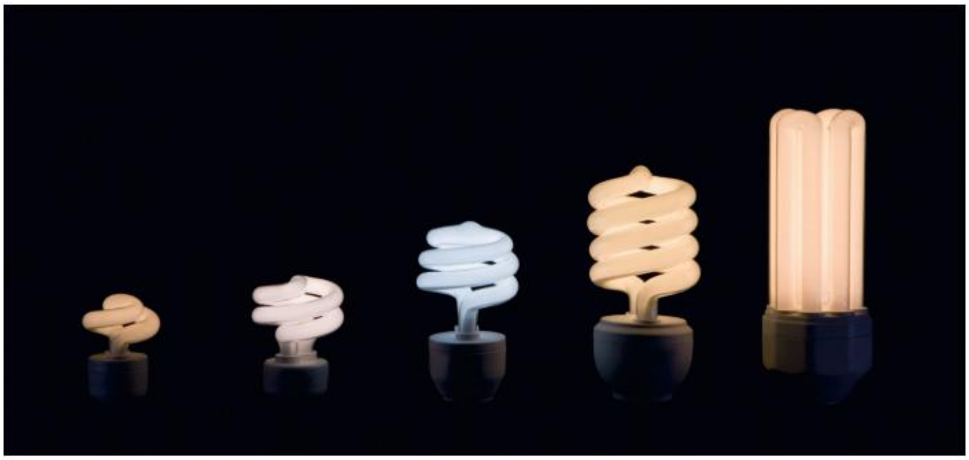
© Dennis MacDonald/Alamy

Figure 8.21 The first electric light globe as patented by Thomas Edison

ISBN 9780170231497

Improvements on Edison's light globe

Incandescent light globes have poor efficiency and a short life span, so better devices to produce light from electricity were sought. The development of the fluorescent light took many decades, and itself led to improved designs for incandescent lights. By the late 1930s, fluorescent lights were available commercially that were reliable and produced much more light than similar incandescent globes. Schools, factories, shops and other outdoor places such as train stations use fluorescent lighting due to its efficiency and strong light output.



Corbis/Joho/cultura

Figure 8.22
Some examples of compact fluorescent light globes

Governments in many countries, including Australia, have phased out most incandescent globes in favour of compact fluorescent lights, as they use much less electricity. Although they are more expensive to buy, the money they save by lasting longer and using less electric power has made them a more efficient alternative to the old-fashioned technology of heating a wire to make it give off light.

Light-emitting diodes

Light-emitting diodes (LEDs) are electronic devices that are small and very efficient. Because of their efficiency and small size, they are used widely for indicator lamps in switches, in modern car brake lights and torches, and as interior lighting for boats, and even in some television and mobile phone screens. LEDs are becoming more widely used as their price comes down and in the near future they will be widely used in household lighting applications, as well as in offices, factories and schools.

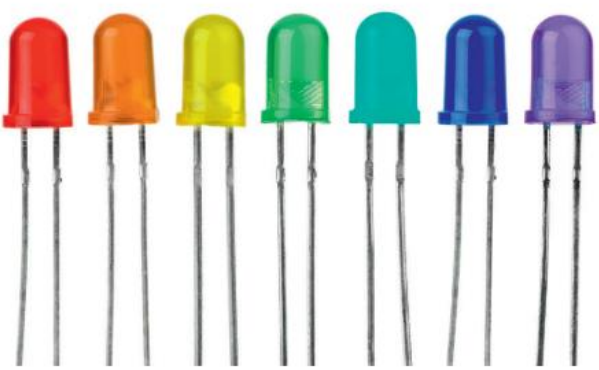


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Figure 8.23
LEDs are compact and very efficient.

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WORKSPACE
What have you learnt? 8.6

QUESTIONS 8.6

What have you learnt?

Understanding

1 **Describe** how you can tell that an incandescent light globe is not efficient at converting electrical energy into light energy.

2 **Compare** how an LED torch would feel to touch after it had been on for several minutes to how a normal torch with an incandescent globe would feel after being left on for the same time.

Applying

3 You are the designer of a boat that is powered by batteries only. **Describe** the type of lights you would install for the inside of this boat.

Analysing

4 Count the number of individual lights there are in your science laboratory. If each of these lights was replaced with an incandescent globe that produced the same amount of light, **describe** two effects that this would have on the school or the laboratory.

5 Observe the brake lights of old cars and **compare** them to the brake lights of a new car that uses LEDs (LEDs look like lots of small dots in the light). **Describe** your observations and **explain** why LEDs are now used in car brake lights.

Reflecting

6 Research the advances made in light technology over the years from the time of fire to the present. **Construct** a timeline to **show** when important advances or discoveries were made.

7 **Predict** what you think might be the next invention or advance in lighting technology. You may be as imaginative as you like!

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Chapter review

Remembering

1 **Recall** how galvanic cells are important in our society today.

Understanding

2 **Describe** the best way in which you could avoid being struck by lightning if caught outdoors in a thunderstorm.

3 **Explain** your observations from Experiments 8.5 and 8.6 by **describing** the sharing of the available electrical energy that occurs between the globes when they are wired in series and then in parallel.

Applying

4 **Explain** how static electricity is different from the electricity that is available from power points in homes.

5 **Describe** how electricity can flow through a conductor such as a wire.

6 **Explain** why power points should not be installed above the basin in a bathroom.

7 **Explain** why a very tall building in the city has a thick copper wire running down the side of the building from the roof into the ground.

8 **Compare** the uses of series and parallel circuits for household lighting.

9 **Explain** why having too many household appliances on at the same time may cause the circuit breaker to switch the power off to the circuit. Use this fact to **justify** the conclusion that power points in a household circuit are wired in parallel.

Analysing

10 It often feels very hot when you are sitting under bright stage lighting. Use this information to **discuss** what types of light globes are used in stage lighting.

11 Fluorescent globes are quite difficult to dim or turn down. **Identify** several applications for which incandescent globes may still be preferred over fluorescent globes.

12 A proposed new type of car brake light is designed to have nine LED globes connected in series with each other. **Justify** the reason that may have been given for this design to have been changed so that the LED globes were connected in parallel.

13 **Discuss** in your group and as a class whether it would be possible to produce a light globe that is 100% efficient. Record your conclusions.

14 **Account** for the fact that all electrical experiments performed in the laboratory with bare wires are done using no more than 12 volts.

WORKSPACE
Chapter 8 review

ACTIVITY SHEET
Chapter 8 checklist

REVIEW QUIZ
Chapter 8

ISBN 9780170231497

Evaluating

15 **Describe** the uses of circuit diagrams and **evaluate** how helpful they are for people who work with electricity, such as electricians.

16 A friend claims to have designed a light globe that can emit 10 times more light energy than any modern light source for the same energy input. **Assess** whether this could be true and give reasons for your decision.

Creating

17 **Justify** the forced replacement of incandescent globes with compact fluorescent globes.

18 **Outline** how different our cities would be if electricity could not be transported over long distances from a power station.

19 **Describe** the role of electricity in society in 30 years from now in *one* of the fields of communication, medicine or computing by predicting how these fields may have changed in this time. **Justify** your ideas.

Reflecting

20 **Examine** your learning process for this chapter. Which types of activities helped you best understand the concept of electrical energy?

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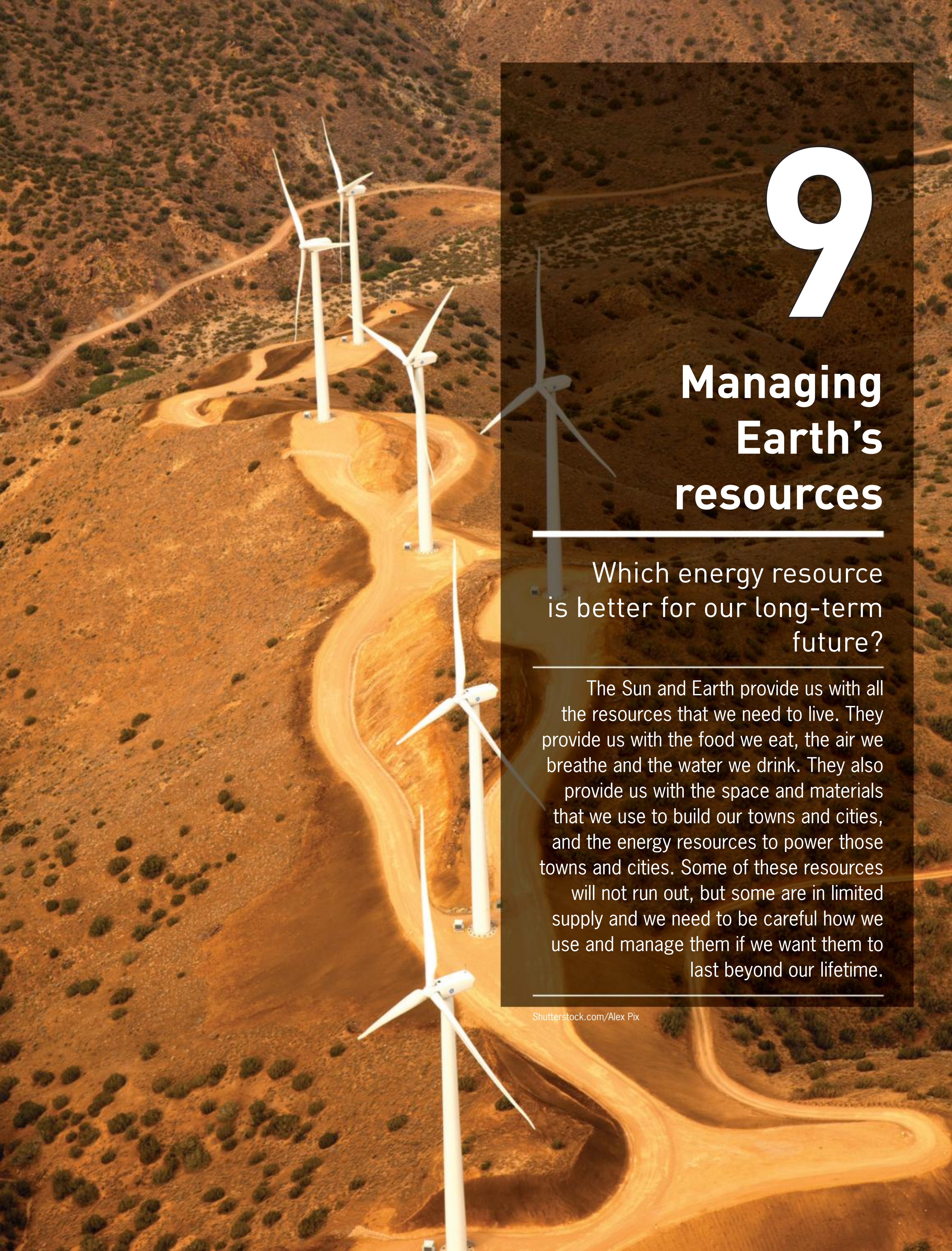

9

Managing Earth's resources

Which energy resource is better for our long-term future?

The Sun and Earth provide us with all the resources that we need to live. They provide us with the food we eat, the air we breathe and the water we drink. They also provide us with the space and materials that we use to build our towns and cities, and the energy resources to power those towns and cities. Some of these resources will not run out, but some are in limited supply and we need to be careful how we use and manage them if we want them to last beyond our lifetime.

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Earth and space – Stage 4

Key knowledge

- Resources may be renewable, such as sunlight or wind; or non-renewable, such as coal or copper.
- Resources can come from many sources in Earth's spheres (e.g. lithosphere, hydrosphere) and from the Sun.
- Water is a precious, finite resource that cycles through the environment via evaporation and condensation.
- Efforts are being made to manage Earth's resources responsibly and seek alternatives.
- Science understanding has helped to develop better water management in the home and in agriculture, including recycling grey water.
- Many factors influence the decision to use a non-renewable resource.
- Research is being undertaken into new resources and materials.
- Scientific advances have helped to develop new sustainable practices in agriculture; they also help people make informed decisions about resource use.

ACTIVITY SHEET
CAT with rubric: Energy resource

CULMINATING ASSESSMENT TASK

Energy resource

Prepare an electronic report about the responsible and sustainable use of one energy resource. **Show** how you might either reduce its use, or increase its use so that the use of another form of energy can be reduced.

In your presentation, present the pros and cons of your energy resource.

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What do you already know about resources?

1 As a class, brainstorm all the different types of resources that we get from the Earth. **Define** each one in a short sentence.
2 **Outline** what each resource is used for. Remember that some types of resources can be produced from other types.
3 **Construct** chains to **show** any links that you can see between resources.
4 **Describe** what you think will happen if these resources ever run out.
5 Use an electronic graphic organiser, such as a concept map, mind map or lotus tool, to connect the word 'resource' to these definitions, ideas and chains.

9.1 Types of resources

The Earth provides many **resources** from both living and non-living sources. Humans exploit these resources in a variety of ways, to provide us with new materials, food and energy. **Energy resources** can be classified into **renewable energy** resources and **non-renewable energy** resources.

What do you understand to be the difference between renewable and non-renewable energy resources?

resource
something that needs to be consumed to gain benefit from it, such as air, food and energy

energy resource
any resource that can be used to transfer or transform energy

renewable energy
energy that, when used, can be readily replaced within a reasonable time

non-renewable energy
energy that, once used, cannot be readily replaced within a reasonable time

ACTIVITY 9.1

Identifying types of energy resources

It is not always completely clear whether an energy resource is renewable or non-renewable.

1 **List** five energy resources that you think are:
  a renewable
  b non-renewable.
2 In a group, **discuss** why you think a resource is renewable or non-renewable.
3 **Propose** an agreed statement that helps to classify resources into 'renewable' and 'non-renewable'.

WORKSPACE
Identifying types of energy resources

ICT

Use a share document such as Google Docs or One Note to collaborate with other students.

ACTIVITY SHEET
Energy use and wealth in different countries

Renewable and non-renewable resources

A resource that is considered renewable will never run out. In the case of timber, once a forest is harvested, new young trees are planted and these grow back within a few years. Solar energy is provided continuously from the Sun, and can never be used up in the foreseeable future. However, **fossil fuels**, which include coal, oil and gas, take too long to re-form again to be considered renewable.

fossil fuel
an energy resource produced over millions of years from once-living organisms

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VIDEO
Alternative fuels

Table 9.1
Classifying resources

Resource	Type
Fossil fuels – coal, oil and gas	Non-renewable
Timber	Renewable
Wind	Renewable
Solar	Renewable
Tidal	Renewable
Uranium (for nuclear power)	Non-renewable
Geothermal	Renewable
Wave power	Renewable
Fresh water	Renewable
Metal ores	Non-renewable

Resources from living things

biofuel
fuel made from plant or animal material

sustainable
can be reliably used as a resource into the future without causing damage to the environment

Resources derived from a living or previously living source include fossil fuels (coal, natural gas, petroleum), **biofuels**, forestry products and other plant products, such as cotton or food, and animal resources, such as fish. All of these resources relate to important industries in Australia and around the world. It is essential that we ensure the **sustainable** use of all resources by carefully managing how these are used. If you want to use a resource, such as the fish in the sea, forests on land or fossil fuels for energy needs, you must make sure you have enough for now and for the future. By sustainable we mean a resource that we manage so that we can continue to rely on the availability of that resource forever. In this chapter, we will explore which of these resources are sustainable and which are not.

ACTIVITY 9.2

Considering sustainability

If you were to manage your use of resources every day, what must you consider? Work in a small group to brainstorm a response. (Hint: Start by listing all the resources you use every day.)

Are all resources from living things renewable?

Indigenous Australians have been managing the Australian environment in a sustainable manner for up to 50 000 years. There is evidence that Aborigines mined the land for more than 40 000 years before European settlement, with ochre and stone mines being found across Australia. Trading of these commodities occurred between Aboriginal clans at that time.

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In more recent history, coal and uranium mining has occurred on Aboriginal land. Confrontations between Aborigines and developers led to the *Aboriginal Land Rights Act* in 1976, which recognised the Aboriginal system of land ownership. This has led to a more peaceful consultation about the use of Aboriginal land and, particularly, the protection of sacred sites.

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Figure 9.1
Ochre pits in MacDonnell ranges, Northern Territory

climate change
a long-term, well-established difference in weather patterns

For a resource to be sustainable you must use no more today than you can replace for use in the future. Firewood, for example, can be grown continuously. This is why firewood is a renewable resource. On the other hand, once you have dug out and used coal, you will have to wait several million years to produce a similar size of resource. Coal is non-renewable.

Sustainability means more than just replacing a resource. You have to consider the effect of the resource on the environment. For example, the burning of firewood and coal produces carbon dioxide and water vapour. Both of these gases contribute to **climate change**.

Figure 9.2 (left)
Firewood is a renewable resource if managed correctly.

Figure 9.3 (right)
Coal is a non-renewable resource as it takes millions of years to regenerate.

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a

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b

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Figure 9.4 **a** Growing trees remove carbon from the atmosphere. **b** When burned, they return the same amount of carbon to the atmosphere.

carbon neutral
the uptake and release of carbon in a process are equal

Trees grow using the process of photosynthesis, which takes carbon dioxide from the air. The carbon is therefore stored in the tree. During the burning of firewood, the carbon stored in the tree is returned to the atmosphere. Thus, the burning of firewood is **carbon neutral** because no new carbon is released into the atmosphere.

Fossil fuels

anaerobic
without oxygen

non-porous rocks
rocks which water cannot penetrate nor flow through

Coal, natural gas and oil are called fossil fuels. Fossil fuels require specific conditions in which to form. They are formed from the remains of animals and plants, so this resource is said to come from a living source. These dead organisms have been covered in silt or mud, usually at the bottom of lakes and seas. The **anaerobic** decay of these organisms means that, although their cell structures break down, the carbon chains that are the basis of their cells do not. Pressure and heat squeeze out other substances, such as water, leaving mostly the carbon chains behind. The forming oil or coal becomes trapped beneath **non-porous rocks**, so it cannot rise to the surface. Large amounts of these organisms are required to make a usable deposit of coal, oil or gas. This process takes millions of years, so fossil fuels are considered to be non-renewable energy resources: once used, they are not replaced in a reasonable amount of time.

Coal is not carbon neutral. The carbon used to grow the trees that eventually becomes coal has been locked up underground for millions of years. The atmosphere has developed without this carbon. When burned, coal releases this carbon into the atmosphere, thus increasing the total amount of carbon dioxide in today's atmosphere.

a

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b

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Figure 9.5 **a** Growing trees removed carbon from the atmosphere millions of years ago. **b** When those trees are burned as coal, they increase the amount of carbon in today's atmosphere.

Biofuels – an alternative to fossil fuels

In recent years there have been significant technological advances and research into producing fuels that have not come from fossils, but rather from plant material. Such fuels are known as biofuels, examples of which include ethanol and biodiesel. By combining

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scientific knowledge across a number of disciplines of scientific research – biology, chemistry and agriculture – it is possible to convert waste plant material from sugar cane or wheat into ethanol.

In New South Wales, 90% petrol largely replaced the normal unleaded petrol in 2012. The use of biofuels has been introduced to reduce our reliance on fossil fuels and to help reduce the emissions of carbon dioxide into the atmosphere. In 2011 the CSIRO announced that, in conjunction with Qantas, it was undertaking research into producing a biofuel that could replace the fossil fuel currently used for jet aircraft engines. In early 2012 the first Qantas plane to use this fuel flew between Sydney and Adelaide using a 50:50 blend of biofuel and conventional jet fuel.

WEBLINK
Biofuel use in New South Wales

QUESTIONS 9.1

What have you learnt?

Understanding

1 **Define** 'renewable energy' and give two examples of a renewable energy resource.

2 **Define** 'fossil fuel'. **Explain** why fossil fuels are regarded as non-renewable.

3 **Describe** what is meant by a 'sustainable' resource.

Applying

4 There are two main issues for the sustainable use of a resource. **Identify** these two issues.

Analysing

5 **Explain** why firewood is regarded as carbon neutral.

6 **List** three advantages and three disadvantages of non-renewable energy.

7 **List** 10 things that you could never do without fossil fuels.

8 Research, and then **identify** the key values involved for the Aborigines, and for the developers, that led to the *Aboriginal Land Rights Act 1976*.

Creating

9 Draw a diagram to **show** and **describe** the links between energy resources, responsible use of resources and sustainability.

10 Write a short speech that you would present to your member of parliament to recommend the further funding of scientific research into developing better biofuels that could be used to replace fossil fuels.

WORKSPACE
What have you learnt? 9.1

ISBN 9780170231497

9.2 Resources from non-living sources

Solar energy

radiant energy

energy that transfers across space without the need of a material in which to travel

The Sun, or Sol as it is named by astronomers, is our nearest star. **Radiant energy** from the Sun does not need a material to travel from Sol to Earth. The Sun has an abundant supply of energy, but this will eventually run out. There is so much sunshine energy in the form of heat and light that every person on the planet could light up over 300 000 large light bulbs every day with it!

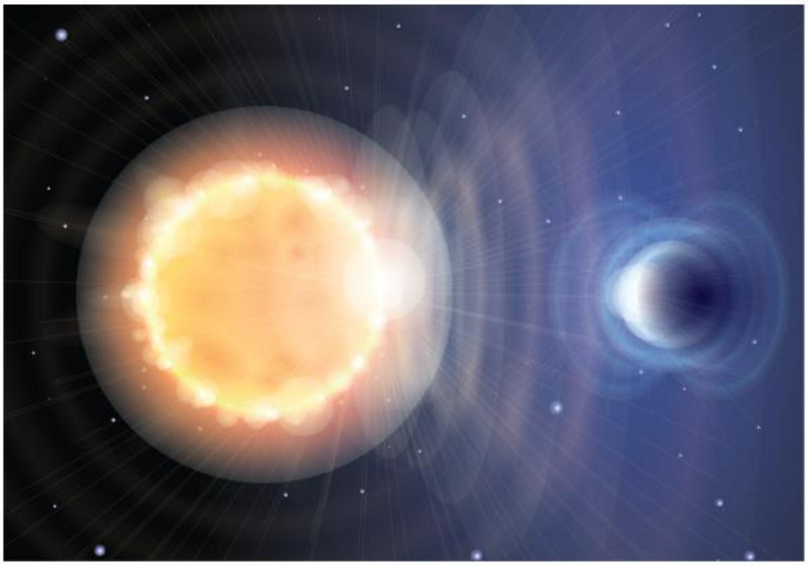

Figure 9.6 Radiant energy from the Sun travels to Earth.

The Sun loses over 4 million tonnes of its own mass each second as it sends out this energy, but the Sun is not going away any time soon. In fact, it will take several million years before it loses one-millionth of its total mass. This is why solar energy is regarded as a renewable energy source.

WOW!

$E = mc^2$

Albert Einstein was a great physicist and humanitarian who showed the world that matter is just another form of energy. His famous equation, $E = mc^2$, tells us how energy, E, and mass, m, are connected. Mass is truly just another form of energy, mass–energy. The Sun converts about 0.000 000 000 000 000 000 01 kg of mass–energy to other forms of energy every time a nuclear fusion reaction occurs. That's incredibly tiny! But there's so much fusion going on in the Sun that it all adds up to something huge!

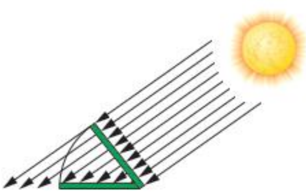

Figure 9.7 The amount of energy received depends on the angle of the surface relative to the Sun's rays.

The amount of solar energy reaching an area on the ground of one square metre (1 m^2) depends also on the angle of the Sun's rays. On a clear day the amount of **insolation** is at its greatest at noon, when the Sun is at the highest point in the sky. As the angle of the Sun to the Earth changes, the amount of insolation decreases.

insolation

exposure to the Sun's rays

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Using solar energy

Even though there is a lot of solar energy available, it is quite spread out. If we want to use solar energy, we need to capture it and concentrate it. There are three main solar energy systems that we use: **solar thermal**, passive solar and photovoltaic.

A solar thermal system converts solar energy directly into heat energy. This is done in a variety of ways, such as:

- direct heating of a solar panel
- concentration of solar energy by a lens (Figure 9.8)
- concentration of solar energy by a curved mirror (Figure 9.9)
- concentration of solar energy in an enclosed space.

solar thermal
the use of energy from the Sun to produce heat

WEBLINK
Solar power

Figure 9.8 (left) The lens in a magnifying glass concentrates sunlight.

Figure 9.9 (right) A power tower in Seville, Spain, receives concentrated sunlight from a field of curved mirrors.

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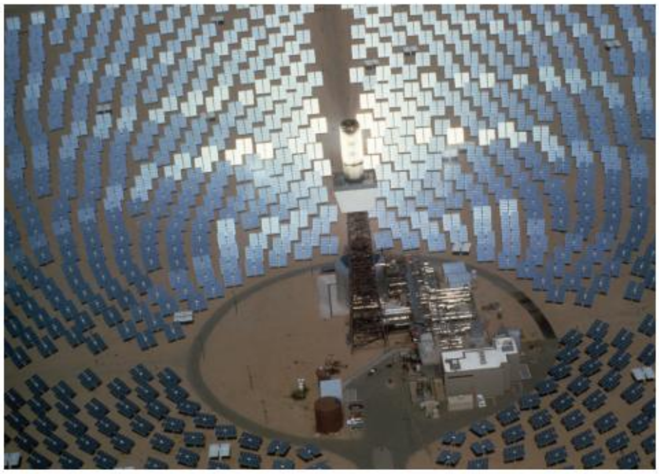

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ACTIVITY 9.3

National Solar Energy Centre (NSEC)

Australian scientists and engineers have done extensive research into solar concentration. The researchers are looking into solar energy concentration, passive solar design and the production of high-energy natural gas called SolarGas™.

1 Use the weblink 'NSEC' to answer the following questions.
   a **Identify** where in Australia the NSEC is located.
   b **Identify** the three main activities of the NSEC.

2 Use the weblink 'NSEC video' to answer the following questions.
   a **Identify** what is meant by 'solar energy concentration' and **describe** how it is different from passive solar energy.
   b **Identify** what the low-concentration array is designed for.
   c **Identify** what the high-concentration array is to be used for.

WORKSPACE
National Solar Energy Centre (NSEC)

ICT

Use Google Earth to locate Seville, Spain. Give one reason why Seville was chosen for the site of a solar power tower rather than Madrid.

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WEBLINK
NSEC

WEBLINK
NSEC video

Solar energy can be allowed to go into a box or room through a transparent material such as glass. The energy is then used in a passive solar energy system. The energy is absorbed by the air and surfaces inside the space. As a result, the solar radiation is changed so that it cannot go back out through the glass. Everything inside continues to receive energy, getting hotter and hotter in the process. (This is how a greenhouse or hothouse used by plant growers works. It is not how the atmosphere works, even though some people still talk about the 'greenhouse effect' when talking about climate change.)

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Figure 9.10 A solar thermal system installed on the roof of a house to heat water

Figure 9.11 Heat energy from the Sun enters the house through the skylight, and this energy is used to heat the room.

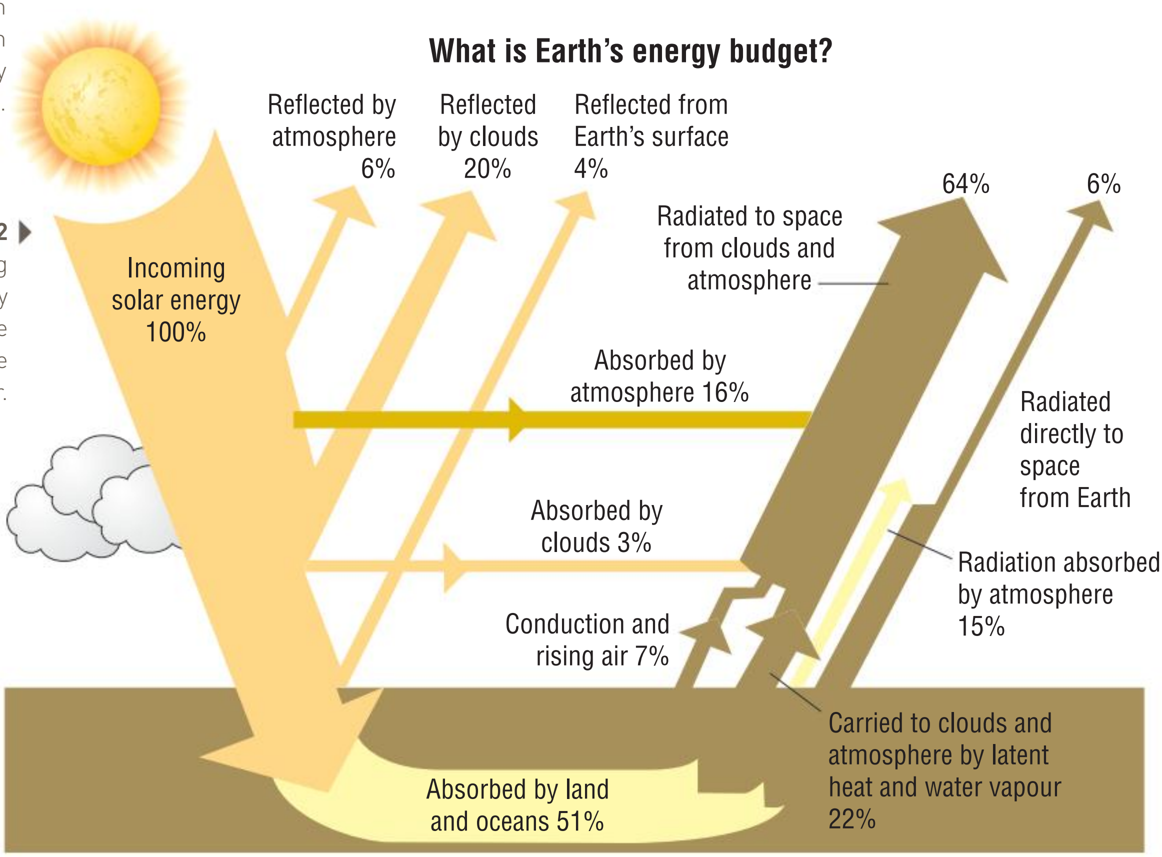

Figure 9.12 A Sankey diagram showing that solar energy is mostly absorbed by the ground. The re-radiated energy is more likely to be absorbed by the air.

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WOW! Solar energy and hot cars

The inside of a car left in full sun can get extremely hot, very quickly. The inside upholstery is often a dark colour or black, which absorbs heat really well. When the temperature outside is a relatively mild 30°C, the temperature inside rises to 55°C in less than an hour. Can you imagine what it would be like for a baby or pet to suffer high temperatures inside a car?

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VIDEO
Heating a house with solar energy

ACTIVITY SHEET
Student investigation: Interior car temperature

EXPERIMENT 9.1

Student investigation: Solar cooker

Possible risks	Safety precautions
Parabolic solar cookers generate a lot of heat and intense reflected sunlight.	Avoid burns from hot surfaces by taking care when touching the cooker. Never look directly at the Sun or at the sunlight reflected by the cooker.

WORKSPACE
Student investigation: Solar cooker

WEBLINK
Student investigation: Solar cooker

Aim

To build a solar cooker and then test it by cooking an egg

Method

1 Work in a team of 3 to 4. Access the weblink 'Solar cooker' to get ideas for how to build your cooker.

2 Create a flowchart to **show** the steps that you took to build a solar cooker.

Results

1 Prepare a video to **show** how you built and used the solar cooker.

Discussion

2 **Assess** the functionality of your solar cooker. **Discuss** the variables that will affect how well it works.

Extension

Design a fair test to measure the heat generated by your solar cooker when:

a the size is varied, or

b the available light is varied.

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WORKSPACE
Designing a passive solar house

ICT

You could use Google Sketchup to design your house.

INTERACTIVE
Energy-efficient house: exploring design

ACTIVITY 9.4

Designing a passive solar house

Work in groups of three to **design** the floor plan for a three-bedroom house, somewhere near where you live, that would be an ideal passive solar house.

Discussion

1 What other rooms will you need?

2 Where will the Sun be in summer and winter?

3 Which spaces do not need to be heated?

4 Which spaces could you use to protect rooms from too much or too little sunlight?

Figure 9.13 shows a possible floor layout for a two-bedroom house. You could use this to begin your thinking.

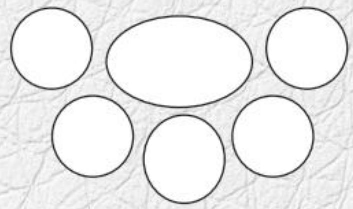

Figure 9.13 Layout for a two-bedroom house – the orientation and room names are not shown.

Extension

5 Would the design be the same for a house in Canada? **Explain** your reasoning.

6 **Outline** the difference, if any, it would make to the position of a passive solar house if it were in Darwin, which is well north of the Tropic of Capricorn.

photovoltaic solar
using the Sun's energy to produce a source of electrical energy

A **photovoltaic solar** cell converts sunlight directly into electrical energy. Several cells connected together form a panel, several panels form a module, several modules form an array, and several arrays form a field. Panels are covered in glass and metal to protect them from the weather.

WEBLINK
How it's made – solar panels

ACTIVITY SHEET
Comfortable low-energy houses

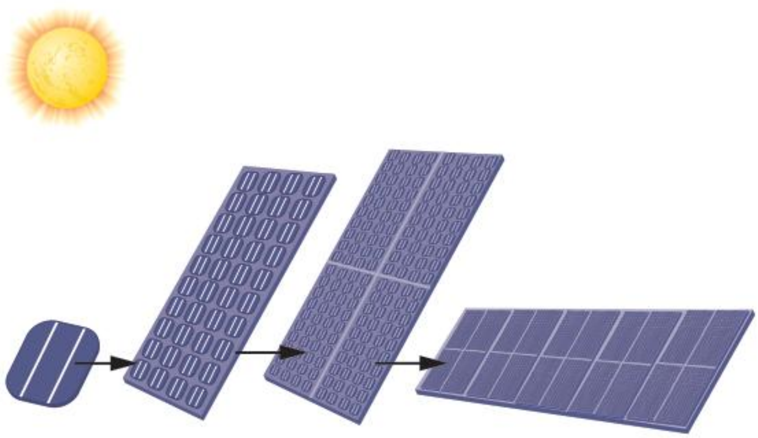

Figure 9.14 From cell to array

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Wind energy

Wind energy has been used by people all around the world for a very long time. Windmills have been used to grind wheat into flour and to pump water. Most recently, wind energy has been used to generate electrical energy in wind-driven **turbines**. Figure 9.15 shows a typical Australian farm windmill used to pump up water for stock. In the background is a wind turbine that generates electrical energy.

The Dutch people are renowned for their windmills, but windmills have been important in other countries, on other continents, for a long time. For example, windmills at Mykonos, in Greece, were built by the Venetians in the 16th century to grind wheat (Figure 9.16). The 7th-century windmills at Nashtifan, in Iran, used the wind to make flour from grain (see weblink 'Nashtifan windmills'); they are still in use today.

turbine

a type of generator; a turbine converts a form of energy into electrical energy

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Figure 9.15 A wind turbine behind a typical farm windmill

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Figure 9.16 Windmills at Mykonos in Greece

WEBLINK
Nashtifan windmills

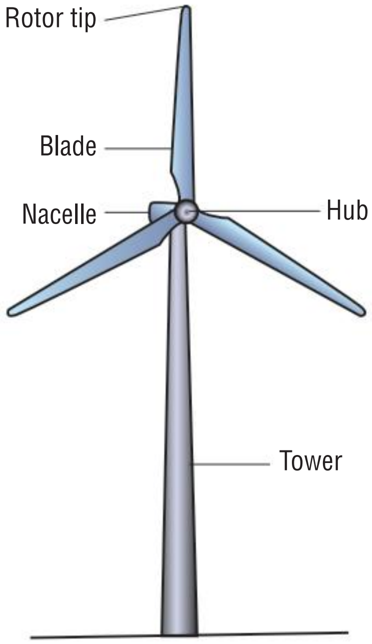
ACTIVITY SHEET
Windmills around the world

VIDEO
Renewable versus non-renewable energy

ISBN 9780170231497

Using wind energy to generate electricity

The energy of the wind is kinetic energy (energy of motion), which makes fans move. When these fans are connected to turbines, they generate electrical energy. Figure 9.17 shows a wind tower. The fan blades, or rotors, move when the wind blows. This movement is controlled by gears in the nacelle (see Figure 9.18). The gears are connected to the generator, which transforms the kinetic energy from the wind movement into electrical energy (Figure 9.19).



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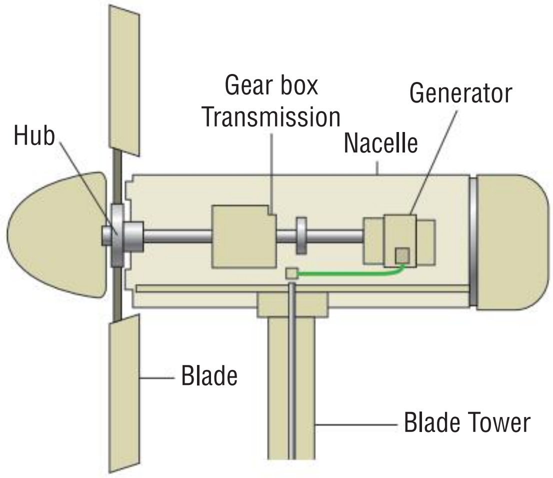


Figure 9.17 (left) The fan blades of the wind tower transfer wind kinetic energy to the turbine that generates electrical energy.

Figure 9.18 (middle) Close-up of the nacelle in which the generator and gears are located

Figure 9.19 (right) The equipment inside the nacelle

The wind turbines start to generate electrical energy when the wind speed reaches 14 km/h. When the wind reaches 90 km/h the system cannot operate, so it automatically shuts down and turns out of the wind to protect the blades.

ACTIVITY 9.5

A better windmill

1. Go to Google images and locate an image of a windmill.
2. Download this image and **describe** how you could improve the windmill by:
   - making one part bigger
   - adding a part
   - removing a part.
3. Upload your ideas to the class wiki.
4. Comment on one another's improved windmills.

ACTIVITY SHEET The Beaufort scale

INTERACTIVE It's not just wind

ACTIVITY SHEET Making a simple generator

WOW!

The Beaufort scale

Sir Francis Beaufort developed the Beaufort scale in 1805 to help sailors talk about different winds and their speeds. Winds are given a number on the Beaufort scale. The number on this scale corresponds to a description of the kind of wind and its effects.

ISBN 9780170231497

Wind turbines capture the energy of both horizontal winds and that of vertical thermals produced in **convection cells**.

convection cell

a movement of heated and cooling fluid, such as air, in a space

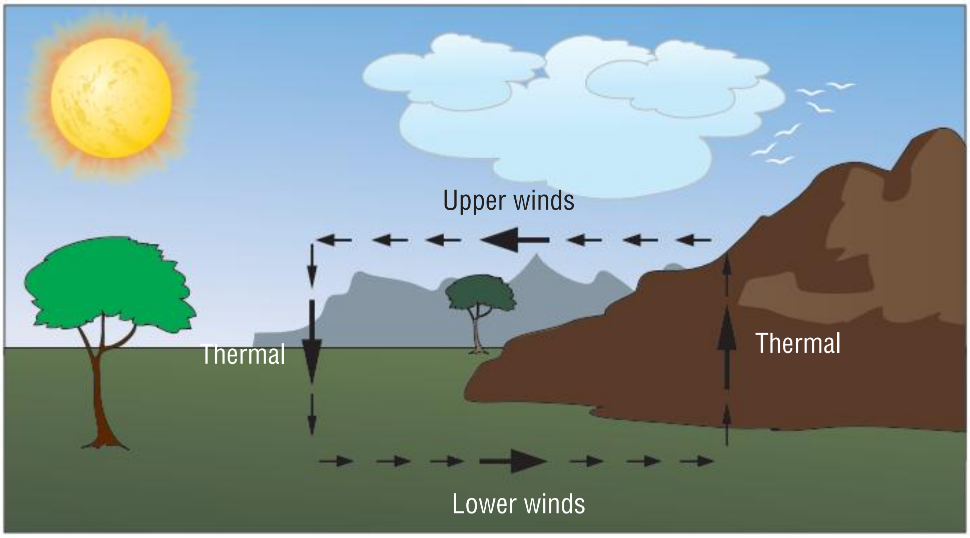


Figure 9.20 Atmospheric convection cell showing upper and lower horizontal winds and vertical thermals

EXPERIMENT 9.2

WORKSPACE
Observing convection currents

Observing convection currents

Aim

To observe **convection currents** in air

convection current

a large-scale movement of a fluid, such as air, away from or towards a source of thermal energy

Materials

- a convection box (If your school does not have a convection box one can be made using instructions found on the Internet.)
- a candle or incense stick

Method

1 Light the candle or incense stick and place it in the convection box under an open chimney.

2 Close the chimneys and observe the flow of the air around the convection box.

Results and discussion

1 Sketch the current of air observed in the convection box when both chimneys were open and again when the chimneys were closed.

2 **Describe** how the flow of air observed in the convection box is similar to the pattern of air currents found near the coast on a hot day.

3 **Explain** your observations by referring to the differences in the heat of the air within the convection box.

ISBN 9780170231497

Fremantle Doctor

WOW!

Almost every afternoon a wind from the direction of Fremantle, on the coast, cools the Western Australian capital, Perth. In summer, people really wait for 'The Doctor'. But it does have a downside – sand at the beach tends to be blown towards bathers, making a trip to the beach in the afternoon very uncomfortable. Cricketers find bowling into the Doctor quite difficult too. The batsmen don't mind so much, nor do the sailors on the Swan River!

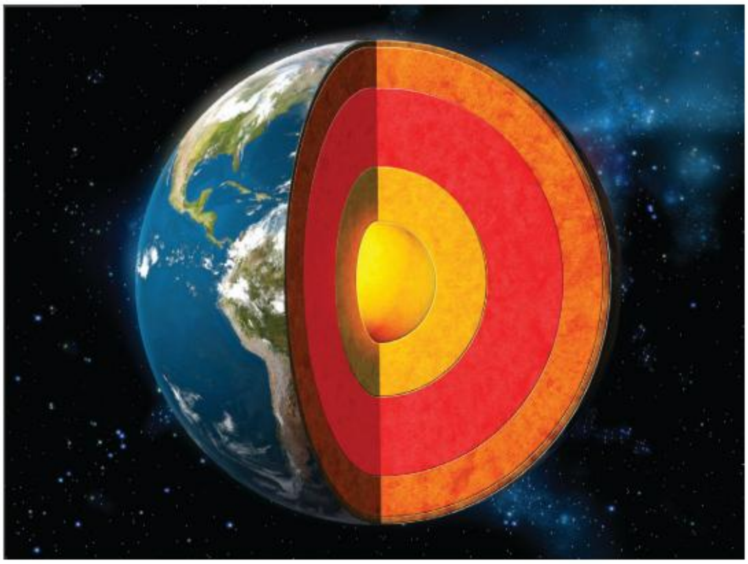
Newspix/News Ltd/Ross Swanborough

Geothermal energy

The Earth used to be a very hot place, even on the surface. It is gradually cooling from the outside. Mostly, we can stand on the surface of the Earth without too much trouble. As we go down into the Earth the temperature rises. The temperature at the centre of the Earth, 6400 km below the surface, is believed to be about 7000°C. It decreases to 1200°C at a depth of 100 km and to 650°C at 80 km. At the surface the temperature is about 20°C.

Hot, molten rock is found deep inside the Earth. There are places on Earth, however, where it has forced its way up closer to the surface. Here, overlying rock, often coal, forms a useful insulating blanket that keeps the temperature higher than normal. It is in these places that energy from the Earth, called **geothermal energy**, can be useful.

geothermal energy
an energy resource that uses heat from deep in the Earth



Shutterstock.com/Andrea Danti

Figure 9.21 The temperature at the centre of the Earth is thought to be 7000°C, decreasing towards the surface.

ISBN 9780170231497

WOW!

World's deepest mine

The world's deepest mine is the Tau Tona gold mine in South Africa. It is just 100 m short of 4 km deep. Australia's deepest mine , in Kalgoorlie, Western Australia, goes down about 2 km and is half the depth of Tau Tona. The Glencore XStrata zinc mine in Mt Isa, Queensland (below), is another very large mine, yielding zinc and lead.

Getty Images/Jack Atley/Bloomberg via Getty Images

Coal and gas-fired power stations all heat water to make steam. The steam, under high pressure, is capable of spinning the magnets of a turbine that generates electrical energy. Geothermal energy does the same. It heats water to steam, which is then used to spin electric generators. One way is to do this by using already heated water from natural **geysers**. Another way is to send water towards hot rocks, where it is heated and returned to the surface for use by a generator.

geyser

a spout of water heated from deep in the Earth

WEBLINK
Tau Tona

Shutterstock.com/Todd Mestemacher

Figure 9.22
Steam rises from a geyser. The energy is used to drive a turbine to generate electrical energy.

ISBN 9780170231497

WORKSPACE
What have you learnt? 9.2

QUESTIONS 9.2

What have you learnt?

Understanding

1 The Sun loses an enormous amount of mass every day. **Describe** why, then, is it regarded as a renewable energy source?

2 **Define** 'geothermal energy'.

3 **Outline** two examples of the way geothermal energy could be used.

Applying

4 Solar energy is used in three different ways. **Identify** each of the ways and give an example of each.

Analysing

5 **Describe** the main features of a passive solar system. How could this be applied to your home or school?

6 Write three questions for which the answer is 'solar energy'.

Creating

7 **Describe** how you could use solar energy in your home or school as part of the sustainable and responsible use of energy resources.

Reflecting

8 Go back to your electronic report in the culminating assessment task and add and subtract things from it to **show** how your thinking and understanding have changed.

9.3 Using resources: making choices

Case study 1: wind farms in Australia

Wind farms are expensive to set up. A lot of planning is done to find the right location. It is essential that the location has winds that blow sufficiently well all day and all night. Along the coast of south-western and southern Australia there are many suitable sites. The winds come uninterrupted over thousands of kilometres from the west and south.

Along the coastline, **thermals** rise up cliffs. There are usually onshore and offshore convection cells during the day and night as well.

thermal
an air current rising vertically as a result of air being heated by the ground

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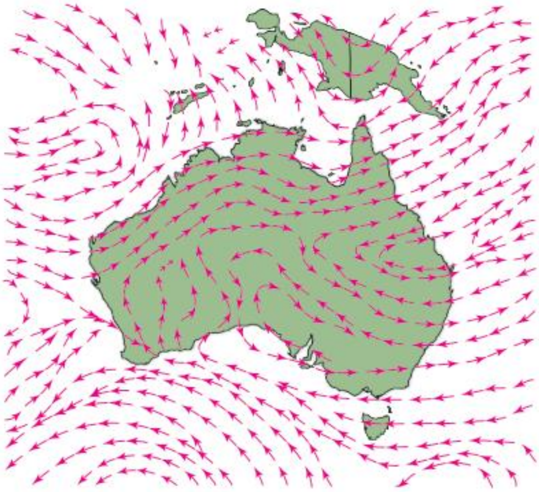

Getty Images/Warwick Kent

Figure 9.23 (left) Wind patterns around Australia

Figure 9.24 (right) This wind farm near Canberra uses thermal winds coming off Lake George.

Wind farms have been criticised because they change the look of the landscape and occasionally birds fly into the rotating blades. However, they provide sustainable, free energy.

ACTIVITY 9.6

Locating wind farms

1 Use Google Earth to find three Australian wind farms.
2 Take a screen grab of each and upload them to the class wiki.
3 Comment on the location of each of the wind farms, and specifically **explain** why each of the locations would have been chosen.
4 Go to the interactive 'Wind farms – pros and cons' and **summarise** both sides of the case.
5 **Discuss** in a paragraph your personal point of view on wind power.

INTERACTIVE
Wind farms – pros and cons

VIDEO
World's largest wind farm

Case study 2: using coal in Australia

The advantages of using a non-renewable resource need to be weighed up against some of the problems caused by its extraction and use. Cheap and plentiful fuel for power stations and for vehicles has allowed our society to prosper and become one of the richest in the world. However, these resources need to be used responsibly and with consideration of other factors, such as the environment (both locally and globally) and health concerns, and with the knowledge that at some time in the future the supply of such resources will eventually become harder to achieve and sustain, before they finally run out altogether.

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WEBLINK
The Australian Mine atlas

Australia is the world's largest exporter of coal. It is used in the manufacture of steel and for burning in coal-fired power stations. Australia is expected to export 450 million tonnes of coal in 2015, mainly to China, India and Japan. New South Wales alone is expected to export almost half of this. We also rely on coal for our own electricity supply, with the vast majority of electricity production in New South Wales coming from coal. Coal is obtained either from open-cut mines or from underground. Both types of mines are found in areas where a seam of coal is found in the layers of rocks. Underground mines can be very dangerous, especially if methane gas, a type of explosive gas associated with coal formation, is allowed to build up in the mine. Open-cut mines require the removal of vast areas of top soil and leave behind huge holes in the ground that require expensive rehabilitation so that the area can be used again. Some of the land where coal is mined is in sensitive national parks or takes up valuable farm land where food crops are grown.


Corbis/Ashley Cooper

Figure 9.25 An open-cut coal mine in the Hunter Valley in New South Wales


NSW Trade & Investment, Minerals Division, photographer David Barnes

Figure 9.26 An underground coal mine near Lithgow

Alternatives to coal

Alternatives to coal, such as natural gas and wind, hydro and solar power, contribute comparatively small amounts to our overall electricity use. The huge size of coal-fired power stations needed to meet the energy demands of a modern society such as ours, as well as the difficulties in being able to store electricity from other sources, results in alternatives to coal being more expensive and less reliable. However, with advances in technology, wind farms and solar

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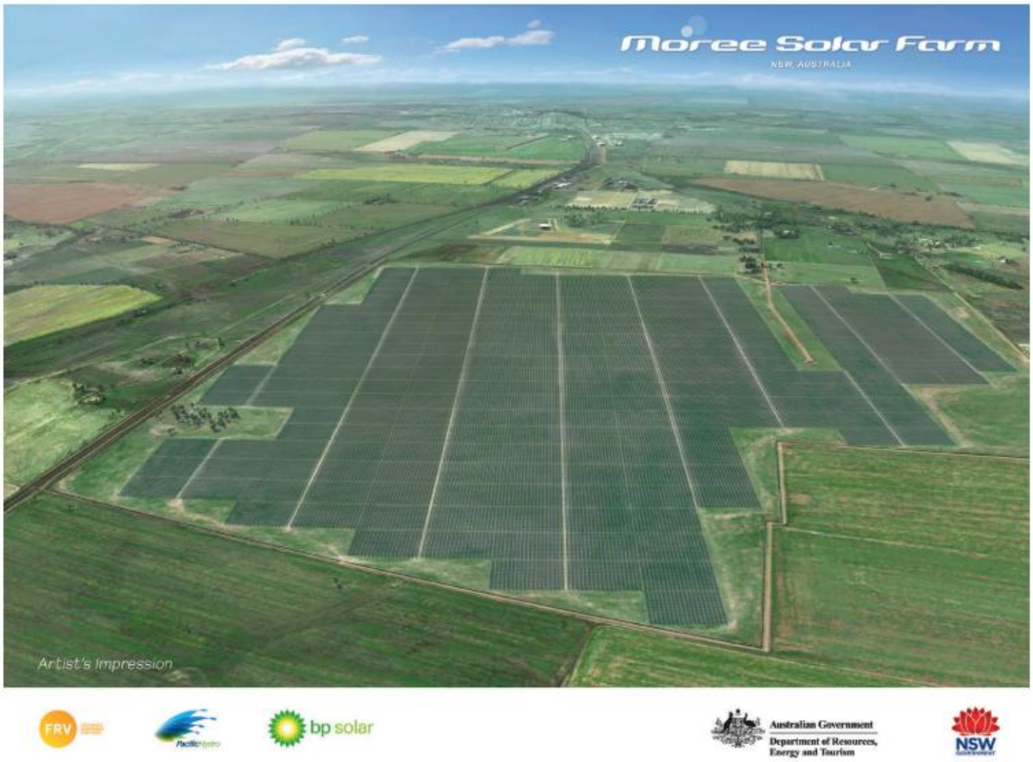
farms are being built around the country to supplement the electricity supply obtained from coal. The Snowy Mountains Hydro-Electric Scheme has been used since the 1960s to help meet the demand for electricity in times of peak demand such as in the early evening.

Critics of alternative sources of electricity say that wind power is not reliable as the wind is not constant and that solar power only works in daylight. Again, technological advances being made in these fields may mean that in the future we will find solutions to these problems.



Moree Solar Farm © BP Solar Pty Ltd

Figure 9.27
A proposed solar power farm near Nyngan, outback New South Wales, will produce enough electricity for 20 000 homes.

ACTIVITY 9.7

Issues with the use of coal in New South Wales — a group debate

In small groups, select two teams of researchers. One team will research and gather information about 'Why we need coal mining in New South Wales'; the other group will research the topic 'Why we need alternatives to coal mining in New South Wales'. Each group should come up with five different points to support their side of the argument. Arrange to present your information in the form of a debate either between the two groups or as part of a larger class debate.

Summarise the main arguments put forward by both sides in point form.

WORKSPACE
Issues with the use of coal in New South Wales – a group debate

ISBN 9780170231497

WORKSPACE
What have you learnt? 9.3

QUESTIONS 9.3

What have you learnt?

Understanding

1 **Explain** why coal is used so extensively in Australia for the production of electricity.

2 **Recall** alternative sources of energy that may be used to produce electricity.

3 **Describe** one other use for coal other than in coal-fired power stations.

Applying

4 **Identify** two problems that would occur if solar power was the only source of our electricity.

5 Suggest reasons to **explain** why most power stations are built near coal mines and not near large cities.

6 **Identify** two types of locations where geothermal energy could be used.

7 **Compare** and **contrast** coal-fired and geothermal power stations.

Analysing

8 Hot rocks used in electrical energy generation have to be at temperatures greater than 100°C. **Explain** why this is so.

9 Remote communities need to ensure energy sustainability. **Describe** how they can achieve sustainable energy resource use.

10 Research hydro-electric power stations and **explain** why they could not supply all of our state's electricity needs.

11 **Analyse** the role that wind farms can play in providing electricity for:

a individual farm houses

b large cities.

Creating

12 **Propose** some of the energy resource issues faced by remote communities anywhere in the world. **Describe** a plan to help overcome these issues in:

a outback Australia

b Antarctica

c a small Indonesian island.

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9.4 The water cycle

The water cycle, or **hydrological cycle**, is the cycling of water through the surface of the Earth and the atmosphere. It can be described as a closed system with no more water going into it, or coming out of it. The amount of water on the Earth and in the atmosphere is always, and has always been, the same. The majority (97%) of water on Earth is sea water found in the oceans; only 3% is fresh water.

hydrological cycle
the movement of water through the natural system; also known as the water cycle

ACTIVITY SHEET
How much rain was that?

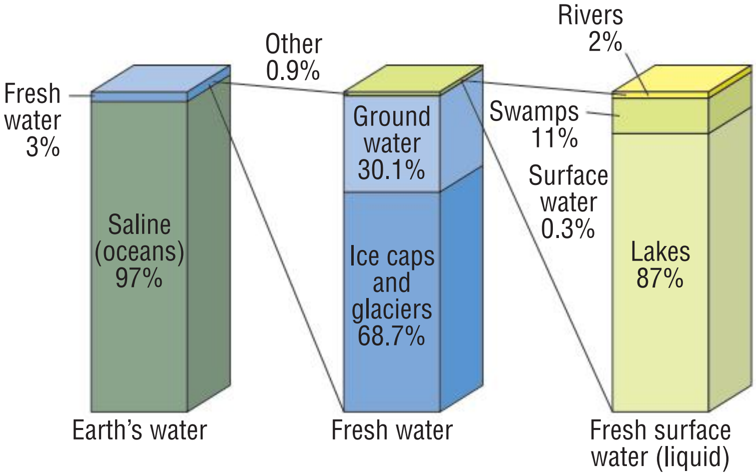

Figure 9.28 Distribution of the Earth's water

Water continually cycles through its three states: solid, liquid and gas. The Sun provides the heat energy required to bring about a change of state in the water cycle. A drop of water in a lake or stream gains energy from the heat of the Sun. When it has gained enough energy, it will change from liquid water to water vapour, which will rise into the air. This process is known as **evaporation**.

It will change from water vapour back into liquid water. This process is known as **condensation**. The condensed water droplets collect in the sky in large masses called **clouds**. When the mass of water droplets in the clouds becomes too heavy, the droplets will start to fall as rain, or **precipitation**.

The water landing on the Earth's surface can either soak into the ground and eventually flow into **aquifers**, helping them become re-charged with water, or fall into a lake, ocean or river. From here, it can evaporate again and the cycle starts over. The water cycle has no starting or finishing point. It continually cycles through all the processes.

If the water falls in a cold part of the planet, such as the Antarctic, energy is lost from the water to the cold atmosphere and the water falls as solid snow. When it hits the ground it can become part of either a frozen snowdrift or a glacier. Water can be stored in this form for thousands of years before it re-enters the water cycle.

evaporation
turning a liquid into a vapour at the surface of the liquid

condensation
turning a vapour into a liquid

cloud
a large mass of condensed water droplets in the sky

precipitation
rain, snow, sleet or hail

aquifer
a layer of porous rock that is saturated with water

ACTIVITY 9.8

Stored water

1. **List** the good, bad and interesting things that relate to the fact that water can be stored for thousands of years.
2. Upload your ideas to the class wiki.

ANIMATION
The water cycle

VIDEO
The water cycle

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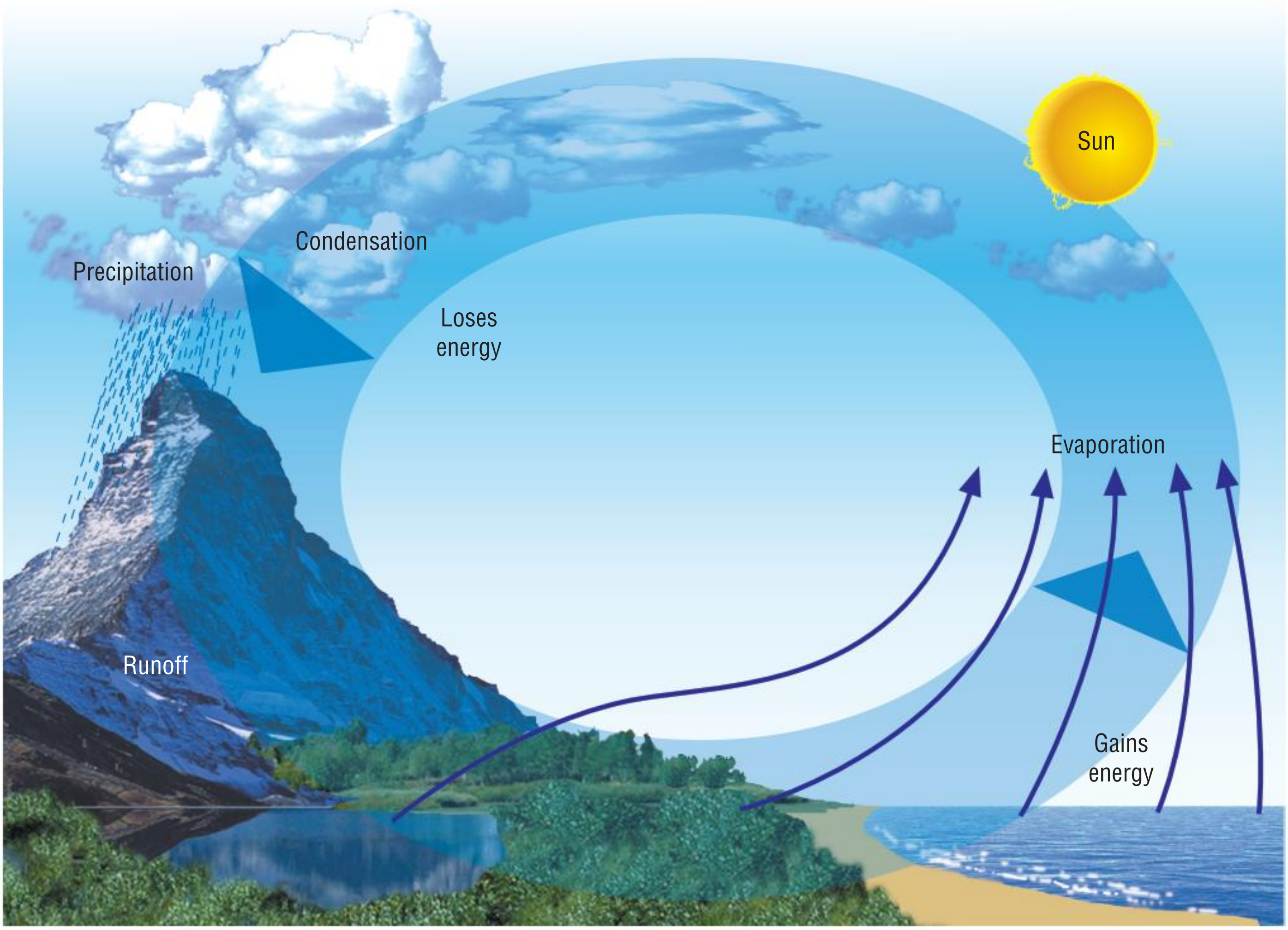

Figure 9.29
The water cycle, showing energy in and out


Shutterstock.com/Photodynamic

Figure 9.30
Water can be stored for thousands of years in glaciers and snow.

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QUESTIONS 9.4

What have you learnt?

Understanding

1 **List** the three states of water.

2 Write five questions for which the answer is the water cycle.

3 **Explain** the energy inputs or outputs required to change:
 a ice to water
 b water to water vapour
 c water vapour to water
 d water to ice.

4 **Describe** where the energy comes from for the water cycle.

5 Using water as the example, **explain** the changes of state that occur in:
 a evaporation
 b condensation
 c precipitation.

6 **Outline** the ways in which water can be stored during the water cycle.

Creating

7 a **Construct** a pie chart from the information in Figure 9.28 on page 253.
 b Using this information, **explain** why people try to manage water supplies so that they always have water available.

8 Imagine that you are a droplet of water in a muddy puddle. Tell the story of how you end up inside a polar bear living on the Arctic tundra.

WORKSPACE
What have you learnt? 9.4

Factors that influence the water cycle

The water cycle is a system in a constant state of change across the Earth. It can be affected by a number of different factors, such as location, **humidity**, solar radiation and temperature. How the water cycle reacts to these factors depends on their interaction and their severity.

humidity
the amount of water vapour in the air

Location

Location is a very important factor when it comes to the water cycle. The water cycle depends on the amount of water available in the soil and atmosphere. This can vary greatly between different locations. The available water evaporates and enters the air as water vapour.

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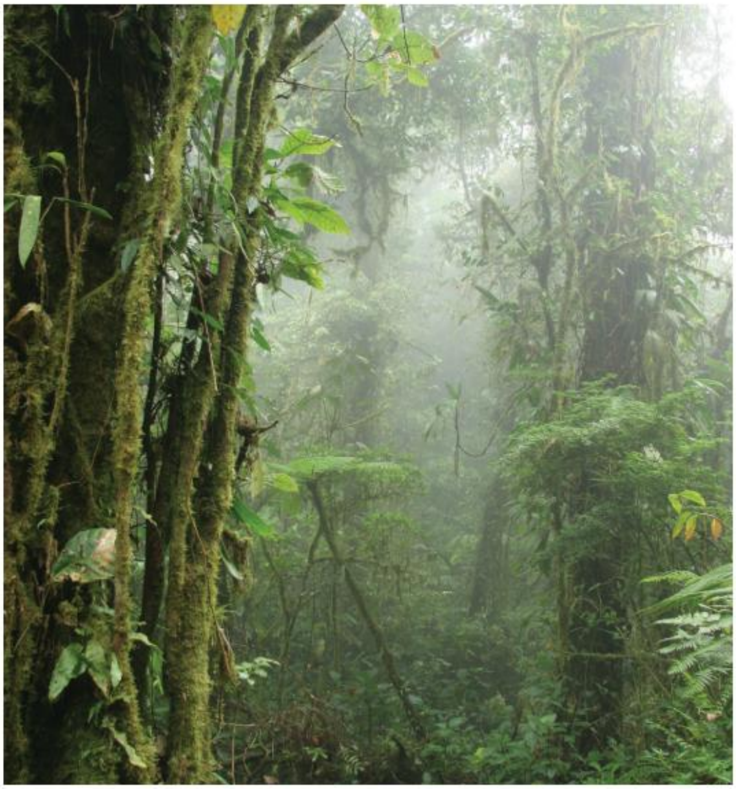
Humidity

Humidity is a measure of the amount of water vapour in the air. It is usually shown as a percentage. A humidity reading of less than 30% means that the air is very dry. A reading over 80% means that there is a lot of water vapour in the air. Humidity is important in determining the amount of evaporation that takes place. If there is a lot of water vapour already in the air, it is less likely that water will evaporate from lakes, rivers, soil and plant leaves.



Shutterstock.com/Brian Lasenby

Figure 9.31 Rainforests have high humidity.

ACTIVITY 9.9

Adding water to the air

transpiration
the loss of water from the leaves of a plant

Water from the soil moves through plants in the process of **transpiration**. This water evaporates from the leaf of the plant and is added to the air as water vapour.

1 Weigh a dry plastic bag (such as a Ziploc® bag) and record its weight.

2 Tightly secure the plastic bag around the end of a eucalypt branch (or any leafy tree). Leave it overnight.

3 Next morning, remove the bag from the tree and reweigh the bag.

4 How much water did you collect? Is this water drinkable?

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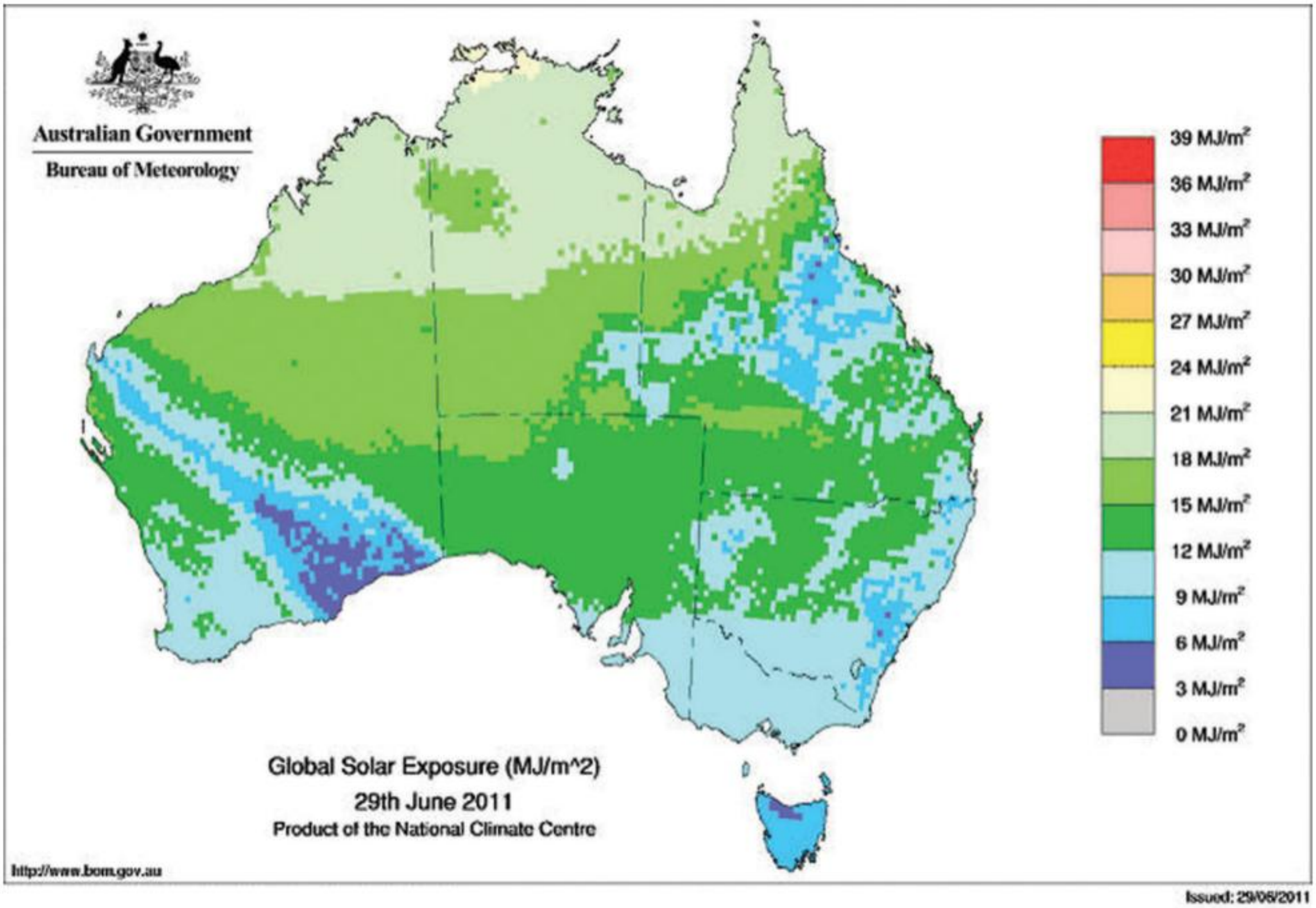
Solar radiation

Only a small percentage of the solar radiation leaving the Sun actually reaches the surface of the Earth (see Figure 9.12, page 240). The Sun provides the heat energy required to evaporate liquid water at ground level to become water vapour in the air.

Figure 9.32 Solar radiation across Australia



Temperature

Water on the ground is usually in its liquid state. In order for the liquid water to change into water vapour, heat energy must be added. This heat energy gives the water particles the energy to leave their liquid state. Areas of high temperature experience higher rates of evaporation, as long as there is water to evaporate.

EXPERIMENT 9.3

Student investigation: the effects of humidity or temperature on evaporation

Evaporation occurs when liquid water turns into water vapour. Work in groups of three to devise a method to determine how the rate of evaporation is affected by either humidity or temperature.

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EXPERIMENT 9.3

Before you begin, make a prediction about the outcome of this investigation based on your knowledge of evaporation.

ICT

Record your investigation using a digital camera. Share your results with the class by uploading the file to the class wiki.

Things to think about

1 What is your hypothesis?
2 What is your dependent variable?
3 What is your independent variable?
4 What is your control?
5 What safety factors do you need to consider?

Method

1 **List** the materials will you need to carry out your investigation.
2 Record your method in detail. Remember, the purpose of this is so that someone else can repeat what you have done.
3 **Discuss** the types of results you will be getting and how you will record them.
4 Carry out your investigation.
5 **Analyse** your results to see whether they match your prediction.
6 Write a conclusion.
7 Write up your experiment using the standard format (see Chapter 1).

Interaction of factors

The Nullarbor Plain stretches 1100 km from South Australia to Western Australia. As its name suggests, there are no large trees on the plain (*null* is Latin for 'none' and *arbor* means 'tree'). The average daily temperature hovers around 35°C in summer and 18°C in winter. Humidity is about 50%, and the area receives, on average, less than 250 mm of rain each year. The air is very hot and dry, and any water left in the open will evaporate very quickly. The area receives a large amount of solar exposure each day: on average about 27 MJ/m^2 (**megajoules** per square metre).

megajoule (MJ)
1 million joules; a measure of energy

The Daintree Rainforest, on the coast of Queensland, north of Cairns (Figure 9.33b), has a average daily temperature of 28°C. Temperatures here do not change much due to the protective canopy of trees that act as a blanket to keep the heat in. The Daintree receives about 15 MJ/m^2 of sunshine each day. The area experiences 1200 to 3000 mm (1.2 m to 3.0 m) of rain each year. As it is a rainforest, there are a large number of plants losing water vapour in the process of transpiration. This water vapour adds to the already humid air, which has a humidity of about 85%.

Antarctica is the driest continent on Earth. It has an annual rainfall of less than 200 mm along the coastal regions, and far less the further you go inland. Much of its water is trapped

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a

b

c

Figure 9.33
a Nullarbor Plain, **b** Daintree Rainforest, **c** Antarctica

in ice and snow and therefore is not available to re-enter the water cycle until the ice or snow melts. The air in Antarctica is very dry, with an average humidity of 0.03%. Due to the Earth's tilt, Antarctica is tilted away from the Sun during winter and so spends these months in darkness. During summer it is tilted towards the Sun, so these months are spent in full sunlight – at the South Pole, the Sun rises in September and sets in March.

WOW!

Do you want ice with that?

The average thickness of the ice in Antarctica is 2000 m. If all the ice in the Antarctic were to melt, global sea levels would rise by 6 m.

ACTIVITY 9.10

Rain, rain everywhere!

What would be the possible consequences if the annual rainfall in the Antarctic doubled every year?

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WORKSPACE
What have you learnt? 9.5

QUESTIONS 9.5

What have you learnt?

Understanding

1 **Recall** four factors that affect the water cycle in nature.

2 **Explain** why each of the factors listed in Question **1** is important in the water cycle.

Applying

3 **Construct** a table to **show** the climate information outlined for the Nullarbor Plain, Daintree Rainforest and Antarctica.

Creating

4 Using the information in the table you have constructed for Question **3**, **identify** the area you think would experience the greatest rate of evaporation. **Justify** your answer using evidence from your table.

5 **Explain** why evaporative air conditioners are less effective when humidity is high.

9.5 Management of water resources

Only a limited amount of fresh water is available for use. In countries such as Australia, fresh water is needed for growing crops, watering livestock, drinking water for towns and cities and for use in industry, all of this in the driest inhabited continent on Earth! Increasingly, it has become necessary to allow fresh water to flow through rivers again to try to reverse the ecological damage that has been caused through the over-use of water.

Throughout history, humans have tried to manage these water resources to enable them to inhabit even the driest areas. For example, reservoirs were built in Girnar, India, as early as 3000 BCE. In about 900 CE the Persians developed and constructed a water management system called the **qanat**. The qanat was able to provide a reliable supply of water to human settlements. It enabled them to use water for **irrigation** in hot, arid and semi-arid climates (Figure 9.36). Ancient history studies have shown that reservoirs have been built and wells dug to access water under the ground in desert regions around the world.

qanat
a method used in ancient Persia to bring water from underground wells to where it could be used

irrigation
water supplied from rivers and lakes for use in agriculture

Corbis/Paul Almasy

Getty Images/Tim Graham

Figure 9.34 (left) Reservoirs in Girnar, India

Figure 9.35 (right) Growing crops in the desert

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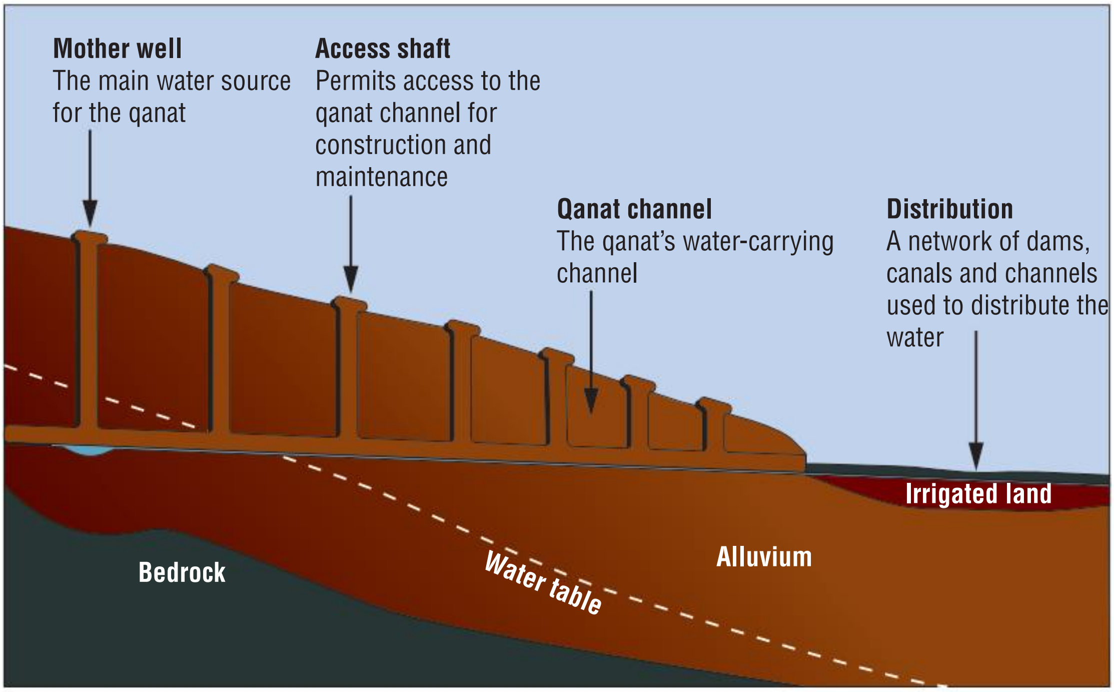

Figure 9.36 A qanat

Qanat technology was used most extensively in areas where there were no large reliable river systems. A qanat relied on an underground water source, such as a well or a cave with a lake. A tunnel was cut from the source of the water to the farming area where it would be used. Shafts were cut to provide an air supply and to remove sand and dirt.

Before European settlement, Australian Aborigines developed a precise classification system for their water sites. Using this system they were able to locate and re-locate them. Many of their water sites were so important to them that they became part of their Dreamtime stories. Many Aborigines now live in permanent settlements that rely on **bores** tapped into **ground water**.

bore
a deep narrow hole drilled into the ground to find water

ground water
water found in the soil or porous rocks

Figure 9.37 Water was traditionally, and still is today, an important aspect of Aboriginal life. In this image, concentric circles represent waterholes, and a stream is shown to the left of the waterholes.

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ICT

Use Google Earth to locate the Darling River in New South Wales. Trace its path. Where does it enter the Murray River? Where does the Murray River enter the sea?

WOW!

Water-storing frog

Rainfall does not happen very often in some parts of Australia. Traditionally, for the Australian Aborigines, the quest for water was a matter of life and death. Their knowledge of the land enabled them to find water in the most unusual places. They knew where the waterholes were, and obtained water from certain trees and roots, such as the red or blue mallee, which stores water in its trunk. They even dug up and squeezed out frogs that store water in their bodies, such as the water-storing frog, *Limnodynastes ornatus*.

Getty Images/Michael McCoy

Irrigation

One of the most common forms of water management is irrigation. Irrigation is the removal of water from lakes and river systems for use on agricultural lands. The water can be pumped from rivers or lakes, and large sprinkler systems disperse the water to the crops. Another way is to collect the water in large dams and allow it to soak into the soil.

There are many large cotton-growing stations along the Murray–Darling river system. They are licensed to remove hundreds of thousands of **megalitres (ML)** of water from the Murray–Darling river system. This water is stored in deep, large dams to reduce surface area and hence evaporative loss. The water is used to grow cotton and other crops such as wheat.

The removal of water from a river system can affect the availability of water downstream. If less water flows downstream, less is available for infiltration of the soil and subsequent seepage into ground water. Reducing the amount of water in an area means that less water in that area is available for evaporation back into the water cycle.

megalitre (ML)
1 million litres

Figure 9.38 (left) Huge irrigation sprinklers water crops.

Figure 9.39 (right) Huge water-holding dams on cotton stations

Shutterstock.com/Tish1

Newspix/News Ltd/David Sproule

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Aquifers

The **watertable** is the level to which water saturates porous rock below the ground. An aquifer is a layer of this porous rock that contains water. Water can be pumped from the aquifer for human use. Use of water from aquifers causes the watertable to drop. It also returns water that has been stored below ground back into the water cycle system.

watertable
the level below the ground that is saturated with water

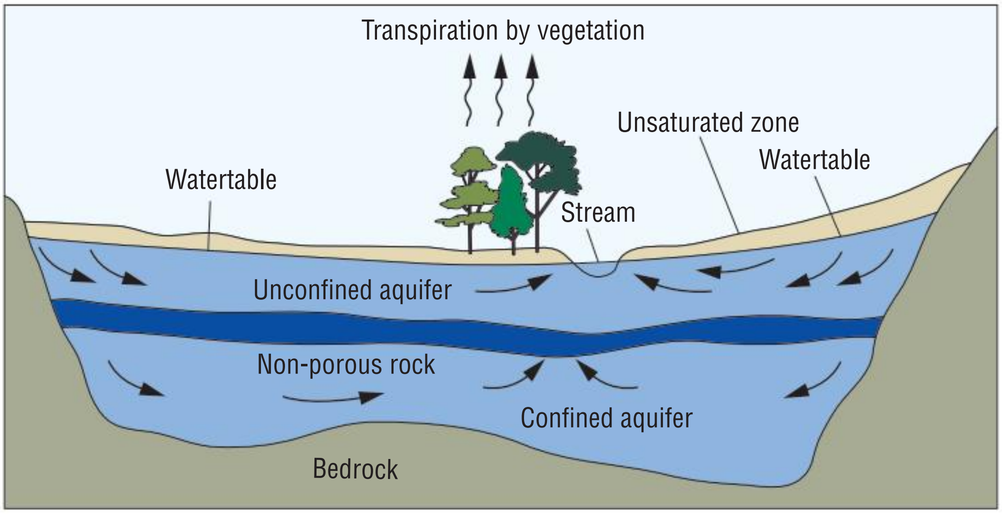

Figure 9.40
An aquifer

The CSIRO in Western Australia is researching into MAR (Managed Aquifer Recharge) for aquifers in the Swan Coastal Plain. The aim of this project is to store **recycled** water in the aquifer where it is naturally purified. The water subsequently taken from the aquifer can be used to irrigate parks, ovals and golf courses – areas that require large quantities of water.

recycled
reused

WOW!

Great Artesian Basin

The Great Artesian Basin is an aquifer that extends from Cape York in the north to Dubbo in the south. It covers 1.7 million square kilometres and holds enough water to fill Sydney Harbour 130 000 times.

Making fresh water out of sea water

Recall that sea water is a mixture made up of salt and water. The water is the solvent and the salt is the solute. Figure 9.28 on page 253 shows that 97% of our water is in the oceans as sea water. Sea water is basically a solution of salt and water with other components mixed in, such as magnesium, sulfate and calcium. As it is a solution, sea water can be separated into its component parts. The removal of salt from sea water is called **desalination**. This can be done in a number of ways, such as **distillation** and **reverse osmosis**.

desalination
the removal of salt from a salt solution such as sea water

distillation
a method of separation by evaporating water from a salt solution and then condensing it back into a liquid

reverse osmosis
a method of desalination that forces water through a membrane

Distillation of sea water

Distillation is the oldest method of desalination. It involves heating sea water to boiling point (100°C) and removing the steam produced. Salts and minerals boil at a much higher temperature, so they are left behind and returned to the sea.

ISBN 9780170231497

Desalination by reverse osmosis

osmosis
the movement of water through a membrane to dilute a more concentrated solution

Osmosis is a naturally occurring process. Osmosis can occur at the cellular level – it is the process by which water enters our cells. It requires no input of energy by our body.

Reverse osmosis, however, is an industrial process that is the opposite of osmosis. It requires a large input of energy to force material the opposite way to which it would naturally go. It is a bit like trying to turn a football crowd around and make them go away from the stadium before the start of a football match. That would take a lot of energy.

ACTIVITY SHEET
Experiment: Distillation

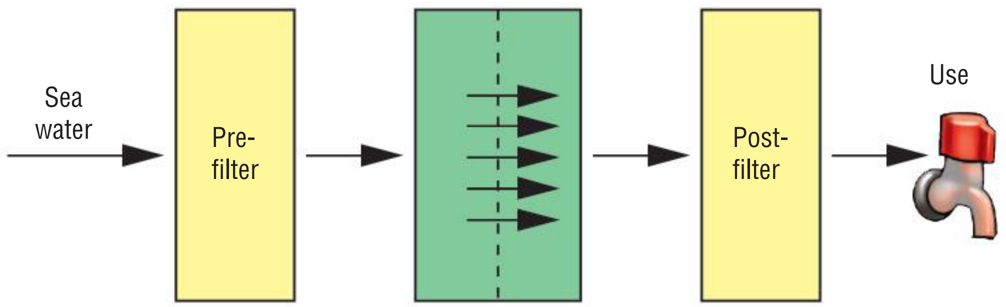

Figure 9.41 The reverse-osmosis process

In reverse osmosis, sea water is placed on one side of a **membrane**. Tiny holes (or pores) in the membrane are small enough to allow only water through. Other particles are too big to fit through these pores. Normally, the water would not move through these pores, and would stay on the salty side. With reverse osmosis, pressure is applied to the salty water, and water is forced through the holes in the membrane. In this way, fresh water is collected on one side of the membrane. The salt, minerals and pollutants remain on the other side and are collected to be pumped back out to sea.

David Shankbone

Figure 9.42 Reverse-osmosis membrane

The first reverse-osmosis desalination plant in Australia came into operation in 2006 at Kwinana in Western Australia. It removes sea water from Cockburn Sound and turns it into about 130 ML of fresh drinking water each day. When it operates at full capacity, it supplies Perth with 17% of its fresh water needs.

WOW!

Reverse-osmosis membrane

Up until 1959, reverse osmosis was only an idea. There was no membrane available that was able to filter water in such a way. In 1959 Sidney Loeb and Srinivasa Sourirajan, working at University of California, Los Angeles (or UCLA) in America, invented the Loeb–Sourirajan membrane. This breakthrough made reverse osmosis a practical solution to water shortages.

membrane
a thin skin that contains pores or holes

ISBN 9780170231497

ACTIVITY 9.11

Desalination by distillation

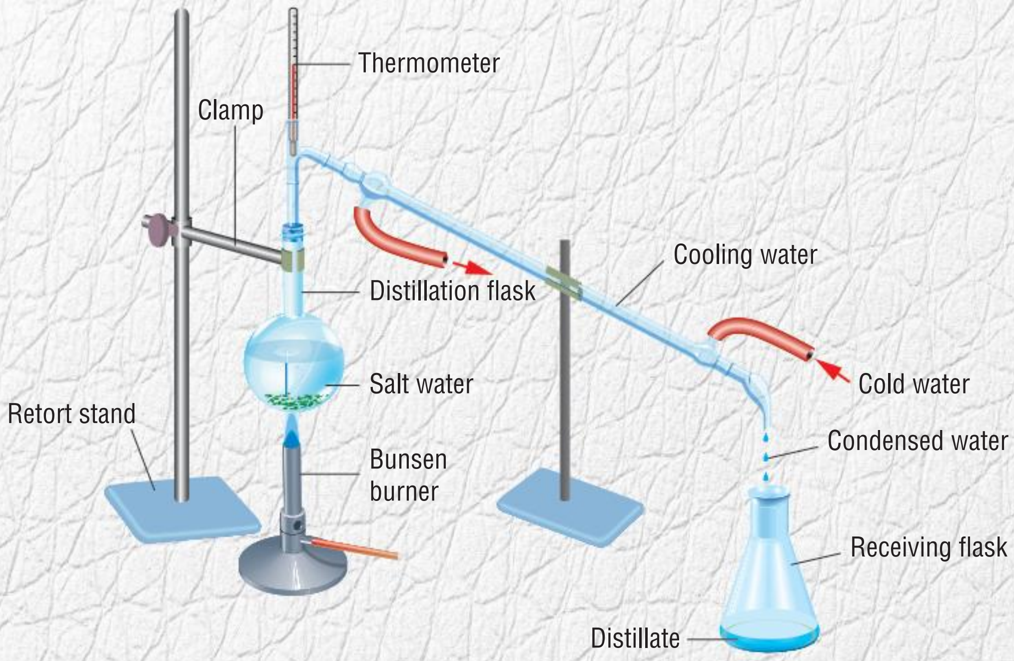

Figure 9.43
Distillation apparatus

1 Arrange the steps in the distillation process in the correct order.
   Water evaporates.
   Water boils.
   Collect the water vapour.
   Collect the steam.
   Water condenses.
2 **Outline** the main difference between evaporation and boiling.
3 **Explain** why a desalination plant has been built at Kurnell to help with our lack of fresh water.
4 **Identify** where the water comes from to supply a desalination plant.
5 **Identify** other major resources required for a desalination plant to operate.
6 **Describe** the environmental effects of placing a large desalination plant near the coast.
7 Draw a diagram to **show** the inputs, processing and outputs of a distillation desalination plant.

Figure 9.44
The desalination plant at Kurnell, Sydney, uses reverse osmosis.

WORKSPACE
Desalination by distillation

WEBLINK
Under the surface

ACTIVITY SHEET
Desal at Kurnell

WORKSPACE
What have you learnt? 9.6

QUESTIONS 9.6

What have you learnt?

Understanding

1 **Identify** at least two reasons why irrigation upstream affects the water cycle downstream.

2 **Explain** how an aquifer works. **Describe** how the use of water from an aquifer affects the water cycle.

3 Use the words 'distillation', 'desalination' and 'reverse osmosis' in a sentence to **show** their meanings.

Applying

4 **Explain** how reverse osmosis is different from naturally occurring osmosis.

5 **Describe** a qanat.

6 **Construct** a flowchart for a reverse-osmosis desalination plant.

Evaluating

7 **Evaluate** the importance of the water cycle to Aboriginal people living traditionally off the land, in the desert.

Reflecting

8 **Describe** how the management of water has affected human civilisation.

Conserving water

Australia is the driest inhabited continent and the largest consumer of water per head of population. How can we ensure that we have enough water for our long-term future? Our relatively small population has made vast changes to the natural water cycle over the past 200 years. The introduction of irrigation has led to increased water wastage through seepage and evaporation, leaving less water available for communities downstream. In times of drought, this has resulted in some towns not having enough water for drinking. The drilling of thousands of bores in the Great Artesian Basin has depleted this vast reserve of underground water. In recent years, steps have been taken to minimise this loss and wastage.

ACTIVITY SHEET
Science career – hydrologist

Storing water

Australia relies mostly on rainfall to provide water. Rainfall and rainfall runoff are collected and stored in large reservoirs, such as the Wivenhoe Dam (Queensland), Thomson Dam (Victoria) and Warragamba Dam (New South Wales).

Engineers and **hydrologists** put a lot of thought into choosing the location of a reservoir. Reservoirs are ideally located upstream, in the narrow part of a deep river valley. In this way, the sides of the valley can act as the walls of the reservoir. Reservoirs need a supply of water from rivers and streams, so ideally there is high rainfall in the **catchment** areas. Another consideration is the destruction of the natural environment when the river valley is flooded. Before a dam is built, ecologists survey the area to ensure that it is not home to endangered species of plants and animals.

hydrologist
a person who studies water and how it moves over land

catchment
an area of high rainfall that feeds water into reservoirs, rivers and streams

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Shutterstock.com/James M Phelps, Jr

Figure 9.45 The sides of the valley act as walls of the reservoir.

infrastructure
a system of connected elements that allows the system to function; water infrastructure consists of pipes, channels, dams, pumps, filters and purifiers

aqueduct
a channel for transporting water

There is another advantage to storing water upstream. Gravitational force is used to transport the water downstream. This saves large amounts of energy, greenhouse gas emissions and money that would otherwise be needed if water had to be pumped against gravity.

Water travels to your house in large and small pipes. This can be by gravity feed, but in flat areas the water needs to be pumped. Such water supply systems rely on **infrastructure** such as reservoirs, pumps and pipes. Much of our water supply infrastructure was built in the middle of last century. As it fails it is replaced and improved. Recent droughts have shown that much of our infrastructure is unsustainable. Open reservoirs and **aqueducts** allow evaporation. Broken and leaking pipes result in the loss of millions of litres of drinking water.

Figure 9.46 (left) Water is still transported in open channels in Australia.

Figure 9.47 (right) Broken water pipes lose valuable drinking water

© Doug Steley B/Alamy

Newspix/News Ltd/John Grainger

Recycling water

Water reservoirs are supplemented with water from desalination plants, such as the Kurnell plant in Sydney. This, however, will still not satisfy our water needs into the future. We use

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greywater
water from the bathroom or laundry; it can be reused on some parts of the garden without treatment

blackwater
water from the toilet, which contains faecal matter; it must be disinfected before it can be reused

approximately 120–150 L per person per day (see Table 9.2). Much of this water can be recycled. Many state governments encourage the use of recycled water. Wastewater can be either **greywater** or **blackwater**.

Table 9.2
Wastewater from daily activities

Type of wastewater		Litres per person per day
Blackwater	Toilet	20
Greywater (total 84 L per person per day)	Shower	63
	Washing machine	13
	Hand basin	6
	Laundry tap	2
Other wastewater (total 17 L per person per day)	Kitchen tap	12
	Dishwasher	5
Total wastewater		121

ACTIVITY SHEET
The Hanging Gardens of Babylon

ACTIVITY SHEET
What goes down your sink?

Greywater is water that has been used in domestic activities, such as bathing or washing clothes. Water from the dishwasher and kitchen sink is not suitable for reuse as greywater as it contains harmful chemicals. Greywater can be reused on site for watering the garden or flushing the toilet. Use on vegetable gardens is discouraged due to the chance of excessive or harmful chemicals. Different Australian states have different regulations about the reuse of water. In some states greywater can only be stored for 24 hours before it is used or released back into the sewerage system.

New suburbs are being built that have greywater piped directly to their homes for use on gardens and for washing cars. Greywater must be differentiated from fresh water by the use of purple taps, hoses and other fittings.

Blackwater is water that comes from toilets. It contains faeces and pathogens that are harmful to humans and other animals. If it is to be reused, blackwater must first be treated in a sewage treatment plant and disinfected. In many places around the world fully treated blackwater is pumped back into rivers and used in drinking water for towns further downstream.

Figure 9.48
a You need to let people know that you are using greywater on your garden.
b Purple fittings show people that you are using greywater.

a

Newspix/News Ltd/Mark Taylor

b

Getty Images/Brigitte Sire

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Would you drink greywater?

WOW!

In 2006 the residents of drought-stricken Toowoomba, Queensland, took part in a **referendum** about whether they would use recycled wastewater for drinking. The result of the vote was 62% no to 38% in agreement.

referendum

a vote by all people aged 18 or over where they are asked either to accept or reject a proposal

ACTIVITY 9.12

WORKSPACE
Reducing your water use

Reducing your water use

Conduct a water audit to find out how your water usage at home could be reduced.

1 **Construct** a table to **show** your results. Use column headings 'Water use', 'Estimated current use', 'Possible water savings' and 'How this saving could be achieved'.

2 **Recall** all the ways you use water during one day.

3 **Identify** whether the water must be fresh and clean, or whether it could have been used for washing or rinsing.

4 **Identify** whether the water could be collected and reused. For example, shower water could be used to water the lawn.

5 a **Describe** how your shower/bath water could be reused.
  b **Outline** what changes must be made to allow this to happen.
  c **Identify** other sources of 'used once' water.
  d **Estimate** the number of litres that could be reused per day.

Extension

Conduct a school water audit to find out how your water usage could be reduced at school.

1 **List** all the uses of water at your school in a normal day.

2 **Identify** whether the water must be fresh and clean, or whether it could have been used for washing or rinsing.

3 **Identify** whether the water could be collected and reused, for example the wastewater from drinking taps.

4 a **Outline** what changes must be made to allow this to happen.
  b Can you **identify** other sources of 'used once' water?
  c **Estimate** the number of litres that could be reused per day.

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WORKSPACE
What have you learnt? 9.7

QUESTIONS 9.7

What have you learnt?

Understanding

1 **Identify** the different groups of people who need to be consulted before the site for a new water storage dam is chosen.

2 **Outline** what sort of infrastructure needs to be built to supply a town with water.

Applying

3 **Outline** two ways in which you and your family could reduce the amount of water used. Put these into action.

Creating

4 **Construct** a pie chart from the information shown in Table 9.1 on page 234.

Reflecting

5 You are in charge of making decisions for the building of new homes. **Outline** three decisions you would make about the supply of water to new homes.

6 **Justify** using recycled water that has been purified in an aquifer.

7 **Discuss** whether you would drink recycled greywater. Give your reasons, using your knowledge of the water cycle.

9.6 Australian research into new materials

genes
parts of chromosomes that determine the characteristics of living things

Research into the development of plants that can tolerate drought is being conducted by the CSIRO. One plant in particular is white clover, which is popular with farmers as it is a source of food for cattle and sheep and helps to replace nutrients into the soil. However, this plant cannot tolerate dry conditions, unlike other, less beneficial grasses that grow in the same fields. The CSIRO has been able to make small changes to the **genes** in white clover so that it is much better at surviving through periods of dry weather.

With increasing demands in all countries around the world to feed the seven billion people on our planet, such developments are necessary to ensure reliable food supplies in the future. This research is also being done on other plants such as cotton and wheat so that less of our valuable water is used in growing them, which results in more water being available for people downstream and for natural water flows in our rivers. As a result of these developments and others like them, we will be able to ensure reliable food supplies in a sustainable way, and reduce the impact on our environment.

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'Improvement of drought tolerance in white clover *(Trifolium repens)* by transgenic expression of a transcription factor gene WXP1', by Qingzhen Jiang, Ji-Yi Zhang, Xiulin Guo, Mohamed Bedair, Lloyd Sumner, Joseph Bouton and Zeng-Yu Wang, *Functional Plant Biology*, 2010, 37, 157–165, CSIRO Publishing, reproduced with permission. www.publish.csiro.au/nid/102/paper/FP09177.htm.

Figure 9.49
Each image shows five pots of the same white clover over time, when exposed to drought conditions. In each image, the first three pots contain varieties of white clover developed by the CSIRO to tolerate drought conditions, and the last two pots contain varieties found in the wild. It can be seen that the CSIRO-developed clover is more resilient.

QUESTIONS 9.8

What have you learnt?

Understanding

1 **Explain** why an organisation such as the CSIRO would want to develop new types of plants.

Applying

2 **Describe** other beneficial characteristics other than drought tolerance that could be bred into plants.

Reflecting

3 **Discuss** what could happen in the future if research into developing new types of plants is not supported.

WORKSPACE
What have you learnt? 9.8

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9.7 Scientific collaboration to manage our resources

Many different areas of science are involved when a resource is managed. In the mining industry, geophysicists and geologists are involved in the discovery and mapping the extent of the resource. They must decide if it is economical to build a mine by estimating how much of the resource is present and whether it will be economical to mine it. Biologists specialising in ecology, the study of the plants and animals in the area, must be able to report on the impact that the mine will have on the environment, along with studies of the water flows or aquifers near the mine site. The mining company would then have to plan how they will repair any damage they cause to the area and rehabilitate the natural vegetation once the mining is finished. Chemists would need to study the impact of any mining activity in the area to prevent toxic wastes from entering natural waterways or the air and the health of all the mine workers would need to be monitored by doctors and scientists to ensure that they are not exposed to mine dust or other dangerous materials while the mine is operating.

WEBLINK
Methods used to mine gold

ACTIVITY 9.13

Developing a gold mine

1 Look at the material contained in the weblink and read about the chemicals used to mine and extract gold.
2 **Construct** a flowchart of the outline of the steps taken in gold mining from the time that gold is first discovered in an area. (You should read the paragraph above before starting this.)
3 At each step on your flowchart, add in the type of scientist who might be involved and briefly **outline** their role.

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Chapter review

Remembering

1 **Recall** the differences between renewable and non-renewable energy.

2 **Define** 'passive solar heating'.

3 **Recall** two ways in which water can be added to the air.

Understanding

4 **Identify** the three quantities involved in measuring insolation.

5 **Describe** how electricity is generated in a coal-fired power station.

6 **Outline** what geothermal energy is.

7 **Describe** how greywater is different from blackwater.

Applying

8 **Construct** a flowchart to **show** the changes in energy during the production of electrical energy in a gas-fired power station.

9 **Describe** an example of where solar photovoltaic energy might be used along a railway in outback Australia.

10 A large ancient volcano has left behind a crater that is now flat and filled with sand and some low shrubs. It is surrounded on all sides by low, treeless hills. Sketch this location and **identify** the best place for a wind farm and a solar power tower. **Explain** your decisions.

11 Coal is an effective fuel and a good insulator. **Explain** why coal deposits are often good sites for geothermal power stations.

12 **Explain** why water storage reservoirs should be deep rather than wide and shallow.

Analysing

13 **Construct** a bar graph to **show** the proportion of different forms of energy in the world. On the graph, **show** how you would change the graph to ensure responsible and sustainable use of energy.

14 **Outline** the steps necessary to ensure that sufficient energy can be supplied to homes when the wind is not blowing if they are being supplied with electricity from a wind farm.

15 Biomass such as firewood is carbon neutral but coal is not. **Explain**.

16 **Compare** and **contrast** coal-fired power stations and wind power generation.

17 **Explain** how the idea of the 'responsible use of energy' is similar to or different from the 'sustainable use of energy'?

18 **Discuss** in your group whether you think it is right for people to manage a natural resource like water for their own benefit.

WORKSPACE
Chapter 9 review

ACTIVITY SHEET
Chapter 9 checklist

REVIEW QUIZ
Chapter 9

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Evaluating

19 You have learnt about a number of different energy resources. **Identify** the type of energy resource you think is the best for the:
 a consumer
 b energy producer
 c environment.
 Explain your choice in each case.

20 **Describe** the short-term and the long-term consequences of less water being available for evaporation.

Creating

21 **Describe** the ways in which all three types of solar energy production could be used at your house.

22 Complete your electronic presentation on energy resources.

23 Draw a diagram to **describe** how water cycles between its three states of matter. On your diagram, **show** where heat energy is added and removed.

Reflecting

24 **Describe** how your understanding of energy resources has been changed as a result of this unit.

25 **Outline** ways in which you developed a better idea about how electrical energy is generated.

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Appendix

How to write a bibliography

Whenever we do research it is very important that we acknowledge where we get our information from. We can do this by including information about the source in a bibliography at the end of our report or assignment.

In a bibliography we list each source in alphabetical order by the author's surname. If there is no author, the title is used instead, ignoring the words 'A' and 'The'.

The information below shows the information needed, and the order in which it is listed, for different types of resources.

Books

Author's surname followed by their initials
Year of publication in brackets
Title in italics or underlined
Edition (if relevant)
Publisher and the place of publication
(If the author is unknown, put the book title first.)
For example:

Denning, A. (1994) *The craft of woodcarving*, Sandstone: London.

Encyclopaedia (printed)

Title of article in single quotation marks
Year of publication in brackets
Title of encyclopaedia in italics or underlined
Volume number
Publisher and place of publication
Page number(s)
For example:

'Minerals in Australia' (1996) *The World Book Encyclopedia,* Vol. 6, World Book: Sydney, p. 308.

Encyclopaedia (online)

Title of article in single quotation marks
Year of publication
Title of encyclopaedia in italics or underlined
[Online]
<URL address>
[Date accessed in square brackets]
For example:

'Jupiter' (2006) *Encyclopaedia Britannica Online School Edition* [Online]
<www.school.eb.com.au/all/comptons/article-9345009> [accessed 10/11/2006].

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Journals, magazines or periodicals (printed)

Author's surname followed by their initials
Year of publication in brackets
Title of article in single quotation marks
Title of magazine or journal in italics or underlined
Volume number if relevant
Issue number if relevant
Page number(s)
For example:
Choi, C. (2003) 'Cleaner living', *Scientific American,* Vol. 289, No. 5, p. 32.

Journals, magazines or periodicals (online)

Author's surname followed by their initials
Year of publication in brackets
Title of article in single quotation marks
Title of magazine or journal in italics or underlined
Volume number if relevant
Issue number if relevant
Page number(s)
[Online]
<URL address>
[Date accessed in square brackets]
For example:
Coghlan, A. (2003) 'GM crops can be worse for environment', *New Scientist.com* [Online] <www.newscientist.com/hottopics/gm/gm.jsp?id=ns99994283> [accessed 9/1/2013].

Newspaper

Author's surname followed by their initials
Year of publication in brackets
Title of article in single quotation marks
Title of newspaper in italics or underlined
Date
Page number
For example:
Shaw, P. (1996) 'Mining shares drop', *The Age,* 31 August, p. 1.

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Internet

Author's surname followed by their initials (if identified)
Last update (if identified) in brackets
Title of article in italics or underlined
Sponsor name
[Online]
<URL address>
[Date accessed in square brackets]
For example:

Ward, C. (2004) *Australian bush fires burn on*, Disaster Relief, [Online] <http://disasterrelief.org/Disasters/020104Austfires4> [accessed 10/1/2013].

Audiovisual materials

Title in italics or underlined
Year of publication in brackets
[Type of media in square brackets]
Publisher and place of publication
For example:

Diet and Health (1997) [videocassette] Classroom videos: Melbourne.

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Glossary

abiotic any non-living factor, such as salinity, pH, humidity, wind, soil

acid a chemical that is corrosive, has a sour taste, turns bromothymol blue a yellow colour and has a pH less than 7

adaptation a characteristic of an organism that improves the organism's chance of survival

alchemy both a philosophy and an ancient practice of science; alchemists attempted to turn base elements into precious metals and to create a substance that would provide immortality

alveoli air sacs at the end of the bronchioles in the lungs

ammeter a device used to measure how much electric current is flowing

amniotic sac a sac containing fluid in which the embryo or foetus develops

amylase the enzyme that digests carbohydrates

anaerobic without oxygen

analogy using something that you already know about to explain a new concept

anther a sac on the end of a filament that produces pollen

antibody a protein that fights infection in our body

aorta a large artery that takes blood from the left side of the heart to the rest of the body

aqueduct a channel for transporting water

aquifer a layer of porous rock that is saturated with water

arid a region characterised by a severe lack of water available to support organisms

arson the deliberate lighting of a fire to cause damage

artery a blood vessel that carries blood away from the heart

asexual reproduction the production of offspring from one parent

atria two upper chambers in the heart that receive blood from veins

autotroph an organism that produces its own sugar through photosynthesis; also known as a producer

battery a series of electrochemical cells designed to deliver electrical energy to a circuit

biodegradable able to be decomposed by the actions of living organisms

biodiversity the variety of different living organisms found in a particular area

biofuel fuel made from plant or animal material

biological control the control of pests by deliberately introducing one of their natural predators or diseases

bioplastic or biopolymer a plastic made from starch derived from plants such as corn and potato

biotic any living part of the ecosystem, such as plants, animals, micro-organisms

blackwater water from the toilet, which contains faecal matter; it must be disinfected before it can be reused

ISBN 9780170231497

bladder the sac that collects urine for excretion

bolus a ball of food that passes into the oesophagus from the mouth

bore a deep narrow hole drilled into the ground to find water

bowel motion the process of egesting faeces through the anus

breaking of the waters the release of amniotic fluid (waters) when the amniotic sac breaks open just prior to birth

breech birth when a baby is born buttocks or feet first, rather than head first

bronchi tubes that branch off the trachea to the left and right lung

bronchiole a smaller tube made when the bronchi divide

capillary minute blood vessel located in between the smallest arteries and smallest veins

carbohydrates a complex food group found in starchy foods such as rice, potatoes and pasta

carbon neutral the uptake and release of carbon in a process are equal

carnivore an organism that feeds solely on animals

carnivorous meat-eating

carpel the female part of a flower

cartilage stiff yet flexible connective tissue found, for example, in joints between bones and around the bronchial tubes

catchment an area of high rainfall that feeds water into reservoirs, rivers and streams

cellular respiration a series of chemical reactions that break down sugar into chemical energy

cervix the narrow region at the lower end of the uterus and top of the vagina

chamber one of the compartments making up the normal structure of the heart

chemical change when the chemical make-up of a substance changes, and a new substance or substances are formed

chemical digestion the chemical breakdown of food into simpler substances, mostly through the action of enzymes

chemical energy energy stored in chemicals and released when the chemicals react

chemical formula a collection of symbols and numbers that represents the number of atoms in a particle of an element or compound

chemical properties the properties that show how a substance reacts when combined with other substances

chemical reaction occurs when a substance changes to produce a new substance

chemical symbol a letter (or letters) of the alphabet used to represent an atom of a specific chemical element

chlorophyll green pigment in plants that absorbs the Sun's energy during photosynthesis

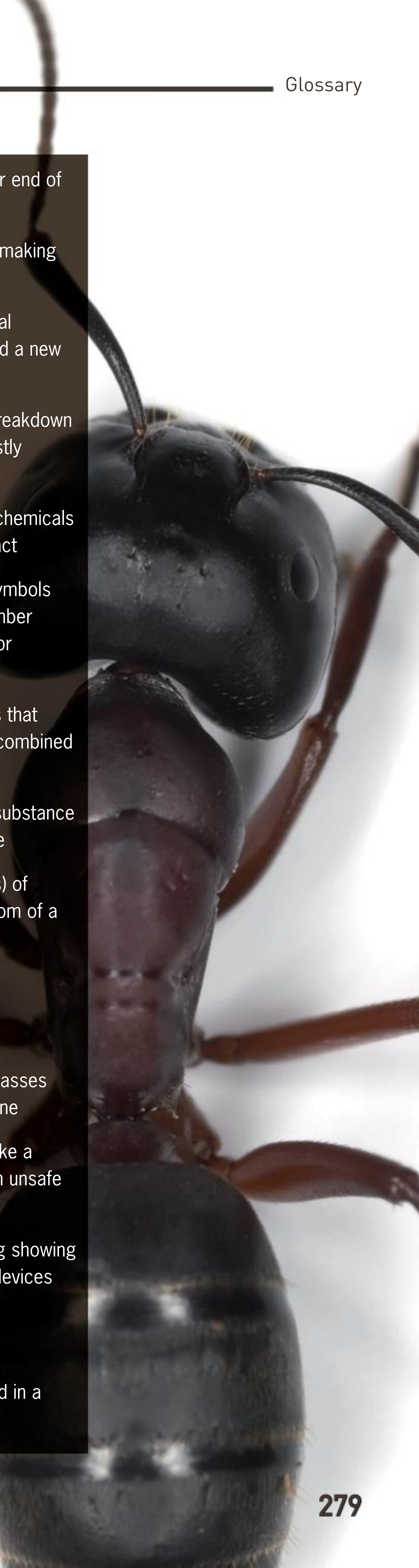
chyme partially digested food that passes from the stomach to the small intestine

circuit breaker a device that acts like a switch and will turn off if it detects an unsafe load on the circuit

circuit diagram a simplified drawing showing the pathways for electricity and the devices connected

cleat a fracture in the coal seam

climate the weather conditions found in a region over a period of time



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climate change a long-term, well-established difference in weather patterns

cloning producing offspring that are genetically identical to the parent

cloud a large mass of condensed water droplets in the sky

compound a pure substance made up of two or more different atoms chemically bonded together

condensation turning a vapour into a liquid

conductor a material that allows electric current to flow through it, such as metals and salt water

congenital born with

consumer an organism that must consume other organisms to gain chemical energy; a heterotroph

contraction tightening and relaxing of muscles

control a scientific set-up that does not include the independent variable to be tested; used to provide baseline data

convection cell a movement of heated and cooling fluid, such as air, in a space

convection current a large-scale movement of a fluid, such as air, away from or towards a source of thermal energy

corrode to break down a metallic substance by a chemical reaction with substances in the environment, such as oxygen and water

decomposer a micro-organism, such as fungi or bacteria, that breaks down dead matter

deforestation the removal of naturally occurring forest by logging or burning

dependent variable the factor that changes as a result of the independent variable; the factor that can be measured or counted

desalination the removal of salt from a salt solution such as sea water

diaphragm a sheet of muscle under the lungs that assists with inhalation and exhalation

distillation a method of separation by evaporating water from a salt solution and then condensing it back into a liquid

diurnal describing an organism that is active during the day

ductility the ability of a substance to be drawn into wires

duodenum the first part of the small intestine

earth wire a wire, coloured yellow and green, that connects all three-pronged appliances to the earth so that harmful currents do not pass through a person

ecologist a scientist who studies ecosystems and the changes in environments

ecosystem a community of organisms interacting with one another and with their environment

ectotherm an organism that cannot maintain its internal body temperature; a cold-blooded organism

egest to pass out of the body

ejaculate to release sperm and semen from the penis

elastic energy energy stored in springs and elastic materials

elastic potential energy energy stored in an elastic band or spring that is ready to be transformed when the elastic band or spring is released

electric circuit a pathway for electric current that leads back to the same starting point

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electric current the flow of electricity, such as the movement of electrons through a wire

electrical conductivity the ability of a substance to transfer electricity: good electrical conductors transfer electricity well; poor electrical conductors (insulators) transfer electricity poorly

electrical current electric charges that move or flow through a conductor

electron the negative particle in an atom that can move through a conductor

element a pure substance made up of only one type of atom; cannot be broken down into a simpler substance

embryo the early stage of development after zygote stage

endangered (a species) threatened with becoming extinct

energy flow the movement of chemical energy through an ecosystem

energy resource any resource that can be used to transfer or transform energy

energy transfer the movement of a single form of energy from place to place or from one body to another

energy transformation the change of one form of energy into another form of energy

environment a unique set of non-living and living factors (conditions) for a particular area and time

enzyme a protein found in the body capable of speeding up chemical changes

ephemeral having a short life cycle

epididymis the part of the male reproductive system that stores the sperm

evaporation turning a liquid into a vapour at the surface of the liquid

exhalation breathing out

external fertilisation fertilisation that occurs outside of the body

faeces undigested waste material

fair test a scientific investigation in which there is an independent variable and one or more dependent variables; all other variables are controlled

fallopian tube the tube that carries ova to the uterus; can be the site of fertilisation if sperm is present

fats a complex food group found in foods such as butter and cream

filament a long stalk that displays the anther in a flower

flammability the ability of a substance to catch fire

foetus the stage of embryonic development after 11 weeks' gestation

food chain a linear diagram that shows the way energy is transferred from producer to consumer

food web a group of interlinked food chains that gives an overall picture of how energy is transferred through an ecosystem

fossil fuel an energy resource produced over millions of years from once-living organisms

gamete sex cell – sperm in males and ova in females; contains half the amount of genetic material of other cells

generate to make or produce

genes parts of chromosomes that determine the characteristics of living things

geothermal energy an energy resource that uses heat from deep in the Earth

germination when a plant emerges from a seed

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gestation the period of time a foetus/embryo spends developing inside its mother; begins with fertilisation and ends at birth

geyser a spout of water heated from deep in the Earth

gravitational potential energy energy associated with the position of an object above the ground

greywater water from the bathroom or laundry; it can be reused on the garden without treatment

ground water water found in the soil or porous rocks

group a column down the periodic table

guard cells cells that surround a stoma, allowing it to open and close

habitat the place where an organism lives, which has a unique set of non-living and living factors (conditions) for a particular area and time

haemoglobin the component of red blood cells that binds with oxygen

heartburn a burning of the oesophagus caused by rising stomach acid

heat conductivity the ability of a substance to transfer heat: good heat conductors transfer heat well; poor heat conductors (insulators) transfer heat poorly

heat energy thermal energy of an object due to the energy of each of its particles; energy measured by a thermometer

herbivore an organism that feeds solely on plants

heterotroph an organism that must consume other organisms to gain chemical energy; also known as a consumer

hibernate to remain dormant for an extended period of time, generally over winter

hormone a chemical messenger

humidity the amount of water vapour in the air

hydrochloric acid the acid found in the stomach to help digest food

hydrological cycle the movement of water through the natural system; also known as the water cycle

hydrologist a person who studies water and how it moves over land

hypothesis an educated guess or prediction that can be tested in a scientific way, usually written in the form: 'If . . . then . . .'

immune system the body system that fights infection and disease

immunosuppressant a drug that stops the body attacking a transplanted organ

in vitro fertilisation (IVF) fertilisation that occurs artificially in a glass Petri dish in a laboratory

incandescent giving off light due to the object being very hot

independent variable the factor that you choose to vary in your investigation

infertility inability to reproduce

infrastructure a system of connected elements that allows the system to function; water infrastructure consists of pipes, channels, dams, pumps, filters and purifiers

ingested taken in, eaten

inhalation breathing in

insolation exposure to the Sun's rays

internal fertilisation fertilisation that occurs inside the body

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introduced species a species that has arrived accidentally or has been deliberately brought to an area

irrigation water supplied from rivers and lakes for use in agriculture

joule (J) the unit of measurement for energy

kinetic energy energy of an object due to its motion

labour muscular contractions that prepare for birth

law of conservation of energy a fundamental law of physics, which states that when energy is transferred or transformed, the total amount of energy remains the same

ligament the tissue that connects bones to bones

light energy energy transferred as radiation; energy detected by eyes or photometer

load the total amount of electricity being used at that time

lustre the shininess of a material

macroinvertebrate an invertebrate large enough to be seen without a microscope

malleability the ability of a substance to bend or be hammered into different shapes

mechanical digestion the physical breakdown of food into smaller pieces

megajoule (MJ) 1 million joules; a measure of energy

megalitre (ML) 1 million litres

meiosis a form of cell division that produces gametes

membrane a thin skin that contains pores or holes

menstruation the monthly shedding of the lining of the uterus in sexually mature females

metabolic rate the amount of energy released in chemical reactions occurring in the body

micro-organism an organism that is too small to be seen with the naked eye, such as a bacterium

mixture a substance made up of different types of particles, physically combined

molecule of a compound a particle in which two or more atoms of different non-metal elements are chemically bonded together

molecule of an element a particle in which two or more atoms of the same non-metal element are chemically bonded together

nanoparticle a particle that has a diameter of less than one billionth (1×10^{-9}) of a metre

nectar a sweet substance secreted by flowers to attract insects and birds

nectaries glands at the base of a flower that produce and secrete nectar

nephron the functional unit of the kidney

nocturnal describing an organism that is active at night

non-biodegradable not able to be decomposed by the action of living organisms

non-porous rocks rocks that water cannot penetrate nor flow through

non-renewable energy energy that, once used, cannot be readily replaced within a reasonable time

omnivore an organism that consumes both plants and animals

ore a rock from which metal can be extracted

organ a collection of tissues, similar or different, that combine to perform a specific function

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organism a living thing

osmosis the movement of water through a membrane to dilute a more concentrated solution

ovary the part that produces and protects the ova

ovulation the release of an ovum from the ovary

ovum a female gamete

parthenogenesis when a new individual grows from an unfertilised egg

period a row across the periodic table

peristalsis a progressive wave of contraction and relaxation of the digestive tract

pH the acidic or alkaline nature of a substance

phloem the nutrient transport system in plants

photosynthesis the process that uses the energy from the Sun to provide nutrition for plants; a series of chemical reactions that convert light energy, carbon dioxide and water into glucose (stored energy) and water

photovoltaic solar using the Sun's energy to produce a source of electrical energy

physical change occurs when the form of a substance changes, but the kind of substance remains the same; examples are a change of state and dissolving

physical properties the properties of a substance that can be observed or examined without changing the composition of the substance

piezoelectricity electricity that is produced when certain crystals are squeezed or distorted

placenta the organ that connects the developing embryo or foetus to the wall of the uterus, and allows gases, wastes and nutrients to be exchanged

plasma the watery component of the blood in which the cells are suspended

platelets fragments of cells that act in blood clotting

pollen grains produced in anthers that contain male sex cells

pollen tube a tube that grows from the pollen grain, down through the style to the ovary, transporting sperm cells to the ova

pollination the transfer of pollen from the anther to the stigma

potential energy energy that is stored; energy ready to be transformed

precipitation rain, snow, sleet or hail

predator an animal that preys on other animals

producer an organism that produces its own chemical energy through photosynthesis; also known as an autotroph

product a new substance produced in a chemical reaction

prostate gland the gland that produces about 30% of the semen

proteins a complex food group found in foods such as meat, fish, soy beans and cheese

puberty sexual maturation in humans

pulmonary artery a blood vessel that takes blood from the heart to the lungs

pulmonary vein a blood vessel that returns blood from the lungs to the heart

pure substance a substance made up of the same type of particle

qanat a method used in ancient Persia to bring water from underground wells to where it could be used

qualitative measurement any information that can be gathered that is not numerical

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quantitative measurement any information that can be measured numerically

radiant energy energy that transfers across space without the need of a material in which to travel

reactant a substance used up in a chemical reaction

recycled reused

red blood cell a blood cell that carries oxygen

referendum a vote by all people aged 18 or over where they are asked either to accept or reject a proposal

refute to show to be false; to disprove

renewable energy energy that, when used, can be readily replaced within a reasonable time

replicated made a copy

reproduction the making of new individuals (offspring) from existing ones (parents)

resource something that needs to be consumed to gain benefit from it, such as air, food and energy

reverse osmosis a method of desalination that forces water through a membrane

root system the part of a plant that is below ground; it absorbs water and nutrients from the soil

rust a compound produced when iron reacts with oxygen and water in the atmosphere

salinity the concentration of salt found in soil or a body of water

Sankey diagram a type of flowchart that uses arrows of various sizes to indicate the amount of energy moving through a system

scientific method a set of rules that enables scientists to plan and conduct experiments in a consistent and repeatable way

secretion a liquid produced by a cell that assists in a bodily function

seed a protective covering for a plant embryo, usually with a rich reserve of starch or oil for a food supply

semen the fluid added to sperm, contains nutrients and provides a medium for the sperm to swim in

seminal vesicle the gland that produces about 70% of the semen

sepal a modified leaf that protects the developing flower bud

septum the dividing wall between the left and right hand sides of the heart

sexual reproduction the formation of genetically different offspring from a male and a female parent

shoot system the leaves and stems of a plant

short circuit a circuit consisting of a wire that directly connects the two sides of a battery or powerpack with no device in between

solar thermal the use of energy from the Sun to produce heat

sound energy energy transferred by a vibrating source; energy measured by a sound-level meter

species a group of individuals having common characteristics, capable of interbreeding and producing fertile offspring

sphincter a ring of muscle that can close off a tube

stamen the male part of a flower

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starch a complex carbohydrate found in potatoes and other plants

static electricity electric charge that remains in the same place

stigma the part of the carpel that captures the pollen

stomata tiny pores on the leaf surface that allow gas exchange for photosynthesis; water is lost through stomata

style the stalk that holds the stigma in position

sustainable can be reliably used as a resource into the future without causing damage to the environment

system a group of organs that work together to perform a specific function

tendon the tissue that attaches muscle to bone

testes the part of the male reproductive system that produces the sperm

thermal an air current rising vertically as a result of air being heated by the ground

tissue a collection of cells that have similar structure and function

torpor a state of hibernation in which the metabolic rate of an organism is lowered in order to reduce its energy consumption

toxicity how poisonous a substance is

trachea a tube that runs from the back of the throat to the bronchi

transpiration the loss of water from the leaves of a plant

tungsten a metal element with the highest melting point of all elements

turbine a type of generator; a turbine converts a form of energy into electrical energy

urea waste from protein breakdown, found in urine

ureter the tube from the kidney to the bladder

urethra the tube that carries urine from the bladder to the outside of the body

vagina the tube leading from the uterus to outside the body; acts as the birth canal

valve a structure in the heart and veins that prevents the backflow of blood

variable a factor that could influence the result of an investigation

variable held constant a factor that needs to be kept the same throughout a scientific investigation so that it does not influence the results

vas deferens the tube that carries the sperm from the epididymis to where it joins with the urethra

vegetative propagation a form of asexual reproduction in plants

vein a blood vessel that carries blood to the heart

vena cava a large vein bringing blood to the heart from all parts of the body

ventricles the two lower chambers in the heart that pump blood to either the lungs or the rest of the body

verdigris a green patina caused by the reaction of copper with air or sea water over a long period of time

villi small finger-like projections on the cells of the small intestine that increase surface area

volt (V) the unit of electrical potential; a measure of how much energy a quantity of electricity contains

voltage a measurement of the energy contained in the electrons

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voltmeter a device used to measure the voltage across another device in a circuit

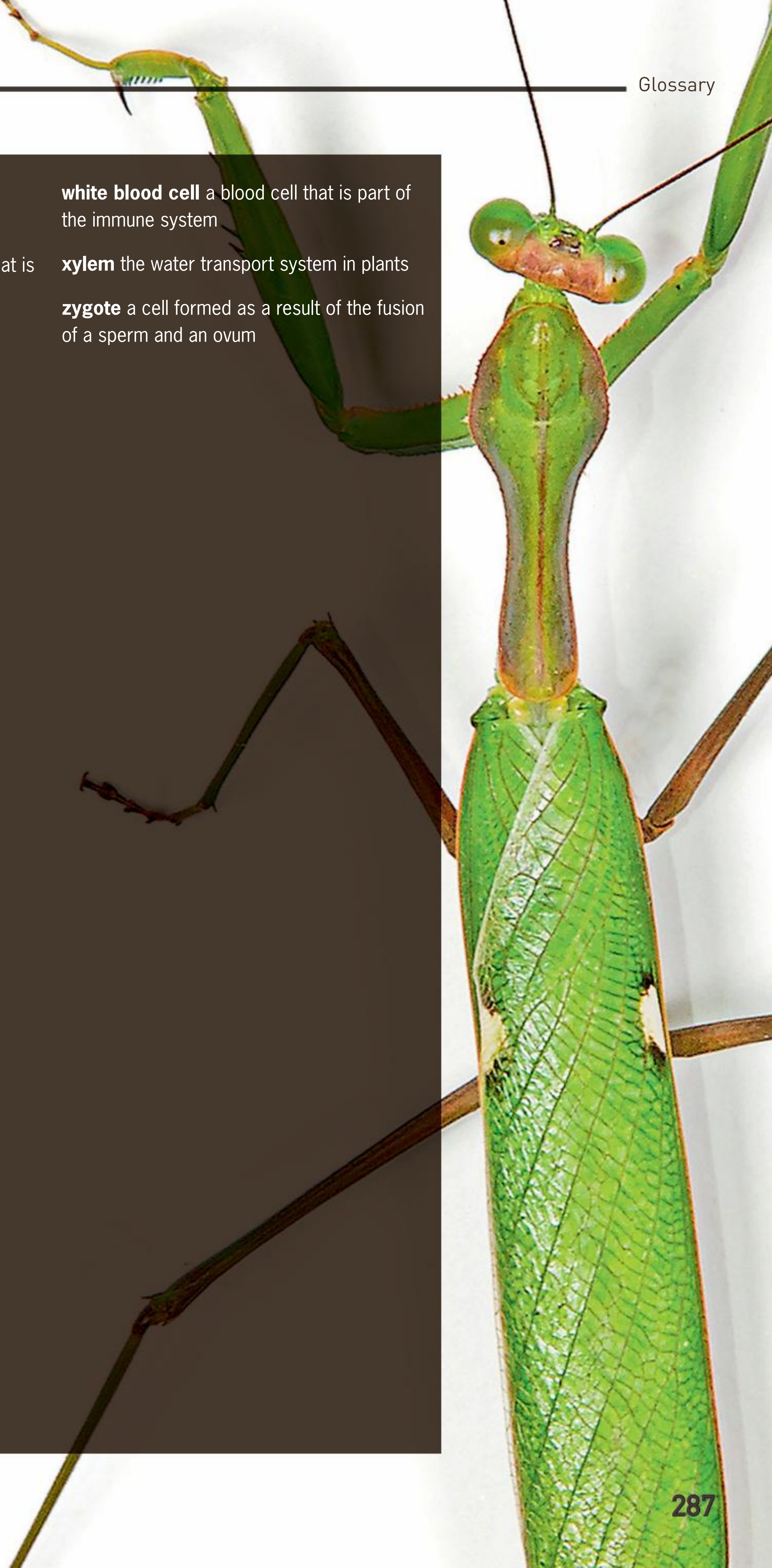
water table the level below the ground that is saturated with water

weathering the breakdown of rocks

white blood cell a blood cell that is part of the immune system

xylem the water transport system in plants

zygote a cell formed as a result of the fusion of a sperm and an ovum



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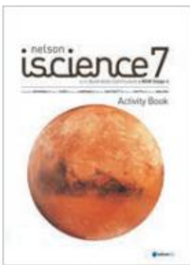

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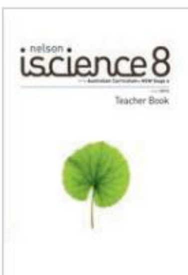

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