OXFORD SCIENCE 7

AUSTRALIAN CURRICULUM

* A BEARDED SEAL (ERIGNATHUS BARBATUS) PUP IS PULLED INTO A BIOLOGIST'S ARMS AS A TOOL TO LURE ITS MOTHER ONTO THE ICE FOR WEIGHING. SVALBARD, NORWAY

HELEN SILVESTER

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HELEN SILVESTER

OXFORD UNIVERSITY PRESS
AUSTRALIA & NEW ZEALAND

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Oxford University Press is a department of the University of Oxford.

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Published in Australia by
Oxford University Press
253 Normanby Road, South Melbourne, Victoria 3205, Australia

First published 2015

National Library of Australia Cataloguing-in-Publication data

Silvester, Helen, author.
Oxford science 7 / Helen Silvester.

ISBN: 9780190300821 (paperback)

Includes index.
For secondary school age.
Science–Study and teaching (Secondary)
Science–Textbooks.

Dewey Number: 507

Edited by Natalie Korszniak and Catherine Greenwood
Proofread by Marta Veroni
Indexed by Max McMaster, Master Indexing
Printed by Golden Cup Printing Ltd

SCIENCE 7

1 Science toolkit

Scientists work collaboratively and individually, in the laboratory or the field, to plan and conduct investigations safely and ethically. Scientists make predictions, control variables and record their results accurately. Scientists communicate their results using scientific language.

2 Mixtures

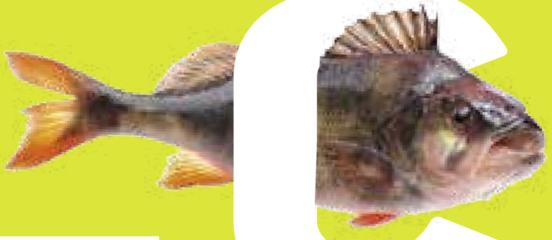
All things are made of materials. Many materials are mixtures. Some materials are not mixtures – they consist of one pure substance. Mixtures contain a combination of pure substances that can be separated using a range of techniques.

3 Water

Like many substances, water can exist in three states: solid, liquid and gas. Water is one of our most valuable resources and it cycles through our environment in a process called the water cycle.

4 Resources

Humans rely on the natural resources of the Earth. Some of Earth's resources are renewable, but others are non-renewable. Managing resources is a key priority.



5 Classification

Living things are called organisms. There are differences within and between groups of organisms. Classification is a system that helps organise the diversity of life on Earth. The system of classification continues to develop and change.

6 Interaction between organisms

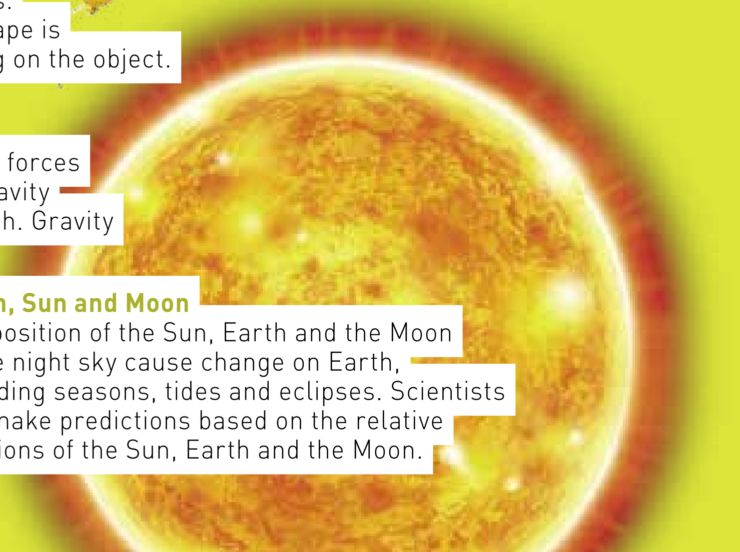
Organisms interact with each other in their environments. Scientists use food webs and food chains to represent these interactions. Humans are part of the food chain and human activity can affect the interaction of organisms.

7 Forces

A force is a push or a pull, arising from the interaction between two objects. Change to an object's motion or shape is caused by unbalanced forces acting on the object.

8 Gravity

Gravity is a non-contact force. Non-contact forces are forces that act at a distance. Earth's gravity pulls objects towards the centre of the Earth. Gravity changes with distance.



9 Earth, Sun and Moon

The position of the Sun, Earth and the Moon in the night sky cause change on Earth, including seasons, tides and eclipses. Scientists can make predictions based on the relative positions of the Sun, Earth and the Moon.

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Using Oxford Science

Oxford Science is a series developed to meet the requirements of the Australian Curriculum: Science across Years 7 to 10. Taking a concept development approach, each double-page spread of Oxford Science represents **one concept** and **one lesson**.

What if?

Student-directed inquiry is encouraged throughout this series using a simple questioning technique. As the series progresses, students discover that their own *What if* questions are actually testable '*if and then*' hypotheses. For example, 'What if *the bubble is touched with a finger*' becomes 'If *the bubble is touched with a finger,* then *it will pop*'.

Concept development

Students are given access to the chapter concepts at the start of every chapter. Each double page spread of this series represents **one concept**. Students explore concepts one-by-one encouraging incremental learning and, by the end of the chapter, complete understanding.

The unit heading introduces the concept.

Each unit begins with a short summary of the concept.

Body text elaborates on the concept in clear and accessible language.

Every spread is linked to one or more experiment, challenge or skills task as a practical application of the concept.

Diagrams and photos are used to illustrate the concept and engage students.

Every double-page spread ends with **Check your learning** questions, allowing students to consolidate their understanding. Questions are graded according to Bloom's Taxonomy – catering for a range of abilities and learning styles.

Accessibility and engagement

Oxford Science has been engineered to be accessible to all science students. We believe that science students are served best when they are free to focus on learning the knowledge and skills of science in simple accessible language, crafted into short sentences. Students will be engaged by the inclusion of stunning photography throughout.

Science as a human endeavour

Concepts are linked to real-world applications in the highly engaging **Science as a human endeavour** spreads. The **Extend your understanding** questions on this spread are designed to be used flexibly as either homework tasks or as an extended project.

Experiments

Uniquely, experiments are organised at the end of the book in an extended experiments chapter, rather than being confined to each double-page spread. There is a link on most double-page spreads to an experiment, challenge or inquiry task to ensure that practical activites remain aligned to the content.

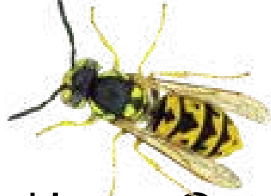
Integrated teaching and learning support

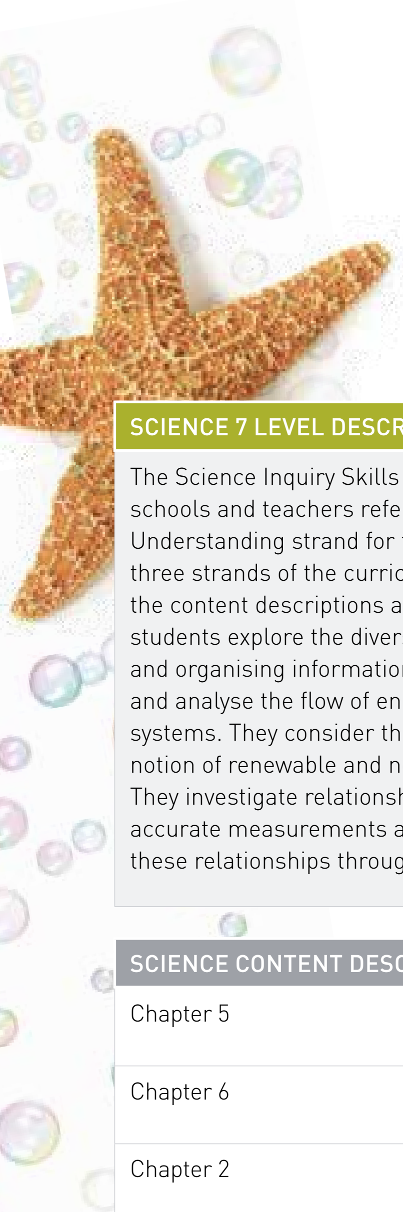
obook assess

obook assess provides an interactive electronic version of the student book in an easy-to-read format. It features multimedia links, interactive learning objects, videos, note-taking, highlighting and bookmarking tools, and live question blocks. **obook** is compatible with laptops, iPads, tablets and IWBs, and also offers page view (in flipbook format) that can be used offline. **assess** provides 24/7 online assessment designed to support student progression and understanding.

DASHBOARD

Oxford Science is supported by teaching strategies, lesson ideas, planning tips, assessment advice and answers to all activities. **obook assess** allows teachers to manage their classes by assigning work, tracking progress and planning assessment. Teacher Dashboard is your online lesson control centre, which allows you to instantly preview or assign related teacher resources to deliver incredibly engaging digital learning experiences. Students can also toggle from their obook to the Dashboard to interact with student resources for each topic.





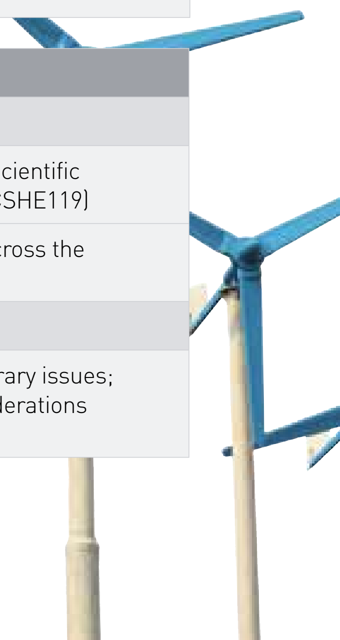
Australian Curriculum: Science 7 scope and sequence

SCIENCE 7 LEVEL DESCRIPTION (ABBREVIATED)

The Science Inquiry Skills and Science as a Human Endeavour strands are described across a 2-year band. In their planning, schools and teachers refer to the expectations outlined in the Achievement Standards and also to the content of the Science Understanding strand for the relevant year level to ensure that these two strands are addressed over the 2-year period. The three strands of the curriculum are interrelated and their content is taught in an integrated way. The order and detail in which the content descriptions are organised into teaching/learning programs are decisions to be made by the teacher. In Year 7, students explore the diversity of life on Earth and continue to develop their understanding of the role of classification in ordering and organising information. They use and develop models such as food chains, food webs and the water cycle to represent and analyse the flow of energy and matter through ecosystems and explore the impact of changing components within these systems. They consider the interaction between multiple forces when explaining changes in an object's motion. They explore the notion of renewable and non-renewable resources and consider how this classification depends on the timescale considered. They investigate relationships in the Earth, Sun, Moon system and use models to predict and explain events. Students make accurate measurements and control variables to analyse relationships between system components and explore and explain these relationships through increasingly complex representations.

SCIENCE CONTENT DESCRIPTIONS	
Chapter 5	There are differences within and between groups of organisms; classification helps organise this diversity (ACSSU111)
Chapter 6	Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions (ACSSU112)
Chapter 2	Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques (ACSSU113)
Chapter 9	Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon (ACSSU115)
Chapter 4	Some of Earth's resources are renewable, but others are non-renewable (ACSSU116)
Chapter 3	Water is an important resource that cycles through the environment (ACSSU222)
Chapter 7	Change to an object's motion is caused by unbalanced forces acting on the object (ACSSU117)
Chapter 8	Earth's gravity pulls objects towards the centre of the Earth (ACSSU118)

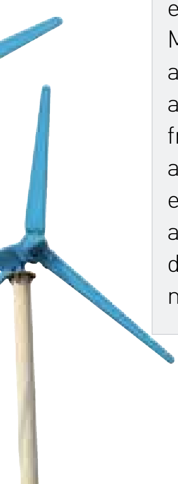
Science as a human endeavour (Year 7–8)	
Nature and development of science	
All chapters	Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world (ACSHE119)
All chapters	Science knowledge can develop through collaboration and connecting ideas across the disciplines of science (ACSHE223)
Use and influence of science	
All chapters	Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations (ACSHE120)



Use and influence of science	
All chapters	Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management (ACSHE121)
All chapters	People use understanding and skills from across the disciplines of science in their occupations (ACSHE224)

SCIENCE INQUIRY SKILLS (YEAR 7–8)	
Questioning and predicting	
All chapters	Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
Planning and conducting	
All chapters	Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)
All chapters	In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS126)
Processing and analysing data and information	
All chapters	Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS129)
All chapters	Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions (ACSIS130)
Evaluating	
All chapters	Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131)
All chapters	Use scientific knowledge and findings from investigations to evaluate claims (ACSIS132)
Communicating	
All chapters	Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133)

YEAR 7 ACHIEVEMENT STANDARD
By the end of Year 7, students describe techniques to separate pure substances from mixtures. They represent and predict the effects of unbalanced forces, including Earth's gravity, on motion. They explain how the relative positions of the Earth, Sun and Moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycle through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society. Students identify questions that can be investigated scientifically. They plan fair experimental methods, identifying variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions. They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. They communicate their ideas, methods and findings using scientific language and appropriate representations.



Acknowledgements

We would like to acknowledge the following educators' contributions to Oxford University Press science content over many years: Kristin Alford, Erin Bruns, Francesca Calati, Debbie Calder, Sally Cash, Amanda Clarke, Craig Cleeland, Leanne Compton, Gillian Coyle, Emma Craven, Ellaine Downie, Karen Drought, Teresa Eva, Anita Giddings, Christina Hart, Rosemary Koina, Greg Laidler, Karen Marangio, Daniela Nardelli, Rebecca Paton, Geoff Quinton, Peter Razos, Pam Robertson, Duncan Sadler, Maggy Saldais, Lynda Schulz, Nola Shoring, Jonathan Smith, Angela Stubbs, Craig Tilley, Mary Vail, Richard Walding, David Wilson

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**CSIRO/**Liz Poon, 6.30 **Fairfax/**John Woudstra, 6.9; **Getty Images/**David Messent, 6.20 /Peter ten Broecke, 6.23 /Stanley Breeden/National Geographic, 6.11; **Istockphoto,** 6.4 (all except eagle); **National Library of Australia**; nla.pic-an2962715-s20, 6.26; **Newspix,** 6.16, 6.21; **NSW Office of Environment & Heritage/**E Slater, 6.14; **Shutterstock,** 6.17 /Alexander Chalkin, 6.19 /Anton Ivanov, pp. 110-111 (row of statues) / Brooke Whatnall, 6.1 (centipede) /dancestrokes, opening page (giraffe) /Eric Isselee, p. 116 (fox) /Eric Milos, opening page (crane) /Ethan Daniels, p. 105 (water lily) /Evgenly Ayupov, 6.10 & opening page /feathercollector, 6.3 (bird) /Federico Rostagno, p. 107 (cactus) /Filipe Frazao, 6.18 /fritz16, 6.1 (currawong) /FXEGS Javier Espuny, opening page (statue) / gopause, opening page (bird) /Joanna22, 6.29 /John Carnemolla, 6.3 (cat) /Kippy Spilker, 6.6 /Kristian Bell, 6.3 (skink) /Markus Gebauer, p. 109 (possum) /Neil Annenberg, p. 118 /nikolae, p. 116 (recycle symbol) /Olga Phoenix, 6.1 (spider) /Peter Gudella, 6.1 (leaf litter) /Peter Waters, opening page (bee) /phildaint, 6.8 /Steve Lovegrove, 6.28 /Taitfin, 6.3 (berries) /Tanya Puntti, 6.15 /THPStock, 6.4 (eagle) /Tom Wang, 6.12 /xpixel, p. 113 (frog). **7 Forces: Alamy/**David Crausby, 7.7 /Peter Steiner, 7.38 /PHOTOTAKE Inc, 7.18 / sciencephotos, 7.1 & opening page; 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Tennant, 7.30 /Eunice Harris, 7.24 /Jasper Juinen, 7.2 / Martin Leigh, 7.23 /Science Photo Library, 7.21 /Scott Barbour, 7.52 /Scott Dickerson, p. 135 (fisherman) /Steve Gorton, p. 133 (wheelbarrow) /Tim Ridley, 7.46 & opening page /Laurent Hamels, p. 129 (balloon) /Martin Mistretta, p. 138 (goggles) /Navid Baraty, p. 134 (hook) & opening page / Stockbyte, p. 131 (pins); **istockphoto/**Nancy Nehring, 7.44; /TommL, 7.45; **Newspix/**James Croucher, 7.51; **Rose Cuddy,** 7.39; **Shutterstock/**Africa Studio, 7.48 /bikeriderlondon, p. 140 (gymnast) /Ensuper, 7.29 /Geofff, 7.47 /homydesign, opening page (weight) /john photon, 7.40 /Ljupco Smokovski, 7.49 /Luis Louro, p. 141 (ball) /lzf, 7.4 /Matthew Ennis, 7.26 /MNI, p. 133 (scissors) & opening page /revers, opening page (magnet) /S_E, 7.22 /tankist276, openeing page (turtle) /Vaclav Volrab, 7.5 /vitor costa, 7.8 /Vladyslav Danilin, 7.50 /withGod, 7.27 & opening page /Jiri Hera, opening page (balloon). **8 Gravity: Alamy/**John Sylvester, 8.11; **Getty Images/**Barcroft Media, p. 153 (elephant) /Robin Smith, Table 8.1; **Lindsay Edwards,** 144 (apple) & opening page; **NASA,** 8.12, 8.12, 8.13, 8.14, 8.16; **Science Photo Library/**Alfred Pasieka, 8.15 /Christopher Meder, p. 154 / Filipe Frazao, p. 147 (earth/moon) & opening page /Georgios Kollidas, 8.7 /Germanskydiver, p. 152 (skydivers) /godrick, 148 (moon) & opening page /Marc Ward, opening page (astronaut) /Nicku, 8.6 /Vitalil Nesterchuk, 8.2. **9 Earth, Sun, and Moon: Getty Images/**David de Groot, 9.9 / Matheisl, 9.12 /SPL/Sheila Terry, 9.5 DR SETH SHOSTAK, 9.8; **NASA,** 9.2, 9.15, 9.17, 9.18, 9.19, 9.20, p. 165 (moon) / GSFC, Reto Stöckli, Nazmi El Saleous, and Marit Jentoft-Nilsen, 9.1; **Newspix,** 9.7 **Ray Norris,** 9.10; **Shutterstock/**FooTToo, opening page (telescope) / MarcelClemens, 9.3 /Photobank Gallery, opening page (tree) /Silvertiger, opening page (sun) TAGSTOCK1, p. 166 / Vladimir Wrangel, 9.21 /Wiratchai Wansamngram, opening page (satellite dish) **The Art Archive/**Eileen Tweedy, 9.16. **10 Experiments: Alamy/**Brian Jackson, 10.17 /Dave Watts, 10.46 (platypus) /Helen Sessions, Experiment 2.2B (milo); **Bill Thomas,** 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 10.9, 10.10, 10.11, 10.12,10.13; **Getty Images/**Science Photo Library, 10.39 /Scott Camazine, 10.51 (hammerhead worm); **Istockphoto/**Oskanov, Challenge 5.5; **Shutterstock/**Alena Brozova, Experiment 2.3 /Andrew Orlemann, 10.36 /Anneka, Challenge 4.6 (waves) /Anteromite, Challenge 4.3 / ArtisticPhoto, Challenge 4.6 (solar panel) /bergamont, Experiment 7.9 (wheel) /Bryan Solomon, 10.41 (muffin) / cigdem, Challenge 9.2 /Claudio Bertoloni, 10.46 (kangaroo) / David Steele, Challenge 4.6 (turbines) /Delpixel, Experiment 3.2 /Dimljana, 10.51 (mosquito) /Eric Isselee, Challenge 6.1 (grasshopper) /foto infot, 10.1 /Fotyma, 10.51 (sponge) / gresei, Challenge 5.1 (nail polish) /Hugh Lansdown, 10.46 (echidna) /ifong, Skills Lab 1.8 (sugar) /Igor Lateci, Challenge 5.1 (laptop) /Inavan Hateren, Challenge 5.8 (grass) /irin-k, 10.51 (fly) /ixpert, Skills Lab 4.1 /John McQueen, 10.51 (spider) /jopelka, 10.51 (starfish) /jps, Experiment 7.9 (wedges) /Julian W, 10.46 (koala) /Kosmoss111, Challenge 2.5 /kritskaya, 10.41 (spoon) /Lippert Photography, Challenge 5.9 (pod) /Maxim Pertichuk, Challenge 4.6 (flowers) /Monticello, Challenge 5.1 (backpack) /Mr Doomits, Challenge 6.1 (caterpillar) /Muskoka Stock Photos, Challenge 6.4 /Pakhnyushchy, Challenge 5.1 (tv) / pandpstock001, 10.53 /PanStock, 10.51 (centipede) /phloxii, Experiment 2.4 /Photobank Gallery, Challenge 9.3 /Polyaz, Challenge 5.1 (coat) /revers, Challenge 7.3 /rtem, 10.40 / sagir, Challenge 5.1 (hoodie) /Sergiy Zavgorodny, Challenge 5.1 (sleeping bag) /Shots Studio, opening page /Steve Holderfield, 10.21 /StudioVin, Experiment 7.9 /Teguh Tirtaputra, 10.46 (lizard) /Tetat Uthailert, Challenge 5.1 (mp3) /tomkaii, Experiment 7.7A /tonympix, Challenge 5.8 (flower) /Tsekhmister, Experiment 6.6 /Viktor1, 10.20 / Withgod, Experiment 7.9 (screw) /yevgenly11, 10.51 (worm).

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SCIENCE TOOLKIT

1

1.1 Science is the study of the natural and physical world

1.2 Scientists use specialised equipment

1.3 Scientists take safety precautions

1.4 Scientists use observation and inference to answer questions

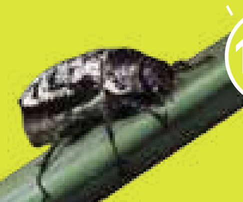
1.5 Science relies on measuring with accuracy

1.6 A Bunsen burner is an essential piece of laboratory equipment

1.7 A fair test is a controlled experiment

1.8 Graphs and tables are used to show results

1.9 Scientific reports communicate findings



1.10 Science skills are used to solve important problems

What if?

Bubbology

What you need:

bubble mix, straw, plastic ruler

What to do:

1 Pour a little bubble mixture onto a clean bench surface.
2 Put the end of the straw in the bubble mix.
3 Blow gently through the straw.

CAUTION: DO NOT SUCK ON THE STRAW.

What if?

» What if you touch a bubble with a wet finger?
» What if you touch a bubble with a dry finger? Why do wet and dry fingers affect the bubbles differently?

1.1 Science is the study of the natural and physical world

Science measures what we **observe** (see, hear, smell and feel) and organises it into testable explanations. **Scientists** have jobs that focus on asking questions and finding answers. All sorts of people are scientists: men, women, young people, old people. Scientists work in fascinating places: in Antarctica, in space, near volcanoes and under the sea. Science also happens in a **laboratory** – a specially designed space for conducting research and experiments. Scientists work alone or in teams, They answer questions by observing, recording and interpreting what they find.

Curiosity through history

Figure 1.1 Early scientists were called natural philosophers.

Many scientific discoveries start with one person who is curious about something. Our world would be a very different place without people wondering 'How does this work?' or 'Why is this so?'

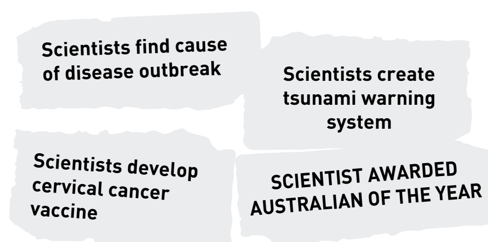
Sometimes curiosity comes from necessity. To survive, the first humans had to discover, through trial and error, which foods were edible and which were poisonous. This was curiosity with life-and-death results! The information was then passed from person to person to benefit many more people.

Curiosity can also come from the desire to find things out. In ancient Greece, there was much curiosity about the stars, the Sun, the Moon and our own planet. Early scientists weren't called scientists at all – they were called 'natural philosophers' because of their interest in studying nature. **Philosopher** means 'lover of knowledge'. Natural philosophers used their observations to develop calendars, to locate the Earth in the universe and to prove that the Earth is round and not flat.

Finding answers to problems that affect people and society is another result of curiosity. Many of the great advances in medicine, such as vaccinations and the discovery of penicillin, are the result of years of research. They have changed our lives immensely, and mostly for the better.

Curiosity today

Science is in the news every day. Some of the issues scientists are curious about right now include alternative and 'green' energy sources, clean drinking water and food for a growing world population and new cures for diseases such as the Ebola virus. Scientists ask questions about the survival of the human race, space travel and the potential of the human brain. Science is an ongoing process that is never 'finished' – it is always changing.



Scientists in the world

There are four main branches of science: biology, physics, chemistry and earth and space science. Within each of these branches there are many different specific science professions. Usually, a scientist has dedicated years of study to specialise in one particular area. Figures 1.2–1.7 show six different types of scientist and a question they may spend time researching. Science is an ever-expanding search for knowledge and, as you will read, there is still a lot of research to be done.

CHALLENGE 1.1: SIDEWAYS PING PONG
GO TO PAGE 170

Figure 1.2 A pharmacologist studies medicines and drugs and their effects on the human body. *Is an experimental vaccine for the Ebola virus safe for human trials?*

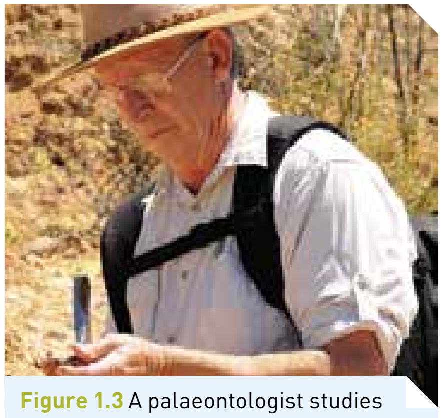


Figure 1.3 A palaeontologist studies ancient life, including dinosaur fossils. *What can the mass extinction of dinosaurs teach us about modern life on Earth?*

Figure 1.4 An environmental scientist studies the environment. *How is climate change affecting the Earth?*

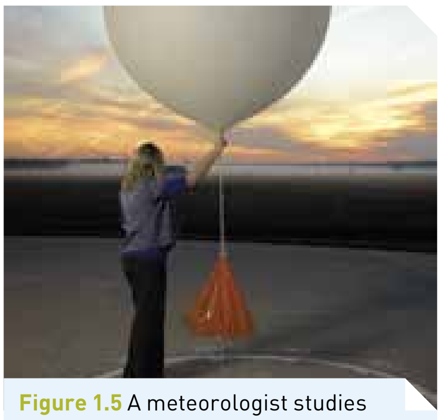


Figure 1.5 A meteorologist studies the **atmosphere** and **weather** patterns. *How can we accurately predict cyclones?*

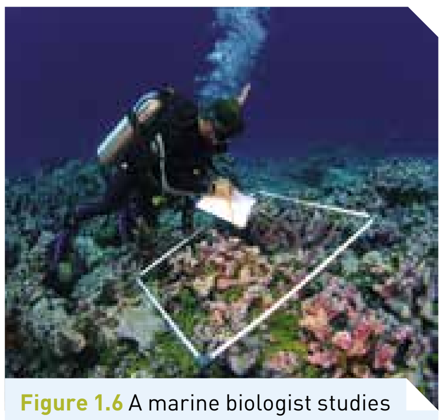


Figure 1.6 A marine biologist studies life in the oceans and seas. *How will rising sea waters affect the Great Barrier Reef?*

Figure 1.7 A nanotechnologist studies substances at the atomic (very small) scale. *Can we design drugs to target individual* ***cells****?*

Check your learning 1.1

Remember and understand

1. What were early scientists called?
2. Why are curiosity and asking questions important in science?
3. Identify the four main branches of science.

Apply and analyse

4. a. Ask an adult to recall one thing that has changed in their lifetime due to science.
   b. What is something that has changed in your lifetime due to science?
5. Examine the question being studied by the meteorologist in Figure 1.5. What benefits could this research have?
6. Which other scientists might the environmental scientist work with to investigate climate change?

Evaluate and create

7. It is often said that science is never 'finished'. Evaluate this statement, providing examples of science never being finished.
8. Look carefully at Figure 1.8. What do you think the scientist is trying to find out about the gorillas? Does he need to be this close to get his answers?

Figure 1.8

1.2 Scientists use specialised equipment

An important part of exploring science is knowing how to conduct experiments safely and successfully. An **experiment** is a way to solve a problem or to find the answer to a question. Only through experimentation can some of the truly big questions of science be answered. Scientists use specialised equipment to conduct experiments in the laboratory and in the field.

Scientific equipment

Equipment is the name given to the beakers, burners, flasks, stands and other items used by scientists to conduct experiments. Using the correct equipment ensures reliable results and the safety of the scientist. Commonly used equipment is shown in Figure 1.9. Some of the names may sound unfamiliar, but you will soon learn what each piece of equipment is called and how it is used. The equipment in your school laboratory may look slightly different because each laboratory has its own type of equipment. Some items of equipment can be used together in an experiment. Equipment placed together for an experiment is called an **apparatus**.

Figure 1.9 Types of equipment used in the laboratory.

SKILLS LAB 1.2: DRAWING SCIENTIFIC DIAGRAMS
GO TO PAGE 171

1.2 CHALLENGE: BRAIN TRAINING

Scientific equipment

1. Your class will divide into two teams and revise Figure 1.9. Spend two minutes reminding yourself of the correct names for the pieces of equipment.
2. Your teacher will uncover a mystery tray containing 16 pieces of equipment. You will be able to view the tray for 60 seconds; it will then be re-covered.
3. Write down the names of all the pieces of equipment you can remember.
4. When you check your answers, score 2 points for each piece remembered and spelt correctly; score 1 point if the spelling is incorrect.
5. Add up the points for each team. The team with the most points wins.

Scientific diagrams

To show others how to set up an experiment, scientists write a list of equipment needed and draw how it should be set up. But imagine how long this would take if every picture was as beautiful and realistic as Sarah's painting in Figure 1.11! Even if you didn't use paints and just sketched with a pencil, it would still take a long time to draw the equipment.

Scientists have a quick and simple way to show scientific equipment. They use drawings called **scientific diagrams**. Using scientific diagrams means you don't have to be an artist to be a good scientist and you have more time to do the experiments.

The procedure for drawing scientific diagrams is as follows:

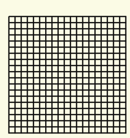
1. Draw clearly and neatly.
2. Use a sharp grey pencil.
3. Draw the equipment from the side view.
4. Don't show any detail, just a simple outline with no shading.
5. Draw lines using a ruler.
6. Print labels neatly and connect them to the diagram with a line or arrow.
7. Spell labels correctly. Incorrect spelling makes good science look bad!
8. Diagrams should be between 6 and 10 centimetres high.

Figure 1.10 Scientific drawings of laboratory equipment.

Check your learning 1.2

Remember and understand

1. Draw the scientific diagram for each piece of laboratory equipment listed below.
   a. filter funnel
   b. beaker
   c. metal tongs
   d. measuring cylinder
2. What is the difference between a scientific diagram and an artist's drawing?
3. a. Laboratory equipment that is put together to do an experiment is called …
   b. Experiment beakers, stands and other items used for experiments are called …
4. Name the following scientific diagrams:

a 

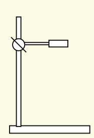
b 

Figure 1.11 In her art class, Sarah painted a still-life picture of some pieces of science equipment. Sarah is a great artist, but she took at least 4 hours to complete the picture!

1.3 Scientists take safety precautions

Scientists may be exposed to a variety of hazards in their work. In unfamiliar environments, such as out in the field, there are many safety hazards they cannot control. In a laboratory, safety issues are easier to manage.

a

b

Figure 1.12 (a) Vulcanologists (scientists who study volcanoes) wear amazing heat-resistant silver suits to protect themselves against heat, ash and molten rock. (b) Microbiologists researching infectious diseases wear protective clothing to ensure they don't get sick.

Laboratory safety

As a science student, just like every scientist, it is your responsibility to be familiar with your laboratory, where the safety equipment is located, what the warning signs mean and what to do in an emergency. Most safety is common sense – common sense can prevent many dangerous situations.

Safety symbols

Safety symbols are used in many different settings. You may have seen the ones in Figure 1.13 on building sites, at entrances to buildings, at school or on roads.

Your laboratory may already have some of these symbols displayed.

Symbols are often simple drawings, although sometimes words are also used. If a picture can show a message clearly, words may not be needed.

Laboratory safety rules

A class laboratory is not like a normal classroom – there are additional rules to follow. The class laboratory is a place where people are learning to be better scientists, but they may not always get it right the first time. You will notice your science skills improving as you do more and more experiments carefully in the laboratory.

In the laboratory do:

- wear a lab coat for practical work
- keep your workbooks and paper away from heating equipment, chemicals and flames
- tie long hair back whenever you do an experiment
- wear safety glasses while mixing or heating substances
- tell your teacher immediately if you cut or burn yourself, break any glassware or spill chemicals
- wash your hands after any experiments
- listen to and follow the teacher's instructions
- wear gloves when your teacher instructs you to.

In the laboratory don't:

- run or push others or behave roughly
- eat anything or drink from glassware or laboratory taps
- look down into a container or point it at a neighbour when heating or mixing chemicals
- smell gases or mixtures of chemicals directly; instead, waft them near your nose and only when instructed
- mix chemicals at random
- put matches, paper or other substances down the sink
- carry large bottles by the neck
- enter a preparation room without your teacher's permission.

Figure 1.13 What does each of these symbols mean?

LABFAB: NOTES FROM THE FASHION LABWALK

Welcome to our fabulous fashion show for the label that is taking the fashion world by storm – *Labfab*.

Olivia is wearing our new designer lab coat, which has three- and four-button options. Note that the buttons are worn done up.

Lab coats are going to be loose this year for stylish comfort during those tricky experiments. And this year, knee length is *the* length to protect you from stray chemicals.

Safety glasses are hot and big. Top model and scientist Corey is modelling a pair from the new range, which are hipper than the latest sunglasses. If you already wear glasses you may not need to wear safety glasses.

This year, laboratory shoes are solid – no tootsies please! Solid and sensible, they scream 'enduring style'.

Finally, you can never have too many accessories. The latest in latex – a cheeky take on rubber – is our fabulous range of disposable gloves. They are available in a range of colours to suit your every experimental mood.

Figure 1.14 The lab fashionistas, Olivia and Corey.

Creating laboratory safety rules

Look at Figure 1.15.

- How many potentially dangerous activities can you identify in this picture?
- What rules might be needed to prevent potential danger?
- Create a list of rules you think might be needed in your science laboratory. Give a possible consequence if the rule is not followed.
- Compare your list of rules to the tips listed on the opposite page.
- Type up your list on a computer, print it out and stick it on the inside front cover of your workbook.

Figure 1.15 Can you see the potentially dangerous activities?

Check your learning 1.3

Remember and understand

1. Identify the three safety symbols shown in Figure 1.16. What does each one stand for?
2. a. Name three items of protective clothing you might wear in the laboratory.
   b. Identify a reason why you should wear each item.
3. List five things you should do to remain safe in the laboratory.
4. List five things you shouldn't do in the laboratory.

Figure 1.16

Apply and analyse

5. With a partner, take turns to mime a safety rule for your partner to guess.
6. Why do you think it is dangerous to drink from laboratory glassware?

Evaluate and create

7. Evaluate Figure 1.17. Write down as many science dos and don'ts that you can find.

Figure 1.17

1.4 Scientists use observation and inference to answer questions

To be good at investigating and solving problems, you need to be observant and notice things around you. All your senses – sight, taste, hearing, smell and touch – send information to your brain. Most experimental results are collected by making **observations**. Good observers make accurate observations and obtain accurate results.

Observations

The skill of observation usually requires you to notice small differences. Figure 1.18 shows two scenes. There are 10 differences between the two. Can you find them all?

Figure 1.18 Use your observation skills to identify the differences between the two pictures.

Observations can be either quantitative or qualitative

Quantitative observations use measurement – they are quantities or 'amounts' and are normally written using numbers. Terms such as 'large', 'small', 'greater than' or 'minimal' may also be used to describe quantitative observations. Numbers are usually accompanied by units (e.g. 2.7 metres or 23.4°Celsius). Warmth is a measure of heat and brightness is a measure of light, so they are quantitative.

Qualitative observations use words to describe anything that isn't an 'amount'. The five sense organs of the human body are essential for qualitative observations. What you see, hear, smell, taste or feel are generally qualitative observations. 'Rough', 'sour' and 'yellow' are all words describing qualitative observations.

Testing your senses

The secret to being observant is to use your senses. The activities in this unit will make you more aware of your senses. In some activities you will need a blindfold. It is best to use safety glasses that have been painted black or covered with dark paper. You will not test your fifth sense, taste, because it is not good safety practice to eat in a laboratory.

CAUTION: NEVER SMELL THINGS IN A TEST TUBE UNLESS YOUR TEACHER SPECIFICALLY INSTRUCTS YOU TO.

SKILLS LAB 1.4: OBSERVATION VERSUS INFERENCE
GO TO PAGE 172

Figure 1.19 Test your sense of smell. Your teacher will provide you with some test tubes (wrapped in paper) lined up in a test tube rack. Gently smell each one by wafting the smell towards your nose with your hand. See if you can name the smell.

Figure 1.20 Test your sense of touch. Wearing your blindfold, feel some common objects. They may be fruit, fabric, sandpaper, plastic or something else. Describe the feel of each and try to recognise each substance by its touch.

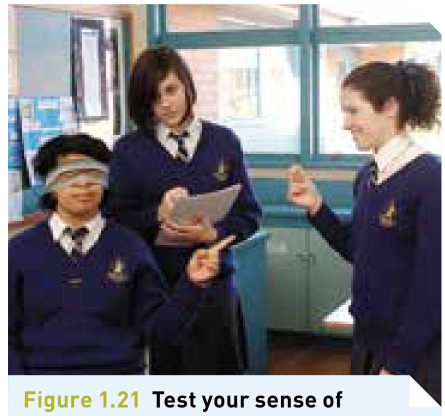


Figure 1.21 Test your sense of hearing. Sit at your desk and put on your blindfold. As your partner taps on the desk or clicks their fingers, point to where you think the noise is coming from. How good are you at finding the direction of a sound?

- Based on this activity, which is your strongest and which is your weakest sense?
- Did you discover anything surprising while doing this activity? If so, what was it?
- Write one thing that you have learnt about your senses of smell, touch, sight and hearing.

Inferences

Scientists need to be skilled at **inference** as well as observation. An inference is a likely explanation of an observation. It is how you explain your observation. An inference doesn't necessarily guarantee that something is true, but it is likely to be true.

Table 1.1 contains examples of observations, paired with possible inferences.

Table 1.1 Some sample observations and inferences

OBSERVATION	INFERENCE
Your house *smells* like cooked onions when you get home from school	You are probably having cooked onions with dinner
A fabric *feels* like satin	The fabric is either satin or something that feels very much like satin
You *see* a man running down the street	The man is either running away from something or running to something
You *hear* a house alarm ringing	Someone has entered the house
Lemon juice *tastes* sour	Lemons contain an acid

Check your learning 1.4

Remember and understand

1 What is an observation? Provide an example.
2 What is an inference? Provide an example.
3 What is the difference between quantitative and qualitative observations?

Apply and analyse

4 Which of the following are observations? Which are inferences?
   a You smell a strong odour from a garbage bin.
   b Coffee stays hotter if you add the milk before the hot water.
   c I measured the temperature today at 37°C.
   d It's so hot that the temperature must be 37°C.
   e There's a person in a Santa suit. It must be Christmas.
   f This soup is so hot it hurts my teeth.
5 Which of the observations from question 4 are quantitative and which are qualitative?

Evaluate and create

6 Why don't scientists use the sense of taste in a laboratory?
7 Observation and inference are very important tools for scientists. Why do you think they are important?

1.5 Science relies on measuring with accuracy

Whether you are always aware of it or not, you use measurements every day. You may buy milk in a 1 litre carton and ask for 200 grams of ham at the supermarket. You might walk 800 metres to school each day. If you are ill, a doctor will measure your body temperature to see if it varies from the normal 37°Celsius. Each time you look at your watch you are measuring time. Measurements are, and have always been, an important part of life and science.

What if?

Human thermometer

What you need:

3 ice-cream containers, very warm water, room temperature water, cold water, ice cubes, thermometer

What to do:

1. Half fill one container with cold water and add the ice cubes.
2. Half fill the second container with room temperature water.
3. Half fill the last container with very warm water.

CAUTION: MAKE SURE IT IS SAFE TO PUT YOUR HAND IN.

4. Place one hand in the cold water and the other in the warm water for 2 minutes.
5. Remove both hands and place them both in the room temperature water.
   - What do you notice about how hot/cold the water is?
   - Do both hands tell your brain the water is the same temperature?
6. Use a thermometer to measure the temperature of the water in all three containers.

What if?

- What if a foot was put in the water instead of a hand?

As you discovered in the 'Human thermometer' activity, your body picks up changes in the environment, but it cannot tell you the exact temperature of the water or air. For this reason scientists rely on accurately measuring all things during their experiments.

Old ways of measuring

For thousands of years, distances have been measured by comparing them to parts of the human body. The height of a horse, for instance, is still measured in hands. Some countries, such as the USA, measure distance in feet. A standard system is now used, instead of human hands and feet.

Table 1.2 Measurements used in ancient civilisations

OLD UNIT	CIVILISATION	ESTIMATED EQUIVALENT TODAY
Royal foot	Ancient Egypt	25.4 cm
Royal cubit	Ancient Egypt	52.4 cm
Finger	Ancient Mesopotamia	1.9 cm
Palm	Ancient Mesopotamia	7.5 cm
Fathom	Ancient Mesopotamia	1.8 m
Knuckle	Ancient Greece	3.9 cm
Lick	Ancient Greece	15.4 cm

SKILLS LAB 1.5: MEASURING MASS AND VOLUME
GO TO PAGE 172

Measurement and units

Using human body parts for basic measurements caused confusion and arguments because everyone's body size is different. So many different systems were being used to measure things that people were often cheated, for example when buying goods by weight.

In 1790, the King of France, Louis XVI, decided that in his country at least, a uniform system should be established. This was ultimately called the metric system, from the Greek word *metron*, meaning 'to measure'.

The idea of having standard **units** for measurement soon spread, so that all types of measurement were included. The **metric system** is now used by scientists worldwide. A measurement of 2.45 metres has to be the same in Wonthaggi as in New York. A temperature of 37°C is just as hot in Kolkata as in Kyabram. Scientists often check each other's work by repeating experiments to see if they get the same results. To do this they need to be able to use measurements that are the same as those of the original experiment. By using a standard system of measurement, scientists everywhere can understand and build on each other's work. Five kinds of measurement are important when you are exploring science: volume, mass, temperature, time and length.

Figure 1.22 Length Measurements of length can be shown using a unit called metres, with the symbol 'm'. For long distances, **kilometres** (km) are used. For short distances, **centimetres** (cm) or **millimetres** (mm) can be used. In school science, the devices we use to measure length and distance are the trundle wheel (pictured), metre rule and tape measure.

Figure 1.23 Mass This measures the amount of **matter** or substance in an object. Mass is measured in units called **grams** (g), **kilograms** (kg) and **tonnes** (t). Smaller masses are measured in **milligrams** (mg). Mass-measuring devices are called scales or balances. You will use an electronic balance to measure mass.

Figure 1.24 Time A watch or clock set to the correct time tells you the time of day. A stopwatch measures how much time has passed. In your experiments, measurements of time will often have the unit called **seconds** (s).

Figure 1.25 Temperature This is usually measured using a thermometer. Some thermometers have a digital scale. Measurements of temperature have the unit called degrees **Celsius**. Its symbol is '°C'.

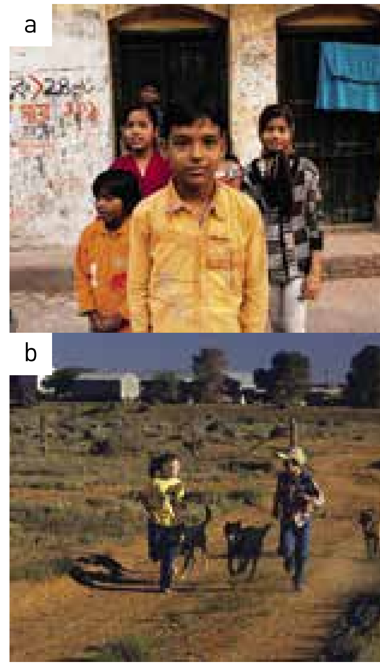


Figure 1.26 A temperature of 37°C is the same in Kolkata, India, and in Kyabram in northern Victoria.

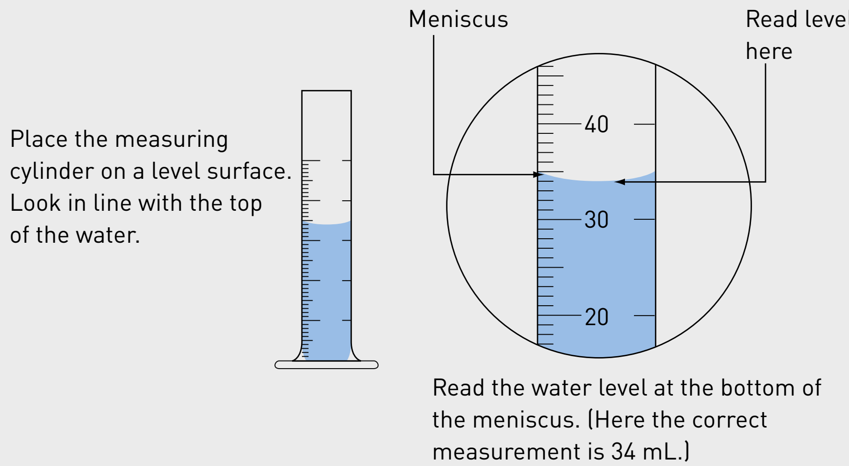


Figure 1.27 Volume This measures how much space something takes up. Measurements of liquid volumes can be shown with units called **litres** (L) or **millilitres** (mL). In science, beakers and measuring cylinders are used to measure the volume of liquids. Some beakers have a measuring scale on them, but measuring cylinders are more accurate than beakers. Scientists usually prefer to use measuring cylinders to measure volume. Liquids cling to the sides of containers, forming a slightly curved surface. This is called a meniscus. The diagram shows how to read a meniscus. Measurements of the volume of solid objects have units such as **cubic centimetres** (cm^3).

Recording measurements

All measurements have two parts: a number and a unit. For example, 5 metres is written as '5 m'. Notice that the unit does not have an 's' after it, even though it stands for 'metres'.

Measurements are usually recorded in a table or a graph so that they can be easily read, compared or used for further calculations.

Table 1.3 Some metric units of measurement

MEASUREMENT	UNIT	SYMBOL	INSTRUMENT USED
Distance or length	Kilometre	km	Trundle wheel
	Metre	m	Metre rule
	Centimetre	cm	Tape measure or ruler
	Millimetre	mm	Tape measure or ruler
Volume	Litre	L	Beaker
	Millilitre	mL	Measuring cylinder
Mass	Tonne	T	Weighbridge
	Kilogram	kg	Beam balance
	Gram	G	Spring balance
	Milligram	mg	Electronic scales
Time	Hour	h	Clock
	Minute	m	Stopwatch
	Second	s	Stopwatch
Temperature	Degrees Celsius	°C	Thermometer

Converting units of length

To compare two measurements, their units must be the same. It is difficult to compare 10 000 metres with 13 kilometres – which is longer? Comparing 10 kilometres with 13 kilometres is much easier. The metric system works in multiples of 10, so we can convert using a formula.

1 kilometre = 1000 metres

1 metre = 100 centimetres

1 centimetre = 10 millimetres

To change a larger unit (e.g. km) into a smaller unit (e.g. m) you need to multiply.

To change a smaller unit (e.g. mm) into a larger unit (e.g. cm) you need to divide.

CHANGE FROM:	CHANGE TO:	
km	m	× 1000
m	cm	× 100
cm	mm	× 10
m	km	÷ 1000
cm	m	÷ 100
mm	cm	÷ 10

Example: Which is longer: 150 metres or 12 000 centimetres?

150 m × 100 = 15 000 cm

Therefore, 150 metres is longer than 12 000 centimetres.

Measuring accurately

Accurate measurement in science is important so that your results are a true record of something. Comparing measurements with other scientists is useful only if your results are accurate.

You can do several things to improve your **accuracy** in the science laboratory. Always take your time when measuring and make sure you write down the result straight away. When reading a scale, line up your eye directly in front of the object and the scale. Looking from above or from the side can produce different readings. This is called **parallax error**.

Sometimes errors in measurement are unavoidable. An **error** is different from a mistake – it can happen for various reasons, no matter how careful you are. Errors can occur if the object you are measuring falls between two markings on a scale; this will mean that you have to estimate the exact measurement. Sometimes scales can be calibrated (set up) incorrectly, which means that no matter what you measure you will get a slightly inaccurate result. You can minimise the effect of this kind of error by always using the same measuring device.

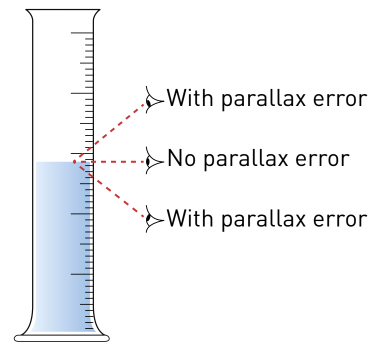


Figure 1.28 Parallax error occurs when you read a scale from an angle.

Check your learning 1.5

Remember and understand

1 Make a list of everything you have measured today. Think carefully – you have probably measured more things than you realise. Try to list at least five things.

2 Why is it a problem to use body parts as a measuring tool?

3 In the USA, people use imperial units of measurement (foot, pound, mile) but scientists in the USA use metric units.

   a Why do the scientists do this?

   b What problems might arise if scientists in the USA used imperial units?

4 What is a meniscus?

5 When you measure volume, what part of the meniscus is read?

Apply and analyse

6 Would you prefer to walk 14 900 centimetres or 3 kilometres? Explain why.

7 What tools would you use to measure the following things?

   a distance around a cricket ground

   b the time it takes a sprinter to run 100 metres

   c mass of a carrot

   d volume of water in a fish tank

   e volume of a square block

   f the temperature of a swimming pool

   g your mass

   h the thickness of this book

8 Which is longer: 10 000 millimetres or 500 metres?

9 Which is shorter: 3 kilometres or 1000 metres?

10 Convert 1 kilometre into metres, centimetres and millimetres.

Evaluate and create

11 Using props, demonstrate that errors in measurement are sometimes unavoidable.

1.6 A Bunsen burner is an essential piece of laboratory equipment

A **Bunsen burner** is one of the most useful pieces of equipment in the laboratory. The flame of the Bunsen burner is used to heat things in the laboratory. Under the right conditions, the hottest part of a Bunsen burner flame can be over 1500°C.

Using a Bunsen burner

A mixture of LPG (liquid petroleum gas) and air is used to produce a good flame for heating. The Bunsen burner has a collar that can be turned to open or close the air hole. The position of the collar controls how much air enters the burner and therefore how hot the flame is. If the hole is closed, less air can mix with the gas. This results in a yellow safety flame. If the collar hole is open, air mixes with the gas, allowing a hotter blue flame to burn.

When alight but not being used for heating, the Bunsen burner should be left on the yellow (safety) flame, which is not as hot and is easy to see. The safety flame is always used when lighting the burner.

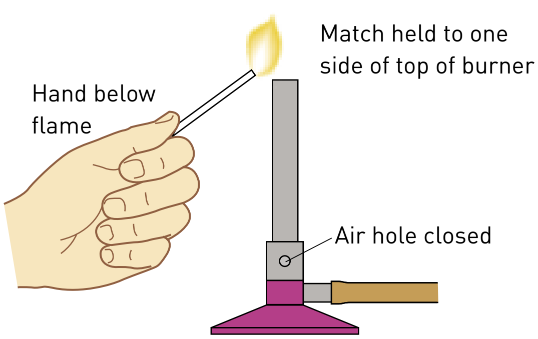


Figure 1.29 The right way to light a Bunsen burner.

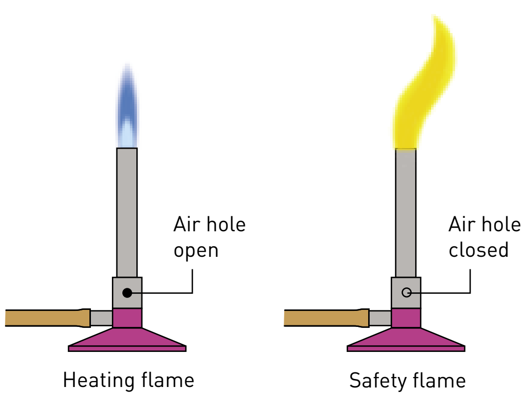


Figure 1.30 Blue (heating) and yellow (safety) flames on the Bunsen burner.

Figure 1.31 A scalded hand.

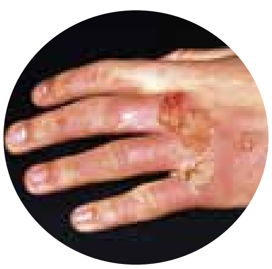


Figure 1.32 A burnt hand.

What to do if there is a fire in the laboratory

1 Let the teacher know immediately (they will turn off the main gas tap if gas is involved).
2 The class fire officer should take a message to the school administration as quickly as possible.
3 If the fire is small, the teacher will use the fire extinguisher.
4 Evacuate the area in an orderly manner.
5 Check that everyone is safe.

Treating scalds and burns

1 Immediately run cold tap water on the scald or burn for at least 15 minutes. Do not use ice or very cold water.
2 Ask another student to tell your teacher about the scald or burn.
3 Remove nearby clothing (unless it is stuck to the burnt area) and jewellery (e.g. watches, rings and bracelets) because burnt areas can swell quickly.
4 Try to handle the area as little as possible. Do not use any creams.
5 Seek medical attention if necessary.

1.6A
SKILLS LAB

REMEMBER TO KEEP YOUR HAND BELOW THE FLAME.

CAUTION: KEEP YOUR NOTEBOOK AND OTHER MATERIALS WELL AWAY FROM THE BUNSEN BURNER (ON A NEARBY BENCH OR FURTHER UP THE BENCH).

Lighting a Bunsen burner

A Bunsen burner is lit in five steps.

1 Place the Bunsen burner on a heating mat.

2 Connect the rubber hosing firmly to the gas tap.

3 Close the air hole by turning the collar.

4 Light a match and place it above the barrel, with your hand below the flame.

5 Open the gas tap fully.

6 After you have followed these steps, the Bunsen burner will have a yellow (safety) flame.

1.6B
SKILLS LAB

Materials

- Bunsen burner
- heatproof mat
- matches
- notebook
- coloured pencils
- grey pencil
- metal tongs
- 2 pieces of white ceramic or porcelain

CAUTION: THE PORCELAIN YOU HEAT WILL REMAIN VERY HOT FOR A LONG TIME. DO NOT PICK IT UP WITH YOUR FINGERS; USE TONGS.

Using your Bunsen burner

Wear safety goggles and a lab coat.

1 Follow steps 1–5 from Skills lab 1.6a: Lighting a Bunsen burner.
2 Change the flame to a blue flame by opening the air hole on the collar.
3 Write down and draw what happens to the flame when the hole is closed, half open and fully open.
4 Close the collar so that a yellow flame is produced.
5 Using tongs, hold a piece of porcelain in the top of the yellow flame for a minute. Place the hot porcelain on the heating mat when you have finished. Describe what happens to the porcelain and draw it.
6 Hold the other piece of porcelain with the tongs. Change the flame to blue and heat the porcelain for 1 minute. Describe what happens to this piece of porcelain and draw it.
   - Why do you think the yellow flame is called the safety flame? Give at least two reasons.
   - Which flame is noisier: blue or yellow? Why is this helpful to know?
   - Which flame leaves a sooty carbon black deposit on whatever object it heats?
   - Which flame is the 'clean' flame for heating?
   - Give reasons for using a blue flame for heating in an experiment.

Check your learning 1.6

Remember and understand

1 What is the colour of the Bunsen burner's safety flame?
2 What is the colour of the Bunsen burner's heating flame?
3 How do you get a heating flame with your Bunsen burner?
4 How should you treat a scald?

Apply and analyse

5 If you were heating a substance to check for colour change, which flame would you use to make it easier to observe?
6 Why should hair be tied back when using a Bunsen burner?

1.7 A fair test is a controlled experiment

Scientists are reliable sources of information because of the way they test their ideas. Unfortunately, some people use the language of science to promote unscientific information. This is called **pseudoscience**. One of the biggest differences between scientists and **pseudoscientists** is that scientists control the **variables** and repeat their experiments, which means their results are reliable. This process is called **fair testing**.

Pseudoscience

Figure 1.33 'Miracle' products are often the result of pseudoscience.

Have you ever seen advertisements for weight loss or hair growth 'miracles' or 'miraculous' wrinkle treatments? Although some of these products may have been partly developed by scientists, the results are usually less fabulous than they seem. The word pseudo' ('seoo-doe') means 'false' – pseudoscience is false science. Real science is based on logic and evidence, and the results can be reproduced by other scientists. The Australian Government has regulations about many of the products sold here, but not all types of products are covered.

Variables

A variable is something that can affect the results of an experiment. Controlling variables ensures that an experiment is fair.

Once you can control the test, you can experiment with it. To do this you must choose only one variable to change. This is called the **independent variable**. This can be done in the form of a 'What if…' question.

- **What if** the amount of vinegar is increased?
- **What if** the amount of bicarbonate soda was decreased?
- **What if** brown vinegar was used instead of white?

What if?

Controlling an experiment

What you need:

a large plastic cup, teaspoon, permanent marker, bicarbonate soda, vinegar, ruler

What to do:

1. Add a small amount of vinegar to the plastic cup and then a teaspoon of bicarbonate soda.
2. Describe what happens. Use the permanent marker to mark on the side of the cup how far up the reaction reached.
3. Use the ruler to measure the distance between the table and the mark on the cup.
4. Rinse the cup with water.
5. Repeat steps 1–4 until you can get the reaction to rise to the same mark three times in a row.

What if?

- What if you didn't add the same amount of vinegar each time?
- What if you didn't add the same amount of bicarbonate soda each time?
- What if you used a smaller cup for the reaction?

Once you ask a 'What if…' question, you can predict what may happen. This prediction, based on past experiences is called a **hypothesis**. A hypothesis can be written by removing the 'what' at the start, and adding a 'then' at the end of the question:

- What if the amount of vinegar is increased?

IF the amount of vinegar is increased, THEN the chemical reaction will be greater.

Independent variable: the variable that is deliberately changed	Dependent variable: the variable that is tested at the end

The first half of the hypothesis is the independent variable, and the second half of the hypothesis is what we are testing for. This is called the **dependent variable**. All other variables must remain the same; these variables are called controlled variables. This is to make it a fair test.

Fair tests ensure that experimental results can be used to make the right decisions. When we consider the results of an experiment and try to draw some conclusions, we need to consider the following questions:

- Did we control every factor, except the one we were changing on purpose?
- Were there any variables in the environment we couldn't control?
- If we did the same experiment again, would we expect the results to be exactly the same?
- Did we estimate any measurements during the experiment?

Asking 'What if…?'

Choose one of the questions on page 16 to investigate.

- Write a hypothesis for your inquiry.
- What *independent* variable will you change from the first method?
- What *dependent* variable will you measure and/or observe?
- What variables will you need to control to ensure a fair test?
- How will you control them?
- Test your hypothesis. Repeat your test at least three times to make sure your results are reliable.
- Record your results in a table.
- What did you find out? Write a summary of your results.

Making your results reliable

Repetition of experiments is very important. If you perform an experiment and achieve certain results, you would conclude that the results are reliable. But what if you did the experiment a second time and the results were slightly different? Did you do something slightly different? Were the conditions slightly different? Did you use the same materials from the same source?

Performing an experiment several times will give you greater confidence in your results. If other people repeat your experiment and achieve the same results, then your results are supported even more.

Check your learning 1.7

Remember and understand

1 What is a 'variable'?

2 Why do most variables need to be controlled?

3 What is the name given to something that is being tested, and therefore changed on purpose?

Apply and analyse

4 Justin decided to conduct an experiment to find out whether his cats preferred full-cream or low-fat milk. He gave one cat a saucer of full-cream milk and the other cat a saucer of low-fat milk and then left them alone. When he returned an hour later, the low-fat milk was gone and there was a small amount of full-cream milk left. Justin concluded his cats preferred low-fat milk.

   a Do you agree with Justin's conclusion?

   b Do you think he conducted a fair test?

   c What were the variables that needed to be controlled? Were they controlled? How could they have affected the results?

   d How would you improve Justin's experiment so his results are more reliable?

1.8 Graphs and tables are used to show results

An important part of science is being able to understand the results of your experiments and what the quantitative data means. Collecting your data in an organised table or showing your results in an accurate graph is a clear way of demonstrating patterns that may exist in your results.

Figure 1.34 Counting people is an example of discrete data (data that can only have whole numbers).

Data tables

When recording the results of your experiments, the data you collect should be neatly presented in a table. There are four steps for drawing a table.

1. Use a ruler to draw a table with the correct number of columns.
2. Write a heading that describes the contents of the table. For example, 'The change in water temperature over time'.
3. Give each column a label and units (what the number means). For example, 'Temperature (°C)'.
4. Add your data in the correct columns.

CHANGE IN WATER TEMPERATURE OVER TIME	
Time (minutes)	Temperature (°C)
5	43
10	37
15	35
20	24

Figure 1.35 A sample table showing heading, column headings with units of measurement, and data in each column.

Graphing data: Discrete and continuous data

There are two main types of data. **Discrete data** is obtained when the numbers can only be whole numbers, for example the number of people in a class (you can't have half a person). Discrete data is often represented in a **column graph**.

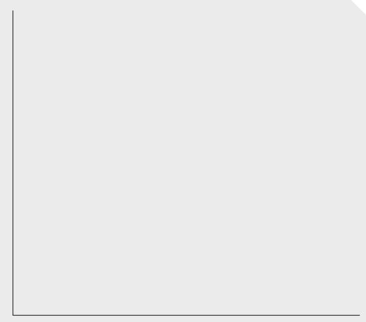
Continuous data is obtained when the numbers can be any value. For example, the fastest time in the world for a 100 metre race is 9.58 seconds; the tallest person in the world is 251 cm tall. Continuous data should always be represented in a line or **scatter graph**.

Figure 1.36 Sultan Kosen is 251 centimetres tall. Usain Bolt ran 100 metres in 9.58 seconds. Height and time are examples of continuous data.

SKILLS LAB 1.8: HEATING WATER
GO TO PAGE 173

Column graph

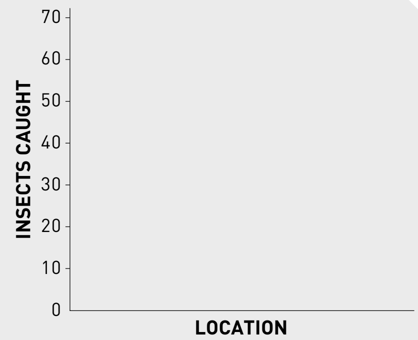
In a column graph, the height of the columns represents the number that you were measuring. This type of graph is good for showing discrete data. The steps for drawing a column graph are listed below.



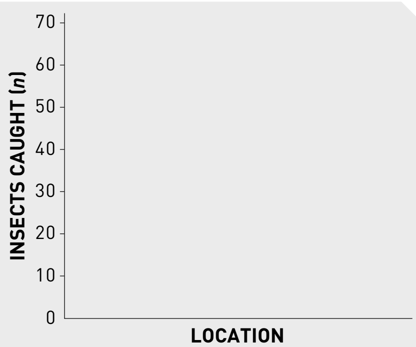
Step 1 Use a pencil and a ruler to draw a large set of axes (the horizontal and vertical lines of a graph).

Step 2 Label each axis. The horizontal (flat) axis should show the independent variable, and the vertical (up) axis should be the dependent variable.

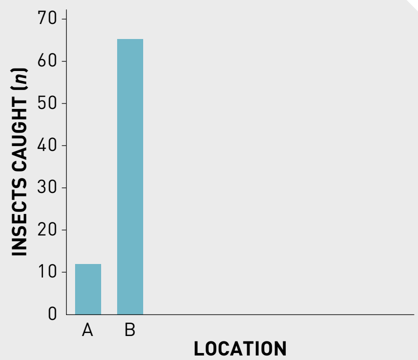
For example: graphing the number of insects found at each location. The location is changed and the number of insects is counted at each point. Therefore, location is the independent variable and is on the horizontal axis and the number of insects is the dependent variable and is on the vertical axis.



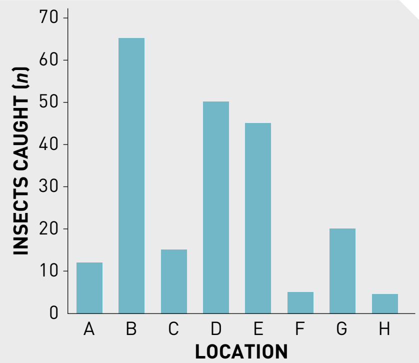
Step 3 Add numbers at regular intervals to the lines on the vertical axis, making sure you will fit the largest number. If the numbers are small, spread them out to use the whole graph.



Step 4 Add units (what the numbers mean) to the axis. This is usually metres (m), seconds (s), minutes (min), but can also be the number (*n*) of things

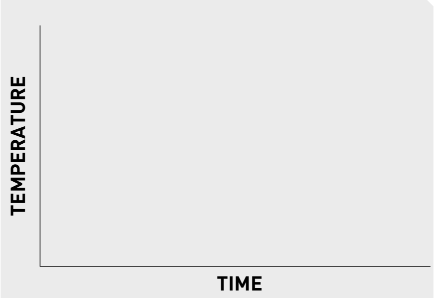


Step 5 Plot your data on the graph. Rule the lines carefully, making sure there is a gap between the columns.



Step 6 A completed column graph showing the number of insects caught at different locations.

Scatter graph

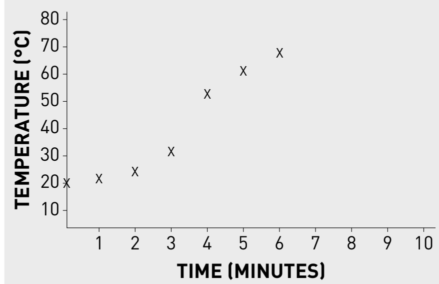


Step 1 Use a pencil and a ruler to draw a large set of axes (the horizontal and vertical lines of a graph). Label each axis. The horizontal (flat) axis should show the independent variable, and the vertical (up) axis should be the dependent variable.

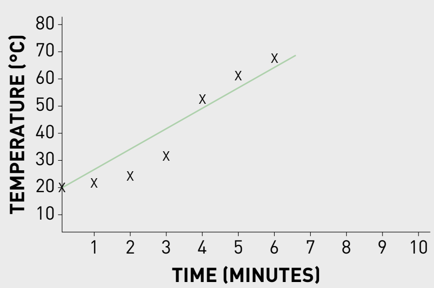
For example: graphing how temperature changes over time. Time is changed and the temperature is measured as a result. Therefore, time is on the horizontal axis and temperature is on the vertical axis.

Step 2 Add numbers at regular intervals to the lines on the axes, making sure you will fit the largest number. If the numbers are small, spread them out to use the whole graph.

Add units (what the numbers mean) to the axes.

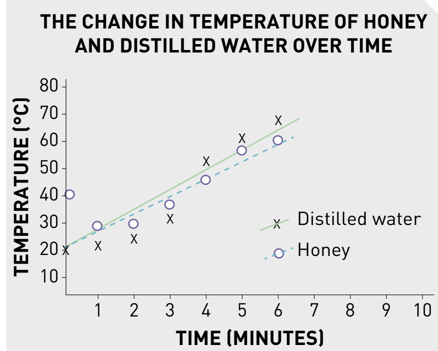


Step 3 Plot your data on the graph. Use small crosses rather than dots. It is easier to find the centre of a cross that the centre of a dot.



Step 4 Draw a **line of best fit**. This refers to a line that passes through or near to as many data points as possible. It can be a straight line or a smooth curve.

Step 5 If you are plotting more than one set of data on the one graph, then use a small circle instead of a cross. Add a legend to help identify which set of data is which.



Step 6 Write a descriptive title at the top of the graph.

Check your understanding 1.8

Remember and understand

1. Name the two types of quantitative data that scientists collect.
2. Which variable should be located on the horizontal axis of a graph?
3. What type of graph should be used to show the number of birds found in a particular area each month?

Apply and analyse

4. Figure 1.37 shows a graph drawn by a student. List all the things that should be corrected on the graph.

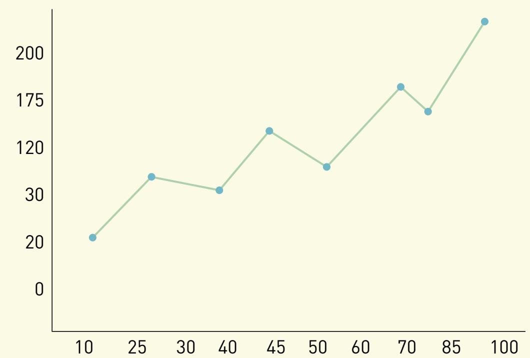


Figure 1.37

Evaluate and create

5. For each set of data below:
   a. describe the type of graph that should be drawn
   b. explain what has happened during each event.
      i. The number of accidents in the science laboratory during the first 6 months of the year.

TIME	NUMBER OF ACCIDENTS
Jan	0
Feb	10
Mar	6
April	3
May	2
June	1

      ii. How the number of cigarettes smoked per day affects the birth weight.

NUMBER OF CIGARETTES SMOKED PER DAY	BIRTH WEIGHT OF BABY (KG)
0	3.5
10	3.1
20	2.6
30	2.2

1.9 Scientific reports communicate findings

There are two key parts to any experiment: the doing and the reporting. A scientific report is an essential part of an experiment – it is where results and findings are recorded. Scientists use a similar style and similar language in their reports so they can be understood by scientists worldwide. Scientists communicate with other scientists so they can learn from each other and expand on each other's work.

What is a scientific report?

A report is a written account of an experiment and usually has eight parts:

1. **Title, date and partners** (if you are working in a group). Don't forget to write your own name.
2. **Aim** or question – what you were trying to find out or why you were doing the experiment
3. **Hypothesis** – your initial prediction about the outcome of the experiment (note: not all experiments contain a hypothesis)
4. **Equipment or materials** – a detailed list of the equipment used
5. **Method** – how you did the experiment, including diagrams of the equipment. There are two reasons to write a method. The first is to plan what you are going to do. This method should be in the present tense. The second type of method is for a formal report. Past tense should be used for this method.
6. **Results** – measurements and observations taken in an experiment, usually presented in a table, graph and/or diagram
7. **Discussion** – your opportunity to discuss the findings, any problems that were encountered and suggestions for improvement or further investigation. This should be written in the third person.
8. **Conclusion** – the answer to the aim or question. It should be clear, reasoned and relate very closely to the starting aim or question and should be written in the third person.

Writing in the third person

The best type of scientific report lets the results speak for themselves. If an experiment has been controlled to make it a fair test, then it shouldn't matter whether Einstein or your 15-year-old brother conducted the experiment. This is one reason that personal pronouns ('I', 'me', 'our') are usually left out of scientific reports. When you use personal pronouns, it's tempting to put in a lot of information that isn't relevant.

Writing a scientific report

Now it is your turn to do an experiment and produce your first scientific report. Read through the instructions before you begin. You will be working in pairs. Before doing the experiment, create an outline of the scientific report, including a table for your results. Conduct the experiment and fill in the table of results. Answer the discussion questions, practising using the third person. Check back to the Aim to remind you of what your Conclusion is answering. Copy the Conclusion from the example and fill in the gaps. Evaluate the design of this experiment.

EXPERIMENT

Sets out what you are trying to discover. It is the 'question' you are asking, and will be different for each experiment.

Egg Bungy Jump

Aim

To drop an egg close to the ground safely.

Materials

- Rubber bands
- Plastic or mesh bag
- Raw egg
- Wire or paper clip
- Retort stand
- Boss head
- Clamp
- Metre ruler

A list of what you need.

Gives step-by-step instructions and often a diagram of equipment.

Method

1 Place the egg in the plastic or mesh bag and seal the bag with the wire or paper clip. Be careful to tie it tightly to prevent the egg from slipping through and spilling on the floor. Make a loop at the top of the wire – this is where the rubber bands will be attached.

2 Connect the rubber band around the wire loop and hook it over the retort stand clamp (as shown in Figure 1.38). One person will need to hold down the retort stand to ensure that it doesn't tip.

3 Carefully hold the egg so that it is level with the clamp and let it drop. One member of the group may need to catch the egg on its return back up to ensure that it doesn't hit the clamp.

4 Measure the distance the egg travelled from the clamp. Be careful to avoid parallax error for this measurement.

5 Repeat steps 2 to 4 using additional rubber bands connected in a chain.

Results

Create a table showing the distance the egg fell for each rubber band added.

Draw a graph of the distance the egg fell against the number of rubber bands.

Where any set questions are answered and where you describe any unusual or interesting results. This is also where you can suggest improvements for an experiment.

Discussion

1 What difficulties did you have when measuring the distance the egg fell?

2 Would your results have been affected if the rubber bands were different sizes?

3 Identify one other variable that could have affected the results. Was this variable controlled? Discuss.

4 Extend your graph so that it shows how many rubber bands would be needed for a 2 metre drop. From this extrapolation/extension, how many rubber bands would you need to safely drop the egg as close to the floor as possible?

5 Would it have made any difference if you added extra weight to the egg before dropping it?

6 How could your results help people who want to bungy jump off a bridge?

7 What safety recommendations would you suggest to anyone trying this experiment?

Conclusion

An answer to the question you set out to investigate. Look back at the Aim before writing the Conclusion. Try to use one to two sentences and to write in the third person.

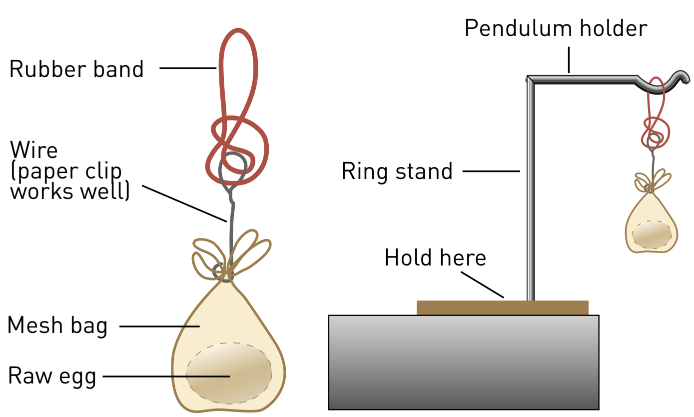


Figure 1.38

Check your learning 1.9

Remember and understand

1 What is a prediction called in an experiment?

2 What are the eight steps in writing a scientific report?

3 What is a conclusion? Why is it written at the end of an experiment?

4 Why are personal pronouns not used in scientific reports?

Apply and analyse

5 Why do you think it is important that scientists complete scientific reports?

6 How would a common format for all scientific reports make it easier for scientists to communicate with each other?

//SCIENCE AS A HUMAN ENDEAVOUR//

1.10 Science skills are used to solve important problems

In 1935, 101 cane toads were brought to Australia from Hawaii to eat an annoying pest – the cane beetle – which was destroying sugar cane crops and costing Australian sugar cane farmers a lot of money. The cane toads quickly multiplied and ate everything in sight: rubbish, plants and Australian native animals, including lizards, fish, frogs and birds. The toads ate just about everything except the cane beetle they were originally brought here to eat! In this chapter you have learnt about asking questions and about doing science safely. You have used your skills of experimentation, observation, inference and measurement. You are now going to apply these skills to a problem facing our country: an invasion of cane toads.

Figure 1.40 Cane toads have taken over much of northern and eastern Australia.

Cane toads in Australia

Cane toads have been successful in Australia for a number of reasons. They can live in a wide range of environments and can breed in almost any body of water, no matter how small. They produce very large numbers of eggs several times a season, and the adults live for a long time. Also, many of the diseases and parasites that keep cane toad populations under control in their native countries are not found in Australia.

Figure 1.39 A cane beetle.

Cane toads are a threat to native Australian animals. When cane toads feel threatened, they release a poison from poison sacs behind their eyes. This poison can kill almost all animals (including the saltwater crocodile and humans). They eat a very wide range of native animals, including small vertebrates, such as birds, and invertebrates, such as beetles. They will also eat processed food, such as pet food. Because they are toxic to most animals that try to eat them, the cane toads have very few predators.

We can learn much from the introduction of cane toads into Australia. Foxes, rabbits and carp (a type of fish) are three other types of animals that have been introduced into Australia and have since created problems.

When they arrived, cane toads ate everything in sight except for the cane beetle that they were brought here to eat. Cane beetles lived halfway up the cane plant, where the toads couldn't reach, or in thick fields where the toads had no reason to go. Also, within 5 years, an insecticide – a chemical that kills insects – became available and the sugar cane farmers no longer needed to rely on the cane toad to destroy the cane beetle.

Kimberley Toad Busters

Australia is now home to over 200 million cane toads. A group of people called the 'Kimberley Toad Busters' have joined together to get rid of the cane toad and to stop it entering Western Australia. They have organised outings to capture and then humanely (respectfully and without pain) kill the toads.

Figure 1.41 In north-west Western Australia, a group called the Kimberley toad busters has formed to keep cane toads out of the area.

Extend your understanding 1.10

1. Look back in time. What are some simple questions that a scientist might have asked about a cane toad before they were brought to Australia? Try and think of at least one question that starts with each of these words: why, what, where and when. Here's one to get you started: How quickly do cane toads breed?
2. Use these questions to design a poster or information pamphlet warning people about the risks of introducing any type of foreign animal into Australia.
3. What safety precautions would the Kimberley Toad Busters use to keep safe?
4. Draw some of the equipment that you would use on a toad-busting mission.
5. Write a list of toad-busting safety rules.
6. Science is not always done in a laboratory. Special safety rules need to be developed for fieldwork. Write a list of general safety rules for fieldwork.
7. In a recent toad-busting mission, the largest toad caught was 14.5 cm long and the smallest 7 cm. If the toads are such a pest, why do the toad busters bother measuring them?
8. Design an experiment that scientists could have conducted before the cane toad was brought here. (Remember how quickly the cane toad breeds in the wild – your experiment must be controlled.)
   a. What is the aim of your experiment?
   b. What equipment would you need?
   c. Write a list of questions you would ask yourself during the experiment.
   d. Imagine you have conducted the experiment. Using the information on this page, write the results of your experiment.
   e. Write the conclusion. Remember to look back at the aim when you write this.
9. Use the conclusion of your experiment to write a letter to the Environment Minister in 1934 (the year before the cane toad was introduced) requesting that the cane toad is not introduced. Make sure you back up your argument with at least three scientific facts.

Remember and understand

1 Draw a diagram of a:
   a conical flask
   b tripod stand
   c test tube.

2 What does this safety sign mean?

3 What is a fair test?

4 What are the metric units for the following?
   a volume
   b temperature
   c time
   d mass

5 What is mass?

6 What is the purpose of controlling variables in an experiment?

7 Are the following quantitative or qualitative observations?
   a The bus is red.
   b The swimming pool smells of chlorine.
   c I am older than 12 years old.
   d The line to the tuckshop is 4 metres long.

8 Why is a measurement not very useful if you don't include the correct units?

9 Think about the Bunsen burner.
   a Why is the Bunsen safety flame important?
   b How do you get a safety flame with your Bunsen burner?
   c The safety flame is not good for heating. Give two reasons for this.
   d Which part of the blue flame is best for heating?

10 Which section of a scientific report would contain the measurements collected?

Apply and analyse

11 Make three observations and three inferences about:
   a this textbook
   b your own hand.

12 What would happen if units were not the same everywhere in Australia?

13 Draw the correct graph for the following set of data on the number of deaths each year due to car accidents.

YEAR	NUMBER OF ROAD DEATHS
2004	1583
2005	1627
2006	1602
2007	1603
2008	1437
2009	1488
2010	1352
2011	1291
2012	1310
2013	1193

14 How long is a palm? Check the length of your own palm against the suggested value in centimetres. How accurate do you think a measurement would be if you bought 50 palms of masking tape? What variation do you think you could get?

15 There are many unusual measurements. Can you find the answers to these measurement problems?
   a How would you measure the temperature inside a furnace?
   b How can you measure the thickness of a sheet of paper?
   c How fast do your fingernails grow? How could you measure this?

Evaluate and create

16 Design one of the following experiments. Write an aim, hypothesis and method for the experiment. Identify the variables and make sure you control all but the experimental variable. Make note of any safety issues. Set it out like one of the experiments in this book.
   - An experiment to test whether three types of material are waterproof or not
   - An experiment to see how high a rubber 'bouncy-ball' can bounce on different surfaces

17 Pseudoscience challenge. Your teacher will provide you with a set of last week's horoscopes. They will be randomly numbered and the dates and star signs removed.

- Decide which horoscope from last week best fits you.
- Collate all the horoscope numbers and class members' names on the board.
- Your teacher will list the corresponding star signs for each number.

a How many horoscopes were correct?

b What does this tell you about astrology?

c Is astrology a science or a pseudoscience?

d Write down two new things you learnt from this activity.

Research

Choose one of the following topics for a research project. Your job is to plan the project, rather than actually do the research. Planning is a very important tool. Place the topic in the centre of a bubble map and fill the surrounding bubbles with big questions. Make sure your questions are big enough to give you an insight into the topic, as well as broader issues. An example has been done for you in Figure 1.42.

Famous Australian scientists

What big questions do you want to explore about a notable Australian scientist? You could consider Frank Macfarlane Burnet, Douglas Mawson, Gustav Nossal, Mark Oliphant, Helen Caldicott, Nancy Millis, William McBride, Struan Sutherland and Suzanne Corey.

Famous scientists in history

What big questions do you want to explore about a scientist who lived long ago? You could consider Archimedes of Syracuse, Hero of Alexandria, Galileo Galilei and Isaac Newton.

Depending on variables

Variables are sometimes described as 'controlled' instead of 'dependent' and 'experimental' instead of 'independent'. How are these terms similar? How are they different? When would each be used?

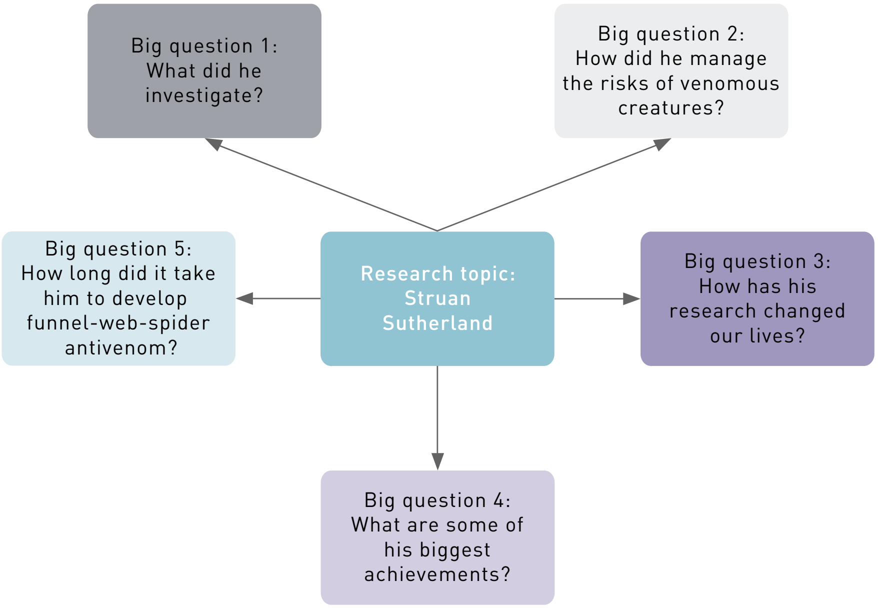


Figure 1.42 A mind map of research project planning.

*KEY WORDS

1

accuracy
careful, correct and consistent measurement or processing of data

aim
purpose of an experiment

apparatus
equipment placed together for an experiment

Bunsen burner
a piece of equipment used as a heat source in the laboratory

Celsius (°C)
temperature scale and unit of measurement of temperature

column graph
a graph in which the height of the columns represents the number measured

conclusion
a statement that 'answers' the aim of an experiment; should be clear and reasoned and relate very closely to the aim

continuous data
data where the numbers can be any value

dependent variable
variable that may change as a result of the experiment

discrete data
data where the numbers can only be whole numbers

discussion
summary of findings, analysis of the design of an experiment, including problems encountered and suggestions for improvement

equipment
items used in the laboratory to conduct experiments

error
the unavoidable and random inconsistency in measurement

experiment
an investigation used to solve a problem or find an answer to a question

fair test
a controlled experiment

hypothesis
a predicted description of what will occur during an experiment; it is able to be tested

independent variable
a variable (factor) that is changed in an experiment

inference
likely explanation of an observation

laboratory
specially designed space for conducting research and experiments

line of best fit
the line on a scatter graph that passes through or as near to as many data points as possible

method
list of how to do an experiment

metric system
a system of measurement

observation
using all your senses to notice things around you

parallax error
an error that occurs as a result of reading a scale from an angle

philosopher
'lover of knowledge'

pseudoscience
claims that are made without evidence to support them

qualitative observation
an observation that uses words and is not based on measurement or other data

quantitative observation
an observation that uses a number, such as a measurement

results
the measurements and observations made in an experiment; they are best presented in a table

scatter graph
a graph used to represent continuous data; it consists of discrete data points

science
the study of the natural and physical world

scientist
a person who studies the natural and physical world

scientific diagrams
clear, side view, labelled drawings using a sharp pencil

units
standard measurements

variable
something that can affect the results of an experiment

MIXTURES 2

2.1 Mixtures are a combination of two or more substances

2.2 A solution is a solute dissolved in a solvent

2.3 Mixtures can be separated according to their physical properties

2.4 Mixtures can be separated according to their size and mass

2.5 The different boiling points of liquids can be used to separate mixtures

2.6 Solubility can be used to separate mixtures

2.7 Waste water is a mixture that can be separated

What if?

Case mix

What you need:

a variety of different pencil cases (size, shape, colour)

What to do:

1 Place all the pencil cases in one pile.

2 List your pencil case's properties that will allow it to be identified easily (e.g. colour, shape, size and weight).

3 Give the list to another student. Can they identify your case by using the list?

What if?

» What if you were blindfolded? Could you still find your pencil case?

» What if the pencil cases were too small to feel? How could you identify yours?

» What if all the pencil cases were exactly the same? Would it still be a mixture?

2.1 Mixtures are a combination of two or more substances

Consider the things around you. Perhaps they are made of wood, glass or plastic. Wood, glass and plastic are all mixtures – each of these materials is made up of two or more **substances**. Some materials are pure substances. A **pure substance** is one that is not combined with anything else. Pure water, oxygen and diamonds are examples of pure substances.

Properties of mixtures

There are many different types of **mixtures**, each with different characteristics. For this reason, scientists have grouped mixtures according to their **properties**: what they are made of and how they behave. Knowing the type of mixture helps us work out ways to separate it into pure substances.

Solutions

When you mix salt into water, it seems to disappear. But we know the salt is still there because we can taste it. The particles of salt become so small, they spread evenly throughout the water. This clear mixture of salt and water will not separate by itself. It is a solution. A **solution** is a mixture of one substance dissolved evenly throughout another. Solutions are usually transparent (see-through).

Figure 2.1 Most of the things we use every day are mixtures. What mixtures can you see in this photograph? Can you see any pure substances?

Suspensions

Dirty water is an example of a suspension. A **suspension** is a mixture of two substances, in which a solid is dispersed, undissolved, in a liquid. The result is a cloudy liquid. Sand in water is also a suspension. If you shake a container of sand and water, the sand spreads through the water, forming a cloudy liquid. The sand will then settle to the bottom of the container as **sediment**. Suspensions often need to be shaken or stirred before use to spread the sediment through the liquid.

Colloids

When two or more substances are mixed, they don't always separate out with time. Suspensions that don't separate easily are referred to as **colloids**. These can be formed by a solid being suspended in a liquid, such as hot chocolate in milk. Occasionally different particles can get suspended in a gas. Fog is an example of this: small drops of water suspended in the air. The word 'colloid' comes from the Greek word *kolla*, which means 'glue'. You can think of a colloid as a substance being 'stuck' – suspended – in another substance. The benefit of colloids is that there is no need to mix them before using them. Hair gel and hand cream are examples of colloids.

Emulsions

An **emulsion** is a colloid of two or more liquids. Usually, one liquid is the 'base' and the other is broken into tiny droplets spread throughout the 'base'. Milk is an emulsion, with tiny droplets of fats and oils spread throughout the base, which is water.

In some cases, when mixtures like this are left to settle, the tiny droplets float above the base liquid. (This is different from what happens in a suspension, where the solid particles tend to fall to the bottom.) A substance called an **emulsifier** can be added to these mixtures to allow the liquids to remain completely mixed.

The most common emulsions we use are mixtures of different types of oil mixed with water and an emulsifier. Examples include food and drinks, and 'emulsion' paints.

CHALLENGE 2.1: COMPARING DIFFERENT TYPES OF MIXTURES
GO TO PAGE 174

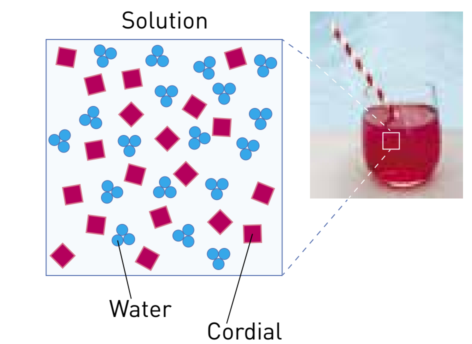


Figure 2.2 This glass of cordial is an example of a solution. The small cordial particles are dissolved evenly throughout the water. The swimming pool water in the background is also a solution, with chlorine and other chemicals dissolved evenly in the water.

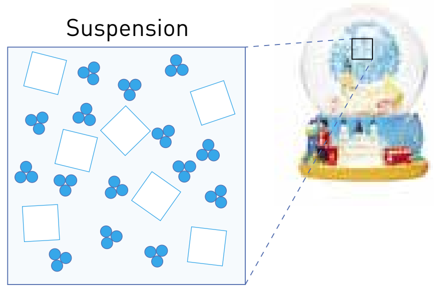


Figure 2.3 A snow dome can be described as a suspension, with the larger 'snow' particles being suspended in the water for a short time before they fall to the bottom of the dome to form a sediment.

Figure 2.4 Fog is a colloid because it is made up of suspended liquid particles in air.

Figure 2.5 Milk is a colloid because it contains many substances suspended in what is mainly water.

Check your learning 2.1

Remember and understand

1 What is a pure substance?

Apply and analyse

2 Identify the following as pure or a mixture:

a cup of tea
b soft drink
c table salt
d soap
e olive oil

3 For any that you think are not pure, write down what substances you think they might contain.

Evaluate and create

4 In which mixture(s) would you find sediment?

5 Complete the table below for mixtures.

TYPE OF MIXTURE	SUBSTANCES INVOLVED	APPEARANCE WHEN LIGHT SHINES THROUGH	SEPARATES ON STANDING?	EXAMPLE
Suspension	Solid + liquid	Cloudy	Yes, slowly	Milo in milk
Emulsion				
Colloid				
Solution				

2.2 A solution is a solute dissolved in a solvent

In Unit 2.1 you learnt that a solution contains one substance mixed evenly through another. An example of this is lemonade, in which the sugar and flavour are dissolved evenly through the water. The more solute (sugar) that is dissolved in the solvent (water), the more **concentrated** the solution. A solution becomes **saturated** when no more solute will dissolve.

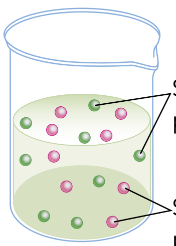


Figure 2.6 A solute dissolves in a solvent to create a solution.

Solubility and insolubility

In some places in Australia, the water from the local water supply has an unpleasant taste. Or washing with soap is difficult because the water forms a scum instead of a foamy lather. In these cases, the water contains metal salts that affect its taste and behaviour. Because they are so small, these metal salts do not fall to the bottom, or float on the top, but remain evenly spread through the liquid. The resulting mixture (a solution) is clear – light will shine through it. We say that the metal salts have **dissolved** in the water.

A substance that is able to dissolve in a liquid is considered to be **soluble**, whereas one that cannot is **insoluble**. The substance dissolving is called the **solute**, whereas the liquid into which it dissolves is called the **solvent**. An example of this is salty water. The salt is the solute, and the water is the solvent. Sometimes it is necessary to help a solute such as salt to dissolve. Warming the solvent (water) is the most common way of making a solute dissolve faster.

Working with solutions

You have seen that a solution is a solute dissolved in a solvent. Solutions can be compared in terms of their **concentration**: how much solute is in the solvent. If just a little solute is dissolved, the solution is described as **dilute** (low concentration). If a lot of a solute is dissolved, then the solution is described as concentrated (high concentration).

Figure 2.7 The concentration of salt in the Dead Sea in Israel is so high that when people try to swim in it, they float instead!

EXPERIMENT 2.2A: WHAT IF SALT WERE DISSOLVED IN WATER?
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EXPERIMENT 2.2B: WHAT IF THE SOLVENT WERE HEATED WHEN MAKING A MIXTURE?
GO TO PAGE 176

It is only possible to dissolve a certain amount of a particular solute in a solvent. If no more solute can dissolve into a solution, the solution is described as saturated. What sort of cordial drink do you prefer: dilute, concentrated or saturated?

We often work with solutions in our everyday lives. By adding solutes to pure liquids, the properties of the pure liquids may change. An example is adding bath crystals to a bath to give the water a pleasant smell.

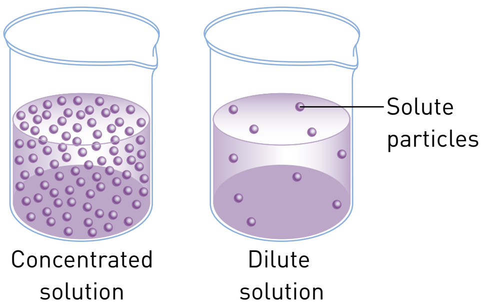


Figure 2.8 A concentrated solution contains more solute particles in a given volume than a dilute solution.

Figure 2.9 Oxygen dissolved in water is essential for aquatic organisms.

Water as a solvent

Water is a good solvent. This is one of its most important properties. Our digestive system uses water to dissolve our solid and liquid food, and to break up the food into nutrients that our body needs to build new cells, grow and repair.

Our bodies are more than 60% water. Our blood, which is mainly water, transports oxygen to every cell and carries away dissolved carbon dioxide gas (a waste product).

Humans are not the only living things that depend on water as a solvent. Without water's ability to dissolve gases, there would be no underwater life in our oceans and lakes and no fish in the rivers. These creatures all live by extracting dissolved oxygen gas from the water.

Imagine you found a colourless and see-through liquid and were really thirsty. Is it water? There many other colourless and clear liquids, and you don't know what substances might be dissolved in them. Tasting may be dangerous. There are more scientific ways of working out whether a liquid is pure. This is explored further in Unit 2.3.

Check your learning 2.2

Remember and understand

1 If someone asked for a dilute glass of cordial, would you add a lot of cordial or only a little?
2 How could you increase the amount of a solute that will dissolve in a solvent?
3 Scientifically, how do you describe a solution that will not allow any more solute to dissolve?
4 True or false: you can see the particles of a solute in a solution.

Apply and analyse

5 Do all solutes dissolve in water? Explain your answer.
6 What happens to the sugar particles when they dissolve in water?

Evaluate and create

7 Are the particles in a suspension, colloid or emulsion soluble? Explain.

SKILLS LAB 2.3A: SEPARATION USING MAGNETIC PROPERTIES
GO TO PAGE 177

2.3 Mixtures can be separated according to their properties

A mixture contains components that can be separated because of their different properties. Properties are how a substance looks (size, mass, texture, shape, volume) and how it behaves around other substances (magnetic, soluble). Before you can separate a mixture, you need to find out what properties its components have that are different. For example, one substance may be soluble in water, whereas another may not. One substance may be magnetic and another not magnetic.

Figure 2.10 Different separations need different techniques.

Simple separation

Some mixtures are quite simple to separate. Sometimes we can simply pick out the bits we need to separate. A bag of mixed lollies may contain a few of your favourites. You could easily use your fingers to pick these lollies out so that you could eat them first. This works well if it is a small bag and you can see the individual lollies. What if the bag contained hundreds of lollies that were too small to see? You may need another way of separating out your favourites.

Magnetic separation

Do you separate recyclables from your rubbish? Have you ever wondered how the different recyclable materials are separated once they're out of your house?

Magnetic separation uses magnets to attract and separate particular objects. Some metals are magnetic. Magnetic substances are attracted to a magnet. They are made of iron, or a mixture containing iron.

Because **magnetism** will only separate substances containing iron, magnetic materials, such as iron nails, can be separated from other non-magnetic materials, such as glass, aluminium and paper.

Figure 2.11 Separating a mixture of packages is simple.

Figure 2.12 Magnets are used to separate metals in recycling plants.

SKILLS LAB 2.3B: SEPARATING MIXTURES USING SEDIMENTATION AND FLOTATION
GO TO PAGE 177

EXPERIMENT 2.3: WHAT IF A FLOCCULENT WERE ADDED TO MUDDY WATER?
GO TO PAGE 178

Figure 2.13 Magnets can be used to separate tin cans (left), which are magnetic, from aluminium cans (right), which are not.

Figure 2.14 Decanting wine separates the undrinkable sediment.

Tin cans are magnetic, whereas aluminium cans are not. Sometimes large magnets are used to separate aluminium cans in the rubbish from tin cans. This means both types of cans can be recycled in different ways.

Decanting, sedimentation and flotation

Have you ever had a piece of food in the bottom of your drink? Did you use a spoon to remove it? Or maybe you carefully poured your drink into another glass, leaving the food behind? The careful pouring of liquid, or **decanting**, is often done to remove sediment from wine.

The objects or liquids that sink are denser than the liquid on the top. The particles in **dense** objects are packed together more tightly than in less dense objects. Oil floats on top of water because the particles in the oil are packed very loosely. The water particles pack together more tightly, so they sink to the bottom, below the oil.

The particles in a grain of sand are packed together very tightly. The sand is more dense than water. Therefore, the sand settles to the bottom of a glass of water. The sand forms a **sediment** in the glass.

Sedimentation and **flotation** are used in sewage treatment to separate the mixture of substances. Sewage is left in settling ponds to allow the sediment to settle to the bottom. Fats and oils that float to the top of the ponds can be scooped off for digestion by bacteria.

Oil spills can be cleaned up using the fact that oil floats on the surface of water. Cork and other substances can be sprinkled on top of the oil to soak it up, and these substances are then scooped off and squeezed out.

In certain situations, sedimentation is more difficult. Chemicals called **flocculants** can be added to a mixture to make suspended particles clump together. This makes them heavy enough to settle to the bottom. Flocculation is regularly used to separate substances from water.

Figure 2.15 Sewage treatment involves sedimentation and flotation.

Figure 2.16 Oil floats on the surface of water.

Check your learning 2.3

Remember and understand

1 What do the following words mean?
   a sediment
   b flocculation
   c decant
   d density
2 What property differs between tin cans and aluminium cans?

Apply and analyse

3 Why does flotation allow oil spills to be cleaned up more easily?
4 If a suspension doesn't separate, what can be done to cause sedimentation?
5 In what situation might you rely on people to separate a mixture by hand?

Evaluate and create

6 What are the limitations for using magnetism to separate a mixture?

2.4 Mixtures can be separated according to their size and mass

Other properties can be used to separate particles. Large particles can be separated from smaller particles by filtering. Heavy particles can be separated from light particles by using a centrifuge.

Filtering

Anyone who has cooked pasta will probably have used a colander or sieve to separate the boiling water from the cooked pasta. The holes in the colander or sieve are designed to let the water through, but not the pasta.

A filter has a series of holes in it that lets through small things, but traps the larger particles. A grate on a storm water drain is an example of a filter. The grate lets the water through while filtering out the leaf matter and rubbish. Fly screens on windows and doors filter bugs and some dust from the air, and tea bags filter the leaves from the liquid.

Filtering separates substances according to the size of their particles. In science, using a sieve is called **filtering**. Filtering is the same process as sieving: it separates particles in a mixture according to their size and the size of the holes in the sieve. The **filtrate** passes through the filter and the **residue** is left behind in the filter.

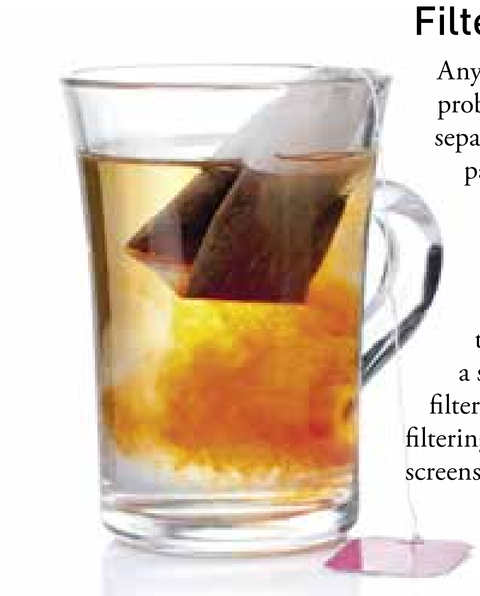


Figure 2.17 Tea bags are a common household filter.

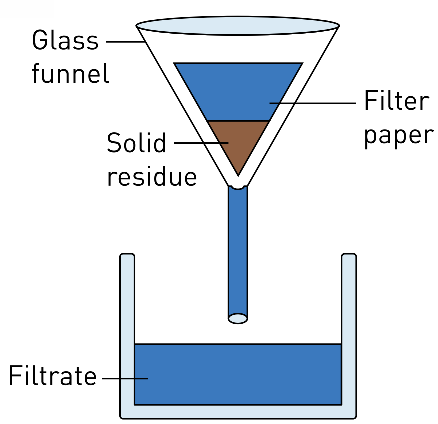


Figure 2.18 Filters are used in science to separate substances. Particles that pass through the filter are called the filtrate. The filter paper traps the residue.

Figure 2.19 A HEPA filter is used to filter fine particles from the air.

Filter paper is a paper sieve with holes that are too small to see. Solutions can flow through the filter paper because the particles in the solution are small enough to fit through the holes; however, most solid particles in suspensions are not. Different filter papers come with different-sized holes. Coffee filters and the filters found in vacuum cleaner bags are both made of paper filters. HEPA (high-efficiency particle arrestance) filters are used in vacuum cleaners, air conditioners and face masks to remove even tiny dust particles.

Sometimes filters remove substances using chemicals rather than by physically stopping them. Gas masks often contain a special type of charcoal that attracts and holds onto some poisonous gases.

SKILLS LAB 2.4: FILTERING A MIXTURE OF SAND AND WATER
GO TO PAGE 179

EXPERIMENT 2.4: WHAT IF YOU CENTRIFUGE MILK?
GO TO PAGE 180

Figure 2.20 A gas mask uses activated charcoal to filter poisonous gases.

Centrifuging

Sometimes mixtures do not separate well using sedimentation because the particles are not dense enough. Sometimes things need to be separated using their weight.

Some playgrounds have equipment that spins around very fast. When you spin very fast on this equipment, you can feel a force pulling you towards the outside of the spin. Heavy objects feel the pull more than light objects.

Centrifuging separates light and heavy particles by spinning a mixture. A centrifuge is a machine that spins very quickly. In a laboratory, small test tubes of mixtures are fixed to the inside of the bowl of the centrifuge. The spinning motion causes the heavier particles to move to the bottom of the tubes.

Centrifuges are used in medical research and at blood banks. When blood is spun in a centrifuge, the red blood cells, which are heavier, sink to the bottom of the test tube, leaving the yellowish liquid part of blood (plasma and platelets) at the top. Medical professionals use different parts of blood depending on the particular medical need.

Centrifuges are used in dairy processing factories to separate cream from milk. Salad spinners and washing machines also use this principle.

Figure 2.21 When blood (right) is separated by a centrifuge, the red blood cells collect at the bottom of the tube and the less dense liquid, the plasma and platelets, collects at the top (left).

Figure 2.22 A spinning washing machine is a centrifuge, separating water from the clothes.

Check your learning 2.4

Remember and understand

1. What filters are used around your home and school? What substances do these filters allow to pass through them and what substances do they collect?
2. For each of the following pairs, write a sentence explaining the difference between them:
   a. mixture – pure substance
   b. sedimentation – flotation
   c. residue – filtrate
3. Complete the sentences below by filling in the missing words.

   Filtering is like using a _____________. The _____________ lumps are caught in the sieve, and the _____________ goes through the _____________ paper.

   The substance caught in the _____________ paper is called the __________. The substance that passes through is called the _________.

Apply and analyse

4. Why would a forensic scientist who was investigating a crime want to compare a mixture of different types of sand found in a suspect's car to a similar mixture found at the crime scene?

Evaluate and create

5. Is a butterfly net an example of a filter? Explain.
6. List two places where centrifuges are used.

2.5 The boiling points of liquids can be used to separate mixtures

The various parts of a mixture will often have different **boiling points**. This means they become a gas at different temperatures. Alcohol boils at 78°C. Water boils at 100°C. In a mixture of alcohol and water, the alcohol will always evaporate first. Any solids left behind will crystallise. Filtering, sedimentation, flotation, centrifuging and magnetic separation are useful for some types of separation. But what do you do when they don't work?

Evaporation and crystallisation

When water in a saucepan is heated, it will quickly start to boil. This means the liquid **evaporates**: it becomes a gas. Every substance evaporates at a different temperature. Table 2.1 shows the boiling point of some common liquids.

The different boiling points of liquids can be used to separate them in a mixture. A mixture of water and turpentine can be easily separated because the water will evaporate first. This means the water will become a gas (steam) and move away from the turpentine. Eventually only turpentine will be left behind.

This method can also be used to separate the parts of a solution. Salt evaporates at 1414°C. When a mixture of salt and water is heated, the water evaporates first, leaving behind the salt crystals. This process of evaporating the solvent (the water) and leaving behind the solute (salt) is called **crystallisation**.

Figure 2.23 Water will evaporate from a mixture of salt and water, leaving behind salt crystals.

Table 2.1 Boiling points of common liquids

LIQUID	BOILING POINT
Water	100°C
Alcohol	78°C
Petrol	95°C
Olive oil	300°C
Tar	300°C
Turpentine	160°C

EXPERIMENT 2.5: CRYSTALLISATION OF SALT WATER
GO TO PAGE 180

CHALLENGE 2.5: DESIGN A WAY TO PURIFY WATER FROM SEA WATER
GO TO PAGE 181

Distillation

What if we want to keep the substance that has the lowest boiling point? Collecting drinkable water from sea water is difficult if all the water evaporates into the air. **Distillation** is a way of collecting the gas that evaporates from a mixture and cooling it down so that it becomes a liquid again. This cooling down of a gas into a liquid is called **condensation**.

The crude oil that is removed from the earth is a mixture of different liquids that all have different boiling points. When the crude oil is heated, petrol is one of the first substances to evaporate. The petrol gas rises up the column until it cools and condenses. The liquid petrol is then collected on one of the trays in the column. The oil used in heating has a higher boiling point. It evaporates more slowly and condenses quicker. It is collected on a tray lower in the column.

Figure 2.25 Crude oil can be separated into different fuels because each boils at a different temperature.

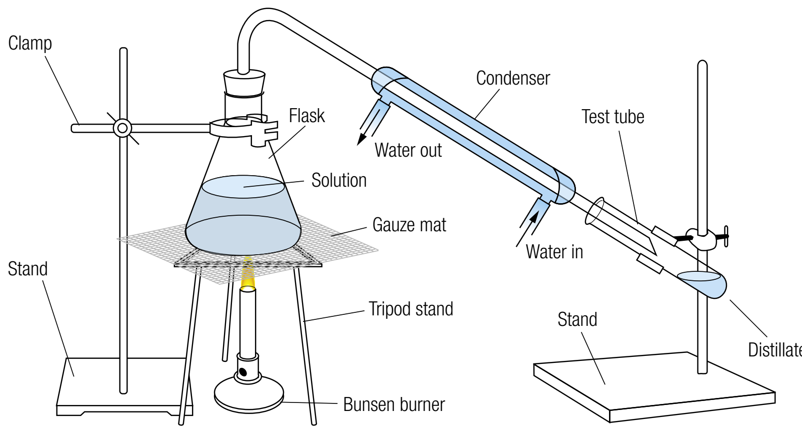


Figure 2.26 Equipment set-up for distillation.

Figure 2.24 Whisky production uses distillation.

Check your learning 2.5

Remember and understand

1 Explain the difference between evaporation and crystallisation.

Apply and analyse

2 Give an example of a mixture you would separate using evaporation and crystallisation. Explain why distillation may not be appropriate.

3 What separation technique is being conducted in Figure 2.27?

Figure 2.27

Evaluate and create

4 Draw the equipment set-up that could be used to produce pure water from sea water by distillation.

2.6 Solubility can be used to separate mixtures

Some substances are able to dissolve more easily than others. **Chromatography** can be used to separate mixtures of substances that have different solubilities.

Solubility

Another property that can differ between substances is solubility. **Solubility** describes how easily a substance dissolves in a solvent. Some dyes have a higher solubility than others. This can be used to separate them from each other. Many dyes are small particles that are suspended in a solvent. They are usually made from plants or minerals. Early Greeks made a mixture of soot and vegetable gum that could be used for writing. One thousand years later, the Chinese made red ink from mercury sulfate and black ink from iron sulfur mixed with sumac tree sap. Today, many of the inks in textas are made of a mixture of these dyes. We can separate these dye mixtures because the dyes have different solubilities.

Chromatography

Paper chromatography is a common way to separate a mixture. **Chromatography** works when the end of the absorbent paper is dipped in water, allowing the water to slowly move up the paper. As the water moves past the dye mixture, the most soluble dye dissolves and starts to move with the water. The other dyes in the mixture take longer to dissolve. Eventually the next dye forms a solution and starts moving towards the top of the paper. Finally, the paper has a series of smudged dyes running up to the top. The coloured dye that is the most soluble is at the top, whereas the dye that is least soluble is at the bottom.

Figure 2.28 Chromatography is used to separate samples, such as inks and dyes.

EXPERIMENT 2.6: WHO WROTE THE NASTY NOTE?
GO TO PAGE 182

CHALLENGE 2.6: SEPARATION CHALLENGE
GO TO PAGE 183

Figure 2.29 Performing gas chromatography.

More complex and sensitive chromatography instruments are used to separate mixtures such as drinks and polluted air. Science laboratories often contain instruments that can be used to detect even one gram of a substance present in thousands of litres of solution. Scientists use chromatography to find out what substances are in a mixture. Different substances will move through at different times. The height of each peak tells the scientist how much of a particular substance there is.

One of the uses of chromatography today is to identify athletes who use banned substances when they compete by testing their urine. A chromatography machine separates all the substances in the urine, including any illegal drugs that leave the body in this way.

Airport security also tests for illegal drugs in this way. A piece of chromatography paper is wiped over a person or their bag, and then inserted into a machine. A gas is pushed through the paper. If the drug is soluble in the gas, then it will dissolve and be detected by the sensors. An alarm sounds and the security guard will take the person for questioning.

Figure 2.30 Airport security also uses chromatography to test for illegal drugs.

Check your learning 2.6

Remember and understand

1. What was used to make the first inks?
2. How does chromatography separate inks and dyes?
3. When is chromatography used to separate substances?
4. What is the solvent used in the chromatography for drugs at the airport?
5. What does solubility mean?

Apply and analyse

6. Some people think they can disguise drugs at airports by putting them in a strong smelling substance such as coffee beans. Explain why this will not work with airport security.

//SCIENCE AS A HUMAN ENDEAVOUR//

2.7 Waste water is a mixture that can be separated

Washing dishes or using the bathroom produces waste water containing a mixture of vegetable matter, paper, cloth and plastics. This cannot be released directly into waterways without harming the environment. Scientists use their knowledge of separating mixtures to make the water safe. Many unusual things have been found at waste water treatment plants, including BMX bikes, toys, false teeth and even money. One of the biggest problems currently is caused by the small stickers found on fruit. If eaten accidentally, the small plastic stickers pass through the digestive system and end up at the water treatment plants.

Primary treatment

Initially, the waste water is filtered to remove any large products.

Aluminium sulfate is added to the waste water to encourage any suspended particles still remaining to coagulate or clump together. This process is called flocculation.

The small clumps are then left to sit in sediment ponds to allow the clumps to form a sediment on the bottom of the pond. This sediment is called sludge and can be removed and disinfected. Many industries use the sludge as fertiliser or to manufacture biofuels.

Secondary treatment

The remaining waste water often contains levels of nutrients (e.g. nitrogen and phosphorus) that would be harmful to rivers or the ocean. When these nutrients enter waterways in large amounts, algae feed off them and grow into large blooms. The large numbers of algae use all the oxygen and nutrients in the water, leaving other aquatic life to starve. Secondary waste treatment pumps the waste water through a series of tanks where bacteria remove the excess nutrients from the water.

Figure 2.31 A water treatment plant.

Figure 2.32 Flocculation results in the clumping together of suspended particles in waste water.

Figure 2.33 An algal bloom.

Figure 2.34 Chlorine and waste water tanks in a tertiary water treatment plant.

Tertiary treatment

Sometimes the water will be treated at a tertiary treatment plant. Once again the water is filtered to remove any particles that may be left in the water. Chlorine can be added (just as in a swimming pool) to kill any bacteria that may still be in the water.

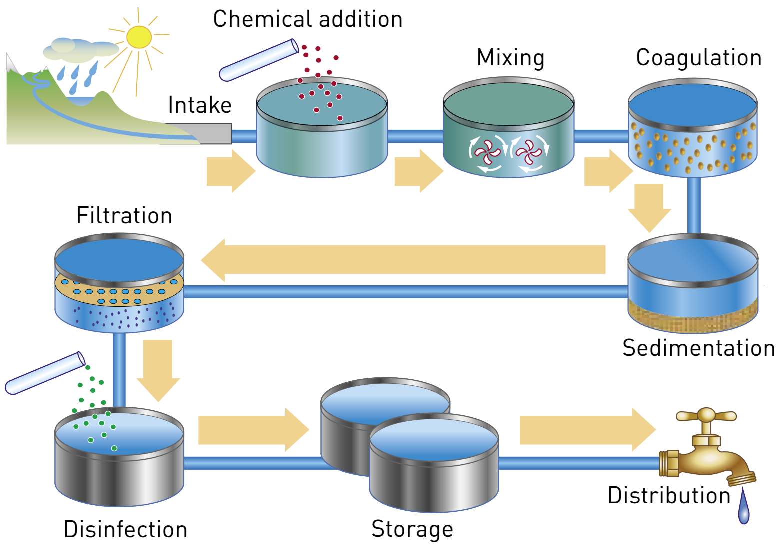


Figure 2.35 Summary of the water treatment process.

Extend your understanding 2.7

1 Water use is often an indication of the amount of waste water produced per person every year. A graph of the annual water consumption per person is shown in Figure 2.36.
   a Which city uses the highest amount of water per person each year?
   b Which city uses the lowest amount of water per person each year?
   c How much water does the average person in Canberra use?
   d Can you suggest why a person living in Brisbane uses more water than a person living in Melbourne?
2 Describe what type of objects might be removed during the primary treatment of waste water.

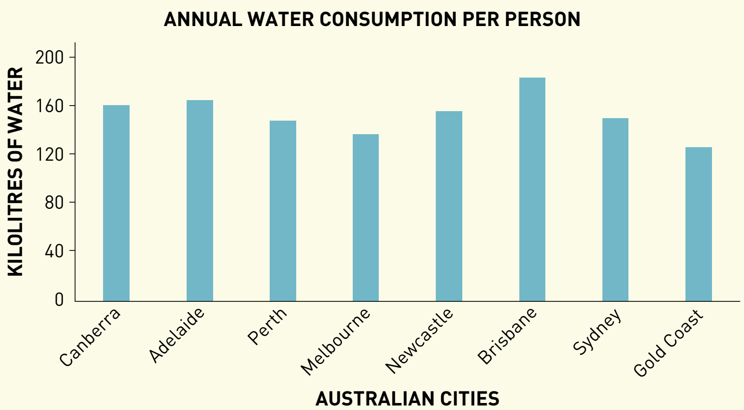


Figure 2.36

3 How can an algal bloom damage a river?
4 What is the purpose of the tertiary treatment of waste water?
5 Draw a cartoon that shows one stage of the treatment process. Join your cartoon with those from others in your class who drew the other two stages, so that combined you show all levels of the water treatment process.

2

Remember and understand

1 Examine Figure 2.37 and identify the suspension, the solution and the colloid.

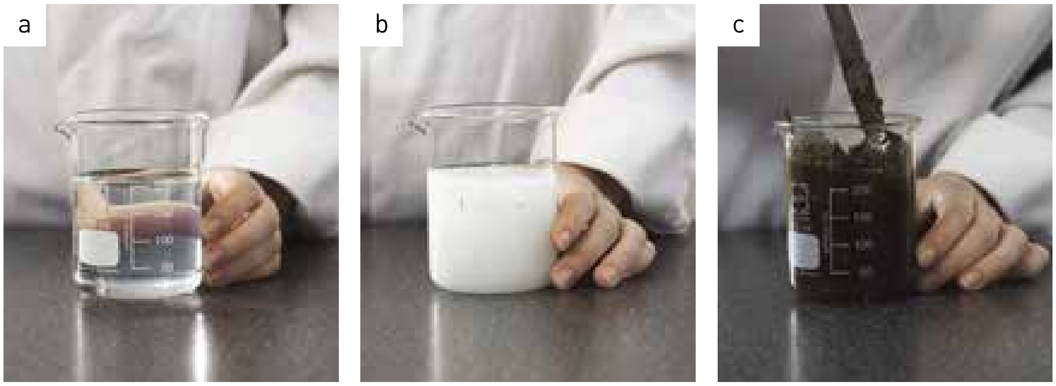


Figure 2.37

2 What is the major difference between evaporation and distillation?

3 a Which separation technique is used to separate the parts of blood?
   b Which physical property is being used to separate this mixture?

4 Give an example of a mixture that could be separated into its parts by filtration.

5 What safety recommendations would you give to someone using evaporation and crystallisation?

6 Imagine dropping salt in sawdust. How would you separate the parts of this mixture?

7 A criminal buries an aluminium drink can containing DNA evidence in the sand. Could the aluminium can be separated from the sand using a magnet? Explain your answer.

Apply and analyse

8 Nail polish remover and paint stripper are both useful solvents.
   a What is a solvent?
   b Identify the solute for each solvent.

9 Daniel was measuring the solubility of two chemicals (A and B) in water. He placed a spatula full of each substance in a separate test tube of water. Figure 2.38 shows what he saw.

   Use the words ***dissolve***, ***solvent***, ***solute*** and ***suspension*** to explain what has happened in each test tube.

Figure 2.38 Test tube A (left) and test tube B (right).

10 Imagine you have just bought a large factory. Due to flood damage it is filled with tonnes of matchsticks mixed with tonnes of iron scraps.
   a How would you separate this mixture?
   b What equipment would you need to make this happen on such a large scale?

Evaluate and create

11 Look at the chromatograms in Figure 2.39, taken from blue pens belonging to suspects (A–D). Compare these with the one taken from the original forged cheque (X). Decide whether any of the suspects is likely to be the culprit.

Figure 2.39

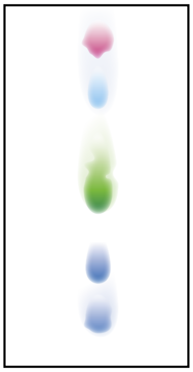


Figure 2.40

12 A particular coloured dye is being created for Fashion Week.

a Look at the chromatogram of the dye mixture in Figure 2.40. How many pure dyes were mixed to create the colour?

b Explain how chromatography could help create an exact copy of the dye for a rival manufacturer.

13 Do you think that performance-enhancing drugs are spoiling the image of sports? Pair up with a partner and make a list of all the implications of athletes using these drugs to compete.

14 Which techniques, and in what order, would you use to separate a mixture of iron filings, sand, marbles and salt? Present your answer as a flow chart.

15 People sometimes need to enter environments containing poisonous gases. In these situations, they will wear a gas mask. Use the Internet or other research tool to find out how gas masks interact with poisonous gases and how they change the air before it is inhaled by the person wearing the mask.

Research

Choose one of the following topics to research about working with mixtures. Some questions have been included to get you started.

How do we work with mixtures?

Research a separation technique that is used in a different industry or in nature. Prepare a 'SWOT' analysis as part of your report, listing the **s**trengths, **w**eaknesses, **o**pportunities and **t**hreats of the separation technique that you choose to research. You may choose to present your report with a series of photographs of the technique.

Filters of the sea

Certain types of whales, known as baleen whales, have a filter in their mouth made of a bone-like substance called baleen. Research what these plates do and what they filter. In addition, investigate how whales are different from other filter-feeders, such as barnacles, sponges and flamingos.

Distillation for survival

Imagine you were hiking in central Australia, became separated from your group and had run out of drinking water. Research some techniques of distilling water from gum leaves. As part of your report, you may like to demonstrate one technique to the class.

Human filtration

The human body needs to control what goes into it and what comes out. In particular, the filtering system of the kidneys prevents us from being poisoned by our own wastes, and tiny hairs in our noses filter dust and germs as we breathe. Find out more about these human filtration systems and see if you can identify others.

Self-cleaning suburbs

As our population grows, new suburbs are being built on the outskirts of cities. In some of these new suburbs, several features have been included to keep the water and air clean. Find out about strategies that are used to purify water and the air in housing estates.

*KEY WORDS

2

boiling point (BP)
the temperature at which a liquid boils and turns to a gas

centrifuging
technique used to separate light from heavy particles by rapidly spinning the mixture

chromatography
technique used to separate substances according to differing solubilities

colloid
type of mixture that always looks cloudy because clumps of insoluble particles remain suspended throughout it – they don't settle as sediment

concentrated
contains a large number of solute particles in the volume of solution

concentration
how much solute is dissolved in a solvent

condensation
the cooling down of gas into a liquid

crystallisation
separation technique used in conjunction with evaporation to remove a dissolved solid from a liquid; after the liquid has been evaporated the solid remains, often in the form of small crystals

decanting
technique used to separate a sediment from the liquid it is in by carefully pouring the liquid away

dilute
contains a small number of solute particles in the volume of solution

dissolved
a solute forms a solution

distillation
technique that uses evaporation and condensation to separate a solid contaminant and the solvent in which it has dissolved

emulsifier
a substance that enables oil and water to form an emulsion

emulsion
a colloid of two or more liquids

evaporation
change in state from liquid to gas; also a technique used to separate dissolved solids from water

filter paper
paper sieve with tiny holes that are too small to see; solutions can flow through but most solid particles will not

filtering
technique used to separate different-sized particles in a mixture depending on the holes in the filter used

filtrate
the substance that passes through a filter

flocculants
chemicals added to a mixture to make suspended particles clump together

insoluble
does not dissolve

magnetic
able to be magnetised or attracted by a magnet

mixtures
something made up of two or more pure substances mixed together

properties
(*chemistry*) characteristics or things that make something unique

pure substance
something that only contains one type of substance

residue
the substance left behind in a sieve or filter

saturated
a solution in which no more solute can be dissolved

sediment
something that settles to the bottom in a mixture

solubility
how easily a substance dissolves in a solvent

soluble
can be dissolved in a liquid

solute
a substance that dissolves in a liquid (solvent)

solution
a liquid made up of a solvent with a solute dissolved in it

solvent
any liquid that dissolves other substances

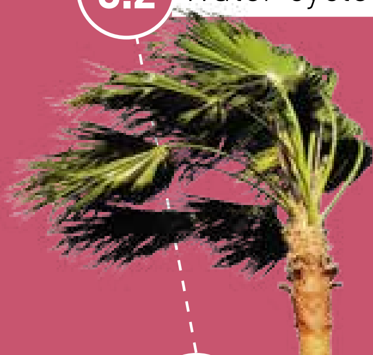
substances
a solid or liquid that can be mixed

suspension
a cloudy liquid containing insoluble particles

WATER 3

3.1 Water can change state

3.2 Water cycles through the environment



3.3 Factors in nature affect the water cycle

3.4 Human management affects the water cycle

3.5 Water is a precious resource

What if?

Water wise

What you need:

2 packets of Post-it notes per group, pens

What to do:

1 In groups of four or five, write down every use of water you can think of, in 2 minutes, on separate Post-it notes. (Hint: don't just think of water humans use; think about animals, the environment, business, farms etc.)

2 When time is up, arrange the notes into common topics and display your group's uses of water on a wall.

3 Check displays created by other groups and note any uses you did not think of.

4 Count the number of different uses the whole class described.

What if?

» What if there was a drought? How would water use be affected?

» What if the water was contaminated by a toxin? How would contamination affect water use?

3.1 Water can change state

Water, like many substances, can exist in three states: solid, liquid and gas. Solid water is ice. We are all familiar with liquid water, and water as a gas is known as water vapour. When heat is added or taken away, water can change between the three states.

Change of state

The temperature that causes water to become a solid is called its **freezing temperature**. If heat is added back to the solid water, the ice melts. This temperature is called the **melting point**.

The process of making steam from water is called **evaporation**. The temperature at which the gas or vapour starts to form is called the **boiling point**. If heat is removed from the steam, the gaseous water slows its movement until it once again forms liquid water. This process is called **condensation**.

All substances – not just water – can change state. Figure 3.4 shows the different changes of state that can occur and words used to describe each change.

Figure 3.2 Solid water. When heat is removed from liquid water, the movement of the water particles slows until they vibrate on the spot. The water has **solidified**. This is the **solid** form of water called ice. Ice, like all solids, holds its shape even when it is tipped from a container.

Figure 3.1 Liquid water. When most of us think of water, we think of the **liquid** form that comes out of our taps. Liquid water sits at the bottom of cups and flows smoothly over surfaces. Water can fit into containers of all shapes and sizes. It is flexible.

Figure 3.3 Gas water. When heat is added to liquid water, the water particles start to move faster. Eventually they are able to move so fast they separate from the rest of the liquid water and become **water vapour**. The particles in a gas have much more energy than those in liquids or solids. They do not sit at the bottom of containers. Instead they move freely around the whole container.

CHALLENGE 3.1A: THREE STATES OF WATER
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CHALLENGE 3.1B: ICE CUBE NECKLACE
GO TO PAGE 184

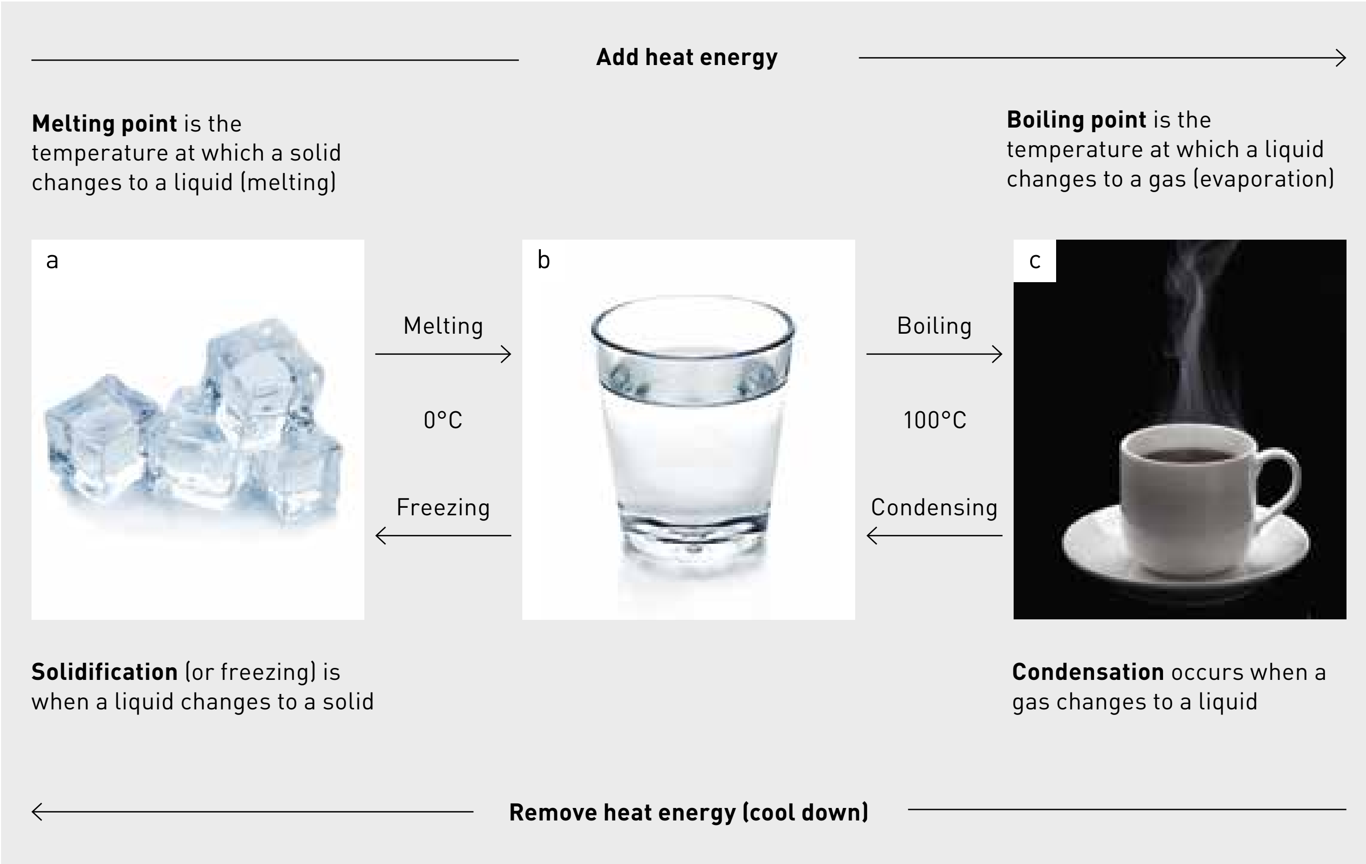

Figure 3.4 Adding or removing heat energy can change the state of water.

Check your learning 3.1

Remember and understand

1 Describe what happens to water when it:
   a evaporates
   b condenses
   c freezes.

2 By applying heat to liquid water, what could happen to its state?

Apply and analyse

3 What is the:
   a melting point of water?
   b boiling point of water?

4 Refer to the table below. Which substance has the:
   a lowest melting point?
   b highest melting point?
   c lowest boiling point?
   d highest boiling point?

SUBSTANCE	MELTING POINT (°C)	BOILING POINT (°C)
Water	0	100
Iron	1535	2750
Lead	327	1750
Mercury	–39	357
Table salt	805	1413
Oxygen	–219	–183
Nitrogen	–210	–196

Evaluate and create

5 A student claimed a frozen drink bottle was leaking because condensation had formed on the outside of the container. How would you explain to the student where the condensed water came from?

Figure 3.5 You can sometimes see condensation when you breathe out on a cold morning. The water gas in your breath becomes a fine liquid when it hits the cold air, making what is commonly called 'dragon breath'.

3.2 Water cycles through the environment

Water on Earth is precious and has always been recycled. Water moves constantly between the three states in a process called the **water cycle**. Like many other resources, there is only a certain amount of water on Earth and this amount does not change. Even when water evaporates and becomes a gas, it has not stopped existing – it is just invisible to the eye.

Evaporation in the water cycle

In the water cycle, heat energy from the Sun evaporates water from lakes, rivers, oceans and the land. Most of Earth's surface is covered by the oceans and seas, so most of the water vapour in the air comes from them. When water evaporates it leaves behind anything that was dissolved in it (like crystallisation, when you separate mixtures).

Condensation in the water cycle

As the water vapour (gas) rises, it is cooled by the air. Eventually the air becomes saturated (filled) with water vapour and cannot hold any more. When this happens, some of the water vapour will change into tiny water droplets (liquid). This is how clouds form.

Precipitation in the water cycle

The tiny warm water droplets rise in the atmosphere and form clouds. The higher the clouds go, the cooler the air becomes. The droplets then combine to form larger droplets, and can fall as rain, hail or snow (different forms of **precipitation**). In this way, the same water that evaporated is returned to the land, flowing through rivers until it finally returns to the oceans.

Sometimes the water droplets in the clouds are moved by the **wind** to the mountains where the air is very cold. This causes the liquid water droplets to freeze into snow and ice (another form of precipitation).

Groundwater

Once the liquid water is on the Earth's surface, it can soak into the ground and form **groundwater**. Deep underground there are rivers and lakes that store water. To get there, the rainwater must soak in through and around the small rocks and pebbles that make up the earth. Eventually, it reaches solid rock and forms small pools of water called aquifers.

Figure 3.6 Rain, hail and snow are all types of precipitation.

EXPERIMENT 3.2: WHAT IF THE TEMPERATURE WERE INCREASED IN THE WATER CYCLE?
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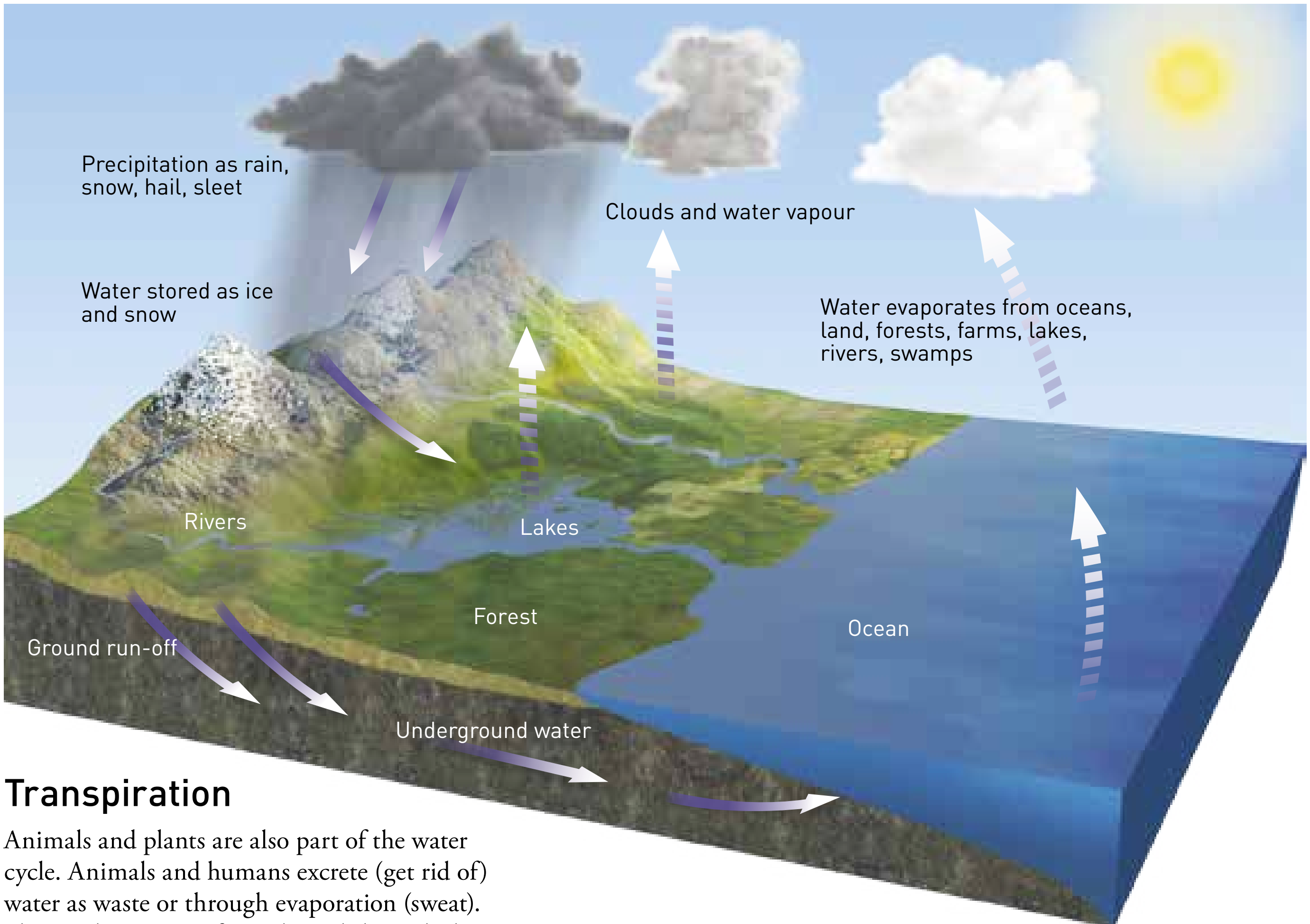

Figure 3.7 The water cycle. Water is constantly on the move. It changes from rain to water vapour to clouds to rain again, over and over. By constantly changing state, water never disappears – it is just recycled through the environment.

Transpiration

Animals and plants are also part of the water cycle. Animals and humans excrete (get rid of) water as waste or through evaporation (sweat). Plants take in water from the soil through their roots. This water travels through the plant to the leaves. Once the water has reached the leaves, it can evaporate. The evaporation of water from a plant is called **transpiration**.

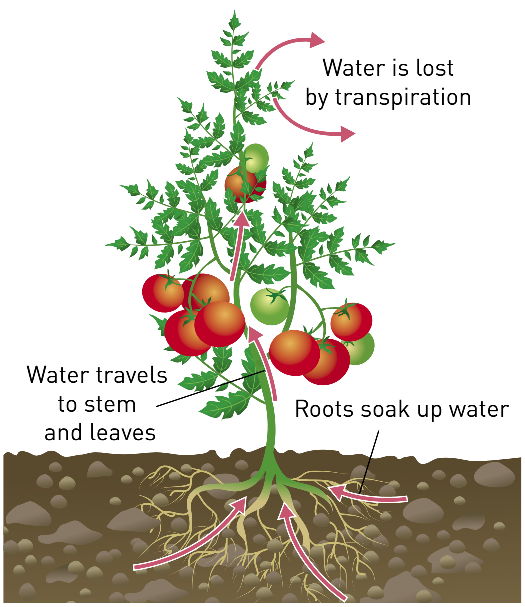

Figure 3.8 Transpiration in a plant.

Check your learning 3.2

Remember and understand

1 Why is the movement of water around the environment called a cycle?

2 Give examples from the water cycle of:

a frozen water

b water gas

c liquid water.

Apply and analyse

3 Create a simple labelled diagram of the water cycle.

Evaluate and create

4 True or false? The same water you drank today could have been drunk by a dinosaur millions of years ago. Explain your answer.

5 Research how much water on Earth is salt water. Can we drink salt water?

3.3 Factors in nature affect the water cycle

Although water has been cycling since the Earth was first formed, this cycle can be affected by many things. Changes in temperature, the direction of the wind and the number of plants all affect how fast water evaporates, and therefore the amount of water vapour in the air.

a

b

Figure 3.9 Areas in Australia affected by (a) drought and (b) flood.

El Niño and its effect on Australia

You have probably heard of the El Niño effect. Fishermen in Peru in South America originally used this term to describe the appearance, around Christmas, of a warm ocean current off the South American coast that brought heavy rain and floods. Nowadays, 'El Niño' describes the extensive warming of the central and eastern Pacific Ocean. Combined with this ocean warming are changes in the atmosphere that affect weather patterns across countries around the Pacific ocean, including Australia. In Australia, El Niño events usually mean less rain will fall.

El Niño events occur approximately every 4–7 years and usually last for about 12–18 months. They are a natural part of the climate system and have been affecting the Pacific countries for thousands of years.

Each El Niño event is unique in terms of how much the ocean temperature warms and how rainfall patterns change. El Niño events usually result in less rain across parts of eastern and northern Australia, particularly during winter, spring and early summer. Where and when this happens differs a lot from one event to another, even with similar changes and patterns in the Pacific Ocean. In 2002–03, a relatively weak El Niño event resulted in severe drought.

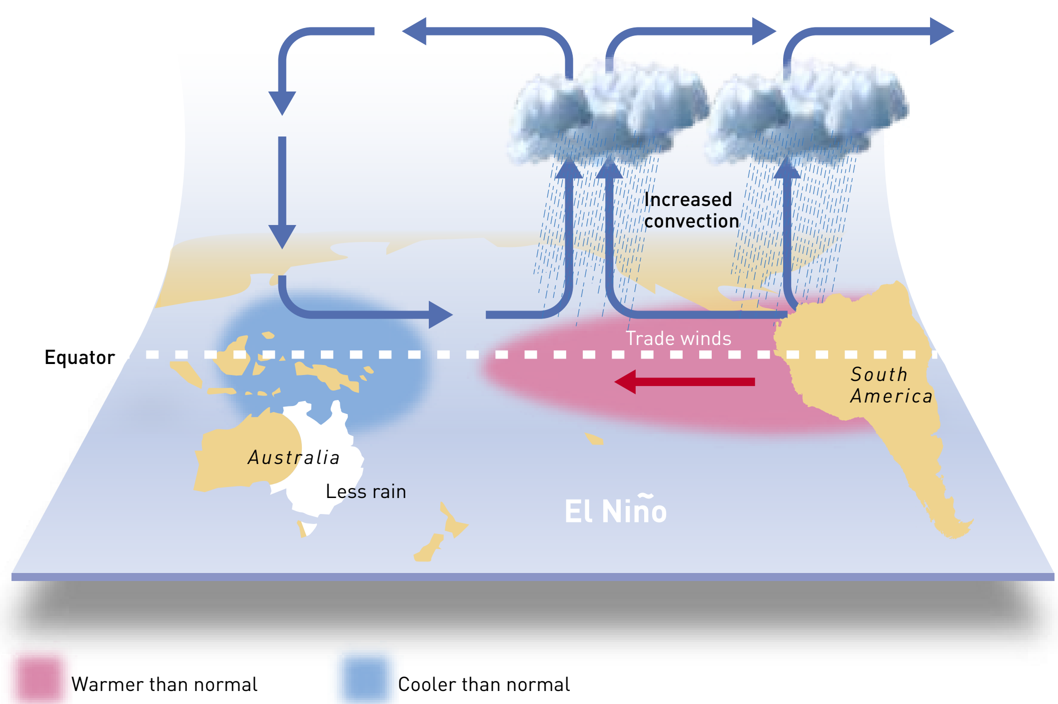

Figure 3.10 During an El Niño event, there is an increased chance of drier conditions in Australia because of the combined effects of ocean warming and changes in the atmosphere that affect weather patterns.

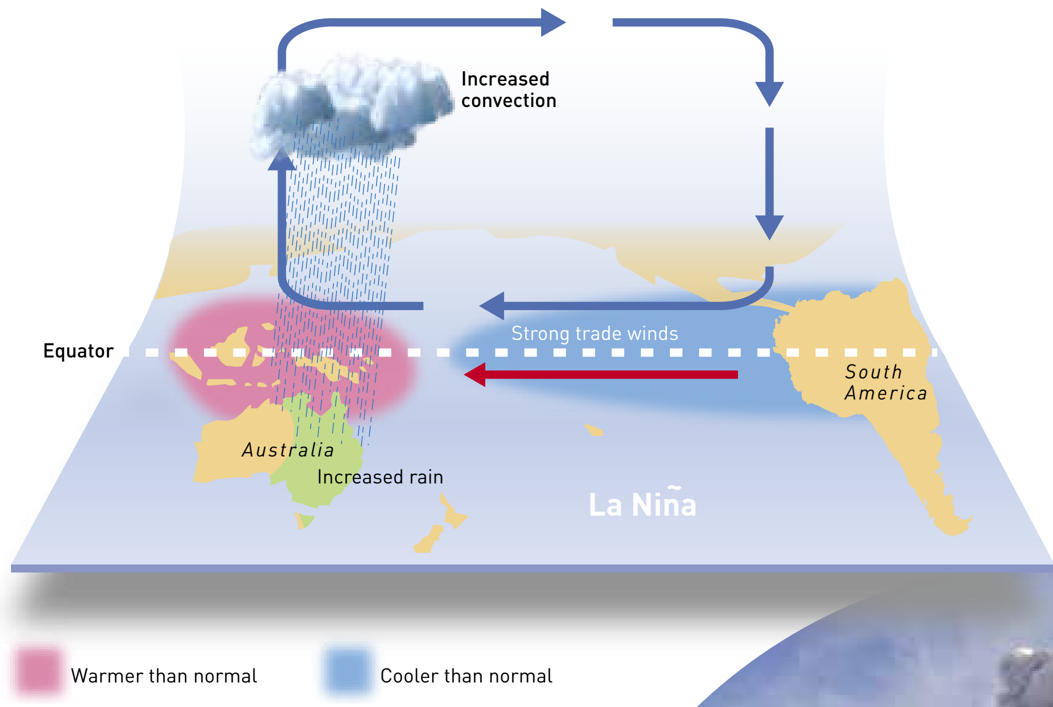

Figure 3.11 A La Niña event results in an increased chance of wetter conditions along the east coast of Australia, because of ocean cooling and stronger winds.

La Niña

More recently, in 2010–11, a La Niña event caused widespread flooding, especially in Queensland and Victoria. The opposite of El Niño, La Niña occurs when the ocean current is cooler and the winds are stronger. This results in greater than usual amounts of rain falling along the east coast of Australia.

Volcanic eruptions

Volcanoes erupt regularly around the world every year. Occasionally there is a major eruption, like the 2011 Nabro eruption in Eritrea, Africa, that discharged large amounts of dust and particles into the air. The particles reflected the sunlight, preventing the Earth (and water) being heated. As a result, less water evaporated, resulting in less water vapour condensing into precipitation (rain). As a result, some countries experienced a drier climate in the year after the eruption.

Figure 3.12 Volcanoes release large amounts of ash into the air when they erupt.

Check your learning 3.3

Remember and understand

1 Describe how El Niño affects Australia.

2 Describe how La Niña affects Australia.

Apply and analyse

3 Are there any erupting volcanoes in Australia?

4 Research where and when the last big volcanic eruption occurred in the world.

Evaluate and create

5 Draw a flow chart of how volcanic dust particles blocking sunlight affect the water cycle. Include all parts of the water cycle.

3.4 Human management affects the water cycle

Water is not just for drinking. We use water in many parts of our life without realising it. Water is used to grow the food we eat, to make the clothes we wear and to clean our homes and ourselves. All of this affects the water cycle.

Figure 3.13 Water is used for the irrigation of crops.

Agriculture

Australia has one of the lowest rainfall levels in the world. This means we need to use water to help us grow the food we eat. Most of the water used by humans in Australia every year is needed for growing our food. Most of this is used for irrigation, the artificial watering of the Earth for agriculture. Often the water is sprayed onto crops to ensure they do not die in dry areas such as the Murray River Basin.

Often this water is taken from the groundwater or from rivers or lakes. This reduces that amount of water flowing into rivers, which affects the native plants downstream. It also washes dirt and fertilisers into the waterways. This affects the plants and animals that rely on the clean water to live. Increased watering in some areas can also result in an increase in the amount of groundwater.

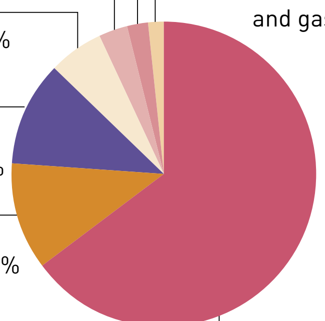

Figure 3.14 Water is used for many purposes across Australia.

Groundwater is often salty, so the salt comes to the surface with the water, making the soil too salty to grow food. Farmers often need to carefully manage water levels so that they balance the need to grow the food with the need to maintain the water cycle.

Industry

One of the biggest impacts on the water cycle is the use of fossil fuels to produce electricity for factories. This burning of fossil fuels causes the production of carbon dioxide. Carbon dioxide is a greenhouse gas. This means it can absorb heat, making the air around the Earth stay warm. The extra heat from high levels of carbon dioxide causes more water to evaporate and stay in the air as water vapour. This can cause changes in the weather, including more rain in some areas and droughts in other areas. It is also contributing to the melting of the ice caps, causing even more water to re-enter the water cycle. The long-term impact of **global warming** due to industry is still being determined.

Domestic

Australia is the world's driest continent. We store more water than any other country – more than 4 million litres of water per person! Australia requires such a large storage capacity to ensure a reliable water supply during periods of drought.

Large dams and reservoirs have been built to collect and store water. Two of the largest storage reservoirs in Australia are the Warragamba Dam in Sydney, which can store 2 million megalitres (2 million million litres) and the Thomson Dam in Victoria, which can store 1 million megalitres. Storing water in dams reduces the water flowing down rivers and into the ocean.

CHALLENGE 3.4: CAN YOU REDUCE THE EVAPORATION OF WATER IN IRRIGATION CHANNELS?
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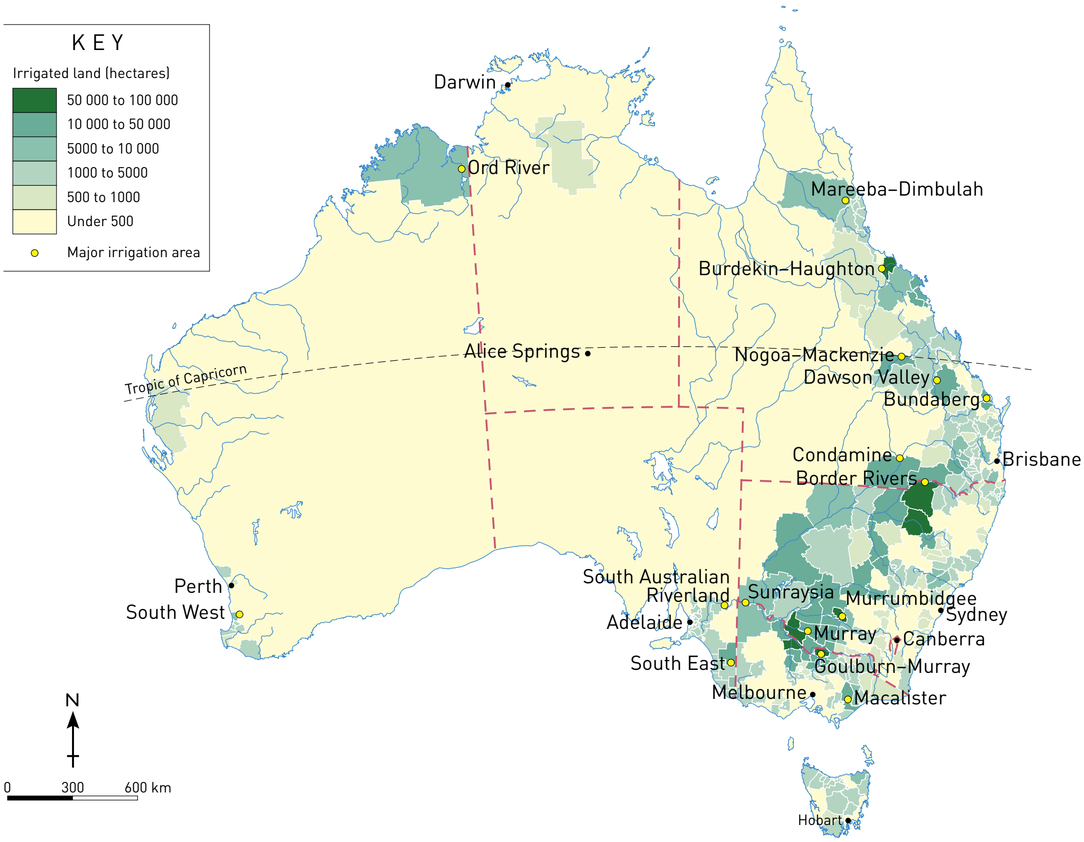


Figure 3.15 Agricultural irrigation to grow food accounts for 65% of the water used in Australia.


Figure 3.16 Industry is responsible for the release of carbon dioxide and water vapour into the atmosphere.


Figure 3.17 The Thomson Dam in Victoria.

Distillation

Even though salt water is not suitable for drinking, in dry countries like Australia the idea of changing salty water into fresh water is very appealing.

One way to do this is by **distillation**. In this separation process, heat is used to evaporate water from the salt. The steam is collected and condensed into pure liquid water.

Distillation has been used for many years in **desalination plants** to produce fresh water from sea water, particularly in some Middle Eastern countries. However, it is very expensive and uses a great deal of energy. With improved technology, Australian state governments are building or planning to build desalination plants to increase the water supply. Some states already have working desalination plants.

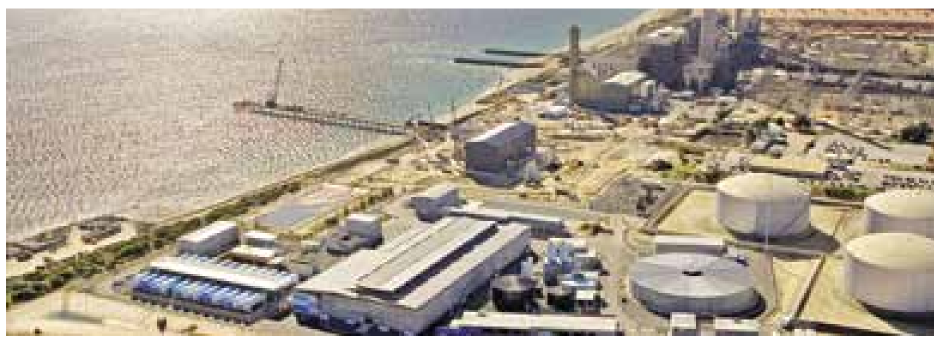


Figure 3.18 The Perth desalination plant was built in 2006. It is located at Kwinana and supplies nearly 17% of Perth's drinking water.

Check your learning 3.4

Remember and understand

1 What is the greenhouse effect?

Apply and analyse

2 How does using too much water cause high salt levels in the soil?

3 Why does desalination use a lot of energy?

4 List three ways you have used water in the last 24 hours.

Evaluate and create

5 Draw a water cycle and highlight where in the cycle the water you use comes from.

6 Research where the water supplies you use come from.

//SCIENCE AS A HUMAN ENDEAVOUR//

3.5 Water is a precious resource

Approximately two-thirds of the Earth's surface is covered with water, yet in Australia we have very little fresh water. Of all the water on Earth, 97.5% is salt water – the remaining 2.5% is fresh water. Of the tiny percentage of fresh water in the world, most of it is locked in ice caps and glaciers or in the soil. This leaves approximately 0.007% of the Earth's water available for drinking.

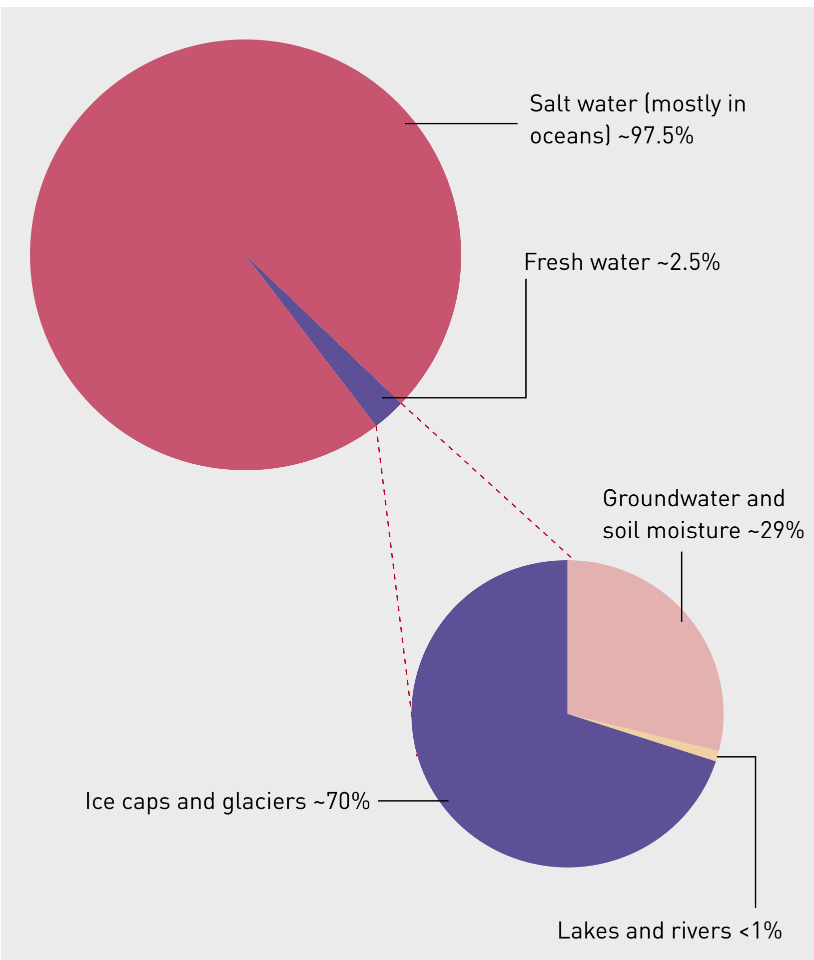


Figure 3.19 Only a very small percentage of water on the Earth is fresh and unfrozen.

Figure 3.20 Water-saving shower heads are used to reduce the amount of water we use when showering.

Sustainable water use at home

Australia's weather can be unpredictable. To cope with this, Australians are encouraged to think carefully when building new homes, businesses and even gardens.

Drought-tolerant plants are big sellers in plant nurseries all over Australia. Gone are the days when 'English' country gardens were practical options; succulents and native species are now the plants of choice. We've reduced the watering needs of our gardens. In some places, the government has restricted our use of water and the price of water is increasing.

Rainwater tanks are popping up in backyards all over the country, more water-saving shower heads are being used and the use of grey water systems is increasing.

Figure 3.21 A rainwater tank is used to capture and store rainwater that can then be used to water the garden, flush toilets and even wash clothes.

Figure 3.22 A grey water apparatus, like this converted wheelie bin, can be used to collect laundry water, which is then used to water the garden.

Extend your understanding 3.5

1 Find out how rainwater tanks collect and purify water for use on the garden and in the home.

2 Find out how water-saving devices, such as shower heads, are able to reduce water flow.

3 Find out more about grey water systems.
   a What is grey water?
   b Which water from the home can be re-used?
   c How is grey water purified?
   d Why don't more people install grey water systems in their homes?
   e What is 'black water'? Where does 'black water' go?

4 Certain plants can act as effective filters of rainwater. When it rains, some water ends up in the underground water table and can be pumped up for use elsewhere. Find out more about plants as filters.

Remember and understand

1 What are the three states in which water can be found?
2 What is transpiration?
3 What are clouds made of?
4 What percentage of the Earth's water is suitable for drinking?
5 Where is fresh water stored on Earth?
6 How can the way we live affect the water cycle?
7 What natural factors can affect the water cycle?
8 What is the difference between melting point and boiling point?
9 What is the gas state of water and how does it form?
10 List three places from which water evaporates as part of the water cycle.

Apply and analyse

11 Salt water has a lower melting point than fresh water. In America, salt is spread over the footpaths in winter. Why do they do this?
12 What factor may affect the ability of soil to grow plants?
13 Working in a small group, investigate the advantages and disadvantages of desalination plants. Make a poster that lists the advantages and disadvantages of these plants.
14 Why should you water the roots of a plant and not the leaves?
15 How would an El Niño event affect your life?
16 In the eighteenth century, Captain James Cook embarked on several voyages to the Pacific Ocean, exploring new lands including Australia. Despite being surrounded by water, his crew was constantly at risk of dying of thirst. How can you explain this?

Ethical understanding

17 Your neighbour waters their garden whenever they like for as long as they like. Is there a certain time of day when it is better to water plants? Are there restrictions in your area about when you can water the garden?

Figure 3.23 What happened in the Queenstown hills?

Evaluate and create

18 Create a model of the water cycle. What could you use to represent the three stages of water? Show how each stage is connected to the others.
19 Make a list of the different categories of water-saving devices currently available. If you could choose only three devices to install in your house, which three would you choose and why? Write a short description of each of the three water-saving devices you have chosen. Include an image for each one and indicate how

it helps save water. What things does your family do to save water around your house?

20 As lack of water becomes a bigger national problem, more people will be required to work in the water industry. This includes hydrologists, environmental scientists and environmental engineers. Choose one of these professions and investigate the following:

a What work does this person do?

b What subjects should be studied in school in order to enter into this career?

21 Much of the area around Queenstown, on the western coast of Tasmania, is now barren and lifeless (Figure 3.23). Research what happened here to cause the devastation. Explain in detail why this land hasn't been rehabilitated and why the area will take many thousands of years to recover.

Research

Choose one of the following topics on which to conduct further research. A few guiding questions have been provided for you but you should add more questions that you wish to investigate. Present your findings in a format that best fits the information you have found and understandings you have formed.

Indigenous management of waterways

In many parts of Australia, the water in rivers and creeks are protected by the state and national governments. This means there are often laws that govern the collection and use of water in the waterways. This can be in direct conflict with the Indigenous people's view of inland waters, rivers, wetlands reefs and islands. Research how each side views water resources and suggest a way that both groups will be able to work together to find a solution.

Sewage treatment

Find out more detail about how your city treats its sewage. What is sewage? What is the difference between sewage and sewerage? How has sewage treatment in your city changed? Many countries drink water that was once sewage but has been treated. Do you think this is a good idea? How do your actions affect sewage and water quality? How can you make a difference to the water in your environment? Give a mulitmedia presentation to the class.

*KEY WORDS

3

boiling point (BP)
the temperature at which a liquid boils and turns to gas

condensation
the cooling of gas into liquid

desalination plant
a large facility set up to produce fresh water from salt water

distillation
technique that uses evaporation and condensation to separate a solid contaminant and the solvent in which it has dissolved

evaporation
change in state from liquid to gas; also a technique used to separate dissolved solids from water

freezing temperature
the temperature at which water becomes a solid

groundwater
water found beneath the Earth's surface

liquid
a substance that is able to flow across a surface and maintain a fixed volume

melting point (MP)
the temperature at which a substance melts

precipitation
(*weather*) rain, hail or snow

solid
a substance that maintains a fixed shape

solidified
what happens to a liquid when its particles lose energy (heat) and the substance is now unable to change its shape

transpiration
the process by which plants take up water from the soil through their roots and loses it through their leaves

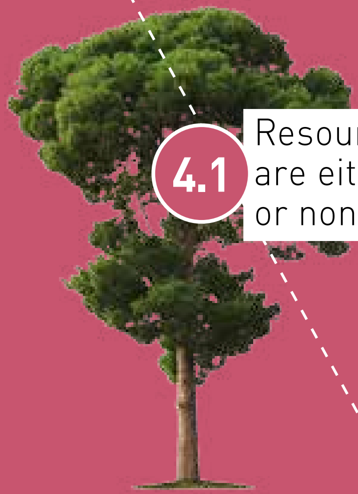
volcano
vent or hole in the Earth through which molten (melted) rock ash and other materials escape onto the surface

water cycle
the cycle of constant evaporation and precipitation that occurs in nature

water vapour
water in the gaseous state

Figure 3.24 Global warming is contributing to the increased melting of the ice caps.

RESOURCES 4



4.1 Resources on Earth are either renewable or non-renewable

4.2 Renewable resources can be quickly replaced

4.3 Renewable resources can be harnessed to provide energy

4.4 Non-renewable resources are limited

4.5 Soil is one of our most valuable resources

4.6 Our future depends on careful management of resources

4.7 Green jobs will increase in the future

What if?

Sustainable fishing

What you need:

packets of M&Ms, trays, spoons, straws, stopwatch

What to do:

1. Place plates of 20 M&Ms (representing fish) around the room.
2. Each student should use a straw (no hands) to collect as many 'fish' as they can in 1 minute.
3. After 1 minute, the remaining fish are available for breeding. Add one new M&M 'fish' for every M&M left.
4. Repeat steps 2 and 3 several times.
5. How long can you keep fishing?
6. Is the fishing sustainable?

What if?

» What if you use hands to help move your straws? (This represents fishermen using technology to help find fish.)

» What if you use a spoon instead of a straw? (This represents fishing with a net.)

4.1 Resources on Earth are either renewable or non-renewable

*

Humans have always relied on the natural resources of the Earth – in the air, the water and the ground. Oxygen and water are essential for keeping us alive. Soil is necessary for us to grow food for ourselves and our livestock. Minerals from the Earth that feed the mining industry are essential to manufacturing and to Australia's economy. Forests provide habitat for animals and timber products for our buildings. In fact, humans have found and used resources in almost every corner of the planet. As the human population continues to grow, we are putting more pressure on our resources than ever before.

Types of resources

Resources on Earth can be classified into two major groups:

> renewable resources
> non-renewable resources.

Renewable resources are either available in a continuous and unlimited supply (e.g. sunlight and wind) or are able to naturally replenish in most conditions (e.g. fast-growing trees in a forest). Despite the fact that they can regenerate naturally, renewable resources still need to be managed carefully and used sustainably.

Non-renewable resources are resources that take an extremely long time to replenish and are therefore only available in limited supply. If we use them at a faster rate than they can replenish naturally, they will run out.

Minerals such as coal and oil are non-renewable resources.

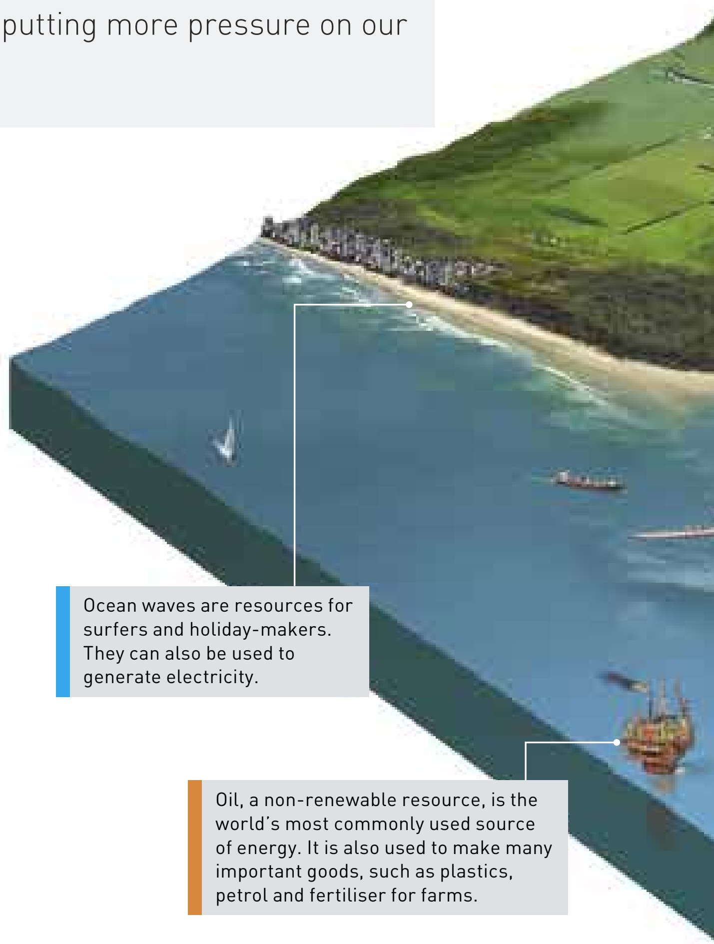


Figure 4.1 Our environment provides us with many resources.

Environmental resources

An overview of the many types of environmental resources

Check your learning 4.1

Remember and understand

1 What are the two main groups of resources?

2 Name one renewable resource that is continuous and one that is non-continuous.

3 List all the non-renewable resources you have used in the past hour.

Apply and analyse

4 List all the resources from Figure 4.1. Place a tick next to the ones you think are well managed in Australia today and a cross next to those you are think are not well managed. Be prepared to discuss your analysis.

Evaluate and create

5 Evaluate Figure 4.1. Which resources do you think are the most important? Explain your answer using examples.

6 How do you think the way we manage resources today differs from the way Indigenous Australians traditionally managed the Earth's natural resources?

4.2 Renewable resources can be quickly replaced

Renewable resources are those resources that can be replaced at the same rate they are used. Any resources that take a long time to be replaced are called non-renewable because they are limited; once used, they take a long time to replace. Our supply of energy resources is running out, so we need to consider how we use energy more carefully now so that there is enough energy in the future.

Figure 4.2 Some of the Earth's natural resources: (a) timber, (b) fish and (c) solar energy.

Renewable and non-renewable resources

When you burn gas in a Bunsen burner, you are using a non-renewable resource. If you burn 1 litre of gas, then there is 1 litre less of that gas in the world. Many non-renewable resources are continually being made, but on a time scale of hundreds of thousands or even millions of years. This makes them practically non-renewable in our lifetime. If we continue to use a non-renewable resource and it is not recycled, then it will run out for humans.

It is estimated that Australia's brown coal will last for another 500 years. By 2030, coal is still expected to be our main energy resource, but there will be a shift to resources such as gas and renewable energy, such as wind.

Renewable resources are made naturally and are available in an almost unlimited amount. Solar energy is a renewable resource: an unlimited amount of it is available while the sun shines in the sky. Of course, if the weather is cloudy then solar energy is not available, so it can have some disadvantages too. Other examples of renewable resources include clean air, timber and fish. Given the right conditions, they will be available if we don't use them too fast. We need to consider the consequences of taking too much.

Table 4.1 Use of Australia's energy resources

RESOURCE	USE	PERCENTAGE OF TOTAL ELECTRICITY PRODUCTION 2007–08
Coal (brown and black)	Electricity generation	76.3%
Gas	Electricity generation	15.9%
Liquefied petroleum gas (LPG)	Transport fuel	0
Uranium	Exports	0
Crude oil	Transport fuel	0.9%
Wind	Electricity generation	1.5%
Solar	Solar heating and electricity generation	<0.1%
Geothermal	Demonstration projects only	<0.1%
Hydro	Electricity generation	4.5%
Wave, tidal	Demonstration projects only	0

Source: Adapted from *Australian Energy Resource Assessment*, Geoscience Australia.

CHALLENGE 4.2: CAN YOU INCREASE THE OUTPUT OF A POWER STATION?
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Figure 4.3 The location of Australia's energy resources.

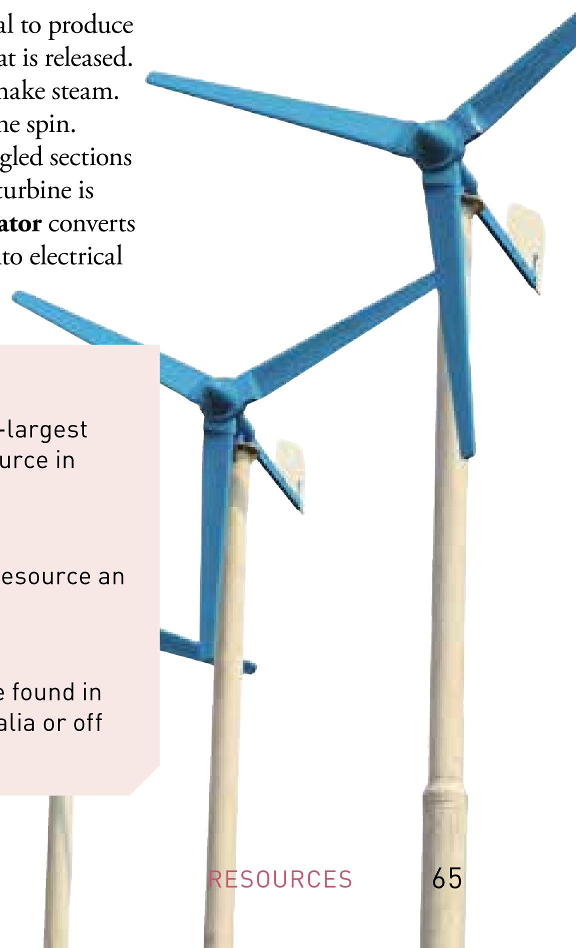
Australia's energy resources

Australia has a variety of **energy resources**. For a long time we have relied on energy resources such as coal and petrol for our energy needs.

According to recent research, Australia is one of the highest **greenhouse gas** emitters in the world. Using non-renewable energy resources for transport and generating electricity for use around the home make up approximately one-fifth of these **emissions**.

How a power station works

Coal-fired power stations burn coal to produce electricity. When coal is burnt, heat is released. This heat is used to boil water to make steam. The steam is used to make a turbine spin. A **turbine** is a large wheel with angled sections called vanes, like a propeller. The turbine is connected to a generator. A **generator** converts the movement from the turbine into electrical energy.



Check your learning 4.2

Remember and understand

1 Give an example of a non-renewable resource. Explain why it is considered non-renewable.

2 Give an example of a renewable resource. Explain your reasoning.

3 What is the time scale for formation of non-renewable resources? What about renewable resources?

4 What was Australia's third-largest electricity production resource in 2007–08?

Apply and analyse

5 Why is the time scale of a resource an important issue?

Evaluate and create

6 What energy resources are found in the state of Western Australia or off the West Australian coast?

4.3 Renewable resources can be harnessed to provide energy

Resources can provide a source of energy to meets our needs. There are many resources that can provide unlimited amounts of energy to help us generate electricity, heat our homes or to transport our goods and services. These include wind, solar, hydroelectric, tidal and geothermal power.

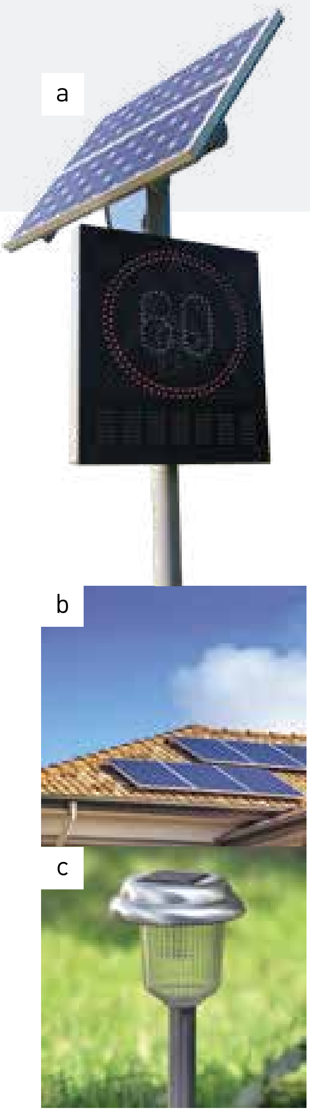


Figure 4.4 Solar power has many uses (a–c). Which of these have you seen?

Wind power

A very important step in generating electricity is turning a turbine. **Fossil fuels** are burned to produce steam to turn a turbine. Wind can also turn a turbine without producing steam and without emitting carbon dioxide.

To generate a significant amount of energy, many **wind turbines** are placed in long rows in a **wind farm**. The stronger the winds, the faster the turbines turn and the more energy is produced.

Solar power

In Australia we are familiar with **solar power** for things such as hot water, outdoor lighting and school zone speed limit signs.

Solar energy is made when **solar cells** (or solar panels) convert sunlight into electrical energy, they do not give off greenhouse gases. However, there are environmental impacts in their construction and disposal.

Figure 4.5 A wind farm in Australia.

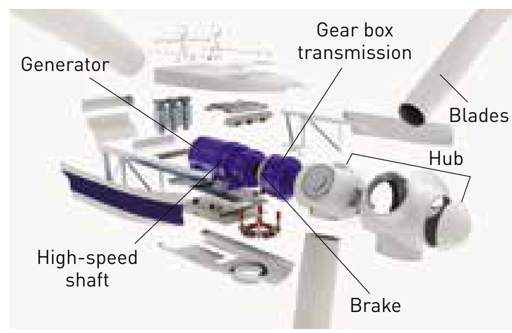


Figure 4.6 The parts of a wind turbine.

Hydroelectric power

Hydroelectric energy (*hydro* = 'water') is produced by falling water that turns turbines to produce electricity. It accounts for approximately 19% of the world's energy production. Hydroelectric schemes need a constant water supply and are often built in high-altitude areas, like mountains. The water supply is held in dams and then released to cause fast-flowing water, which turns the turbines efficiently. Hydroelectric power in Australia meets approximately 4.5% of our electricity needs.

Figure 4.7 A large-scale solar farm.

CHALLENGE 4.3: CAN YOU INCREASE THE POWER OF SOLAR CELLS?
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Tidal and wave power

Have you ever been to a surf beach and experienced the ferocity of the waves? It has been estimated that **wave energy** alone could power the entire Earth five times over! The problem has been working out how to do it. Wave energy uses the energy of waves to drive air turbines.

Tidal energy can also be used to drive turbines in the water. The major disadvantage of tidal power is that it only provides a relatively small amount of electricity and has a negative impact on the nearby natural environment. The world's largest tidal power station is in France.

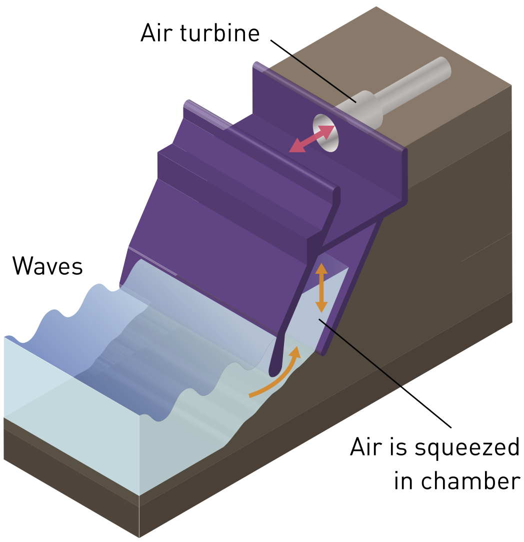


Figure 4.8 How wave power drives air turbines.

Geothermal energy

Geothermal energy comes from heat beneath the Earth's surface. The super-heated liquid rock under the Earth's surface is called magma. Magma heats the layers of rock above and below it. This heat is geothermal energy and some of it is released as steam. The steam can be used to turn a turbine in a generator, producing electricity.

Australia's only geothermal power station is in Birdsville, in western Queensland. The power station has a bore (pipe) that goes 1230 metres into the ground and taps into 98°C water from the Great Artesian Basin. This power station provides approximately one-quarter of Birdsville's energy supply. After the steam has been used to drive the turbine, the cooled water becomes the town's water supply.

Australia has access to a technology that could produce electricity to power parts of Australia for many years. This technology is called **hot dry rock geothermal energy**. Australia has the world's best geology for this type of energy. Proven reserves of hot dry rock have been found in Central Australia, and reserves in the Hunter Valley in New South Wales are being tested. To use the energy from the hot dry rock, water is injected through bore holes into hot granite rock 5 kilometres underground. The steam produced can be used to generate electricity. This technology consumes none of the Earth's valuable resources because the steam can be condensed back into liquid water and injected again.

Figure 4.9 Superheated water is produced at the geothermal power plant in Birdsville, Queensland.

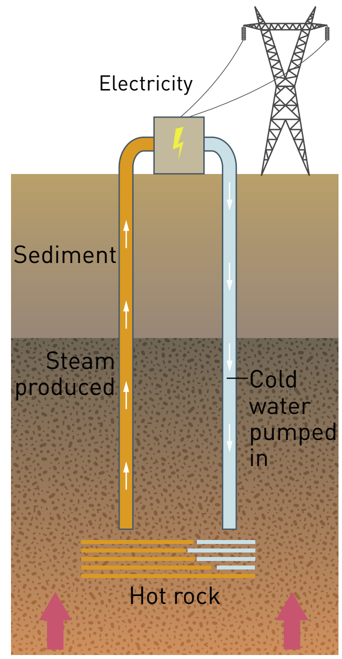


Figure 4.10 How hot dry rock technology works.

Check your learning 4.3

Remember and understand

1 What are two advantages of hydroelectric power over fossil fuels?
2 What is required for a successful hydroelectric power station?

Apply and analyse

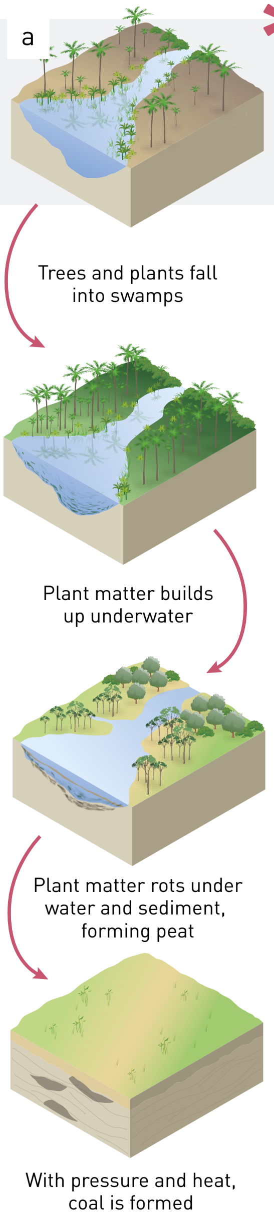
3 A large group of wind turbines in the same location is called a wind farm. Where do you think is the most suitable location for a wind farm? List the important features of your chosen location.
4 Why do you think most wind turbines are mounted on towers 40–100 metres high?
5 If the major hot dry rock resource is in Central Australia, what could be the disadvantages of this resource?

Evaluate and create

6 Coal-fired power stations in Victoria run 24 hours a day, 7 days a week. Is wind power as reliable a source of energy as coal? Explain your answer.
7 New Zealand produces a large amount of its energy from geothermal power. Why is this so different from Australia?

4.4 Non-renewable resources are limited

We have all heard of the dinosaurs, and the large forests that once covered the Earth. The trees became fossil fuels over millions of years, which we now know as coal, oil and gas. They are called non-renewable resources.



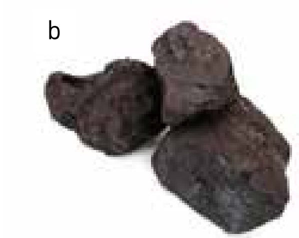


Figure 4.11 (a) Formation of fossil fuels. (b) A piece of brown coal.

Coal and other fossil fuels

Most of the energy used to produce electricity in Australia comes from coal. The energy stored in the coal is converted into electrical energy in a power station. In Victoria, most electricity is generated by power stations in the Latrobe Valley using brown coal. Large black coal resources are found near Sydney and in central and eastern Queensland. Coal is mined in open-cut mines if it is close to the surface or in underground mines.

To produce and provide electricity to homes and businesses, we use a 'big circuit'. This circuit begins with the generators at a **power station**. Electrical energy is transported from the power station to homes, businesses and factories by transmission and distribution lines.

Forming fossil fuels

Fossil fuels were formed about 300 million years ago, during the Carboniferous period, before the time of the dinosaurs. **Coal** is formed from the remains of trees and other plants that grew in tropical swamps during the Carboniferous period. When the trees and other plants died, they fell into the swamps. Because they were underwater where there was not much oxygen, the dead plants could not rot completely. The partly rotted plant material gradually built up, forming a layer of peat.

Over time, the layers of peat built up and then rocks formed on top of them. The pressure from the rocks on top and the heat from the Earth's crust underneath caused chemical reactions that gradually changed the peat into coal.

When coal is burnt, the chemical energy originally stored in the plants is released. Carbon dioxide and water are also produced.

Uranium

Uranium is the most common radioactive element on Earth, and Australia has the world's largest supply. Uranium is a non-renewable resource and Australia's supply is expected to last 140 years. Uranium gives out energy, called radiation, as it splits into other elements. Many of these other elements are also radioactive. This splitting process continues for a long time until a stable element is formed.

Figure 4.12 Loy Yang Power, in the Latrobe Valley in Victoria, generates approximately one-third of Victoria's electricity.

Figure 4.13 An artist's impression of a tropical swamp in the Carboniferous period.

EXPERIMENT 4.4A: WHAT IF A MUFFIN WERE MINED IN DIFFERENT WAYS?
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EXPERIMENT 4.4B: WHAT IF A METAL WERE OBTAINED FROM A MINERAL?
GO TO PAGE 190

Figure 4.14 A nuclear power station.

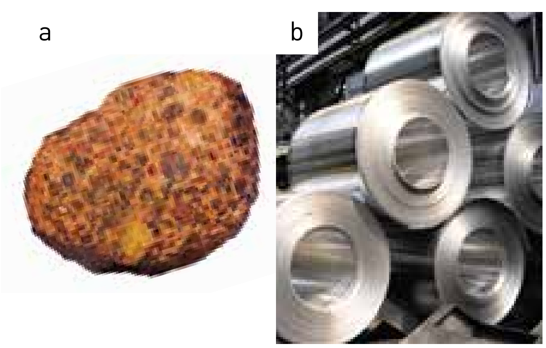
The energy from the splitting of uranium heats water, turning it into steam. The steam drives turbines, which drive generators, just as in a conventional coal-fired power station. Unlike coal-fired power, nuclear power produces hardly any carbon dioxide emissions; however, it does produce radioactive waste that takes a long time to become safe or stable. Too much exposure to radiation can be harmful for humans.

Minerals

Most of the man-made objects we use every day are made from materials that come from the Earth. The process of extracting useful minerals from the Earth is known as mining. **Minerals** are tiny grains or crystals that are the building blocks of rocks. Only a few minerals are found in a pure state, for example gold. Mostly they are combined with other substances and need to be purified before they can be used.

Aluminium, for example, is not found as solid sheets in the ground. It is part of the ore called bauxite, which is made of aluminium, oxygen and iron. **Ores** are materials that contain a lot of a useful mineral mixed in with other substances. Australia is rich in ore deposits and many mines have been in operation for a long time.

How a mineral is mined depends on the location of the ore body. If the ore is on or close to the surface, then open-cut mining is used (see Figure 4.16). If the ore body is deeper, then underground mining is used and shafts are cut down into the ground to reach the ore. This attempts to protect the environment above, but can be expensive and sometimes dangerous.



a b

Figure 4.15 Bauxite ore contains aluminium.

Figure 4.16 Australia's single largest deposit of bauxite is at Weipa in northern Queensland, an open-cut mine.

Figure 4.17 The Mt Isa mine in Queensland produces lead, zinc, copper and silver.

Figure 4.18 Transporting coal from the mine to the power station.

Check your learning 4.4

Remember and understand

1 What are fossil fuels? Give three examples.
2 What conditions are necessary for coal to form?
3 What does radioactive mean?
4 Why are minerals classified as non-renewable resources?

Apply and analyse

5 How is a nuclear power station different from a coal-fired power station? How are they similar?
6 What is the difference between a mineral and an ore?

Evaluate and create

7 Why do you think Australia has not turned to nuclear power yet?

4.5 Soil is one of our most valuable resources

Figure 4.19 Soil is a valuable resource.

Soil is one of our most valuable resources. It is made up of minerals, gases, liquids and living and dead **organisms**. It provides the essential nutrients for all plants. Lots of things come from our soil, including us! If we could take out all the water from our bodies, most of what's left has come from the soil via the food we've eaten. And where do we end up when we die? Even if you are cremated, the carbon dioxide gas released is taken up by plants, which release it into the soil when they die.

Most people think of soil as dirt, but good soil contains everything plants need to stay alive and grow. Without plants, many of our food sources would not exist. Pick up some soil – you will be holding your life in your hands.

Ingredients of soil

Soils are complex mixtures of several materials, including sand, silt, clay and **humus** (decomposed plants and animals), as well as various minerals that plants need for healthy growth. Soils are formed when weather breaks down rocks over extremely long periods of time. Sand, silt and clay are all valuable natural resources because they can be mixed for use in construction.

Soil for life

Good gardeners know what makes good soil and they add different things to the soil to improve it. They might add compost or animal manure to the soil to improve its organic content. They might add fertiliser, wetting agents or chemicals to change the soil structure. Gardeners also need to monitor the tiny organisms that live in the soil. Many organisms, such as worms, help keep the soil healthy.

Water-loving soil

Many Australians are frustrated by soils that don't let water soak in. How well a soil holds water plays a big part in how well plants will grow in that soil. Water drains easily through

Figure 4.20 Crops do best in soils that are carefully maintained.

Figure 4.21 Sand is one of the materials in concrete mix.

EXPERIMENT 4.5: WHAT IF DIFFERENT SOILS WERE EXPOSED TO WATER?
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Figure 4.22 Healthy soil grows healthy plants.

sandy soils, but sandy soils dry out easily. Heavy clay soils drain slowly, but if the water can't run off the clay becomes waterlogged and muddy.

Managing soils

Early European settlers used the land in very different ways to Indigenous Australians. The settlers cleared the forests and had large numbers of sheep and cattle grazing the grasslands. This meant there were few grasses and plants to absorb the rain. As a result, water stored underground (the water table) rose, bringing salt closer to the surface. In addition, much topsoil was compacted by animal hooves. Land clearing and grazing have caused significant **erosion**. Thankfully, many farmers now practise sustainable agriculture, and landcare groups help manage **land degradation**.

Figure 4.23 Additives are used to improve soil.

Figure 4.24 Many plants and trees cannot survive in soils that are high in salt.

Figure 4.25 Planting trees helps prevent further soil erosion.

Check your learning 4.5

Remember and understand

1 What are the basic components of soil?

2 How are soils formed?

Apply and analyse

3 How would your life be affected if there was no soil?

4 What are four things good gardeners might do to improve their soil?

Evaluate and create

5 Should a good soil drain water quickly or slowly? Explain your answer.

4.6 Our future depends on careful management of resources

We take many of our resources for granted, only thinking of them when they are in short supply. There are some people – scientists, engineers and others – who are very aware of the shortage of resources, and their jobs involve making the most of what is left. The key question we all need to ask is, do we have enough resources for our future?

Cars of the future

In Australia, **emissions** from cars are a major contributor to greenhouse gases. Most car companies have designed one or more LEVs (**low-emissions vehicles**). These cars have been available for the past few years and include hybrids, as well as very efficient petrol and diesel models. Cars with efficient engines use very little fuel. **Hybrids** use a mix of petrol and electricity.

The electric motor works with the petrol engine to reduce fuel consumption and emissions, but it does not eliminate them. Some cars, such as the Mitsubishi i-MiEV, are completely electric.

Figure 4.26 The Mitsubishi i-MiEV, Australia's first all-electric car.

New types of batteries have made electric vehicles a reality. Although these cars can only run a certain distance before they need to recharge, battery life is improving all the time.

Ethyl alcohol (also known as **ethanol**) has been added to some fuels for cars for many years. The ethanol is distilled from sugar cane in a way that is similar to the way in which alcoholic drinks are made.

Figure 4.27 Electric cars can be charged using a normal household power point.

CHALLENGE 4.6: RESOURCES FOR YOUR FUTURE
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Electricity of the future

BlueGen fuel cell units for houses are about the size of a dishwasher. They can generate electricity at up to three times the efficiency of current electricity systems. They significantly reduce greenhouse gas emissions and cut household energy bills. This is because they burn natural gas in an efficient closed system that collects both electricity and heat for use in the home. Each unit can produce up to 17 000 kilowatt hours of electricity per year. This is more than double the normal amount of electricity used in an average Australian home. The excess electricity generated by BlueGen can then be exported back to the electricity grid.

Figure 4.28 A BlueGen fuel cell unit.

Homes of the future

Scientists are collaborating with engineers and architects to make our homes smarter and more energy efficient. Homes of the future will have technology that switches off lights when the sun comes out, will be built from 'smart materials' (including paint that helps insulate the walls) and will have plants and solar panels on the roof. 'Smart plugs' will monitor electricity use of each appliance, and you may be able to get an alert at school or work if you have left your television on, allowing you to switch it off remotely. Rainwater tanks will be located under the eaves, meaning that the water can flow into toilets and laundry appliances using gravity, rather than a pump. Every external window and surface will have a role in the overall efficiency of the home, and surfaces will be designed to store heat during the day and release it at night. Homes will be smaller and will be designed to not only save energy, but also to generate energy.

Figure 4.29 Homes of the future will be designed to be 'smarter' and more energy efficient.

Check your learning 4.6

Remember and understand

1 What is a hybrid car?
2 Where does ethanol fuel come from?
3 Why are BlueGen fuel cells more efficient than other gas-burning devices?

Apply and analyse

4 Some people do an audit of all the energy they consume. Suggest a reason why a person might do an energy audit of their home.

Evaluate and create

5 Would it be practical for you to use an electric car in your area? Why or why not?

4.7 Green jobs will increase in the future

With the importance of renewable energy becoming widely acknowledged, more and more jobs in the 'green' sector are being created. There are many jobs and industries to choose from.

Adrian Morphett, Senior emissions auditor at Carbon Planet Australia

My typical day at work: I work with businesses to help them understand their environmental impacts and then come up with ideas to reduce their emissions. I go out to businesses and do energy audits, where I look for energy and greenhouse gas savings and then tell the business how to make the changes.

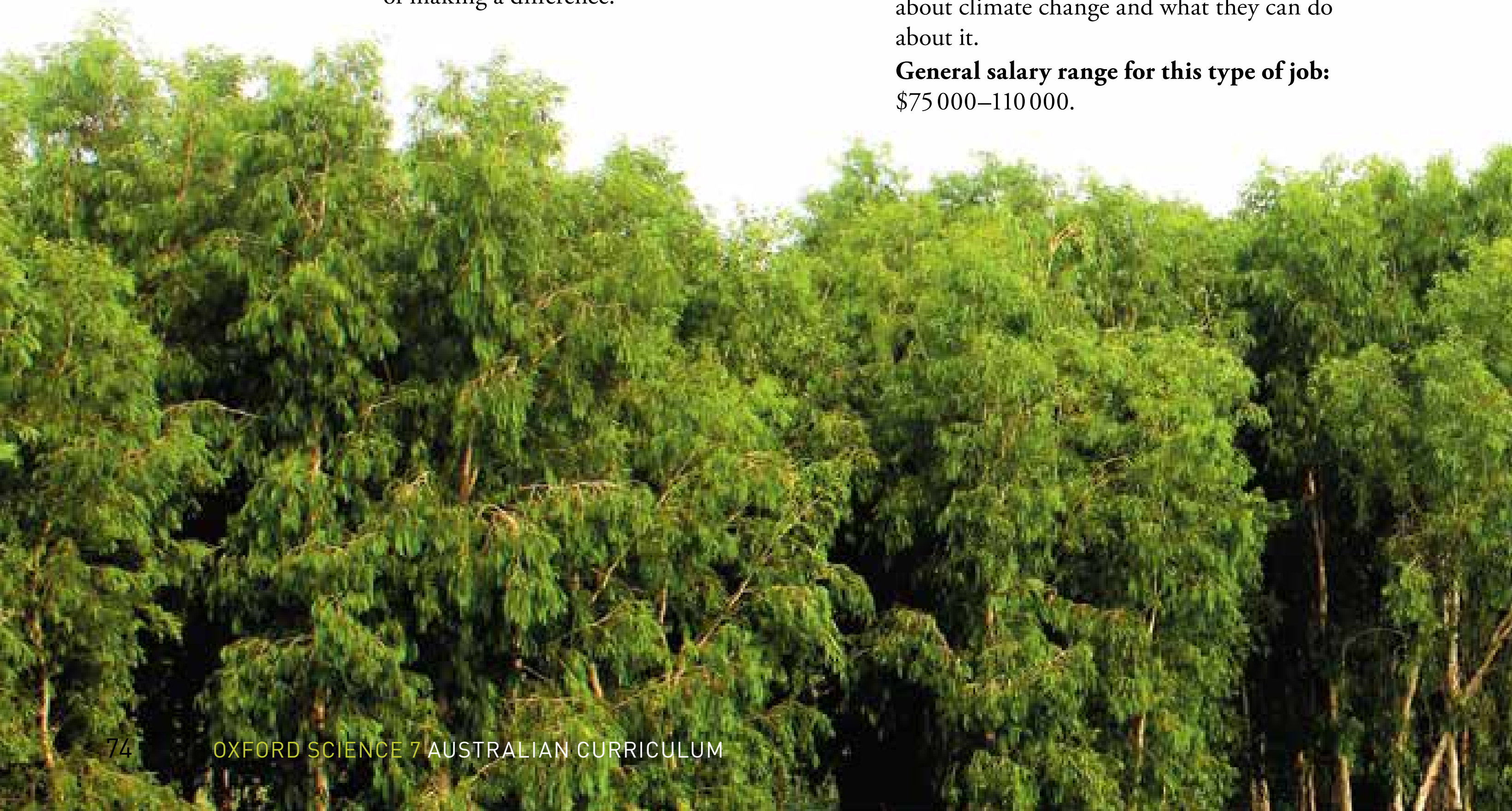
Why I love my job: Hopefully it makes a difference. This industry has to go well, and be smart, effective and help other businesses drive their emissions down if we are to have a chance of making a difference.

Worst thing about my job: The science of climate change is actually pretty scary, and the worst-case scenarios are frightening!

Skills, courses or training people need for this job: You need a degree in something like mechanical engineering. Good research skills are essential, and a good head for figures and data analysis skills are important. Good people skills are essential too.

Why my work and Carbon Planet's work are important: We are working towards reducing greenhouse gas emissions, informing businesses about climate change and what they can do about it.

General salary range for this type of job: $75 000–110 000.



Melissa Supangat, Environmental engineer at Earth Systems

My typical day at work: I write proposals on energy efficiency projects, usually for developing countries, calculate greenhouse gas emissions of specific sites and research new ways to reduce greenhouse gas emissions.

Why I love my job: I can help other people and companies to cut down their emissions by applying what I learnt in school.

Worst thing about my job: I encounter people who are still sceptical about global warming or who are reluctant to implement emissions reduction strategies because they may affect the money the organisation makes.

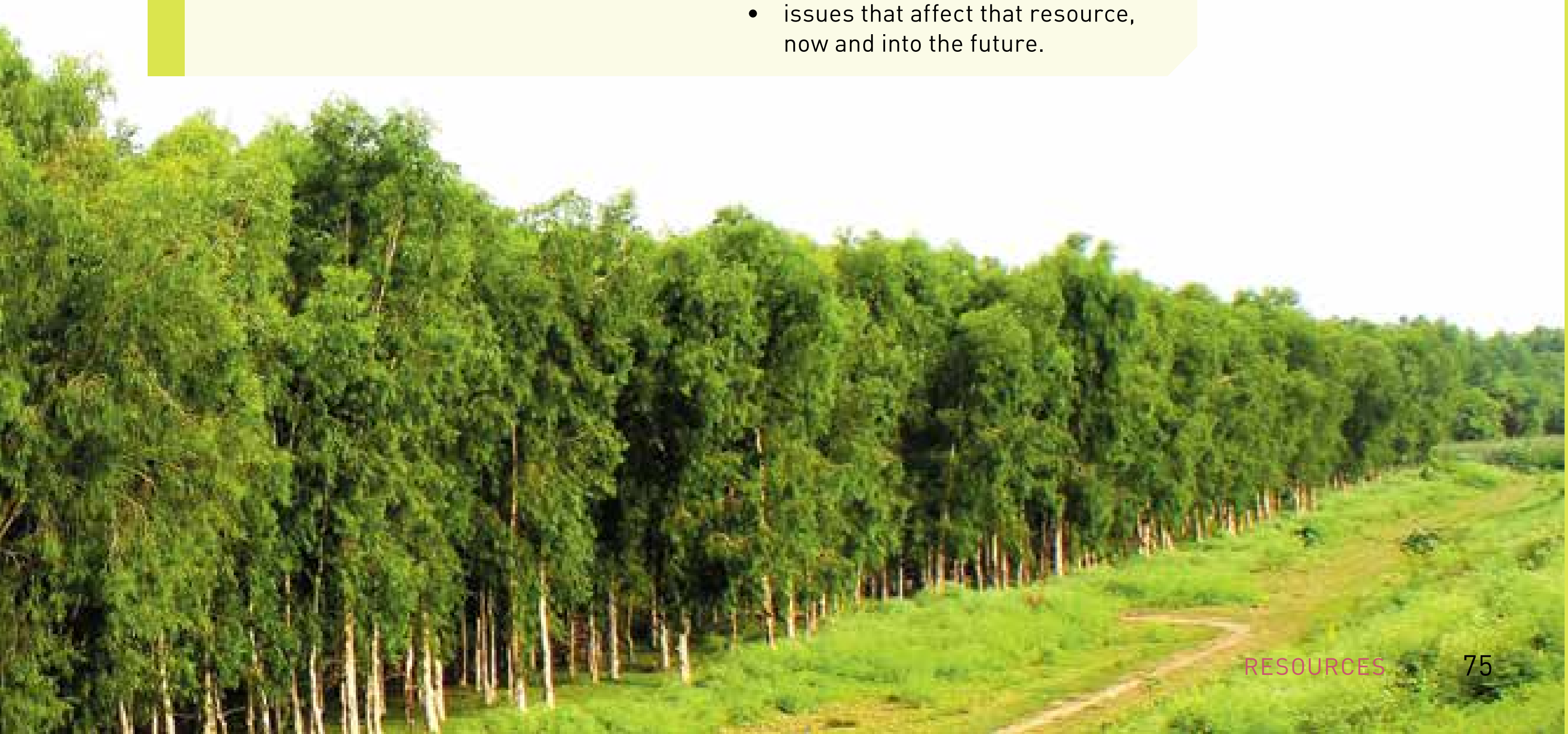
Skills, courses or training people need for this job: You need to study something like environmental science, environmental engineering or other areas of engineering (chemical, civil, mechanical, electronic and electrical).

Why my work and Earth Systems' work are important: We work with other countries, especially developing countries, that are most in need of education about global warming and ways to prevent it.

General salary range for this type of job: \$50 000–60 000 (for someone starting out).

Extend your understanding 4.7

1. Examine your local area. This might be within 10 kilometres of your home or further if necessary – you or your teacher will choose your distance. List all the natural resources you can locate. Identify what each is used for. Present your findings on a large map in the classroom where every student can contribute their research.
2. Focus on one resource from your list that really interests you. Develop a case study for that resource. A case study looks in detail at:
   - the history of the resource
   - how it is extracted or used
   - what humans use it for
   - the impact on the environment of developing that resource
   - issues that affect that resource, now and into the future.



*REVIEW

4

Remember and understand

1 What is the difference between renewable and non-renewable energy sources?

2 Give two examples each of:

a renewable resources

b non-renewable resources

3 Examine Figure 4.3 on page 65. Locate a resource that is close to your area. What type of resource is it? What would this resource be used for?

4 Describe three different uses of energy.

5 What is a generator?

6 How is coal used to generate electricity?

7 Give a definition of geothermal energy.

8 What factors can affect the amount of electricity generated by a solar panel?

9 What are the advantages and disadvantages of using uranium as an energy resource?

Apply and analyse

10 What advantages and disadvantages do electric vehicles have over petrol-driven cars?

11 What is wind farming? Are there any disadvantages to this method of energy production?

12 Suggest one reason why it is important for soil to be 'water-loving'.

13 What is the difference between a mineral and an ore?

14 How does clearing plants from soil cause salt to come to the surface? Why is this a problem?

Evaluate and create

15 Why are coal, oil and gas described as fossil fuels?

16 If coal is so widely used for generating electricity, why are some people concerned about building new coal-fired power stations?

17 Is a hybrid car a low-emissions vehicle or a zero-emissions vehicle? Explain your answer.

18 Coal is considered to be a non-renewable fossil fuel. Is this really true? Explain in relation to the changes that are required for coal to form.

19 Produce an A4 fact sheet with a diagram of your own electricity company (give it a name), describing how electricity is produced at your power station. Justify your choices.

20 Write a letter to the Federal Minister for Resources, Energy and Tourism, suggesting changes you would like to see happen in Australia. In your letter, include evidence that you know the current sources being used and have an understanding of the advantages and disadvantages of all options. You might like to prepare a renewable energy plan for Australia and explain how your plan will be more sustainable than current uses of our country's energy sources.

Ethical behaviour

21 What is Greenpeace's attitude towards coal and nuclear power? What alternatives do they support for Australia?

22 Do you think nuclear power will be used in Australia in the future? Explain.

23 Passenger cars, like those your parents drive, are responsible for a significant amount of the population's energy consumption. Should people consider walking, cycling or taking public transport to reduce their energy consumption? What issues might they consider?

Research

Choose one of the following topics to research. Some questions have been included to get you started. An important part of your report must be to include references to the 'big picture', thinking about how your topic relates to the entire planet.

A simple pencil

Examine a normal wooden pencil and determine all its component parts, including the lettering on the side. You may even want to dismantle the pencil and isolate each part. Next, think of all the steps needed to make the pencil. What are the components made of? Where would all the components have come from? What resources are needed to make the components? What resources are needed to assemble and finish the pencil in the factory? Present your research in a creative way.

Clean coal

Is there such a thing as 'clean' coal? Why does coal need to be cleaned? Does clean coal exist now or is it still in the future? Is it costly? Find out about this technology and how it applies to Australia.

Trapping carbon

The use of fossil fuels causes the release of carbon dioxide into the atmosphere. This has been linked to the gradual increase in global temperatures. Many countries are now finding ways to trap the carbon dioxide and store it in a less destructive way. How are Australia and other countries encouraging industry to use less fossil fuels? Describe one way that carbon can be trapped and stored. Which countries are using this method of trapping carbon?

*KEY WORDS

4

coal
fossil fuel formed from the remains of trees and plants that grew about 300 million years ago

emissions
the production and release of something (e.g. gas)

energy resources
resources that can be used for the production of energy

ethanol
a type of alcohol that can be used for fuel

fossil fuels
non-renewable energy source formed from plant and animal matter

generator
converts the energy from the movement of a turbine, for example, into electrical energy

geothermal energy
energy that comes from heat beneath the Earth's surface

greenhouse gas
a gas (carbon dioxide, water vapour, methane) in the atmosphere that can absorb heat

hot dry rock geothermal energy
a method of pumping water into deep hot rocks in the ground in order to get steam, which is then used to drive a turbine to provide electricity

humus
decomposed plants and animals

hybrids
cars that use a mix of petrol and electricity

hydroelectric energy
energy produced by falling water that turns turbines to generate electricity

land degradation
the process of using up or removing the resources of land (e.g. water, topsoil, plants)

low-emissions vehicles
cars or buses that release very little exhaust gases, including carbon dioxide

minerals
tiny grains or crystals that are the building blocks of rocks

non-renewable
resources that are limited because, once used, they take a long time to replace

ores
materials that contain useful amounts of minerals mixed with other substances

power station
place where energy is converted to electricity

renewable
resources that are made naturally and are available in an almost unlimited amount

solar cells
convert sunlight into electrical energy

solar power
energy from the Sun

tidal energy
energy produced using the tides to drive turbines in the water

turbine
a large wheel with angled sections called vanes, like a propeller, that is used to generate electricity

wave energy
energy produced using the power of waves to drive air turbines

wind farms
a large group of wind turbines in the same location

wind turbines
a wheel with blades that turn in the wind

CLASSIFICATION 5

5.1 Classification organises our world

5.2 Living organisms have characteristics in common

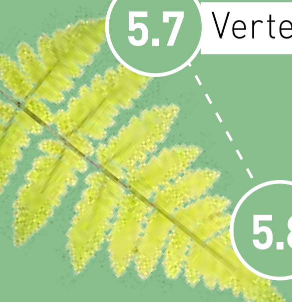
5.3 Classification keys are visual tools

5.4 The classification system continues to change

5.5 All organisms can be divided into five Kingdoms

5.6 Animals that have no skeleton are called Invertebrates

5.7 Vertebrates can be organised into five Classes



5.8 Plants can be classified according to their characteristics

5.9 The first Australian scientists classified their environment

What if?

Identifying animals

What you need:

paper, pencil

What to do:

1 Work in pairs. Describe an animal to your partner – without using the animal's name. Can your partner draw the animal you describe.

2 Now draw an animal while your partner tries to guess what it is. How quickly did they guess your animal?

What if?

» What if you had code words that described several features of an animal at once? For example 'mammal' could mean four limbs, covered in fur and feeds their baby with milk. How would this affect the way you communicate?

5.1 Classification organises our world

Early scientists did not have photography or computers to record and catalogue images of the curious new plants and animals they discovered. Instead, they needed to rely on hand-drawn pictures and worded descriptions. Classification systems were developed to help scientists communicate with each other despite their different locations and languages.

Figure 5.1 The mature pine tree looks very different from its sapling.

Early classification methods

Early humans first classified plants by learning which plants were edible and which were poisonous. A new plant or animal discovered by humans was (and still is) studied and put into a group. Some plants were found to help sick people and others were poisonous. Some animals could produce food (e.g. milk and eggs). Each generation of scientists worked to improve how these groups were classified.

Common names or scientific names

Scientists try to communicate with each other regularly to help with their research. Before the existence of photographs or computers, scientists would have to draw creatures, for example birds, by hand and describe them in as much detail as they could. This was difficult, as the photographs of the American magpie and the Australian magpie (Figure 5.2) show. Both birds look so similar they have been given the same common name, 'magpie'. However, their scientific names are different. The name *Cracticus tibicen* for the Australian magpie means the same to scientists in every country around the world.

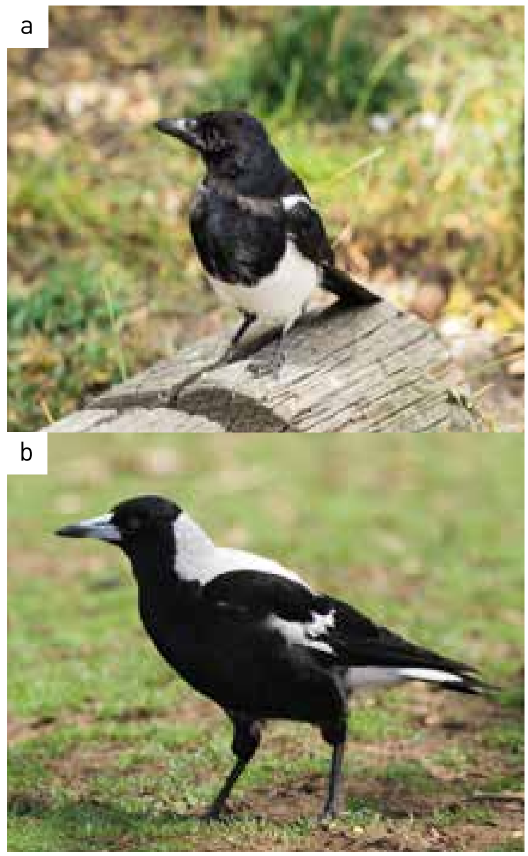


Figure 5.2 The American magpie *Pica hudsonia* (top) and the Australian magpie *Cracticus tibicen* (bottom).

Aristotle (384–322 BCE) sent his students out to gather local samples and stories. He ordered the samples and stories from least important (rocks) to the most important (wild animals, men, kings, fallen angels, angels and God).

Andrea Caesalpino (1519–1603) suggested classifying plants into groups according to their trunks and fruits.

John Ray (1627–1705) suggested that organisms needed to be observed over the whole of their lifespans.

Augustus Quirinus Rivinus (1652–1723) and Joseph Pitton de Tournefort (1656–1708) suggested using a hierarchy of names. Each organism had a long Latin name that described the characteristics of each level of the hierarchy.

CHALLENGE 5.1: DEPARTMENT STORE CLASSIFICATION
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The Linnaean classification system

The Greek philosopher Aristotle (384–322 BC) was the first scientist to start using systems to describe plants and animals. By the 17th century the early classification systems used a hierarchy of names, starting with large general groups (e.g. plants, animals) and making subsequent groups smaller and smaller depending on their characteristics. Each organism ended up with a long Latin name that described the characteristics of each level of the hierarchy. Carl Linnaeus (1707–1778) tried these classification systems but found their descriptions to be too long. He decided a simpler system was needed. He changed the descriptions to single words and reduced the number of classification groups to seven.

Finding new species

Small groups of scientists are trying to find undiscovered plants in Brazilian rainforests before they are destroyed by logging and farming. Often the scientists are supported by large pharmaceutical companies from other countries. Why would companies on the other side of the world be interested in saving plants and animals in the rainforest? One reason is that we may one day need these undiscovered organisms. Many of the medications we currently use come from organisms. The antibiotic penicillin was discovered from a type of mould; aspirin comes from a substance in the bark of willow trees. The next painkiller could come from a small fungus in the rainforest or from an insect that relies on the fungus for food.


CAROLI LINNÆI
I QUADRUPEDIA
II AVES
III AMPHIBIA
PARADOXA

Figure 5.3 Part of Linnaeus's classification system.

Check your learning 5.1

Remember and understand

1 Why did Carl Linnaeus simplify the classification system used by previous scientists?

2 Give two reasons scientists still classify organisms today.

Analyse and apply

3 Why would it be difficult to classify frogs and tadpoles using the early methods of classification?

Evaluate and create

4 The earliest scientists did not have pens or paper. How would they have passed on the information they received? How accurate would it have been?

5 Aristotle was one of the first scientists to try to gather information from wide regions. What method might he have used to tell the differences between a horse and a fly?

Figure 5.4 The rainforests of Brazil contain many undiscovered plant species.

Figure 5.5 Carl Linnaeus.

Carl Linnaeus (1707–1778) introduced the Linnaean classification system.

Carl Woese (1990) suggested that the bacterial kingdom Monera be split into two domains, and the third domain contain all other organisms.

Thomas Cavalier-Smith (1998) suggested the kingdom Plantae be split into two kingdoms because of differences in their cells.

5.2 Living organisms have characteristics in common

Biology is the study of living organisms and what it means to be alive. Both plants and animals are considered to be alive. They share many characteristics that apply only to organisms.

Figure 5.6 Living things move. Sunflowers turn to follow the sun as it moves across the sky.

Characteristics of living things

It has taken many years of observation and discussion for scientists to develop eight characteristics that all living things – plants, animals and even microorganisms such as bacteria – have in common. To remember all eight characteristics, just remember MR N GREWW.

M Living things can MOVE by themselves

Animal movements are easy to see. But do plants move? Look at the leaves on an indoor plant – they usually face the window (a source of light). Turn the plant around so that the leaves face into a darker part of the room. In a few days, the leaves will again be facing the window. The leaves have moved by themselves. Sunflowers turn their heads to follow the sun as it moves across the sky each day.

R Living things can REPRODUCE

Living things can make new individuals that grow up to look like them. Animals mate and produce offspring, plants produce seeds that grow into new plants, and bacteria divide to produce more bacteria. **Reproduction** is the process by which living things make new life.

N Living things need NUTRITION

All living things need nutrients to survive. Animals obtain most of their nutrients by eating food and drinking. Plants absorb nutrients through their roots and fungi feed on decaying organisms. Plants are **autotrophs**, which means that they make their own food. Animals and fungi are **heterotrophs** – they rely on other living things for food.

G Living things GROW as they get older

All living things grow during their lives. Mushrooms start off as tiny spores. Humans are born as babies and develop into children, teenagers and then adults. Insects hatch from eggs as larvae, then metamorphose into adult insects. In every case, living things, when fully grown, resemble their parents.

Figure 5.7 Living things reproduce.

Figure 5.8 Living things need nutrients to survive.

Figure 5.9 Living things grow during their lives. These larvae will grow into mosquitoes.

Figure 5.10 Living things respond to change.

R Living things RESPOND to change

When an animal realises it is being chased, like the antelope in Figure 5.10, it runs. It is responding to stimuli (the sight and sound of a charging predator) or to changes in its environment (the sudden brush of leaves or movement of shadows). The sunflowers shown in Figure 5.6 are responding to the changing stimuli of light and warmth.

E Living things EXCHANGE GASES with their environment

Plants and animals have organs and structures that allow them to exchange oxygen and other gases. Some animals, such as humans, use their lungs to inhale and then exhale. Other animals, such as fish and the axolotl (Figure 5.11), have gills. Some animals, such as worms, breathe through their skin.

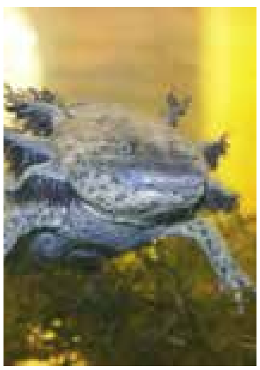

Figure 5.11 The axolotl has gills to exchange gases with its environment.

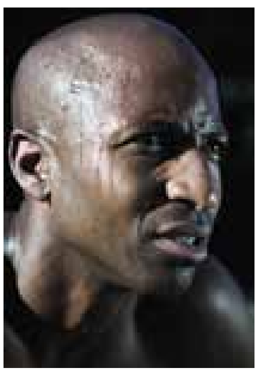

Figure 5.12 Sweating is one way humans get rid of waste products from their bodies.

W Living things produce WASTES

We, like other animals, take in food, water and air to fuel our bodies. Chemical reactions occur in our bodies and wastes are produced as a result. We get rid of these wastes by exhaling, sweating, urinating and defecating (emptying our bowels). Plants get rid of their wastes through their leaves.

W Living things require WATER

All living things need water; it is required for many jobs. For example, it transports substances in our bodies to where they are needed and it is involved in many important chemical reactions that must take place. In animals such as humans, water helps maintain body temperature. No wonder a large proportion of our body is water!

Non-living or dead?

Something classified as **living** needs nutrition and water, and is able to move by itself, reproduce, exchange gases, grow, respond to stimuli and produce wastes.

If something doesn't have these characteristics, it would seem logical to assume that the thing is **non-living**. But, what about something that is dead? Something **dead**, such as a dried flower or an Egyptian mummy, was once living; when it was alive it *did* have the characteristics of a living thing. Something that is **non-living**, such as a computer or your watch, has *never* had these characteristics.

Check your learning 5.2

Remember and understand

1 The system scientists' use to group things divides them first into two groups. What are the two groups?

Apply and analyse

2 Consider the things listed below.
Eucalypt tree, water, paper, robot, leather belt, wombat, roast chicken, chair
  a With a partner or by yourself, decide whether each of the items meets the requirement to be classified as a living thing.
  b Decide whether each should be classified as living or non-living.

3 Are any of the items listed in question 2 dead? Explain your answer.

Evaluate and create

4 Use the characteristics of a living thing to describe a bushfire.

5 Is a bushfire alive? Explain your answer.

Figure 5.13 The human body uses water for many jobs, including maintaining body temperature.

5.3 Classification keys are visual tools

A **key** is a visual tool used in the classification of organisms. A key is often more useful than a list of characteristics and similarities of each group. A **branched key** (it looks like a tree) helps us see how a particular member of the group fits in with all the rest. When you visit an outdoor market, you may wander around for some time before you find what you want. A department store is more organised, with similar items grouped together. Scientists use a system similar to this to sort things into groups, or **classify** them. The system makes the names and descriptions of organisms easier to find.

Figure 5.14 Dr Redback's family.

Using dichotomous keys

One common type of key is called the **dichotomous key** (pronounced 'dye-COT-o-muss') because the branches always split into two (*di* = 'two'). Scientists use this type of key to make simple 'yes' or 'no' decisions at each branch. For example, does the animal have fur (yes/no)? Does it have scales (yes/no)? Each answer leads to another branch and another question. This key only works if the animal has already been identified by someone else. A newly discovered organism would need to be studied first and then new branches added to an existing key.

Dr Redback's family

Dr Redback loved to send out Christmas cards with a family photo on the front. One year, just for fun, he included two dichotomous keys to help everyone identify all his family and pets.

Use the picture of Dr Redback's family and one of the dichotomous keys provided (Figure 5.15) to work out who is who.

Tabular keys

If a scientist is going out into the bush to study plants and animals, a large drawing like the one on the left in Figure 5.15 may not be useful. Instead, a field guide or tabular key, such as that shown on the right of Figure 5.15, can be used. This is used in the same way as the diagram version. Two choices are offered at each stage. When a decision is made, the scientist is led to the next characteristic choice.

CHALLENGE 5.3: DICHOTOMOUS KEY
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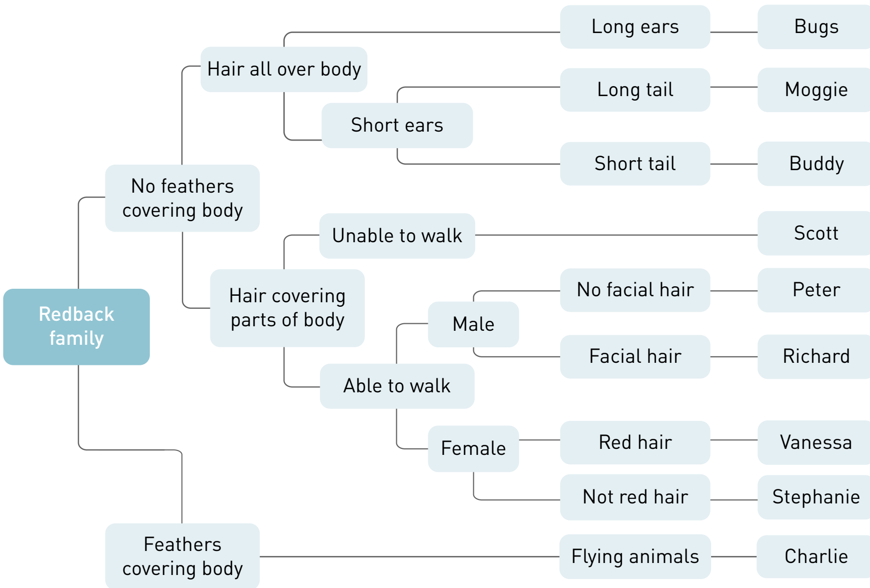

1	No feathers covering body	Go to 2
	Feathers covering body	Go to 9
2	Hair all over body	Go to 3
	Hair covering parts of body	Go to 4
3	Short ears	Go to 5
	Long ears	Bugs
4	Unable to walk	Scott
	Able to walk	Go to 6
5	Long tail	Moggie
	Short tail	Buddy
6	Male	Go to 8
	Female	Go to 7
7	Red hair	Vanessa
	Not red hair	Stephanie
8	No facial hair	Peter
	Facial hair	Richard
9	Flying animals	Charlie

Figure 5.15 Dichotomous keys for Dr Redback's family. The key on the right is the tabular key for the diagram on the left.

Check your learning 5.3

Remember and understand

1 What is a dichotomous key?
2 Why is it called 'dichotomous'?
3 What does the term 'classifying' mean?

Apply and analyse

4 Which of the following descriptions would be good to use to classify a group of birds in a dichotomous key? Give a reason why each one is or is not a good method of classification.
   a is eating bird seed
   b has a blue stripe above the eye
   d has a broken leg
   e is sitting on the ground

Evaluate and create

5 Draw a key that could be used to identify laboratory equipment. Include these items: tripod stand, Bunsen burner, gauze mat, 50 mL beaker, 150 mL beaker, 100 mL measuring cylinder, 10 mL measuring cylinder, 500 mL beaker, 500 mL measuring cylinder, retort stand, clamp.
6 Use the dichotomous key in Figure 5.16 to help with the following tasks.
   a Identify and name the four beetles in Figure 5.17.
   b Draw a simple sketch of the following:
      i frope beetle   ii gring beetle
      iii gripe beetle   iv frong beetle

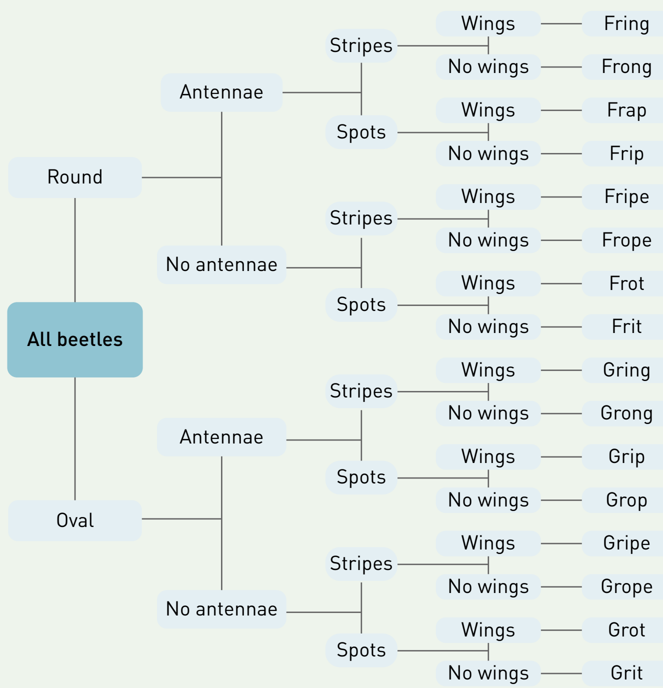

Figure 5.16 A dichotomous key to help identify 16 different types of beetle.

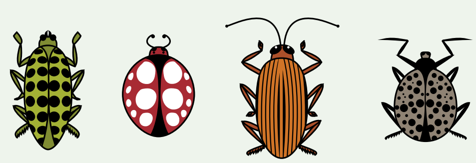

Figure 5.17

5.4 The classification system continues to change

Deciding to use an enormous dichotomous key to classify every living thing was largely the work of a man named Carl Linnaeus (1707–1778). His system of classification, called the **Linnaean taxonomy**, is still used today.

Giving organisms a precise name

When trying find your house on Google Earth, you first find Australia, then the state you live in. Each time you narrow your search closer to your town, your suburb, your street until you finally find your house.

The Linnaean dichotomous key for all living things works in a similar way. It starts with large groups called **kingdoms**, and then divides into smaller groups called phyla. Each phylum has several classes. The classes have orders, and so on. There are seven different levels to get to the final name of each organism. They are *kingdom*, *phylum*, *class*, *order*, *family*, *genus*, *species*. (Tip: Some people use the following mnemonic to remember the Linnaean system: '**K**ing **P**hillip **C**rawled **O**ver **F**our **G**ooey **S**nails'.)

KINGDOM: Animalia
e.g. insect, fish, bird, lizard, kangaroo, fox, lion, jungle cat, domestic cat

PHYLUM: Chordata
e.g. fish, bird, lizard, kangaroo, fox, lion, jungle cat, domestic cat

CLASS: Mammalia
e.g. kangaroo, fox, lion, jungle cat, domestic cat

ORDER: Carnivora
e.g. fox, lion, jungle cat, domestic cat

FAMILY: Felidae
e.g. lion, jungle cat, domestic cat

GENUS: *Felis*
e.g. jungle cat, domestic cat

SPECIES: *catus*
domestic cat

Figure 5.18 The Linnaean classification system uses seven different levels. It is used to give names to living things such as the domestic cat, Felis catus.

Linnaeus's double-name system

Have you eaten a *Musa sapientum* lately or have they been too expensive to buy? And did you pat your *Canis familiaris* this morning? These are the kinds of double names given to every living thing using the Linnaean classification system.

Our homes can easily be found by using only the two smallest groups in an address (the street and the suburb). The information about the bigger groups, like the Earth and the country, is not really necessary. In much the same way, an organism can also be named from the two last groupings on the Linnaean dichotomous key, the *genus* and the *species*.

In the double-name (or **binomial**) system, the **genus** group name always starts with a capital letter. The second word is the species name and it does not have a capital letter. The double name is always written using italics (sloping letters).

Figure 5.19 *Musa sapientum* is the Linnaean name for a banana.

CHALLENGE 5.4: CAN YOU UNDERSTAND SCIENTIFIC NAMES?
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A **species** is a group of organisms that look similar to each other. When they breed in natural conditions, their offspring are fertile (in other words, they can also breed). Domestic cats belong to the one species because they can breed together and have kittens.

The changing face of science

After 250 years, scientists are still testing and modifying the Linnaean classification system. The development of microscopes led to the discovery of single-celled organisms (bacteria). This led to the number of kingdoms increasing from three (plants, animals and minerals) to the current five (Plantae, Animalia, Fungi, Protista and Monera). In the 1970s, a group of organisms previously thought to be bacteria was discovered to be something else: single-celled organisms that could live in extreme conditions, such as very salty or hot waters. The genetic material (DNA) of these organisms was different from that of other bacteria. This led to the suggestion that a sixth kingdom, Archaea, was needed. Scientists are currently testing this idea and comparing it with a whole new system that comes before kingdoms.

The 'three domain system' was first suggested in 1990. This system suggests one super domain, Eukaryota, for the plants, animals, protists and fungi. The single-celled organisms in Kingdom Monera would then be split into two domains according to their genetic material.

a

b

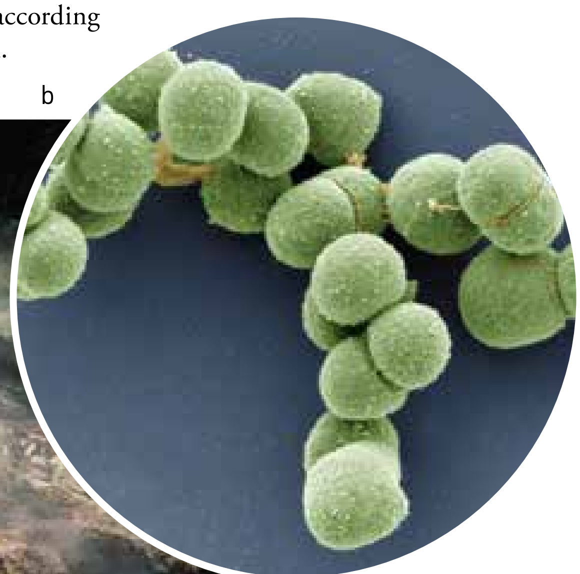

Figure 5.20 (a) Biologist collecting Archaea samples in the hot springs of the Obsidian Pool in Yellowstone National Park, USA. (b) A magnified view of a clump of Archaean organisms.

Check your learning 5.4

Remember and understand

1. Who invented the naming system that is still used today to name living things?
2. What are the seven groups that living things are divided into? Write them in order from largest to smallest level of organisation.
3. How do you know if two organisms are the same species?

Apply and analyse

4. Select three species of animal. For each animal:
   a. describe its appearance
   b. give its common and scientific names.

Evaluate and create

5. How has an understanding of genetic material changed classification?

5.5 All organisms can be divided into five Kingdoms

Taxonomists have been classifying all living things into five kingdoms for over 250 years. The comparison of genetic material may cause changes to this system in the future. That is the very nature of science – to change and develop as new evidence becomes available.

Figure 5.21 Simple animal (top), plant (middle) and bacterial (bottom) cells.

Building blocks of life

Cells are often called the building blocks of life. Think of the way bricks are used to build a house. Cells build living things in a similar way. However, there are usually many more cells in living things than bricks in a house. Any living thing with more than one cell is **multicellular**. Many living things, such as bacteria, consist of only one cell. These are single-celled or **unicellular** organisms.

Parts of a cell

Taxonomists ask three questions when they are trying to classify the cells of an organism.

1 Does the cell keep all its genetic material (called DNA) inside a **nucleus**? The nucleus protects the DNA that carries all the instructions for staying alive.

2 Does the cell have a **cell wall** around it for extra support?

3 Does the cell use sunlight to make its own nutrients (autotroph)? Plant cells can do this, but fungi (like mushrooms) need to absorb their nutrients from other living things (heterotroph).

It is the correct combination of these three features that help divide all living things into the first big group called kingdoms.

Kingdom Animalia

All organisms in this kingdom are multicellular. Each cell stores its genetic material in a nucleus but doesn't have a cell wall. Animals gain energy from other living things. We belong in this kingdom. **Zoologists** are the scientists who study animals.

Kingdom Plantae

Plants include trees, vines, bushes, ferns, mosses, weeds and grasses. They all gain energy by making their own food from sunlight

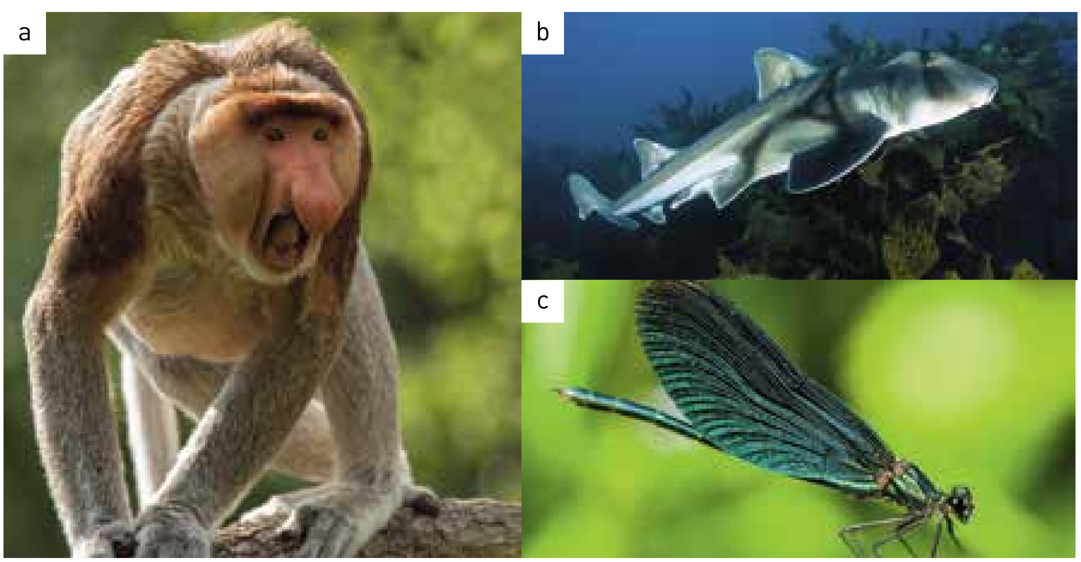

Figure 5.22 Kingdom Animalia: (a) the proboscis monkey (*Nasalis larvatus*), which has the biggest nose; (b) the Port Jackson shark; and (c) the damselfly.

CHALLENGE 5.5: CLASSIFYING LIVING THINGS
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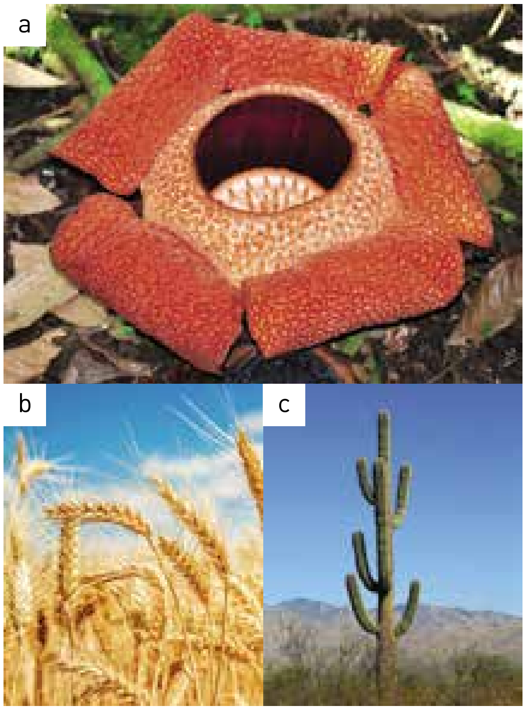

Figure 5.23 Kingdom Plantae. (a) The smelliest plant, the *Rafflesia*, is found in South-East Asia. Its flower can measure up to 90 centimetres across and weigh about 11 kilograms. It gives off a rotten meat odour when it blossoms to attract insects (b) Wheat. (c) Cactus.

(autotrophs). They are multicellular and their cells have a cell wall around the outside of the cell, as well as a nucleus inside the cell. **Botanists** are the scientists who study the plant kingdom.

Kingdom Fungi

Kingdom Fungi includes mushrooms, toadstools, yeasts, puffballs, moulds and truffles. Some fungi grow in wood and in soil, and develop from tiny spores. Fungi store their genetic material in a nucleus and do not make their own food. Instead, they feed on the remains of dead animals and plants. Some fungi can cause diseases, such as tinea (athlete's foot). **Mycologists** are the scientists who study Kingdom Fungi.

Kingdom Monera

This kingdom is made up of the simplest and smallest living things. There are approximately 75 000 different organisms in Kingdom Monera and they are all unicellular and have a cell wall but no nucleus. **Bacteria** are the most

Figure 5.24 Kingdom Fungi: (a) mushrooms; (b) mould.

common in this kingdom. Many people think of bacteria as harmful to humans, but this is not always true. Bacteria in the soil break down rubbish and wastes produced by animals (especially us). Without bacteria, we would be surrounded by mountains of smelly rubbish. Bacteria have been put to use by humans to make food, such as cheese and yoghurt.

Microbiologists are the scientists who study microorganisms in Kingdoms Monera and Protista.

Kingdom Protista

There are approximately 55 000 species of protists. Their cell structure is more complex than that of the Monera. Often, organisms that don't fit into any other kingdom will belong in Protista. They may range in size from single-celled organisms to much larger ones, like kelp (seaweed). They do all have one feature in common: they store their genetic material in a nucleus. **Plankton**, the tiny sea creatures eaten in their millions by whales, are part of this kingdom. **Amoeba**, microscopic organisms that change their shape to trap their food, also belong to this group.

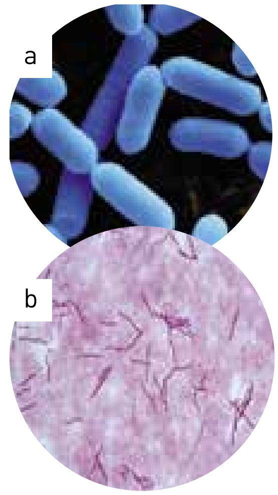

Figure 5.25 Kingdom Monera, as seen under a microscope: (a) *Lactobacillus casei*; and (b) *Spirillum volutans*.

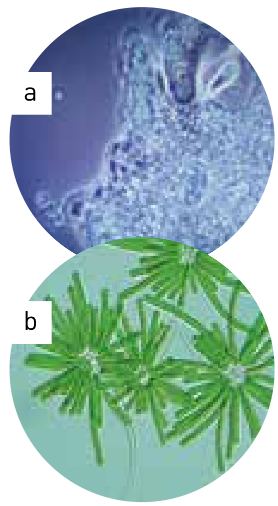

Figure 5.26 Kingdom Protista, as seen under a microscope: (a) amoeba; and (b) *Giardia lamblia*.

Check your learning 5.5

Remember and understand

1 Name four features that all animals have in common.
2 Name four features of Kingdom Fungi.
3 Name an organism made up of just one cell.

Apply and analyse

4 How is a protist different from a bacterium?
5 What is the difference between cells in Kingdom Plantae and Kingdom Fungi?

Evaluate and create

6 Why was the invention of the microscope important to our understanding of living things?

5.6 Animals that have no skeleton are called invertebrates

Kingdom Animalia contains approximately 35 phyla. Most commonly scientists break them into two main groups: vertebrates and invertebrates.

Figure 5.27 The giant squid is an invertebrate.

Internal or external skeleton?

In the same way as when creating any kind of dichotomous key, dividing the animal kingdom into groups first requires a question. The system scientists use to divide animals into groups is based on their structure. The question is, 'Does this animal have an internal or external skeleton?'

Animals such as cats, humans and birds with an internal skeleton (called an **endoskeleton**) are put in a group called **vertebrates**. Because these animals often have a spinal cord that threads its way along the vertebrate bones, the phylum is called Chordata. Other animals with an external skeleton (**exoskeleton**), such as beetles and crabs, and those with no skeleton at all, such as slugs, are known as **invertebrates**. Invertebrates dominate the animal kingdom.

Invertebrates

There are many more invertebrates on the Earth than vertebrates: 96% of all animals are invertebrates. Invertebrates have either an external skeleton (exoskeleton) or no skeleton at all. As well as enormous animals such as the giant squid, thousands of tiny insects and other creatures belong to the invertebrate group.

Identifying invertebrates

In the same way that vertebrates are classified, invertebrates are grouped into six main groups of phyla on the basis of their characteristics. Characteristics used to classify invertebrates include the presence of a shell or hard cover, tentacles or spiny skin. Organisms with similar features are placed in the same group. The dichotomous tabular key in Table 5.1 can be used to place an organism in a particular phylum.

Table 5.1 Tabular key for identifying invertebrates

1	Body spongy, with many holes	**Poriferan**
	Body not spongy	Go to 2
2	Soft body, no shell	Go to 3
	Outside shell or hard cover	Go to 6
3	Many tentacles or arms	Go to 4
	Long body without tentacles	Go to 5
4	Tentacles around the mouth of a sac-like body	**Cnidarian**
	Arms with suction discs	**Mollusc**
5	Soft body, large foot	**Mollusc**
	Worm-like or leaf-like	**Nematode, platyhelminth or annelid**
6	Proper shell or smooth, hard covering	Go to 7
	Spiny skin with rough covering	**Echinoderm**
7	Limbs in pairs	**Arthropod**
	Shell, no segments, large foot	**Mollusc**

EXPERIMENT 5.6: DISSECTING SKELETONS
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CHALLENGE 5.6: IDENTIFYING INVERTEBRATES
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Arthropods

- segmented bodies
- paired and jointed legs
- exoskeleton

Examples: insect, spider, centipede, scorpion

Poriferans

- spongy body with holes
- found in water, attached to rocks

Examples: breadcrumb sponge, glass sponge

Molluscs

- soft body
- usually have a protective shell

Examples: snail, octopus, oyster

Cnidarians

- soft, hollow body
- live in water
- tentacles

Examples: coral, sea jelly, anemone

Nematodes, platyhelminths and annelids

- soft, long body
- can be segmented, flat or round

Examples: leech, tapeworm, flatworm

Echinoderms

- rough, spiny skin
- arms radiate from centre of body
- found in the sea

Examples: sea urchin, sea cucumber, brittle star

Figure 5.28 Some commonly found invertebrate phyla.

Check your learning 5.6

Remember and understand

1 Animals are divided into two main groups.
   a What are the names of the groups?
   b What do the names of these two groups mean?

2 What percentage of animals are invertebrates?

3 Give two examples of animals with an exoskeleton.

4 Give two examples of animals with no skeleton at all.

Apply and analyse

5 Beetles have segmented bodies and jointed legs. To which phylum do they belong?

Evaluate and create

6 Eighty per cent of animals on the Earth are arthropods.
   a Which characteristic does their name refer to? (Hint: 'arthritis' and 'podiatrist')
   b Draw three different arthropods and label the features that make them part of this phylum.

5.7 Vertebrates can be organised into five Classes

Vertebrates are animals with a spine or backbone. Vertebrates as a group can be broken down into further subgroups called classes based on their body covering, how their young are born, and their body temperature. Vertebrates either have a constant body temperature (**endotherm**) or a body temperature that changes with the environment (**ectotherm**).

Class Mammalia

Mammalia is a class of vertebrates well known to many people. Many of our pets belong to this class: horses, dogs, cats, rabbits, guinea pigs and mice. We belong to this class too.

Mammals are animals with hair or fur and they have a constant body temperature. Female mammals give birth to live young and feed their young with their own milk.

Class Mammalia can be further broken down into three subgroups, as shown in Figure 5.29. The main feature used to separate mammals is the way in which their young develop.

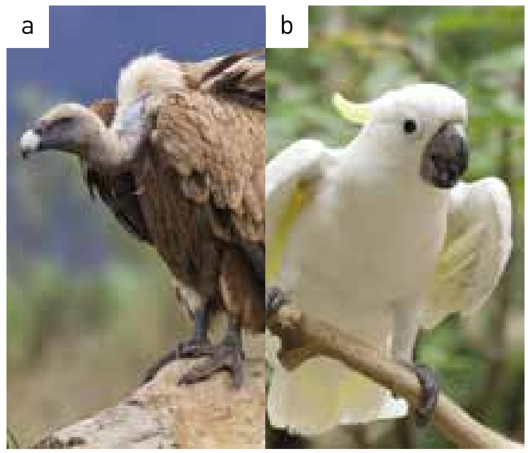

Figure 5.30 Class Aves: (a) a vulture; and (b) a cockatoo.

Class Aves

All birds in Phylum Chordata belong in this class. Like mammals, they are endotherms (having a constant body temperature). Two of their main distinguishing characteristics (the way they differ from the other classes) are their covering of feathers and their scaly legs. All animals in this class lay eggs with a hard shell.

Figure 5.29 The three subgroups of mammals: monotremes, marsupials and placentals.

Class Reptilia

The skin of reptiles, such as snakes and lizards, is usually covered in a layer of fine scales. Reptiles use lungs to breathe, even if they live under water (sea snakes). These animals are ectotherms – we do not use the term 'cold-blooded' to describe these animals because a lizard that has been lying in the sun has very warm blood, even though at night its blood is cool.

Turtles also belong to this class. Many people become confused by the hard outer shell of turtles and tortoises, thinking it is an exoskeleton. Underneath the shell there is a hard backbone with a nerve cord running through it.

CHALLENGE 5.7: WHO ARE THE VERTEBRATES?
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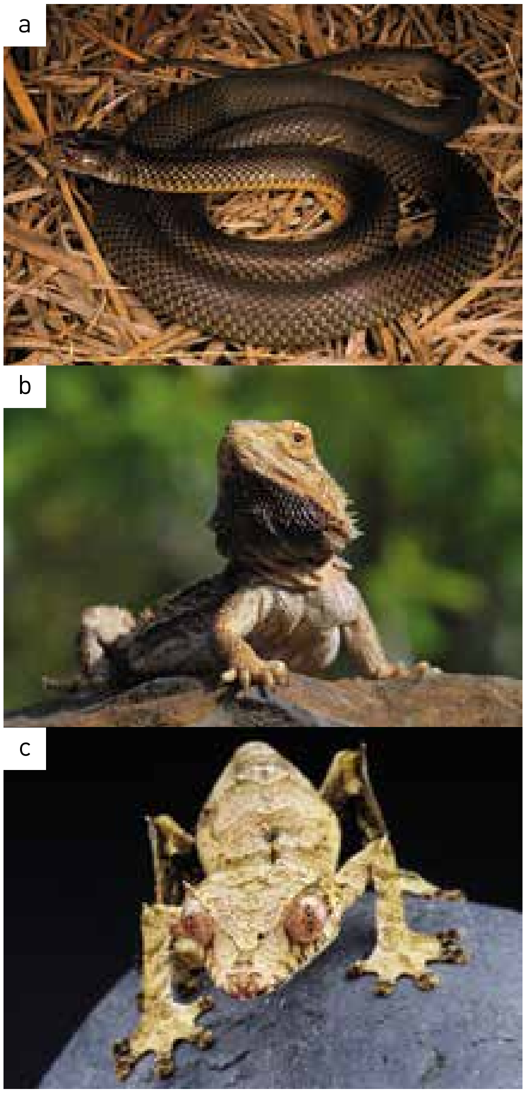

Figure 5.31 Class Reptilia: (a) a king brown snake; (b) a bearded dragon; and (c) a gecko.

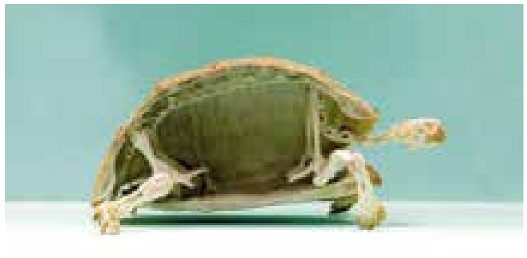

Figure 5.32 Despite having a hard outer shell, turtles and tortoises have a hard backbone with a nerve cord running through it.

Class Amphibia

Like reptiles, amphibians are ectotherms; however, their skin is usually soft and slimy to touch. They lay their eggs, without shells, in water. For the first part of their life they have gills and live in the water. As they get older, lungs develop and they become able to live on land. The only remaining group of amphibians in Australia is frogs. In other parts of the world, caecilians and salamanders may be found.

Class Pisces

Most fish are ectotherms. They are covered in a layer of scales and most have fins. They spend all their life in water and so need gills to breathe. Fish are further grouped according to their skeleton. Sharks, rays and skates have a skeleton made entirely of cartilage, whereas all other fish have bony skeletons.

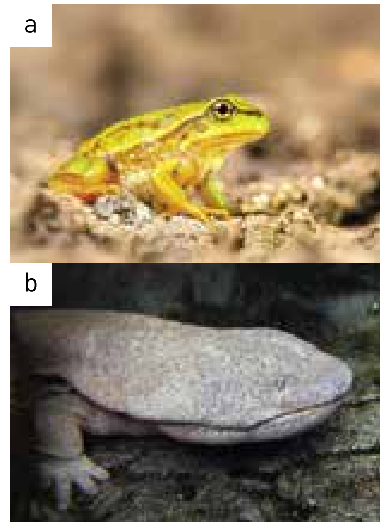

Figure 5.33 Class Amphibia: (a) a growling grass frog; and (b) a Chinese giant salamander.

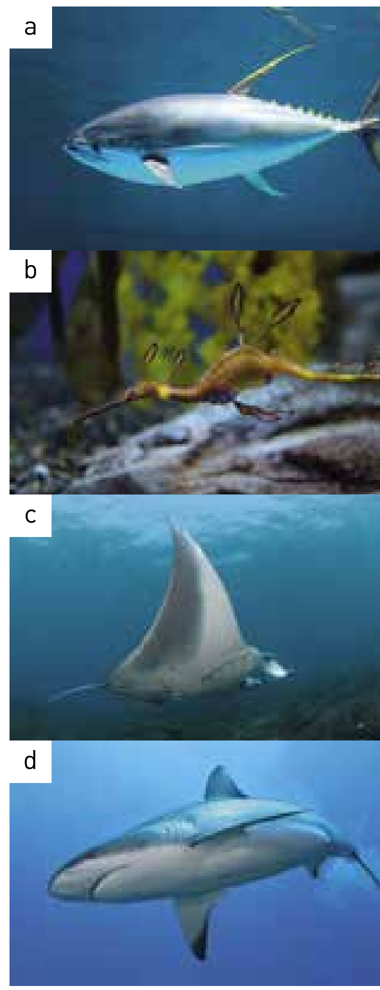

Figure 5.34 Class Pisces: (a) tuna; (b) weedy seadragon; (c) manta ray; and (d) reef shark.

Check your learning 5.7

Remember and understand

1 What are the main characteristics of mammals?

Apply and analyse

2 A dolphin lives in the ocean and has fins. It breathes air, gives birth to live young and feeds them milk. To which class does it belong? Explain.

3 A flying fox can glide through the air like a bird but is covered in fur. To which class does it belong? Why?

4 What does a placental mammal look like when it is born? How does this differ from monotremes and marsupials?

Evaluate and create

5 Seals have fins like fish and live on the land and in the water like amphibians.
   a Find out how a seal's young are born.
   b Given that the seal has long whiskers, is endothermic and breathes air, to which class of vertebrate does it belong?

6 The vertebrates have five classes: Mammalia, Reptilia, Amphibia, Aves and Pisces. What are the more common names for these classes?

5.8 Plants can be classified according to their characteristics

Plants belong in one of the five kingdoms of living things. All plants are multicellular organisms that are able to produce their own energy by using sunlight. This does not mean all plants look the same. They have a variety of different characteristics that allow us to classify them into different phyla.

Figure 5.35 Not all plants germinate from seeds. Ferns produce spores instead.

Seeds or spores

Planting a seed and watching it grow is something most people have done at some stage. But not all plants have seeds. Some plants, such as ferns, produce spores. Spores are much smaller than seeds and only contain half the genetic material needed to make a fern. They can be found clinging to the underside of a fern frond.

Vascular tissue

Plants, like all living things, need water to survive. Many plants use their roots to absorb water and transport it through tube-like structures to the leaves. This system of tubes is called the **vascular tissue** of the plant. Not all plants are so organised. Many plants, such as mosses and liverworts, need to live in damp places where they can absorb water through all parts of their structure.

Figure 5.36 Mosses and liverworts can absorb water through all parts of their structure.

The importance of flowers

Most plants you will have in your school garden produce flowers. Flowers are the way plants attract birds and insects to encourage **pollination** and therefore enable them to produce seeds. Not all plants have true flowers. Conifers have needle-like leaves and produce cones instead of flowers. Pollen from one cone is often transferred to another cone (pollination) so that a seed can produced.

Figure 5.37 Some plants use flowers or cones to produce seeds.

Figure 5.38 The number of petals on a monocot flower is always a multiple of three.

Figure 5.39 A dicot flower.

CHALLENGE 5.8: IDENTIFYING PLANTS
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Monocots and dicots

Flowering plants can be divided into two main groups. Monocotyledons (monocots) have a single leaf that grows from the seed. They can usually be recognised by the parallel veins in the leaves and by counting the number of petals in the flowers. Monocot flowers always have petals that are multiples of three.

Dicotyledons (dicots) grow two leaves from the seed. Their leaves have veins that are reticulated (spread out from a central vein) and they tend to have four or five petals on each flower.

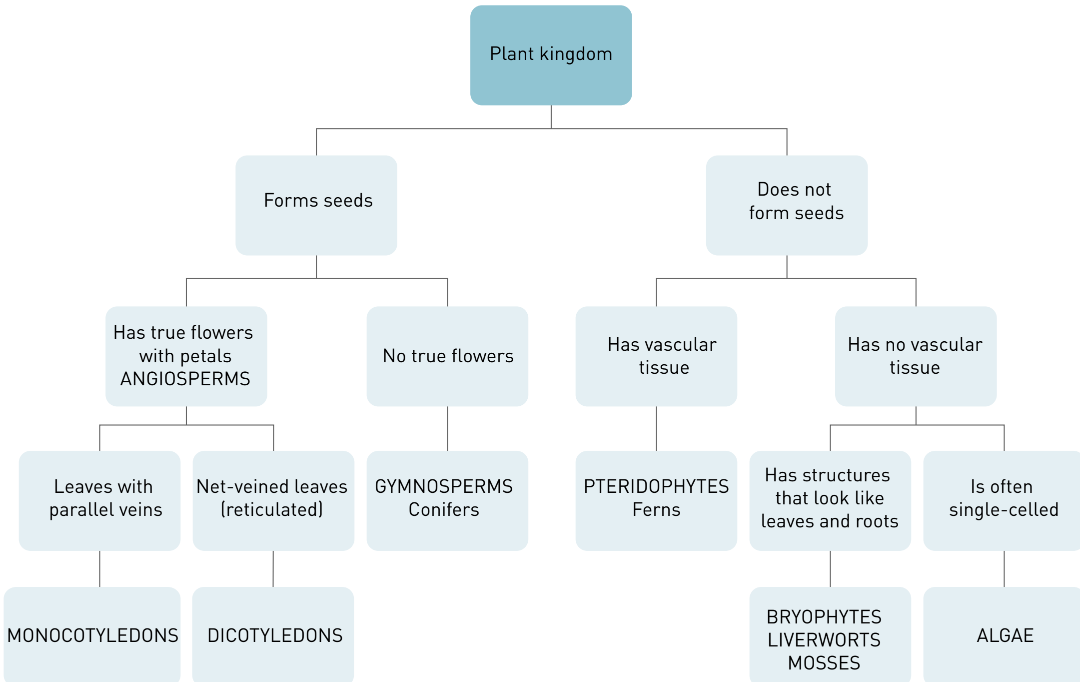


Figure 5.40 A sample plant key.

Check your learning 5.8

Remember and understand

1 What kind of plants are:
   a ferns?
   b mosses?
2 Which group do these household plants belong to?
   a fruit tree
   b palm tree
   c green weed in a fish tank
   d maidenhair fern
   e bird nest fern
   f moss on the path
   g rose bush
   h vegetables
   i pine tree
   j grass and lawn
3 How do mosses, ferns and conifers reproduce?
4 What is the difference between vascular and non-vascular plants?

Apply and analyse

5 Who am I? I am large and green. I use sunlight to make my own food. I smell nice and like to come inside at Christmas. Some people do not like me because my leaves can be prickly and needle-like. I use a cone to help me reproduce. Which plant phylum do I belong to?

Evaluate and create

6 Locate a plant in your garden.
   a Draw a labelled diagram of the plant.
   b What features could you use to classify your plant?
   c Name at least one feature that is not currently present that would help you classify your plant.

//SCIENCE AS A HUMAN ENDEAVOUR//

5.9 The first Australian scientists classified their environment

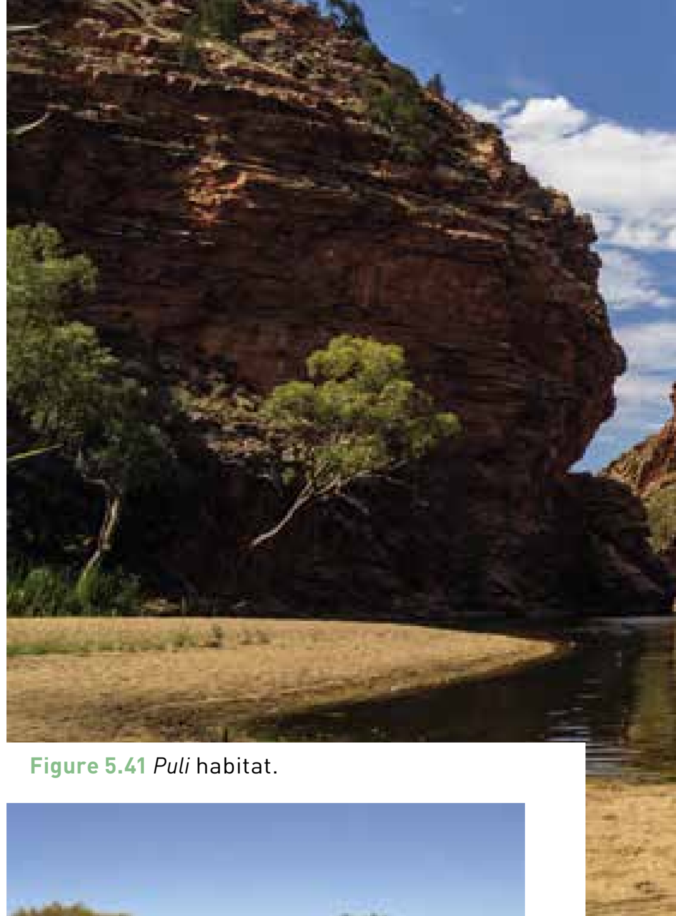


Figure 5.41 *Puli* habitat.

*

Have you ever visited Uluru or Kata Tjuta (the Olgas)? This area is part of Australia's arid zone, a region that receives less than 250 millimetres of rainfall per year. Australia is the second driest continent in the world. Despite the harsh climate, this area is home to hundreds of different organisms.

The Australian environment

When early European explorers first visited this region in the 1870s, they were confronted with a harsh landscape. Their initial aim was to find a route for the overland telegraph line from Adelaide to the Top End and to set up pastures for sheep and cattle grazing. They soon decided that the region was unsuitable, and left.

However, the traditional owners of the land, the Anangu people, had lived on this land for thousands of years and understood it well. They lived a nomadic life, travelling in small family groups and surviving by hunting wildlife and gathering food from the land.

The Anangu knew where to find food to survive and, more importantly, which areas were the best for hunting and gathering. The Anangu classified their environment to help them locate the precious food. They used these names:

- *Puli:* rocky areas, gorges, stony slopes; animals come to this area to find shelter and water
- *Puti:* open woodland; after the rains, this area has an abundance of grass, which the kangaroos eat, and honey ants build their nests in this area

Figure 5.42 *Puti* habitat.

Figure 5.43 *Pila* habitat.

- *Pila:* spinifex plains, low areas between dunes; this is the best place to gather seeds to eat

Reptiles are particularly suited to this environment. The thorny devil, like all reptiles, uses the environment to regulate its temperature. When it wants to become active, it lies in the sun; but, when it is too hot outside, it hides in a burrow until the heat has passed.

One fascinating thing the thorny devil can do is drink water with its feet! It places its feet in a puddle and water moves up by capillary action along grooves in its skin to the corner of its mouth.

Mammals are rarely seen during the day in Uluru–Kata Tjuta National Park. Most are nocturnal and come out in the evening, avoiding the heat of the daytime desert. The most abundant groups of mammals are the placentals (see Figure 5.29) and the marsupials.

Marsupials, such as the bilby, give birth to underdeveloped young but protect them by having a pouch in which further development can occur. The pouch is similar to that of a kangaroo; however, it is a backward-opening pouch. When the young are fully developed, they can leave the pouch and survive the harsh climate.

Extend your understanding 5.9

1 Find out about the kind of environment that the Anangu lived in and the foods they ate to survive. List at least five animals and five plants they ate.

2 The early explorers left this environment because they couldn't survive. Why did they struggle to find food here?

3 In a group of four, use a large sheet of paper to create two collages on the one sheet, one showing living things and one showing non-living things you would expect to find in Uluru–Kata Tjuta National Park. One pair should create the 'living' collage and the other should create the 'non-living' collage.

4 Why do you think the Anangu devised a system of classification for the natural habitats around them?

5 Investigate the mammals, reptiles, birds and invertebrates found in the Uluru–Kata Tjuta National Park. Make a list of five for each category. Classify each one into its correct group.

7 One of the classes of vertebrate is Amphibia. What characteristic of amphibians would make it difficult for them to live in arid environments? What other animal classes would struggle to survive in arid environments?

8 Why do you think the bilby's pouch is rear facing?

9 Discuss why monotremes would find it difficult to breed in arid environments.

10 Investigate which mammals can be found in Australia's arid environments. Classify each of these mammals as placentals, monotremes or marsupials. List any specific Latin double names (genus and species) given for each animal.

5

Remember and understand

1 What is an organism?

2 Give an example of plants moving by themselves.

3 What are the advantages of using a dichotomous key?

4 Why is it important for scientists to use a common system to group all living things on the Earth?

5 What is the difference between vertebrates and invertebrates? Write a definition for each.

6 List the five main classes of vertebrate and give an example of each.

7 List at least five phyla of invertebrates and give an example of each.

Apply and analyse

8 'Biodiversity' is the word used by scientists to describe a variety of different organisms in the same region. Why is it important to preserve a large biodiversity of plants and animals in the world?

9 Imagine that an unknown organism was discovered during a space mission and brought back to Earth. Briefly outline two different methods that scientists could use to decide whether it was living or non-living.

10 Refer to Figure 5.14 showing Dr Redback's family. How might you adjust the dichotomous key in Figure 5.15 if his 'family' included his sister, Melinda; his mother, Frances; he had two daughters, Stef and Gemma (Stef wears glasses); and he had a pet lizard named Stealth but not a bird named Charlie?

11 Place the items in the following list in the correct columns in Table 5.2: *stewed apple*, *iPod*, *daffodil bulb*, *DVD*, *hairs in your brush*, *your teacher*, *shark's tooth*, *germs*, *soft drink bottle*, *your pet*, *silver chain*, *dinosaur skeleton*.

Table 5.2

LIVING		NON-LIVING
CURRENTLY LIVING	DEAD	

Evaluate and create

12 One of the main contributors to the *Encyclopedia of Life* is the *Atlas of Living Australia*. Do an Internet search for the *Atlas of Living Australia* and click on 'Explore'. From this page you can create a species list and map for the area in which you live.

a What is the most frequently seen animal in your area?

b What is the most frequently seen plant in your area?

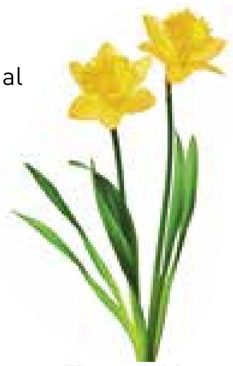


Figure 5.44

13 Look at Table 5.3, showing the number of living things on the Earth.

Table 5.3 Types and numbers of living things on the Earth

GROUP	NUMBER OF SPECIES DESCRIBED	NUMBER OF SPECIES ESTIMATED TO EXIST	PERCENTAGE OF TOTAL ESTIMATED NUMBER OF LIVING THINGS
Animals with internal backbones (vertebrates)	64 788	80 500	0.7%
Animals without a backbone (invertebrates)	1 359 365	6 755 830	61.8%
Plants	297 857	390 800	3.6%
Fungi	98 998	1 500 000	13.7%
Bacteria (Monera)	35 351	>1 200 500	11%
Algae and protozoa (Protista)	28 871	>1 000 000	9.2%
Total number of species	1 885 230	>10 927 630	100%

Source: Chapman, A.D., *Numbers of Living Species in Australia and the World*, 2nd edn, September 2009

a How many species of plant are estimated to be on the Earth?

b Compare the number of *known* plant species with the total number of *known* animal species (add animals without a backbone and animals with a backbone together). Are you surprised with the result? Explain.

14 Download a copy of the collection of insects in Figure 4.45 from your obook.

   a Cut out the pictures of the insects so you can move them around on your desk.

   b Working on your own, sort the insects into groups based on some aspect of their appearance. Justify your system of classification.

   c Compare your groupings with those of a partner. Between the two of you, can you think of other ways to classify the insects?

   d With your partner, create a dichotomous key for this group of insects.

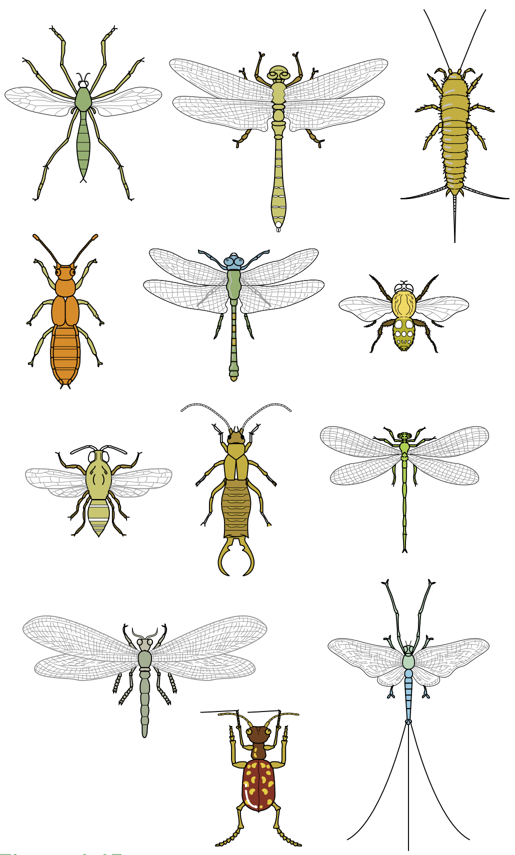


Figure 4.45

15 Design an experiment to show that plants are living things that respond to stimuli. Choose one stimulus only (such as reaction to light or to a lack of water) to investigate. This stimulus is the experimental variable, so you will need to change the variable in some way and control the rest of the variables in the experiment. Make a list of the equipment you would need.

16 Why was the invention of the microscope important to the development of the classification system? How did it change the number of organisms for identification, classification and communication?

Research

Choose one of the following topics to present a report in a format of your own choice. Some ideas have been included to get you started. Your report must include a key of some description (you have seen many in this chapter).

A newspaper article

Write a newspaper article about how life on Earth is organised. It needs to be about two pages long (no more than 500 words) and you should explain how living things are classified for an audience that is not familiar with science. Make a list of the living things whose photographs you would like to use to illustrate the article. Try to find their scientific names as well as their common names. Your newspaper article must contain a key of some description.

A trip to the Kimberley

You have just returned from a trip to a remote mountain area of the Kimberley, in Western Australia. While there, you took your portable microscope and examined water from a previously unknown lake. To your surprise you found some new creatures in the water that looked a bit like bacteria. They are single celled and are either square or oval; some are hairy (have hairs either on the end of the cell or along the edge of the whole cell).

1 Draw six different versions of these organisms.

2 Create a dichotomous key for these six new organisms so you can describe them to other scientists.

3 Name each of the groups at the bottom of your key (you might like to name some of them after yourself).

4 Assuming they are a type of bacteria, to which kingdom will they belong?

*KEY WORDS

5

amoeba
type of single-celled organism belonging to the Protista kingdom

autotroph
organism that makes its own food (e.g. plants)

bacteria
unicellular organisms with a cell wall but no nucleus

binomial name
double-name system created by Linnaeus to name organisms; the first name is the genus, the second name is the species

botanist
scientist who studies plants

branched key
a method of identifying a species using questions that lead to further questions and eventually to the name of the species

cell wall
a structure that provides support around some cells

dead
something that was once living but no longer has the characteristics of a living thing

dichotomous key
diagram used in classification; each 'arm' of the key contains two choices

ectotherm
organism with a body temperature that changes with the environment

endoskeleton
internal skeleton

endotherm
organism with a constant body temperature

exoskeleton
external skeleton

genus
a group of closely related species

heterotroph
organisms (e.g. fungi) that need to absorb nutrients from other living things

invertebrate
organisms with an exoskeleton (external skeleton) or no skeleton at all

key
(biology) visual tool used in the classification of organisms

Linnaean taxonomy
system of classification first developed by Carl Linnaeus (1707–1778) in which all organisms are grouped into one of five kingdoms

microbiologist
a scientist who studies microorganisms

multicellular
organism that has more than one cell

mycologist
a scientist who studies fungi

non-living
something that has never had the characteristics of a living thing

nucleus
a membrane-bound structure found in cells that contains most of the cell's genetic material

plankton
microscopic organisms that float in fresh or salt water

species
group of organisms that look similar to each other, can breed in natural conditions and produce fertile young

taxonomist
scientist who classifies living things into groups

unicellular
living things consisting of only one cell (e.g. bacteria)

vascular tissue
in a plant, tube-like structures that transport water from the roots to the leaves

vertebrate
organisms with an endoskeleton (internal skeleton)

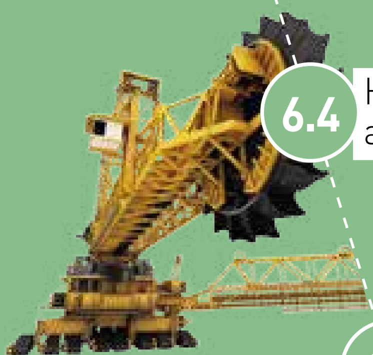
INTERACTIONS BETWEEN ORGANISMS

6

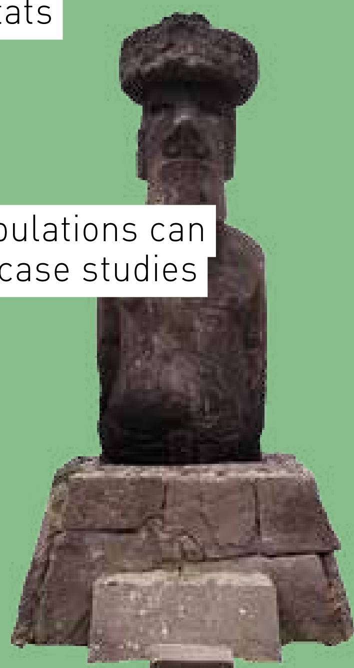
6.1 All organisms are interdependent

6.2 All organisms have a role in the ecosystem

6.3 Food webs can be disrupted

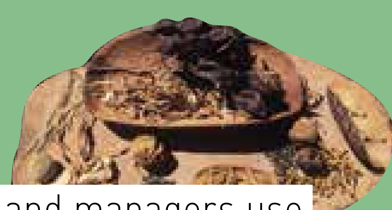


6.4 Human activity can affect local habitats



6.5 Isolated populations can be used as case studies

6.6 Environments can be responsibly managed



6.7 Modern land managers use traditional Indigenous techniques

What if?

Food webs for humans

What you need:

whiteboard, whiteboard marker, index cards, Blu-Tack

What to do:

1. Draw a circle at the bottom of the whiteboard to represent the Sun.
2. Write the following on separate cards and distribute among the class: grass, kangaroo, turtle, human, corn, chicken, duck, pig, hay, grasshopper, cow, trout, shark, seal, plants, twigs, rabbit, berries, carrot, mosquito, worm.
3. Read the statements below and attach corresponding index cards to the whiteboard with Blu-Tack.
   - 'Plants obtain their energy from the Sun.'
   - 'Your organism eats plants.'
   - 'Your organism eats any of those already displayed'.
4. Repeat the third statement in step 3 until all cards are used.

What if?

» What if pesticides killed all the insects?

6.1 All organisms are interdependent

Knowing who eats whom can be very useful information, particularly when looking at how people have an impact on the natural environment. Scientists use a **food chain** to show the flow of food in an ecosystem. A possible food chain for a backyard ecosystem is shown in Figure 6.1.

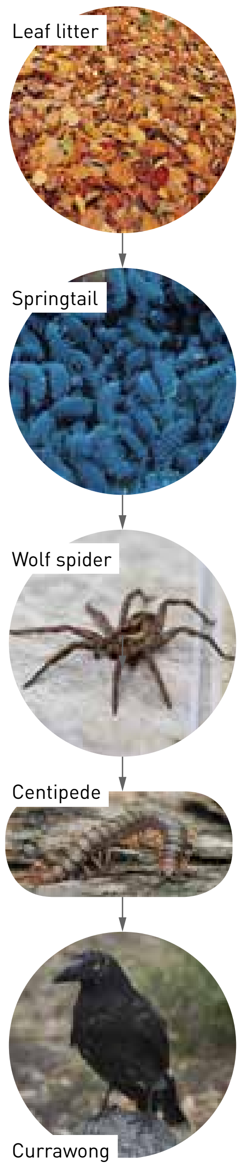


Figure 6.1 An example of a backyard food chain.

Food chains

A food chain always points towards the animal doing the eating. For example, a centipede eats a wolf spider. This means the arrow points from the wolf spider to the centipede. These arrows show the movement of energy (food) in the system. The wolf spider provides the centipede with energy to grow and move.

Plants and plant-like organisms are always found at the start of food chains because they only need air, water, sunlight and a few trace minerals to live and grow. These organisms are known as the **producers** of the ecosystem. Most producers convert light energy from the Sun into sugars (stored chemical energy). These sugars are known as biological molecules and are stored in the leaves, stems and roots.

Animals cannot use the Sun's energy in this way. They are **consumers** and must eat to get the energy they need in order to survive. They then use this energy to stay alive – to pump their blood, to move their muscles and to operate their nerves. The first consumers in a food chain are also referred to as first-order or primary consumers.

In Figure 6.3 the mountain water skink is a first-order consumer. Because the noisy miner bird eats a first-order consumer, it is called a second-order consumer. The feral cat eats the second-order consumer and becomes a third-order consumer. Most food chains only have four to five organisms in them. This is because only some of the energy is stored in the consumers. The rest is converted to heat and movement by the organism.

Food webs

Like humans, most animals will eat more than one type of food. This can be represented in a **food web**, which shows several food chains intertwined. Some consumers will have several labels, depending on their eating habits.

Figure 6.4 shows a food web in which there are four different producers. In this example, the mouse can be considered a primary and secondary consumer, whereas the snail is only a primary consumer.

Food webs show how every living thing in the environment needs every other living thing to survive. When people talk about the 'web of life', they are referring to the interactions between all living things.

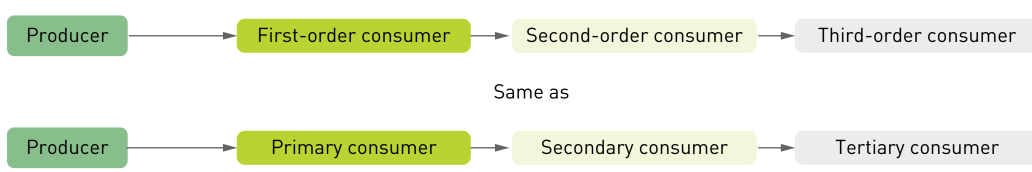


Figure 6.2 A food chain starts with producers, such as plants, and moves through several orders of consumer.

CHALLENGE 6.1: STUDYING FOOD WEBS
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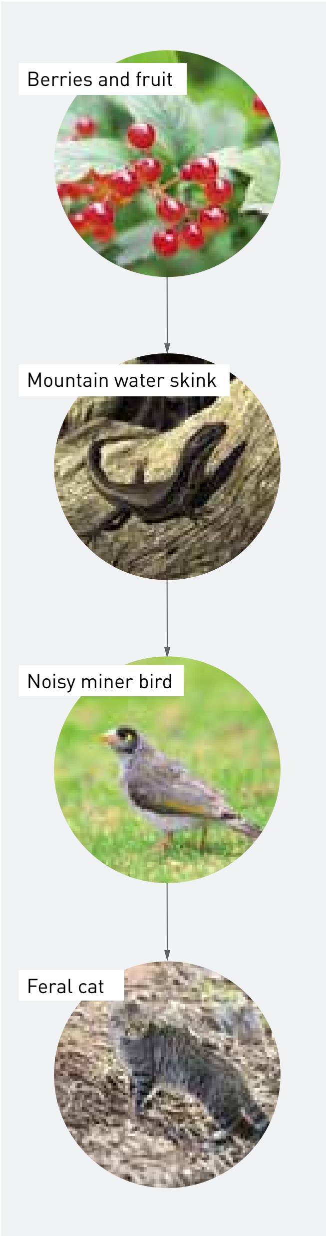

Figure 6.3

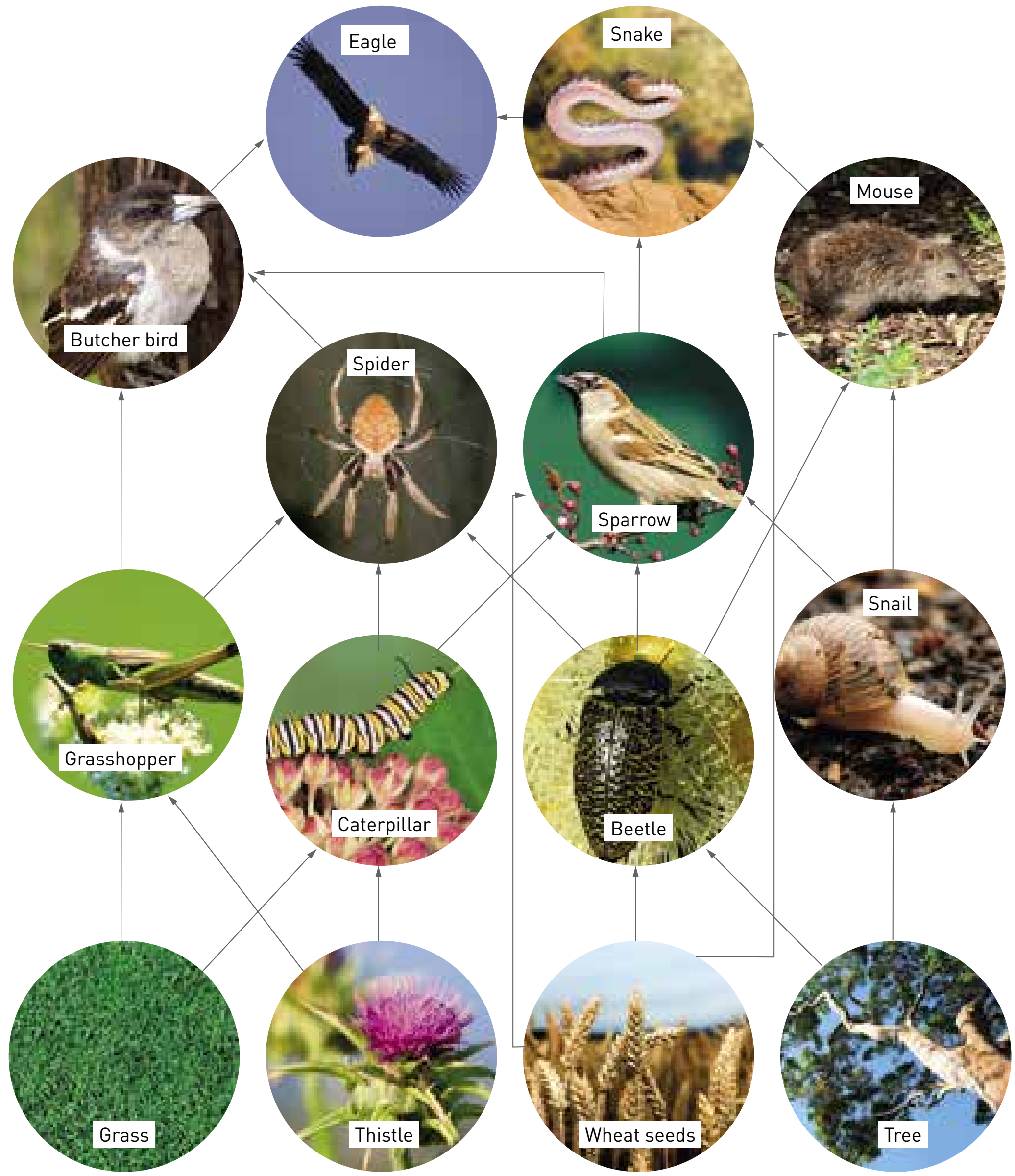

Figure 6.4 A food web shows the extended relationships between various organisms.

Check your learning 6.1

Remember and understand

1 If food chains start with plants, where do plants get their energy from?

2 What is the difference between food chains and food webs?

Analyse and apply

3 Imagine you were asked to find out how many different types of animals lived in your backyard or local park. How would you go about finding out? Would it be possible to count them all?

4 Examine the food web in Figure 6.4.

a Can you identify an animal that is both a secondary and a tertiary consumer?

b How would you classify the snake?

Evaluate and create

5 Construct your own food web of organisms you would find in the local park. Correctly identify the producer and all the consumers.

6.2 All organisms have a role in an ecosystem

Animals can also be named according to the food they eat. Animals that only eat plants are called **herbivores**. Animals that only eat meat are called **carnivores**. Animals that eat both plants and animals, like many humans, are called **omnivores**.

Insects, birds and bats pollinate plants

Plants and animals interact in their search for food. Bees and other insects, as well as some birds and bats, transfer pollen from plant to plant. While stopping at a flower for a sip of sweet nectar, the animals or insects get dusted with pollen.

When the animals or insects fly to another flower of the same or similar species, some of that pollen brushes off and the pollinated flowers are then able to produce seeds. Pollination is important not only for wild plants, but also for crop plants. Over 70% of plant species worldwide, including fruits and vegetables, are pollinated by animals, insects or birds.

Figure 6.5 Some plants use bats to transfer pollen from one plant to another.

Figure 6.6 Insects, such as bees, are important pollinators of plants.

Some organisms decompose organic matter

Locked inside all organisms is an enormous amount of nutrients. All organisms in a food web end up passing these nutrients and energy on to decomposers. **Decomposers**, such as bacteria, fungi and invertebrates (slugs and worms), get the food they need by feeding on dead things. This prevents the dead organisms from piling up. Instead, the nutrients stored in the dead organisms are used for energy by the decomposers. When another organism eats a decomposer, the nutrients once again become part of the food chain. The nutrients that pass through the decomposers as waste end up in the soil in simpler forms. Plants roots can then absorb the nutrients and the cycle starts again. Imagine what life would be like without decomposers!

CHALLENGE 6.2: EXPLORING LEAF LITTER
GO TO PAGE 199

EXPERIMENT 6.2: WHAT IF WATER WERE FILTERED THROUGH A POT WITH NATIVE GRASSES?
GO TO PAGE 199

Figure 6.7 Decomposers recycle important nutrients in an ecosystem.

Figure 6.8 Mushrooms (fungi) are decomposers. They get the nutrients they need by feeding on dead things, such as rotting logs.

Figure 6.9 Forested water catchment areas are vital for keeping Melbourne's water supplies clean.

Wetlands and forests help clean water

If you poured dirty water through a filter, you would expect cleaner water to come out. A similar thing happens in nature when water passes through a forest or wetland ecosystem. By slowing the flow of water, the plants and bacteria trap some of the pollutants and sediments. But plants aren't the only living things that clean water. Aquatic animals, such as freshwater clams, pump water through their bodies to filter out food for themselves and, in so doing, clean the water they live in.

Check your learning 6.2

Remember and understand

1. What are animals that eat both meat and plants called?
2. What could be one of the consequences if decomposers didn't exist?
3. List three organisms that act as decomposers.

Analyse and apply

4. How would you be affected if all bees died as a result of infection?
5. We get the energy we need by eating other living organisms. Where do the following organisms get their energy?
   a. producers
   b. first-order consumers
   c. decomposers

Evaluate and create

6. Design an organism for a food web. What role does your organism play in the food web? What factors would affect the survival of your organism?

6.3 Food webs can be disrupted

Most food webs have a balance between producers and consumers. If more grass grows, then the number of animals that eat the grass will also grow. In time, the amount of grass available will decrease. This balance can be disrupted by the introduction of new organisms or the removal of predators.

Figure 6.10 European wasps are a threat to many Australian ecosystems.

Introduced organisms

Introduced organisms may become pests or weeds. An example of the accidental introduction of a pest into Victoria is the European wasp, otherwise known as a 'picnicker's nightmare'. The first European wasp in Australia was recorded in Tasmania in 1959, and the wasps are now common there. On the mainland, the European wasp was reported in Melbourne in 1977 and in Sydney in 1978.

The wasps may have originally arrived in wood shipments but, with few predators, no diseases and no competition for nest sites, their numbers have increased quickly.

So, how does this affect a food web? If it had no predators and no competition for nest sites, the European wasp may be able to fit in without affecting other organisms in an ecosystem. However, every living thing consumes resources to live, and the European wasp is no exception. By the end of an Australian summer, each European wasp nest may contain several thousand individuals. The larvae complete their development after being fed a diet that consists mainly of other insects that the workers catch and kill. This means that each European wasp nest has the potential to remove several thousand native insects – often the caterpillars of moths and butterflies – from the environment. This can have a devastating effect on local animal populations.

Unfortunately, European wasps don't just consider other insects as food – they also attempt to steal food from picnics and barbecues. This, along with a very painful sting, can make outdoor eating in summer a very difficult task!

Loss of organisms

Removal or loss of organisms from an ecosystem can have dramatic effects. Amphibians, such as frogs, are an important part of the **biosphere**. Amphibians may be warning us of unsafe environmental conditions that could eventually seriously affect our health. Consequently, they are commonly referred to as indicator species – indicators of environmental health, as well as protectors of human health. Amphibians watched the dinosaurs come and go, but today almost one-third of them, representing 1896 species, are threatened with extinction. As many as 165 amphibian species may already be extinct and the population numbers of at least 43% of all species are declining. This means that there will be even fewer frogs and other amphibians in the future.

The thin skin of amphibians helps them drink and breathe, but it also makes them vulnerable to environmental contaminants, especially agricultural, industrial and pharmaceutical chemicals.

Figure 6.11 The corroboree frog is one of Australia's many endangered species.

EXPERIMENT 6.3: WHAT IF THE EFFECTIVENESS OF POLLINATORS WERE REDUCED?
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Amphibians feed mainly on insects and other invertebrates. It has been estimated that a single population of approximately 1000 frogs could consume almost five million invertebrates in 1 year. Amphibians are significant predators of small invertebrates and abundant prey for larger predators. In areas of the world where numbers of amphibians have declined, there has been an increase in invertebrate pests that damage crops and carry human diseases.

Fish numbers in the oceans are dwindling as the demand for seafood continues to increase across the globe. Larger predatory fish, such as tuna, marlin and salmon, are often the most prized, but their numbers are declining, allowing smaller species to thrive in their absence.

Commercial fishing boats with large nets (Figure 6.13) are removing large numbers of many species, including 'by-catch' – fish and other marine species that are not wanted but are left to die before being thrown back.

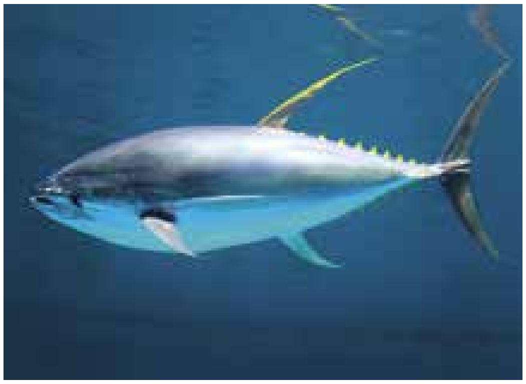


Figure 6.12 Predatory fish, such as tuna, are in decline.

Figure 6.13 Commercial fishing boats using nets catch many species, including some that are not wanted (by-catch).

Check your learning 6.3

Remember and understand

1 Give an example of an introduced animal.

2 What is an indicator species?

Analyse and apply

3 Why do you think some animals and plants can become pests when introduced into Australia?

Evaluate and create

4 One way to control an introduced organism is to introduce another organism that eats it. This is called biological control. When it works, it can be very good. However, sometimes things can go wrong and the organism introduced to help the problem becomes a much bigger problem. Research the introduction of the prickly pear plant and the cane toad. How successful were these forms of biological control?

5 In winter and spring after it has rained, the most common animal to find outside is the humble garden snail. Don't be fooled by this animal – it is probably the most successful of all introduced animals and causes millions of dollars of damage to food production each year. What might surprise you is how it got to Australia in the first place. Research the introduction of the garden snail. (Hint: The Royal Botanic Gardens in Melbourne had something to do with it.)

6 Organism numbers can decrease for a number of reasons including loss of habitat, climate change and direct removal by humans. Describe an example of each.

6.4 Human activity can affect local habitats

Organisms are constantly having an impact on the environment around them (their **habitat**). They use resources such as food and water and, in turn, provide resources for other organisms. Humans are certainly no exception. Human impact on environments is considerable because of our population numbers and our ability to manipulate our surroundings to suit our needs. People are able to make both positive and negative changes to the environment. Most environmental changes so far have been detrimental – understanding these impacts is the first step to reducing and reversing them.

Figure 6.14 Only one specimen of the Hastings River mouse has ever been found. It is considered extinct due to changes brought about by European colonisation.

Deforestation

Our landscape was once covered by patches of different types of landscapes, such as swamp, grassland, forest and heath. This variety of vegetation supported many species of animal that moved, reproduced and spread throughout their territories and beyond.

Today, Australians are clearing land at the massive rate of over half a million hectares a year. That is approximately one million football grounds each year. Much of that land is used for our homes, to grow our food or to manufacture products. The food webs that existed in these areas have been changed as new predators (dogs and cats) move in and the number of producers decreases.

Land degradation

Human activities have led to a degradation of the physical environment. Soil erosion is a major problem caused by the clearing of land for agriculture. In ecosystems with many trees, the soil is stabilised by a dense mat of plant roots. Its surface is covered by a layer of leaf litter, which protects the soil surface from being eroded by wind and water. Water from rainfall is quickly absorbed through the top layers of soil.

Once land is cleared of trees for agriculture, there is little to protect the soil from the action of wind and water. Grazing by animals with hard hooves, such as cattle, compacts the soil. This slows the absorption of water into the soil, increasing the amount of water run-off. This, in turn, erodes the soil. Wind also contributes to the removal of the nutrient-rich topsoil.

Urban sprawl

More than half the world's population lives in cities. The population in the world's urban areas has grown by more than one billion people since the 1970s. Much of this growth has contributed to a phenomenon or process known as urban sprawl.

Figure 6.15 Urban sprawl around many of Australia's capital cities is on the increase.

CHALLENGE 6.4: CALCULATING YOUR ECOLOGICAL FOOTPRINT
GO TO PAGE 201

Figure 6.16 In 1983, large amounts of topsoil were carried across Melbourne and into the Southern Ocean as a result of wind erosion.

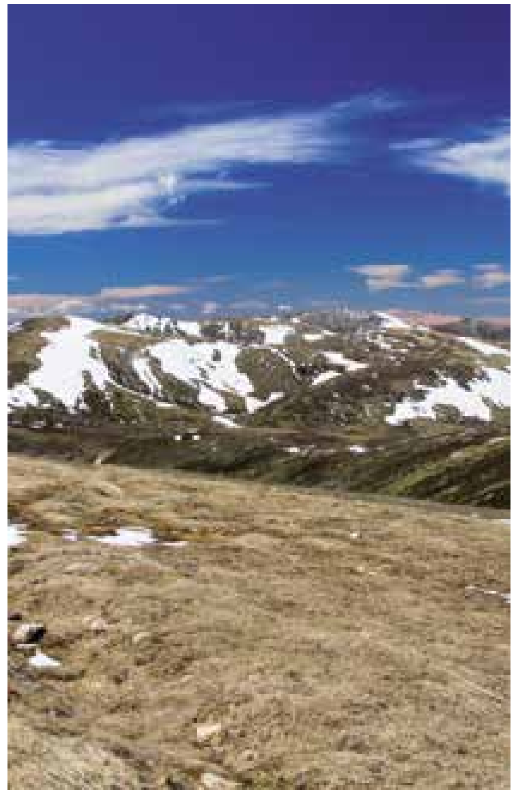


Figure 6.17 Alpine areas are reducing as the climate changes.

Urban sprawl means the spread of urban areas into rural areas, such as farmland, forests and coastal lands that lie on the outer edges of cities. Urban sprawl increases the distance between the city centre and its outer edge.

Urban sprawl is common in rapidly developing cities or those with large populations. Some of Australia's cities rate among the world's worst in terms of their sprawling nature, particularly because everyone wants their own gardens and local parks, and most don't like the idea of living in apartment blocks.

A changing climate

Human activities are contributing to more significant changes to weather and climate. These changes can have a huge impact on ecosystems. In alpine areas, changing rainfall and temperature patterns alter the amount of suitable wet alpine habitat.

Check your learning 6.4

Remember and understand

1 What does the term 'urban sprawl' mean?

2 Suggest four things you can do to reduce the damage you may do to the environment (your ecological footprint).

Analyse and apply

3 The 'Australian dream' is a term that has been used to describe the wish of many Australians to own a home on a block of land in the suburbs. What problems have arisen as a consequence of many Australians living this dream?

Evaluate and create

4 Create a table with the headings 'Problems' and 'Solutions'. In the Problems column, list the types of thing that people do that affect wildlife (e.g. building homes and roads, cutting down trees). In the Solutions column, provide some solutions to each problem.

//SCIENCE AS
A HUMAN ENDEAVOUR//

6.5 Isolated populations can be used as case studies

Figure 6.18 There are 887 giant carved statues dotted around Easter Island. The tallest is almost 10 metres high!

*Easter Island is shrouded in mystery. Where did the people come from? Why did their civilisation disappear? Why had an island of lush tropical forests become a harsh and barren landscape by the time European explorers first visited this region in the 1870s?

Easter Island

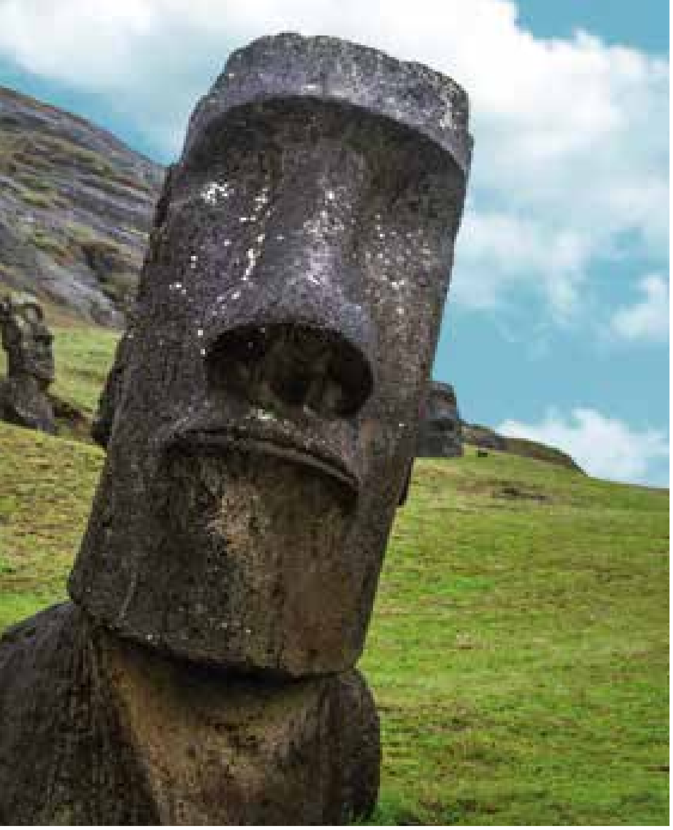
Easter Island is over 3000 kilometres from the nearest population centres (Tahiti and Chile), making it one of the most isolated places on Earth. A triangle of volcanic rock in the South Pacific, it is best known for the giant stone monoliths that dot the coastline.

Easter Island is one of the most isolated islands in the world, but approximately 1200 years ago Polynesian seafarers in double-hulled canoes filled with crops, chickens and drinking water landed on its distant shores. The first islanders were greeted with a lush tropical paradise when they arrived at Easter Island. They called themselves the Rapa Nui. Over the centuries that followed, a complex, well-populated society developed in isolation on an island with a volcanic environment rich enough to support it. For reasons still unknown, the people began carving giant statues out of volcanic rock. These monuments, known as *moai*, are some of the most incredible ancient relics ever discovered.

Scientists believe that, at its peak, the population on the island exceeded more than 10 000 people, with a sophisticated culture that included a written language, music and, of course, stone carving.

Organising the carving, transport and erection of the *moai* is evidence of the complexity of the society and the resources it had access to.

The *moai* were carved in a volcanic quarry, from which they had to be transported across the island to various ceremonial platforms. It is believed that the massive *moai* were rolled along the island's roads on two large logs that were placed on other logs perpendicular to them. The logs were lubricated with palm oil. To transport a *moai* probably took about 5 days and 70 men.



Early explorers called the island *te pito o te henua* ('navel of the world'). Admiral Roggeveen named it Easter Island when he spotted the island on Easter Sunday in 1722.

The Dutch Admiral Roggeveen, onboard the *Arena*, was the first European to visit the island. He found a society in a primitive state with approximately 3000 people living in squalid reed huts or caves, engaged in almost perpetual warfare and resorting to cannibalism in a desperate attempt to supplement the meagre food supplies available on the island. Fishing was difficult because the island's inhabitants could only build reed canoes, and the once-rich volcanic soils were eroded and unproductive.

In 1862, slave traders arrived on the island and took away people as slaves. Then, the missionaries came and, with them, came the loss of any remaining Rapa Nui culture. Eventually, all pure-blood Rapa Nui died out. Today, there are only a few people who can trace their ancestry back to the original inhabitants of Easter Island.

Extend your understanding 6.5

1. Figure 6.19 shows a desolate, treeless landscape. Yet, when the Rapa Nui first encountered the island, it was covered in a lush forest of giant palms. What types of materials would have been available on Easter Island to support such a complex society?
2. What types of materials would Rapa Nui have brought with them to establish their society?
3. How would the Rapa Nui have used the island's resources to survive and increase in population?
4. Do you think the people of Easter Island realised they were destroying their natural resources? Explain.
5. In what way did the loss of trees affect the ability of the Rapa Nui to survive?
6. On an island as small as Easter Island, a person could stand on the highest point and see every part of the island. The person who cut down the last tree would have seen that this was the last tree, but they still cut it down. How do you think this person would have felt? Do you think they would have understood what they were doing?
7. We like to think that, in our culture, we would never put ourselves in the same position as the person on Easter Island who cut down the last tree. What similarities do you see between what our culture is doing and what happened on Easter Island?

Figure 6.19 Lush forests once covered this barren landscape.

//SCIENCE AS
A HUMAN ENDEAVOUR//

6.6 Environments can be responsibly managed

Changes to food webs and habitat have had a significant impact on biodiversity. We can do a lot to reduce our demands on the natural environment. Calculation of your ecological footprint will give you some ideas about how you can reduce your demands on the environment.

Figure 6.20 Green wedges around a city provide 'green lungs' for the city.

Figure 6.21 Bushland near urban areas is important for native animals and people.

Corridors of green

Many cities have set aside a permanent 'green belt' as part of their future planning. **Green wedges** are the non-urban areas of metropolitan areas. These active, living areas protect a city's open spaces and natural areas from overdevelopment. In some places they are important habitat for animals such as the platypus. They are also important for tourism and recreation. Some green wedges include areas with high heritage value for local Indigenous people.

Green corridors allow animals to move from one location to another, through farmland or developed areas. Young animals can use these corridors to move out and form their own territories. Areas of bush with a range of vegetation are linked to provide a safe and suitable area for native birds and animals to live in and travel through. These areas benefit farmers by acting as windbreaks and shelter belts. Pest problems are significantly reduced because of the increased number of predatory birds and insects that thrive in these native habitats.

Backyard stepping stones

Maintenance of biodiversity is essential to the health and functioning of ecosystems. Interactions between organisms in an ecosystem are complex and losing a key species could have a devastating effect on the ecosystem.

Figure 6.22 The Australian bush is a wonderful place to relax.

At one time, conservation was thought to be the responsibility of politicians and scientists. Today, individuals and local communities also work to help conserve biodiversity.

There are also many cultural reasons for maintaining biodiversity. Native plants, animals and ecosystems are part of our cultural identity. People value such areas for relaxation and enjoyment, as well as outdoor activities such as bushwalking and bird watching. The Australian natural landscape has featured in films, literature and photographs. Our natural

CHALLENGE 6.6: MAKING A BIOSPHERE
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Figure 6.23 We are only one of many species on the planet.

Figure 6.24 The Svalbard Seed Vault was established in 2008 on a remote island in the Arctic Circle. When it started, 100 million seeds from 100 different countries were shipped there.

environment is a major international tourist attraction. Indigenous Australians are well known for describing themselves as custodians rather than owners of Australian land, placing such immense value on the country.

If you have access to a piece of land, no matter how large or small, such as your backyard, school grounds or local reserve, then you have the power to conserve a part of our biodiversity. The secret is learning how to share our living space with the plants and animals around us.

Microbes and genebanks

Conserving biodiversity is not only about habitats and food webs. Some scientists are working to preserve biodiversity by storing seeds and microorganisms. Keeping samples of as many organisms (or parts of organisms) as possible provides us with options for the future. Seeds are a great way to preserve plant information because they can be stored for many years without being destroyed. Many microorganisms are resilient and can be dried or frozen indefinitely and then revived when needed.

Extend your understanding 6.6

1. How would building a frog pond in your local school, park or backyard help local wildlife?
2. Research two community organisations that help protect the natural environment. Where are they located? Who are their members? How do people join? What do members do to help the environment?
3. Why is it no longer just governments that are responsible for the environment? Do you think they would have achieved much without the support of local communities?
4. Imagine a friend asked, 'Why is biodiversity so important?' Draft a reply that takes into account the key concepts covered here.
5. Do you have remnant bushland near where you live or near your school? Draw a map of your house or school and the locations of remnant bush reserves. Do these reserves connect to each other?
6. Find out what native animals may still live in the reserves in your local area. Many places have conservation or field naturalist clubs that might be able to help you.

//SCIENCE AS A HUMAN ENDEAVOUR//

6.7 Modern land managers use traditional Indigenous techniques

Figure 6.26 This 1817 painting is called 'Aboriginals using fire to hunt kangaroos'.

As the oldest continuous culture on Earth, Indigenous Australians are custodians of the land. This means their role is that of a caretaker, responsible for looking after the land.

Figure 6.25 Foods of the Australian bush.

In the traditional Indigenous lifestyle, the Australian landscape dictates what people use for clothing, what they eat and what they use for building materials. The seasons dictate their movements, where they hunt and what they gather.

Responsible cultivation

A large variety of food is eaten to ensure no one thing is overeaten, thus preventing extinction. Stories warn of overusing the land. When hunting bird eggs, some eggs are always left to hatch. This ensures that there will always be more birds (and therefore eggs) in the future.

The hunting techniques ensure a balance is maintained. Sticky sap is placed on tree branches to slow down a bird flying away. Small stone dams in small streams trap fish, giving the fish a chance to breed. When people leave an area at the end of a season, they ensure that the river environment (and the organisms that rely on it) survives until their next visit. Some Torres Strait Island people also cultivate bananas, coconuts and yams from season to season.

Firestick farming

Indigenous Australians are respectful of fire and work with it to ensure the continuing health of the plant and animal life. When the first Europeans arrived, they described the bush as being very open and being able to drive coaches between the trees. This was largely due to the Indigenous Australian's ritual use of fire to regularly burn off the bush. The small regular fires prevented the build-up of dense eucalypts and scrub. This meant there was plenty of sunlight for new shoots to grow, which then encouraged the herbivores, such as kangaroos, to live in that habitat.

Figure 6.28 The shoots on these eucalypt trees have sprouted after a fire from epicormic buds under their bark.

Figure 6.27 Modern land managers are now using traditional methods of regenerating bushlands.

Learning from the past

Many land managers are learning the skill of firestick farming. They are researching local plants and how flammable they are. At the top end of Australia, it has been found that woodland areas should be burned in the early dry season every 2–3 years. This removes the thick undergrowth and allows time for new plant growth, which, in turn, attracts animals to grow and breed. In contrast, rainforest areas should not be burnt at all. Instead, they need areas of clear land around them to act as firebreaks, protecting the plants and animals that live there. The goal is to develop the skills that the Indigenous Australians used in 1788 and therefore learn to manage the landscape effectively.

Extend your understanding 6.7

1. What does 'custodian of the land' mean to Indigenous Australians?
2. Describe two ways Indigenous Australians made sure they did not disrupt the ecosystem too much.
3. What is meant by firestick farming?
4. Draw up a table of pros and cons of controlled burning of bushland. Evaluate the points you raise in your table. Do you agree or disagree with the use of fire to control the environment?

6

Remember and understand

1 True or false?
   a School ovals and nature strips are known as green wedges.
   b A frog pond in your backyard or school could help protect the diversity of frogs in your area.
   c The world's population is decreasing.

Figure 6.29 A well-designed backyard pond can provide a habitat for frogs.

2 What is the difference between a producer and a consumer?

3 What is an ecological footprint?

Apply and analyse

4 Compile a list of introduced organisms that can be found around your school.
   a Try to find out how the organism came to your area.
   b How does this organism interfere with the local ecosystem?

5 With a growing population, humans are requiring more from the land around them. Describe three ways in which humans are changing the environment.

Evaluate and create

6 Consider the food web in Figure 6.4. If the mouse were to become locally extinct, list the possible changes that may occur to the other organisms in the food web.

7 In the same ecosystem, what would have happened if another animal was introduced? Would it matter if the animal was a herbivore or a carnivore?

8 Imagine a world without spiders. Describe what the world would be like. In your answer, consider what spiders eat and what organisms eat spiders.

9 In some cases, introduced animals, like the monkeys introduced to Hobart, fail and never become established. In other cases, they are spectacular 'successes', such as the rabbits and foxes across much of southern Australia. In terms of the environment in which these animals live and their interactions with other animals, explain why some animals succeed and others do not.

10 Create a poster that illustrates why it is important to protect ecosystems.

11 A simple change to your daily habits, such as reusing and recycling paper at school, can make a difference to ecosystems. Use this example, or another, to explain how your actions impact on biodiversity.

12 The balance of nature is very delicate, and changes to the environment or any member of a food web bring about changes throughout the whole system. Food webs are graphical ways of showing eating relationships inside ecosystems. If the food web is changing, then so is the ecosystem. Which do you think would be more resistant to change: big complicated ecosystems with numerous species interacting or simple ecosystems with relatively few species interacting? Explain.

13 In this unit you have learned about the Earth's growing population. Create a visual representation (sketch, drawing, poster or similar) to represent the Earth's changing population 50 years ago, now and 50 years into the future.

Figure 6.30 The introduction of rabbits to Australia has resulted in considerable environmental damage.

14 The diversity of livestock, such as cattle, is declining in Africa. Why should Australians care about cows in Africa? Should livestock diversity be conserved? Who should be responsible for maintaining livestock diversity?

Ethical behaviour

15 Do you consider it okay to step on an ant? What about squashing a spider? How is this similar to killing a larger animal? How is it different?

16 Humans have tried a number of methods to reduce rabbit numbers in Australia, including the introduction of a virus that caused serious deformities and led to a slow and painful death. Do you agree with this method? Do you think the people involved knew what the consequences would be before they released this 'biological control'? Find out more about controlling rabbit populations and suggest your preferred method.

Research

Choose one of the following topics on which to conduct further research. A few guiding questions have been provided for you but you should add more questions that you wish to investigate. Present your findings in a format that best fits the information you have found and understandings you have formed.

Mars biosphere

Earth is particularly special because, as far as we know, it is the only planet that sustains life – our biosphere. The biosphere concept has been looked at as a means of long-distance space travel and as a way to colonise planets such as Mars. As a class project, undertake the mission to Mars project to set up a biosphere on Mars.

Decade of Education for Sustainable Development

The United Nations Decade of Education for Sustainable Development (DESD) ran over the period 2005–14. Find out what governments were invited to do as part of the DECD. What opportunities did/does the DESD provide for Australia? What is the Australian Sustainable Schools Initiative (AuSSI)? What outcomes can schools involved in AuSSI achieve?

*KEY WORDS

6

biodiversity
the variety of life; the different plants, animals and microorganisms and the ecosystems they live in

carnivores
animals that eat only meat

consumers
animals who can't convert the Sun's energy into sugars and must eat to get the energy they need to survive

decomposers
organisms that feed on dead things (e.g. bacteria)

food chain
a diagram that shows who eats who in an ecosystem and how nutrients and energy are passed on

food web
several intertwined food chains, showing the extended relationships between different organisms

green wedges
non-urban areas around metropolitan areas

habitat
environment in which an organism lives

herbivores
animals that eat only plants

omnivores
animals that eat both plants and animals

producers
plants and plant-like organisms found at the start of food chains

urban sprawl
the spread of urban areas into rural areas

FORCES 7

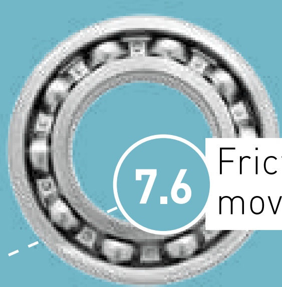
7.1 A force is a push or a pull

7.2 An unbalanced force causes change

7.3 Forces can be contact or non-contact

7.4 Magnetic fields can apply a force from a distance

7.5 Electrostatic forces are non-contact forces



7.6 Friction slows down moving objects

7.7 Simple machines decrease the amount of effort needed to do the work

7.8 A pulley changes the size or direction of force

7.9 There are different types of machines

7.10 Forces are involved in sport

What if?

Rolling jars

What you need:

ramp, jar with a lid

What to do:

1 Roll the empty jar down the ramp.
2 How far did it roll?
3 What made it roll that far?
4 How could you make the jar roll further without changing the ramp?

What if?

» What if the ramp were covered with another material?
» What if the jar were full or half full of water?
» What if the jar were bigger or smaller?

7.1 A force is a push or a pull

A **force** is a push or pull that happens when two objects interact. One object pushes or pulls on another. You cannot see forces, but you can see their effect. Sometimes forces are easy to identify and describe, such as a foot kicking a ball. Other forces are harder to identify and describe; for example, the force that keeps you on the ground.

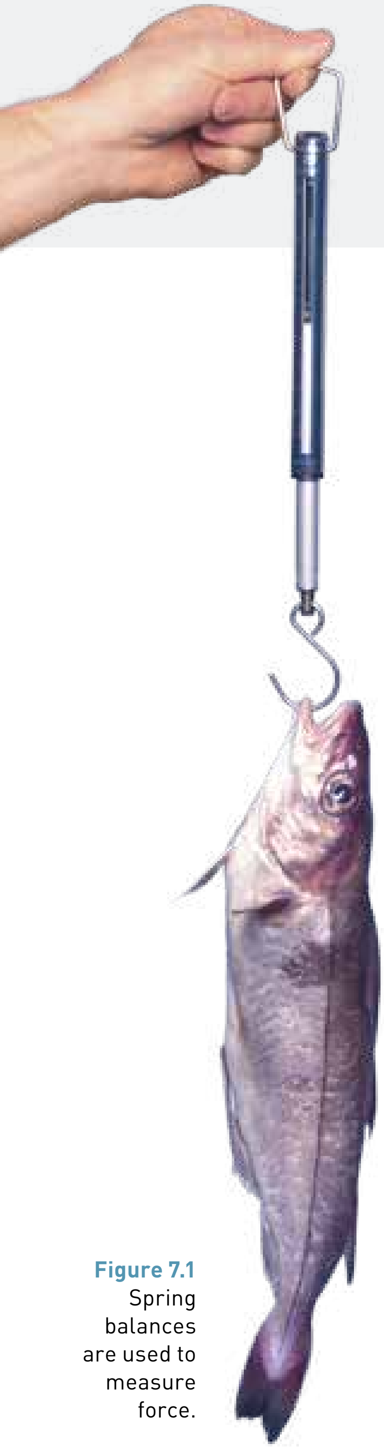


Figure 7.1 Spring balances are used to measure force.

Forces in action

Forces act on everything around us all the time. Usually, more than one force is acting on any object at one time, but often we do not notice them. You have many forces acting on you at the moment. **Gravity** is pulling you towards the centre of the Earth. The chair you are sitting on is pushing back against you, changing the shape of your leg muscles. Because these forces acting on you are in balance (the same strength), you do not move. You sit still on the chair.

When you kick or throw a ball, you use energy to create a push force. This force causes the ball to move. When you catch a ball, you are still giving it a push. This time, the push force causes the ball to stop moving.

Forces act on everything around us all the time. Forces cause objects to:

> begin to move
> speed up
> slow down or stop moving
> change direction
> change shape
> remain still.

Examples of these forces are shown in Figures 7.3–7.8.

Measuring forces

One way to 'see' a force at work is to measure it. In the kitchen, cooks use scales to measure how much the Earth's gravity pulls on the ingredients. Twenty grams of flour is pulled to the centre of the Earth, causing the flour to push down on the scales. In the laboratory, force is measured using a **spring balance**. A stiff spring in the balance stretches when an

Figure 7.2 The force of Ronaldo kicking the ball is easy to identify and describe, but what force is pulling him towards the centre of the Earth?

object pulls on it. This moves the marker so that the amount of force can be measured. A rubber band can measure the size of forces in a similar way to a spring balance.

Before we can use a rubber band to measure a force, it must be **calibrated**. This means matching the stretch of the rubber band to the force pulling on it. The unit used to measure forces is called the **newton** after Sir Isaac Newton (1642–1727), who first described the force used to pull an apple from a tree. Spring balances are also sometimes known as newton meters. Scientists around the world have agreed to this standard measurement so that they can communicate with each other. In every country, the force of 100 grams being pulled to the centre of the Earth is about 1 newton (N). This is about the same as one large chocolate bar sitting on your hand.

EXPERIMENT 7.1: MEASURING FORCES
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Figure 7.3 Begins to move. The golf club pushes the ball. The club exerts a force on the ball, causing it to begin to move. If the club misses the ball, there is no additional force on the ball from the club and the ball stays still.

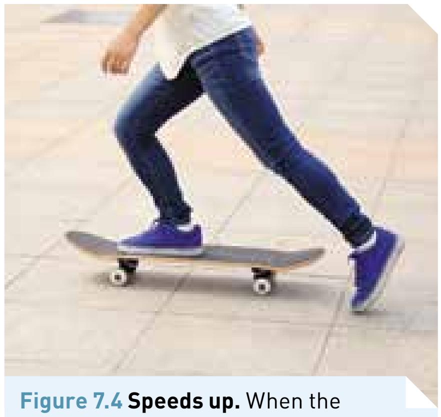


Figure 7.4 Speeds up. When the skateboarder wants to move faster, they use their foot to exert a force on the ground.

Figure 7.5 Slows down. The brakes on this bicycle wheel push down on the tyre, causing the tyre to slow down. This in turn brings the bicycle to a stop.

Figure 7.6 Changes direction. The tennis racquet pushes the ball in a different direction.

Figure 7.7 Changes shape. The hands push the plasticine into a different shape. When the hands stop pushing, the plasticine no longer changes.

Figure 7.8 Remains still. The gravitational force pulling down on the pot plant and the weight of air above it are in balance with the force of the ground pushing up on the pot.

Check your learning 7.1

Remember and understand

1 What is a force?
2 List six things that forces do.
3 How do you measure force?
4 What is the unit of force?
5 Who is the unit of force named after?

Apply and analyse

6 Order these forces from biggest to smallest.
   a A truck hitting a pole
   b A rocket being launched
   c Typing one letter on a computer keyboard
   d Kicking a soccer ball
   e Pushing a car along the street
7 Can you see a force? Always, never or sometimes? Explain.
8 Many measuring instruments have to be calibrated. What does this mean? Give an example.

Evaluate and create

9 A student was using the force measurer in Skills lab 7.1 when the rubber band broke. Can a different rubber band be used with the same scale? Explain.

7.2 An unbalanced force causes change

Forces always come in pairs. Forces are balanced when they are pushing or pulling equally in opposite directions. If one of the push or pull forces is larger than the other, then the object will change its speed, direction or shape. When this happens, the forces are said to be unbalanced.

Figure 7.9 Forces can balance each other.

Balanced forces

Pushing on a brick wall does not usually cause the brick wall to move. This does not mean your force did not exist. There are many forces around us but most of them do not cause movement. This is because the forces are balanced. If the forces of the two people in Figure 7.9 balance each other, then there is no movement. The people are pushing or pulling with equal and opposite forces. **Balanced forces** are very important. Two tug-of-war teams will be balanced if they pull with the same amount of force but in opposite directions.

Unbalanced forces

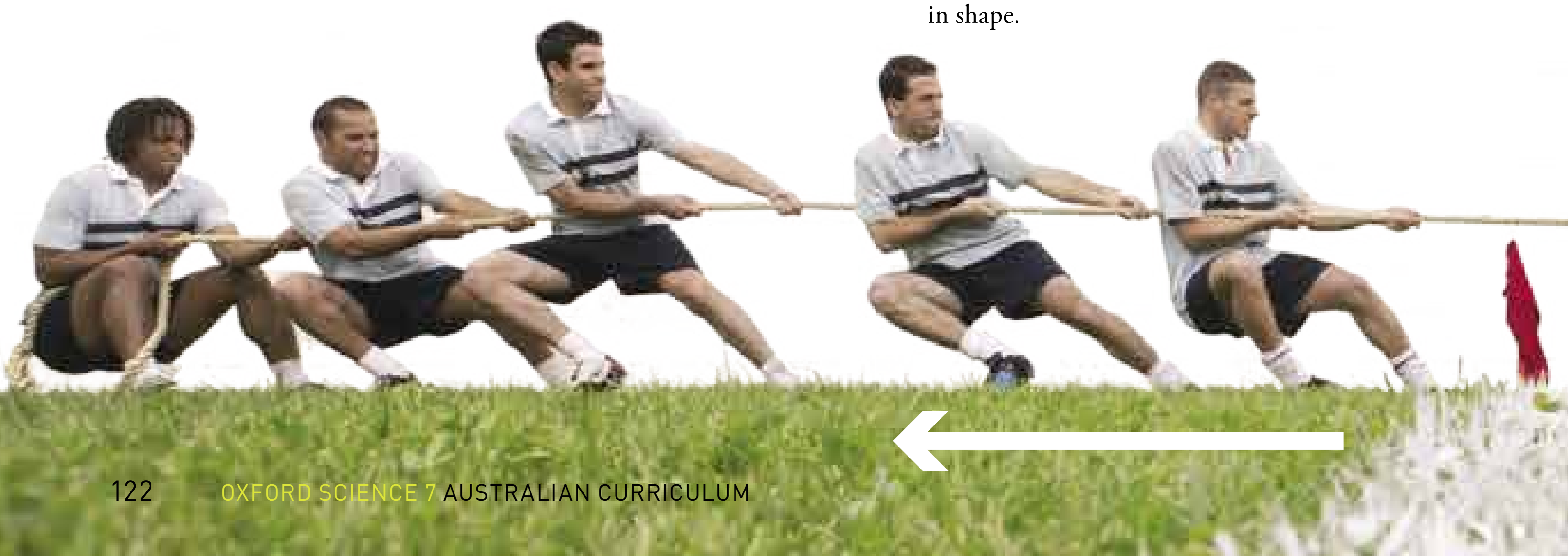
Unbalanced forces are also very important. Consider the forces acting on the barbell in Figure 7.10. The barbell stays up in the air at a particular height because the forces on it are in balance. The weightlifter is pushing the barbell up with exactly the same amount of force as the Earth is pulling down. To move the barbell up, the weightlifter must use a force stronger than the Earth's pull. This will make the forces on the barbell unbalanced.

Evidence of an unbalanced force

There are three ways you can tell if a force is unbalanced. Forces are unbalanced if there is a change in speed, direction or shape of an object. If a ball is resting on the ground, then all the forces acting on it are balanced. If two people are pushing equally on a stationary object, then the forces are balanced and the object does not move. If one person starts pushing harder, then the object will start to move. There is a change in motion because the forces are unbalanced.

Consider a soccer ball rolling towards the goal. If the goalkeeper kicks it away, then the ball will change direction because the goalkeeper's kick unbalanced the forces.

Playdough sitting on the bench will not change unless you add a push force with your finger. Your finger unbalances the forces. The evidence for this unbalanced force is a change in shape.



CHALLENGE 7.2: DESIGN A BALL WHACKER
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Representing forces

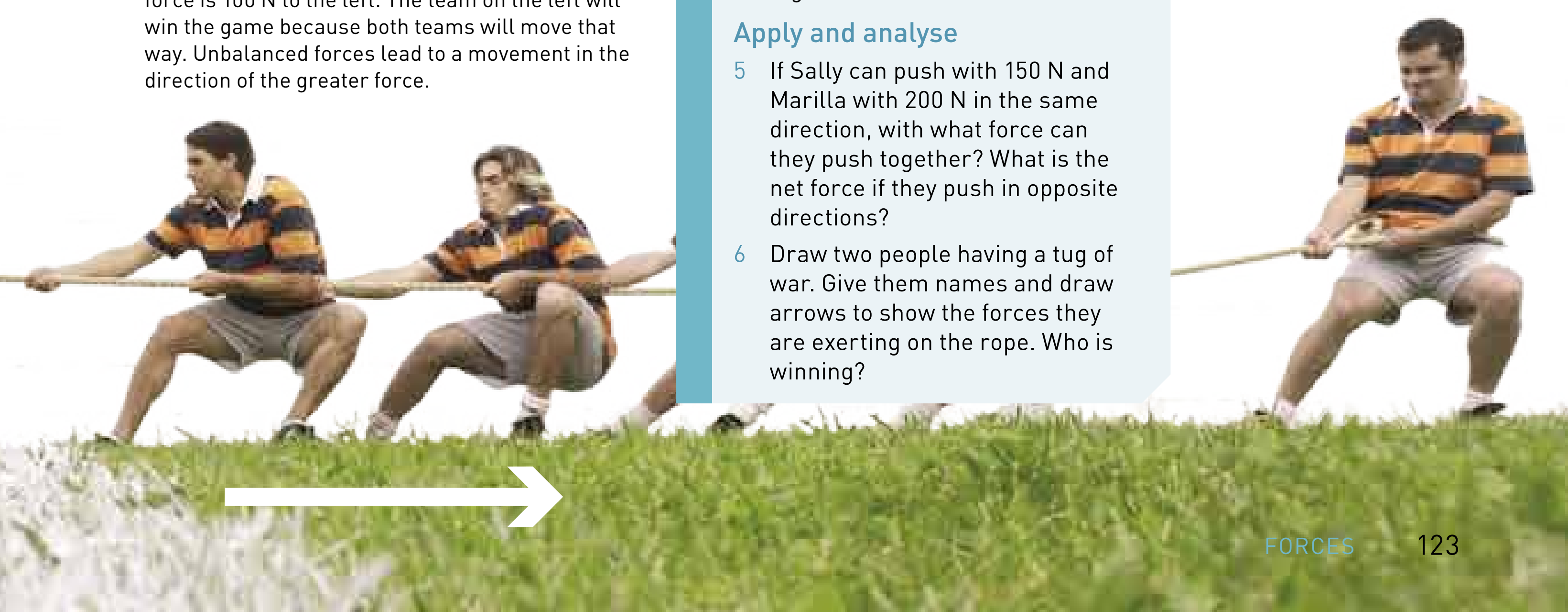
Force diagrams can be represented using an arrow. A short arrow shows a weak force and a long arrow shows a strong force. The direction of the arrow shows the direction of the force. Figure 7.11 shows a tug of war between two teams. The arrows show the pull force they are exerting on the rope. One team is much stronger than the other team. Which team will win? What evidence will you see in real life that this team is stronger?

Forces can be added together

If you tried to lift a heavy object such as a piano, you would not succeed because the upward force you exert on the piano would be too weak. But if a few of your friends helped you by also adding their force to yours, the combined upwards forces would be stronger than the downwards pull of the Earth. The **net force** is the combination of all the forces acting on the piano. If the piano is lifted up, the forces are unbalanced and the net force on the piano is upward.

If an object is stationary (not moving) or moving at a steady speed in the same direction, then the net force acting on that object is zero. All the forces are balanced. If an object changes it speed (by speeding up or slowing down), shape or direction, then a net unbalanced force must be acting on it.

Figure 7.11 When forces are unbalanced, a change in motion will occur, with the greatest force 'winning'. In a game of tug of war, if one team pulls with a force of 200 N to the right and the other team pulls with a force of 300 N to the left, the net force is 100 N to the left. The team on the left will win the game because both teams will move that way. Unbalanced forces lead to a movement in the direction of the greater force.



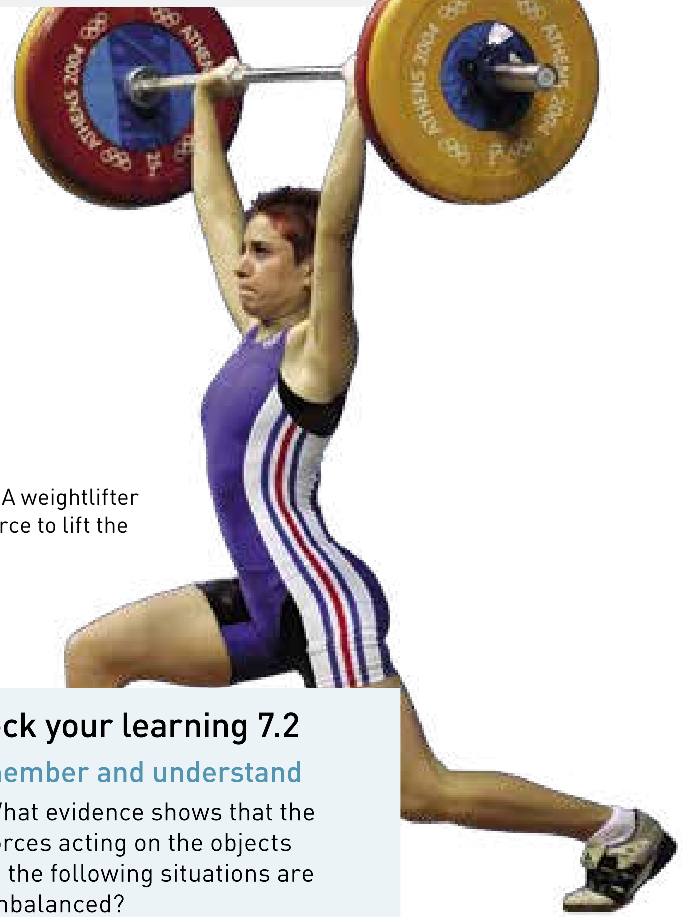


Figure 7.10 A weightlifter applies a force to lift the barbell.

Check your learning 7.2

Remember and understand

1. What evidence shows that the forces acting on the objects in the following situations are unbalanced?
   a. Pushing down the lever on the toaster
   b. Jumping on a trampoline
   c. A car starts moving
2. When you push against a brick wall, why doesn't it fall over? Why can a bulldozer push it over?
3. Explain why weightlifters get tired when they hold heavy masses in the air.
4. Give examples of forces that cancel each other out (net force = 0) and of two forces that add together.

Apply and analyse

5. If Sally can push with 150 N and Marilla with 200 N in the same direction, with what force can they push together? What is the net force if they push in opposite directions?
6. Draw two people having a tug of war. Give them names and draw arrows to show the forces they are exerting on the rope. Who is winning?

7.3 Forces can be contact or non-contact

Contact forces involve two objects touching each other. Friction is an example of a contact force and you will learn more about it later in this chapter. If one object is able to push or pull another without touching, the push or pull is called a **non-contact force**. Magnetism and gravity are examples of non-contact forces.

Contact forces

Some forces make objects move because of a direct push or pull. It is much easier to move a pencil if you push it with your finger. Your finger has to touch the pencil or be in contact before the pencil will move. This is called a contact force.

Non-contact forces

Some forces cause movement without touching. These are called non-contact forces. An example of this is the force of attraction between a magnet and a metal paperclip. When a magnet is held near a metal paperclip, the paperclip is pulled towards the magnet. There is no touching, or contact.

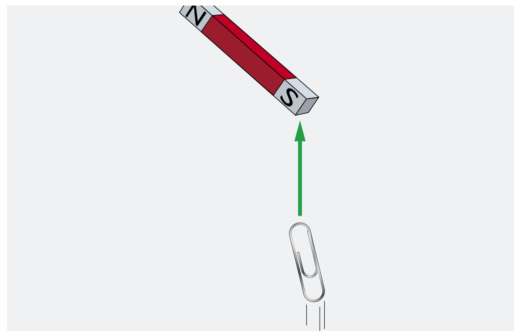


Figure 7.12 The attraction between the paperclips and the magnet is a non-contact force.

How magnets push and pull

Magnets are made of an alloy (a mixture of metals) that is mostly iron. The bar magnets used most commonly in schools are usually made of the alloy alnico, which is iron mixed with aluminium, nickel and cobalt. New, strong magnets are made from metals known as 'rare earth' metals. These are much stronger than normal magnets and do not lose their magnetism.

One end of a magnet is labelled 'N' for north and the other end 'S' for south. If you hang a bar magnet from its centre by a piece of string, then the north end will swing to point north. The magnet is said to have two **magnetic poles** – north and south.

When the north pole of one magnet is placed near the south pole of another magnet, the two magnets are pulled to each other. This is called

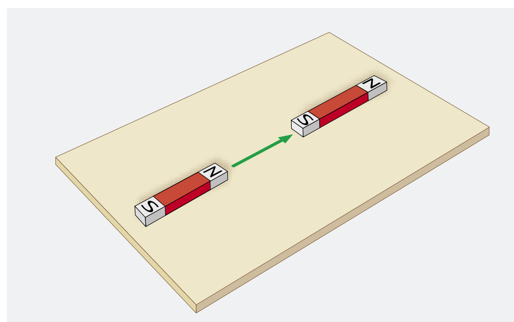


Figure 7.13 The north pole of one magnet is pulled by the south pole of another magnet.

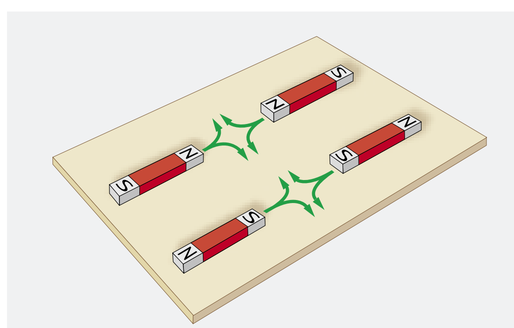


Figure 7.14 Like poles push/repel each other.

CHALLENGE 7.3: CAN YOU USE THE PUSH AND PULL OF A MAGNET?
GO TO PAGE 203

an **attraction force**. The two **unlike poles** (a north and a south) attract each other. Magicians use this attraction force to slide something along a table. You can do this too. Place one magnet on top of a thin table and a second magnet under the table. Can you make the top magnet move? Can you see the pull force? Are the two magnets contacting each other?

When two **like poles** (two north poles or two south poles) are placed together, they push each other apart. You can use one magnet to push another magnet along a table. This is called a **repulsion force**. The two magnets do not need to touch to be affected by the repulsion force. It is a non-contact force.

What causes a magnetic force?

An iron needle can be made to become a magnet by sliding a strong magnet along one side of it (in one direction only). The strong magnet pulls tiny groups of particles so that they all line up in one direction. Each time you stroke the needle, these particles line up. This causes larger sections of the magnet called **domains** to point in the same direction. When most of the domains are pointing the same way, they can pull or attract a metal pin. Dropping the needle can cause the domains to become mixed up again.

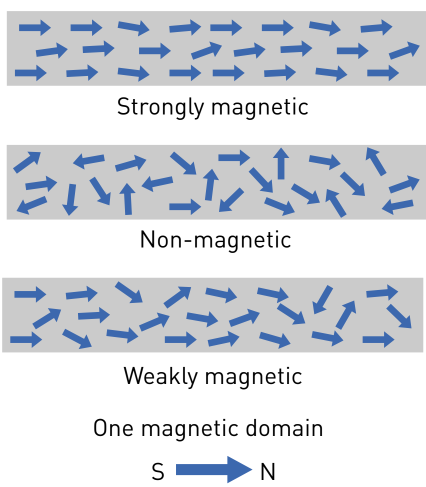


Figure 7.15 The magnetic domain theory.

Some magnets never lose their magnetic force. These magnets are called permanent magnets. The domains in these magnets are often arranged while the metal is still buried deep under the ground. Breaking these magnets in half does not change the

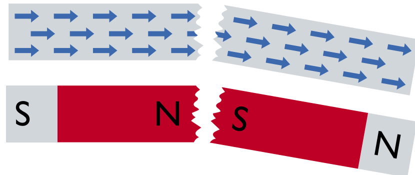


Figure 7.16 When a magnet is broken, it forms two magnets.

arrangement of the domains. The two halves become smaller magnets with the same pull or push forces as the larger magnet.

The push forces of magnets are used in the design of Maglev (magnetic levitation) trains. A series of electronic magnets on the train and track suspend the train above the tracks. The magnets on the train and the track have like poles, causing the train to sit above the track. There is no contact between the train and the metal track. To make the train move, the driver changes the pole of the train magnet, and the track magnet pushes the train magnet forward.

Figure 7.17 Repulsive magnetic forces cause this Maglev train to move.

Check your learning 7.3

Remember and understand

1. Name three places where you might find a magnet.
2. Is magnetic force a contact or non-contact force? Explain your answer.
3. Why is one part of a magnet called north?
4. What happens when the following poles of two magnets are pushed close together?
   a. N and S
   b. N and N
   c. S and S
   d. S and N
5. Draw how you might arrange bar magnets to spell your name. Label the north and south poles of the magnets.

Apply and analyse

6. Describe how you might levitate a magnetic skateboard above a large magnet on the ground. Mention the arrangement of the poles of the magnet in your description.

7.4 Magnetic fields can apply a force from a distance

The area around a magnet, where magnetic force is experienced, is called a **magnetic field**. The further away an object moves from the magnet, the weaker the field is. We cannot hear, see or smell a magnetic field but we can see the way a paperclip or another magnet reacts to it. In chapter 8, you will investigate gravitational fields.

How compasses work

A compass needle is a weak magnet. When a compass is placed near a strong magnet, the compass needle points in the direction of the field. You can see this by moving a compass around the sides and ends of a bar magnet. The north pole of a compass always points to the south pole of a magnet. Iron filings and iron powder are tiny bits of iron. If you put them near a strong magnet, they become temporary magnets. They line up like tiny compass needles around the strong magnet. You can draw this pattern and make a map of the magnetic field.

There is a magnetic field around the Earth. A compass needle will line up with the Earth's magnetic field. The part of the compass needle with the 'N' on it points to the north magnetic pole of the Earth. It is important to note that the 'geographic' North Pole of the Earth is not the same as the magnetic North Pole. They are both in the Arctic Circle but hundreds of kilometres apart.

The North Pole, also known as the geographic North or true North Pole, is the northernmost point of Earth. If you tunnelled through the Earth from the North Pole in a straight line, you would come out the other side at the South Pole. The magnetic North Pole is quite different. The magnetic North Pole is not a fixed point – it moves about according to the magnetic field of the Earth and has done so for hundreds of years. This movement is caused by the Earth's magnetic field. The magnetic South Pole does not always line up with the magnetic North Pole.

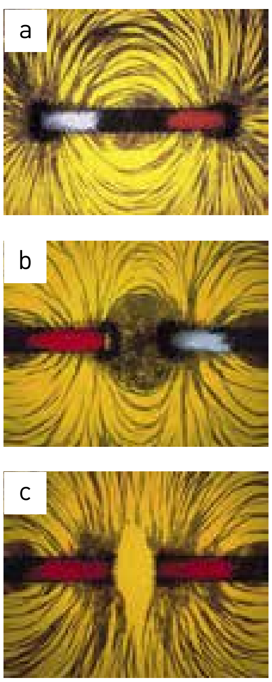


Figure 7.18 Magnetic fields: (a) around a single bar magnet; (b) between two attracting bar magnets; (c) between two repelling magnets.

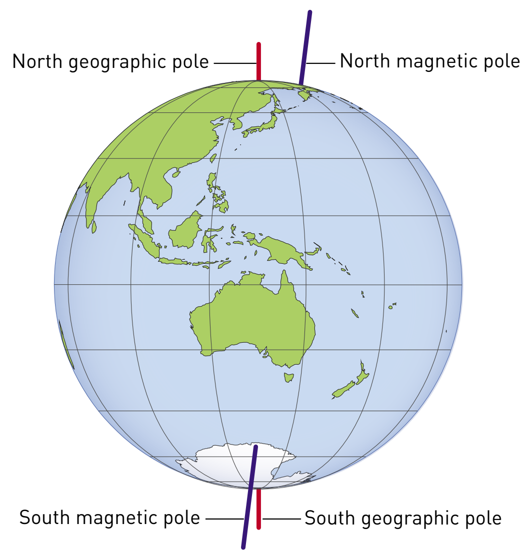


Figure 7.19 The Earth's geographic poles are not in the same place as its magnetic poles.

How turtles use the Earth's magnetic field

When a turtle hatches, it crawls down the beach to the water and swims out to the brightest light on the horizon, which is usually the Moon. For the next 30 years, it will swim the fast flowing sea currents around the world. When it is ready, the turtle is able to detect the magnetic field around the Earth. It can measure the direction of the magnetic field (just like a compass) and how strong it is. All it needs to do is follow the magnetic field back to exactly the same beach where it hatched. Once there, it will mate and lay eggs, completing the cycle of life once again.

Figure 7.20 What do magnets and turtles have in common? Magnets create a magnetic field, and turtles use the magnetic field to find their way back to the same beach where they hatched.

Flipping the magnetic poles

Throughout history, the magnetic North and South Poles have flipped upside down every now and then. The last flip happened 780 000 years ago. These flips are produced by electric currents inside the Earth and are eventually reversed. The flip takes a few thousand years to complete. While this happens, the poles become very disordered and a magnetic North or South Pole can appear anywhere. How will this affect the turtles being able to find their beach?

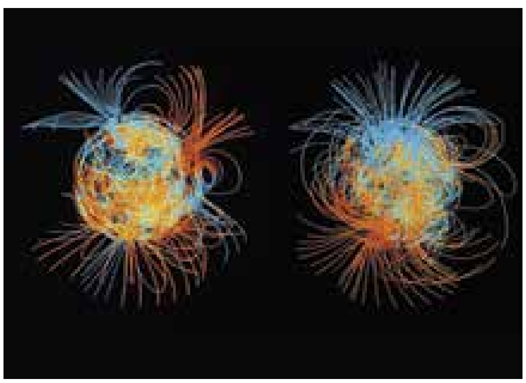


Figure 7.21 The Earth's magnetic poles between reversals and during a reversal.

Bankcards and magnets

You use magnetic fields in your own life. The black strip on the back of a bankcard has a series of small magnetised zones separated by demagnetised zones. You can see these zones if you sprinkle fine iron filings on them (Figure 7.22). The iron filings arrange themselves according to the magnetic field surrounding the magnetic zones, which look a bit like a bar code. When the card is swiped through a card reader, the magnetic bar code is read and the person's name, their bank and account number are decoded.

The information on the black strip on a bankcard can be changed if it is put next to a strong magnet. This includes the magnetic clasps on a purse, or wallet. Some stores also attach magnetic security devices to their stock to protect against theft. They remove these using a demagnetiser near the cash register. Leaving a bankcard on a store demagnetiser will also change the magnetic strips on the card.

Figure 7.22 The magnetic strip on a bankcard contains zones of magnetised and demagnetised areas.

Check your learning 7.4

Remember and understand

1 What is a magnetic field?

2 How could you map the field around a magnetic nail?

3 Describe in words the shape of the magnetic field when two magnets are:
   a attracting
   b repelling.

4 By looking at the magnetic fields made by different magnets, can you decide which magnet is stronger? Suggest a rule to use.

5 Draw the magnetic field around a broken magnet:
   a that has been re-joined
   b with the two pieces 10 cm apart
   c with the two pieces 1 cm apart.

Apply and analyse

6 Explain how a compass works.

7 Explain why you should never leave a library card on the demagnetising panel of a shop.

7.5 Electrostatic forces are non-contact forces

When two objects rub together, there can be a build-up of negative charges on one object. This causes other objects to be pushed away or pulled towards it. This is known as an **electrostatic force**.

What causes electrostatic force?

Have you ever rubbed a balloon on your hair and seen the hair cling to the balloon? This is a result of another force called the electrostatic force. When two objects rub against each other, a small electrical charge builds up. One object becomes positively (+) charged and the other becomes negatively (–) charged. These two charges act like the north and south poles of a magnet. The positively charged objects are pulled, or attracted to, the negatively charged objects. The unlike charges attract. Rubbing the balloon on hair causes the hair to become positively charged and the balloon to become negatively charged. When the (negative charged) balloon moves away, the (positively charged) hair is still attracted to it. The hair lifts up and tries to cling to the balloon (Figure 7.23).

Figure 7.23 When the negatively charged balloon moves away, the positively charged hair is still attracted to it.

Van de Graaff generators

A Van de Graaff generator works in the same way as rubbing a balloon on hair. In the long shaft of the machine, two long belts rub against one another, making the rounded dome of the machine positively charged. Negative charges are attracted to the dome. If anything comes close enough to the dome, the negative charges are attracted and jump through the air. You might see this as a spark (Figure 7.24).

It is not just negatively charged objects that are pulled or attracted to the dome. Uncharged objects (neither positively nor negatively charged) are also attracted to the positively charged dome. If you stand too close to the Van de Graaff generator, your uncharged hair might be attracted to the dome.

Anything touching the dome also becomes positively charged. The girl in Figure 7.25 is standing on a rubber mat so that the negative charges cannot move from the ground into the dome. This means that she becomes positively charged like the dome. Every part of her body becomes positively charged, including all her hair. Just like the forces in a magnet, the like charges in the hair repel each other. This make the strands of the girl's hair try to push away from each other.

The rules of electrostatic forces are:

> unlike charges attract
> charged objects attract uncharged objects
> like charges repel.

EXPERIMENT 7.5: WHAT IF A BALLOON WERE ELECTROSTATICALLY CHARGED?
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Figure 7.24 Sparks jump across to a Van de Graaff generator when negative charges come close enough.

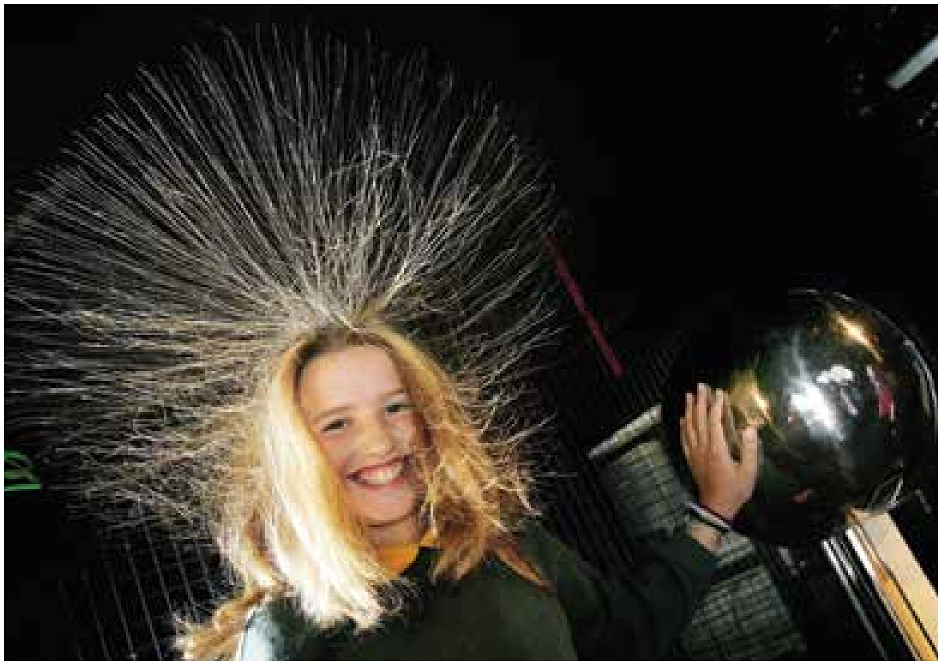

Figure 7.25 This girl has become positively charged, like the dome of the Van de Graaff generator that she is touching. The strands of her hair are repelling each other.

Electrostatic forces in everyday life

You may have experienced electrostatic forces when you were jumping on the trampoline. Every time you jump, your feet rub against the trampoline mat. This causes a charge to build up in your body. Sometimes this causes your hair to stand up because the strands are pushing away from each other. When you touch someone else, or the framework of the trampoline, you may feel the spark as the negative charges are attracted.

Electrostatic charge can build up on cars as they drive along the road. It is this charge that can cause explosions when filling up at a petrol station. If the driver gets out of the car without touching the metal of the car, then the car can still have the positive charges built up. It is usually safe to start filling up the car, but if the driver gets in and out of the car when the petrol fumes are in the air, the negative charges can be pulled between the car and the driver. This causes a spark and in rare cases could result in an explosion.

Check your learning 7.5

Remember and understand

1 Are electrostatic charges contact or non-contact forces?

2 Describe how electrostatic forces can be created.

3 Finish these statements.

a Unlike charges _______________.

b ____________ charges repel.

c Charged objects __________ uncharged objects.

4 Explain why the hair of a person touching a Van de Graaff machine may be standing up.

Analyse and apply

5 Isaac was leaving the carpeted library to go home. When he touched the door handle, he received an electric shock. Explain why this happened.

6 When it is about to rain, the water particles in the clouds rub against one another and an electrostatic charge forms. How does this cause lightning?

7.6 Friction slows down moving objects

It is much easier to slide along ice than along a gravel road. This is because the friction of the gravel road acts to slow the forward motion. **Friction** is the force that resists movement between two objects in contact. In other words, friction slows down moving objects.

What is friction?

When buying sports shoes, many people look for shoes with good grip. This grip prevents the shoe from sliding when they run and helps to avoid sliding when they stop. The grip provides friction between the ground and the wearer. Friction slows everything down that is moving. It acts in the opposite direction to the movement. The greater the friction, the more the movement slows down and eventually stops. Friction happens because objects rub together. When you start walking, you rely on the shoe rubbing against the ground so that you can push forward. When you try to stop, you rely on the friction between the shoe and the ground to stop your movement. Without friction, your feet would just slip over the ground. It would be like trying to walk on ice.

Figure 7.26 Friction between the shoe and the ground stops you from sliding around.

Evidence of friction

We can see evidence of friction in many parts of our lives. Any time a movement is slowed down, it is because of friction. Without friction, a bike would keep rolling along a road without the need to pedal. A pen or pencil would slide over a page without leaving a mark. Friction is very useful to us, but it can create problems and we often try to reduce it.

How to decrease friction

Rollers or balls are one way to reduce friction. Because the balls roll across the ground, it is much easier than being dragged along. Tiny balls are often used as bearings to allow two surfaces to slide over one another easily.

Figure 7.27 These ball bearings allow the two metal circles to move past each other with very little friction.

Hovercrafts and air pucks have low friction because they use a layer of air to glide over a surface. There is no contact between the surfaces and, as a result,

EXPERIMENT 7.6: WHAT IF THE AMOUNT OF FRICTION WERE CHANGED?
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almost no friction. The same idea is used in magnetic levitation (Maglev) trains, where the train carriages are held above the tracks by strong magnetic forces.

Lubricants, such as oils and grease, also reduce friction. This is called **lubrication**. If a kitchen drawer sticks, you can use candle wax or soap as a lubricant. Lubricants work by coating the surface with an oily or waxy substance, which makes them slippery. Putting oil on bicycle chains and grease on the wheel axles makes the wheels spin more easily, with less friction.

Air resistance, or **drag**, is the friction between a moving object and the air it is moving through. Air resistance limits the speed of an object in the air. Air resistance is necessary for parachutes but it is a problem for cars and trucks. **Streamlining** (makes the surface smooth and rounded) helps overcome air resistance (Figure 7.28).

Fish and sharks have streamlined bodies. This allows them to move through the water with the least amount of friction.

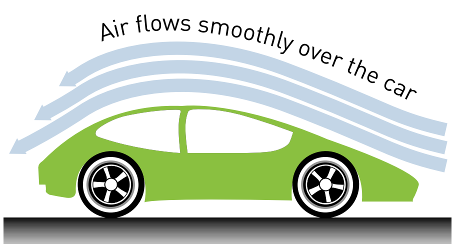


Figure 7.28 Streamlining reduces friction.

Figure 7.29 Oil is added to a car engine to reduce friction between engine parts.

Check your learning 7.6

Remember and understand

1 List three examples where friction is useful and three examples where friction is a problem.

2 Why is a penguin streamlined, but a sea anemone is not?

3 Why do surfers wax their surfboards?

4 Why does the tread on the tyres of your bike wear down over time? Explain this in terms of force.

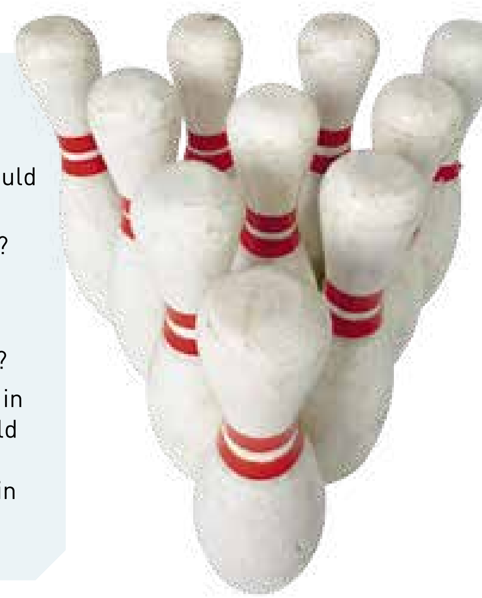
5 A hovercraft moves across water on a cushion of air. What is the benefit of this?

Apply and analyse

6 In a world without friction, what would happen if you tried to:
   a go down a slide in a playground?
   b play tenpin bowling?
   c tie your shoelaces?

7 How are speed and friction related?

8 If you used the same pushing force in each case, over which surface would an object move the fastest: sand, wood, or metal coated in oil? Explain your answer.



7.7 Simple machines decrease the amount of effort needed to do work

The ancient Egyptians, Romans and Greeks understood forces very well. They made **simple machines** that helped them build the pyramids, fight wars and build cities. The simplest machine they used was a lever. A lever can be used to decrease the amount of effort needed to do work. You use levers every day. Scissors, pliers, brooms, shovels, wheelbarrows and can openers are all levers.

Figure 7.30 Ancient Egyptians used round logs and rope to haul large blocks of stone when they built the pyramids.

Levers

A **lever** is a solid rod or bar that is supported at a turning point called a **fulcrum**. Figure 7.32 shows the main features of a simple lever – a see-saw. The force used to operate a lever is called the **effort**, and the resisting force it overcomes is called the **load**.

When one person on the see-saw is pulled down by the Earth, the other person is pushed up. The weight of the two people does not need to be equal for this see-saw lever to work. One person can lift a heavier weight by moving further away from the fulcrum in the middle. In fact, a single person 2 metres away from the fulcrum can lift two people who are 1 metre on the other side of the fulcrum.

Mechanical advantage

The lever gives you a mechanical advantage. The size of the advantage can be calculated by dividing the size of the load by the size of the effort:

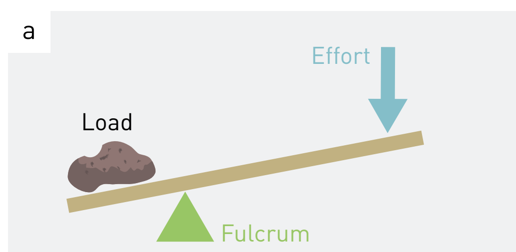
$$\text{Mechanical advantage} = \frac{\text{size of the load}}{\text{size of the effort}}$$

The magnification of the force comes with a disadvantage. For this type of lever, the distance from the fulcrum the effort must move is greater than that moved by the load.

These levers are called **force magnifiers**. They can change a weak force into a stronger force. A crowbar can be used to lift a heavy

Figure 7.31 The trebuchet was a powerful machine used to fling objects such as rocks against enemy defences.

a



b

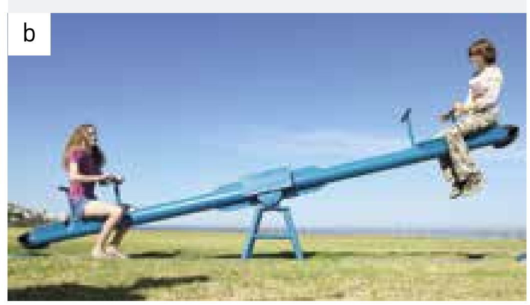


Figure 7.32 (a) A lever has three features: the fulcrum, effort and load. (b) A see-saw is an example of a lever.

EXPERIMENT 7.7a: USING A FIRST-CLASS LEVER TO LIFT WEIGHTS
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EXPERIMENT 7.7b: USING A SECOND-CLASS LEVER TO LIFT WEIGHTS
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rock even though the distance the effort is larger than that moved by the rock.

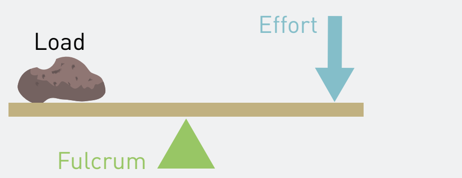
Other levers are **distance magnifiers**. They can change a strong force that acts over a short distance into a weak force that acts over a longer distance. An example of this is a tennis racket. The end of the tennis racket moves a greater distance than the hand holding the racket. The end of the racket moves faster than the end of the hand.

Types of levers

There are three types of levers and they are classified according to the position of the fulcrum (turning point).

- **First-class lever**: the fulcrum is between the effort and the load (EFL)
- **Second-class lever**: the load is between the effort and the fulcrum (ELF)
- **Third-class lever**: the effort is between the load and the fulcrum (LEF)

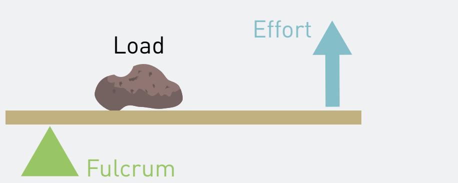
a



b

Figure 7.33 (a) In a first-class lever, the fulcrum is between the load and the effort. (b) Scissors are an example of a first-class lever.

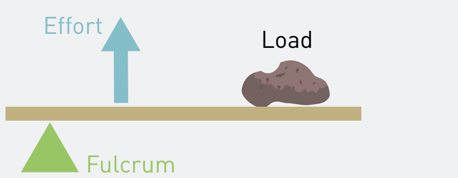
a



b

Figure 7.34 (a) In a second-class lever, the load is between the effort and the fulcrum. (b) A wheelbarrow is an example of a second-class lever.

a



b

Figure 7.35 (a) In a third-class lever, the effort is between the load and the fulcrum. (b) A hammer is an example of a third-class lever

Check your learning 7.7

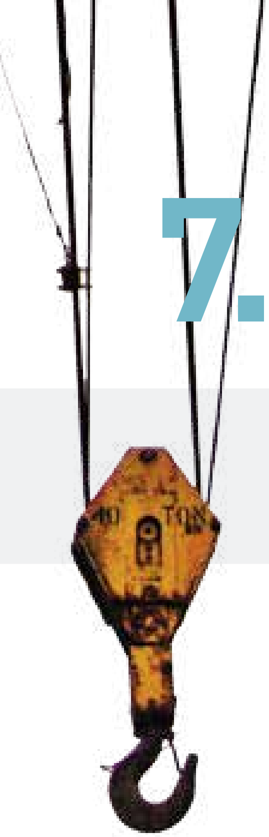
Remember and understand

1. Look at Figure 7.36.
   a. What type of lever is shown?
   b. Would an effort of less than 200 kg be able to lift the load?
   c. How would you reposition the fulcrum so that a weight much less than 200 kg can lift the load?
2. A crowbar (see Figure 7.37) can be used to move a load.
   a. What class of lever is it?
   b. Is this class of lever a force magnifier or a distance magnifier? Explain your answer.
3. Modern cranes use leverage to lift heavy objects (see Figure 7.38).
   a. Where is the load located?
   b. Where is the effort located?
   c. Where is the fulcrum for this lever?
   d. What class of lever is this?
   e. Is this lever designed to magnify force or distance? Explain your answer.

Figure 7.36

Figure 7.37

Figure 7.38



7.8 A pulley changes the size or direction of force

A **pulley** is a simple machine that makes it easier to lift an object. Pulleys are wheels with a groove along their edge. The wheel is used to change the size or direction of the force used.

History of the pulley

Between the 15th and 17th centuries, a period known as the Age of Discovery, the people of Europe were desperate for spices, gold and silver. Sailors navigated the seas looking for these treasures. They returned with large amounts of bounty that included food, weapons and slaves. All this cargo needed to be loaded on and off the ships as quickly as possible. To help the sailors do this work, they used a simple machine invented by Archimedes many centuries before.

Figure 7.39 The simplest pulley system is made of one pulley.

Figure 7.40 Sailing ships have pulley systems for lifting heavy sails and cargo.

Types of pulley

The simplest pulley system is made of one pulley. This system only changes the direction of the applied force, not the size of the force. As a person pulls *down* on the rope, the weight on the other end moves *up*. This doesn't change the amount of effort needed, but it makes lifting easier. This is because the person can use their weight to help in the lifting. You have probably used this type of pulley when you pull the cord to open a window blind at home. The mechanical advantage is calculated by the number of ropes between the upper and lower pulleys; in the roller blind system it is one.

The more pulleys that are used, the easier it is to lift a load because its mechanical advantage is increased. For example, if two pulleys are used, then the system can lift twice the load of a single-pulley system. The mechanical advantage of this system is two (Figure 7.42).

A four-pulley system can magnify the effect of the effort four times. For example, a 25 kilogram effort can lift a 100 kilogram load in a frictionless pulley system. The simple system shown in Figure 7.43 not only changes the direction of the applied force, it also multiplies it by four. This system has a mechanical advantage of four.

Groups of pulleys are often mounted together in a frame or 'block'. This device is called a **block and tackle** (Figure 7.44). A small effort pulling through a long distance lifts a large load through a much smaller distance.

EXPERIMENT 7.8: CALCULATING MECHANICAL ADVANTAGE
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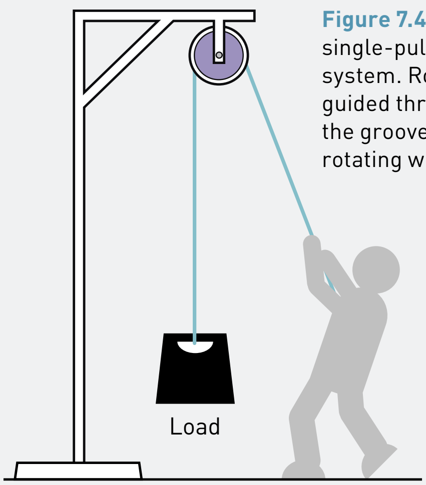


Figure 7.41 A single-pulley system. Rope is guided through the groove of a rotating wheel.

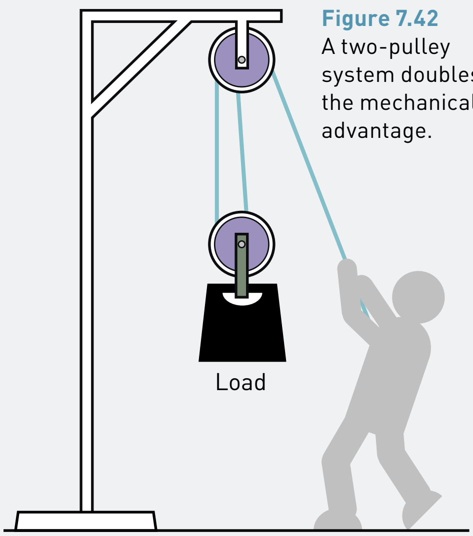


Figure 7.42 A two-pulley system doubles the mechanical advantage.

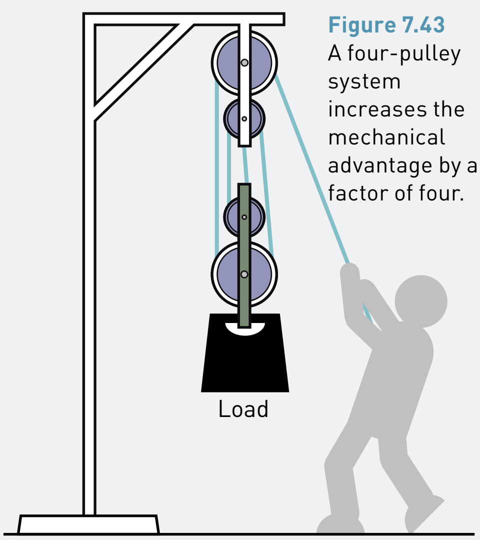


Figure 7.43 A four-pulley system increases the mechanical advantage by a factor of four.

Figure 7.44 This block-and-tackle system is used to lift heavy objects.

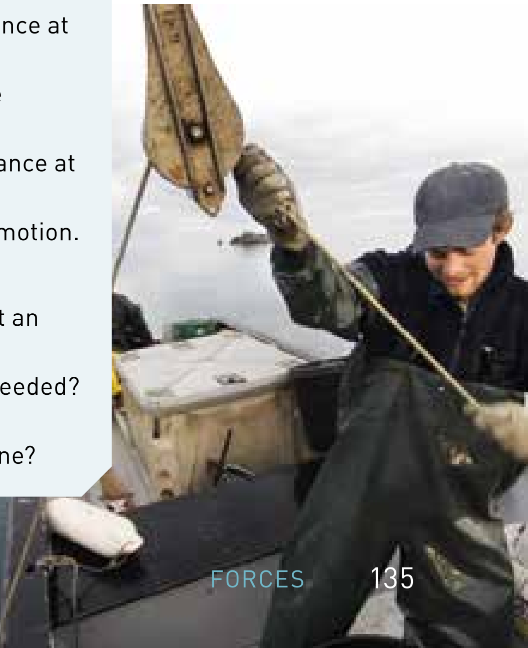
Check your learning 7.8

Remember and understand

1. Why are two pulleys better than one?
2. A block and tackle provides a mechanical advantage because it can lift heavy loads. Does it have any disadvantages?
3. Give three examples of where single pulleys or pulley systems are used.
4. Describe how pulleys made loading and sailing huge cargo vessels possible.
5. Choose the correct option. A pulley system can:
   a. increase force and distance at the same time
   b. decrease distance while increasing force
   c. decrease force and distance at the same time
   d. change the direction of motion.

Analyse and apply

6. A 100 kg mass is used to lift an 800 kg mass.
   a. How many pulleys are needed?
   b. What is the mechanical advantage of this machine?



7.9 There are different types of machines

Many different machines have been developed through the centuries that make less work for us. The famous mathematician Archimedes developed a screw that carried water to the top of a house. The screw was just a hollow pipe with an inclined plane (a simple machine) wound around the inside.

As well as pulleys and levers, other simple machines are ramps, wedges, screws and wheels and axles.

Ramps

Ramps are the simplest types of inclined planes. A **ramp** is used to lift heavy objects up to a higher level. For example, a piano mover might use a ramp to get a piano from the ground onto a truck. Ramps are used to bridge gaps between uneven surfaces. Escalators are moving ramps with steps (Figure 7.45). A ramp is called a simple machine because it makes moving a load easier. Going up the ramp might take longer than a single step up, but it takes a lot less force from your legs.

Figure 7.45 An escalator is an example of a ramp.

Figure 7.46 An axe is an example of a wedge.

Wedges

A **wedge** is an inclined plane that moves through another object and changes the direction of a downwards forces to a sideways force. An axe is a wedge. When an axe hits a log, the downwards force is changed to a sideways force, which splits the log (Figure 7.46).

Humans discovered the benefits of the wedge when they used the jagged edges of rocks to cut animal flesh and skin. It is more than likely that you have used a wedge today: a knife is a wedge and so are your teeth. Each tooth in a zipper is a tiny wedge that fits tightly with the adjacent teeth.

EXPERIMENT 7.9: COMPARING DIFFERENT MACHINES
GO TO PAGE 208

Figure 7.47 Corkscrews are used to pull the cork out of a bottle.

Figure 7.48 A Ferris wheel is an example of a wheel and axle.

Figure 7.49 A bike wheel is an example of a distance magnifier.

Screws

You might be surprised to know that a **screw**, like the wedge and the ramp, is also an inclined plane. The indent that spirals around a screw, called the **thread**, looks almost like a road (a ramp) spiralling up the side of a mountain. Screws penetrate materials such as wood or cork by using the turning effect of a force. The effort needed to turn a screw into an object is much less than that required to hammer the screw into the same object.

Wheels and axles

If you've used a circular door handle or travelled in a car, bus or train today, then you have used a wheel and axle simple machine. A wheel is a type of lever that turns in circles about its centre – the fulcrum or pivot point. An axle usually links the lever and the wheel. For example, when you turn a doorknob you apply an effort force to the door handle and the axle exerts a force on the load (the latch), which opens the door.

A **wheel and axle** is sometimes a force magnifier. For example, you apply a small effort to a doorknob to move a larger load, the latch. This is because the outside edge of the wheel, or doorknob, moves a larger distance than the axle, or latch. A Ferris wheel is an example of a wheel and axle (Figure 7.48).

Wheel and axle machines can also act as distance magnifiers. When you pedal a bike, you apply a force to the pedals. This force causes the larger wheels to turn. The distance the wheel travels is much further than the distance the pedal travels. The distance has been magnified.

Check your learning 7.9

Remember and understand

1 List the six types of simple machine.
2 Are any of the six simple machines similar? Explain your answer.
3 Which one of the following is not considered an inclined plane?
   a A knife used to cut bread
   b A screwdriver used to turn a screw
   c A nail driven into a piece of wood
   d A spear thrust into a tree
4 Which part of a circular doorknob is the wheel and which part is the axle?

Apply and analyse

5 Is a circular doorknob a force magnifier or a distance magnifier?
6 Is the can opener shown in Figure 7.50 acting as a wheel and axle? Explain how it works.

Figure 7.50 A can opener is a lever.

//SCIENCE AS A HUMAN ENDEAVOUR//

7.10 Forces are involved in sport

Figure 7.51 Smart suits provide an advantage to the wearer by reducing friction. They have been banned at major swimming competitions.

Many athletes dream of winning Olympic gold medals. They train for long periods, control what they eat and make sure they have the best equipment available. Having a good understanding of the forces involved in their sport can give the athlete an advantage over their competitor.

Forces in swimming

A swimmer must have a good understanding of how the water moves around them to maximise their speed. First, they must control how they dive into the water. Breaking the water's surface creates friction and can slow them down. So they must make sure that their whole body enters the water at the place where their hands originally broke the surface.

Many swimmers shave all their body hair before a big competition. A smooth surface allows the water to move along their body with less friction.

The swimmer's position in the water is important. If the body is straight, the water moves along without interruption. If the legs hang down, the moving water must change direction. This creates more friction and slows the swimmer down.

In 2012 FINA (Federation Internationale de Nation), the international governing body of swimming, banned the use of full body smart suits (Figure 7.51). These suits were designed by scientists to reduce the friction between the swimmer and the water. The suits were made of a material that mimicked the small scales on a shark. This material repelled the water rather than absorbed it, making it lighter for the swimmer to wear. It also reduced the friction between the swimmer and the water. The suits were also designed to be very tight with smooth seams. This helped the swimmer be more streamlined in the water.

Many world records were broken when this suit was first used but FINA decided that it gave an unfair advantage to the countries that could afford this expensive technology. New rules were drawn up that limited the type of swimming costumes that could be worn in high-level swimming competition.

Forces in tennis

The human arm acts as a third-class lever for which the shoulder is the fulcrum, the muscle attached to the middle of the upper arm provides the effort and the load is usually near the hand. A tennis racquet acts as an extension of the player's arm. This increases the distance between the load (where the tennis ball hits) and the fulcrum. Third-class levers are speed multipliers as well as distance multipliers. When a player hits the tennis ball with a racquet, the speed of the ball is increased. If the tennis player's arm is bent, the end of the racquet is travelling more slowly, and therefore the ball will rebound more slowly.

Tennis players will often have longer tennis racquets, not to increase their ability to reach for the ball, but to increase the speed at which they can hit the ball.

Figure 7.52 Tennis racquets increase the distance between the load and the fulcrum.

Forces in golf

The benefit of a dimpled surface on a golf ball is now widely known. However, golf balls originally had smooth surfaces. When golfers noticed that their old and battered golf balls flew further than the newer, smoother balls, a group of scientists investigated why this occurred.

The dents and bumps in an old golf ball cause the layer of air next to the ball to stay close to the ball, moving in an organised way over the surface. This decreases the overall air resistance of the ball moving through the air, making it fly further. As a result, a golf manufacturer started making the 'pre-dented' golf balls that you see today.

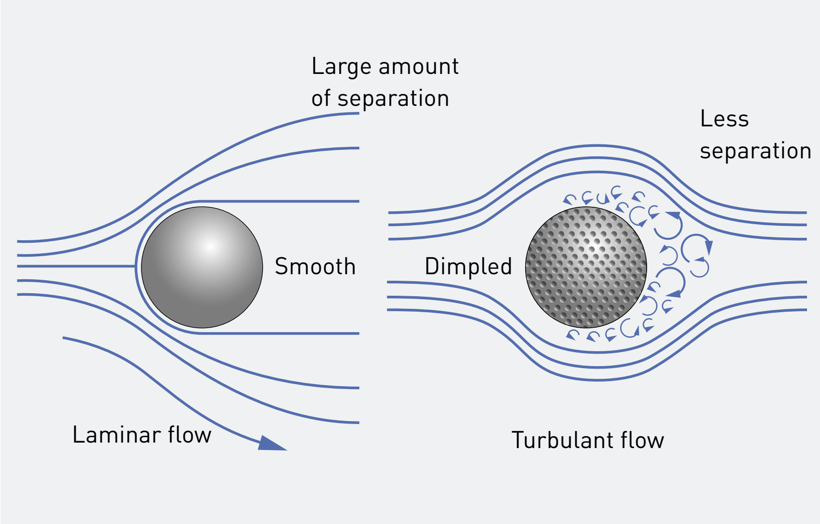


Figure 7.53 Air flows over a smooth ball differently from how it flows over a dented ball so that air resistance is decreased over the dented ball and it flies further.

Extend your understanding 7.10

1. Choose a sport in which you regularly participate.
2. List the forces and the machines involved in your sport.
3. Give an example of how these forces and machines interact in your chosen sport. When are the forces balanced or unbalanced? What evidence do you have that the forces are unbalanced?
4. Explain how you could maximise or minimise these forces in order to achieve better results in the sport.

*REVIEW

7

Remember and understand

1 Think back to the start of your day. Describe the forces that you experienced from the time you got up, to the time you arrived at school.

2 Copy and complete the following sentences.

a A force is a _______ or a _______ between _______ objects.

b To measure a force, you can use a _______ _______.

c The unit used to measure forces is called the _______. Its symbol is _______. The weight force of 50 g is about _______ newtons.

d When an object is not moving, its forces are said to be _______. Evidence of an unbalanced force is a change in _________, ____________ or ___________.

3 Which of the following involve forces, and which do not? Explain.

a Opening a window

b Turning a screw with a screwdriver

c Smelling food cooking

d Modelling clay

e Standing on a diving board

f Watching a candle burn

4 How is mechanical advantage calculated?

5 What is the difference between a contact force and a non-contact force? Give an example of each.

Apply and analyse

6 Explain the following in terms of friction.

a Gymnasts put chalk on their hands.

b People driving cars on ice or snow put chains on their tyres.

c A car uses more petrol when it has a load on the roof.

d It is hard to run on ice.

7 Investigate the action of an Olympic shot-putter.

a Why does the athlete bend backwards just before releasing the shot?

b What class of lever is formed by the upper torso?

c Identify as many levers acting as possible. Label each lever as first, second or third class.

Analyse and evaluate

8 Think about how far a toy car and a marble would roll along a flat bench. Which has the least friction? Which rolls the furthest? What is the connection between rolling and friction?

9 Consider the pulley system in Figure 7.54. How far will the 100 kg load rise if 2 m of rope is pulled through the pulleys?

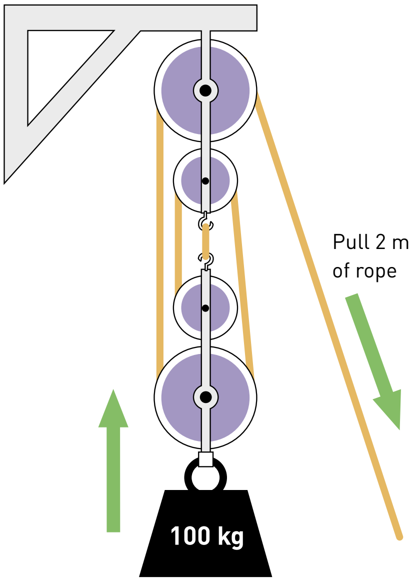


Figure 7.54

10 Figure 7.55 shows what happens when you stand on your toes.

  a What type of lever is formed by the foot when you do this?

  b Discuss why this lever is a force magnifier.

Figure 7.55

11 Investigate the kicking action of a soccer player.

  a Draw a picture of a leg kicking a ball. On your diagram identify which of the muscles are involved in moving the foot.

  b What class of lever is formed by the muscle and bone attachments?

  c Are they force magnifiers or distance magnifiers?

Critical and creative thinking

12 Suppose Matilda fills her car with petrol and drives 100 km along a freeway. She then turns off the freeway and travels 100 km along country roads, one of which is very rough.

  a Which part of the trip would the car use more petrol?

  b Explain your answer using your knowledge of forces and friction.

Review

13 Forces are needed to keep cells together, to pump blood around the body and to move our muscles. Research the different forces in the human body and how they work. Present your findings as a poster.

14 Musical instruments often use simple machines. For instance, levers are used in pianos. Consider the following questions as part of your research:

  a How are levers used in pianos?

  b Which other musical instruments use levers?

  c How does the lever help make sounds?

15 The wearing of seatbelts in cars was first made law in Australia in 1970. Research the materials that are used to make seatbelts. Use your knowledge of forces to explain how seatbelts prevent injury in a car accident.

16 Even though Leonardo da Vinci lived long before the Industrial Revolution, he designed numerous machines. Some of these machines were designed for civil purposes and some for military purposes. Find out about some of his machines. What types of simple machine did he use in his designs? Have any of his machines become a reality? What factors might have prevented his machines becoming a reality?

*KEY WORDS

7

air resistance
friction between a moving object and the air it is moving through

attraction force
the force that attracts one object to another

balanced forces
two forces equal in size and opposite in direction

block and tackle
group of pulleys mounted together in a frame or block, which provides significant mechanical advantage

calibrate
to check the accuracy of a meter against known measurements

distance magnifier
lever that changes a strong force that acts over a short distance into a weak force that acts over a longer distance

domain
very small section of a magnet

drag
see air resistance

effort
force used to operate a lever

electrostatic force
force between two objects caused by a build-up of negative charges

force
push or pull acting on an object

force magnifier
lever that can change a weak force into a strong force

friction
force that acts to oppose the motion between two surfaces as they move over each other

fulcrum
turning point of a lever

gravity
force of attraction that objects have on one another due to their masses

lever
simple machine that reduces the effort needed to do work

like poles
two north poles or two south poles of a magnet

load
resisting force

lubrication
using a lubricant, such as oil or grease, to decrease friction

magnetic field
three-dimensional space around an object where a magnetic force is experienced

magnetic poles
north and south ends of a magnet

net force
combination of all forces acting on an object

newton
unit used to measure force; symbol N

pulley
simple machine with a rope or chain in a groove around its edge that makes it easier to lift an object

ramp
simplest type of inclined plane

repulsion force
force that pushes one object away from another

screw
inclined plane

simple machine
a device that makes a task easier by changing the direction of the effort

spring balance
device consisting of a spring and a scale, used to measure forces in the laboratory

streamlining
making a surface smooth and rounded to reduce friction

thread
spirals around a screw

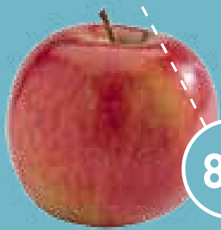
unbalanced forces
two or more forces that are unequal in size and direction and therefore change an object's speed, direction or shape

unlike poles
north and south poles of magnets

wedge
inclined plane that moves through another object and changes a downwards force to a sideways force

wheel and axle
lever that can rotate about its centre, magnifying force or distance

8 GRAVITY



8.1 Earth's gravity pulls objects to the centre of the Earth

8.2 Gravity keeps planets in orbit around the Sun

8.3 The Moon's gravity causes tidal movements

8.4 Scientists work collaboratively to explore microgravity

What if?

Parachutes

What you need:

plastic bag, string, paper plate, play dough, ruler, pen, timer, scissors, sticky tape, hole punch

What to do:

1. Mark a paper plate-sized circle on the plastic bag and cut it out.
2. Fold the circle into four and mark the folds. Open the circle and place a 2 cm piece of sticky tape over each mark.
3. Punch a hole in the plastic at each mark, 1.5 cm in from the edge.
4. Tie a 15 cm length of string through each hole.
5. Tie the other ends of all four pieces of string together and wrap the play dough around the tie.
6. Time how long it takes for your parachute to drop from a set height.

What if?

» What if the parachute was larger?

» What if the weight on the end was less?

8.1 Earth's gravity pulls objects to the centre of the Earth

In chapter 7, you learnt about different types of forces. Gravity is a non-contact force. We experience the effects of gravity every day. When you throw something in the air, the force of Earth's gravity pulls it back to the ground. **Gravity** is a force that pulls objects towards the centre of the Earth.

What is gravity?

One day in 1665, a young student named Isaac Newton was sitting under an apple tree when an apple fell to the ground. 'Why did it fall?' he wondered. There was nothing he could see that could push it or pull it. He realised that there must be a force that pulled the apple towards the Earth. This is how he first had the idea of gravity.

Gravity is the force that attracts an object to the centre of the Earth. This happens to people, animals and objects in every corner of the planet. Consider Figure 8.1. If everyone in the picture dropped an object, those objects would fall towards the centre of the Earth.

Every object that is made of matter (small particles called atoms) has gravity. The Earth is made up of enormous amounts of matter. As a result, it has a large **gravitational field** surrounding it. Even you have weak gravity surrounding you. The Earth has much more matter than you do, and therefore the Earth's gravitational field is much stronger than yours. The more matter an object has, the stronger its gravitational pull.

Figure 8.1 Gravity pulls objects to the centre of the Earth.

Figure 8.2 Gravity pulls base jumpers towards the centre of the Earth, 6371 kilometres below.

The difference between weight and mass

The Moon is made of less matter than the Earth. This means that the Moon's gravitational field is much less than the Earth's. An astronaut jumping on the Moon will be able to jump much higher than on Earth. This is because the Moon does not have as strong a pull force as the Earth. **Weight** is a measure of how much gravity pulls on an object. Your weight on the Moon would be less than on Earth. This does not mean you are smaller. It just means gravity is pulling you down less. Because weight is a measure of force, it is measured in newtons.

If weight is a measure of the force of gravity, then how do scientists describe the amount of matter of an object? **Mass** (measured in kilograms) is the term used to describe how many particles or atoms make up an object.

SKILLS LAB 8.1: CALCULATE WEIGHTS IN THE SOLAR SYSTEM
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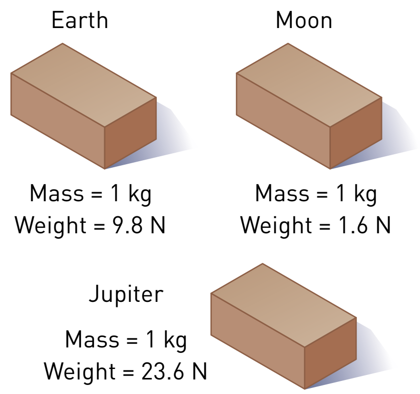

Figure 8.3 The mass of a brick doesn't change, but its weight is affected by gravity.

The mass of an object doesn't change, no matter where in the universe it is. If a brick has a mass of 1 kilogram on Earth, it has this mass everywhere. However, the weight of the brick will change; on Earth, the brick may weight 9.8 newtons, but on a large planet like Jupiter it would weigh 23.6 newtons. On the Moon, the brick it would weigh approximately 1.6 newtons because the Moon is small and has less gravitational pull.

Gravity changes

As you move away from the Earth, the gravitational force slowly decreases. This means that if you stand on a chair your weight will have decreased slightly. Most scales will not be sensitive enough to measure this small change. However, if you stood on the top of Mount Everest, you would be several kilometres away from the centre of the Earth. As a result, your weight (the amount of pull force the Earth exerts on you) is 0.25% less than if you were at sea level.

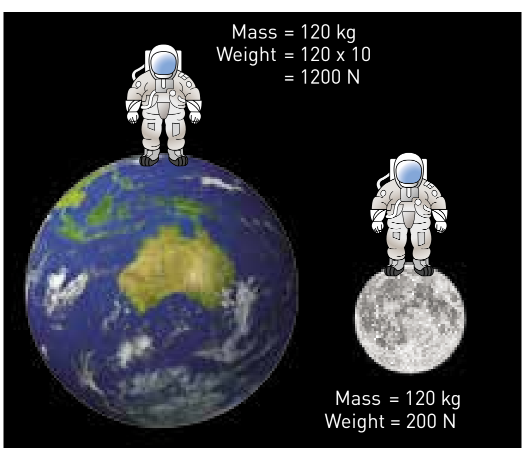

Figure 8.4 A person who wants to lose weight should go to the Moon. A person who wants to lose mass, should go on a diet.

Gravity is not the same for every object. Objects with a larger mass experience a greater gravitational pull than objects with less mass. This means a 3 kg medicine ball feels a stronger pull of gravity than a basketball does. Does this mean the medicine ball will fall faster than the basketball?

If you do this experiment, you will find that both balls hit the ground at exactly the same time. This is not what most people expect to happen. Logic suggests that heavier things fall faster. You may need to do the experiment a few times until you believe it. The heavy medicine ball needs more force to start it moving than the basketball. This offsets the larger gravitational pull on the medicine ball, so both balls hit the ground at the same time.

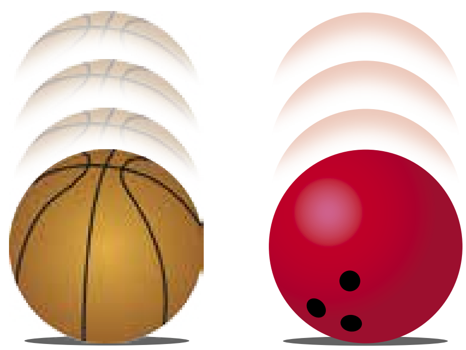

Figure 8.5 A bowling ball has more mass than a basketball. Although gravity pulls more on the bowling ball, they both fall at the same speed.

Check your learning 8.1

Remember and understand

1. What is the difference between mass and weight?
2. Who first described gravity?
3. If a half-full water bottle was dropped from the top of a flight of stairs at the same time as a full bottle of water, which would hit the ground first?
4. True or false: the pull of gravity is stronger on an elephant than on a feather.

Apply and analyse

5. An astronaut on the Moon dropped a feather and a hammer at the same time. There is very little atmosphere on the Moon to slow down objects. Explain why the feather and hammer hit the ground at the same time.

Evaluate and create

6. Building a settlement on the Moon has been suggested several times since Buzz Aldrin first walked on the Moon. What advantages and disadvantages would there be in building such a structure in a low-gravity environment?

8.2 Gravity keeps planets in orbit around the Sun

The Sun has so much mass its gravity affects all the planets, **dwarf planets** and **moons** in the solar system. The Earth orbits the Sun, while the Moon orbits the Earth.

Jailed for being a scientist

Figure 8.6 Nicolas Copernicus.

In ancient times, humans believed that the Sun, planets and **stars** travelled around the Earth. This was a natural thought. During the day we see the Sun move across the sky, and at night the Moon and stars move in set patterns that vary according to the time of year. Few people thought to consider that the big, flat ground we walked on could also be moving through space. Some scientists spent many years trying to explain the complex movements of the stars in the night sky. Some stars even appeared to travel backwards every month.

It wasn't until the 16th century that Polish **astronomer** Nicolas Copernicus considered a very outrageous explanation for this phenomenon. Instead of the Sun travelling around the Earth, he suggested that the Earth travelled around the Sun. His idea only reached a small number of people before his death two months later.

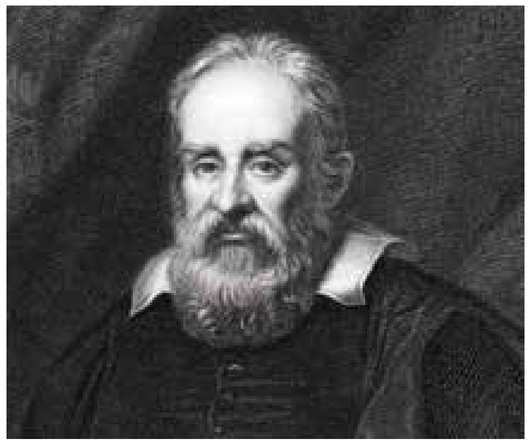

Figure 8.7 Galileo Galilei.

It wasn't until 100 years later that the Italian scientist Galileo Galilei was able to use a basic telescope to perform calculations that supported Copernicus' theory. Galileo published his evidence supporting Copernicus and confirming that the Earth travelled around the Sun. This upset the the authorities, who preferred to consider that humankind

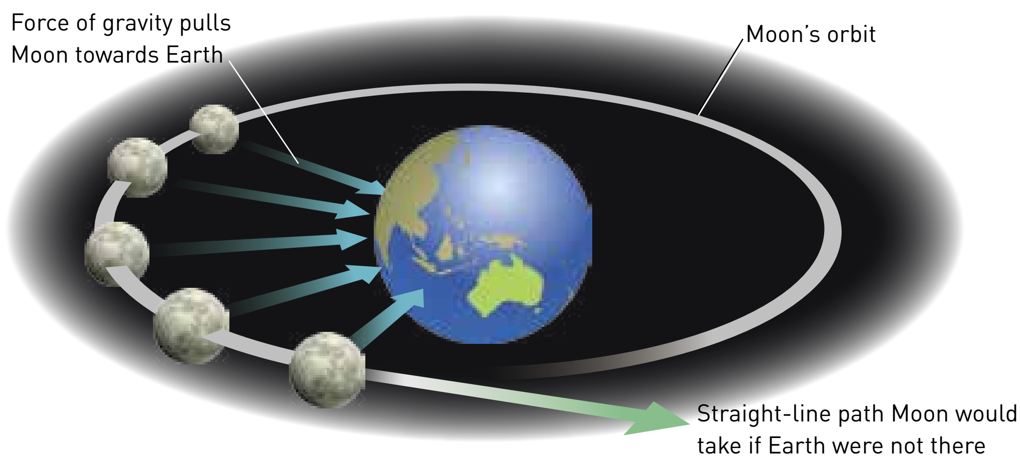

Figure 8.8 The Moon's orbit is determined by its size and the force of gravity exerted on it by the Earth.

CHALLENGE 8.2: MODELLING GRAVITY IN THE SOLAR SYSTEM
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was the centre of the universe. As a result, Galileo was called to Rome and faced trial. Galileo was cleared of all charges, but he was warned that he should no longer publicly state his belief that the Earth travelled around the Sun. Galileo maintained his studies quietly for the next 20 years before publishing a book restating his beliefs with all the underlying evidence. As a result, he was convicted of being a heretic (a person who opposed the churches teaching). Because of his age, Galileo was placed under house arrest for the remaining 10 years of his life.

The balance of forces in space

The Sun has the largest mass of anything in the solar system. Its mass is 1000 times larger than the largest planet, Jupiter. All planets in the solar system travel around, or **orbit**, the Sun.

An orbit is the result of a planet moving through space. As the planet tries to travel forwards, it is also pulled in by the Sun's gravity. As a result, the planet ends up travelling around the object with the larger mass.

This also happens when the Moon moves around the Earth. There is a balance of forces between the forwards motion of the Moon and the gravitational pull of the Earth. This means that the Moon orbits the Earth every 27 days.

Although the orbit of the Moon appears to be constant, the Moon is slowly moving away from the Earth by approximately 3.7 cm every year. This is about the same speed that your fingernails grow. Although this may worry many people, it would take many thousands of years before this would have any noticeable impact on our lives. More than enough time for humans to develop a way to travel to yet another planet orbiting the Sun.

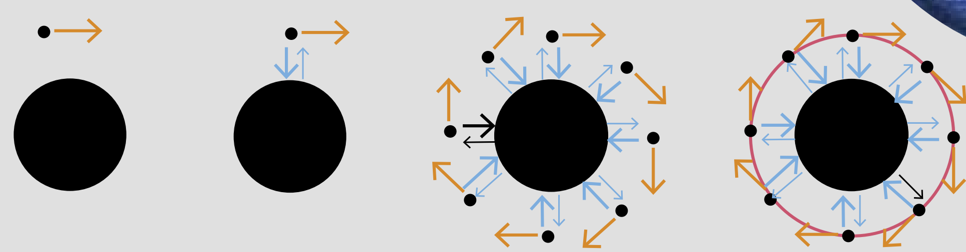


Figure 8.9 A satellite's motion is a balance of forwards motion and the pull of gravity.

Check your learning 8.2

Remember and understand

1 Who was the first scientist to suggest the Earth travelled around the Sun?

2 Why was Galileo put under house arrest?

3 What causes the planets to orbit the Sun?

Apply and analyse

4 'The Earth orbits the Moon.' Explain what is wrong with this statement. Provide evidence to support your view.

Evaluate and create

5 Research one possible impact of the Moon no longer orbiting the Earth.

8.3 The Moon's gravity causes tidal movements

The relationship between the Moon and the tides was recognised by early Indigenous Australians. Arnhem Land stories tell of high tides filling the Moon. As the tide falls, the Moon is left empty for 3 days before filling once more.

What causes tidal movements?

The Earth's gravitational pull holds the Moon in orbit. The Moon has its own gravity, even though it is far less than the Earth's. The effects of gravity are related to the size of an object and its distance from the objects on which it acts. The Moon is approximately one-quarter the size and one-eightieth the mass of the Earth, so its gravity is much weaker, but it is very close so its gravity has some effect. The gravitational pull of the Moon causes the oceans to bulge out in the Moon's direction. This causes the oceans to cover slightly more land, which we see on the Earth as a **high tide**. The Earth is also being pulled towards the Moon (and away from the water on the opposite side), so another high tide occurs on the opposite side of the Earth. As the Moon travels around the Earth and as both bodies travel around the Sun, the combined force of gravity causes the world's oceans to rise to high tides and fall to low tides. Because the Earth is rotating while this is happening, two high tides occur each day, approximately 11 hours apart. High tides happen when the land at the beach turns towards the water being pulled by the Moon's or Sun's gravitational field. Low tides happen when the land turns away from the water bulge.

When the Sun, Moon and Earth are aligned, the combined pull of the Moon and the Sun causes very high tides in some parts of the Earth. These are known as **spring tides** (Figure 8.10). Smaller

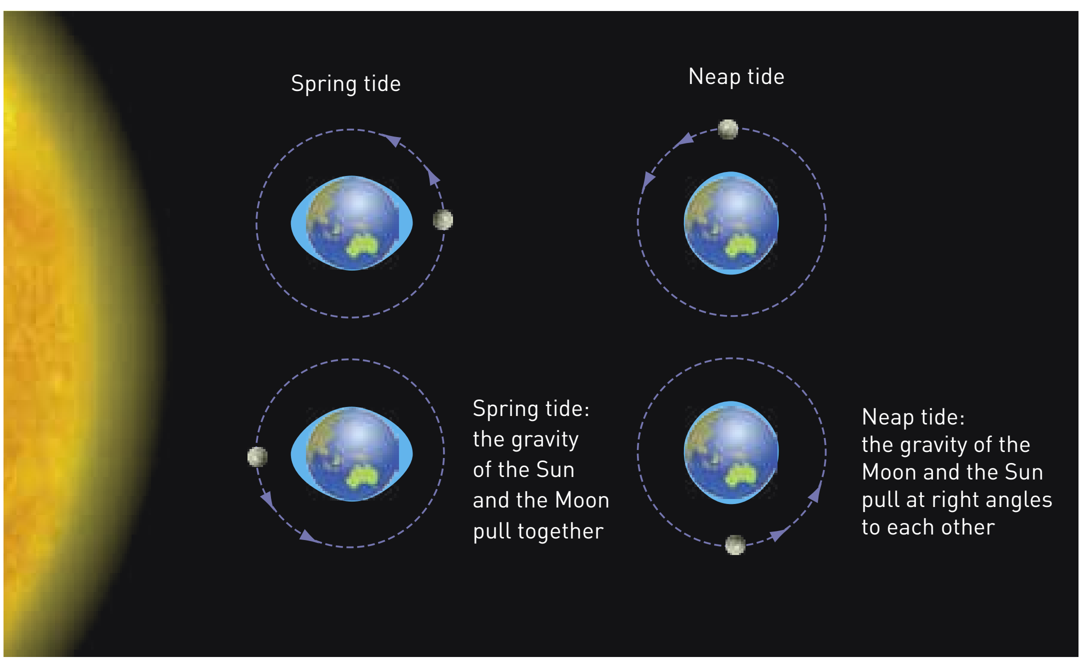


Figure 8.10 The Moon's gravitational pull on the oceans creates spring and neap tides. (The bulges shown here have been exaggerated so they are easier to see.)

neap tides occur during the Moon's quarter phases. At these times the Sun and Moon are at right angles to the Earth, causing the sea tides to be pulled in both directions at once.

World's biggest tides

The biggest change in the depth of water between low and high tide occurs at the Bay of Fundy in Nova Scotia, Canada. Twice a day, 100 billion tonnes of sea water flows in and out of the Bay of Fundy. This is more than the combined flow of the world's freshwater rivers. The narrow, funnel-shaped inlet causes changes in depth of up to 17 metres, making life interesting for boating.

Calculating tides

Table 8.1 shows the times of high tide at Williamstown, in Melbourne, Victoria, over three days in February 2008. To calculate the difference in height between the two high tides on Friday, one being 0.79 m at 4.20 am and the other 0.72 m at 3.16 pm, subtract the smaller tide from the larger tide: 0.79 – 0.72 = 0.07 m.

a

b

Figure 8.11 (a) High tide and (b) low tide at the Bay of Fundy, Nova Scotia, Canada.

Table 8.1 High tides in Williamstown, Melbourne, in February 2008

FRIDAY 8 FEBRUARY		SATURDAY 9 FEBRUARY		SUNDAY 10 FEBRUARY	
TIME	HEIGHT (M)	TIME	HEIGHT (M)	TIME	HEIGHT (M)
4.20 am	0.79	4.52 am	0.80	5.22 am	0.82
10.19 am	0.42	11.00 am	0.36	11.40 am	0.31
3.16 pm	0.72	4.20 pm	0.75	5.15 pm	0.79
10.17 pm	0.18	11.02 pm	0.19	11.42 pm	0.22

Check your learning 8.3

Remember and understand

1 Why does the Moon have a greater effect on the tide levels than the Sun?

Analyse and apply

2 Referring to Table 8.1, calculate the difference between:

  a the last high tide on Saturday and the next one on Sunday

  b one high tide and the following low tide on Saturday.

3 Can you predict the times and heights of the tides for Monday?

Evaluate and create

4 For 1 week, graph the high and low tide levels of a beach in your state. Compare this against the times of Moon rise and set. Can you find any correlation between the two? Describe the relationship between Moon's position and tide levels.

//SCIENCE AS
A HUMAN ENDEAVOUR//

8.4 Scientists work collaboratively to explore microgravity

The International Space Station (ISS) is a project shared between space agencies from the USA, Russia, Japan, Canada and 11 European countries. The ISS has been continuously inhabited since the first resident crew of three in 2000. Although the astronauts appear to float, they are experiencing **microgravity**.

The International Space Station

The ISS is a research facility that is being assembled in space. Assembly began in 1998. The ISS orbits the Earth approximately 350 kilometres above the Earth's surface and can be seen from the Earth with the naked eye. Travelling at a speed of 27 700 km/h, it orbits the Earth 15.8 times a day.

The ISS will eventually consist of 14 pressurised sections that include laboratories, docking compartments and living quarters. It is powered by the Sun using solar panels. Atmospheric pressure, oxygen levels, water and wastes are all controlled on board the ISS. Scientific research is being done in biology, physics, astronomy and meteorology.

A long-term goal of the research is to develop the technology for humans to explore and colonise space and the planets. The ISS will operate until around 2016.

Figure 8.12 The International Space Station is being assembled in space.

Microgravity

Although the force of gravity decreases as you move further away from the centre of the Earth, astronauts on the ISS still experience very small amounts of gravity called microgravity. The space station orbits the Earth approximately 350 km above the Earth's surface. Even at that height an astronaut who weighs 500 newtons on Earth would still weigh 450 newtons on the station. The reason why the astronauts appear to float is because they are moving at the same rate as the space station. Yes, the space station is falling towards Earth too. It is falling at a very slow rate that the astronauts correct slightly every day. Because the space station is slowly falling and the astronauts inside it are falling at the same rate, they appear to float. Their gravity, relative to the cameras on the space station, is zero.

Figure 8.13 Astrounauts in space still experience small amounts of gravity called 'microgravity'.

The effects of microgravity on the astronauts

Astronauts can spend months in the microgravity environment of the space station and this has an effect on their body. Because their bones and muscles do not have to work very hard, they become weaker. This makes it more likely that the astronauts will break their bones when they return to Earth. The heart is also a muscle and it is also changed by microgravity. In the first few weeks after astronauts return to Earth, they can experience problems standing up, walking and turning around.

Mission to Mars

NASA is already planning a crewed mission to Mars. But could humans travel all the way to Mars? The trip is expected to take 7 months to complete. This means the astronauts will be travelling in microgravity for all that time. Once they get to Mars, the gravity there will be less than half that on Earth (62% less than on Earth). By the time the astronauts return to Earth, they will have spent almost 2 years in microgravity. What effect will this have on their bodies?

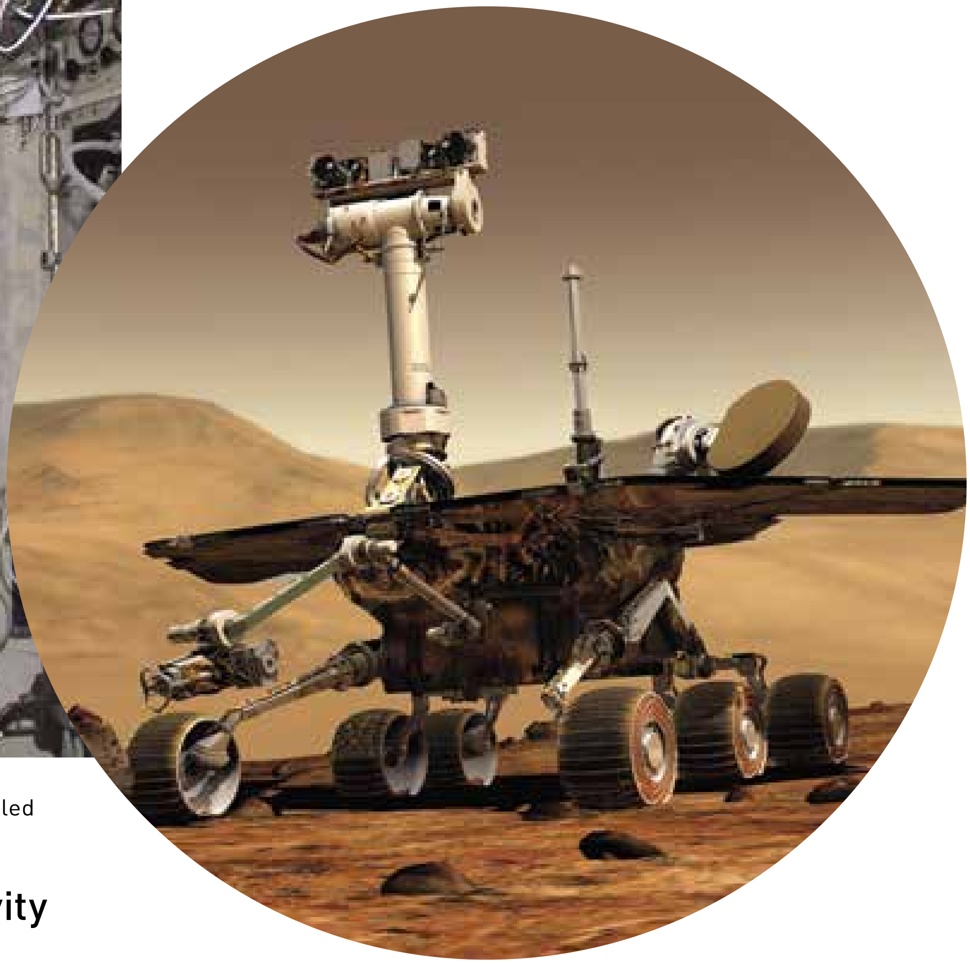


Figure 8.14 The Mars exploration rovers are being used to explore the possibility of humans living on Mars.

Extend your learning 8.4

Remember and understand

1 What is microgravity?

Apply and analyse

2 Why are rockets needed to launch spacecraft?
3 A student said astronauts are weightless on the space station. Do you agree? Explain your answer.
4 Why do you think we send probes into space rather than humans?

Evaluate and create

5 What sort of knowledge about our bodies has been discovered as a result of sending astronauts to the space station?
6 What is the benefit of having an International Space Station?

*REVIEW

8

Remember and understand

1 Who was Sir Isaac Newton?

2 What is the difference between mass and weight?

3 Why did many people originally think the Sun moved around the Earth?

4 Who was Nicolas Copernicus?

5 What is a gravitational field? How does the gravitational field of the Sun affect the planets?

6 Your mass at a given time remains the same, regardless of gravity. Your weight, however, changes as a result of gravity.

  a Why isn't the mass of any object changed by gravity?

  b Why does the weight of an object sometimes change?

7 Why was the Catholic Church upset by Galileo's claims in the 17th century?

Apply and analyse

8 Our Sun is part of a spiral galaxy that is spinning. Why might scientists think there is a heavy object in the centre of the galaxy?

Figure 8.15 Our solar system is part of the spiral Milky Way galaxy.

9 Imagine life on the Moon. Write a paragraph describing how your day would have been different if you lived on the Moon. Which actions would be easier? Which actions would be harder or impossible?

Figure 8.16 Astronaut Alan Shephard hitting a golf ball on the Moon.

Evaluate and create

10 When sky divers step out of an aeroplane they begin to fall towards the Earth. What causes this?

11 Why would animals and plants living near a high tide mark need to be more resilient than those living near a low tide mark?

12 An adult male elephant has a mass of 7000 kg. Predict the mass of the elephant if it were:

  a in your bedroom

  b on top of Mt Everest

  c on the Moon

  d swimming in the ocean.

13 You are slightly shorter at the end of the day than when you wake up in the morning. In a small group, design an experiment to test this hypothesis. Conduct the test over a series of days. Compile your results and compare your group's results with those of other groups in the class. As a group, come up with a conclusion for this experiment that draws on your knowledge of gravity.
   a Was your hypothesis supported by the results??
   b Did your group work well together?
   c How would you change your experiment next time?
   d Evaluate your own contribution to this experiment and give yourself a score out of 5 (5 being 'excellent', 1 being 'needs improvement') for:
      i group cooperation
      ii listening to other members of the group
      iii being reliable
      iv doing your homework.

14 Write a creative short story called 'A day without gravity'. You might begin by listing the main activities in your day, then considering how they are affected by gravity. Incorporate as many examples into your story as possible.

15 How is gravity responsible for the Earth's interactions with the Sun and Moon? How important is this effect of gravity on the ability of the Earth to support life? How have modern technologies improved our understanding of the effects of gravity?

Research

Choose one of the following topics on which to conduct further research. A few guiding questions have been provided for you but you should add more questions that you wish to investigate. Present your findings in a format that best fits the information you have found and understandings you have formed.

Keeping time

We often think of time as a fixed amount, 24 hours in a day, 60 minutes in an hour, 60 seconds in a minute. Most time is regulated by the appearance of the Sun in the sky. Find out about the time zones across Australia and the world. How are the time zones set? How does this affect astronauts on the space station?

Living on the space station

Astronauts living on the International Space Station face many challenges to their everyday living conditions. This has necessitated the invention of many things to make their life possible. Research ten things that were invented to help astronauts survive. Record why each invention was needed and how it solved the problem.

Famous astronauts

Research the first animal that went into space. What type of animal was it? What country was it from? Did it return to Earth? Research an astronaut. It may be the first man or woman who went into space, the first person to land on the Moon or an astronaut who is currently on the International Space Station. Find out their profession, age and country of origin.

Careers with space

Becoming an astronaut is just one way to be involved in working in space. Research other careers that are involved in the space programs around the world. What type of qualifications do you need to work in this area? What types of things would you do in an average day? What would be the most challenging part of your job?

*KEY WORDS

8

astronomer
scientist who studies planets, stars and the solar system

gravitational field
the area around a body in which another body experiences a force of attraction

gravity
force that pulls objects towards the centre of the Earth

high tide
when oceans cover slightly more land

low tide
when oceans cover slightly less land

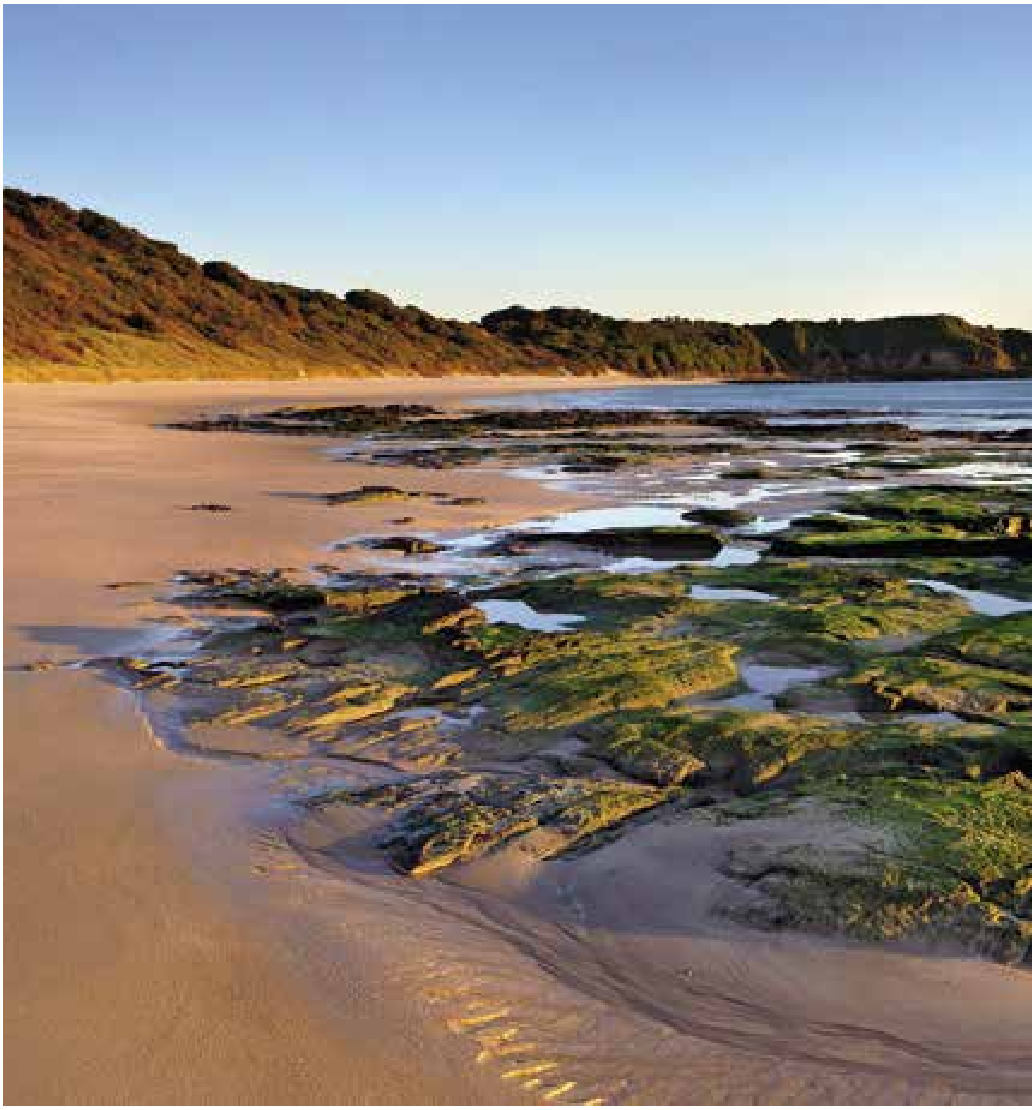
mass
how many particles or atoms make up an object; the mass of an object does not change

neap tides
smaller tides that occur during the Moon's quarter phase

orbit
the path a planet moves around the Sun/star, or a moon moves around a planet

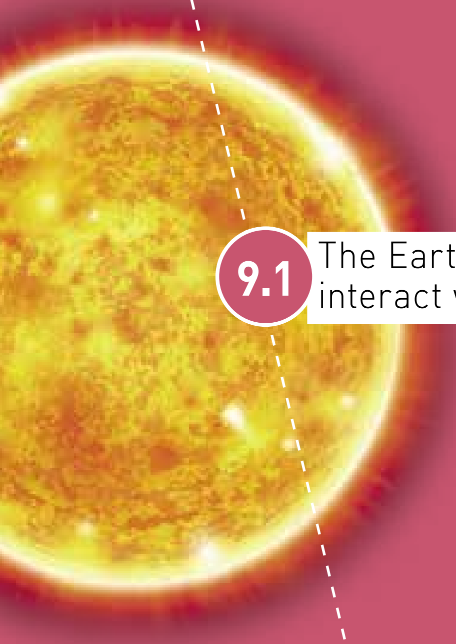
spring tides
high tides caused by the combined pull of the Moon and the Sun

weight
a measure of how much gravity is pulling on an object



EARTH, SUN AND MOON

9



9.1 The Earth, Sun and Moon interact with each other

9.2 The Moon reflects the Sun's light

9.3 Seasons are caused by the tilt of the Earth

9.4 Astronomers explore space

What if?

Modelling the Earth and Moon

What you need:

2 balloons, ruler

What to do:

1. Blow up one balloon until it is 20 cm in diameter. This represents the Earth.
2. Blow up the other balloon to 5 cm in diameter. This represents the Moon.
3. Move the two balloons until they are 5 metres apart. This represents approximately how far the Earth is from the Moon.
4. With your partner, discuss what effect the Moon has on the Earth.
5. Does the Moon always look the same size?

What if?

» What if the Moon was closer to the Earth? Would we notice any difference?

» What if you needed to include the Sun in your model?

9.1 The Earth, Sun and Moon interact with each other

Scientists have explored the relationship between the Earth, Sun and Moon for hundreds of years. We know the Moon orbits the Earth every 27 days, whereas the Earth orbits the Sun every 365.25 days. How does this cause solar or lunar eclipses?

Figure 9.1 The Earth is held in orbit by the Sun's gravitational pull.

Our Sun is a star. It is the closest star to Earth and provides all the energy for every living thing. This **solar energy** is made by atoms colliding with each other in the centre of the Sun. Without the heat and light given off by the Sun, there would be no life on Earth.

Our small planet (it is the fourth smallest in the solar system) is one million times smaller than the Sun. The **solar system** is made up of the Sun at the centre and all the planets, dwarf planets, moons and **asteroids** that travel around the Sun or each other. The path taken by a planet is called its orbit because of its oval or 'elliptical' shape.

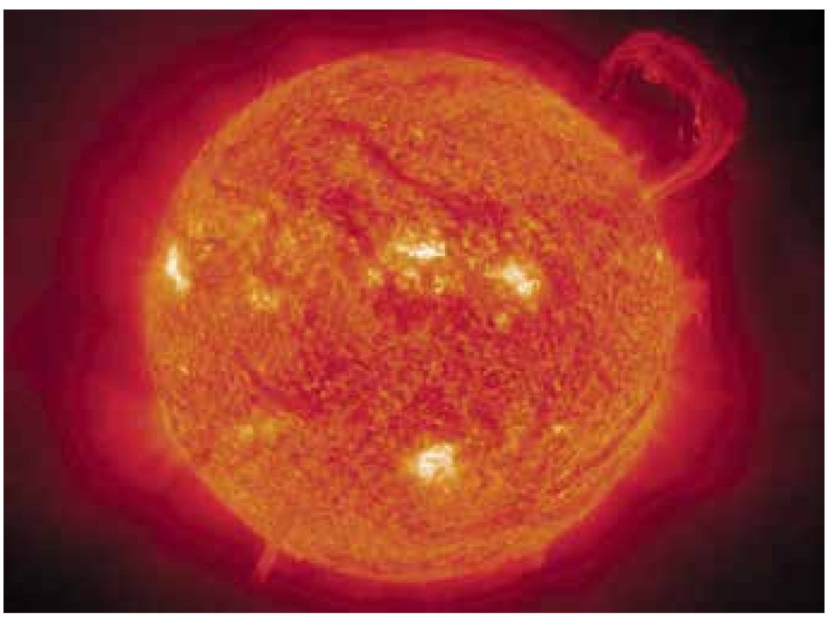


Figure 9.2 A solar flare is just one indicator of the powerful nuclear reactions happening inside the Sun. Solar flares begin as bright regions and result in explosions (top right).

A year

A year is the time it takes a planet to make one orbit around the Sun. It takes the Earth 365.25 days to complete one orbit. This means that every 4 years our calendar is one full day behind (4 × 0.25 days). We account for this by adding an extra day (29 February) every **leap year**.

Night and day

Day and night are caused by the Earth spinning on its **axis**, an imaginary straight line joining the North and South Poles. You can model this in your classroom. Stand facing the front of the room and turn around on the spot until you face the front once again. This is one complete rotation. The Earth takes 24 hours to complete one full rotation.

Because of its shape, only half the Earth is exposed to sunlight at any given time. The other half is in shadow. The part facing the Sun is experiencing daytime, whereas the part facing away from the Sun is experiencing night. Because the Earth rotates, all parts of the Earth experience day and night, just at different times.

In Figure 9.3, it is daytime for countries on the right and night-time for those on the left. Can you tell in which countries the Sun would be rising or setting?

Have you ever watched the New Year's Eve celebrations around the world on television? The celebrations in New Zealand are always just before those in Australia. The Earth rotates west to east. We know this because as the Earth spins towards the Sun we see the Sun rise above the horizon in the eastern sky. Sunset occurs when your part of the Earth rotates away from the Sun. New Zealand is east of Australia, so the Sun rises in their sky first.

CHALLENGE 9.1: MODELLING HOW THE EARTH MOVES IN SPACE
GO TO PAGE 211

Solar eclipse

The Moon passes between the Sun and the Earth once every 27.3 days. Occasionally, the Moon will be in a position where it blocks some of the light from the Sun. This is known as a **solar eclipse**. During a **total solar eclipse**, the Moon blocks the maximum amount of light from the Sun and the sky goes dark for a short time during the day. The last total eclipse of the Sun visible from northern Australia was on 13 November 2012; the next one is due on 20 April 2023 in Western Australia.

When a total eclipse is visible in Australia, people somewhere else in the world may only see a **partial eclipse**. This is when only some of the Sun's light is blocked. Because the Earth and Moon are always moving along their orbits, an eclipse takes a few minutes and then gradually passes as the Earth and Moon continue their motion.

WARNING! NEVER LOOK DIRECTLY AT A SOLAR ECLIPSE BECAUSE IT CAN CAUSE PERMANENT DAMAGE TO YOUR EYES.

Figure 9.3 The half of the Earth facing the Sun experiences day and the half in shadow experiences night.

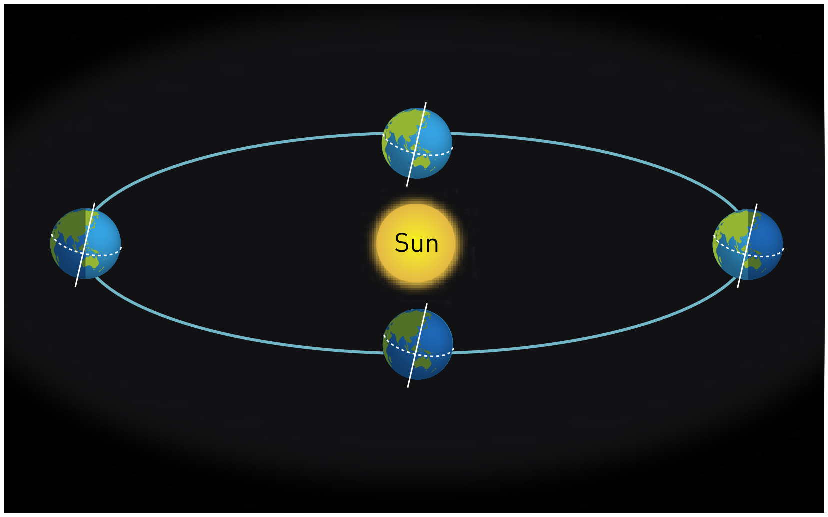


Figure 9.4 What sort of eclipse is visible in different parts on Earth can be explained by angles.

Check your learning 9.1

Remember and understand

1. What is the difference between 'rotation' and 'orbit'?
2. Match these terms with the listed explanations: *day*, *night*, *year*.
   a. experienced by the part of the Earth that is facing away from the Sun
   b. name for the rotation of the Earth over 24 hours
   c. time for the Earth to orbit the Sun once
3. Why do we have a leap year every four years?
4. What is the difference between total and partial solar eclipse?

Analyse and apply

5. Why couldn't you in Melbourne and a friend in Darwin see exactly the same solar eclipse?

Evaluate and create

6. Compare the different time zones around the world. Describe what people in America, China, Africa and France be doing while you are having lunch.

9.2 The Moon reflects the Sun's light

Figure 9.5 Galileo's observations through his telescope showed that the Moon's surface was not smooth.

Many scientists believe that a giant collision between two planetary bodies resulted in the formation of Earth and the Moon. Early astronauts collected samples from the surface of the Moon and compared them with the surface of Earth: they are almost identical.

The first scientific description of the Moon was made in 1609 by the Italian astronomer and physicist Galileo, based on his observations through a telescope. At the time it was believed that the Moon had a smooth surface, which explained its ability to reflect light from the Sun. Galileo knew differently. He saw the rough, mountainous terrain and vast craters that we know cover the surface of the Moon. He even described large flat plains that we call 'maria' (pronounced MAHR-ee-ah; Latin for 'seas') because they look like dark oceans. We now know these plains to be solidified lava.

Moonlight

Unlike the Sun, the Moon does not create its own light. Instead, it reflects sunlight. The amount of light reflected varies with the different phases of the Moon, but even the full Moon only provides a faint light that appears bluish to the human eye. We always see the same side of the Moon from Earth because the Moon rotates at the same speed as it orbits. This is just like walking around a person, making sure that you always face towards them. The Moon takes 27.3 days to completely orbit the Earth.

Sometimes, only a part of the Moon is visible. You might see half a Moon or a crescent or a fully round Moon. Sometimes the Moon can't be seen at all, even though it is in the sky. These changes in the shape of the Moon are called the **phases of the Moon** (Figure 9.6). Of course, the Moon does not change shape – it is always round. What changes is the amount of the Moon that is lit by the Sun, which makes it possible for us to see the Moon from Earth. We are really looking at the 'day' and 'night' parts of the Moon. The Moon rises and sets, just like the Sun. The Moon rises approximately 50 minutes later from one day to the next. The Moon is always in the sky, but during the day the sky is usually so light that the Moon is hard to see.

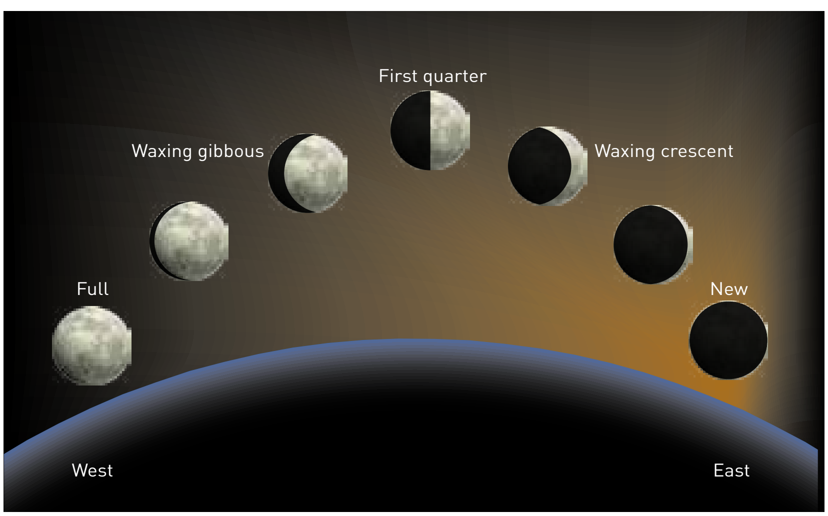


Figure 9.6 Phases of the Moon.

Exploring the Moon

The Moon is the only body in space on which humans have actually stepped. It has a weak gravitational pull and very little atmosphere; therefore, there is not enough oxygen to breathe. Astronauts must wear space suits fitted with breathing apparatus.

Neil Armstrong and Edwin 'Buzz' Aldrin were the first humans to walk on the Moon, in July 1969 as part of the *Apollo 11* mission. They found 'kangaroo hopping' easier than walking on the Moon. The astronauts could jump higher and further because the force of gravity on them was only about one-sixth of Earth's gravity.

CHALLENGE 9.2: MODELLING THE PHASES OF THE MOON
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THEIR DAY ON THE MOON

SOUVENIR ISSUE

EARLY today Neil Armstrong and Edwin Aldrin were dozing in the Eagle after their historic two-hour walk on the moon. They were due to blast off at 3.55 a.m. to rejoin the Columbia command ship after 21 hours 7 minutes on the Sea of Tranquillity.

The Sun NEWS-PICTORIAL

Figure 9.7 The first Moon landing was televised around the world and was front-page news on 21 July 1969.

The surface of the Moon is made of fine grains of dust that stick together like damp sand. The footprints made by the *Apollo 11* astronauts should still be visible in a million years because there is no erosion to destroy them. However, the footprints may be covered with dust from meteor impacts.

Figure 9.8 Australian scientists at the Parkes Observatory played a critical role in the Moon landing.

Figure 9.9 A time-lapse photograph of a lunar eclipse.

It was possible to beam images of the Moon landing around the world because of the satellite dishes located at Honeysuckle Creek in Canberra and Parkes in New South Wales.

Lunar eclipse

A **lunar eclipse** occurs when the Earth moves between the Moon and the Sun. The Moon passes into the Earth's shadow and appears dark (see Figure 9.9).

Check your learning 9.2

Remember and understand

1 True or false?
   - a The Moon creates light.
   - b The Moon does not supply light to the Earth.
   - c The Moon changes shape during different phases.
   - d Tides are controlled by the Sun.
   - e The Moon is the closest body in space to the Earth.
   - f Craters are large indentations on the Moon's surface.
   - g Astronomers are pseudoscientists.
   - h The Moon is small compared to other moons in our solar system.
   - i We can see both sides of the Moon from the Earth.

Apply and analyse

2 The Greek scientist Aristotle noticed that, during lunar eclipses, the Earth's shadow was always round. How did this lead him to suggest the Earth was spherical in shape?

Evaluate and create

3 Research an alternative explanation for the phases of the Moon as told by early Indigenous Australians. How did they explain the variation in the appearance of the Moon?

9.3 Seasons are caused by the tilt of the Earth

*

July in Australia is often the coldest month. It is the middle of winter. In Europe and North America, July is the middle of summer and many people enjoy their summer holidays. This difference in seasons is caused by the tilt of the Earth.

Figure 9.10 Early Indigenous astronomers marked the movement of the Sun with waist-high stones.

The arrangement of stones shown in Figure 9.10 was found at Little River, Victoria, by European settlers nearly 200 years ago. The layout of 100 large boulders is thought to have been set out by the Wadda Wurrung people, the traditional inhabitants of the area. It is only recently that archaeologists have discovered that the 1-metre high rocks at the ends of the egg shape mark the points where the Sun sets during the middle of winter (the winter **solstice**) and the middle of summer (the summer solstice).

Summer

The Earth does not rotate evenly. Rather, the Earth rotates around an imaginary line (the axis) that is on an angle of 23.5 degrees. This means that for part of the year the southern hemisphere (including Australia) is tilted towards the Sun. The days are longer and the nights are shorter. The Sun is higher in the sky. This allows more time for the Sun's rays to hit the ground and therefore warm up the air. We experience summer. The Wadda Wurrung people knew this, and placed stones that marked the place where the Sun set during the longest day (21 December). This is called the summer solstice.

Equinox

After 21 December, the Earth continues its orbit around the Sun, slowly angling the southern hemisphere away from the Sun. Twice a year (in autumn on 20 March and in spring on 22 September) the position of the Earth allows an equal length of day and night. This is called the **equinox**. The Wadda Wurrung people marked the sunset of these events with the equinox stone.

Figure 9.11 The seasons are caused by the Earth's rotation at an angle of 23.5 degrees.

CHALLENGE 9.3: MODELLING THE SEASONS
GO TO PAGE 212

Winter

In winter, the southern hemisphere is angled away from the Sun. This means the Sun shines lower in our skies and for less time. As a result, there is less time for the Sun to warm up the ground and therefore the air is cooler. We experience winter. The shortest day (21 June), the winter solstice, was also marked by the Wadda Wurrung people.

The Wadda Wurrung people found a way to mark the movement of the Sun, and hence the seasons, without using telescopes or undertaking long sailing trips around the world.

The northern hemisphere's seasons are the opposite of ours, so during a northern summer there is a southern winter.

This tilt of the Earth is more noticeable in the Antarctic. In the summer, the tilt of the Earth causes the Sun to remain in the sky for five months. The Sun does not set; instead, it sits just above the horizon for the whole time.

The reverse is true for winter in the Antarctic. The angle of the southern hemisphere away from Sun means the Sun sets in May and does not rise again until July.

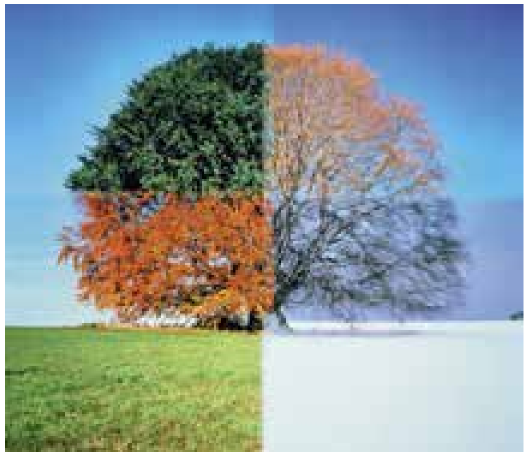


Figure 9.12 Deciduous plants change with the seasons.

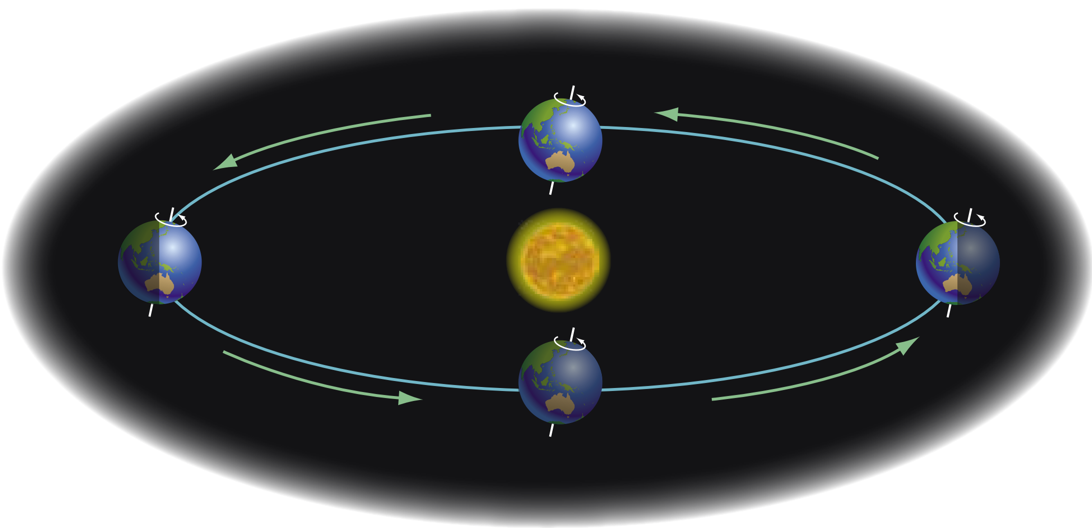


Figure 9.13 The Earth's rotation and orbit cause day and night, as well as the seasons.

Check your learning 9.3

Remember and understand

1 Match the four seasons experienced in Australia with the letters on Figure 9.14.

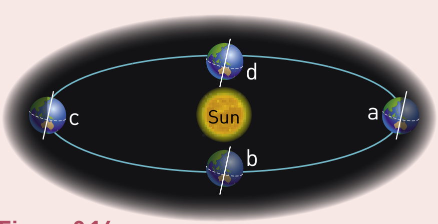


Figure 9.14

2 What is the angle of the Earth's rotational tilt away from the Sun?

Analyse and apply

3 Use the motion of the Earth around the Sun to explain why January is hotter than July in Australia.

Evaluate and create

4 What other evidence can you find that the traditional inhabitants of Australia were aware of celestial events such as eclipses and the phases of the Moon?

//SCIENCE AS A HUMAN ENDEAVOUR//

9.4 Astronomers explore space

* It can take many years of travel for a rocket to land on another planet. Scientists therefore need to rely on other methods to learn about space.

Astronomy

Astronomy is one of the oldest sciences, and astronomy and astrology used to be intertwined. Ancient astronomers believed that stars were permanently fixed to a heavenly sphere and never changed. They tracked the movement of the planets against these heavenly lights, which they grouped into constellations, and used these observations to calculate time and develop calendars. From this they determined the seasons and calculated the best time to plant their crops. They observed solar and lunar eclipses, and used the positions of the stars and planets to navigate the oceans.

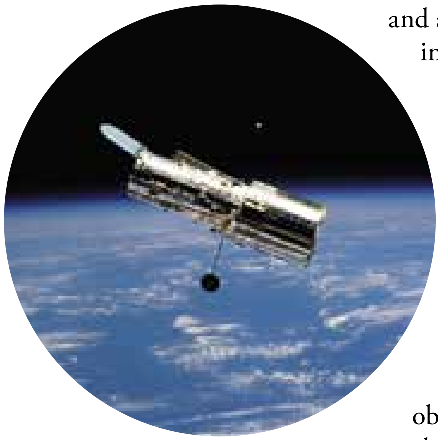


Figure 9.15 The Hubble Space Telescope is in orbit around the Earth.

It is impossible to send a space probe to galaxies, stars or even gas clouds that are millions of light-years from Earth and yet we know so much about these bodies. To view stars and galaxies, we use instruments such as telescopes and spectroscopes.

Telescopes

A lot of information can be gathered about our Sun and distant stars by analysing the light coming from them.

Analysing this light reveals information about distant galaxies and stars that would otherwise be impossible to get.

Figure 9.16 An early example of a telescope to view the stars.

Telescopes have been used since the 17th century to view distant objects. The most common type of telescope used in astronomy is the optical telescope. This works by collecting more light than the human eye can collect and then focusing this light using lenses or mirrors. A distant object viewed through an optical telescope becomes brighter and magnified.

Figure 9.17 The Antennae galaxies are about 45 million light-years away from the Milky Way.

The Hubble Space Telescope

Our atmosphere distorts and blocks the light coming from planets and stars. In 1990, NASA launched the Hubble Space Telescope. The Hubble Space Telescope orbits the Earth at 569 kilometres above our atmosphere. This has given scientists a view of our universe far beyond that of any ground-based telescope because different forms of electromagnetic radiation, such as gamma rays, X-rays and ultraviolet radiation, are available for observation.

From the images beamed back to Earth from the Hubble Space Telescope, **astronomers** have been able to make an enormous number of new observations. The Hubble Space Telescope is available for observations by people throughout the international astronomical community, and information and observations are available worldwide. Astronomers have been able to see galaxies developing, and have estimated the age of the universe more accurately at around 13–14 billion years.

Mars mission

NASA is already planning a crewed mission to Mars. But could humans live on Mars? The Mars exploration rovers, *Spirit* and *Opportunity*,

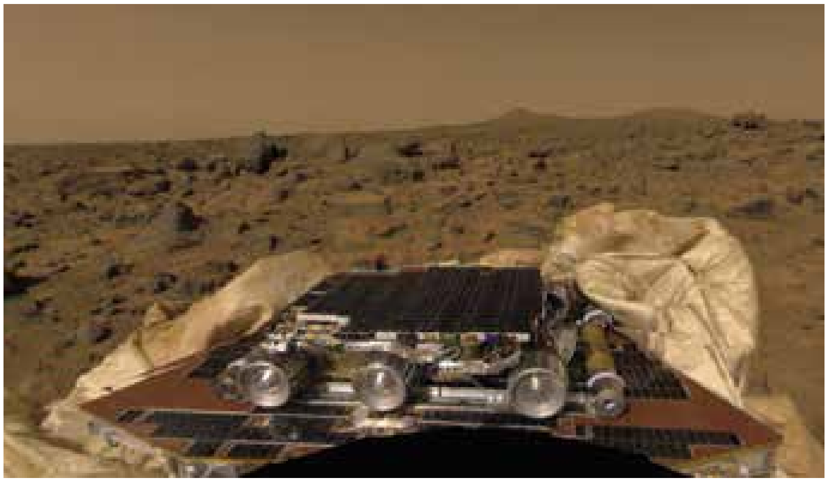


Figure 9.19 The Mars exploration rovers are being used to find out how water has affected the red planet.

were launched in 2003 and landed on Mars in 2004 to find out more about the 'red planet'.

In 2008, the *Phoenix* Mars Lander touched down on an ice sheet on the Martian surface. Operated from the Earth, its instruments took photographs of ice that was melting away. The Lander's robotic arm, shown in Figure 9.20, scooped up soil samples. Analysis by the Lander's instruments revealed traces of magnesium, sodium, potassium and, importantly, water. NASA scientists described this discovery as a 'huge step forward'.

Figure 9.20 The *Phoenix* Mars Lander delivers a soil sample to a microscope.

Figwure 9.18 Dark matter cannot be photographed, but it is represented in blue in this Hubble Space Telescope image of a galaxy cluster. This can be used to help understand the nature of dark energy.

Extend your learning 9.4

Remember and understand

1 How does a telescope help us view distant objects?

2 What sort of information are we looking for when we launch probes into space?

3 What is the purpose of the Mars exploration rovers?

Apply and analyse

4 Why is the discovery of water on Mars so important?

5 What sort of knowledge about our universe has been gained by launching space probes?

Evaluate and create

6 Imagine you are an astronomer with NASA. Prepare a list of reasons explaining the importance of maintaining the Hubble Space Telescope instead of relying on traditional telescopes on the Earth's surface.

*REVIEW

9

Remember and understand

1 What causes day and night?

2 What is the name for one revolution of the Earth around the Sun?

3 During summer in Australia, what is the season in Norway?

4 What do we call the event when the Moon totally blocks the light from the Sun?

5 How does the Sun affect day and night and seasons at the Earth's two poles?

6 Look at Figure 9.21, which shows a total eclipse of the Sun as it would be seen in the middle of the day from the Earth. Draw and label a diagram to illustrate how:

- a a solar eclipse may occur
- b a lunar eclipse may occur.

Figure 9.21

Apply and analyse

7 What is the difference between astronomy and astrology?

8 Why does 29 February only occur every four years?

9 Figure 9.22 shows how the seasons occur. Answer A or B to each question.

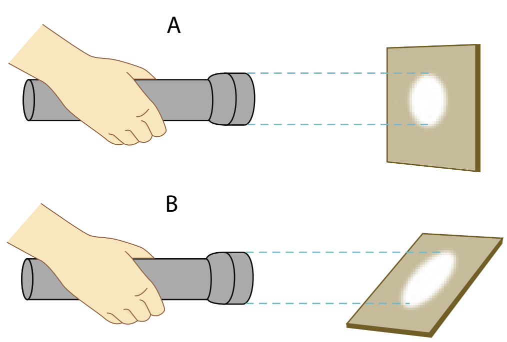


Figure 9.22

- a Which of the two drawings represents summer?
- b If the piece of card was the Earth, in which case would the Sun be most overhead?
- c If the piece of card was the Earth, which one would give warmer days?

10 The Persian calendar celebrates the New Year at the moment the sun crosses the celestial equator on approximately 21 March each year. In 2014 it was celebrated at 4 am on the east coast of Australia. In 2015 it was celebrated at 10 am. Explain why the exact time of the New Year changes from one year to the next.

11 A student claims that the Moon is a mini Sun that shines at night. Are they correct? Provide evidence to support your argument.

12 What is the purpose of the Hubble Space Telescope?

Evaluate and create

13 When will the next solar eclipse occur? Which country or countries will see the total eclipse?

14 Study Figure 9.23 and answer the following questions.

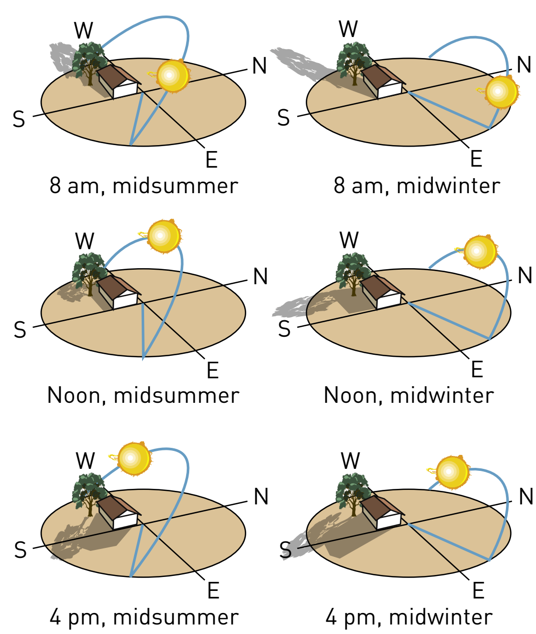


Figure 9.23 The path of the Sun across the sky in winter and summer.

a In which season do we get the longest shadows?
b Which season gives the least opportunity for solar heating?
c In which season does the Sun travel furthest across the sky?
d On which side of the house is it best to grow plants that like sunlight?
e If a plant is growing on the eastern side of a house, will it receive sunlight in the morning or afternoon?

15 Could humans colonise the Moon? Explain your answer.

16 Find data for the sunrise and sunset times over 7 days in summer and winter. From this information, calculate the length of the day and the length of the night. Present your findings in a table. What do you notice about the length of the days and nights for each season? How can you explain the difference?

17 Many early Europeans claimed the early Indigenous Australians didn't use any of the sciences. Provide evidence that refutes this claim.

Research

Choose one of the following topics on which to conduct further research. A few guiding questions have been provided for you but you should add more questions that you wish to investigate. Present your findings in a format that best fits the information you have found and understandings you have formed.

Search for extraterrestrial intelligence

Astronomers are also involved in a Search for Extraterrestrial Intelligence (SETI). Find out what instruments astronomers are using in this search. How will these instruments help them find extraterrestrial intelligence? What are they looking for exactly? Will it be in human form? You, too, can use your computer to become a part of this search.

Galileo space probe

Investigate the path of the *Galileo* space probe. To reach Jupiter more quickly, it used the gravitational field of some planets. How was this done?

Mission to the Moon

The huge *Saturn* rocket that took *Apollo 11* to the Moon was an extremely powerful system in its day. The rocket had three 'stages' that each carried their own fuel and dropped off as the rocket went higher into the sky. The rocket carried the 'lunar lander', which was itself a very complicated piece of technology. Build a model of the *Saturn* rocket and explain the role of each stage and how it performed.

The far side of the Moon

The Moon rotates at the same rate as the Earth, so we never see the far side of the Moon from Earth. So what is it like? Is it the same as the near side of the Moon? The far side of the Moon has been seen. Find out who saw it and how, what it's like in comparison with the side we know from Earth and what future missions to the Moon might be tasked with.

*KEY WORDS

9

astronomer
scientist who studies planets, stars and the solar system

axis
an imaginary straight line joining the north and south poles of the Earth

equinox
day on which day and night are the same length

lunar eclipse
when the Moon is in the Earth's shadow and appears dark

orbit
the path a planet moves around the sun/star or a moon moves around a planet

partial eclipse
when only some of the Sun's light is blocked by the Moon

phases of the Moon
changes in the shape of the Moon visible on Earth

solar eclipse
when the light from the Sun is blocked by the Moon

solar energy
energy made by atoms colliding with each other in the centre of the Sun

solar system
the system made up of the Sun and all the planets, dwarf planets, moons and asteroids that travel around the Sun or each other

telescope
an optical instrument that uses lenses and mirrors to make distant objects appear closer and larger

total solar eclipse
when the Moon blocks the maximum amount of light from the Sun

EXPERIMENTS

10

Learning and working in a laboratory

Working in a science laboratory requires you to use a variety of special skills. Many of these you may not use anywhere else. You must know how to identify, prepare and clean up equipment safely to prevent chemicals contaminating future experiments, or harmimg yourself or someone else.

Wearing lab coats and safety glasses, having hair tied back

Figure 10.1

How to clean equipment

Figure 10.2 Place warm water in the equipment (e.g. beaker).

Figure 10.3 Add a small amount of detergent.

Figure 10.4 Use a brush or cloth to wipe around the equipment.

Figure 10.5 Clean test tubes using a small bottle brush.

Figure 10.6 Tip out water and rinse the equipment with fresh water to prevent contamination for the next experiment.

Figure 10.7 Place the equipment upside down to drain.

What to do with broken glass

Figure 10.8 Place the glass in a special glass bin. Alternatively, wrap the glass in newspaper and dispose in the normal rubbish.

DO NOT USE YOUR HANDS TO PICK UP THE GLASS!

How to clean up common spills

Figure 10.9 If it is safe, wipe the spill up with paper towel and dispose of in the rubbish.

TELL YOUR TEACHER FIRST.

Figure 10.10 If it is not safe, follow your teacher's directions. Some schools have a special spill kit you can use.

Safely smelling chemicals

Figure 10.11 Hold the chemical slightly away from your face.

Figure 10.12 Use your hand to gently waft a small amount of air above the container towards your face.

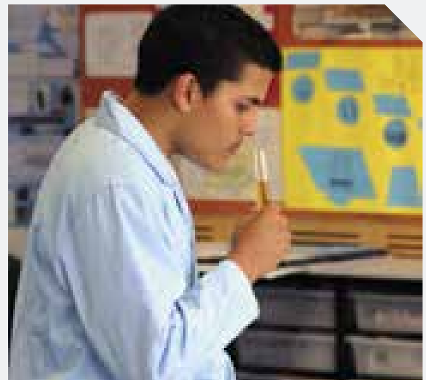


Figure 10.13 Take a small breath through your nose.

CHECK WITH YOUR TEACHER IF IT IS SAFE TO SMELL THE CHEMICAL, AND ONLY PROCEED IF IT IS.

1.1

CHALLENGE

Sideways ping pong

What you need:

ping pong ball, measuring tape or ruler, cardboard cylinder

What to do:

1 Working in pairs, drop a ping pong ball from a height of 1.5 metres above the ground. Do not throw or flick it.

2 Measure how far the ball travels sideways after it bounces.

What if?

» What if you change the colour of the ball?

» What if you change the type of floor covering?

» What if you drill holes in the ball?

» What if you roll the ball down a tube?

» What if you spin the ball?

» What if you vary the height from which the ping pong ball is dropped?

Figure 10.14 Making a ping pong ball bounce sideways.

1.2 SKILLS LAB

Drawing scientific diagrams

Station 1

What you need:

five boxes from your teacher (each containing five different pieces of equipment), grey pencil, ruler, piece of plain A4 paper

What to do:

1 Share a box with a partner. Without using this textbook, write down the name of each piece of equipment in the box and draw a scientific diagram of each in pencil. When finished, return the box to the teacher and collect a different one.

2 Check your answers and diagrams (and spelling) for the pieces of equipment from Figures 1.9 and 1.10 on pages 4 and 5. Correct any mistakes.

3 Look at your list of equipment. On a sheet of plain paper, divide the list into groups according to use. For example, you might put all pouring equipment together, or all heating equipment or all safety equipment. Decide on categories first and then allocate the equipment.

Figure 10.15

Station 2

What you need:

large flask, retort stand, boss head, clamp, funnel, small beaker

What to do:

1 Set up the stand with the boss head and clamp, placing the boss head approximately two-thirds of the way up the stand, as shown in Figure 10.15.

2 Carefully place the flask neck into the clamp and tighten the clamp so the flask is secure. (The flask should be approximately 10 cm above the bench, not resting on it.)

3 How many beakers of water do you think will fill the flask? Write down your prediction (your best guess of what will happen).

4 Fill the beaker with water. Use the funnel to transfer the water into the flask.
   - How many full beakers of water did you need to completely fill the flask?
   - Was your prediction correct?

5 Draw a scientific diagram of what you have set up, labelling all equipment.

6 Take the apparatus apart and place each piece of equipment in its appropriate cupboard.

Questions

1 Which piece of equipment was the most difficult to draw?

2 Which did you find the easiest to draw?

3 Name up to five pieces of equipment you had not seen before and list their uses in a laboratory.

4 Name two pieces of equipment that can be used for:
   a holding things
   b mixing chemicals
   c pouring.

5 Where in your laboratory do you find:
   a test tubes?
   b Bunsen burners?
   c tongs?
   d retort stands?
   e test tube racks?
   f heating mats?
   g a rubbish bin?
   h beakers?

1.4
SKILLS LAB

Observation versus inference

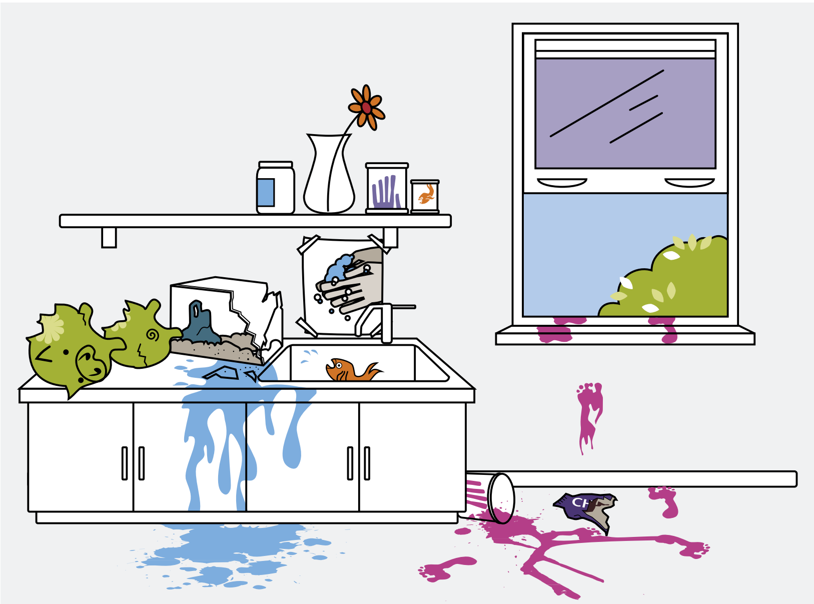


Figure 10.16

How good are you at making observations? Do you confuse observations with inferences? There are many things you can observe.

1 Draw up a table with two columns, one for observations and one for inferences.
2 Examine Figure 10.16, which is a drawing of a crime scene. Write six observations from the crime scene.
3 Write down three inferences you can make from your observations.

1.5
SKILLS LAB

Measuring mass and volume

What you need:

a variety of soft drinks, flavoured milk, fruit juices, bottled water, sugar, scales, measuring cylinder, beakers

What to do:

1 On the sides of each container you will find a nutrition panel showing the volume of one standard serve and the amount of sugar in each drink. An example is shown in Figure 10.17.
2 Using the scales, measure out the mass of sugar in each serve of drink in a beaker.
3 In another beaker, carefully measure out the volume of a single serve of each drink.
4 Create a table to record the name of each drink, the sugar content per serve for each drink, how many serves of drink were in each container and how much sugar there was in a whole container.

Questions

1 Which drink had the most sugar?
2 Which drink had the most serves in a single container?
3 Which drink had the most sugar in a whole container?
4 Was there any volume or sugar content that surprised you?

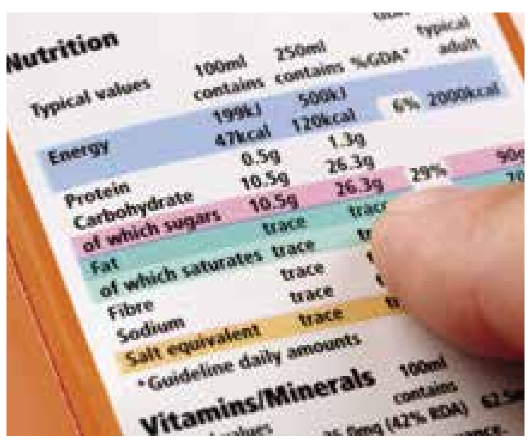


Figure 10.17

Heating water

What you need:

beaker, water, thermometer, retort stand, boss head, clamp, tripod, gauze mat, safety mat, stopwatch

What to do:

1. Set up the equipment as shown in Figure 10.18.
2. Draw a scientific diagram of the equipment in your notebook.
3. Create a table with two columns, one for time (in minutes) and the other for temperature (in °C), as per the example below.

TIME (MINUTES)	TEMPERATURE (°C)

4. Measure the starting temperature of the water. Write this in the table for 0 minutes.
5. Safely light the Bunsen burner and then open the collar to get a blue flame.
6. Heat the water over the Bunsen burner, recording the temperature of the water every minute for a total of 12 minutes.

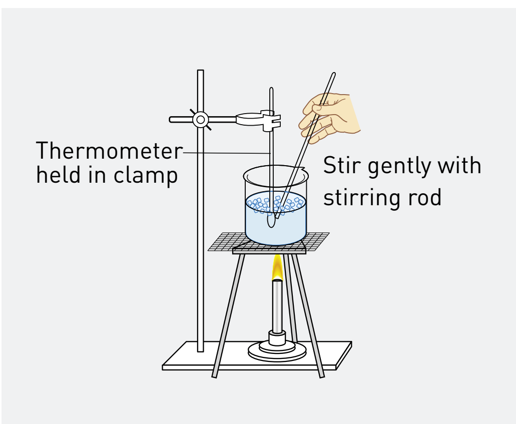


Figure 10.18

Inquiry: What if another substance is added to the water?

Choose one of the inquiry questions below.

- What if sugar was added to the water?
- What if salt was added to the water?

Answer the following questions with regard to your inquiry question.

- Write a hypothesis for your inquiry.
- What *independent* variable will you change from the first method?
- What *dependent* variable will you measure and/or observe?
- What variables will you need to control to ensure a fair test? How will you control them?
- Test your hypothesis.
- Draw an appropriate graph for your data.

Questions

1. What type of data have you collected?
2. What type of graph should you draw for this type of data?
3. Does your graph support your hypothesis? Explain.
4. Was your experiment a fair test? Explain why or why not.

Comparing different types of mixtures

A DIRTY WATER

What you need:

soil, water, jar with screw-top lid

What to do:

1. Put some soil and water in the jar to create a watery mixture.
2. Screw the lid on tightly, then shake the jar.
   - What happens to the soil particles?
   - Does anything float on the water?
   - How can you explain the behaviour of this mixture?
   - What type of mixture is dirty water?

B MAKING A FOAM

Safety: check for egg or dairy allergies

What you need:

cream or egg white, hand or electric whisk, large metal bowl

What to do:

1. Whip the cream or egg white until it increases significantly in size and holds its shape.
   - Explain why the foam you have created is classified as a colloid.

C MIXING OLIVE OIL AND WATER

What you need:

olive oil, water, jar with screw-top lid, detergent

What to do:

1. Two-thirds fill a jar with equal parts of water and oil. Observe what happens.
2. Screw the lid on the jar tightly and shake the mixture vigorously. Observe what happens immediately and over time.
3. Add a couple of drops of detergent to the mixture and shake the jar again.
   - How does the mixture change when you add the detergent?
   - Explain what is happening using the terms 'colloid', 'mixture', 'emulsion' and 'emulsifier'.

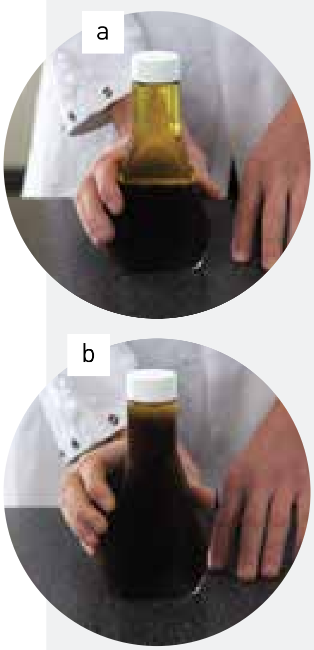


Figure 10.19 Salad dressing (a) before and (b) after adding an emulsifier.

D ADDING SUGAR TO WATER

What you need:

water, table sugar, teaspoon, beaker or glass

What to do:

1. Add a small amount of sugar to water in a glass and stir.
   - Describe what has happened to the sugar.

Figure 10.20 Sugar dissolves easily in a hot cup of tea.

E MAKING PERFUME: ANOTHER SOLUTION

What you need:

lavender flowers, methylated spirits, scissors, jar with a lid

What to do:

1. Cut the lavender flowers into tiny pieces and place them in the jar.
2. Cover the lavender flowers with methylated spirits.
3. Seal the jar and leave overnight.
4. The following day, dip your finger in the methylated spirits and dab it on a piece of paper or your wrist.
5. Allow the methylated spirits to evaporate, then smell.
   - Why is this mixture considered to be a solution? Identify the solute and the solvent.
   - Would this experiment work if you put the lavender flowers in a jar of water?
   - Why is it handy that the methylated spirits evaporate easily?

2.2A EXPERIMENT

What if salt were dissolved in water?

Aim
To investigate whether a mixture of salt and water forms a solution.

Materials
> Test tubes
> Test tube rack
> Spatula
> Salt

Method
1 Add 5 cm of water to a test tube.
2 Add 1 spatula of salt to the test tube. Carefully stir the mixture.
3 Does the mixture form a solution? Record your results.

Inquiry: What if other substances are mixed with water?
Powders to test: copper carbonate, bath salts, talcum powder, brown sugar, flour

- What (independent variable) are you changing from the method above?
- Name three variables you will need to keep the same as in the method above.
- How will you know if your new powder forms a solution with water?
- Predict which powders will form a solution.
- What equipment will you need to complete this experiment?
- Write down the method you will use to complete your investigation.
- What sort of table will you need to draw to show your results?

(Show your teacher your planning for approval.)

Results
Complete your investigation, filling in your table of results.

Discussion
1 How many substances were soluble in water? List them.
2 Of the substances that did not dissolve, did any form a suspension?
3 Which substances took the longest to dissolve? Why do you think this happened?
4 Were any of your results unexpected?
5 Name three other substances you know dissolve in water.
6 Do you think water is a good solvent? Give reasons based on the results of your experiment.
7 How would you change this experiment to find out more about dissolving substances?

Figure 10.21

2.2B
EXPERIMENT

What if the solvent were heated when making a mixture?

Many solutes dissolve only in certain solvents. Some dissolve very slowly and, when they do, only a certain amount of solute dissolves before the solution becomes saturated.

Aim

To investigate ways to alter the rate (speed) at which a solute dissolves and/or the amount of solute that will dissolve.

Materials

- Milo
- Milk
- Teaspoon
- Small beaker
- Measuring cylinder
- Thermometer
- Hot plate to heat milk

Method

1. Measure out 50 mL milk and add it to the small beaker.
2. Carefully measure 1 teaspoon of Milo by smoothing the surface until it is even with the edges of the spoon.
3. Add the spoonful of Milo to the milk and stir until it dissolves.
4. Repeat steps 2 and 3 until the Milo no long dissolves.
5. How many spoonfuls of Milo dissolved in the milk?

Inquiry: What if the milk were heated?

- What (independent) variable will you change from the first method?
- What (dependent) variable will you measure and/or control?
- Name three variables that you will keep the same as in the first method.
- What equipment will you need to complete this experiment?
- Predict how many spoonfuls of Milo will dissolve in warm milk.
- Write down the method you will use to complete your investigation.
- What sort of table will you need to draw up to show your results?

  (Show your teacher your planning for approval.)

Results

Complete your investigation, filling in your table of results.

Discussion

1. Describe how the amount of Milo that dissolved changed the second time.
2. What did you do differently to achieve this change?
3. What variables did you keep the same during the experiment?
4. Can you think of any situations in everyday life that would benefit from understanding the results of your investigation?
5. How would you change this experiment to find out more about dissolving substances?

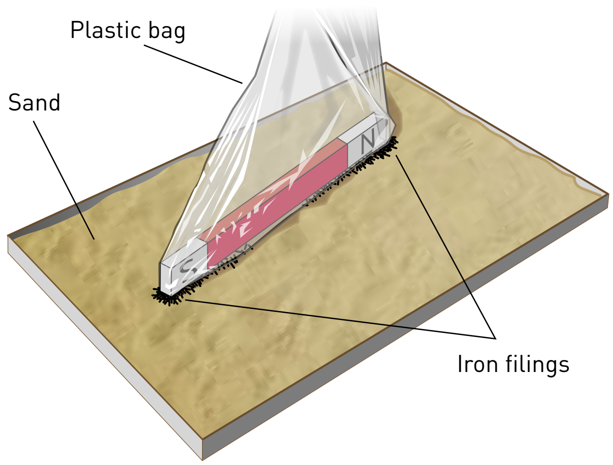
SAFETY: DO NOT EAT OR DRINK IN THE LABORATORY.

2.3A SKILLS LAB

Separation using magnetic properties

What you need:

mixture of iron filings and sand, magnet, plastic bag



What to do:

1 Place the magnet inside the plastic bag.
2 Pass the bagged magnet over the mixture so that the iron filings are attracted.
3 Turn the plastic bag inside out so that all the iron filings are trapped.

Questions

1 How effective do you think this method was at separating the iron filings from the sand?
2 Could you use this method for all metals? Explain.

2.3B SKILLS LAB

Separating mixtures using sedimentation and flotation

What you need:

two mixtures ('A' contains sand and sawdust; 'B' contains sand and salt), water, spatula, stirring rod, two beakers

What to do:

1 Place at least three heaped spatulas of mixture A into a beaker.
2 Add water and stir the mixture.
3 Wait until sedimentation has occurred.
4 Scoop off any floating material from the top of the water. Decant the water to retrieve the sand.
5 Repeat the procedure for mixture B.
6 Draw a labelled diagram of your results.

Questions

1 How successful was the method for separating and collecting the sand from mixture A?
2 How successful was this method for collecting sand from mixture B?
3 What are some of the difficulties with decanting?
4 List the advantages of the combined sedimentation–flotation separation system.
5 After separating the two substances from mixture B, what would need to be done to collect the salt as a solid?

Clean up

After separating a mixture, make sure that all insoluble solids go into a specially provided container. Only throw substances in the bin if your teacher says it is okay to do so. Never wash solids down the sink.

6 Think of three reasons why disposing of solids down the sink is not a good idea.

2.3 EXPERIMENT

Aim

To investigate the effect of a flocculent.

Materials

- Muddy water (3 g dirt in 50 mL water)
- 2 jars
- 0.5 M sodium carbonate solution
- 0.5 M aluminium sulfate solution
- Test tubes

What if a flocculent were added to muddy water?

Method

SAFETY: HANDLE THE ALUMINIUM SULFATE SOLUTION WITH CARE, WEAR EYE PROTECTION AND AVOID CONTACT WITH SKIN.

1 Half-fill each jar with muddy water and label one A and the other B.
2 Add half a test tube of aluminium sulfate solution to jar A.
3 Slowly add half a test tube of sodium carbonate solution to jar B.
4 Leave both jars undisturbed for approximately 15 minutes.
5 Record your observations, comparing the water in jar A with that in jar B.

Inquiry: How much flocculent is needed to effectively separate a mixture of mud and water?

- What amounts of the flocculent will you add to the muddy water mixture?
- How will you measure if the muddy water is separated enough? (HINT: how much light should shine through the mixture?)
- Name three variables you will keep the same as in the first method.
- Write down the method you will use to complete your investigation.
- What sort of table will you need to draw up to show your results?

  (Show your teacher your planning for approval.)

Results

Complete your investigation, filling in your table of results.

Discussion

1 What effect did the aluminium sulfate solution have on the muddy water?
2 What effect did the sodium carbonate solution have on the muddy water?
3 Which of the two substances (aluminium sulfate or sodium carbonate) acted as a flocculent? Give evidence to support your answer.
4 Why might it be important for water treatment plants to minimise the amount of flocculent added to waste water?

Conclusion

What affect does a flocculent have on mixtures?

2.4
SKILLS LAB

Filtering a mixture of sand and water

What you need:

mixture of sand and water, beaker, 100 mL conical flask, spatula, small funnel, filter paper, stirring rod

What to do:

1. Fold a round filter paper in half, then in half again to get quarters and then in half again to get eighths, as shown in Figure 10.22.
2. Unfold the filter paper and lay it flat (Figure 10.23).
3. Re-fold back and forth over the creases in the filter paper to obtain a fluted shape, as shown in Figure 10.24.
4. Set up the funnel and flask as shown in Figure 10.25.
5. Place the filter paper into the funnel as shown in Figure 10.26.
6. Dampen the filter paper with some extra water to help it stick to the sides of the funnel (see Figure 10.27).
7. Swirl the sand mixture and slowly pour it from the beaker into the funnel (Figure 10.28). Do not overfill the funnel.
8. Keep adding the mixture slowly until it is all used up.
9. Extra water can be added to the beaker mixture to pour out the last solid particles.
10. Wait for the filtering to finish. Remove the filter paper carefully and allow it to dry. In most experiments the residue (the solid on the paper) is kept and the filtrate (the liquid in the flask) is discarded.

Questions

1. Draw a scientific diagram of your equipment. Label the filtrate and residue.
2. What physical properties are being used to filter substances?
3. Describe at least three things you need to be careful about when filtering.


Figure 10.22

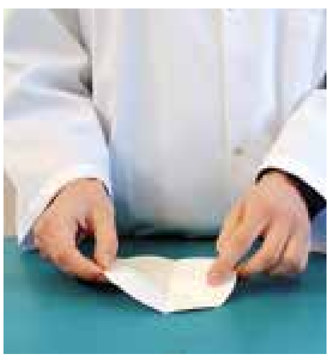


Figure 10.23


Figure 10.24


Figure 10.25


Figure 10.26


Figure 10.27


Figure 10.28

2.4 EXPERIMENT

Aim

To separate the components of milk.

Materials

> Centrifuge
> Different types of milk (full cream, low fat, soy milk)
> Test tubes

What if you centrifuge milk?

Method

1 Label your test tube with your name and part fill it with milk.
2 Pass your test tube to the teacher and observe how he or she sets up the centrifuge.
3 Examine the test tubes when the centrifuge completes the separation.
4 Use a ruler to measure the amount of each separated component of milk.
5 Draw one of the test tubes after centrifuging. Identify and label the parts of the milk.

Inquiry: What if different types of milk were centrifuged?

- What type of milk will you centrifuge?
- What differences might you expect from the original milk you tried?
- What variables will you keep the same as in the first method?

Results

1 Centrifuge your milk. Draw and label the various components of the milk.
2 Draw a column graph showing the type of milk and the amount of each component.

Discussion

1 What differences did you notice between the different types of milk after they had been centrifuged?
2 Can you explain why the different types of milk might vary in their components?

2.5 EXPERIMENT

Aim

To separate a salt from a solution by evaporation and crystallisation.

Materials

> Evaporating dish
> Tripod
> Clay triangle
> Bunsen burner and mat
> Salt solution
> 250 mL beaker
> Magnifying glass
> Matches

Crystallisation of salt water

Method

1 Collect a sample of the salt solution.
2 Half-fill an evaporating dish with the solution.
3 Place the evaporating dish on the clay triangle over the tripod.
4 Heat the evaporating dish, with a blue flame.
5 When the solution starts boiling, half-close the Bunsen burner collar. (Don't change to a yellow flame – this is not the same.)
6 Add more solution to the dish as the level drops due to evaporation. Be careful as the evaporation nears completion because the hot salt may spit and splatter.
7 Turn off the Bunsen burner when just a little liquid remains with the salt. Leave the dish to cool.
8 Examine the salt crystals with a magnifying glass.

Results

Draw a diagram of the crystals in your notebook.

Discussion

After the water has evaporated from the solution, salt remains in the evaporating dish.

1 If the solution contained a mixture of more than one solute, would the separation technique used in this experiment be suitable? Explain.
2 What is wasted in this experiment? Can you think of any way this could be avoided?

Conclusion

Explain how evaporation and crystallisation can be used to separate a mixture of salt and water.

Design a way to purify water from sea water

Design brief

You are preparing for a natural disaster that will affect the water supply. Design some equipment that will enable you to provide drinking water for a single person from sea water indefinitely.

Criteria restrictions

- Your materials must be available in a supermarket or your home.
- You must provide the cost of building your equipment.
- Your only available heat source is the Sun.

Questioning and predicting

> How will you heat the water so that it evaporates?
> How will you collect the water vapour?
> How will you cool the steam so that it condenses?
> Draw a labelled diagram of your design.
> Build a prototype of your design.

Processing, analysing and evaluating

1 What changes did you have make to improve your design?
2 What was the most successful feature of your design? What was the least successful?
3 What was the final cost of your design?
4 Is there any practical use for your design?
5 If you were doing this experiment again, how would you modify your design? Explain.

Communicating

Present the various stages of your investigation in a formal experimental report.

2.6
EXPERIMENT

Who wrote the nasty note?

Aim

To separate the inks from three different water-soluble black felt-tip pens.

Materials

- 3 black water-soluble felt-tip pens (they must all be different brands and labelled A, C and U) (Note: Permanent markers are not suitable for this experiment because they are not water-soluble.)
- 250 mL beaker
- Glass rod
- Salt solution (1%)
- Filter paper or chromatography paper
- Scissors
- Pencil
- Ruler

Your forensic laboratory is investigating a crime of extortion: one person is forcing or frightening another into handing over money.

The police have identified that the extortion note was written with a black felt-tip pen. They have collected a black felt-tip pen from the three suspects: Aunt Aggie (A), Cousin Cranky (C) and Uncle Buncle (U).

Other forensic scientists in your laboratory have already run a chromatography test on the note written by the extortionist. After you have tested the three pens from the suspects, collect the chromatogram from the original note from your teacher for comparison.

Figure 10.29 The suspects.

Method

1 Cut the filter or chromatography paper into three strips measuring approximately 2 cm × 10 cm.

2 Draw a faint pencil line across the width of each paper strip, 3 cm from the bottom.

3 Label one strip A, another C and the remaining one U. Make sure the label is at the very top of the paper strip.

4 Carefully trace over the pencil line at the bottom of strip A with the first felt-tip pen. (Do not make the line too thick.)

5 Do the same for the other two pens on their separate strips.

6 Add the salt solution to the bottom of the beaker, no deeper than approximately 2 cm.

7 Hang the paper strips over the glass rod so that they just dip into the salt solution. Make sure the salt solution does not touch the pen lines on the paper.

8 Leave the papers to soak up the salt solution for approximately 10–15 minutes, or until the solvent level is up to the top of the paper.

9 In the meantime, draw a diagram of the chromatography equipment in your notebook, labelling all the parts.

10 When the chromatogram is finished, take the papers out of the solution to dry.

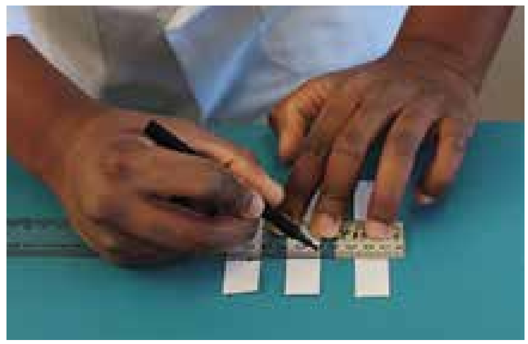


Figure 10.30 Trace over the pencil lines at the bottom of the chromatography paper.

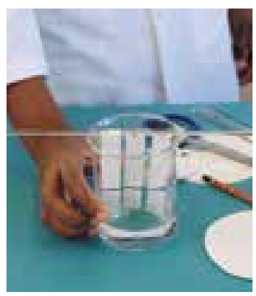


Figure 10.31 Hang the paper strips over a glass rod so they just dip into the salt solution.

Figure 10.32 Take the papers out to dry.

Results

Tape the dry chromatograms for suspects A, C and U in your notebook or workbook. Collect and copy the chromatogram from the original note. Label this as the extortionist's chromatogram.

Discussion

1 Compare the chromatogram for the extortionist with the chromatograms from the three suspects. Do any of the suspects' chromatograms match the one from the original note? If so, who is most likely to be guilty?

2 Which felt-tip pen (A, C or U) had the most colours in its black ink?

Conclusion

How can the inks from three different black felt-tip pens be separated?

Separation challenge

Challenge

Now that you are a scientist who has trained in separating techniques, it is time to separate a mixture of sand, salt, sawdust and iron filings.

Criteria restrictions

You may only use equipment available in the laboratory.

Questioning and predicting

Think about the properties of each pure substance. This may help you decide on a way to separate the substances. Write what you know about the properties of sand, iron filings, sawdust and salt in the table below.

SUBSTANCE	SOLUBLE IN WATER?	ATTRACTED TO A MAGNET?	FLOATS/ SINKS IN WATER?
Sand			
Iron filings			
Sawdust			
Salt			

Discuss with a partner some possible ways to separate the four substances.

Planning and conducting

> Draw up a flow chart showing the steps you will take to separate the four substances.
> Devise an aim and an equipment list for your experiment.
> Write a detailed method for separating the substances. Include at least two diagrams.
> What safety issues might there be when doing this experiment?
> Have your plan checked by your teacher.
> Perform your separation experiments and make relevant observations.

Processing, analysing and evaluating

1 How well did your plan work? Grade the success of the plan on a scale of 1–5, where 1 means the experiment did not work well and 5 means the experiment was a great success. If you completed this challenge as a group, discuss your grading with others in your team.

Figure 10.33 Some of the equipment you may need for the separation challenge.

2 If your success was lower than 5 on the scale, how would you change 'plan B' to improve the results on another occasion?

3 Did you manage to separate the four substances successfully? Write your answer to this question as the conclusion in your laboratory report.

Communicating

Present your investigation in a formal experimental report.

3.1A
CHALLENGE

Three states of water

What you need:

large test tube, tap water, Bunsen burner, heatproof mat, wooden test tube holders, ice cube, copper wire (approximately 8–10 cm long), pliers

What to do:

1 Collect an ice cube that will fit into a test tube.
2 Wrap copper wire around the ice cube so that it will sink in the water.
3 Pour tap water into the test tube until it is one-third full. Drop the ice cube with the wire around it into the water.
4 Gently heat the water at the top of the test tube. (With the ice cube in it, the test tube should be half to two-thirds full.)

Question:

1 Did you manage to have ice and boiling water in the same test tube? Explain how this could happen.

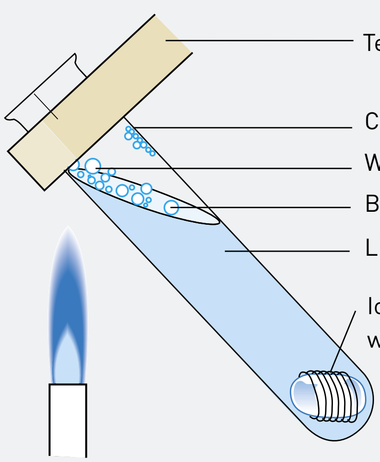


Figure 10.34

3.1B
CHALLENGE

Ice cube necklace

What you need:

some ice cubes, a glass of water, a piece of cotton string, salt

What to do:

1 Float a few ice cubes in a glass of water.
2 Wet a piece of cotton string with water. Lay the string on top of the ice cubes.
3 Sprinkle salt over the string and wait approximately 10 seconds.
4 Now lift the string and the ice cubes will be stuck to it. You've just made a cool ice cube necklace!

Questions:

1 Is the ice a solid, a liquid or a gas? Provide evidence to support your reasoning.
2 The salt lowers the freezing point of the ice for a short time, before it refreezes. Define:
   a melting
   b freezing.

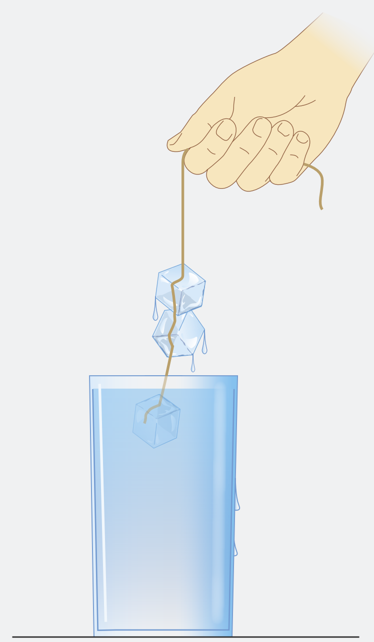


Figure 10.35

3.2
EXPERIMENT

Aim

To design and create a model of the water cycle.

What if the temperature were increased in the water cycle?

Materials

- Large clear plastic bowl
- Plastic wrap
- Small weight
- Smaller container, such as the bottom half of a yoghurt pot
- Water
- Large elastic band or string and tape

Method

1. Place the small container in the middle of the large clear bowl.
2. Pour a little water into the large bowl, being careful not to get any in the small container.
3. Cover the bowl with plastic wrap and fix the plastic wrap to the rim of the bowl with either a rubber band or a tight piece of string.
4. Put a small weight on top of the plastic wrap in the centre so that it hangs over, but does not touch, the smaller container.
5. You have now created a portable water cycle. Place your water cycle in partial shade under a tree. Record the time it takes for water to appear in the small container for each model. Record your observations too.

Inquiry: What if the temperature was hotter in the water cycle?

- Write a hypothesis for your investigation.
- What (independent) variable will you need to change to test your hypothesis?
- What (dependent) variable will you measure and/or observe?
- Name three variables you will keep the same or control.

Results

Record your measurements in an appropriate table.

Discussion

1. Describe the movement of the water as it continues to collect on the plastic wrap.
2. Can any of the water escape from your mini water cycle model? How does this compare with the actual water cycle?
3. Give reasons why your model is or is not an accurate representation of the real water cycle.
4. Describe any modifications that you could make to improve the design of your water cycle model.

Conclusion

What do you know about the water cycle?

3.4
CHALLENGE

Can you reduce the evaporation of water in irrigation channels?

Design brief

The Mulwala Canal in the River Murray region of NSW discharges approximately 9000 million litres of water a day. Over 700 000 hectares of land is irrigated from 2880 km of channels in the area.

These open channels allow a lot of water to evaporate before a single drop reaches the plants. Prepare a report that describes a cost-effective way to prevent the loss of water from the irrigation channels.

Criteria restrictions

> All materials must be available in Australia.
> All prices must be in Australian dollars.

Questioning and predicting

> Research the average width of the channels.
> What materials could you use to replace 1 metre of channel?
> How much would it cost for this material?
> Is there a cheaper material that could do the same job?
> What is the cost of the materials for a 1 km length of channel?
> How much would it cost for 2880 km of channels?

Processing, analysing and evaluating

1. How did the cost of your design compare with that of other students' designs?
2. Describe one feature of your design that was an improvement on other students' designs.
3. If you were doing this experiment again, what feature would you change? Explain.

Communicating

Present the various stages of your investigation in a formal experimental report.

Figure 10.36 An open irrigation channel.

Can you increase the output of a power station?

Design brief

Modify the design of a model power station so that you increase the rate at which the turbine spins.

Criteria restrictions

Only the following materials can be used:

> Square paper (15 cm × 15 cm) cut from one A4 sheet
> Ruler
> Pencil with eraser on the end
> Scissors
> Pin
> Electric kettle
> Bunsen burner
> Tripod
> Gauze mat
> 150 mL beaker
> Aluminium foil (1 piece, 10 cm × 10 cm)
> Large nail

Questioning and predicting

> How could you improve the turbine?
> How could you increase the production of steam?
> How could you ensure the quantity and speed of the steam that hits the turbine?

Planning and conducting

THE TURBINE

1. Mark the square paper as shown in Figure 10.37 using a pencil and a ruler. Draw a circle in the centre about the size of a 5-cent piece.
2. Cut along the lines, but stop at the edges of the circle.
3. Fold all four corners in towards the centre, one at a time, and hold them in place.
4. Insert a pin through the four corners and into the tip of the pencil's eraser.
5. Blow on the pinwheel to see if it spins (Figure 10.38). If not, pull the pin out slightly to create room for the paper to spin. The pinwheel will act like the turbine of the power station.

Figure 10.37

Figure 10.38

Figure 10.39 A turbine assembly in a power station.

Figure 10.40 A generator in a power station.

THE BOILER

1 Set up your Bunsen burner, tripod and gauze mat. Place the beaker on top of the gauze mat.
2 Boil the kettle and transfer the boiling water to the beaker.

> **CAUTION:** HANDLE THE KETTLE CAREFULLY TO AVOID BURNS AND SCALDS.

3 Use the nail to punch a small hole in the centre of the aluminium foil.
4 Place the aluminium foil over the top of the beaker and fold it down the sides of the beaker.

> **CAUTION:** THE BOILING WATER IN THE BEAKER WILL HAVE MADE THE SIDES OF THE BEAKER HOT. BE CAREFUL TO AVOID BURNS WHEN PLACING THE FOIL.

5 Light your Bunsen burner and heat the water until it boils again.
6 Steam should be coming out of the hole. Hold your pinwheel over the hole and let the steam spin the 'turbine'.

Processing, analysing and evaluating

1 Describe what happened to your pinwheel when it was placed in the steam flow.
2 What else would you need to add to make your 'power station' generate electricity?
3 What is the fuel in your power station?
4 Will your power station run out of fuel?

Communicating

What do you know about the action of a power station?

4.3
CHALLENGE

Can you increase the power of solar cells?

Design brief

Modify the design of the solar cell so that it produces the highest voltage.

Materials

> Small solar cells
> Electrical wires
> Voltmeter

Questioning and predicting

> How could you maximise the amount of sunlight the solar cell receives?
> Does cleaning the solar cell improve the voltage produced?
> How could you connect more than one solar cell so that the amount of voltage produced increases?

Planning and conducting

1 While inside, connect a solar cell to the voltmeter using the electrical wires.
2 While still inside, record the voltmeter reading.
3 Cover the solar cell with your hand and record the voltmeter reading.
4 Take the solar cell over to a window and record the voltmeter reading.
5 Take the solar cell outside, face it towards the sun and record the voltmeter reading. If it is cloudy outside, take a reading and then repeat the measurement when the clouds clear or on another day when it is sunny.
6 Cover the solar cell with a thin layer of dust and repeat the measurement. Clean the solar panels carefully.
7 Connect solar cells together in series (i.e. in a line) and record the voltmeter reading.

Processing, analysing and evaluating

Record your results in a table like the one shown below.

LOCATION	NUMBER OF SOLAR CELLS	VOLTMETER READING (V)
Inside		
Inside, covered		
Window		
Outside, sunny		
Outside, cloudy		
Outside, dusty		
Outside, multiple cells		

1 What are the best conditions for generating electricity from a solar cell?
2 Why do you think a house with a solar energy installation will have six, eight or more solar cells on its roof?
3 Why should solar panels on a house roof be cleaned regularly?

Communicating

What do you know about the amount of electricity produced by solar cells?

4.4A EXPERIMENT

Aim

To compare the effectiveness of different methods of mining and their impact on the environment.

Materials

- 2 homemade chocolate chip muffins (each with the same number of chocolate chips – approximately 20),
- Plastic plates
- Spoons

What if a muffin were mined in different ways?

Method

1 Imagine each muffin is an area of land that contains a valuable ore: chocolate.

2 Use spoons to 'mine' the chocolate from the first muffin using the 'open cut' method, taking layers off the top and collecting the chocolate as it appears.

Inquiry: What if the muffin was mined using the underground method?

- How will you mine this muffin so that the top remains intact?
- What (dependent) variable will you measure and/or observe to determine which method was more effective?
- Is the way you determine which method was more effective different from the way you will compare the impact of the two methods on the muffin top?
- Name three variables you will keep the same or control.

Results

Draw or take a picture of your two muffins.

Discussion

1 Which method recovered the most ore?

2 Which method was faster?

3 Which methods was easier?

4 Which method would allow the environment to be rehabilitated more easily?

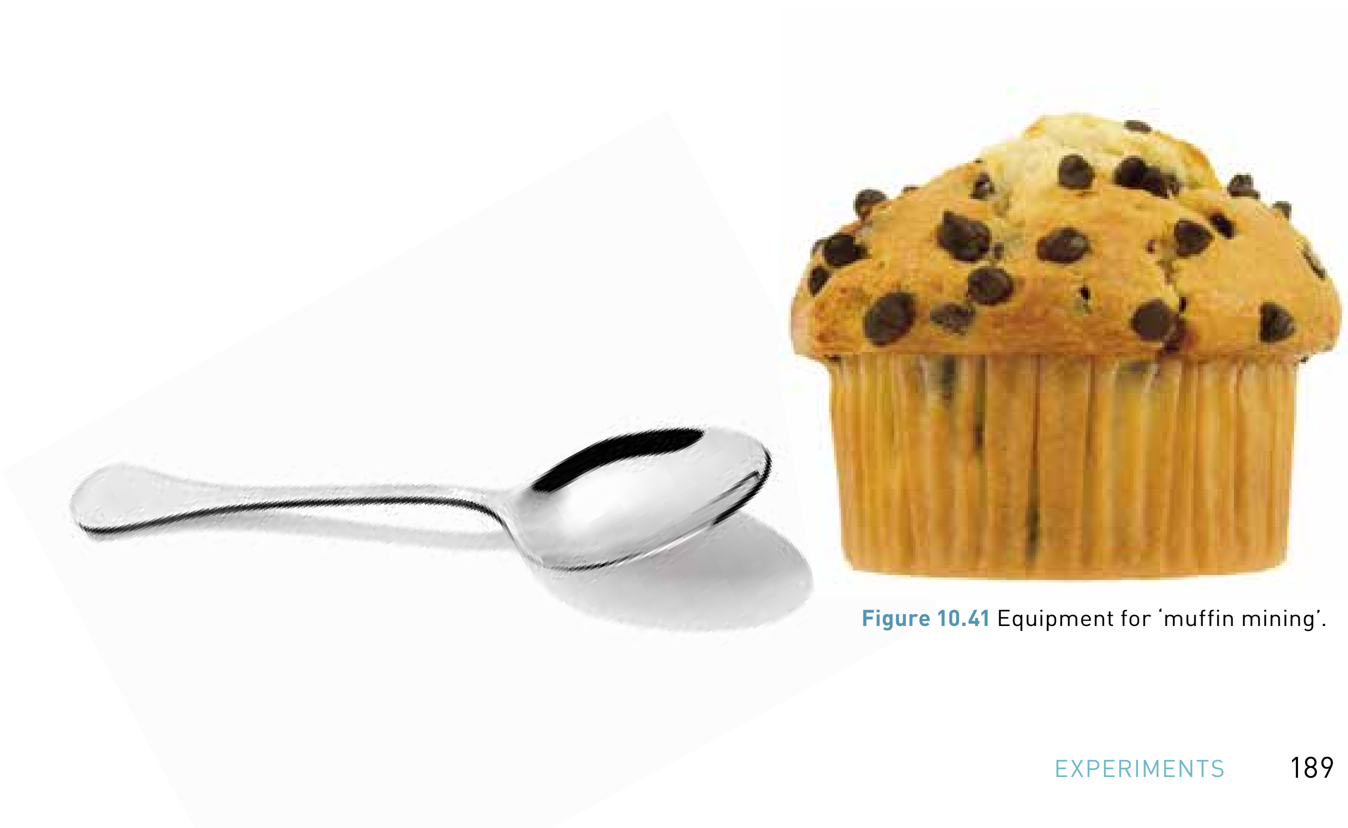


Figure 10.41 Equipment for 'muffin mining'.

4.4B
EXPERIMENT

What if a metal were obtained from a mineral?

Aim

To obtain pure copper from the mineral copper sulfate.

Materials

- Power supply
- 2 electrical leads with alligator clips on one end
- 2 carbon rods
- 250 mL beaker
- 0.5 M copper sulfate solution
- Safety glasses
- Paper towel

Method

1. Plug the electrical leads into the DC terminals of the power supply.
2. Connect the top end of the carbon rods to the alligator clips on the end of the electrical leads.
3. Fill the beaker with approximately 100 mL of the copper sulfate solution.
4. Place the carbon rods into the copper sulfate solution, being careful not to let them touch each other or the beaker.
5. Set the power supply knob to 6 volts and turn the power on.
6. Observe the rods over the next 10 minutes.
7. After 10 minutes, turn the power supply off. Remove the carbon rods and place them on paper towel.

Inquiry: Improving metal production

Choose one of the inquiry questions below.

- What if the voltage was increased?
- What if more copper sulfate was used?

Answer the following questions with regard to your inquiry question.

- Write a hypothesis for your inquiry.
- What (independent) variable will you change from the first method?
- What (dependent) variable will you measure and/or observe?
- Name three variables you will keep the same or control.
- What variables will you need to control to ensure a fair test? How will you control them?

Results

Record your observations about the appearance of the rods and the copper sulfate solution.

Discussion

1. Examine something else made of copper, such as an old 1 or 2 cent coin or a copper water pipe. Does the coating on the rods look like pure copper?
2. Where did the copper coating come from?
3. What do you think the electricity did in this experiment?

Conclusion

How successful were you in obtaining pure copper from copper sulfate?

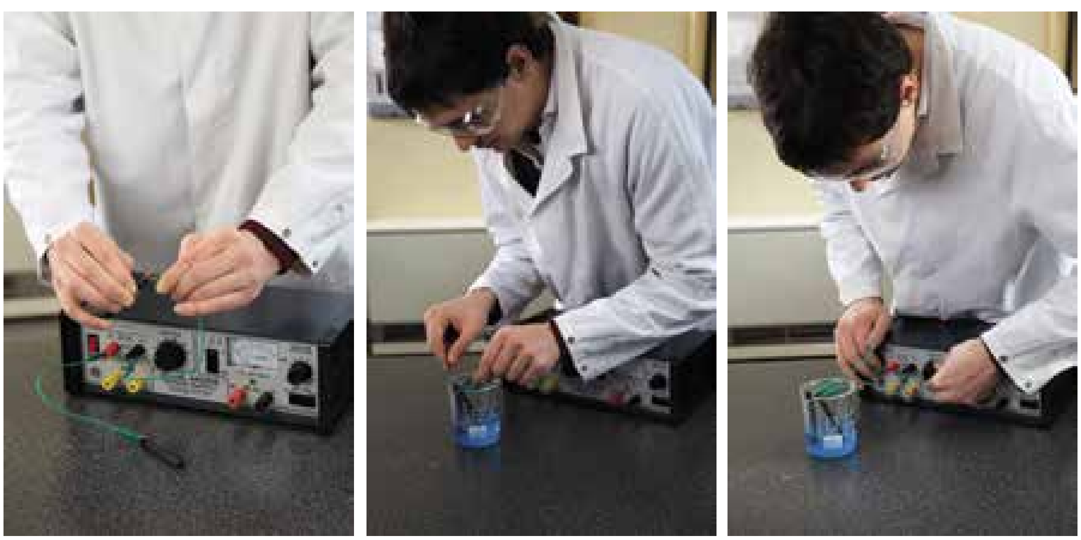


Figure 10.42
Experimental set-up.

4.5 EXPERIMENT

Aim

To compare the components of different soils.

What if different soils were exposed to water?

A LOOKING AT DRY SOIL

Materials

- 4 soil samples (beach sand, dry clay, good garden soil, potting mix)
- 4 petri dishes
- 4 white tiles
- Hand lens (or magnifier)

Method

1. Grind each sample with a mortar and pestle and then spread each thinly on a Petri dish on top of a white tile.
2. Examine each sample with a hand lens and describe what you can see.
3. Draw a labelled diagram of each soil type.
   - Do all the particles have the same colour?
   - Are they the same size?
   - Are they clear and glossy or dull and grey?
   - Are any of the particles rounded?
   - Are there any animal or plant remains?

B WHAT'S IN SOIL?

Materials

- Small sample of good garden soil
- 100 mL measuring cylinder

Method

1. Place the soil in the measuring cylinder and add water (Figure 10.43).
2. Carefully shake the mixture.
3. Allow the mixture to stand undisturbed for at least 48 hours, or longer if needed. This will allow the components of the soil to separate into layers.
   - Did your soil separate into layers? Describe each layer.
   - Did any of your soil components float?

Figure 10.43

Figure 10.44
Experimental set-up.

C TESTING

After examining the dry soil (part A) and what is in the soil (part B), predict which sample the water will flow through fastest in part C.

Materials

- 4 × 100 mL measuring cylinders
- 4 filter funnels
- 4 cotton balls
- 4 soil samples (beach sand, dry clay, good garden soil, potting mix)
- Stopwatch

Method

1. Press a cotton ball firmly into the V of each filter funnel.
2. Add 3 teaspoons of each soil sample to different funnels and press down firmly.
3. Place a funnel in the top of the measuring cylinder and add 20 mL of water.
4. Record the time it takes for the water to flow into the funnel.
5. Repeat steps 3 and 4 for the remaining three samples.
   - What is the independent variable in your experiment?
   - What is the dependent variable in your experiment?
   - Name three variables you will need to control during this experiment.

Results

Record your observations and measurements in a table.

Discussion

1. Which soil drained the fastest?
2. Which soil stopped the most water from flowing?
3. Which soil absorbed water best?
4. Why were the water-holding abilities different?
5. How accurate was your prediction? Explain why you think this was so.
6. What qualities does a good soil need to have for plants to grow well in it?

Conclusion

Compare the water-holding ability of the four soils.

4.6
CHALLENGE

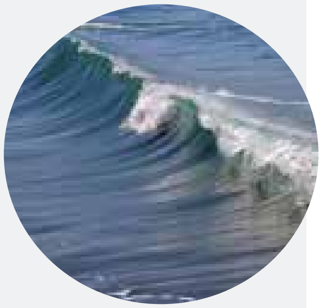
Resources for your future

Working in a small group, research and prepare a report about the depletion (using up) of one of the world's natural resources.

In your report, include:

> a brief summary of the topic
> what has caused the depletion of your chosen natural resource
> the effects of depletion of this natural resource
> short- and long-term solutions to this problem
> the role of public education in solving this problem
> what you could do about this problem.

Present your report to the class as a speech and short multimedia presentation.



5.1
CHALLENGE

Department store classification

1 With a partner, divide the items listed below into six department store groupings of your choice. Justify your choices.

snowboard, CD, 'miracle' moisturiser, waterproof tent, golf balls, jeans, mountain bike, T-shirt, atlas, cricket bat, Hacky Sack, laptop computer, sleeping bag, nail polish, digital alarm clock, TV celebrity poster, backpack, surfing magazine, ultrashine lip gloss, plasma TV, winter coat, wetsuit, R&B CD box set, glitter eye shadow, perfume, swimming costume, MP3 player, travel book, CD player, hoodie jumper

2 Divide the products in your six departments into smaller groups or 'sub-departments'.

3 Draw a plan of your department store layout. Think carefully about what departments you will put next to each other and why.

4 Join up with another pair and 'take them on a tour' through your department store.

5 How is your department store different to the one prepared by the other pair? What are the advantages and disadvantages of each design?

5.3
CHALLENGE

Dichotomous key

Using what you have discovered about the characteristics of living things, design your own dichotomous key.

Questioning and predicting

Think about objects that could be sorted into two groups; for example, you might like to use snack foods, such as corn chips, flavoured chips or plain chips.

Planning and conducting

- What similarities or differences can you find to separate the objects into two groups?
- What other similarities or differences can you find to separate them into further subgroups?
- Keep dividing each group into another two groups until each item is on its own.

Processing, analysing and evaluating

1. Draw a dichotomous key to show how you grouped the objects.
2. How hard was it to divide your objects into different groups? Could you have used a better group of objects?

Communicating

Swap dichotomous keys with another group. How effective is the dichotomous key constructed by the other group? Ask them to evaluate your key. Which was the best dichotomous key designed in your class? What features made it the best key?

Figure 10.45

Can you understand scientific names?

The scientific names of organisms usually come from Latin (and sometimes Greek) words. Latin was the language of science for many centuries. This enabled scientists who lived in different countries and spoke different languages to communicate their work and discoveries.

The words used in the scientific names of organisms describe physical features, behaviours and even colours. Some examples are given Table 10.1.

1 Use the information in Table 10.1 to match the scientific names of the Australian animals with their pictures in Figure 10.46.
   a *Macropus rufus*
   b *Tachyglossus aculeatus*
   c *Phascolarctus cinereus*
   d *Ornithorhynchus anatinus*
   e *Chlamydosaurus kingii*
2 What do you think a *Macroglossus aculeatus* might look like? On a sheet of A4 paper, sketch this imaginary animal, using the information in Table 10.1 to help you.

Table 10.1 Some scientific words and their meanings

LATIN OR GREEK ROOT WORD	ENGLISH MEANING
Aculeat	Spiny
Arctus	Bear
Anatinus	Duck-like
Cinereus	Grey
Gloss	Tongue
Hynchus	Snout
Macro	Large
Ornitho	Bird
Phascol	Pouch
Pus	Foot
Rufus	Red
Tachy	Fast
Chlamy	Caped
Saurus	Lizard

Figure 10.46

Classifying living things

The scientist whose main role it is to classify living things is known as a taxonomist. In this activity, you become the taxonomist.

What you need:

A3 card or paper, scissors, glue, pictures of different living things (from the Internet or magazines)

What to do:

1. On a sheet of A3 card or paper, mark up a table with four columns.
2. Label the columns 'Animalia', 'Plantae', 'Fungi' and 'Other (Monera and Protista)'. (Don't try to distinguish between Monera and Protista.)
3. Paste each of your pictures into the correct column.

5.6

EXPERIMENT

Aim

To examine the skeletal structures of three marine organisms.

Materials

- 1 fish (whole)
- 1 prawn
- 1 squid
- Newspaper
- Dissecting board
- Dissecting kit
- Pair of vinyl or latex gloves

CAUTION: SCALPELS ARE EXTREMELY SHARP. USE WITH GREAT CARE.

ALWAYS WEAR GLOVES WHEN HANDLING THE ANIMALS.

ANIMALS MUST ALWAYS BE ON THE DISSECTING BOARD WHEN THEY ARE BEING HANDLED OR DISSECTED.

IF CUT, REMOVE GLOVES AND WASH THE CUT UNDER CLEAN WATER. APPLY ANTISEPTIC TO THE CUT AND COVER IT WITH A DRESSING. TELL YOUR TEACHER.

Dissecting skeletons

Method

1 Observe the external features of the fish.
2 Carefully cut the fish in half lengthways so you can see the internal skeleton.
3 Observe the skeleton of the fish.
4 Feel the outside of the prawn and then peel it.
5 Cut the prawn in half and observe the insides.
6 Feel the outside of the squid and then cut it in half.
7 Observe the inside of the squid.

Results

Draw labelled diagrams of the skeleton of each specimen.

Discussion

1 Consider the fish.
   a Where is the skeleton of the fish located?
   b What is this type of skeleton called?
2 Consider the prawn.
   a Where is the skeleton of the prawn located?
   b What is this type of skeleton called?
3 Does the squid have a skeleton?
4 In which group of animals (vertebrate or invertebrate) would you place each of the organisms observed? Why?
5 What are you: a vertebrate or an invertebrate?

Conclusion

What types of skeleton are possible?

Figure 10.47

Figure 10.48

Figure 10.49

Figure 10.50

5.6

CHALLENGE

Identifying invertebrates

What you need:

magnifying glass or stereomicroscope, Petri dishes, jars with lids, tweezers, vinyl or latex gloves, newspaper

Alternatively, your teacher may provide prepared samples for you to look at. Complete the classification exercise for each prepared sample.

What to do:

> Do not touch any animal that might bite or sting. Check with your teacher if you are unsure.

> Use tweezers to pick up the animals.

> Place any animal immediately in a jar and secure the lid.

1. Visit a local natural environment (e.g. a garden, beach, park or pond) and observe invertebrate specimens.
2. Wearing gloves, use tweezers to collect up to ten invertebrate specimens in separate jars.
3. Use the tabular key in Table 5.1 on page 90 to classify the invertebrates into their particular phylum.
4. Use a magnifying glass or stereomicroscope to help you sketch each animal. Write the common name for the animal (if you can) and write down its classification group under the drawing.
5. Return the invertebrates to their natural environment after you have finished.

> Use the tabular key in Table 5.1 on page 90 to identify the phylum of each of the invertebrates shown in Figure 10.51.

Figure 10.51

5.7

CHALLENGE

Who are the vertebrates?

What you need:

A3 paper, pencils

What to do:

Vertebrate alphabet graffiti

This task could also be completed as a webpage, with images and links to further information about each animal.

1. Divide the class into five groups, each of which will be allocated one class of vertebrate.
2. Label an A3 sheet of paper with the name of your class of vertebrate.
3. Write the letters of the alphabet down the left-hand side of the page.
4. For each letter, write the name of an animal that fits this category.
5. When finished, you will have the names of up to 26 different vertebrates. Some categories will be harder to fill than others.
6. Put the finished sheets up around the room.

Jellyfish organiser for vertebrates

A jellyfish graphic organiser is a good way to show how subgroups make up a whole. It can also be used to list specific examples at the same time.

1. Individually, go around to each of the five lists of vertebrates and select six animals from each class.
2. On a full page, draw five 'jellyfish' connected to the main group (vertebrates), as shown in Figure 10.52.
3. Label each jellyfish with the class name (fish, reptiles, amphibians, mammals and birds).
4. Write a description of the characteristics of each class in the appropriate body of each jellyfish.
5. Place the six animals you selected along the six tentacles on each jellyfish.

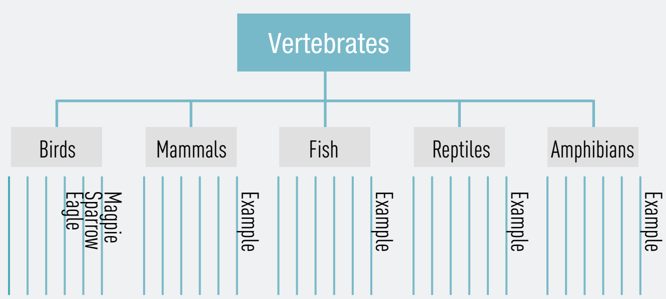


Figure 10.52 A jellyfish organiser for vertebrates.

5.8 CHALLENGE

Identifying plants

What you need:

camera, measuring tape, pencils, paper

What to do:

1 Observe and take digital photos of at least five different types of plants from a local bushland or from your garden.
2 Make detailed observations of each plant, including:
   a the height of the plant
   b the width of the plant
   c the shape, smell, texture and size of the leaves (take a close-up photo of the leaves)
   d the position and number of leaves on the plant.
3 Does the plant produce flowers, seeds or nuts? If so describe these.
4 Is there anything else unusual or special about this plant?
5 Repeat steps 2–4 for all the plants you observed.
6 What features did all the plants have in common?
7 What differences did you observe between the plants? Describe these differences.

6.1 CHALLENGE

Studying food webs

What you need:

metre-long sticks, metric rulers, poster board, markers, photographs of ecosystems

What to do:

1 Think about what you know about food webs in your area. Write a list of at least 10 components within these food webs. Do some areas support more life than others?
2 Select two 1 m^2 areas in your backyard, schoolyard or neighbourhood to study. The study areas should be near each other but in two different habitats (e.g. on a footpath and on some grass, or just inside a forest and in a clearing).
3 Observe and record all organisms in the area above and within this study area.
   - Which organisms are producers?
   - Which organisms are consumers?
   - How do the numbers (of individuals and species) of producers and consumers compare?

6.2
CHALLENGE

Exploring leaf litter

Leaf litter is the dead and rotting leaves that lie on the ground under trees and in gardens. Leaf litter helps protect soil and is home to many tiny, fragile invertebrates that work together to keep the soil in good condition.

BEFORE YOU START, ASK YOUR TEACHER ABOUT ANY BULL ANTS, POISONOUS SPIDERS OR CENTIPEDES IN YOUR AREA. THERE MAY BE SOME ANIMALS THAT COULD BITE YOU. IF IN DOUBT, LEAVE THE ANIMALS ALONE AND ASK YOUR TEACHER.

What you need:

old newspaper, gloves, plastic test tubes or specimen tubes with lids, wet paintbrush, hand lens, pen, paper

What to do:

1 Find an undisturbed area approximately 50 cm long by 50 cm wide. Work only in this area.
2 Lift up the leaves slowly. Use your brush to pick up the tiny animals and make sure not to crush them.
3 Make a list of the animals you find. Make a separate list for eggs, cocoons, larvae or types of fungi.
4 Return the animals to the place where you found them.
- Why is it important to know about the animals you are likely to find before looking for them?
- Why should you return animals to the place where you found them?
- A leaf litter community doesn't contain any producer organisms, such as healthy green plants. What is the energy source for this community?
- How does this leaf litter community help the soil?

6.2
EXPERIMENT

What if water were filtered through a pot with native grasses?

Aim

To find out how effective natural systems can be at filtering water.

Materials

> 1 medium-sized plastic pot
> 2 plastic buckets
> Stopwatch
> Gravel
> Sand
> Soil
> Plants
> Mixture of castor oil, soil, small pieces of paper, water, salt water
> Native grasses

Method

1 A few weeks in advance, prepare one plastic pot with a layer of gravel, then sand and finally soil. Plant some native grasses in this pot. Wait until the grasses have established themselves in the pot before proceeding. (Hint: You should be able to see the roots of the plant in the bottom of the pot.)
2 Mix the castor oil, dirt, finely shredded paper, salt and any other materials you wish to include in a bucket of water. The mixture should be very cloudy and have an odour.
3 Slowly pour an equal amount of the mixture through the pot, using the second bucket to collect the solution that filters out of the base of the pot. Time and record the flow of solution out of the base of the pot. Also take note of the odour of the solution.

Inquiry: What if the water was filtered through a pot with no plant?

> Write a hypothesis for your question.
> What (independent) variable will you change from the first method?
> How will you measure if the absence of the plant makes a difference to the filtering of the water?
> How will you make sure that all parts of the plant are removed?
> What other variables will you need to control?

Results

Create a table to record the time taken for the solution to flow out of the base of each pot. Include a description and/or photograph of the appearance of the solution before and after it has gone through each pot.

Discussion

1 Did the solution flow out of each pot at a different rate? Suggest a reason for any differences observed.
2 Compare the cloudiness of the final solutions. Suggest a reason for the differences observed.
3 Compare the odour of the filtered solution with that of the original mixture.

Conclusion

How effective are natural systems at filtering water?

6.3
EXPERIMENT

Aim:
To examine factors that affect the pollination of fruit.

Materials

- 10 chairs
- 2 large bags of popcorn
- 10 paper bags

What if the effectiveness of pollinators were reduced?

Method

1. Divide the class into groups with six students in each group. Each group represents a team of bees.
2. Gather the bees in one corner of the room or on the oval. This is the bee hive.
3. Place approximately ten chairs around the room or oval to represent apple trees. On the seat of each tree, place one handful of popcorn and an empty paper bag.
4. The bees must fly from tree to tree, taking a single piece of popcorn from one tree and putting it in the paper bag of another tree. This represents a bee pollinating the apple trees. Twenty seconds represents one growing season. This can become a competition if the number of pieces of popcorn on each tree is controlled.
5. At the end of 20 seconds, the bees gather back in the hive. A representative counts how many pieces of popcorn they have in each paper bag. Each piece of popcorn represents one apple that was able to grow on that tree during the season.
6. Record how many apples are grown in each team's first season. Average the number of apples grown that season across all the teams.
7. Empty the paper bags and reset the popcorn on each chair tree.

Inquiry: What factors can affect the effectiveness of pollinators?

Choose one of the variations below to investigate.

- What if the weather becomes colder so that the bees fly more slowly?
- What if a harsh winter kills half the bees in the hive?
- What if overcrowding in the hive causes half the bees to swarm out of the area?
- What if the apple trees are damaged and lose half their leaves?
- How will you represent your independent variable in the pollination model?
- What effect do you expect to see on your dependent variable?
- What variables will you have to control in your inquiry?

Results

Draw up an appropriate table and graph to show the results of your inquiry.

Discussion

1. What effect did changing bee populations have on the amount of fruit produced?
2. Suggest one way your pollination model was not an accurate depiction of real-world pollination.
3. Suggest one way to improve the model you used.
4. Name one situation that scientists may use computer modelling to research.

Conclusion

How important are pollinators to the supply of fruit?

6.4
CHALLENGE

Calculating your ecological footprint

Ecological footprint calculators are online surveys that help you and your family compare the impact of different activities you do or decisions you make.

1 Search the Internet for an ecological footprint calculator. Calculate the ecological footprint for your home or school.
2 Calculate your greenhouse gas emissions and the impact of your car, if your family owns one.
   - What things can you do at home to live more sustainably?
   - What changes would you have to make to your home to live more sustainably?
   - What changes would you and your family have to make to your lifestyles to live more sustainably?
   - Will these changes eventually save you and your family money?

6.6
CHALLENGE

Making a biosphere

Design brief

Use what you have learnt in this unit to construct a stable ecosystem for aquatic plants and macroinvertebrates (water fleas or pond snails).

Criteria restrictions

> Your materials are limited to those you find in a school pond or those provided by your teacher.
> A 1-litre bottle should be recycled for this challenge.

Questioning and predicting

> How will you place each organism in the container?
> What quantities of each organism should you use?
> What role will each organism play in your ecosystem?
> How will you prevent spillage from the container?
> Where will you store your container?
> How often will you evaluate the health of your organisms?
> What will you do if you find your organisms are unable to survive in the environment you create?
> What is the primary source of energy for the food webs in your ecosystem?

Processing, analysing and evaluating

1 What was the most successful feature of your design? What was the least successful?
2 Is there any practical use for your design?
3 If you were doing this experiment again, how would you modify your design? Explain.

Communicating

Present the various features of your design in a detailed poster.

Figure 10.53 Biosphere in a bottle.

6.7 CHALLENGE

Looking at eucalypt adaptations

What you need:

nuts, leaves and bark of a eucalypt

What to do:

1 Place the nuts in a 40°C oven for 24 hours to open and shed their seeds. Each of these thick woody capsules contains hundreds of tiny seeds.
- Why is the seed of the gumnut protected with such a thick external capsule?
- What might trigger the release of the seed from the gumnut?

2 Feel the leaves of the eucalypt. They have a thick cuticle that is effective in preventing water loss.

3 Hold a leaf up to the light or under a binocular microscope. Notice the numerous small dots, which are oil glands in the leaf.
- What is the function of the oil glands in a eucalypt leaf?

4 Have a close look at the bark of the tree. Many eucalypt trees have a bark that is thick and fibrous.
- What are some of the functions of bark?

7.1 EXPERIMENT

Measuring forces

Aim

To measure a variety of forces in common situations.

Materials

> Rubber band
> Thin strip of timber (or a ruler)
> Mass carrier and masses
> Pen

Method

A rubber band can measure the size of forces in a similar way to a spring balance. But before it can, it must be calibrated. This means matching the stretch of the rubber band to the number of newtons pulling on it.

1 Calibrate the rubber band on the strip of timber as shown in Figure 10.54.

2 Mark the distance that the rubber band is stretched on the timber when the mass carrier holds a 100 g mass. Remember: The weight force of 100 g equals 1 N of force.

3 Repeat for masses of 200 g, 300 g, 400 g and so on, marking the timber each time.

4 Use your measuring device to measure the force needed to:
   a open the door to the room
   b drag a chair across the floor
   c close a drawer in the laboratory
   d move your pencil case
   e pull up your sock
   f do three other movements of your choice.

Results

Draw a column graph showing the amount of force needed to move each object.

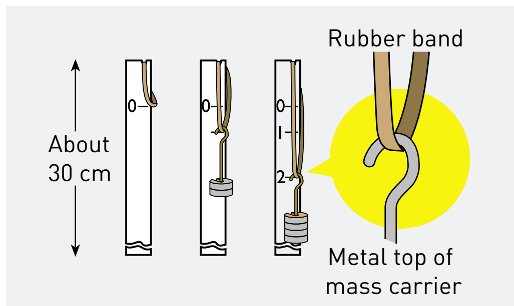


Figure 10.54 Calibrating the force measurer.

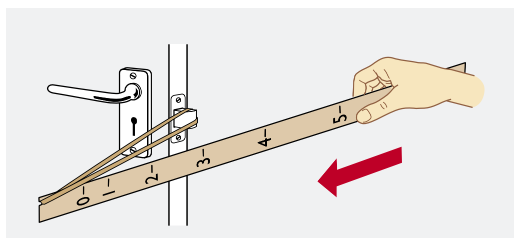


Figure 10.55 Measuring the force needed to open a door.

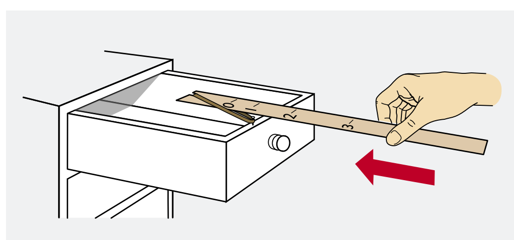


Figure 10.56 Measuring the force needed to close a drawer.

7.2
CHALLENGE

Design a ball whacker

Design brief

Design equipment that uses a block of wood to hit a tennis ball. A block of wood from home or the woodwork room is ideal. You must not use the force of gravity or push the block.

Questioning and predicting

1 How will you create a contact force between the wooden block and the ball?
2 How will you make the wooden block swing?
3 How far do you want your ball to move?

Planning and conducting

Figure 10.57 shows one way to set this up. Suggest two ways to modify this design.

Processing, analysing and evaluating

1 What changes did you have to make to move the ball further?
2 What was the most successful feature of your ball whacker? What was the least successful?
3 Is a heavy block better than a light one?
4 Is there any practical use for a 'whacker' like this?
5 If you were doing this experiment again, how would you modify your device? Explain.

Communicating

Present the various stages of your investigation in a formal experimental report.

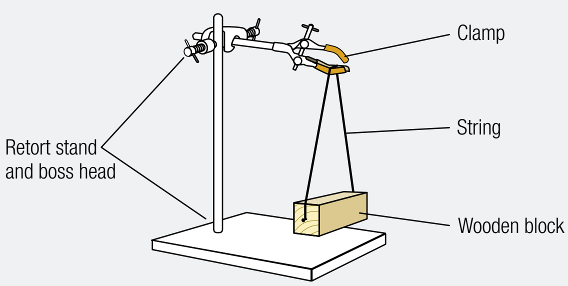


Figure 10.57 A possible design for the experiment.

7.3
CHALLENGE

Can you use the push and pull of a magnet?

Design brief

Choose one of the following design briefs.

1 Have a magnet race. Who can push a magnet across the length of a desk the fastest using another magnet?
2 Can you use the push force between two magnets to suspend the end of one magnet above the end of the other?
3 Design an experiment to determine how far away your magnet needs to be to attract a metal paperclip. What if you used another magnet? Design an experiment to test if the second magnet has a stronger pulling force than the first magnet. Remember to control all other variables.

Questioning and predicting

1 Should you use like or unlike poles?
2 Do all magnets have equal force?
3 Which part of a magnet has the strongest force?

Processing, analysing and evaluating

1 What changes did you have to make to improve your design?
2 What was the most successful feature of your design? What was the least successful?
3 Is there any practical use for your design?
4 If you were doing this experiment again, how would you modify your design? Explain.

Communicating

Present the various stages of your investigation in a formal experimental report.

7.5
EXPERIMENT

Aim

To examine the push or pull forces involved in electrostatically charged balloons.

Materials

- Two balloons
- String
- Wool/nylon material

What if a balloon were electrostatically charged?

Method

1. Blow up both balloons and tie knots in the ends.
2. Tie string to the ends of both balloons.
3. Rub one of the balloons on your jumper or with the material provided.
4. Hold the balloon by the string so that it does not lose its charge.
5. Hold the second balloon by the string and bring it close to the first balloon.
6. Would you describe the force as a push or pull force?
7. Does the balloon have to make contact for the force to be noticed?

Inquiry: What if both balloons are charged?

1. What (independent) variable will you change from the first method?
2. What (dependent) variable will you measure and/or observe?
3. Name three variables you will keep the same or control.
4. Write a hypothesis for your inquiry.
5. Describe what happened.
6. Explain why it happened.

7.6
EXPERIMENT

Aim

To investigate how friction may be reduced.

Materials

- Force measurer (see Experiment 7.1) or spring balance
- Thick textbook
- Wooden rollers (round pencils)
- Book
- Sand

What if the amount of friction were changed?

Method

1 Use your force measurer to measure the friction of your textbook being dragged along the table. (Hint: Drag it at constant speed.)

2 Place two books on top of each other and measure the friction.

Inquiry: Choose one question to investigate.

1 What if rollers were placed under the textbook?

2 What if sand was placed under the textbook?

3 Write a hypothesis for your inquiry.

4 What (independent) variable will you change from the first method?

5 What (dependent) variable will you measure and/or observe?

6 What variables will you need to control to ensure a fair test? How will you control them?

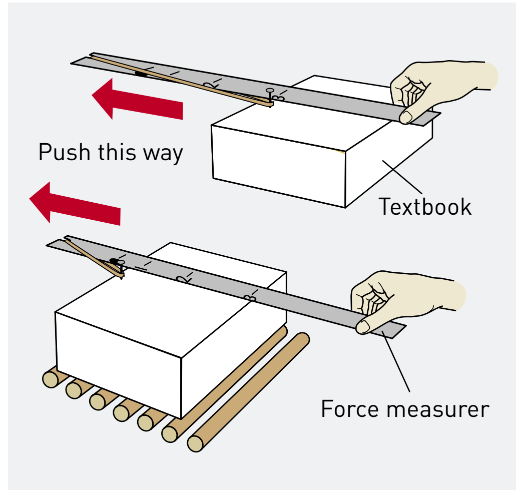


Figure 10.58 Measuring the friction of a textbook.

Results

Record your results in a table like the one at the bottom of the page.

Draw a column graph showing the effect of sand or rollers on the object's friction.

Discussion

1 Compare your results to those of others in the class.

2 What was the best way to reduce friction?

3 Would five rollers be better than two for reducing friction?

4 Would 10 rollers be better than five for reducing friction?

5 Would bigger or smaller rollers be better for reducing friction?

6 What are some problems with using rollers?

7 Write down a practical example of rollers being used to reduce friction.

8 Why wouldn't square rollers be any good?

9 Would fine sand or coarse (large-grained) sand be better for increasing friction?

10 Write down a practical example of sand being used to increase friction.

11 What are some problems with using sand for this purpose?

Conclusion

What do you know about how to reduce friction?

OBJECT	FORCE NEEDED TO MAKE IT MOVE (N)			
	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
Textbook				
Textbook with a second book on it				
Textbook with rollers under it				
Textbook with sand under it				

7.7A EXPERIMENT

Aim

To determine how a first-class lever balances different weights.

Materials

- Wooden or metal ruler
- 50 g weights
- Rounded glue stick or large pencil
- Blu-Tack

Using a first-class lever to lift weights

Method

1. Place the glue stick or pencil flat on the desk and hold it in place with Blu-Tack.
2. Place the centre of the ruler over the glue stick or pencil so that it forms a simple see-saw.
3. Add three 50 g weights 4 cm from the centre of fulcrum on one side.
4. Add three 50 g weights to the other side so that the see-saw becomes balanced.

Inquiry: Choose one question to investigate

1. What if a greater weight was placed closer to the fulcrum?
2. What if greater weight was placed further from the fulcrum?
3. What if less weight was placed closer to the fulcrum?
4. What if less weight was placed further from the fulcrum?

Results

Record your results by copying and completing the table.

Discussion

1. What pattern do you notice between the left-hand side and the right-hand side of your first-class lever?
2. What is mechanical advantage?
3. Calculate the mechanical advantage of the lever when the single weight on the left-hand side lifts the five weights on the right-hand side.
4. Provide another example of a first-class lever that you have used.

Conclusion

Draw and label a first-class lever and describe how to determine its mechanic advantage.

LEFT-HAND SIDE			RIGHT-HAND SIDE		
NUMBER OF WEIGHTS	POSITION FROM FULCRUM (CM)	NUMBER OF WEIGHTS × DISTANCE FROM FULCRUM	NUMBER OF WEIGHTS	POSITION FROM FULCRUM (CM)	NUMBER OF WEIGHTS × DISTANCE FROM FULCRUM
3	4	12	3		
3			2		
3			1		
1			5		

7.7B
EXPERIMENT

Aim

To investigate the mechanical advantage of a second-class lever.

Materials

- Shoebox
- 2 spring balances
- Cardboard
- Sticky tape
- 2 rulers
- Weights

Using a second-class lever to lift weights

Method

1. Use sticky tape to stick the rulers together in a V shape.
2. Divide the shoebox into two compartments using the cardboard.
3. Attach the box on the top of the rulers so that it looks like a wheelbarrow with a front and rear compartment.
4. Add weight to the front of your second-class lever.
5. Use the spring balances on the handles to calculate the total effort force need to lift this weight.
6. Repeat this measurement three times.

Inquiry: What if the weight were placed further from the fulcrum?

1. Write a hypothesis for your question.
2. What (independent) variable will you change from the first method?
3. What (dependent) variable will you measure and/or observe?
4. Name three variables you will keep the same or control.
5. Record your measurements in a table.

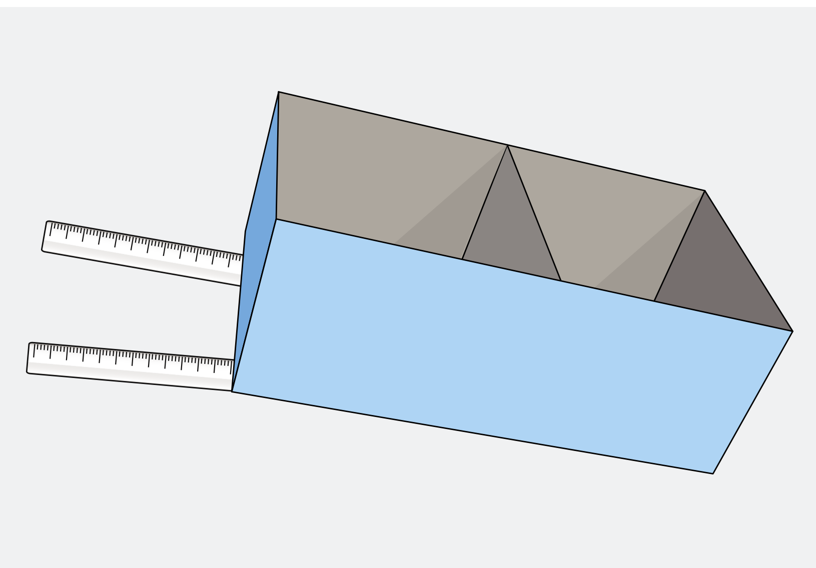


Figure 10.59 Experimental set-up.

Results

Copy and complete the following table to show the effort required when the front of the wheelbarrow is loaded.

	SPRING BALANCE 1	SPRING BALANCE 2	TOTAL EFFORT
Attempt 1			
Attempt 2			
Attempt 3			
Average			

Copy and complete the following table to show the effort required when the rear of the wheelbarrow is loaded.

	SPRING BALANCE 1	SPRING BALANCE 2	TOTAL EFFORT
Attempt 1			
Attempt 2			
Attempt 3			
Average			

Discussion

1. Why did you repeat each measurement three times?
2. Describe the difference in total effort required when the weight was shifted further from the fulcrum on the second-class lever.
3. What does this suggest about how a wheelbarrow should be loaded by its user?

Conclusion

Describe the mechanical advantage of using a second-class lever.

7.8 EXPERIMENT

Calculating mechanical advantage

Aim

To see how the number of pulleys affects the size of the effort needed to lift a load and the distance this load travels.

Materials

- Retort stand
- 500 g weight
- Spring balance
- Set of pulleys
- String

Method

1 Set up four pulley systems using one, two, three and four pulleys.

2 Pull on the spring balance to raise the load by 10 cm.

3 Record the average reading on the spring balance and the distance moved by the spring balance.

4 Calculate the mechanical advantage in each case.

Results

1 Copy and complete the following table.

NUMBER OF PULLEYS	EFFORT READING ON THE SPRING BALANCE (N)	DISTANCE THE EFFORT HAS TO MOVE (CM)	MECHANICAL ADVANTAGE (LOAD ÷ EFFORT)
1			
2			
3			
4			

2 Draw a column graph showing the relationship between the number of pulleys and the mechanical advantage.

Discussion

1 What happens to the effort needed to lift the 500 g load as more pulleys are used?

2 What happens to the distance the effort moves compared to the distance the load moves?

3 What would the spring balance read if six pulleys were used to lift the 500 g load?

4 What length of string would have to be pulled through the pulleys to lift the 500 g load 20 cm upwards?

Conclusion

Write a statement that relates the number of pulleys to the size of the effort and the distance moved by the load.

7.9 EXPERIMENT

Comparing different machines

A INCLINED PLANE

Materials

- 500 g mass (with a hook to attach to the spring balance)
- Ramp (30 cm ruler or a wider or longer piece of thin wood or plastic)
- Shoebox (or pile of books or plastic tub upside down)
- Spring balance
- Metre ruler

Method

1 Measure and record the height of the shoebox (or pile of books).

2 Measure and record the force required to carefully lift the 500 g mass vertically at a constant speed onto the top of the box.

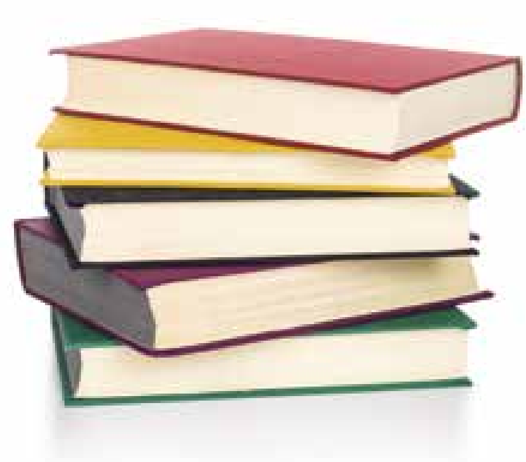
3 Repeat step 2 several times and calculate an average force.

4 Position the ramp against the box and measure and record its length.

5 Slowly pull the 500 g mass up the ramp using the spring balance and record the force required.

6 Repeat step 5 several times to get an average force.

7 Which method provided the greatest mechanical advantage? What evidence do you have to support your conclusion?



Materials

- 2 blocks of wood
- 2 thick, tight rubber bands
- Wedge-shaped piece of wood

B WEDGES

Method

1. Place the rubber bands over the two pieces of wood to hold them tightly together.
2. Try pulling the blocks apart with your hands.
3. Place the pointed edge of the wedge between the two blocks and push it in.
4. What advantage did using a wedge have on separating the two blocks of wood?

Materials

- G-clamp
- Matchbox

C SCREW

Method

1. Try crushing the matchbox using only your fingers, but don't actually crush it.
2. Place the matchbox between the faces of the G-clamp and tighten it until it crushes.
3. Did using the screw mechanism in the G-clamp provide a mechanical advantage in crushing the matchbox? Describe the differences you noticed between using the two methods.

Materials

- Simple machine kit with a wheel and axle model or one made from Lego® or K'NEX®
- Cotton thread or string
- 2 weights

D WHEELS AND AXLES

Method

1. Design and build your own working model of a wheel and axle simple machine.
2. Use cotton thread or string and two weights to demonstrate how your model can work as a force magnifier.
3. Modify your model or build another one to demonstrate how it can work as a distance magnifier.
4. How is a force magnifier different from a distance magnifier?
5. What did you change for the second model?
6. Why did you decide to change this aspect?

8.1

SKILLS LAB

Calculate weights in the solar system

The effects of gravity are affected by the mass of the objects involved. Gravity on the Earth is determined by the mass of Earth. How this gravity affects objects on the Earth is determined by their mass.

By doing some simple calculations, you can work out what your weight would be if you lived on the Sun, on other planets in the solar system or on the Moon. Note that the Earth has a gravity factor of 1, which is often referred to as 1*g*. To calculate weight, you will need to multiply mass (the reading on the bathroom scales) by the gravity factor for the planet, Sun or Moon. Remember that weight is measured in newtons.

1 Using the Earth's gravity factor, calculate the weight of a 65 kilogram person on the Earth and record it in Table 10.2 (in the first row).
2 Complete Table 10.2, filling in the weight for the 65 kilogram person on the other planets, the Sun and the Moon.
3 Imagine holding an Olympic Games on the different astronomical bodies listed in Table 10.2. Based on your calculations, do you think the gravity factor for the planet would affect the results of the events? For example, would diving or high jump be affected? What about other events?
4 How would gravity affect your lifestyle on Mercury compared with Jupiter? What everyday tasks would be easier or harder? Explain.

Table 10.2 A person's weight in the solar system

PLANET	GRAVITY FACTOR	PERSON'S MASS (KG)	PERSON'S WEIGHT (N)
Earth	1.00	65.00	
Mercury	0.38	65.00	
Venus	0.90	65.00	
Mars	0.38	65.00	
Jupiter	2.87	65.00	
Saturn	1.07	65.00	
Uranus	0.93	65.00	
Neptune	1.23	65.00	
Sun	27.80	65.00	
Moon	0.16	65.00	

8.2

CHALLENGE

Modelling gravity in the solar system

What you need:

1 small hula hoop, 1 thin stretchable plastic sheet (i.e. garbage bag or cling wrap), 2–4 small marbles, one 5 cm Styrofoam ball, ½ cup of play dough

What to do:

Many scientists describe the gravitational field in space as acting like a trampoline. If the trampoline is flat, a marble is able to roll straight across the surface, much like an asteroid through empty space. If the trampoline is not flat because a brick is sitting on it, then the marble will curve around the object as it rolls along, much like an asteroid curves around a planet as it moves through the solar system.

You can mimic this using the hula hoop to represent space.

1 Cover the hula hoop with the thin sheet of plastic.
2 Suspend your model universe on books or bricks.
3 Roll a marble across the tight plastic sheet. Describe its movement.
4 Place two marbles on the plastic sheet. Describe how the two marbles move.
5 Place the rounded ½ cup of play dough in the centre of the plastic sheet.
6 Describe what happens when the marbles are now dropped onto the sheet.
7 Replace the play dough with the Styrofoam ball. Describe the motion of the marbles when they are dropped onto the sheet a second time.

Questions

1 In your model, how was gravity represented?
2 Which had the strongest 'gravitational pull', the play dough ball or the Styrofoam ball? What evidence do you have to support your answer?
3 What type of object in the solar system could the Styrofoam ball represented? (Hint: large and low density.)
4 Black holes are space objects with such a strong gravitational field that nothing can escape them. Why are they called *black* holes?

9.1

CHALLENGE

Modelling how the Earth moves in space

Night and day, the seasons and a year can be demonstrated using a simple model.

What you need:

Model of the Earth (this can be a globe, an Earth ball or a balloon with the continents drawn on it with a felt-tip pen), torch or projector, light bulb on stand

What to do:

Night and day

1 Make your classroom as dark as possible and shine a light from a torch or a projector onto the model of the Earth. This shows night and day on the model Earth. It is daytime on the part of the Earth with the light shining on it, and it is night-time on the part of the Earth in shadow.
2 Rotate the globe so that dawn, then dusk, then dawn appear.
   - In which direction should the Earth spin? (Hint: In winter, it is dawn in Melbourne 2 hours before the Sun comes up in Perth.)

A year

1 Darken your classroom and set a single light bulb on a stand in the middle of the room. This is a model of the Sun, which shines light in all directions.
2 Hold your model of the Earth and walk in a circle around the lamp. This is the Earth going around the Sun. One circle, or orbit, is one year. To model the Earth accurately, you should spin the Earth as it orbits the Sun.
   - How many times should the Earth spin in one orbit?

Modelling solar eclipses

Model a solar eclipse by positioning the Moon between the Sun and the Earth. You will need to suspend the Moon from a piece of string to avoid casting your own shadow onto the Earth. Observe the Earth as the Moon comes into position.

- During which phase of the Moon does a solar eclipse occur?

9.2

CHALLENGE

Modelling the phases of the Moon

What you need:

torch or lamp with exposed light bulb, globe or basketball, tennis ball, 1 small foam ball

What to do:

1 In small groups, use a torch or light bulb in a fixed position to represent the Sun. One person should then hold a globe or basketball to represent the Earth, and another should hold a tennis ball to represent the Moon.

2 Begin by rotating the Earth as it orbits the Sun. Try to work out how the Moon would orbit the Earth as the Earth orbits the Sun.
   - Does this explain why we only see one side of the Moon?
   - When people refer to the 'dark side of the Moon', are they always talking about exactly the same side?

3 Use a black permanent marker to colour half of the foam ball. Face the white side of the foam ball towards you. This represents the fully lit face of a full Moon. Slowly rotate the foam ball so that the Moon appears to be getting smaller. (You will gradually see more of the darkened side of the Moon.) Draw each phase of the moon as you see it on the foam ball. Shine the light on the white section of the Moon. Pass the tennis ball between the light and the foam ball. What does this represent?

9.3

CHALLENGE

Modelling the seasons

What you need:

torch or lamp with exposed light bulb, globe or basketball, tennis ball, 8 small foam balls

What to do:

1 Use a torch or light bulb in a fixed position to represent the Sun. One person should then hold the globe or basketball to represent the Earth.

2 The Earth is tilted as it orbits the Sun. Hold your model Earth so that it is tilted slightly. Imagine the axis is tilted to point towards the numbers 1 and 7 on a clock face. Do not change this tilt during the activity.

3 Walk slowly in a circle around the lamp, at the same time rotating the model Earth. Make sure the tilt always points in the same direction. When it is summer in Australia, the Sun is almost overhead. In winter, the sunlight arrives at an angle and is more spread out.
   - When you have walked half a circle around your Sun, stop and look at the model Earth. How is it different? Which part of the Earth is having summer?

GLOSSARY

A

accuracy
careful, correct and consistent measurement or processing of data

aim
purpose of an experiment

air resistance
friction between a moving object and the air it is moving through

amoeba
type of single-celled organism belonging to the Protista kingdom

apparatus
equipment placed together for an experiment

asteroid
rocky body that orbits the Sun

astronomer
scientist who studies planets, stars and the solar system

atmosphere
layer of gases that surrounds Earth and other planets

attraction force
the force that attracts one object to another

autotroph
organism that makes its own food (e.g. plants)

axis
an imaginary straight line joining the north and south poles of the Earth

B

bacteria
unicellular organisms with a cell wall but no nucleus

balanced forces
two forces equal in size and opposite in direction

binomial name
double-name system created by Linnaeus to name organisms; the first name is the genus, the second name is the species

biodiversity
the variety of life; the different plants, animals and microorganisms and the ecosystems they live in

block and tackle
group of pulleys mounted together in a frame or block, which provides significant mechanical advantage

boiling point (BP)
the temperature at which a liquid boils and turns to a gas

botanist
scientist who studies plants

branched key
a method of identifying a species using questions that lead to further questions and eventually to the name of the species

Bunsen burner
a piece of equipment used as a heat source in the laboratory

C

calibrate
to check the accuracy of a meter against known measurements

carnivores
animals that eat only meat

cell
(*biology*) the building blocks of living things

cell wall
a structure that provides support around some cells

Celsius (°C)
temperature scale and unit of measurement of temperature

centimetres (cm)
unit of length used to measure short distances; equal to one-hundredth of a metre

centrifuging
technique used to separate light from heavy particles by rapidly spinning the mixture

chromatography
technique used to separate substances according to differing solubilities

classify
group or organise

coal
fossil fuel formed from the remains of trees and plants that grew about 300 million years ago

colloid
type of mixture that always looks cloudy because clumps of insoluble particles remain suspended throughout it – they don't settle as sediment

column graph
a graph in which the height of the columns represents the number measured

concentrated
contains a large number of solute particles in the volume of solution

concentration
how much solute is dissolved in a solvent

conclusion
a statement that 'answers' the aim of an experiment; should be clear and reasoned and relate very closely to the aim

condensation
the cooling of gas into a liquid

consumers
animals who can't convert the Sun's energy into sugars and must eat to get the energy they need to survive

contact forces
forces occurring when two objects are touching each other

continuous data
data where the numbers can be any value

crystallisation
separation technique used in conjunction with evaporation to remove a dissolved solid from a liquid; after the liquid has been evaporated the solid remains, often in the form of small crystals

cubic centimetres (cm^3)
a volume equivalent to that of a cube of length one centimetre

D

dead
something that was once living but no longer has the characteristics of a living thing

decanting
technique used to separate a sediment from the liquid it is in by carefully pouring the liquid away

decomposers
organisms that feed on dead things (e.g. bacteria)

dense
when particles are packed more tightly in an object

dependent variable
variable that may change as a result of the experiment

desalination plant
a large facility set up to produce fresh water from salt water

dichotomous key
diagram used in classification; each 'arm' of the key contains two choices

discrete data
data where the numbers can only be whole numbers

discussion
summary of findings, analysis of the design of an experiment; it includes any problems encountered and suggestions for improvement

distance magnifier
lever that changes a strong force that acts over a short distance into a weak force that acts over a longer distance

distillation
technique that uses evaporation and condensation to separate a solid contaminant and the solvent in which it has dissolved

domain
very small sections of a magnet

dormant volcano
volcano that is not currently erupting but may erupt again in the future

drag
see air resistance

dwarf planet
new term adopted by scientists in 2006 when Pluto was downgraded from planet status; dwarf planets are round and orbit the Sun but they do not have a clear orbit and intersect with other celestial bodies; Ceres and Eris are two other dwarf planets in our solar system

E

ectotherm
organism with a body temperature that changes with the environment

effort
force used to operate a lever

electrostatic force
force between two objects caused by a build-up of negative charges

emissions
the production and release of something (e.g. gas)

emulsifier
a substance that enables oil and water to form an emulsion

emulsion
a colloid of two or more liquids

endoskeleton
internal skeleton

endotherm
organism with a constant body temperature

energy resources
resources that can be used for the production of energy

equinox
day on which day and night are the same length

equipment
items used in the laboratory to conduct experiments

erosion
the movement of weathered rock and soil away from its place of origin

error
the unavoidable and random inconsistency in measurement

ethanol
a type of alcohol that can be used for the production of energy

evaporation
change in state from liquid to gas; also a technique used to separate dissolved solids from water

exoskeleton
external skeleton

experiment
an investigation used to solve a problem or find an answer to a question

F

fair test
a controlled experiment

filter paper
paper sieve with tiny holes that are too small to see; solutions can flow through but most solid particles will not

filtering
technique used to separate different-sized particles in a mixture depending on the holes in the filter used

filtrate
the substance that passes through a filter

flocculants
chemicals added to a mixture to make suspended particles clump together

flotation
when a substance is less dense than the liquid it is put in, it will float to the top

food chains
a diagram that shows who eats who in an ecosystem and how nutrients and energy are passed on

food web
several intertwined food chains, showing the extended relationships between different organisms

force magnifier
lever that can change a weak force into a strong force

fossil fuels
non-renewable energy source formed from plant and animal matter

freezing temperature
the temperature at which water becomes a solid

friction
force that acts to oppose the motion between two surfaces as they move over each other

fulcrum
turning point of a lever

G

generator
converts the energy from the movement of a turbine, for example, into electrical energy

genus
a group of closely related species

geothermal energy
energy that comes from heat beneath the Earth's surface

global warming
increase in the Earth's temperature due to the presence of certain human-made gases

gram (g)
unit of mass

gravitational field
the area around a body in which another body experiences a force of attraction

gravity
the force of attraction that objects have on one another due to their masses

green wedges
non-urban areas around metropolitan areas

greenhouse gas
a gas (carbon dioxide, water vapour, methane) in the atmosphere that can absorb heat

ground water
water found beneath the Earth's surface

H

habitat
environment in which an organism lives

herbivores
animals that eat only plants

heterotroph
organisms (e.g. fungi) that need to absorb nutrients from other living things

high tide
when oceans cover slightly more land

hot dry rock geothermal energy
a method of pumping water into deep hot rocks in the ground in order to get steam, which is then used to drive a turbine to provide electricity

humus
decomposed plants and animals

hybrids
cars that use a mix of petrol and electricity

hydroelectric energy
energy produced by falling water that turns turbines to generate electricity

hypothesis
a predicted description of what will occur during an experiment; it is able to be tested

I

independent variable
a variable (factor) that is changed in an experiment

inference
likely explanation of an observation

insoluble
does not dissolve

invertebrate
organisms with an exoskeleton (external skeleton) or no skeleton at all

K

key
(*biology*) visual tool used in the classification of organisms

kilogram (kg)
unit of mass

kilometres (km)
unit of length used to measure long distances; equivalent to 1000 metres

kingdoms
(*biology*) a rank that scientists use to classify living things; the most commonly used system of classification uses five kingdoms: Animalia, Plantae, Fungi, Monera, Protista

L

laboratory
specially designed space for conducting research and experiments

land degradation
the process of using up or removing the resources of land (e.g. water, topsoil, plants)

leap year
an Earth year is approximately 365.25 days; to enable our calendar to have an exact number of days we have a 365-day year; in a leap year, which occurs once every 4 years, an extra day is added to the month of February to make up the difference

lever
simple machine that reduces the effort needed to do work

like poles
two north poles or two south poles of a magnet

line of best fit
the line on a scatter graph that passes through or as near to as many data points as possible

Linnaean taxonomy
system of classification first developed by Carl Linnaeus (1707–78) in which all organisms are grouped into one of five kingdoms

liquid
a substance that is able to flow across a surface and maintain a fixed volume

litres (L)
unit of volume used to measure liquids; equivalent to 1000 millilitres

load
resisting force

low tide
when oceans cover slightly less land

low-emissions vehicles
cars or buses that release very little exhaust gases, including carbon dioxide

lubrication
using a lubricant, such as oil or grease, to decrease friction

lunar eclipse
when the Moon is in the Earth's shadow and appears dark

M

magnetic
able to be magnetised or attracted by a magnet

magnetic field
three-dimensional space around an object where a magnetic force is experienced

magnetic poles
north and south ends of a magnet

magnetism
a property of matter that produces a field of attractive and repulsive forces

mass
how many particles or atoms make up an object; the mass of an object does not change

matter
anything that has mass and takes up space (i.e. has volume)

melting point (MP)
the temperature at which a substance melts

meniscus
the phenomenon that occurs when water is put into a glass container and is 'pulled up' where it touches the glass; volume should always be measured from the bottom of the meniscus

method
list of how to do an experiment

metres (m)
the standard unit of length

metric system
a system of measurement

microbiologist
a scientist who studies microorganisms

microgravity
a situation where there is minimal gravitational force (e.g. an orbit, a free-falling object or out in space)

milligrams (mg)
unit of mass; equivalent to one-thousandth of a gram

millilitres (mL)
unit of volume used to measure small or exact quantities of liquids; equivalent to one-thousandth of a litre

millimetres (mm)
unit of length used to measure short distances; equivalent to one-thousandth of a metre

minerals
tiny grains of crystals that are the building blocks of rocks

mixtures
something made up of two or more pure substances mixed together

moons
natural satellites that rotate around a planet

multicellular
organism that has more than one cell

mycologist
scientist who studies fungi

N

neap tides
smaller tides that occur during the Moon's quarter phase

net force
combination of all forces acting on an object

newton (N)
the unit used to measure force

non-contact forces
forces that operate between two objects when they are not touching each other (e.g. gravitational)

non-living
something that has never had the characteristic of a living thing

non-renewable
resources that are limited because, once used, they take a long time to replace

nucleus
a membrane-bound structure found in cells that contains most of the cell's genetic material

O

observation
using all your senses to notice things around you

omnivores
animals that eat both plants and animals

orbit
the path a plant moves around the Sun/star, or a moon moves around a planet

ores
materials that contain useful amounts of minerals mixed with other substances

organism
living thing

P

parallax error
an error that occurs as a result of reading a scale from an angle

partial eclipse
when only some of the Sun's light is blocked by the Moon

phases of the Mooth
changes in the appearance of the shape of the Moon

philosopher
'lover of knowledge'

plankton
microscopic organisms that float in fresh or salt water

pollination
occurs in flowering plants when a pollen cell (the male sex cell) lands on the stigma (the uppermost tip of the female part of a flower)

power station
place where energy is converted to electricity

precipitation
(*weather*) rain, hail or snow

producers
plants and plant-like organisms found at the start of food chains

properties
(*chemistry*) characteristics or things that make something unique

pseudoscience
claims that are made without evidence to support them

pseudoscientist
a person who pretends, or mistakenly believes, that they are a scientist but whose work is not based on research or evidence (e.g. astrologer)

pure substance
something that only contains one type of substance

Q

qualitative observation
an observation that uses words and is not based on measurement or other data

quantitative observation
an observation that uses a number, such as a measurement

R

ramp
simplest type of inclined plane

renewable
resources that are made naturally and are available in an almost unlimited amount

reproduction
the process by which living things make new life

repulsion force
force that pushes one object away from another

residue
the substance left behind in a sieve or filter

results
the measurements and observations taken in an experiment; they are best presented in a table

S

saturated
a solution in which no more solute can be dissolved

scatter graph
a graph used to represent continuous data; it consists of discrete data points

science
the study of the natural and physical world

scientific diagrams
clear, side view, labelled drawings using a sharp pencil

scientist
a person who studies the natural and physical world

screw
inclined plane

second (s)
unit of time

sediment
something that settles to the bottom of a mixture

solar cells
energy from the Sun

solar eclipse
when the light from the Sun is blocked by the Moon

solar energy
energy made by atoms colliding with each other in the centre of the Sun

solar system
the system made up of the Sun and all the plants, dwarf plants, moons and asteroids that travel around the Sun or each other

solidified
what happens to a liquid when its particles lose energy (heat) and the substance is now unable to change its shape

solstice
the summer solstice (the longest day and shortest night) occurs on 21 December in the southern hemisphere when the Sun in the highest in the sky; the winter solstice (the shortest day and longest night) occurs on 21 June in the southern hemisphere

solubility
how easily a substance dissolves in a solvent

soluble
can be dissolved in a liquid

solute
a substance that dissolves in a liquid (solvent)

solution
a liquid made up of a solvent with a solute dissolved in it

solvent
any liquid that dissolves other substances

species
group of organisms that look similar to each other, can breed in natural conditions and produce fertile young

spores
reproductive cell produced by some plants, protozoa and bacteria

spring balance
device consisting of a spring and a scale, used to measure forces in the laboratory

spring tides
high tides caused by the combined pull of the Moon and the Sun

star
a hot, gaseous celestial body that produces heat and light; the Sun is the closest star to Earth

streamlining
making a surface smooth and rounded to reduce friction

substance
a solid or liquid that can be mixed

suspension
a cloudy liquid that contains insoluble particles

T

taxonomist
scientist who classifies living things into groups

taxonomy
the scientific process of sorting living things into groups

telescope
an optical instrument that uses lenses and mirrors to make distance objects appear closer and larger

thread
spirals around a screw

tidal energy
energy produced using the tides to drive turbines in the water

tonne (t)
unit of mass

total solar eclipse
when the Moon blocks the maximum amount of light from the Sun

transpiration
the process by which plants take up water from the soil through their roots and loses it through their leaves

turbine
a large wheel with angled sections called vanes, like a propeller, that is used to generate electricity

U

ultraviolet (UV) radiation
radiation emitted by the Sun; humans need this to make vitamin D for healthy bones; UV radiation causes skin cancer

unbalanced forces
two or more forces that are unequal in size and direction and therefore change an object's speed, direction or shape

unicellular
organism that consists of only one cell (e.g. bacteria)

units
standard measurements

unlike poles
north and south poles of magnets

urban sprawl
the spread of urban areas into rural areas

V

variable
something that can affect the results of an experiment

vascular tissue
in a plant, tube-like structures that transport water from the roots to the leaves

vertebrate
organisms with an endoskeleton (internal skeleton)

volcano
vent or hole in the Earth through which molten (melted) rock ash and other materials escape onto the surface

W

water cycle
the cycle of constant evaporation and precipitation that occurs in nature

water vapour
water in the gaseous state

wave energy
energy produced using the power of waves to drive air turbines

weather
the state of the atmosphere at a particular place and time

wedge
inclined plane that moves through another object and changes a downwards force to a sideways force

weight
a measure of how much gravity is pulling on an object

wheel and axle
lever that can rotate about its centre, magnifying force or distance

wind
movement of air caused by low and high pressure systems

wind farms
a large group of wind turbines in the same location

wind turbines
a wheel with blades that turn in the wind

Z

zoologist
scientist who studies animals

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OXFORD
UNIVERSITY PRESS
AUSTRALIA & NEW ZEALAND

ISBN 978-0-19-030082-1

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