Heinemann Interactive Science 1

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Heinemann

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All the experiments described in this book have been written with the safety of both teacher and student in mind. However, all care should be taken and appropriate protective clothing should be worn when carrying out any experiment. Neither the publisher nor the authors can accept responsibility for any injury that may be sustained when conducting any of the experiments described in this book.

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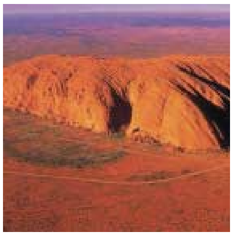

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Introduction

The Heinemann Interactive Science series has been specifically designed to assist schools in the implementation of the New South Wales Science Syllabus Stages 4 and 5. This resource will provide students with a wide range of learning experiences to achieve the knowledge and understanding, skills and values and attitudes outcomes of the syllabus.

Features of Heinemann Interactive Science

Chapters begin with a short **Introduction** which places the content in a context which will engage students and stimulate their interest. The chapter context gives coherence to the knowledge and understandings, skills and values and attitudes being developed. The chapter outcomes are descriptions of the intended student outcomes which could reasonably be expected to be demonstrated by students who successfully complete the chapter. They address both core and options outcomes from the syllabus. A **grid** relating the **Stage 4 Outcomes** to the relevant chapter(s) follows this introduction.

Each chapter contains one or two **Science in Focus** double-page spreads which specifically address the mandatory **Prescribed Focus Areas** of the syllabus. These spreads are:

- History of science: 5.5, 6.1, 11.4
- The nature and practice of science: 1.8, 2.5, 7.2, 8.7, 9.2, 10.5
- Implications for society and the environment: 1.4, 4.9, 8.9, 9.9
- Applications and uses of science: 2.9, 3.6, 3.9, 4.5, 5.10
- Current issues, research and development: 6.8, 7.7, 11.9

The double-page spread format of Heinemann Interactive Science provides all the content, experiments, discussion topics, activities and questions for a lesson. Each spread gives teachers the flexibility to treat a topic in whatever way is most appropriate for their students.

Experiments are detailed guided investigations relevant to each topic. Suggested extensions encourage students to investigate further, often using a more open-ended approach.

This icon is used to identify experiments for which safety glasses should be worn.

This icon is used to identify experiments that are regarded as having significant and identifiable risks associated with them. The Teacher's Resource Disk includes extra advice on minimising these risks.

The **Using Science** activities include a wide variety of learning experiences such as model making, the manipulation and interpretation of given data and diagrams, group discussions and debates.

Talk about involves students sharing and developing their personal understandings. These may be used as a lesson introduction, to place the topic in context and establish the students' prior knowledge.

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Each double-page spread contains a range of question types to reinforce students' understanding of the concepts. **Think about** questions ask students to go further with the concept they are learning about, to consider the application of the concept to different situations. **Find out** questions encourage students to research from a range of sources information related to the topic. They are aimed at extending students to obtain a greater depth of knowledge and understanding. Additional **Activities** are provided on many spreads. These additional learning experiences could be used as homework or assignment tasks. Many of the Find out questions and Activities involve students in writing tasks such as descriptive reporting, recounting, experimental reporting and narration.

Fact files are snippets of information designed to heighten students' interest in the concepts covered in each spread.

Each chapter concludes with a **Chapter Review**. These include exercises to reinforce the development of vocabulary, questions to check knowledge, and higher order questions to check application of knowledge. Some 'challenge' material is also included as additional or extension work.

Teacher support

The Teacher's Resource and Assessment Pack consists of a teacher resource disk and a student's book. The disk contains assessment and course advise. The safety guidelines are of particular interest to less experienced teachers. Foundation and Extension worksheets are also provided for each chapter. One worksheet per chapter addresses a functional approach to literacy. An end-of-chapter test with answers provided and answers to textbook questions will also save teacher preparation time.

Heinemann Science Online, an email service which brings relevant current events in science into the classroom, provides student worksheets with questions and activities and teacher notes which provide answers and further suggestions.

Christine Watson

About the Author

Christine Watson is currently head teacher science at Colo High School. She has 19 years of teaching experience in both rural and metropolitan high schools. She has been involved in the writing and editing of numerous resources to support science teaching.

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Stage 4 Correlation Grid

The following grid references the **Stage 4** ***knowledge and understanding*** **outcomes** to the relevant chapters of **Books 1** and **2**. The Teacher's Resource and Assessment Disk contains detailed information on mapping core content and assessment. A sample Work Program is available on hi.com.au.

bold = principal source
italics = secondary source

Outcomes		Book One Chapter	Book Two Chapter
4.1	identifies historical examples of how scientific knowledge has changed people's understanding of the world.	**5 6 11**	**1 5 10**
4.2	uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena.	**1 2 7 8 9 10**	**2 3 4**
4.3	identifies areas of everyday life that have been affected by scientific developments.	**2 3 4 5**	**3 5 7 9 10**
4.4	identifies choices made by people with regard to scientific developments.	**1 4 8 9**	**2 4 6 8**
4.5	describes areas of current scientific research.	**6 7 11**	**1 6 7 9**
4.6	identifies and describes energy changes and the action of forces in common situations.	**4 5**	**3 4 5**
4.7	describes observed properties of substances using scientific models and theories.	**2 3**	**1 2**
4.8	describes features of living things.	**6 7** *8*	**6 7**
4.9	describes the dynamic structure of Earth and its relationships to other parts of our solar system and universe.	**9 11** *10*	**10** *9*
4.10	identifies the factors affecting survival of organisms in an ecosystem.	**8**	**8**
4.11	identifies resources used by humans and where they are found and describes ways in which they are exploited.	*4*	**9**
4.12	identifies, using examples, common simple devices and explains why they are used.	**4** *5 6 8 9 11*	**10** *5*

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CHAPTER 1

YOU CAN BE A SCIENTIST

New discoveries are constantly being made about ourselves, our world and the space beyond our world. These discoveries lead to changes. We are constantly changing the way we communicate with one another, travel, feed and clothe ourselves, treat disease and spend our leisure time.

Scientists the world over continue to make advances by asking questions and searching for answers. How might this scientific progress change the world in the future? Here are some predictions.

2005 Active contact lenses allow the wearer to read email and use the Internet just by closing their eyelids.
2007 Cars are equipped with anti-collision radar and thermal imaging systems to prevent accidents.
2010 Robotic pets do household tasks.
2017 Humans land on Mars.
2022 Babies grow and develop inside incubators, never having been inside another human.
2025 Computers are connected directly to the brain to respond to thoughts.
2500 Human life-spans reach 140 years.

During your science studies you will learn about the great discoveries of the past and about the methods used to make these. You may even be someone who will make a discovery that will change our lives in the future.

Web links

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Identify and correctly draw diagrams of laboratory equipment.
- Use laboratory equipment safely.
- Recognise hazardous situations in the laboratory and environment and describe ways in which these can be reduced.
- Recognise the importance of the use of the five senses in making observations.
- Accurately measure volume, mass, temperature, time and distance.
- Identify and control variables in experiments.

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1.1

Discovering science

This year you will build on what you already know about science. You will develop scientific knowledge, skills and attitudes that can be extremely useful in everyday life. A knowledge of science can help you cope in our highly technological world. For example it may help you to:

- grow plants in a garden
- keep yourself healthy and fit
- protect the environment
- use machines to make work easier
- follow an instruction manual
- reduce your electricity bill.

Developing scientific skills and attitudes can help you to make better decisions about yourself and your environment.

FIGURE 1.1
Young scientists at work.

What do you already know about science?

Learning about science was an important part of your primary schooling. You may have experienced a range of fun activities which involved investigating, using technology, designing and making. You may have learnt about science by investigating any of the following topics: transport systems, electric circuits, weather patterns, living things, communication systems, water, air or light and leisure.

Talk about

Think about the science you learnt last year. Which topics did you most enjoy? Talk about an investigation you performed or a problem you solved by designing and making.

FACT FILE

The word science comes from a Latin word 'scientia' which means knowledge. However, science is not just concerned with knowledge. It is also a way of discovering new knowledge by observing and experimenting.

Questions

1 Explain in your own words what you think science is about.

2 How can scientific knowledge, skills and attitudes help you in today's society?

3 Write down five things you do in your everyday life that use scientific ideas or inventions.

Find out

1 Use a dictionary to find out what is studied in the following science subjects: astronomy, biology, chemistry, geology and physics.

2 Look through a newspaper to find an article that you think requires some scientific knowledge to understand fully. Cut out the article and paste it in your workbook. Write down how scientific knowledge would help a reader understand the article better.

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Foundation worksheet 1

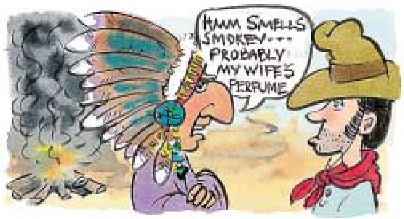
Scientists observe.
When observing things, you can use one or more of your five senses — sight, hearing, smell, touch and taste — to help you collect information about your surroundings.

Scientists infer.
When you suggest a possible explanation for an observation, you are making an inference.

Scientists measure.
When exact information about an observation is needed, a measurement can be taken.

Scientists predict.
If you make a statement about what you think may happen in the future, then you are making a prediction. Predictions are usually based on past observations and experiences.

Scientists classify.
Classification involves grouping things that have similar features.



Scientists hypothesise.
Using information they already have, scientists come up with a possible answer to a problem. An experiment is then designed to test the hypothesis.

Scientists make models.
Models are used by scientists to represent real objects or events. Scale models can be used to test whether structures are stable. Models can also be in the form of diagrams or ideas.

Scientists analyse.
After scientists have collected their data or are presented with an unfamiliar situation, they need to analyse it by looking for patterns or trends.

Scientists work with others.
Sharing ideas and data with others allows scientists to get a better idea of what something is, how something works or to discover patterns in nature.

FIGURE 1.2
Besides carrying out experiments, what else do scientists do?

Activities

A

1 Draw a diagram that shows a scientist at work. Compare your finished diagram with that of another student. In what ways are your diagrams similar? In what ways are they different? What is our common 'image' of scientists?

2 Write down three things you would like to learn about in science this year. Your teacher will write all the ideas on the blackboard. Group together similar topics. In which topics were the most number of students interested? Which topic do you think was the most unusual?

3 Interview someone in the work force about their job. Find out how they use science in their daily work.

4 Work in groups of two. Using only one sheet of A4 paper, 10 straws and one pair of scissors, build a structure that can support a marble at least 30 centimetres above the ground and at least 10 centimetres out from the base of your structure. Describe how helpful your partner's ideas were in designing and building the structure.

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1.2 Safety first

FIGURE 1.3
A laboratory can be a source of accidents if you are not careful. Eye injuries may be caused by chemicals splashing into your eyes during an experiment. Burns and scalds may be caused by touching hot equipment or by spilling hot liquids onto your skin. Broken glass may lead to cuts. Unsafe electrical connections may lead to electric shock. Poisoning may occur if you taste chemicals, spill poisonous chemicals onto your skin or breathe in dangerous gases produced in the laboratory.

A **science laboratory** is a place where you can investigate things and conduct experiments. It has equipment and chemicals that can be used to help you find out the answers to your questions. All materials in a laboratory should be well labelled.

Talk about

What steps should you take to work safely in your laboratory? In groups, discuss the five most important rules for avoiding accidents in the laboratory. How does your list compare with that of other groups? How does it compare with your teacher's ideas?

USING SCIENCE 1 YOUR SCIENCE LABORATORY

Draw a plan of your laboratory as if you could look down on it from above (a bird's-eye view). Your plan should include the following features, which should be clearly labelled or listed in a key:

- tables/desks/work benches
- chairs
- water taps (hot and cold)
- gas taps
- fire extinguisher
- fire blanket/sand bucket
- heating equipment
- protective clothing
- power points
- safety glasses
- glassware
- first aid kit
- rubbish bin
- fume hood
- safety exits
- broken glassware bin
- chemical storage area
- eye bath
- preparation room

DISCUSSION

Suggest why each of the features listed above is important in a laboratory.

EXTENSION

Find out what a scale drawing is, then try to draw your laboratory plan to scale.

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USING SCIENCE 2 HOW SAFE IS YOUR LABORATORY

1 You have just been appointed Regional School Laboratory Safety Officer. Your task is to ensure that school laboratories are safe places for students to work. Use the checklist of safety features below to determine a safety rating for your laboratory.

2 Develop and present a laboratory safety policy for your school laboratory, including any suggestions for improvement.

Checklist	Yes	No
1 Are water taps easy to control?		
2 Are the sinks clean and unblocked?		
3 Is there at least one power point and at least one gas outlet, in good condition, for each pair of students?		
4 Is the glassware stored safely and is it accessible?		
5 Are the bottles, jars, containers and shelves clearly and correctly labelled?		
6 Are the chemicals stored safely?		
7 Is appropriate protective clothing (such as goggles and aprons) available?		
8 Does the laboratory floor have a non-slip surface?		
9 Is there enough space for students to work without crowding?		
10 Is the laboratory well lit?		
11 Is the laboratory well supplied with fresh air?		
12 Is there a separate bin for broken glass?		
13 Does the room have a first aid kit?		
14 Does the room have a fire extinguisher and a fire blanket?		
15 Does the laboratory have an instruction chart for accidental poisoning?		
16 Are there two exits out of the room?		

Questions

1 Copy and complete the following table, adding three rules of your own.

Laboratory rule	Reason for rule
Always carry hot equipment using tongs.	To avoid burning your fingers
Never run in the laboratory.	
Tie back long hair when using a Bunsen burner.	
Never leave a Bunsen burner unattended.	
Wipe up spilt chemicals immediately.	
Wash glassware thoroughly after use.	
Tell your teacher when you break something.	
Always follow instructions carefully.	

Activities

1 Produce a poster that shows one safety rule we should always remember in the laboratory.
Your poster should:

- **be clear and easy to read**
- **have a simple message**
- **have large, bold headings and pictures**
- **be colourful and neat.**

2 Try out your poster on other students. How effective is it in communicating a safety message to others?

a What are its strengths and weaknesses?

b What improvements would you make if you could redraw it?

Web page

FIGURE 1.4
Safety posters can help to get the safety message across.

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1.3

Laboratory equipment

FIGURE 1.5
A selection of equipment found in most laboratories.

Talk about

Look carefully at each piece of equipment in Figure 1.5. Can you work out what each item is used for? The name of each item may help you.

You will perform many different experiments in your laboratory. Sometimes you will need to use special equipment, for example to heat, mix, separate, filter, weigh and measure things. It is very important to know which equipment to use and how to use it safely. All equipment should be clean and dry before and after use.

USING SCIENCE 3 RECOGNISING SCIENTIFIC EQUIPMENT

1 Draw a table like the one below.

Apparatus	Drawing	What it is used for

2 Your teacher will place the following labelled equipment around your laboratory: Bunsen burner, tripod, gauze mat, tongs, test-tube, beaker, filter funnel, measuring cylinder, evaporating dish, dropping pipette, spatula, watchglass, retort stand, heatproof mat, test-tube brush, pipe clay triangle, boss head and clamp, stirring rod, test-tube rack, conical flask, test-tube holder.

3 Walk around the laboratory and locate each item. Once you have found it, write its name in the first column of your table and sketch it in the second column.

4 What do you think each item is used for? Write your ideas in the third column of your table. Your teacher will discuss your ideas when you have completed your table.

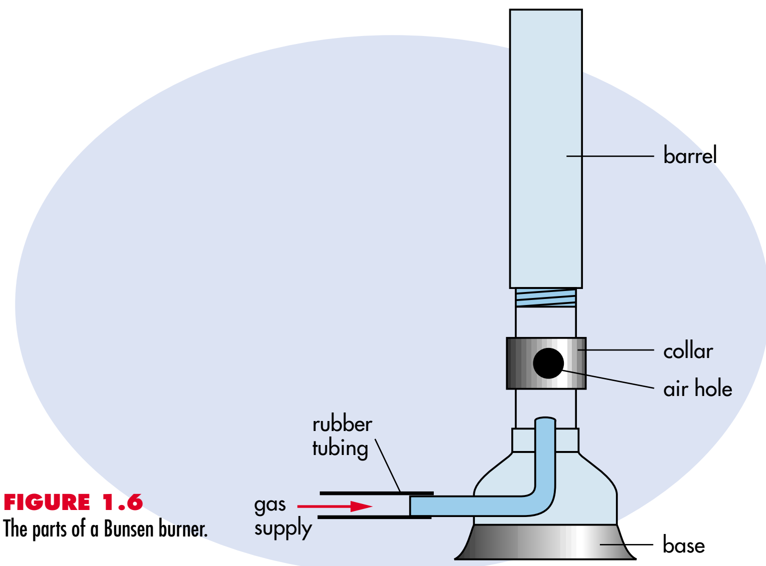

FIGURE 1.6
The parts of a Bunsen burner.

Talk about

Collect a Bunsen burner and compare it with the one in the picture. (You may need to unscrew the barrel to see what is inside your burner.) Check the rubber hosing. Why is it important that there are no holes in it? Turn on the gas tap for a few seconds, then turn it off again. What did you hear? What did you smell? Discuss the safety rules that should be followed when using a Bunsen burner.

Many experiments need heat. In the laboratory, a Bunsen burner can be used to provide heat. It is important that you learn how to use it safely.

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Foundation worksheet 2

EXPERIMENT 1 GETTING TO KNOW YOUR BUNSEN BURNER

AIM

To learn to use a Bunsen burner safely.

MATERIALS

- Bunsen burner
- matches
- heatproof mat
- platinum or nichrome wire
- test-tube
- test-tube holder
- tongs

METHOD

1 Connect your Bunsen burner to the gas tap. Make sure the rubber tubing does not have a hole in it and that it is connected firmly to the burner.

2 Close the air hole by turning the collar.

3 Hold a lighted match at the top of the barrel towards the side of the opening.

4 Turn the gas tap to the fully open position.

5 Note the appearance of the flame. This flame is called a **safety flame**. Make a coloured drawing of the flame in your book.

6 Using the test-tube holder, hold the test-tube near the top and place the bottom of the test-tube into the flame. Observe the deposit that forms on the test-tube. Record your results in your book.

7 Place the test-tube onto the heatproof mat so that your bench is not damaged. Remember, it will be hot!

8 Slowly open the air hole until it is fully open. As you do so, observe and report the changes in:

a the amount of light and heat given off

b the colour of the flame

c the size of the flame.

DISCUSSION

Summarise your results in a table. Try to explain why the flames are different.

EXTENSION

1 Using a pair of tongs, hold a piece of platinum wire across the flame near the barrel of the Bunsen burner. Observe how the wire is heated.

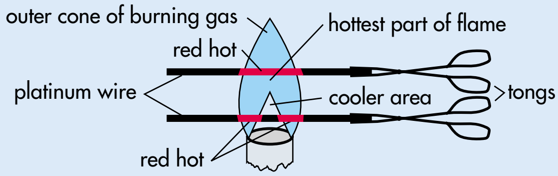

FIGURE 1.7
Place the platinum wire at different parts of the flame to see which is the hottest part of the flame.

2 Now move the wire upwards and locate the hottest point of the flame. Where is this point? Record your observations in your book.

RULES FOR USING BUNSEN BURNERS

1 Always use a heatproof mat.
2 Close the air hole.
3 Connect the gas tube to the gas outlet.
4 Hold a lighted match over the mouth of the barrel. Turn on the gas.
5 Open the air hole slowly. Set the air hole for the type of flame required.
6 When not using the burner immediately, close the air hole and have the gas on full to create a safety flame.
7 When using a burner to heat things, have the gas on full and the air hole fully open.

Questions

1 Name item(s) of equipment which can be used to:

a mix large amounts of liquid

b heat small amounts of liquid

c measure small volumes of liquid

d hold test-tubes

e support equipment

f heat small amounts of solids.

2 When the air hole is closed on a Bunsen burner you get a safety flame. How is this flame safer than the heating flame?

FACT FILE

The equipment used in science experiments is sometimes also called the apparatus which comes from a Latin word meaning 'to prepare'.

Find out

Who invented the Bunsen burner?

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1.4 SCIENCE IN FOCUS

IMPLICATIONS FOR SOCIETY AND THE ENVIRONMENT

Fire safety

FIGURE 1.8
Smoke from the New South Wales bushfires in the summer of 1994 could be seen as far away as Tahiti.

FACT FILE

Many forest trees need fire for regeneration. Banksia fruit, for example, release their seeds only when fire has burst open their hard seed pods. Fire also helps the seeds of mountain ash trees to germinate and clears the area around them so that when the seedlings sprout, they will receive enough light to grow.

Talk about

Does your community have a fire outbreak emergency plan? Does your school have a fire drill? Should all members of the community in bushfire-prone areas be required to work with the fire brigade for a certain number of hours per year?

In many everyday situations, fire can be very useful. Fire allows us to cook our food, heat our homes and run our transport and factories. In the laboratory, fire can be used to speed up chemical reactions or make new substances. On the other hand, fire can be a hazard. It can burn down houses, destroy forests and kill people and animals. Uncontrolled bushfires in Australia destroy thousands of hectares of bushland every year, sometimes claiming lives.

The fire triangle

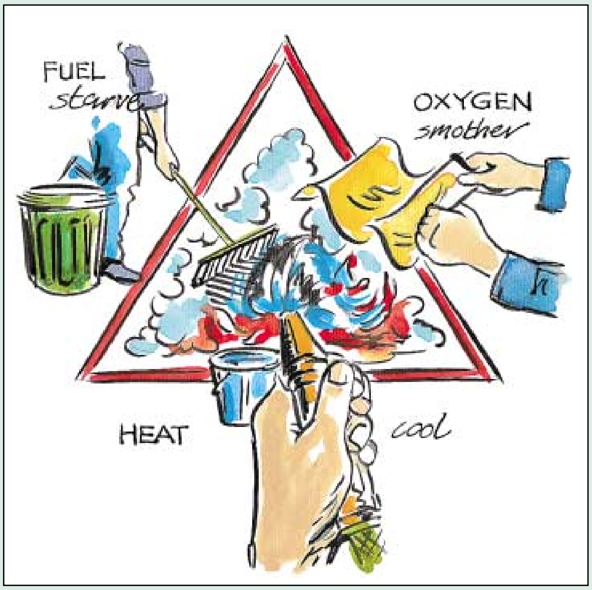

FIGURE 1.9
The fire triangle
If a fire is to be controlled, it must be deprived of at least one of the parts of the 'fire triangle': oxygen (in the air), heat or fuel.

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Fire is the result of **heat** (which starts the fire and keeps it burning), **oxygen** (which makes up one-fifth of the air) and **fuel** (something that burns). These three things act together to form the **'fire triangle'**. If you take away one of the parts of this triangle, there won't be a fire. This idea can be used by fire-fighters when controlling bushfires.

Smothering the fire with soil or beating it with a wet sack will deprive it of oxygen. Making a firebreak, for example by back-burning, will starve the fire of fuel. Cooling a fire, usually with water, will reduce the heat. The method selected to control a bushfire depends on the size of the fire, the type of fire and the resources available.

Controlled burning reduces the risk of uncontrolled fires by clearing away dry grass and undergrowth that may cause more dangerous bushfires or wildfires. This involves burning off sections of forest during the cooler times of the year when forest fuel will burn gently rather than blaze uncontrollably. Controlled burning is a regular fire-control measure in bushfire-prone areas of Australia.

Not everyone agrees with controlled burning. While it reduces the risk of wild-fire, controlled burning does have an impact on wildlife and air pollution. Ground-nesting birds, such as quails, can be particularly at risk during controlled burning. For this reason an environmental assessment must be undertaken before any burning takes place.

Smoke from controlled burning also reduces air quality. When air pollution levels are already high the Environmental Protection Authority may declare 'no-burn' days. This attempts to prevent situations where people experience breathing problems and loss of visibility. In every location both the benefits and costs of controlled burning must be weighed up before a final decision is made.

Questions

1 **Describe three methods of putting out a fire and explain how each works.**

2 **Controlled burning can benefit many native plants and animals. Give two benefits.**

3 **Imagine you were in charge of a local bushfire brigade unit and you were responsible for planning controlled burning in your area. What factors would you consider before you selected locations for burning.**

4 **Explain how each of the hints in Figure 1.10 for bushfire-proofing your house could help save lives and property in a bushfire.**

Think about

In what ways would your life be different without fire? How did Aboriginal people control bushfire?

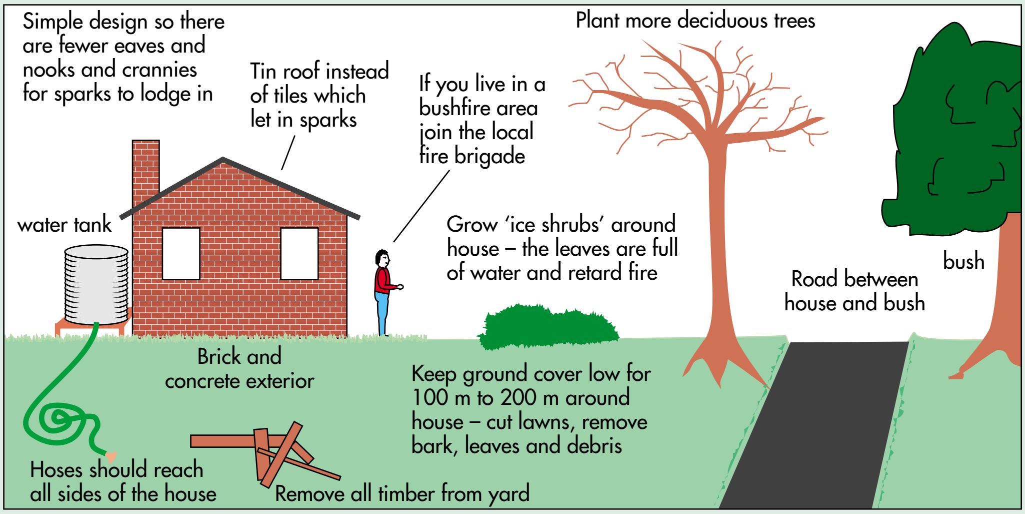

FIGURE 1.10
How to bushfire-proof your house.

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1.5 Let's observe

FIGURE 1.11
Imagine you are standing below this display. What would you see, hear and smell?

When we observe we are collecting information directly from our surroundings. We use our senses of **sight**, **hearing**, **smell**, **touch** and **taste** to collect information. Scientists spend a great deal of time making careful observations especially when conducting experiments.

Sometimes our senses are not sensitive enough to detect slight changes in our environment. To overcome this we use instruments that can help to increase our powers of observation. Microscopes, thermometers and stop-watches help us make more accurate observations.

Sense organs

Special structures called **sense organs** detect changes in our surroundings and send messages to the brain. The brain can then send messages to other parts of the body in response to the change.

Your two **eyes** are the sense organs involved in sight. They provide a detailed, three-dimensional, constantly updated, coloured view of the world around you.

Your two **ears** are the sense organs involved in hearing. Some animals' ears are more sensitive to certain sounds than ours. For example, dog whistles have been developed that can be heard by dogs but will not interrupt human hearing.

Your **skin** is the sense organ involved in touch, and can detect sensations including **pressure**, **heat**, **cold** and **pain**.

Your **nose** is the sense organ involved in smell. At least 20 different types of smells can be recognised by humans.

Your **tongue** is the sense organ involved in taste. Microscopic, onion-shaped clusters on the upper surface of the tongue, called **taste buds**, can detect four different tastes: **sweet**, **salty**, **sour** and **bitter**. Substances in food that have one of these tastes can only be detected after they have been dissolved in saliva and seep down around your taste buds.

EXPERIMENT 2 A TOUCHING EXPERIENCE

AIM
To detect objects using the sense of touch.

MATERIALS
- blindfold
- noseclip

similar sized samples (about a teaspoon) of everyday substances including:
- coffee
- rubber
- fat
- candle wax
- oil
- jam
- fabric
- leather
- hair gel
- sugar
- polystyrene
- soap
- water
- detergent
- honey
- plastic
- vinyl
- hair mousse

METHOD
1 Work in pairs. One student (the subject) wears a blindfold and a noseclip to eliminate the senses of sight and smell.
2 The other student (the tester) presents small samples for identification. (Take care with liquid samples.)
3 The subject describes the sensation experienced after touching each sample. Consider hardness, wetness, heat, slipperiness and smoothness. Comments are recorded by the tester.
4 Switch roles and repeat.

DISCUSSION
1 How many samples were correctly identified by each student?
2 Which samples were particularly difficult to identify?

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EXPERIMENT 3 WHAT SMELLS AROUND HERE?

AIM
To determine the concentration at which different people can detect a smell.

MATERIALS
- 25 paper cups
- 25 labels
- dropping pipette
- vanilla essence
- banana flavouring
- 25 filter papers
- 500 mL jug
- water
- perfume
- strawberry essence

METHOD
1 Place 15 drops of vanilla essence into the jug filled with water.
2 Half-fill a paper cup with the solution. Label this solution 'full-strength vanilla' and cover the cup with a filter paper.
3 Half-empty the jug then refill it with water. Half-fill another paper cup with this solution and label it 'half-strength vanilla'. Cover the cup with a piece of filter paper.
4 Repeat step 3 to obtain quarter-strength, eighth-strength and sixteenth-strength vanilla solutions. Cover each cup with a filter paper.
5 Repeat steps 1 to 4 using perfume, banana flavouring and strawberry essence.
6 Half-fill a paper cup with water. This will serve as a 'control'.
7 Test blindfolded students to find out what concentrations of vanilla, perfume, banana flavouring and strawberry essence they can detect. Start with the weakest strengths of each solution, then keep increasing the strengths tested. Let the blindfolded student breathe fresh air between 'smell tests'.

DISCUSSION
1 How does the sense of smell differ amongst students in the class?
2 What difficulties are associated with this experiment?
3 What was the purpose of the 'control'?

Questions

1 List the five senses and describe the importance of each in your daily life.
2 Imagine that you had to do without one of your five senses.
a Which sense would you choose to do without? Explain your choice.
b How could the use of your other four senses help to compensate for the loss of the other sense?
3 In science, what does it mean to 'observe'?
4 Name three instruments, other than those mentioned, which can increase our powers of observation.
5 Our senses are limited in what they can do. Give a different example of an animal with a sense better able to detect changes, compared to human capabilities.

Activities

1 Place a marble in an empty shoe box, replace the lid and listen as the marble rolls around the sides. Can you 'hear' the rectangular shape of the box? Place pieces of cardboard around the inside of the shoe box so that it no longer has only four walls. Give your sealed shoe box with a marble inside to a friend. By moving the marble around, can they draw the internal design of your shoe box?
2 Think of a food. Picture the food in your mind, then write a description of it without actually mentioning the name of the food. What does it look like? What does it feel like? What does it smell like? What does it taste like? What noise does it make as you eat it? Swap descriptions with another student and see if you can guess which food they have described.

FACT FILE

In the animal world there are many unique 'senses'. Some snakes have infrared detectors that allow them to find prey in the dark; some birds can detect the Earth's magnetic field to navigate by; and the platypus is able to detect weak electric fields with sensors in its bill.

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1.6 Let's measure. 1

FIGURE 1.12
Imagine buying a block of land advertised as '60 paces by 100 paces'. What size could the block of land be? Why is it important to know exactly how large a 'pace' is?

Measuring is a very important part of science. Accurate **measurements** can help to solve scientific problems.

To take measurements, a **scale** is needed. Scales are divided into **units** such as metres, litres, grams, degrees or seconds.

Scientists often rely on scientific instruments to take accurate measurements. Instruments such as digital watches and petrol pumps have a **digital read out**. Other instruments such as electrical meters have a needle or pointer which moves along a scale. These instruments are called **analogue instruments**.

Time

The basic unit of time is the **second**. Other units of time include the minute, hour and day. The earliest devices to measure time are thought to be sun dials, which were made by the ancient Babylonians. Today, a range of clocks, watches and stopwatches can time events to an accuracy of one-hundredth of a second.

Temperature

Temperature is usually measured in **degrees Celsius** using a **thermometer**. In school laboratories, alcohol thermometers are most commonly used to measure temperature.

Warning: Thermometers break easily, so handle them carefully. The bulb of a thermometer should never be placed in a Bunsen burner flame, since it is only designed to measure temperatures up to 110°C.

Datalogging

Questions

1 A car assembly line relies on the accurate measurement of parts. Explain what would happen if the parts that fit together to make a car were not measured accurately.

2 Estimate each quantity listed, then measure and compare your estimate.

a walking a kilometre (time)

b a cup of tea (time taken to cool)

c your skin (temperature)

USING SCIENCE 4 READING SCALES

Record each scale reading in your workbook. Compare your results with a partner.

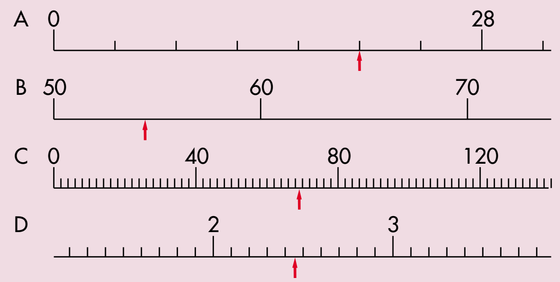

FIGURE 1.13
Linear scales.

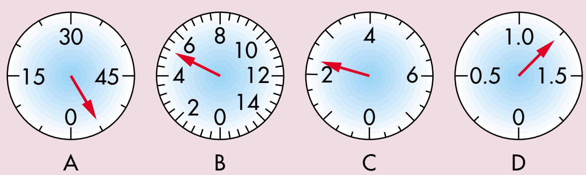

FIGURE 1.14
Circular scales or dials.

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EXPERIMENT 4 MAKE YOUR OWN THERMOMETER

INTRODUCTION
Most thermometers contain a fluid, usually mercury or alcohol, which expands or contracts according to the temperature.

AIM
To make a thermometer using coloured water instead of mercury or alcohol.

MATERIALS
- glass bottle with a one-holed rubber stopper fitted with a 30 cm thin glass tube
- beaker
- water
- sticky tape
- coloured ink
- a strip of card 30 cm long
- ice

METHOD
1 Fill the bottle completely with ink-coloured water.
2 Stopper the bottle, and adjust the glass tubing so that it is about 20 cm into the coloured water.
3 Cut a piece of card the same height as the glass tube and tape it to the glass tubing.
4 Mark the level of water in the glass tubing on the card.
5 Put the bottle into a beaker containing iced water. Again, mark the level of the water in the glass tubing.
6 Repeat step 5 using hot water.

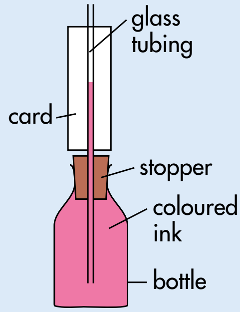

FIGURE 1.15 The experimental set-up.

DISCUSSION
1 What happened to the level of the water when the bottle was placed in:
a iced water? b hot water?
2 How could you check the effectiveness of your thermometer?
3 How would evaporation of the water in your thermometer affect its accuracy?

EXTENSION
Make a scale on your thermometer by marking the level of water in the tube compared with temperatures on an alcohol thermometer. Try scaling your thermometer at room temperature, in iced water and in heated water.

3 The world population in the year 2000 is expected to be 6.2 billion. How can such an estimate be made?

4 What happens to the boiling point of a beaker half-filled with water if you add to it a teaspoon of:
a salt? b sugar?

Activities

1 Investigate how the angle of a ramp affects the time taken for a marble to roll down it. Explain why it would be wise to take four measurements instead of only one for each angle of the ramp that you test.

2 Egg-timers help cooks to boil eggs perfectly. Design and construct a device that measures a time of exactly two minutes. The egg-timer idea may help get you started.

3 How does exercise affect breathing rates and pulse rates? In pairs, count the number of breaths and the pulse rate per minute when you:
a sit quietly for 2 minutes
b walk for five minutes, and
c walk quickly up and down a staircase twice.
i Graph your results.
ii Compare your graphs with other students in the class, noting similarities and differences in the patterns that you see.

Datalogging
Spreadsheet

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1.7

Let's measure. 2

FACT FILE

French scientists developed the metric system in 1799 for weights and measures. The system for length is based on the distance between the North Pole and the Equator. This is divided into 10 000 000 parts. Each of these parts is called a metre.

TABLE 1.1 Units of mass.

1 gram = 1000 milligram (mg)
1000 gram = 1 kilogram (1 kg)
1000 kilogram = 1 tonne

TABLE 1.2 Units of length.

10 millimetres (mm) = 1 centimetre (cm)
1000 mm = 100 cm = 1 metre (m)
1000 metres = 1 kilometre (km)

Talk about

Imagine you wanted to buy a packet of potato chips. What types of measurements should be included on a packet of potato chips? What is the advantage of including measurements on the packet?

Mass and weight

The word **weight** refers to the force with which an object is attracted by the Earth. If the force of attraction (or gravity) changes, the weight will also change.

The word **mass** refers to the total amount of material in a body. This will not change if nothing is added to or taken out of the object.

The unit of weight is the **newton** (N). Although many people use **grams** (g) or **kilograms** (kg) to talk about weight, these are really the units for mass.

Distance

The basic unit of length is the **metre**. Other units of length include the millimetre, centimetre and kilometre. You can measure distances by using a **ruler**. Very small distances can be measured using a **micrometer**.

Talk about

How could you find out whether people are taller in the morning than at night?

FIGURE 1.16
A beam balance measures mass.

FIGURE 1.17
An electronic balance measures weight.

FIGURE 1.18
A spring balance measures weight. The object in this picture weighs 0.5 newton. It has a mass of 50 grams.

USING SCIENCE 5 BREAKFAST CEREALS

Choose your favourite packaged breakfast cereal. Use the contents label to discover how much salt, sugar and fat your cereal contains per serving or per 100 g. Prepare a display that shows:

1 the packet in which your cereal is sold;

2 the amount of salt, sugar and fat in your food (weigh out the exact amount of salt to represent the salt content of your food, sugar to represent the sugar content of your food and lard to represent the fat content of your food). Salt may be listed as sodium, in which case multiply by 2.54 to convert to salt (sodium chloride).

Note: Take precautions to prevent insects invading your display!

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Extra worksheet

Volume

Volume is the amount of space that something takes up. Volume may be commonly measured in **cubic metres** (m^3), litres (L) or millilitres (mL).The volume of a liquid may be measured by pouring it carefully into a **measuring cylinder**. The liquid surface usually curves downwards to form a **meniscus**. To measure the volume of a liquid accurately, read the scale at eye level at the lowest part of the meniscus.

TABLE 1.3 Units of volume.

1 litre (L)= 1000 millilitres (mL)
= 1000 cubic centimetres (cm^3)
1000 litres = 1 cubic metre (m^3)

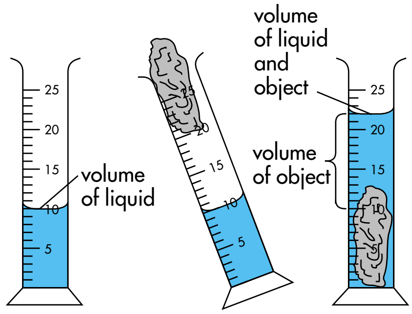

FIGURE 1.19
To determine the volume of a solid object, follow three simple steps:
- Read the volume of liquid accurately.
- Gently lower the solid object into the measuring cylinder.
- Read the volume again, accurately.

(Remember to read each volume with meniscus at eye level.)
The difference between the two volumes is the volume of the solid object.

FACT FILE

You weigh more at the Equator than at the North Pole, and more on a beach than on top of Mount Everest. You would weigh less on the Moon but more on Jupiter. Your mass is always the same.

USING SCIENCE 6 THE LONG AND THE SHORT OF IT

1 Compare your left and right hands.
a Are the lengths of your fingers the same?
b Are the areas of both hands the same?

2 Compare your left and right feet.
a Are the lengths of your toes the same?
b Are the widths the same?
3 Find out who has the highest arches in your class.

EXPERIMENT 5 MEASURING VOLUMES

AIM
To measure the capacity of different containers.

MATERIALS
- measuring cylinder
- test-tube
- tea cup
- coffee mug
- conical flask
- evaporating dish
- small beaker
- crucible
- egg cup

METHOD
1 Estimate the volume which each object listed can hold. Record your estimates in a table.
2 Measure the volume each object holds and write it down in your table.

DISCUSSION
How accurate were your estimates of volume?

Questions

1 Asif measured the volume of a liquid. Why did he place the measuring cylinder so that his eyes were level with the liquid's surface?

2 Estimate, then measure using different weighing instruments, the mass of the following objects: pen; eraser; ruler; beaker; book; marble.

3 How could you measure:
a the thickness of a hair?
b the mass of one paper clip?
c the volume of one drop of water?
d the depth of a cave?

4 Estimate, then measure, each quantity below:
a an apple (volume)
b a carton of milk (mass)
c this book (height, width and length)

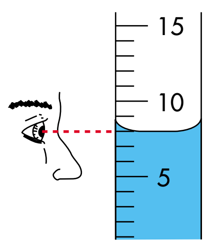

FIGURE 1.20
What volume is shown here?

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SCIENCE IN FOCUS

Let's experiment

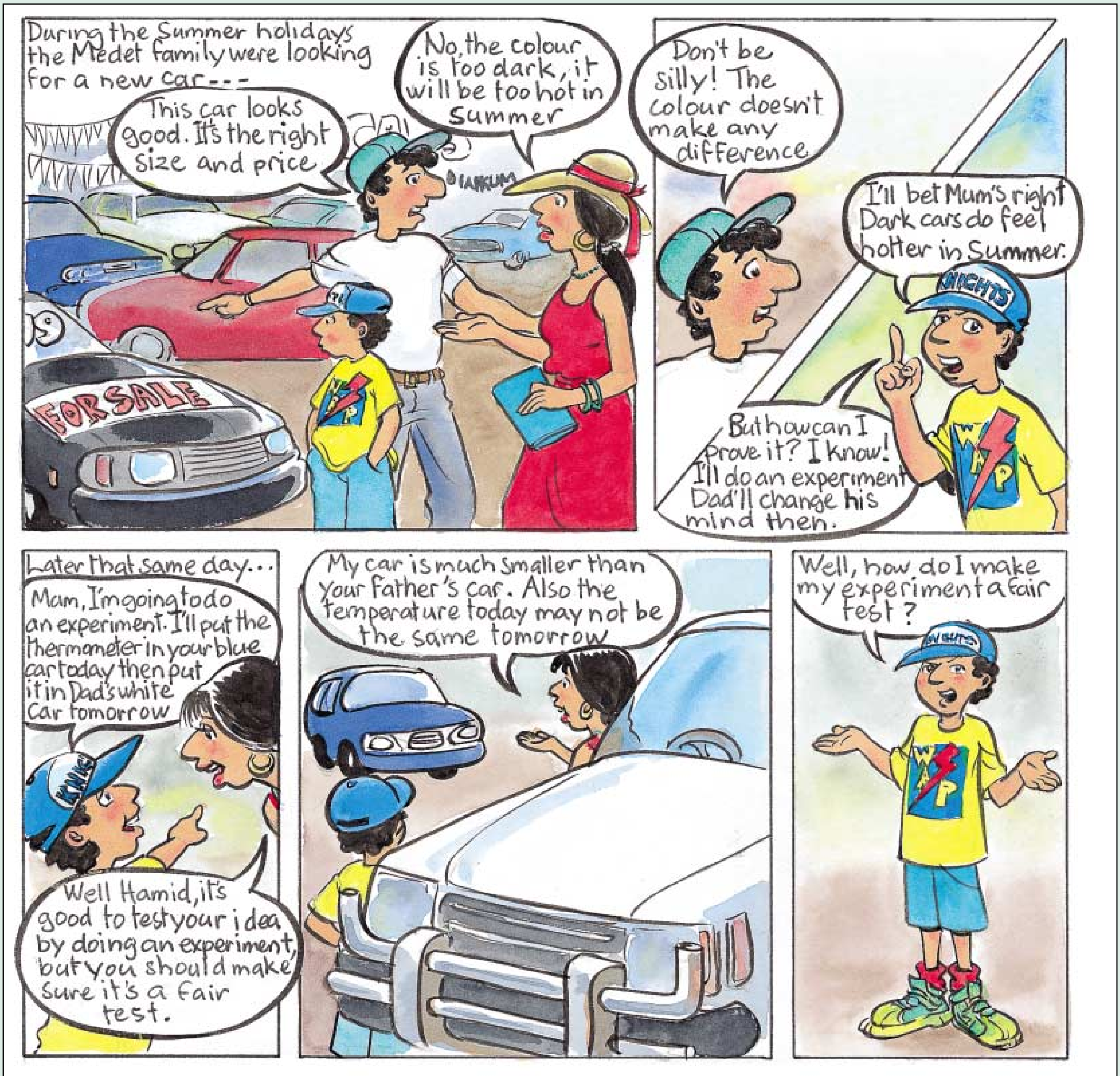

FIGURE 1.21

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Hamid was on the right track when he decided to test his idea by doing an experiment. Well-designed experiments may be used to answer a question, solve a problem or find out new information. If Hamid wants his experiment to be a fair test he must think about all the things or factors which could affect the results. These things or factors are called **variables**. The colour of a car is just one variable which can affect the internal temperature.

A fair test is designed so that only one variable is allowed to change while another variable is measured. All other variables must be controlled or kept the same. Hamid must design his experiment so that variables like the size of the cars, how much sunlight they receive and where he measures the temperature, are all kept the same.

As well as controlling the variables scientists repeat their experiments many times. They repeat their experiments to check their results. Well-designed experiments give very similar results each time they are performed.

Conclusions must be supported by evidence and should be based on results that can be repeated. As a young scientist, you must try to get honest answers. Never insist that an answer or result is correct until you have enough evidence to support it.

FACT FILE

When experiments are repeated many times the results are used to calculate an average result.

Questions

1 What are variables?

2 Why should variables be controlled in an experiment?

3 In Hamid's experiment

a which variable should he change?

b which variable should he measure?

c list five variables he should control.

4 Explain why experiments are repeated many times.

5 Write out a procedure for Hamid's experiment.

6 Elizabeth designed an experiment to find out if square ice blocks melt faster than round ice blocks. She froze 100 mL of water in a square mould and 50 mL in a round mould. Elizabeth took the ice blocks out of the fridge at the same time. She then placed the square ice block in the refrigerator while she measured the time for the round ice block to melt. Later in the day she measured the time for the square ice block to melt. This was not a fair experiment. Explain two mistakes that Elizabeth made and say how you would correct them.

7 You are asked to design an experiment to find out if an expensive brand of battery lasts longer than a cheap brand.

a Which variable should be changed?

b Which variable should be measured?

c List two variables which should be controlled if this is to be a fair experiment.

Activities

A

You be the scientist! Choose one of the problems below and design a fair test. Select one variable to change, one to measure and remember to control the rest.

1 Which thread is stronger, cotton or polyester?

2 Which paper is most absorbent, facial tissues or kitchen towel?

3 Which ball bounces highest, a tennis ball or a golf ball?

Carry out your experiment and write a scientific report to present your findings to your class.

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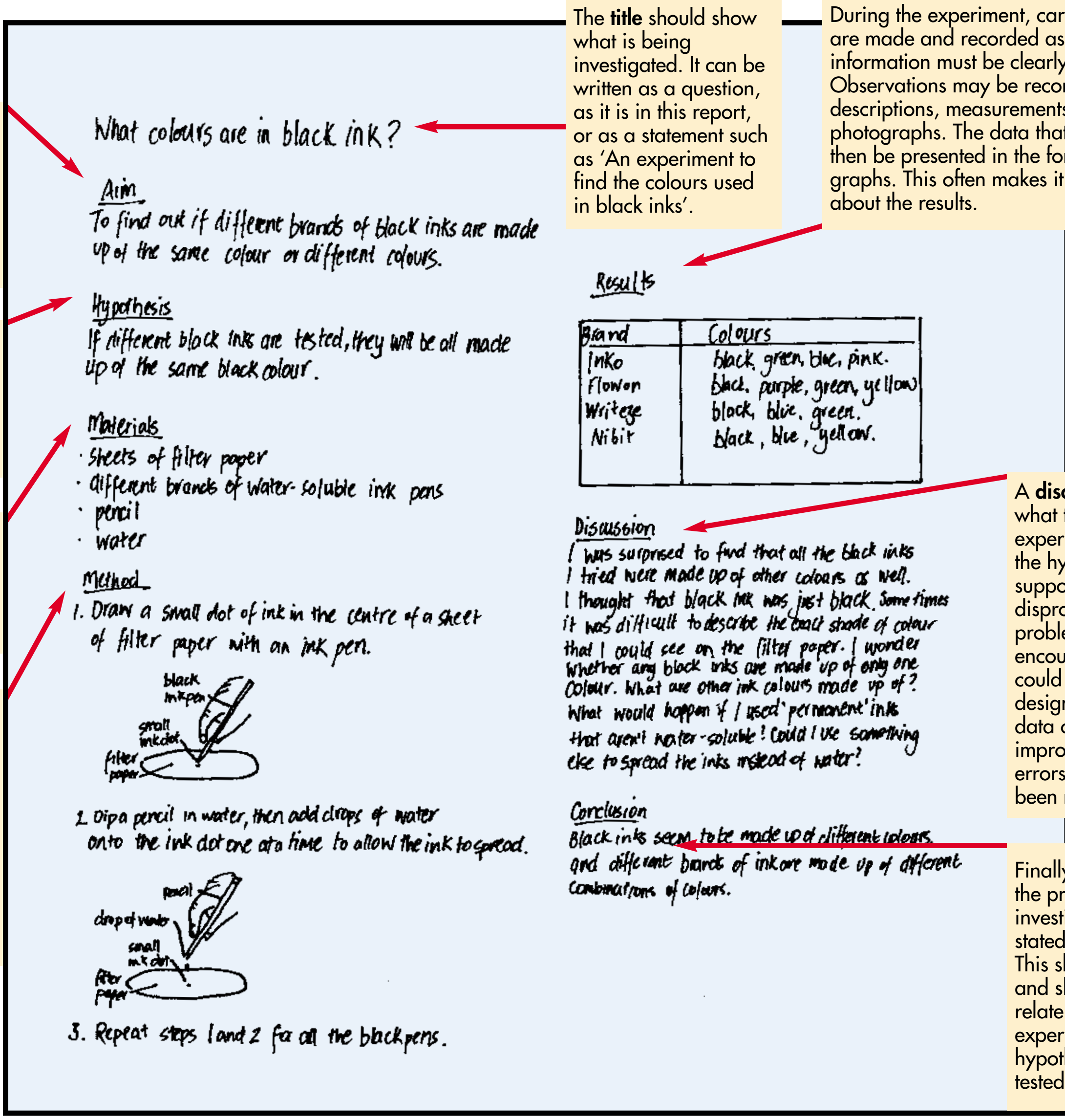
1.9 Let's record

Scientists try to get their thoughts clear about the problem they are investigating. A short statement or question, written as an **aim**, helps them to do this.

Sometimes a **hypothesis** may also be stated. This is a possible answer to the problem being investigated.

Experiments usually involve the use of equipment or chemicals. These may be listed as **materials.**

The **method** is an outline of what was done during an experiment. Diagrams may be used to show how the experiment was set up, and step-by-step instructions for performing the experiment may be listed.


What colours are in black ink?

Aim

To find out if different brands of black inks are made up of the same colour or different colours.

Hypothesis

If different black inks are tested, they will be all made up of the same black colour.

Materials

- sheets of filter paper
- different brands of water-soluble ink pens
- pencil
- water

Method

1. Draw a small dot of ink in the centre of a sheet of filter paper with an ink pen.

black inkpen, small inkdot, filter paper

2. Dip a pencil in water, then add drops of water onto the ink dot one at a time to allow the ink to spread.

pencil, drop of water, small ink dot, filter paper

3. Repeat steps 1 and 2 for all the black pens.

Results

Brand	Colours
Inko	black, green, blue, pink.
Flowon	black, purple, green, yellow
Writege	black, blue, green.
Nibit	black, blue, yellow.

Discussion

I was surprised to find that all the black inks I tried were made up of other colours as well. I thought that black ink was just black. Sometimes it was difficult to describe the exact shade of colour that I could see on the filter paper. I wonder whether any black inks are made up of only one colour. What are other ink colours made up of? What would happen if I used 'permanent' inks that aren't water-soluble? Could I use something else to spread the inks instead of water?

Conclusion

Black inks seem to be made up of different colours and different brands of ink are made up of different combinations of colours.

The **title** should show what is being investigated. It can be written as a question, as it is in this report, or as a statement such as 'An experiment to find the colours used in black inks'.

During the experiment, careful observations are made and recorded as **results**. All information must be clearly labelled. Observations may be recorded as written descriptions, measurements or photographs. The data that is collected may then be presented in the form of tables or graphs. This often makes it easier to think about the results.

A **discussion** outlines what the results of an experiment show. Is the hypothesis supported or disproved? What problems were encountered? How could the experiment design or method of data collection be improved? What errors could have been made?

Finally, an answer to the problem being investigated can be stated in a **conclusion**. This should be clear and short, and should relate to the aim of the experiment and/or the hypothesis being tested.

FIGURE 1.22
Denise performed an experiment to investigate the black ink used in pens. This is her scientific report. Read Denise's report. Do you think Denise's teacher would have been pleased with her report? Why?

In science there are special ways to record information about experiments. An experimental report is written so that information is organised in a clear way. This allows other people to understand how the experiment was conducted and what was found out. A good experimental report usually has the following parts:

- a **title**
- an **aim**
- a **hypothesis**
- a list of **materials** used
- an outline of the **method** used
- the **results** of the experiment
- a **discussion** of the results
- a **conclusion**.

Experimental reports often contain drawings showing the eqguipment used and how it was set up. Not everyone is good at artistic drawing so scientists use simple flat line drawings to represent equipment. These scientific diagrams are used instead of true, three-dimensional drawings. To draw a scientific diagram you have to imagine you could cut a piece of equipment in half, place it on a sheet of paper, then trace around its outside edge. This view is called a cross-section.

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USING SCIENCE 7 SCIENTIFIC DIAGRAMS

1 Look at the following scientific diagrams of equipment you should have already seen in your laboratory.

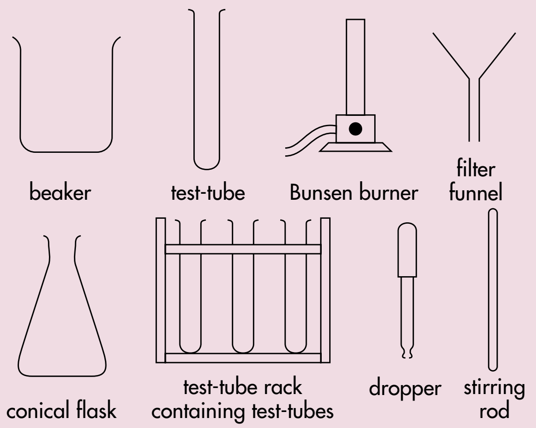

FIGURE 1.23
Scientific diagrams of common laboratory equipment.

2 List the ways in which these scientific diagrams are similar to, and different from, your earlier drawings of laboratory equipment.

Remember these seven steps for success in drawing scientific diagrams:

1 Use a lead pencil.
2 Use a ruler for all straight lines.
3 Draw a cross-section of the equipment (as though it had been cut right through the middle).
4 Do not draw lines across the tops of glassware.
5 Label all pieces of apparatus.
6 Label the substances in the apparatus.
7 Each diagram should be at least 5 cm high.

Questions

1 In which part of an experimental report would you find information on

a what was observed?

b what was done?

c what question was asked?

d what was found out?

2 Rewrite the following passage into brief step-by-step instructions.

When I used a triple-beam balance to measure the mass of my pencil case I firstly checked the zero on the balance. Then I placed my pencil case on the pan and the beam immediately tipped up. I moved the largest hanging mass along the beam until the beam went down again, then I moved it back one groove towards the pan.

I repeated the process with the middle-sized hanging mass. Finally by sliding the smallest hanging mass along the beam slowly I found the position where the pointer on the end of the beam was in line with the centre of the zero position. I then read the scale.

3 Draw a scientific drawing for the following situation.

Elaine wants to check the melting point of paraffin wax, so she places some in a test-tube and puts the test-tube in a beaker half-filled with cold water. She then places a safety mat on her bench, puts a Bunsen burner on the mat and arranges a tripod and gauze mat above the burner. She puts the beaker on the gauze mat, lights the burner and measures the temperature of the paraffin wax by placing a thermometer in the test-tube containing the wax.

4 Two students, Su-Li and Ben, drew the following scientific drawings of a tripod. Suggest how Su-Li and Ben could draw their diagrams more accurately.

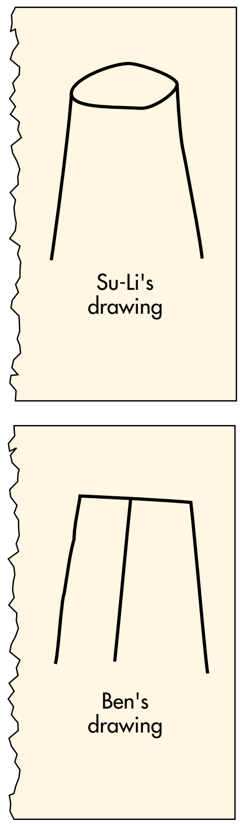

FIGURE 1.24
Two students' drawings of a tripod.

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1.10

Student research projects

A student research project is an excellent opportunity for you to experience real science first hand. You can work like a scientist as you design and carry out your own experiment to solve a problem. There are a number of steps you will go through in planning and carrying out a student research project. These steps are:

1. Selecting a problem to investigate
2. Clarifying the problem
3. Designing an experiment
4. Conducting the experiment and recording observations
5. Making a conclusion and writing a report.

Each step will allow you to develop and practise a wide range of science skills. You will also be able to demonstrate your creativity, imagination and perseverance.

How will I select a problem to investigate?

Selecting a problem to investigate involves using your creativity and imagination. Have you ever wondered why or how something happens? Have you ever asked what would happened if you changed something? Have you ever had to choose the best product to use? Well now is the time to think of a problem you can investigate.

Here are some questions to get you started.

- Is there any part of your favourite sport, hobby or pastime you would like to investigate?
- Is there a problem to solve in your home or in your local environment?
- Is there a topic in science you would like to investigate further?
- Try talking with friends, family and your science teacher about possible project topics. Visit your local library and read science magazines or try the Internet for ideas.
- The list of project topics may help you to get started.

Possible project topics

- Why do soft drinks go flat?
- Which is the strongest fabric to use for school pants?
- Which is the best method of removing graffiti?
- How can cut flowers be made to last longer in a vase?
- Which is the most absorbent kitchen paper?
- Will a hot tennis ball bounce higher than a cold tennis ball?
- Who has the fastest reactions, males or females?
- What is the best bait to attract garden snails?
- Which type of correction fluid dries fastest?
- Which socks keep feet warmest in winter?
- Which shape of paper aeroplane flies the furthest?
- What is the best way to stop iron nails from rusting?
- Which brand of cling wrap is the strongest?
- How much salt can seedlings stand before their growth is affected?
- Who has the strongest hair?
- Which is the best way to keep take-away food hot?
- Which liquid is the thickest?
- How do you make the strongest mud bricks?
- What effect does caffeine have on heart rate?
- Can you give plants too much water?

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How do I clarify the problem?

Once you have an idea of the problem you would like to investigate, you need to make it clear exactly what it is you want to find out. This is done by stating the problem as a specific question. For example, Gazi has a problem with mosquitoes. Every time he goes to football training he comes home covered in bites. He wants to investigate personal insect repellents to find out which one is best. This is a very broad topic. What does he mean by 'the best'? He could mean which repellent prevents the mosquitoes from biting. Or which repellent lasts the longest. Other factors such as the smell and feel of the repellent may also be important.

To clarify this problem Gazi should select just one aspect of insect repellents to investigate and state the problem as a simple question. For example, 'Which brand of insect repellent will keep mosquitoes from landing on bare skin the longest?

As you state your problem as a simple question you should keep in mind how you will go about answering it. Your question should be able to be investigated by carrying out an experiment. It should suggest what it is you will observe and measure. In Gazi's case the question suggests that an experiment could be carried out by applying various insect repellents to skin and measuring the time it takes for the first mosquito to land on each. Remember, experiments involve making observations and measurements. Experiments are not based on people's opinions. If Gazi were to simply ask people which insect repellent kept mosquitoes away the longest, he would not be doing an experiment!

How do I design an experiment?

An experiment is a test of a possible solution or answer to a problem. The possible solution to a problem is called a hypothesis. For example, based on his experience with various brands of insect repellent, Gazi made the following hypothesis. 'Bug Off will prevent mosquitoes from landing on bare skin longer than Aeroblock and Repel.'

An experiment must be designed to be a fair test of the hypothesis. This involves controlling the variables which can affect the results. A fair experiment involves changing one variable and measuring another. All other variables should be kept the same. Gazi will change the brand of insect repellent and measure the time it takes the first mosquito to land on the test area. He will keep the following variables the same each time he carries out

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Student research projects (continued)

the test: the amount of insect repellent; the area of the body it is applied to; the time of day and location where the repellents are tested. What other variables might affect his results?

One way of improving an experiment is to repeat it and obtain several sets of measurements. Gazi has decided to ask all of his football team to take part in his experiment so he can get many sets of results.

At this stage of the design process it is important to check that your experiment can be carried out. Before you proceed further find out if the equipment and materials you need to use are available. It may be possible to borrow some items, but you may need to purchase other materials. Next, write a draft plan of your experiment. Write down what you intend to do as a series of simple steps (a procedure). Discuss your plan with your teacher. Your teacher will check your plan to make sure your experiment is safe to carry out and can be completed in the time available. Be prepared to modify or change your plan if necessary.

How will I carry out my experiment and record the observations?

Once your plan has been approved you will need to collect your equipment and materials together. Select a suitable time and place to carry out your experiment. Before you begin, think about how you will record your observations and measurements. It may make the task easier if you draw up a data table to enter your results as you carry out your experiment. Follow your plan, be honest and record all observations and measurements, even if they are not what you expected.

Day	pH
Monday	7.2
Tuesday	7.4
Wednesday	7.3
Thursday	7.5
Friday	7.1
Saturday	7.2
Sunday	7.3

Volume (mL)	Time (minutes)
0	0
30	1
55	2
73	3
92	4
104	5

Time (s)	Distance travelled (cm)
5	0
7.5	1.5
12	3.0
16.5	4.5

Experiment A

Time						
Temperature						

Experiment B

Mass (grams)						
Height (cm)						

Test-tube	Substance	Observation
A	salt	
B	sugar	
C	copper sulfate	

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How will I make a conclusion and write my report?

When you have completed your experiment and recorded all your observations you will need to think about what the results show and make a conclusion. (If you repeated your experiment and obtained several measurements you should first calculate an average result.) Ask yourself 'Do the results support my hypothesis?' If they do, that is good. If they don't that is equally as good. All results, even ones that don't agree with the hypothesis, are important.

The final step in your student research project is to write a report. It is important that what is found out is clearly communicated with others so that knowledge is shared. Most scientific reports consist of the following parts.

Title
Think up a short name for your experiment which gives the reader an idea what the topic of your research project was about.

Aim
In the aim you state the purpose of your experiment. This can be to find out the answer to the question you wanted to investigate.

Hypothesis
The hypothesis is the possible answer to the question you asked. Write this as a simple statement.

Method
The method is the steps you followed when carrying out your experiment. This section can include labelled drawings showing how the equipment was set up.

Results
This section contains your observations and measurements neatly set out in data tables or represented as graphs. You may also include sketches or photographs to illustrate what you observed.

Discussion
This section is used to write about the experiment and the results. Write about what the results show. Also describe any problems you experienced with your experiment. You may be able to suggest how you could improve on its design.

Conclusion
The conclusion should be a brief statement on whether your results supported or rejected your hypothesis.

Multimedia   Internet assignment

One final suggestion

If you are really pleased with your student research project, consider entering it in one of the many science competitions such as Young Scientist.

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1.11 CHAPTER REVIEW

Using scientific language

1 Imagine that you need to describe a Bunsen burner to someone who hasn't seen one before. Explain, without using a diagram, what the parts of a Bunsen burner look like, how they fit together and how they work.

2 For each of the following statements correct the units used so that the sentence makes sense.
 a A baby weighs 75 cm.
 b I drank 1.0 m of water.
 c In 1 hour, Friedrich ran 4 kg.
 d Mary has a height of 183 seconds.

Check your knowledge

1 Mrs Andrews, the science teacher of Year 7B, was bombarded with the following questions from her students.

lee Why can't we bring food into the laboratory?
john When can we dissect a rat?
kim Why can't we go into the laboratory without a teacher?
indira When will we use the Bunsen burner?
mario Do we have to learn all these new names?
bill What's in the preparation room?

Discuss your ideas in groups of four, then prepare an answer for each of Mrs Andrews's students.

2 Five students each drew a piece of scientific equipment as shown below.

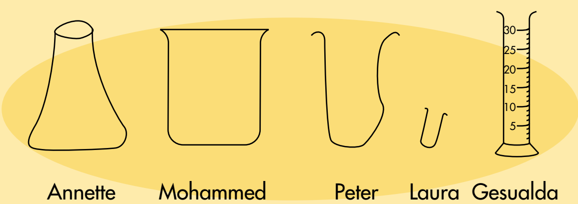

FIGURE 1.25
Drawings by (left to right): Annette, Mohammed, Peter, Laura, Gesualda.

 a Identify the errors in each diagram.
 b Draw a correct scientific diagram for each piece of equipment.

3 Tom listed the following steps in lighting a Bunsen burner, but he got them confused.

Step 1: Light a match.
Step 2: Connect the rubber hose of the Bunsen burner to a gas tap.
Step 3: Turn on the gas tap.
Step 4: Place the lighted match at the top of the Bunsen burner.
Step 5: Place the Bunsen burner on a heatproof mat.
Step 6: Turn the collar of the Bunsen burner so that the air hole is open.

Rewrite the steps in the correct order.

4 What three things are necessary to keep a fire burning?

Apply your skills

1 For each of the items below:
 a estimate the quantity in brackets, then measure and compare
 b choose a different quantity to measure, take the measurements and record your results in a table.
  i your pen (mass)
  ii a table (height)
  iii a cut banana (time taken to go brown)

2 Draw scientific diagrams for the apparatus you would use to:
 a filter a sample of muddy water
 b melt wax
 c separate salt from salty water
 d find out whether or not a chemical dissolves in a liquid.

3 The following is a list of ways to reduce the risk of fire:
- clear away fallen leaves, long grass and dead undergrowth within 30 metres of your home
- remove wood piles, heavy mulch and other flammable materials
- check that hoses reach all sides of the house
- check that electrical leads are not worn or frayed.

Using the fire triangle, explain how each of these preventative measures reduces the risk of fire.

Challenge yourself

1 Explain why a hypothesis is sometimes described as being an 'educated guess'.

2 Place a retort stand on a heatproof mat. Set a tripod on the retort stand, with a gauze mat on top of the tripod. Use a measuring cylinder to measure 100 mL of water. Pour the water into a beaker, then put the beaker on the gauze mat. Set up a Bunsen burner under the tripod then use a boss head and clamp to fix a thermometer halfway into the water in the beaker. Light the Bunsen burner and heat the liquid until it boils, recording the temperature every minute. Write a scientific report of this experiment.

Tester

Glossary

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CHAPTER 2

MATTER AND MATERIALS

Rock concerts and stage shows use a variety of special effects to create spectacular results.

The smoky haze which is used with coloured lights is made by a portable smoke machine. The machine contains an oil which is forced around a heated coil. The oil is turned into a white smoke. Unlike ordinary smoke it has a slight odour and can be inhaled without causing breathing problems.

A thick mist is made when dry ice (solid carbon dioxide) is placed into a container of warm water. The vapour formed is heavier than air so it will fall and roll across the stage floor. The warmer the water the faster the mist is formed.

Explosions on stage use specially designed fireworks. Like ordinary fireworks these are based on gun powder mixed with either aluminium or magnesium powder to create a bright flash of light. Other chemicals such as strontium nitrate and barium nitrate are added to the mixture to create colourful effects.

How do all these special effects work? A knowledge and understanding of matter can be used to explain each effect.

In this chapter you will begin to investigate the nature of matter and materials.

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Classify matter as solid, liquid or gas.
- Identify the changes of state which occur when matter is heated and cooled.
- Use the particle model to explain why gases can be easily compressed and matter can expand and contract.
- Explain diffusion of gases and liquids in terms of particle movement.
- Investigate the physical properties of various materials.
- Describe how scientists use models to explain observations.
- Make careful and accurate observations.

Web links

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2.1

Everything matters

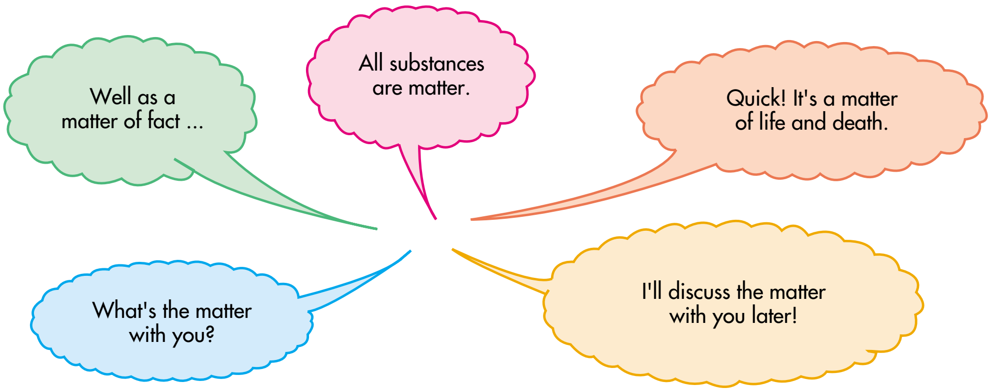

FIGURE 2.1
Different ways to use the word matter.

The word 'matter' can be used in many ways. In science the word matter has a special meaning. Matter is what all things are made of. Everything in the universe is made of matter. Plants and animals, rocks and soil, air and water, are all made of matter.

All matter has **mass** and **volume** (it takes up space). Matter can be found in the form of a **solid** (such as a blackboard duster), a **liquid** (such as water) or a **gas** (such as air). Solids, liquids and gases are known as the three **states** (or **phases**) of **matter**.

EXPERIMENT 1 INVESTIGATING MATTER

INTRODUCTION

AIM

To investigate the mass and volume of matter.

METHOD

1 Copy the following table into your book.

Type of matter	Volume (cm^3)	Mass (g)
Solid (blackboard duster)		
Liquid (water)		
Gas (air)		

2 Complete each part of the experiment below and record your results for mass and volume in the table.

A INVESTIGATING THE MATTER IN A SOLID

AIM

To determine how much matter there is in a blackboard duster.

MATERIALS

- blackboard duster
- electronic balance
- ruler marked in centimetres

METHOD

1 Using the electronic balance, measure the mass of the blackboard duster in grams.

2 You can calculate how much space (volume) the blackboard duster takes up in the following way. In this experiment volume is measured in cubic centimetres (cm^3) or millilitres (mL).

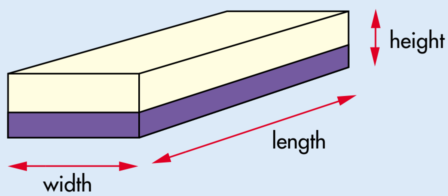

FIGURE 2.2
Volume of blackboard duster = length (cm) x width (cm) x height (cm).

DISCUSSION

1 How much did your blackboard duster weigh?

2 What was the volume of your blackboard duster?

Glossary

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Foundation worksheet 1

EXPERIMENT 1 CONTINUED

B INVESTIGATING THE MATTER IN A LIQUID

AIM

To determine how much matter there is in a quantity of water.

MATERIALS

- balance
- water
- 100 mL measuring cylinder

METHOD

1 To measure the mass of a quantity of water, first weigh an empty measuring cylinder, then add a volume of water and weigh the cylinder again. In this experiment mass is measured in grams.

Mass of water (g) = mass of cylinder + water (g)
– mass of empty cylinder (g)

2 To calculate the volume of the water, you can use a measuring cylinder. Measure the volume of the water you have just weighed.

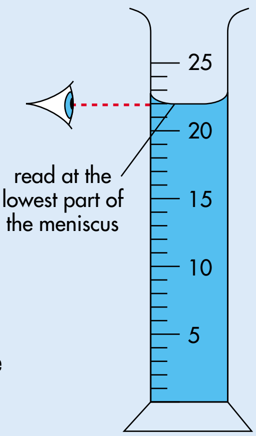

FIGURE 2.3
When you want to measure the volume of a liquid, place the measuring cylinder on the bench so it is level and the liquid is still. The surface of a liquid such as water curves downwards to form a **meniscus**. To measure the volume accurately, read the scale at eye level at the lowest part of the meniscus.

DISCUSSION

1 What was the mass of your quantity of water?
2 What was the volume of your quantity of water?

C INVESTIGATING THE MATTER IN A GAS

AIM

To determine how much matter there is in a quantity of air.

MATERIALS

- evacuated flask
- scales
- vacuum pump with rubber tubing and clamp

METHOD

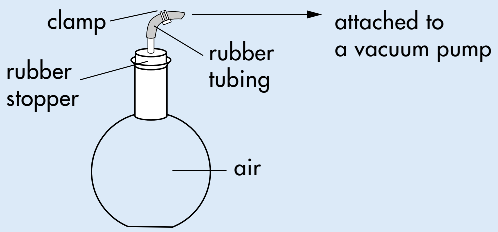

FIGURE 2.4
A vacuum pump can be used to remove the air from a flask.

1 Obtain a flask which has had all the air removed with a vacuum pump. Weigh the flask and record the mass. Now open the clamp. What happens when you do this? Record the mass of the flask with air in it. How much does the air in the flask weigh?
2 The air in the flask takes up the whole container. How can you calculate its volume? Check with your teacher before using your suggested method to find the volume of air in the flask.
3 Record the mass and volume of the air in your table.

Questions

1 How do we know if something is made up of matter?
2 Which of the following do you think are forms of matter?

natural gas, an elastic band, a push, a nail, salt, a chair, mineral water, electricity, thunder

3 Write down the names of four solids, four liquids and four gases that you use every day.
4 Using your list from question 3, write down what the solids have in common, what the liquids have in common and what the gases have in common.

Activity

Find an irregularly shaped rock. Design and carry out an experiment to show that your rock is composed of matter.

Think about

How would you show that an elephant is made of matter?

FACT FILE

There is a fourth state of matter called 'plasma'. Plasma exists at extremely high temperatures. Stars contain plasma.

Extension worksheet

Glossary

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2.2

The particle model of matter

Animation

Internet assignment

Matter comes in millions of forms which look, feel, sound and smell different. Some matter is hard, some is soft, some is shiny, some is dull. Some matter will bend and stretch and some is brittle. Matter will behave in different ways when it is heated or cooled or when electricity flows through it. How can we explain the differences in the behaviour of matter?

Scientists have developed a way of thinking about matter which explains the nature and behaviour of matter. They believe that matter is made of tiny particles which are so incredibly small that no light microscope can see them. Only the most powerful electron microscopes have been used to photograph these tiny particles. The particles which make up matter have spaces between them and are always moving. Solids, liquids and gases are different from each other because of the

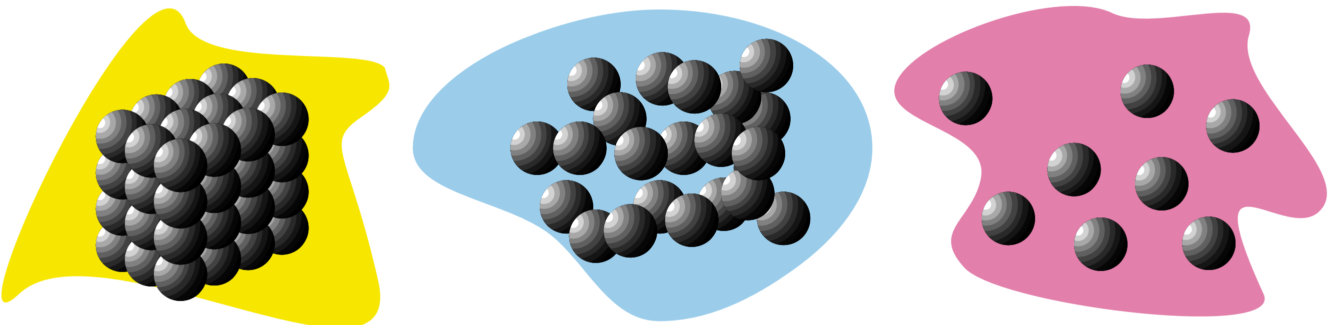

FIGURE 2.5
The particles in solids, liquids and gases.

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amount of space between the particles as well as the amount of movement of the particles. In solids the particles are packed very tightly together. They only move by vibrating in a fixed position. Solids have their own shape. In liquids the particles are packed tightly together but they are able to slide over one another, moving quite rapidly. Liquids do not have their own shape. They take the shape of the containers they are in and are flat on top. In gases the particles are spread far apart. They move very rapidly and freely, spreading out to take the shape of the containers they are in.

These ideas about matter are called the **particle model of matter**. We use this model of matter to help us explain what we observe. We can explain why liquids and gases can be poured, why solids have their own shape and why the volume of a gas is the same as the volume of the container it is in. For example, gases completely fill their containers because the rapidly moving particles are colliding with each other and pushing outwards.

Foundation worksheet 2

EXPERIMENT 2 INVESTIGATING PARTICLES

AIM
To find out how small a crystal of potassium permanganate can become.

MATERIALS
- 5 test-tubes with stoppers to fit
- test-tube rack
- water
- tweezers
- a single crystal of potassium permanganate

METHOD
1 Use the tweezers to place a single crystal of potassium permanganate into the first test-tube.
2 Fill the test-tube with water and carefully shake it until the crystal completely breaks up.
3 Pour one-fifth of the coloured mixture into the second test-tube and fill with water.
4 Pour one-fifth of this mixture into the third test-tube and again fill with water.
5 Continue until all test-tubes have been used.
6 Describe the appearance of each test-tube.

DISCUSSION
1 What happened to the crystal of potassium permanganate when water was added to the first test-tube?
2 Was there potassium permanganate in the second test-tube? Explain your answer.
3 Would it be possible to continue this process and still have some potassium permanganate particles in the water? Explain your answer.

Questions

1 Ice, water and steam contain the same type of particles. Why are these states of matter so different?

2 Copy and complete the table.

	Solid	Liquid	Gas
Space between particles			
Movement of particles			
Shape of state			
Drawing showing particles			

3 Julia has suggested that passengers on a train could be used as a model of the particles in matter.

a In what ways is Julia's 'train model' accurate?

b In what ways is it inaccurate?

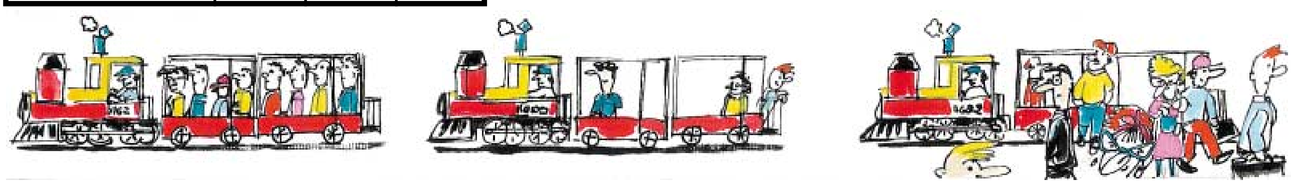

FIGURE 2.6 Julia's 'train model'.

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2.3

Going through a phase: heating up

FIGURE 2.7
Look carefully at the melting candle. List at least five of your observations.

Talk about
Why do candles get smaller as they burn? What do you think happens to the particles in the candle?

When a substance changes from a solid to a liquid, from a liquid to a gas, from a gas to a liquid or from a liquid to a solid, it **changes state (phase)**. The type of material or substance does not alter, it just changes from one state to another.

As a substance is heated, the particles that make up the substance gain energy and move around faster, eventually causing the substance to change state.

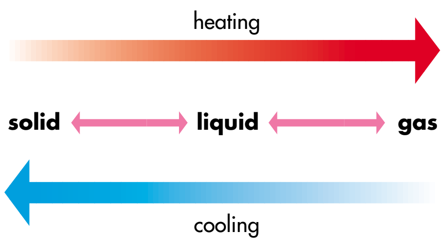

FIGURE 2.8
Substances can be changed from one state to another by heating or cooling.

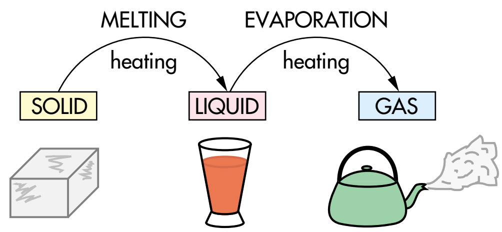

FIGURE 2.9
Changes of state occur when a substance is heated.

EXPERIMENT 3 OBSERVING CHANGES OF STATE

A HEATING ICE

AIM
To observe what happens when an ice block is heated.

MATERIALS
- evaporating dish
- tripod and gauze mat
- Bunsen burner
- ice block

METHOD
1 Set up the equipment as shown in the diagram.
2 Gently heat the evaporating dish and write down your observations.
3 Continue heating the liquid until it starts to boil.
Warning: Always wear safety glasses when heating substances. Never put your face over, or too near, the evaporating dish. If the ice melts too quickly it may splatter out of the dish and scald you.
4 Record your observations as the ice block changes state.

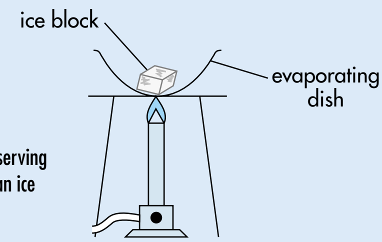

FIGURE 2.10
Experimental set-up for observing the changes in state when an ice block is heated.

DISCUSSION
What happened to the particles in the ice block as it was heated? Draw a flow chart to show what happened.

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EXPERIMENT 3 CONTINUED

B EXPANDING WAX

AIM

To observe the change in volume as a solid is heated.

MATERIALS

- test-tube
- beaker
- solid paraffin wax (about 3 cm)
- test-tube rack
- hotplate
- felt pen

METHOD

1 Put the paraffin wax into the test-tube, place the test-tube in a water bath (a beaker half-filled with water) and heat over a hotplate. When the paraffin has melted, leave the test-tube to stand in the test-tube rack until the wax cools and hardens.

2 Mark the level of the paraffin on the side of the test-tube with a felt pen.

3 Put the test-tube back in the water bath and melt the paraffin again. While the wax is still liquid, hold the test-tube vertically and again mark the level of the wax. **Warning:** Always make sure that the mouth of the test-tube is not pointing towards you or anyone else.

4 Record your observations in your book.

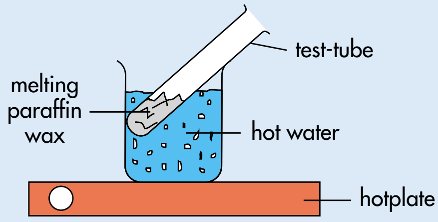

FIGURE 2.11
Does wax expand when heated?

DISCUSSION

1 What was the point of step 1 in this experiment?

2 Using the particle model, explain why the level of the wax changed.

Questions

1 When a solid changes to a liquid, the solid is said to _____ . This change is caused by _____ . When a liquid changes to a gas, the liquid is said to _____ . This change is caused by _____ .

2 When a solid is heated, what happens to the particles in the substance?

3 Which takes up more space: 1 kilogram of solid gold or 1 kilogram of liquid gold? Why?

4 List 10 everyday examples of substances changing state as they become hotter.

Think about

Aretha thinks it requires more energy to change a solid to a liquid. Rhyl thinks that more energy would be needed to change a liquid to a gas. Who do you think is right?

Activity

Work in groups of six or eight students. Imagine that each group represents a substance and each person in the group represents a particle in the substance. Arrange the groups around the classroom. Start by standing very close together in your group, with your arms folded across your chest. Imagine the substance is being heated, causing the particles to vibrate. As the particles obtain more energy, they move about more, vibrating much faster.

1 Describe what happens to the closely packed group of students as each student starts to move about.

2 How does this demonstrate what happens to particles when they are heated?

Glossary

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Going through a phase: cooling down

FACT FILE

Water is the only liquid that takes up more space when it solidifies. All other substances take up less space as a solid. That is why ice floats: it is less dense than water.

FIGURE 2.12
When molten rock (lava) cools, it solidifies and forms various types of rock.

FIGURE 2.15
Special effects can be achieved at rock concerts and in theatre productions by shining coloured lights through the gas that forms when dry ice is placed in warm water. Dry ice (solid carbon dioxide) changes directly from the solid state to the gaseous state without becoming a liquid.

Talk about
In what ways would molten lava be different from solidified lava?

As substances cool, the particles lose energy and slow down. The substance changes state from a gas to a liquid or from a liquid to a solid.

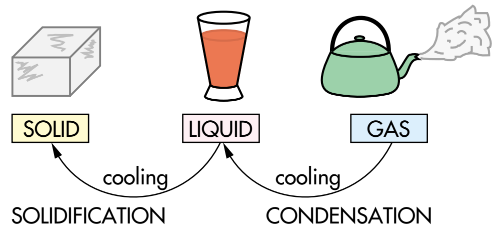

FIGURE 2.13
Changes of state occur with a loss of energy, or cooling.

Sublimation

Some substances can change state from a solid to a gas, or from a gas to a solid, without going through the liquid state. This is called **sublimation**.

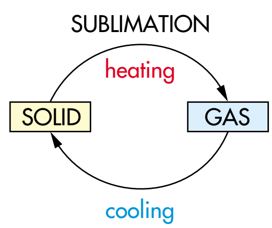

FIGURE 2.14
The term sublimation is used to describe a change of state in either direction.

Dry ice (solid carbon dioxide) changes directly into a gas. This is because air pressure as well as temperature affects the state of matter. At ordinary air pressure carbon dioxide particles boil off the surface of the dry ice without melting first. Carbon dioxide will change into a liquid only if placed under very high pressures as in a fire extinguisher. Another substance which sublimes is iodine.

Glossary

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All matter will condense into a liquid or freeze into solid when cooled to the right temperature. As the temperature is lowered the particles lose energy and slow down. When particles of gas slow down sufficiently they begin to clump together to form droplets of liquid. If the particles in a liquid lose more energy they stop sliding over one another and become fixed into position in a regular pattern to form a solid. Some substances can be used to reduce the temperature at which matter freezes. These substances are known as **cryogens**. Salt will lower the temperature at which water freezes. Dry ice will lower the temperature at which alcohol freezes.

FIGURE 2.16 Iodine changing state from solid to gas.

EXPERIMENT 4 INVESTIGATING A CRYOGEN

Datalogging

AIM

To find out how much salt is needed to stop water from solidifying in a freezer.

MATERIALS

- 1 large beaker
- 5 test-tubes
- measuring cylinder
- teaspoon
- water, salt and a freezer

METHOD

1 Label test-tubes 1 to 5.
2 Use the measuring cylinder to put 10 mL of water into each test-tube.
3 Add one-quarter of a teaspoon of salt to test-tube 2.
4 Add half a teaspoon of salt to test-tube 3.
5 Add three-quarters of a teaspoon of salt to test-tube 4.
6 Add one teaspoon to test-tube 5.
7 Shake each tube well and stand in beaker. Place the beaker in a freezer and leave overnight.
8 Examine each tube and record whether the water has solidified

DISCUSSION

How much salt is needed to stop 10 mL of water from turning into ice in a freezer? When might it be useful to prevent water from turning into ice?

Questions

1 When a liquid changes to a solid, the liquid is said to _____ . This change is caused by _____ . When a gas changes to a liquid, the gas is said to _____ . This change is caused by _____ . When a solid changes to a gas, the solid is said to _____ . This change is caused by _____ .

2 When a gas is cooled, what happens to the particles in the substance?

3 List 10 everyday examples of substances changing state as they cool down.

4 Draw a flow chart to show all the changes of state (melting, evaporation, condensation, solidification and sublimation). Include the states of matter on your diagram and show whether the substance gains or loses energy in each change of state.

Multimedia

5 A ship's bell has a crack in it. To repair it, half of the bell must be replaced. As the new half will be cast in molten metal, what must be taken into consideration if the two halves are to fit together?

6 List two examples of substances that solidify at room temperature.

Think about

On a cold morning, why does the window of a car 'demist' faster if you use the air-conditioner than if you use the heater?

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2.5

SCIENCE IN FOCUS

THE NATURE AND PRACTICE OF SCIENCE

Using models

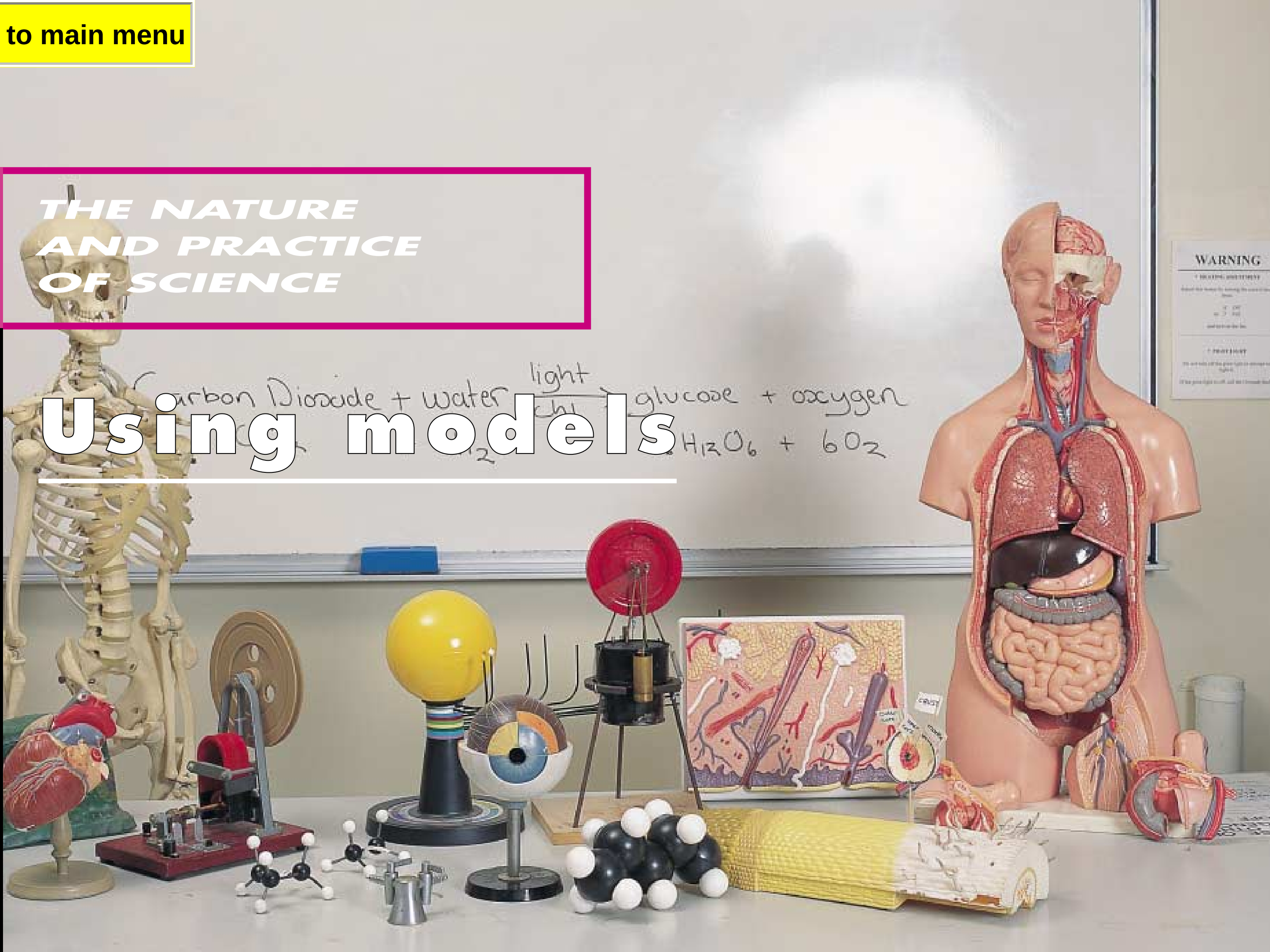

FIGURE 2.17 A collection of different models.

People, including scientists, use models to help understand things that are either too big, too small or too complicated to be seen. A model train is a small but exact copy of the real thing. A scientific model is not a small copy but an idea that helps us to think about or visualise something. This idea can be used to draw a diagram or develop a mathematical formula to explain our observations.

People have been coming up with models to explain the nature of matter for thousands of years. As new evidence about the behaviour of matter is made available, the model is changed and improved.

The earliest ideas about matter were held by the ancient Greeks. One group believed that any lump of matter could be split up into smaller and smaller pieces forever. Another Greek, Democritus (*c.* 460–370 BC), disagreed. Democritus put forward a different model of matter. He said matter was made of tiny indivisible (unable to be divided) particles. He called these particles atoms.

For over 2000 years most people were not prepared to accept this model. It was not until the late eighteenth century that the work of John Dalton gave good evidence to support the particle model of matter. Dalton made models of atoms out of wooden balls to help explain his ideas.

Since the work of Dalton many scientific discoveries have been made which have changed the way we think about atoms and matter. Atoms are no longer considered the smallest particles. The discovery of subatomic particles called **electrons**, **protons** and **neutrons** has changed the model further. Protons and neutrons are thought of as making up a core or nucleus in the atom. Electrons travel at high speeds around the nucleus.

Recently scientists have found that even protons and neutrons are made up of tinier particles called **quarks**. Quarks are about 1000 times smaller than protons.

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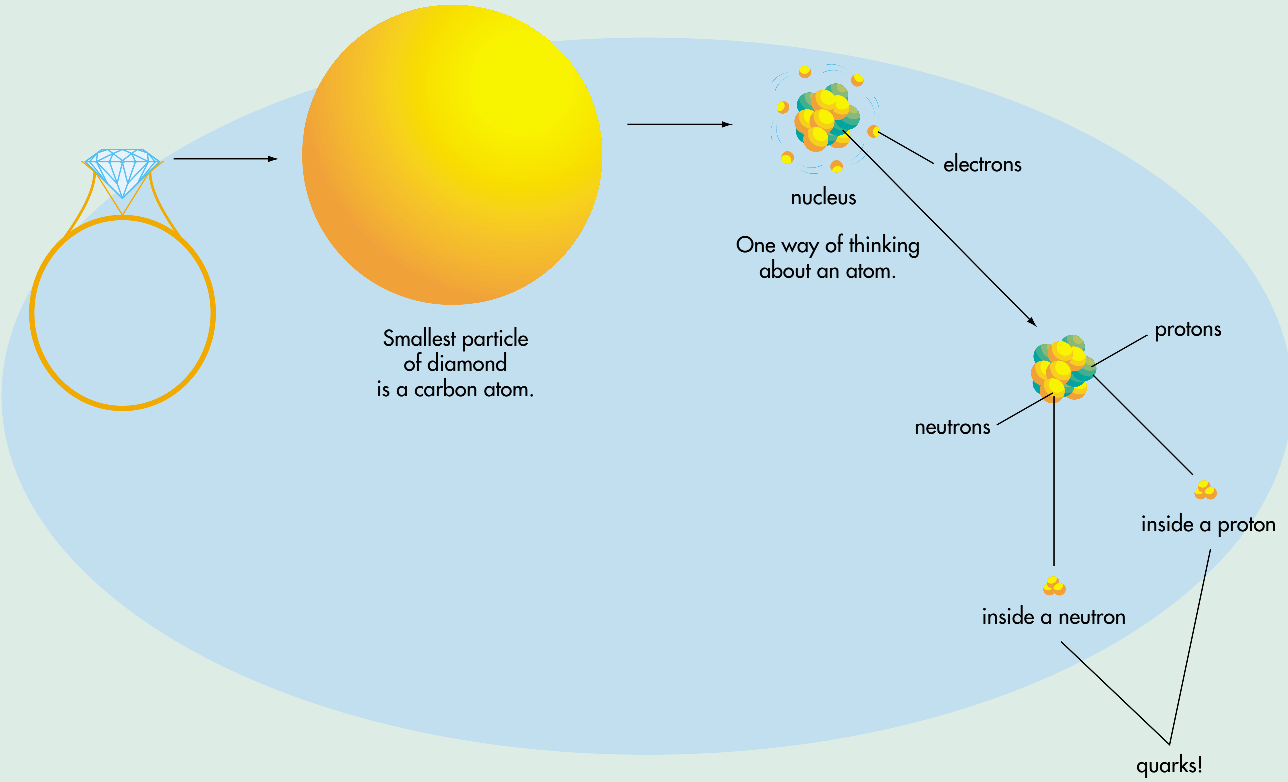

FIGURE 2.18
From atom to quark.

USING SCIENCE 1 MAKING MODELS

WHAT YOU NEED

- cardboard
- glue
- polystyrofoam balls
- paint

WHAT TO DO

Use the polystyrofoam balls to represent particles and make models of solids, liquids and gases. Arrange the particles to show some feature of each state of matter. Glue the balls to the cardboard to create a poster.

Questions

1 Write three uses of models in everyday life.

2 Explain in your own words what a scientific model is.

3 Models are used in every field of science to help explain and make predictions. Use the models suggested in the examples below to predict what happens when:

a blood enters a partially blocked artery. Think of the artery as a highway with two lanes blocked and the blood as the stream of cars.

b a fish enlarges its swim bladder. Think of the swim bladder as a ballast tank on a submarine when air is pumped in to force the water out.

Find out

How big is the smallest atom?
How big is the largest atom?

Glossary

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2.6

Compression and expansion

FIGURE 2.19
Scuba divers need a good understanding of compression and expansion of gases.

We have seen how the particle model of matter can be used to explain what is happening when materials change state. This model can help us to understand why some matter can be compressed (squashed to take up less space) and some not. It can also be used to explain why most materials expand (take up more space) when they are heated and contract (take up less space) when they are cooled.

Compression

Solids cannot be easily compressed. This is because the particles in solids are already closely packed together. This property makes them useful building materials. Bricks, steel and concrete cannot be easily compressed, so they will support the weight of a multi-storey building. Liquids, like solids, cannot be easily compressed. The particles in liquids are also closely packed together. The fact that liquids cannot be easily compressed, makes them useful in hydraulic brakes and car jacks. Gases are quite different: they can be easily compressed. This is because the particles in gases are far apart. When a gas is compressed the particles are forced closer together. This means that a large amount of gas can be squashed into a small volume. Compressed gas is used by scuba divers in their air tanks.

Expansion

Expansion occurs in solids, liquids and gases when the substance is heated. The substance does not always change state but will expand, or take up more room, as the particles move about more because they have more energy.

EXPERIMENT 5 COMPRESSION OF SOLIDS, LIQUIDS AND GASES

AIM
To find out whether we can compress particles (squeeze them closer together).

MATERIALS
- plastic syringe
- water
- piece of dowel that fits into the syringe

METHOD
1 Place a small piece of dowel into the plastic syringe.
2 Place your finger over the open end, then press down with the plunger. Can you compress the wood?
3 Remove the dowel and half-fill the syringe with water. Make sure no air is present in the syringe. Place your finger over the open end and press the plunger. Can you compress the water?
4 Remove the water and withdraw the plunger about three-quarters of the way. What is inside the syringe now? Place your finger over the open end and press the plunger. Can you compress the air?
5 Record your observations in a table.

DISCUSSION
Compare how easy you found it to compress a solid, a liquid and a gas.

Glossary

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EXPERIMENT 6 EXPANSION IN A LIQUID AND A GAS

AIM
To observe the expansion of liquids and gases when they are heated.

MATERIALS
- 2 small flasks
- glass tube with cork attached to fit small flask
- coloured water
- large beaker of ice
- balloon
- large beaker of hot water

METHOD
1 Fill the first flask with coloured water and carefully twist the cork and glass tube into the top, allowing the coloured water to move up into the tube.
2 Mark the level of the coloured water on the glass tube then place the flask into the beaker of hot water and leave for several minutes.
3 Transfer the flask into the beaker of ice and allow to stand, then record your observations.
4 Stretch the balloon over the neck of the second flask and sit the flask in the beaker of hot water.
5 Transfer the flask to the beaker of ice and record your observations

DISCUSSION
Use the particle model of matter to explain why liquids and gases expand when heated and contract when cooled. You can use diagrams to help show what happens to the particles during expansion and contraction.

EXPERIMENT 7 EXPANSION IN A SOLID

AIM
To observe the expansion of solids when heated.

MATERIALS
- ball and ring
- Bunsen burner
- heatproof mat

METHOD
1 Try to pass the ball through the ring.
2 Heat the ring over the Bunsen burner and then try to drop the ball through the ring while it is still hot.

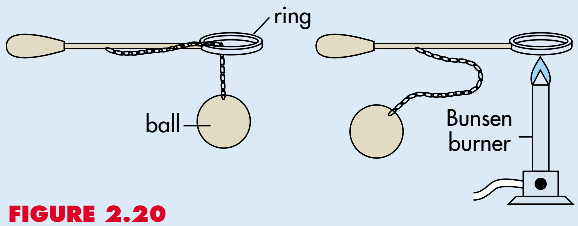

FIGURE 2.20
Experimental set-up for the ball and ring experiment.

DISCUSSION
Describe what happened in this experiment using a set of labelled diagrams.

Questions

1 Explain why aerosol cans explode if they are thrown into a fire.
2 A glass stopper has become stuck in a bottle. You gently heat the neck of the bottle to loosen the stopper, at the same time keeping the stopper cool.
a Explain why this will work.
b What would happen if you heated the stopper rather than the bottle?
3 Why are thermometers filled with mercury or alcohol, not with water? Explain using your knowledge of the particle model of matter.
4 Which property of gases allows you to inflate a balloon?

Think about

Look at Figure 2.21. Why did these train tracks bend? What would you include in the design of the track to prevent this? What noise does a train make as it travels along a track? Can you explain why it makes this noise?

FIGURE 2.21

Glossary

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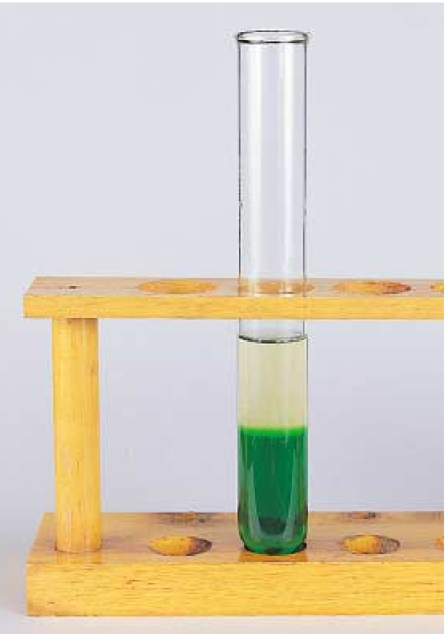
2.7

Diffusion: spreading it around



Diffusion is the 'spreading out' of a substance. A substance diffuses from an area where there is more of it to an area where there is less.

When two gases are mixed in a container, the particles of each gas will diffuse, or spread, through each other until they are evenly spread out in the container.

Talk about

What do you observe about the test-tubes in these photos? Try to explain your observations by describing what happens to the particles in the colourless jelly and the coloured jelly.

FIGURES 2.22 & 2.23
The test-tube shown in Figure 2.22 (far left) contains layers of colourless and coloured jelly. Figure 2.23 (left) shows the same test-tube two weeks later.

EXPERIMENT 8 DIFFUSION IN A LIQUID

Animation

AIM

To observe what happens when a crystal of potassium permanganate is allowed to stand in a beaker of water.

MATERIALS

- 250 mL beaker
- spatula
- crystal of potassium permanganate

METHOD

1 Three-quarters-fill a beaker of water and wait for it to be still.
2 Carefully lower a crystal of potassium permanganate down the side of the beaker.
3 Observe what happens immediately, after 20 minutes and after one day.
4 Draw a series of labelled diagrams to record your observations.

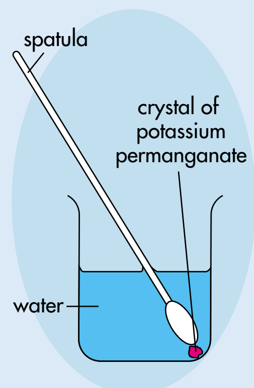


FIGURE 2.24
Lower the crystal of potassium permanganate very carefully down the side of the beaker.

DISCUSSION

Explain, in terms of particle movement, what has happened to the potassium permanganate.

Glossary

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EXPERIMENT 9 OH, THAT SMELL!

INTRODUCTION

What is an odour? An odour, whether it is pleasant like perfume or unpleasant like the smell of rotting seaweed, is caused by a vapour, or gas, which is given off by the substance involved. This vapour reacts with nerve endings in the back of your nose causing you to register the smell.

AIM

To observe how an odour diffuses around a room.

MATERIALS

- perfume or other material with a strong odour

METHOD

1 Release a small amount of an odour (perfume) in one corner of the room.

2 Students sit at different points around the room with their eyes closed and raise their hands as soon as they can smell the odour.

3 Two students 'map' the order of student responses to show how the odour travels in the room.

DISCUSSION

1 Why has the odour in this experiment travelled across the room?

2 Where is the odour the strongest: near the source or on the other side of the room? Why?

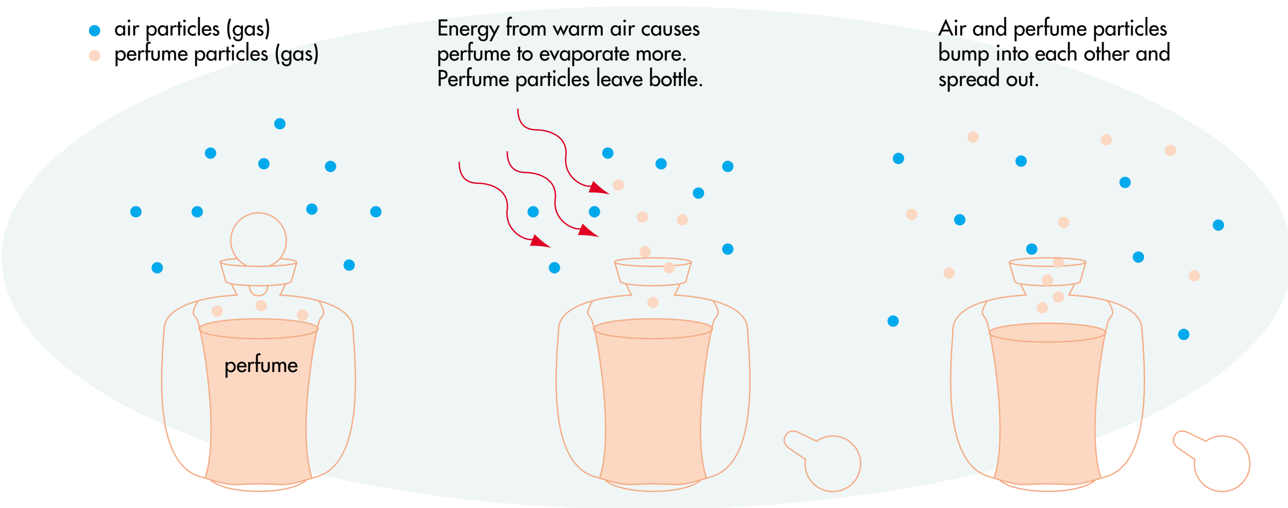

FIGURE 2.25 When the lid from a bottle of perfume is removed the perfume particles can escape from the bottle and diffuse through the air.

Questions

1a What is diffusion?

b List four examples of diffusion that occur around you every day.

b Why would gases diffuse faster on a warm day than on a cold day?

3a Which do you think would diffuse more rapidly: the particles of a gas or the particles of a liquid? Use the particle model of matter to explain your answer.

b Why can you can smell food being cooked on a barbecue from a long way away?

c Spices are often used to improve the flavour of food. How is this possible?

4 The particles in blue gas A are twice as heavy as the particles in red gas B.

a If gas A was pumped into one jar and gas B was pumped into another jar, would each gas spread through the jar at the same rate? Explain.

b Draw time-lapse diagrams of what you would expect to see if the two gases were pumped into the same container from different ends.

Glossary

2.8

Properties of materials

FIGURE 2.26
Racing cars are built from a wide range of materials with different properties.

Talk about

How many different materials are used in a car? Make a list. For each material give a reason why it is used the way it is.

In science we often describe the properties of a material. Used in this way the word ‘properties’ means the special features or characteristics of a substance. The properties describe how a material behaves when heated or cooled, when scratched or bent, when squashed or stretched and so on.

Strength

Strength is the property of a substance that allows it to retain its shape when twisted, pulled or crushed.

Flexibility

Some flexible solids will bend without breaking. We say the solid is malleable. A solid is called ductile if it can be stretched and drawn into wires. Solids which crumble and break apart if you try to bend them are said to be brittle.

Heat and electrical conductivity

Materials which allow heat and electricity to flow through them easily are called conductors. Insulators are materials which do not allow heat or electricity to flow through them.

Elasticity

Elastic materials can be stretched and will return to their original shape when released.

Density

Density is a measure of how closely particles are packed together in a material. To find the density of a sample of material you measure its mass and volume. Density is calculated by dividing the mass (in grams) by the volume (in cubic centimetres).

Boiling point

The boiling point of a substance is the temperature at which that substance changes state from a liquid to a gas. Different substances have different boiling points.

Melting point

The melting point of a substance is the temperature at which that substance changes state from a solid to a liquid.

Hardness

Hardness is the property of a substance that allows it to resist scratching. Hard materials are used to cut softer ones. The hardest substance on Earth is diamond. Diamond-tipped drills are used to cut concrete; metal drills are hard enough to cut into wood.

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Extra worksheet

EXPERIMENT 10 COMPARING PROPERTIES

AIM
To test a range of materials and describe their properties.

MATERIALS
- materials to test such as plastic pen case, wooden paddle-pop stick, rubber band, glass rod and length of copper wire
- coin
- nail
- metal file
- electronic balance
- measuring cylinder
- multimeter

METHOD
1 Attempt to scratch each test material firstly with your finger nail (very soft), secondly with a coin (soft), thirdly with the nail (hard) and lastly with the file (very hard). Record the hardness of each test material.
2 Use the electronic balance to measure the mass of each material in grams.
3 Pour exactly 30 mL of water into a 50 mL measuring cylinder, add a test material to the cylinder and note the new water level. The increase in volume in millilitres is equal to the volume of the test material in cubic centimetres. Divide the mass by the volume to calculate density in g/cm^3. Repeat this for each test material.
4 Your teacher will show you how to use the multimeter to test the electrical conductivity of each sample.
5 Record your results in a table with the following headings:
Material Hardness Mass (g) Volume (cm^3) Density (g/cm^3) Conductor or insulator

DISCUSSION
1 Which material was the hardest?
2 Which material was the most dense?
3 Which material was the best conductor of electricity?

Questions

1 **What properties would the metals used to make saucepans need to have (other than being good conductors of heat)?**

2 **Using the information in Table 2.1, answer the following questions.**

a **Which substances would be solid at room temperature.**

b **Which substances would be liquid at room temperature?**

c **It would be possible to separate a mixture of iron and silver by heating the mixture until the melting points were reached. Why? Would it be possible to separate magnesium and aluminium by the same method? Why?**

Find out

Select a material you are interested in and research its properties. Write a descriptive report on your chosen material.

Think about

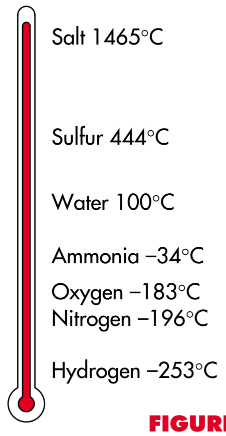

FIGURE 2.27 The boiling points of various substances.

Look at the boiling points of the various substances shown on the diagram above.

1 **Which substances would be gases at room temperature, which would be liquids and which would be solids?**

2 **Why are those substances with very low boiling points gases?**

TABLE 2.1 Melting points of some metals.

Metal	Melting point (°C)
Sodium	98
Magnesium	651
Aluminium	659
Iron	1535
Silver	960
Mercury	−39
Gold	1062

Glossary

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APPLICATIONS AND USES OF SCIENCE

Making snow

FIGURE 2.28
Why is the invention of artificial snow an advantage to skiers?

Snow in the atmosphere can take the form of snowflakes or ice crystals. Ice particles fall through the atmosphere. If the air temperature is a few degrees above 0°C, these particles will melt to form raindrops. If the air temperature is between –40°C and 0°C, the ice crystals will cluster around a nucleus (generally tiny clay particles 0.1 micrometre in diameter). Sometimes they remain as ice crystals but generally they join together to form snowflakes. These are normally hexagonal (six-sided) in shape and contain about 100 ice crystals.

At ski resorts, snow does not always fall when it is wanted so special machines have been developed to make snow. The type of snow they make does not have the crystal structure of natural snow, but it is fine to ski on.

To make snow, the air temperature must be below 0°C. Large quantities of water are needed (600 litres of water will make about 1 cubic metre of snow), as well as a power source, either electricity or a fuel-driven generator.

Just as in nature, the water in snow-making machines needs to group around a small nucleus or particle to form crystals. This process is called **nucleation**. Sometimes there are enough impurities in the water supply to help the water form crystals but often a special ‘nucleating enzyme’ must be added.

When rain falls on natural snow the snow tends to melt and then refreezes to form ice. Artificial snow forms in ‘ball bearing’ shaped crystals that allow rain to drain through so less ice forms.

FIGURE 2.29
The hexagonal shape of snowflakes. Are all snowflakes the same shape?

FIGURE 2.30
A machine for making artificial snow. Water is forced out of the jets under pressure and forms into droplets. Very cold air is forced out below the stream of water. This cools the water which crystallises and falls to the ground as snow. The longer the water remains in the air, the larger the crystals that form.

Glossary

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EXPERIMENT 11 GROWING CRYSTALS

AIM
To observe the types of crystals that grow at different rates of evaporation.

MATERIALS
- alum solution
- evaporating dish
- Bunsen burner
- heatproof mat
- tripod and gauze mat
- 2 petri dishes (or watchglasses)

METHOD
1 Divide the alum solution between the evaporating dish and the two petri dishes.
2 Place the evaporating dish on the tripod and gauze mat and heat gently using the Bunsen burner.

Warning: Do not allow the solution to boil rapidly as it may start spitting.

3 When all the water has evaporated, observe the size of the crystals that have formed.
4 Place one petri dish in a warm position.
5 Place the second petri dish in the refrigerator.
6 After three days observe the size of the crystals in the two petri dishes.
7 Record your observations in a table with the headings 'rapid crystallisation', 'slow crystallisation' and 'very slow crystallisation'.

DISCUSSION
What conclusion can you reach about the size of crystals and the rate at which they form?

Questions

1 In artificial snow-making, why would larger crystals form the longer the water droplets are in the air?

2 Look at the graph opposite that shows the volume of snow produced per hour against air temperature, then answer the following questions.

a What unit is used to measure air temperature?

b What unit is used to measure the volume of snow produced?

c What volume of snow could be produced at the following air temperatures? (i) –4°C (ii) –16°C

d If the snow-making machine produces 70 square metres of snow per hour, what would the air temperature be?

3 How would spreading artificial snow on crops prevent frost damage?

4 Think about the materials used to build a high-rise building (steel, concrete, etc.). Using your knowledge of the properties of solids explain why, in cold climates, it would be necessary to protect construction sites against frost using artificial snow.

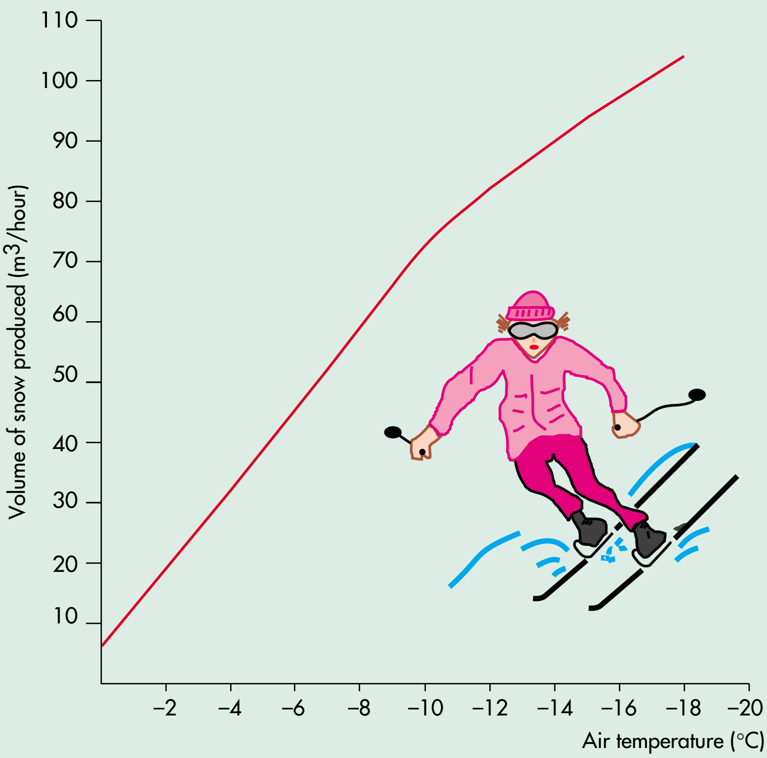

FIGURE 2.31 Snow production and air temperature.

Find out

1 Find out how big a micrometre is compared to a millimetre.

2 The word 'nucleus' has been used to describe the formation of snow. Use a dictionary to find out what this word means.

Glossary

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Using scientific language

You should be familiar with the words in the following list.

condense	solid	boiling
matter	gas	diffusion
melting	solidify	particles
substance	liquid	property
compression	mass	freeze
model	evaporate	volume
density	sublime	

a Choose at least 12 words from the list and draw a labelled diagram of an experiment that involves all the words you have chosen.

b Below your diagram, outline the experiment using the words you have chosen and underline them.

Check your knowledge

1 Name the state of matter that has:
- a a definite volume but takes the shape of the container
- b a definite shape and volume
- c no definite volume but fills the container completely.

2 Match the property of matter in the box with the correct description below.
- a particles of one substance moving between particles of another substance
- b the distance between particles being increased
- c particles of a substance being forced closer together

expansion	diffusion
compression	vibration

3 For each of the following sentences, choose the word in brackets that makes the sentence correct.
- a If the temperature of a gas is increased, its (mass, volume, weight, particle size) also increases.
- b The particles of matter move slowest in a (solid, liquid, gas).

Apply your skills

Word process

1 Choose 10 objects in your classroom.
- a Make a list of the objects and write down at least one physical property of each.
- b Classify or group the 10 objects based on their physical properties. For each group, describe the property on which you based your classification.

2 a For each of the following diagrams, decide which state of matter is represented.

b The five beakers represent the contents at different times as a solid substance is heated. Arrange the beakers in the correct order to show what happens when the solid is heated until the liquid form evaporates. Write down the order you have decided on.

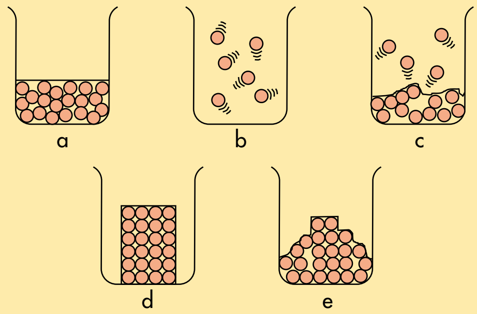

FIGURE 2.32

3 A beaker which is half-filled with water is sitting on a bench in your laboratory. Imagine that you are a particle in the water. A student is asked by the science teacher to use the beaker to show the evaporation of water and condensation of steam. Write an imaginary story called 'A Day in the Life of a Water Particle' to describe what happens.

4 Explain why it is necessary to put 'antifreeze' in the radiators of cars when travelling in very cold areas.

5 State whether energy is needed or released when:
- a ice melts
- b water freezes.

Challenge yourself

1 The table below shows the boiling points of various gases present in air.

Gas	Boiling point (°C)
helium	−268.9
neon	−245.9
nitrogen	−195.8
argon	−185.7
oxygen	−182.7
krypton	−152.9
xenon	−107.1

If air can be liquefied at about −200°C, list the gases which would not be liquid at this temperature.

2 You go on a bike ride on a hot summer's day. Consider the particles of air in the tyres.
- a Describe their movement (i) at the start of the ride (ii) at the end of the ride.
- b Explain why this change has happened.

3 Why is salt sometimes spread on roads and airport runways in winter in cold countries?

Tester

Glossary

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CHAPTER 3

SEPARATING SUBSTANCES

What's in a bottle of soft drink? Soft drink is a mixture of substances. About 90% of soft drink is water. Dissolved in the water are substances such as carbon dioxide, edible acids, sweetener, flavouring, salt, preservatives and caffeine. Soft drink can be sweetened naturally with sugar or artificially with sweeteners such as saccharin, cyclamate and aspartame.

Most soft drinks are made by combining carbonated water with a syrup containing the sugar and flavouring. The water is first treated to remove any impurities. This is done by passing it through a sand filter to remove minute solid matter. Then the water is pumped into an activated carbon purifier to remove colour, chlorine and any other tastes and odours. Carbon dioxide is added to the water using either dry ice or liquid carbon dioxide from pressurised tanks. It is the carbon dioxide which makes the water fizz and sparkle.

The final step at the bottling factory involves adding the syrup to each bottle and diluting it with carbonated water, injected under high pressure. The bottles are then capped, packed in cartons and are ready for delivery.

In this chapter you will investigate mixtures and ways to separate them.

Web links

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Explain the difference between soluble and insoluble substances.
- Distinguish between solutions, suspensions, colloids and emulsions.
- Investigate factors such as temperature that affect the solubility of a substance.
- Use a variety of techniques including filtration, evaporation, distillation and chromatography to separate mixtures.
- Obtain and grow crystals.
- Describe how separation techniques are used in everyday life.
- Solve problems by designing and investigating.

Glossary

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3.1

Does it dissolve?

FIGURE 3.1
You will have seen labels with instructions such as these on many products around your home. What do all these instructions really mean?

When a substance dissolves in another substance, a **solution** is formed. A solution is clear, that is no particles can be seen. The substance which takes in, or dissolves, other substances is called the **solvent**. The substance being dissolved is called the **solute**. If sugar is mixed with water, for example, a solution is formed since the sugar dissolves. The water acts as the solvent and the sugar is the solute.

A **sediment** may be formed when insoluble substances settle to the bottom of the container they are in. A mixture in which some or all of the particles settle out is called a **suspension**.

Soluble and insoluble substances

Many substances will dissolve in water. These substances may be described as water-soluble. A **soluble** substance is one that can dissolve in another substance. Substances which do not dissolve in water are called water-insoluble substances. **Insoluble** substances do not dissolve.

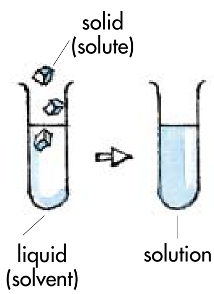

FIGURE 3.2
A solute dissolves in a solvent to form a solution.

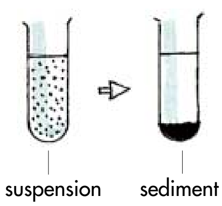

FIGURE 3.3
A suspension settles on standing to form a sediment.

FACT FILE

Some substances are insoluble in water, but are soluble in other solvents. Nail polish is soluble in nail polish remover or acetone, methylated spirits will dissolve biro ink, dry cleaning fluid dissolves grease.

Solutions in the home

FIGURE 3.4
In effervescent soft drinks, the solution is formed when a gas (solute) is bubbled into a flavoured liquid (solvent).

Solutions are not always made up of a solid dissolved in a liquid. Liquids and gases can also dissolve in solvents.

Liquid dishwashing detergent dissolves in water. Two-stroke motor fuel, used in lawn mowers and outboard motors, is a solution of oil in petrol.

Glossary

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EXPERIMENT 1 SOLUBLE AND INSOLUBLE SUBSTANCES

AIM

To investigate the differences between soluble and insoluble substances.

MATERIALS

- 6 test-tubes labelled A, B, C, D, E, F
- test-tube rack
- rubber stoppers
- small quantities of the substances in Table 3.1

METHOD

1 Place 30 mL of water in each of the six test-tubes and then to each test-tube A, B, C, D, E and F add a small quantity of the substance listed in Table 3.1 for it.
2 Place a rubber stopper in each of the test-tubes in turn and shake the tube gently. (If you are reusing a stopper, rinse it in water between test-tubes.)
Safety: Never put your finger or hand over a test-tube to shake it since what is in the test-tube may be poisonous or may burn you.
3 As you shake each tube, hold it up to the light. Is it cloudy, or does the light shine through it? Is the liquid coloured or colourless?

TABLE 3.1

Test-tube	Substance	Observation	Type of substance (soluble etc.)
A	copper sulfate		
B	salt		
C	copper carbonate		
D	sugar		
E	chalk		
F	sand		

4 Allow the test-tubes to stand in the rack for five minutes. Have any of the substances you added to the water settled to the bottom?
5 Record your observations in a table like Table 3.1.

DISCUSSION

1 Which of the substances you tested were soluble and formed a solution in water?
2 Which of the substances you tested were insoluble in water?
3 Did any of the insoluble substances form a sediment?

In soda water and soft drinks, carbon dioxide gas is dissolved in water and bubbles out when you take off the lid.

Oxygen is only slightly soluble in water but sufficient oxygen can dissolve in water for fish to breathe using their gills.

Questions

1 Copy and complete the following sentences:
When one substance dissolves in another a ___ is formed. The substance which dissolves is the ___ and substance in which it dissolves is the ___ .
___ is the most common solvent.
Any substance which does not ___ in a solvent is said to be ___ in that solvent.

2 Many substances which are insoluble in water will dissolve in another solvent. Make a list of five such substances and include the name of both the solute and the solvent.

3 In your own words describe the difference between dissolving and melting.

4 You buy a bag of garden fertiliser to use in the watering can and you suspect it contains a quantity of sand. Use a series of labelled diagrams to show how you could demonstrate this is true.

Think about

1 70% of human blood is water. Why do you think it is necessary to have such a large percentage of water in the blood?

2 When a substance dissolves in water it disappears. Where do you think it goes?

Glossary

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3.2

Solutions, suspensions, colloids and emulsions

FIGURE 3.5
Calamine lotion is a suspension. It contains particles which settle out to form a sediment. Gels, aerosols, foams and emulsions are all types of colloids.

Solutions and suspensions

Solutions consist of mixtures in which the solute particles are so small that they remain spread throughout the solvent. They cannot be filtered and do not settle out to form a sediment.

Suspensions consist of mixtures in which the particles are so large that they can be filtered out of the mixture. They settle out to form a sediment.

FIGURE 3.6
The contents of a saline drip may be described as a solution. It is important that the particles are spread evenly throughout the solution and don't settle out to form a sediment.

Colloids

Colloids are mixtures that contain particles that are larger than the particles in a solution but smaller than those in a suspension. If you shine a light through a colloid some of the light will be reflected back to your eyes by the tiny particles floating in it. Light will pass straight through a solution.

Colloids are different from suspensions because the particles in a colloid do not settle out. Also, the particles in a colloid can pass through a filter.

The particles in a colloid may be solid grains, liquid droplets or gas bubbles. The material in which they are spread out may also be solid, liquid or gas. Four common types of colloids are gels, aerosols, foams and emulsions.

FIGURE 3.7
Many medicines form suspensions and must be shaken prior to use.

Emulsions

A colloid in which tiny droplets of one liquid are spread evenly throughout another liquid is called an **emulsion**. Because the particles in an emulsion cling together, individual particles do not settle out.

Ointments and cosmetic creams are emulsions. Margarine and some dairy products, including homogenised milk and butter, are emulsions of oil and water.

How strong is it?

If you add three teaspoons of sugar to a cup of tea, the sugar taste will be a lot stronger than if you only add one teaspoon. We say that the 'one teaspoon solution' is weak or **dilute** and that the 'three teaspoon solution' is strong or **concentrated**.

If you keep adding sugar to the cup of tea you will reach a point where no more sugar will dissolve. The undissolved solute (sugar) will collect on the bottom of the cup. A solution in which no more solute will dissolve in the solvent is called a **saturated solution**.

Glossary

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Extra worksheet

EXPERIMENT 2 EFFECT OF TEMPERATURE ON SOLUBILITY

AIM

To investigate the effect of temperature on the solubility of potassium chloride in water.

MATERIALS

- test-tube
- potassium chloride
- Bunsen burner
- test-tube holder
- stirrer
- safety glasses

METHOD

1 Add 10 drops of water to a test-tube then add a small quantity of potassium chloride (about the size of a grain of rice).
2 Stir the solution gently, then add another 'rice grain' of potassium chloride. Keep adding potassium chloride in this manner, stirring, until a small quantity remains undissolved after stirring.
3 Gently warm the solution (do not boil) and observe what happens. Hold the test-tube with the test-tube holder. Record your observations.
4 Now add more potassium chloride in the same way as above until some remains undissolved in the bottom of the test-tube.
5 Warm the test-tube again. What happens to the undissolved potassium chloride?

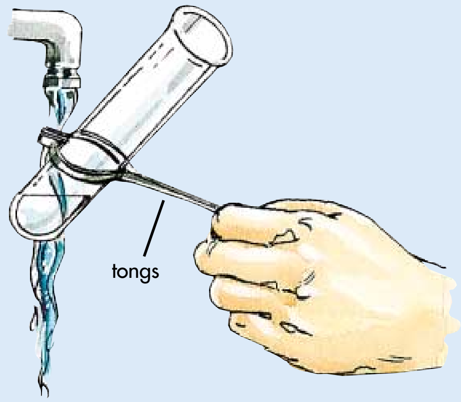

FIGURE 3.8
Observe what happens to the contents of the test-tube as it cools.

6 Allow the test-tube to cool slightly then run it under a gentle stream of cold water.
7 Observe what happens to the solution. Record your observations.

DISCUSSION

Referring to your observations, what can you say about the effect of increasing temperature on the solubility of potassium chloride in water?

EXTENSION

Repeat the experiment using other solutes. Substances such as common salt, sugar, potassium nitrate and copper sulfate could be tried. Do these substances all behave the same?

Questions

1 What is the difference between a solution and a suspension? A colloid and an emulsion?
2 Why does sugar dissolve faster in hot tea if you stir it?
3 To make jelly the instructions tell you to add boiling water to the jelly crystals. Why would you use boiling water rather than cold water?
4 Is fog a solution, a suspension, a colloid or an emulsion? Justify your answer.
5 You are given two solutions of sugar in water, each of a different concentration. How could you tell which is the more concentrated?
6 The water in a mountain stream is usually crystal clear. After heavy rain, however, the stream would become muddy. Explain, in your own words, why this is so.

Interactive

Glossary

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3.3

All mixed up: can you separate it?

FIGURE 3.9
Although you may think that chocolate is a pure substance, it is actually a mixture of over 300 flavour substances!

Some substances are single or **pure substances**: pure water, gold and silver, even baking soda, are made up of just one substance. It is far more common in nature, however, to find **mixtures** of two or more of these pure substances and we often need to separate them. Mixtures are often relatively easy to separate into their components. The method we choose for separating substances depends on the properties of the substances involved.

Talk about

Classify the following substances into two groups: **pure substances** and **mixtures**. Draw up a table to record your choices.

water gold coffee orange juice
air helium mud glass sugar
cordial glue aluminium

How does your classification compare with those of other students in the class? If any of your answers differed from other students' answers, how could you decide who was right?

Sieving

The muffin recipe says 'add the sugar and sultanas separately' but you have mistakenly mixed them. Now you need to separate them before you can continue making the muffins. What is the easiest and quickest way to do this?

Using a **sieve** will allow the smaller grains of sugar to pass through the holes and retain the sultanas.

In refining metals from their ores large screening sieves are often used to separate small chunks of ore from larger ones which require further crushing; in quarries the material is graded by screening to provide different size pieces of rock for different purposes such as road building and concrete mixing.

FIGURE 3.10
A sieve is a convenient separation device in the kitchen.

Decanting

Sometimes you may want to separate an insoluble solid substance which is mixed with a liquid, for example a bottle of red wine which contains sediment.

Decanting is a method you can use to roughly separate the liquid from the solid. To do this, allow the solids to settle to the bottom of the bottle then gently pour the liquid off the top, trying not to shake the bottle. This will leave the sediment in the bottom of the bottle.

Gravity separation

Gold panning is a well known example of **gravity separation**. A stream of water is used to move the lighter particles of sand away from the heavier gold particles.

Centrifuging

Sometimes it is not possible to separate the heavier particles in a mixture using the gravity method. A **centrifuge** separates a mixture by spinning. Cream is separated from milk by this method and in medicine a centrifuge is used to separate red blood cells from the blood plasma. The spin drier in a washing machine is a form of centrifuge and the same method is used to separate sugar crystals from liquid sugar.

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USING SCIENCE 1 MAGNETIC MINING

AIM
To use **magnetic separation** to extract the iron filings from a mixture of iron filings and sand.

WHAT TO DO
Caution: Do not try to pick up the iron filings directly with the magnet. Always have a piece of paper or plastic between the magnet and the iron or put the magnet in a small, clear plastic bag.

FIGURE 3.11
Magnets in plastic bags can be used to separate magnetic objects from non-magnetic objecs.

1 Place a sheet of newspaper on the bench and pour the mixture of iron filings and sand evenly onto the paper.

2 Using a sheet of normal writing paper between the magnet and the mixture, use a magnet to separate the iron filings from the sand.

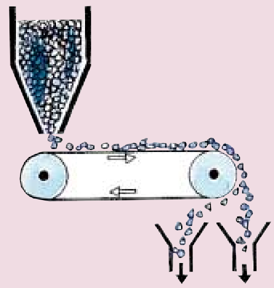

FIGURE 3.12
A magnetic ore separator. In a magnetic ore separator, the iron ore is crushed then dropped onto a conveyor belt. At one end of the conveyor belt there is a magnetic roller which attracts the pieces of ore which contain iron. As the ore drops off the end of the belt the non-magnetic pieces drop straight down but the magnetic pieces containing the iron are carried further round the belt until they too drop off and are collected for processing.

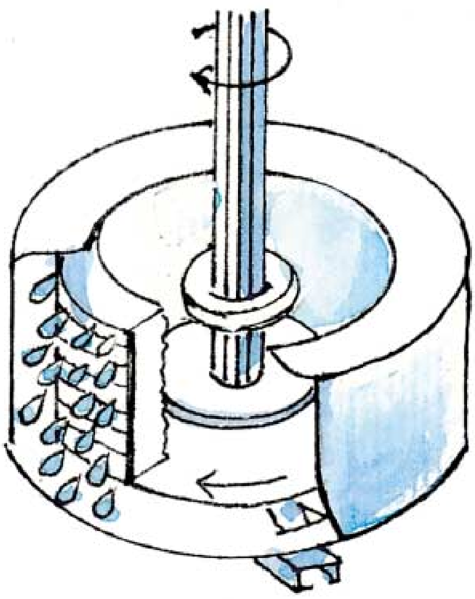

FIGURE 3.13
A cut-away view of a sugar centrifuge.

Questions

1 What is the difference between a pure substance and a mixture? Give one example of each.

2 Milk is often described as being 'pure' but can be separated into various components using a centrifuge. How, then, can it be advertised as pure milk?

3 What method of separation would you use for each of the following:

a iron filings spilt on the floor and swept up with dirt

b honey from honeycomb

c ball bearings from a vat of oil in a car workshop

d grading apples by size

e water from wet clothes.

4 What is one disadvantage of decanting as a method of separation? Why would you use decanting rather than sieving to remove the sediment from wine?

Think about

Suggest how you could separate a mixture of salt and sand.

Foundation worksheet 1

Internet assignment

Glossary

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3.4

Filtration: the strain of it all

FACT FILE

Baleen whales like the right whale and the blue whale have baleen plates along each side of their jaw which act as strainers or filters when collecting food. The flexible plates have hundreds of tangled hair-like tubes to filter the water and remove food—generally krill, a very small shrimp. Some whales swim with their mouths open and let the water spill out the corners through the baleen; others gulp water and use their enormous tongue to push the water through the filter.

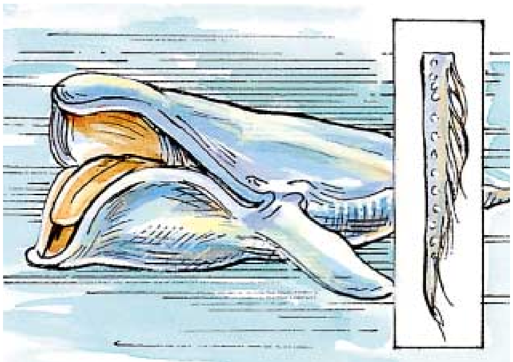

FIGURE 3.14
Right whale and detail of a baleen plate. Rows of baleen plates strain the food from the water in the right whale, *Eubalaena*.

Talk about

You have made a cup of brewed coffee but have lots of coffee grounds in the pot. You have a sieve but the holes are too large and the coffee grounds fall through. How can you separate the fine grounds from the liquid?

Some coffee makers use a filter, usually a type of paper, which allows the liquid to pass through but traps the fine grains of the solid. **Filtration** is the process in which insoluble particles in a liquid are screened out by a **filter**. The material that passes through the filter is called the **filtrate**. The material that is held back by the filter is called the residue.

Animation

In a laboratory we can use special **filter paper** in much the same way as the coffee maker, to separate the fine grains of insoluble substances from the liquid. The filter paper comes in different grades to trap different size grains.

FIGURE 3.15
The use of filters in coffee makers enables people to enjoy their coffee without needing to worry about solid residue!

Filters in the home

There are many other types of filters which you will recognise in everyday life. The lint filter in a clothes dryer filters solid particles from the air in the dryer. Some filters remove gases from the air (gas masks and odour eaters for shoes) and others remove solid particles from liquids, such as in fish tank filters, swimming pool filters and water filters/purifiers.

Questions

1 Give two everyday examples for each of the following situations:
a filtering a solid from a gas
b filtering a solid from a liquid
c filtering gases from the air.
2 Make a list of household utensils and appliances which use a method of separation. Beside each, state the method of separation employed.
3 Draw and label the equipment you would need to separate an insoluble substance from water. Show clearly the position of the filtrate and the residue following the process.
4 Let's go back to the coffee problem. Imagine you have successfully filtered the coffee using

Glossary

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USING SCIENCE 2 FILTRATION: FOLDING FILTER PAPER

Before you can conduct an experiment involving filtration, you must set up your filtration equipment correctly. The steps for folding filter paper are illustrated in Figure 3.16.

Your equipment is now set up for experiments involving filtration. When filtering, you should remember to:

- pour the mixture down a spatula or stirring rod to prevent a hole developing in the bottom of the filter paper.
- only add a small amount of the mixture at a time.

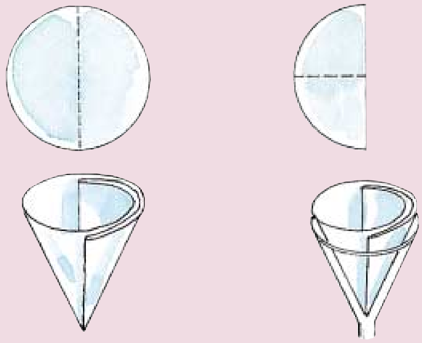

FIGURE 3.16
Folding the filter paper.

EXPERIMENT 3 SEPARATING INSOLUBLE SUBSTANCES FROM A LIQUID

AIM
To separate a suspension of insoluble copper carbonate and water.

MATERIALS
- 150 mL conical flask
- filter paper
- stirring rod
- filter funnel
- test-tube half-filled with water and a teaspoonful of copper carbonate

METHOD
1 Set up your filtration equipment as shown in Figure 3.17.
2 Carefully filter your suspension of copper carbonate and water. Be sure you don't poke a hole in the filter paper with the stirring rod.
3 Record your observations about the liquid in the conical flask, the filtrate, and the residue in the filter paper.

DISCUSSION
1 How effective was your separation?
2 How could this experiment be modified so that you can determine exactly how accurate your separation technique is?

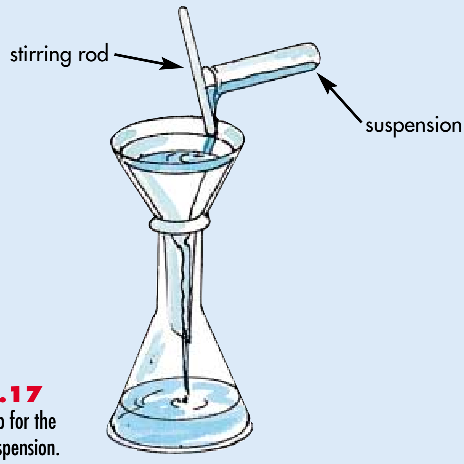

FIGURE 3.17
Equipment set-up for the filtration of a suspension.

filter paper and have removed the coffee grounds from the coffee.
a Which part of the coffee is the residue?
b Which part of the coffee is the filtrate?
5 Explain, in words, how the water filter in Figure 3.18 works. Include in your description the terms: solution; filtrate; residue; filter.

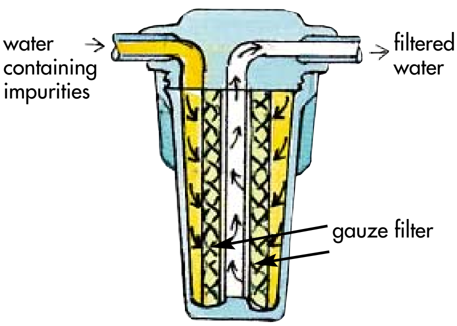

FIGURE 3.18
Cross-section of household filter. Home water filters are often used to purify local water supplies.

Multimedia

Glossary

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3.5

Crystal capers

FIGURE 3.19
Slow evaporation often causes substances to **crystallise**. Crystals have regular, solid characteristic shapes.

Evaporation

Filtration cannot be used to separate the substances in a solution because the particles of the solute are small and pass through any filter paper.

Evaporation is a process in which a liquid can be removed from a solution by using heat, leaving the solute behind. This is ideal for separating solutions which have very small particles that cannot be removed by filtration.

Crystallisation

Evaporating the water from the salt solution by heating is a very quick method of separating the solvent from the solute. Sometimes this is not a practical method to use as the quantities may be very large. In the production of salt for commercial use the heat of the sun is used to evaporate the water. The salt forms larger **crystals** because the evaporation is slow. This process is called **crystallisation**.

EXPERIMENT 4 SEPARATING A SOLUTION BY EVAPORATION

AIM

To find out how much solid (solute) is dissolved in soft drink (solution).

MATERIALS

- Bunsen burner
- tripod and gauze mat
- evaporating basin
- 50 mL of soft drink solution
- electronic balance
- safety glasses

METHOD

1 Use the balance to find the mass of the empty evaporating basin. Record this in your workbook.
2 Carefully add the 50 mL of soft drink to the basin.
3 Set up the Bunsen burner under the tripod and gauze. Then put on your safety glasses.
4 Heat the basin until almost all of the water has evaporated. Leave the basin to stand so that the remaining water evaporates as the basin cools.
5 Find the mass of the basin and its contents. Subtract the mass of the empty basin to find the mass of the solids dissolved in 50 mL of soft drink.

DISCUSSION

1 Describe the appearance of the solid material in the basin.
2 The solid material remaining in the basin is a mixture of substances. Suggest what might be in this mixture.
3 How much solid would be present in a 500 mL bottle of this soft drink?

USING SCIENCE 3 SEPARATION BY CRYSTALLISATION

Make up a concentrated solution of either salt or sugar. Pour this into a shallow dish (petri dish) and allow it to stand in a warm place for a few days. What do you notice about the size of the crystals which have formed?

Glossary

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EXPERIMENT 5 GROWING CRYSTALS

AIM

To grow crystals of copper sulfate or alum.

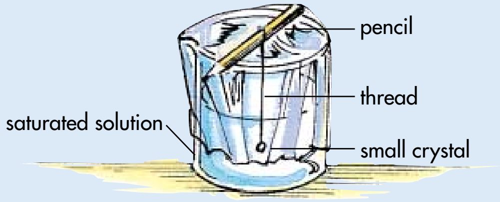


FIGURE 3.20
Very large crystals can be grown from a small 'seed' crystal.

MATERIALS

- copper sulfate or alum (potassium aluminium sulfate) crystals
- hot water
- two 250 mL beakers
- cotton thread, pencil and plastic cling wrap

METHOD

1 Prepare a saturated solution of copper sulfate or alum in hot water in a beaker. How will you know when it is saturated?

2 Allow the solution to cool to room temperature so the excess solute settles to the bottom of the beaker.

3 Decant or filter the saturated solution into a clean beaker, making sure you remove all the solid.

4 Suspend a thread from a pencil into the solution and cover the beaker with cling wrap to prevent dust settling in it. Store the beaker in a place where it will not be disturbed.

5 After a few days you will find some small crystals have formed on the thread. Remove all but the one with the most regular shape, replace the thread with this one remaining crystal (called the seed crystal) still on it, and every few days remove any small crystals which may have grown on the surface of the large one.

DISCUSSION

1 How large did your crystal grow? Record its dimensions (diameter or weight) in a graph every two days for a fortnight.

2 How large was your crystal at the end of a fortnight? How large do you think your crystal could grow?

Questions

1 Copy and complete the following sentences:
A solution of blue copper sulfate is separated by allowing the container to sit in a warm place. The solvent, which is ____ , will ____ leaving ____ of copper sulfate. The slower the rate at which this occurs the ____ the crystals which will form. If the evaporation is fast the crystals will be ____ .

2 Why can't filtration be used to separate the solute and solvent of a solution?

3 When you separate a solution by evaporation you lose the solvent. What part of the solution are you left with?

4 In question 3, how could you prevent the solvent being lost?

5 What causes the water to evaporate from a salt solution left to stand open in the laboratory?

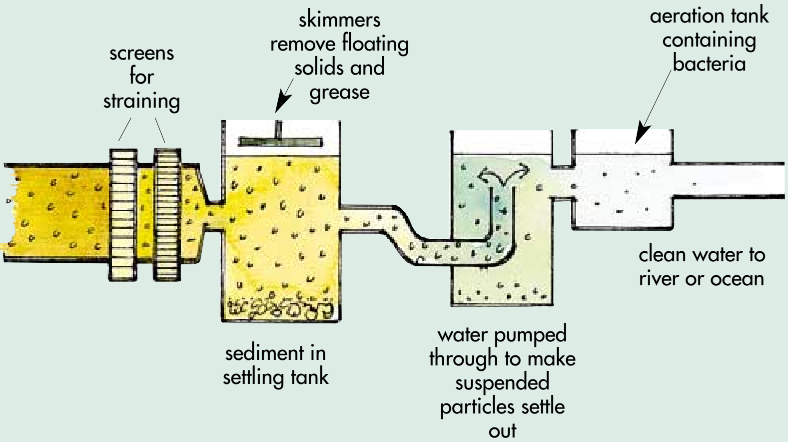
FIGURE 3.21
Salt can be separated from water in large salt pans.

Glossary

Sewage treatment

FIGURE 3.22
Large sewage purification plants cater for society's need for waste disposal. Imagine life without them, especially in crowded cities!

FIGURE 3.23
The operation of a sewage plant.



The wastes we produce

If you live in a large city or town there are two ways in which waste water is removed from your home.

Run off from rain water on the roof and the garden goes into the **storm water** drain and flows directly into a river, bay or the ocean. It is generally left untreated so it is important that it should not contain chemicals or solid rubbish.

Sewage comes from the wastes which we put down the drains in our kitchen, laundry, bathroom and toilet. These pipes are connected to the **sewerage system**. Sewage will contain a large quantity of water together with grease and dirt, paper, foodscraps and human waste, a huge variety of things which must be removed before the water can be safely released back into the environment.

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There are a number of stages in the treatment of sewage. If the quantity is small, a **septic tank** can be used, but generally household wastes are treated at a larger sewage works.

Sewage treatment at a sewage plant

The stages in sewage treatment are:

- floating solids and grease are removed using skimmers.
- **grit chambers** remove inorganic solids and organic solids such as seeds—the sewage flows through these chambers so the organic matter doesn't settle.
- fine solids are removed using screens with very small openings between 1.5 mm and 0.8 mm across, and by sedimentation. Many of the solids are very fine and suspended in the water, which can have air pumped through it to make them settle out.
- the remaining effluent is pumped into a tank where it can be **aerated** or it can be sprayed over a trickle filter (a layer of rock) into the tank. Special bacteria in these aeration tanks feed off the material which is left, removing the last of the polluting matter.
- the clean water is then discharged into the ocean or river.

Septic tanks

Houses which cannot be connected to a sewerage system have a septic tank to process the household waste. This tank is buried underground and waste disposing bacteria process the sewage. It is therefore important that no chemicals that may kill the bacteria are put down the drains. The clean water is piped out of the tank and allowed to drain through the nearby soil. As an extra precaution the water often passes through a series of sand filters to ensure it is free of pollutants.

FACT FILE

A biodegradable material is one which can be broken down by the action of living things. Non-biodegradable materials last for long periods of time.

USING SCIENCE 4 — DESIGN YOUR OWN 'EFFLUENT PURIFICATION SYSTEM'

Collect two nights' worth of kitchen effluent in a bucket. Do not dispose of anything down the sink. Your effluent composition could include:

- food scraps (grated apple, tea leaves, pea pods, bread crusts)
- liquid leftovers (soup, tea, coffee)
- sand/dirt
- paper labels and plastic bottle tops
- a few stray paper clips.

Design a purification system which will enable you to use your solid and liquid kitchen wastes as garden water, mulch and/or fertiliser. Separate the biodegradable materials from the non-biodegradable materials. Your design should include the following features:

- simple construction, using materials which are easily obtainable
- environmentally friendly
- inexpensive
- sturdy
- a trade name.

Try out your system.

Questions

1 What are the two methods by which waste water is removed from your home?

2 If you live in the country, what generally happens to the water from the roof of the house? How is this different from houses in the town or city?

3 Describe the chemical separation techniques that are used during the stages of sewage treatment at a sewage purification plant.

4 Why is it important that you do not wash the car on the path or roadway where the soapy water can drain into the storm water?

5 Think about the rubbish which is washed down the street in a storm. What will happen to this waste?

Glossary

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3.7

Distillation

FIGURE 3.24
Distillation is used to extract perfume from flowers or the oil from eucalyptus or tea-tree leaves

Distillation is a method used to separate the liquid part of a mixture by evaporating the solvent, collecting the solvent vapour and then condensing it to form a liquid again. The material collected during distillation is called the **distillate**. The residue is the mixture that remains in the original container.

EXPERIMENT 6 GETTING THE WATER BACK

AIM

To separate and collect the solvent from a salt solution.

MATERIALS

- salt solution
- 100 mL conical flask
- 250 mL beaker
- test-tube
- Bunsen burner
- one-hole stopper and glass delivery tube
- tripod and gauze mat
- retort stand, boss head and clamp
- wet paper towelling or similar
- cobalt chloride paper

METHOD

1 Set up the equipment as shown in Figure 3.25, making sure the delivery tube does not touch the bottom of the test-tube.

2 *Gently* heat the salt solution in the conical flask. *Do not boil the flask dry.*

3 If wet paper towelling is not sufficient to condense the vapour, put ice around the test-tube in the beaker.

4 Using the cobalt chloride paper, test the solvent you have collected.

Note: Cobalt chloride paper is an indicator paper which is blue when dry and turns pink in the presence of water.

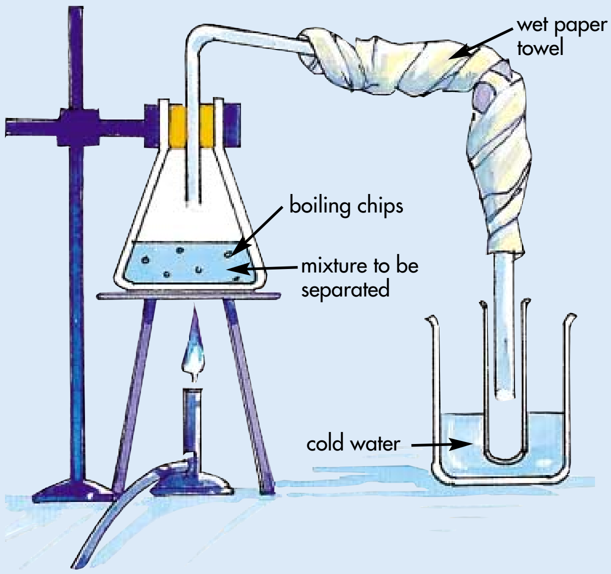

FIGURE 3.25
Experimental set-up for distillation. The solvent evaporates and is condensed in the cold delivery tube. The solute remains at the bottom of the flask.

RESULTS

Record your observations including any colour change when you tested the solvent with the cobalt chloride paper.

DISCUSSION

What conclusion can you make about the substance you collected in the test-tube?

Glossary

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Extension worksheet

EXPERIMENT 7 DESIGN YOUR OWN PERFUME

AIM

To make your own personal blend of perfume.

METHOD

1 Use the same equipment set-up and method as for the previous distillation experiment.

2 Collect a handful of lavender flowers, lemon peel, orange peel, eucalyptus leaves or any of your favourite fragrant flowers or fruits. You could combine them all together before distilling them, or you could distil each fragrance separately then produce your own perfume blend.

3 Place each perfume you wish to extract in a small quantity of water in the conical flask and perform your distillation.

4 Collect the distillate produced. Does it have a stronger odour than the original? What colour is it?

5 Develop your own 'personal fragrance'.

DISCUSSION

Comment on the success of your designer fragrance. You may need to conduct some 'market research', but remember—most people cannot distinguish more than two or three fragrances at a time!

EXTENSION

Give your designer perfume a name, design a package for it, and produce a marketing strategy for its sale. What are its best features? Who would you try to sell it to? What other types of substances should be added to it if you want to keep your perfume from going off and want it to be more marketable?

Questions

1 Distillation is used to make brandy from wine. As the wine mixture is heated gently and the alcohol and wine evaporates and is condensed, some of the water is removed. Does the wine have a greater or lesser concentration of alcohol than brandy?

2 Why does steam become water as it passes through a condenser?

3 Distillation uses two changes of state to separate and collect a liquid. What are these changes of state?

Think about

1 Name two situations where it would be more useful to use distillation as a method of separating a solution than evaporation or crystallisation.

2 It is possible to use the principles of distillation in a very practical way. Imagine you are trapped on a desert island. You are surrounded by sea and you have no fresh water—but you have salvaged some gear from your ship wreck! You managed to save some dinner plates, two tea cups and a large tin . . .
You desperately need fresh drinking water. What are you going to do? Draw a diagram to illustrate your solution.

Find out

Distillation can be used not only for purifying water but also for separating a mixture of liquids with different boiling points. This is most common and extensively used in the processing of crude oil into more useful substances.
Find out how distillation is used to separate the petroleum products (substances such as aviation fuel, petroleum jelly, petrol and bitumen) in crude oil so they can be used. You will need to explain what is meant by fractional distillation in your report.

Web page

Glossary

3.8

Chromatography— a colourful separation

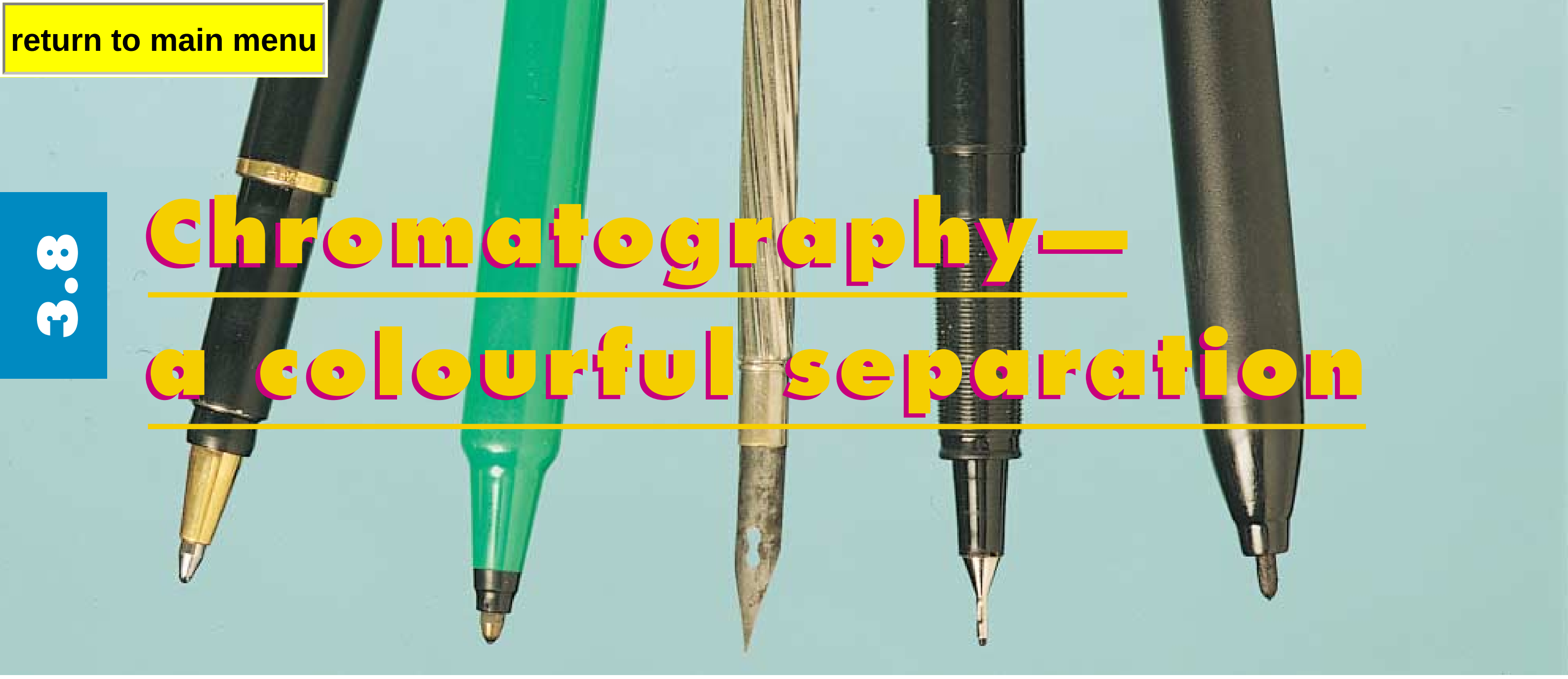

FIGURE 3.26
Is black ink really black ink? Ink is often made from a mixture of different colours.

Different solids which are mixed together may sometimes be separated by a process called **chromatography** (*khroma* is Greek for colour). This involves dissolving them in a solvent and allowing the solvent to carry the solids along a strip of filter paper. The solids which dissolve the best in the solvent, or which grip onto the filter paper the least, will be carried the furthest along the filter paper. When the substances are different colours, it is easy to see the components of the mixture.

EXPERIMENT 8 A CHEMICAL INVESTIGATION OF BLACK INK

PART A
Is black ink a single substance or a mixture?

AIM
To determine whether or not black ink is a single substance.

MATERIALS
- distillation equipment as used in Experiment 6.
- quantity of black, *water-soluble*, ink
- porcelain chips

METHOD
1 Set up your distillation equipment as shown in Figure 3.25. Again, make sure the delivery tube does not touch the bottom of the test-tube and place the porcelain chips in the bottom of the conical flask.
2 Gently heat the ink in the conical flask. The porcelain chips will prevent the ink solution from boiling too quickly. *Do not boil the ink dry.*
3 Collect a quantity of the solvent in the test-tube and keep the remaining ink solution for Part B. You now have a more concentrated ink solution.
4 Test the substance in the test-tube using the cobalt chloride paper.

RESULTS
Record your observations.

CONCLUSION
Is ink a single substance or a mixture? Justify your answer, using the results from your experiment.

PART B
Is the dye in black ink a single substance or a mixture?

AIM
To determine whether the dye in black ink is a single substance or a mixture.

MATERIALS
- 100 mL beaker
- scissors
- water
- concentrated ink solution from Part A
- filter paper
- glass stirring rod

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EXPERIMENT 8 CONTINUED

METHOD

1 Cut a strip of the filter paper so it forms a 'tongue' and place a drop of the ink concentrate in the centre of the filter paper.

2 Allow this drop of ink to dry then add another drop on top of it.

3 Half-fill the beaker with water and place the filter paper in the beaker so the tongue sits in the water.

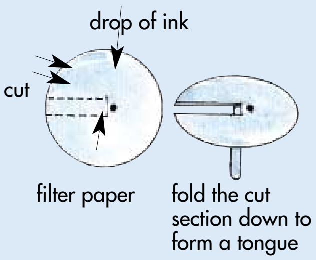

FIGURE 3.27
The preparation of filter paper for chromatography.

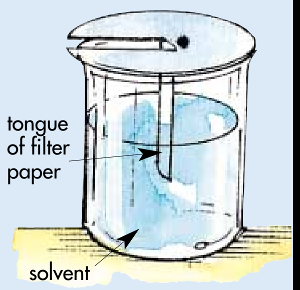

FIGURE 3.28
Experimental set-up for the chromatography of black ink. Be sure that the tongue of the filter paper is dipping into the solvent.

4 Observe what happens as the solvent moves through the ink spot.

RESULTS

Describe what has happened to the drop of ink as the water soaked through the filter paper.

DISCUSSION

Is the dye in black ink a single substance or a mixture? Justify your answer, using the results from your experiment.

EXTENSION: USING OTHER SOLVENTS

Often, as you have already discovered, a substance does not dissolve in water. In this case another solvent must be used in the chromatography process. Analyse the ink in the pens in your pencil case by performing chromatography. If your pens are water-soluble, you may use water as the solvent. If you have any 'permanent' markers you may have to use a solvent such as methylated spirits for the experiment.

USING SCIENCE 5 THE COLOURS OF SMARTIES

Smarties come in a number of different colours. Design and perform an experiment to decide:

1 which Smartie colours are single substances

2 which Smartie colours are mixtures

3 how many different dyes are needed to make all the Smartie colours.

Present your results in the form of a report. Paste in your 'chromatograms'.

Questions

1 Why must the substance being separated in chromatography be soluble in the solvent being used?

2 What is meant by a permanent marker? Why is it 'permanent'?

3 A bank calls in the police when they suspect a cheque for $6 has been altered to $600. How could they tell if this is the case?

Think about

Can you think of any other uses for chromatography?

Find out

The method you used to separate the substances in your chromatography experiments shows the simple principle behind the sophisticated chromatography machines used in industry, medicine and science. Use library resources to research various uses for chromatography in these areas.

Word process

FACT FILE

Chlorophyll, found in all green plants, contains a number of pigments: orange xanthophyll and carotene, and green chlorophyll.

Glossary

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APPLICATIONS AND USES OF SCIENCE

Kidnapping from the zoo: A forensic science activity

BRING $50,000 TO THE PHONE BOX OUTSIDE NORTH BROADVILLE STATION AT 9.30 TOMORROW MORNING – OR YOU WILL NEVER SEE THE MONKEYS AGAIN!

FIGURE 3.29
The ransom note.

KIDNAPPING FROM THE ZOO!

BROADVILLE—WED. In the small hours of this morning an unknown person or persons broke into the primate section of the local zoo and made off with two rare monkeys from their enclosure. There were signs of forced entry but the reason for the theft is not known at this stage. Police are investigating.

The Gazette

Zoonappers leave ransom note

BROADVILLE—THURS. The Director of the Broadville Zoo this morning received a ransom note from the kidnappers of the monkeys stolen yesterday. Police hope forensic tests on the ransom note will lead them to the perpetrators of this awful crime.

The Gazette

Glossary

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The suspects

Suspect 1: zoo keeper in charge of the primate enclosure, always carries her pen with her keys in the pocket of her overalls.

Suspect 2: zoo maintenance officer, fell in the water tank yesterday and came out with black ink stains on his pocket.

Suspect 3: vet in charge of the breeding program for the endangered monkeys, lost her bag somewhere near the reptile house.

Suspect 4: director in charge of the zoo, carries a pen and clipboard with him to monitor progress and problems around the zoo.

Suspect 5: a university student who takes a great interest in the endangered species breeding program, researching and taking notes on his observations of primate behaviour. He often works in the rain.

FIGURE 3.30
These five suspects all had the opportunity to steal the monkeys. Did they have a motive for this crime?

USING SCIENCE 6 WHODUNNIT?

There are five suspects and you are able to obtain a black pen belonging to each suspect. Your teacher will supply these.

You are also given the ransom note. Now, with your knowledge of chromatography, design and carry out an experiment to test which pen could have been used to write the ransom note. Write down exactly what you are going to do and back this up with diagrams of your experimental set-ups.

Check your experimental design with your teacher so that all the materials you need can be provided.

The evidence you collect will be used in court so you will need to keep detailed notes on your procedure, results and conclusions.

Use these results, together with the descriptions of the suspects and any other information, to solve the crime. Remember, not all inks are water soluble.

DISCUSSION: CAN YOU BE SURE?

1 How sure are you that you have identified the zoonapper?

2 Could there be any other explanation for your results?

3 Does identifying the pen necessarily identify the zoonapper? Explain.

EXTENSION

You may like to organise a 'mock trial' for the prosecution and defence of the zoonapper.

Forensic science is the science used in criminal investigations and can be presented as evidence in court. This can involve many different areas of science, including chemistry, physics, biology and metallurgy.

Chromatography is used extensively in forensic science, medicine and industry to separate small quantities of substances and identify them. It can be used to test that a product contains the substances it should and it can be used to detect harmful substances which occur in very small amounts, such as pesticides in food.

The results of forensic science tests need to be accurate. People may be convicted on the evidence from forensic science.

Think about

Should people rely on forensic reports when deciding whether to convict someone for a crime? Share your ideas in a class discussion. You may even like to organise a class debate.

Glossary

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Using scientific language

a You are given a mixture of three solids: iron filings, copper sulfate and yellow chalk dust. The mixture is dry. Design (and carry out if time permits) an experiment to separate these three substances. Outline the procedures used, and draw a fully labelled diagram of the apparatus you would use. Include as many words from the following list as possible.

solution filtrate dissolve magnet
funnel dilute solute distillation
suspension solubility evaporate
solvent sieve insoluble residue
decant concentrated mixture
sediment colloid condense

b For each word that you did not use from the list, define it and explain why it is not related to your experiment.

Check your knowledge

1 In a solution of salt dissolved in water
  a Which substance is the solute?
  b Which substance is the solvent?
2 What happens to the particles of sugar when a sugar cube is dissolved in water?
3 The solvent in a solution does not always have to be water. Name three other liquids which could be used as solvents.
4 What gas is dissolved in water to make soda water?
5 Name two mixtures which are formed by mixing a liquid with a liquid.
6 What is the name of the insoluble substance which settles to the bottom of its container?
7 Copy and complete Table 3.2.

TABLE 3.2

Solution	Solute	Solvent
permanent ink		
sea water		
soft drink		
cup of coffee		

8 How would you make a saturated sugar solution?
9 The particles in an emulsion, a colloid and a suspension are different sizes. List them in order of size from smallest to largest.
10 You have made two cups of instant coffee. One has one teaspoon of coffee, the other two teaspoons. Which is the more concentrated?
11 List two factors which will affect the solubility of potassium chloride when you dissolve it in water.
12 Choose the correct answers. Which of the following would you filter to separate the mixture?
  A salt water
  B muddy water
  C copper sulfate solution
  D a suspension of copper carbonate in water

Apply your skills

1 In a recipe you are asked to dissolve a quantity of gelatine in half a cup of water, but when you stir it in not all the gelatine disappears. What could you do to dissolve all the gelatine?
2 Jean was doing the gardening and found that the soil contained large pieces of clay and small nails left over after the building renovations. Describe how she would separate the soil from the debris.
3 The lid was left off a bottle of lemonade on a warm day and the lemonade was later found to be flat. Suggest why this would be so.
4 Suggest two different ways of separating each of the following mixtures:
  a oil and water
  b salt and pepper
  c iron filings and sugar
  d polystyrene beads and metal bearings.
5 How could you decide if a sample of a substance is a pure substance or a mixture?

Challenge yourself

1 In nature, many animals feed by filtering plant or animal life from the water. Find out how prawns and sponges obtain their food. How is it different from the baleen whales and how is it similar?
2 The River Jordan flows into the Dead Sea. No streams leave the Dead Sea and the fierce sun causes sufficient evaporation to keep the water level of the Dead Sea constant. The water in the River Jordan contains a small amount of dissolved salts. Would you expect the Dead Sea to become more salty each year, less salty each year, or stay about the same concentration? Explain your answer.
3 Israel is recovering, from the waters of the Dead Sea, about one million tonnes of dissolved salts each year. What process would you expect them to use? Describe and draw the process.

Tester

Glossary

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CHAPTER 4

INTRODUCING ENERGY

The World Solar Challenge is a car race with a difference. All the cars are powered by sunlight. The 3008 km race begins in Darwin and finishes in Adelaide. The idea for a solar race began after Hans Tholstrup and Larry Perkins drove the world's first solar car, the Quiet Achiever, across Australia. They took 20 days to travel 4058 km from Perth to Sydney.

The first World Solar Challenge took place in 1987 and was won by a General Motors car called Sunraycer. An Australian entry came second. Since 1987 the World Solar Challenge has been run every three years. Each race sees more entries from big companies, universities and even high school teams. Improvements in solar cells and car design have resulted in faster races each year. In 1996, winner Honda's 'Dream' had an average speed of 90 kilometres per hour, over 25 kilometres per hour faster than the winner of the 1987 event. The next race may see the winner increase the average speed to 100 kilometres per hour as solar cells are improved to trap the Sun's energy more efficiently.

In this chapter you will learn about energy's different forms and how energy can change from one form to another. You will also find out why we need to find new sources of energy and use it more wisely.

Web links

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- **Recognise different forms of energy in everyday situations.**
- **Distinguish between objects that possess energy because of their motion (kinetic energy) and objects that possess stored or potential energy.**
- **Recognise and investigate a range of energy transformations.**
- **Describe processes of heat transfer by conduction, convection and radiation.**
- **Classify energy sources as renewable or non-renewable.**
- **Describe the formation of fossil fuels.**
- **Investigate methods of reducing energy consumption.**

Glossary

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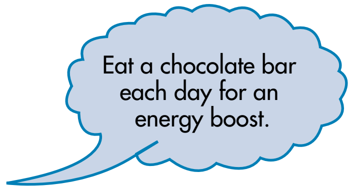
4.1

What is energy?



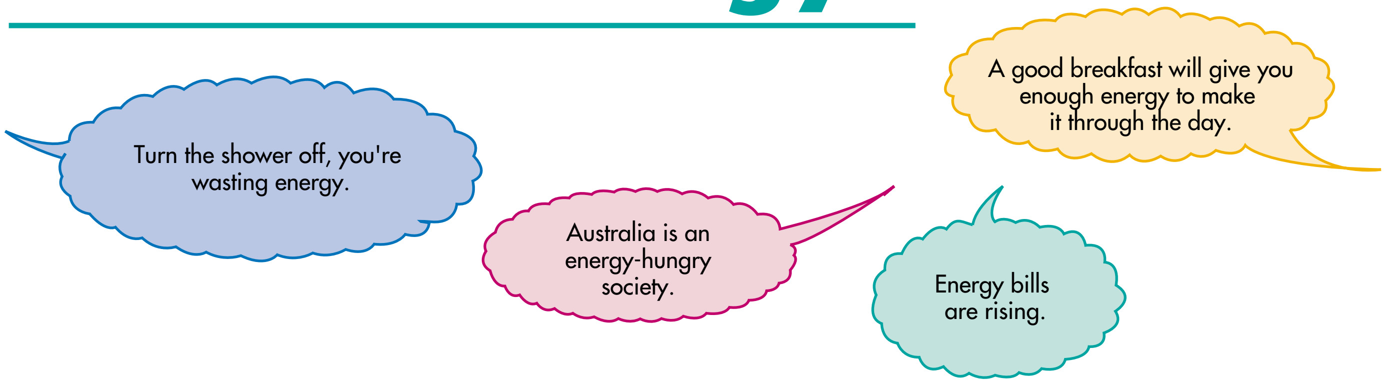


FIGURE 4.1
Here are some statements about energy. You probably have your own ideas about energy but can you say what it is?

Talk about

Work in a small group to brainstorm ideas on energy. What is energy? Where does it come from? What different forms does it take? Record your group's ideas on paper. Use your group's ideas to write a statement about energy. Compare your energy statement with those of other groups.

It is difficult to say exactly what energy is. Instead we can say what energy does. Energy makes things happen. Energy causes changes. Scientists say that energy is the ability to do work.

USING SCIENCE 1 DESCRIBING CHANGES

WHAT YOU NEED

- ice cube
- beaker
- matches
- photographic or diazo paper
- a 500 g mass
- Plasticine
- tuning fork

WHAT TO DO

1 Place an ice cube in a beaker and leave it for 5 minutes.

2 Strike a match and allow it to burn then blow out the flame.

3 Hold a small piece of photographic or diazo paper up to a light.

4 Drop the 500 g mass from a height onto a ball of Plasticine.

5 Strike a tuning fork then push the end straight into a beaker of water.

DISCUSSION

1 Write a description of the changes that took place in steps 1 to 5.

2 For each change say where the energy came from. Also try to name the forms of energy involved.

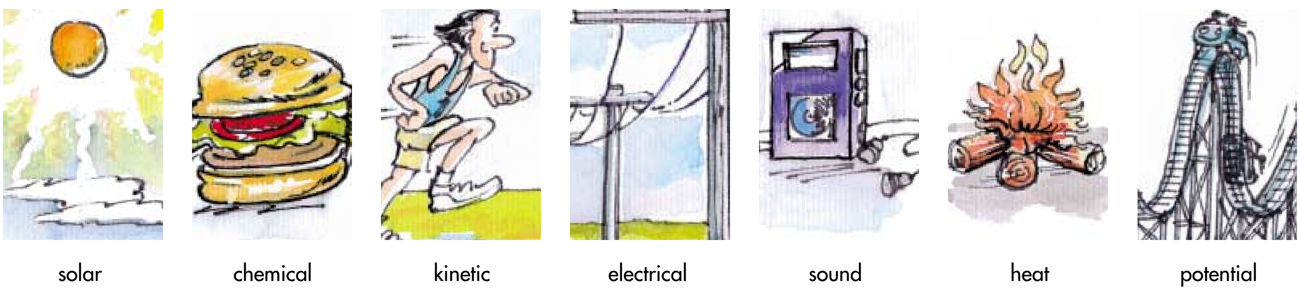


FIGURE 4.2
Energy is all around us. It can take many forms.

Glossary

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Forms of energy

Energy can exist in many forms. **Solar** (or radiant) energy from the Sun is received on Earth as **heat** and **light** energy. Anything that moves has **kinetic** energy. Moving water and air have kinetic energy. Moving machines and animals have kinetic energy. Even moving particles of matter have kinetic energy. **Sound** occurs when particles move or vibrate. **Electricity** occurs when tiny charges called electrons move through a material.

Some forms of energy are not as easy to observe. This is because the energy is stored. Stored energy is called **potential** energy. There are several types of potential energy:

1 Raised objects which can fall contain **gravitational** potential energy.

2 Stretched or compressed objects which can return to their original shape contain **elastic** potential energy.

3 All chemicals including fuels and food contain **chemical** potential energy. When chemical reactions take place the stored energy may be released.

4 All atoms store energy. When atoms take part in nuclear reactions the energy may be released.

Energy can change

Any form of energy can be changed into another form of energy. When you strike a match chemical potential energy is changed into heat and light energy. A child jumping on a trampoline changes elastic potential energy into kinetic energy and back again. A device or machine which can change energy is called an energy converter. Energy changes can be shown in the form of a flow diagram. For example, the energy change in a car battery can be shown as:

chemical potential energy → electrical energy

FACT FILE

Energy can be measured by using the unit called the joule (symbol J). It is a small amount of energy about equal to the amount of energy used to lift a 100 g object 1 metre.

USING SCIENCE 2 BUILDING AN ENERGY CONVERTER

WHAT YOU NEED

- test-tube with cork
- cork fitted with two bent glass tubes
- pin
- string
- retort stand, boss head and clamp
- Bunsen burner

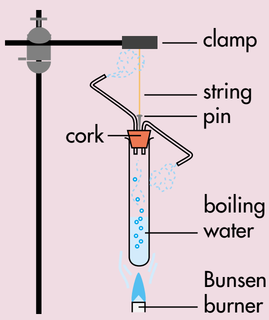

FIGURE 4.3
Steam turbine.

WHAT TO DO

1 Pour water into the test-tube to one-third depth.
2 Push the pin into the top of the cork, bend it and tie the string to the pin.
3 Fit the cork into the test-tube; the glass tubes should be above water level.
4 Hang the test-tube above the Bunsen burner, using the retort stand.
5 Heat gently and observe. (Be careful of steam.)

DISCUSSION

1 What happens to the water when it boils?
2 What happens to the steam turbine?
3 What happens to the string?
4 What energy change is happening here? Draw a flow diagram.

Questions

1 Write down three things that energy can do.
2 Which forms of energy involve movement of something?
3 Name four different types of stored energy.
4 Use flow diagrams to show the energy changes caused by the following devices.
a washing machine
b sling shot
c car engine
d radio
e torch

Find out

Who was James Prescott Joule and what important discoveries did he make?

Multimedia

Glossary

FACT FILE

A turbine is a device which uses moving steam, water or air to turn a generator to make electricity.

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4.2

Renewable sources of energy

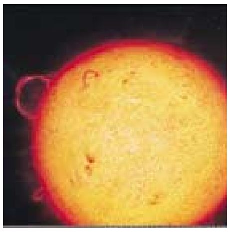

FIGURE 4.4
Nuclear reactions in the Sun produce the energy which radiates into space.

FIGURE 4.5
Australia's first wind farm at Esperance, Western Australia. Wind farms provided a clean renewable source of energy.

FIGURE 4.6
The oceans absorb nearly 75% of the solar energy that reaches the Earth.

FIGURE 4.7
Rubbish tips are a source of methane which can be burned to drive electricity generators.

People have been using heat and light energy to cook food, keep warm and protect themselves from wild animals since prehistoric times. During daylight the Sun provided the heat and light energy but at night burning wood was often used. The Sun and the burning wood are sources of energy. Heat and light are forms of energy.

Energy from the Sun

Nearly all of the energy on Earth can be traced back to the Sun. Energy from the Sun heats up the land, the water and the air, causing wind, rain, waves and sea currents. The Sun is the original source of energy for all life on Earth. Green plants are able to trap light energy and convert it into chemical potential energy.

Energy from wind

Solar energy heats the air and causes wind. Moving air has kinetic energy which can be used to move sailing boats or turn the blades of a wind machine. Wind machines can be used to grind grain, pump water and generate electricity (turbine).

The use of wind as a source of energy is increasing worldwide. In Australia, single wind-driven turbines exist in a number of locations such as Newcastle (New South Wales), Breamlea (Victoria) and Coober Pedy (South Australia). A wind farm consisting of nine wind turbines has generated electricity since 1993 at Esperance (Western Australia). The Crookwell wind farm (New South Wales) consisting of eight turbines will provide electricity for up to 3500 homes when completed.

Energy from moving water

The energy from the Sun causes water to evaporate from oceans, lakes and rivers. The water falls as rain and snow over high ground. The water then flows back to the oceans and the cycle continues. Moving water can be a source of energy. It can turn the blades of a water-wheel or a turbine. Electricity is generated in this way in hydroelectric power stations. Moving water due to ocean waves and tides can also be a source of energy.

Energy from living things

Plants trap energy from the Sun, so they can be a source of useful energy. The energy can be obtained directly by eating plants or indirectly by drying and burning them, for example wood, straw and sugar cane.

Some plant material can be fermented to make alcohol. This can then be burnt to release heat energy. Plant and animal wastes can be broken down by bacteria to make a gas called methane. Methane is another source of energy.

Questions

1 Explain the difference between a form of energy and a source of energy.

Internet assignment

Glossary

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Foundation worksheet 1

USING SCIENCE 3 BUILD A WATER-WHEEL

WHAT YOU NEED

- 25 L drink bottle with base removed
- 2–3 cm cork with hole in centre
- 15 cm length of coathanger wire

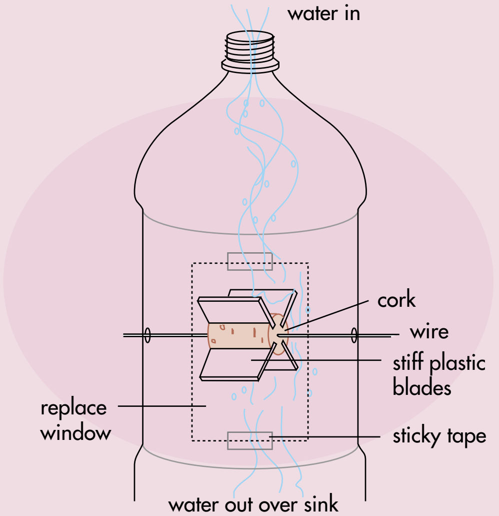

FIGURE 4.8
Model water-wheel.

- stiff plastic (margarine pot)
- Stanley knife and scissors
- sticky tape

WHAT TO DO

1 Cut four blades, 3 cm × 3 cm, from stiff plastic.
2 Your teacher will help you use the Stanley knife to cut four slits around the cork and push in the plastic blades.
3 Cut two holes in the sides of the bottle to thread wire through.
4 Cut a window in the bottle big enough to allow you to put the cork and blades inside.
5 Push the wire through the cork to suspend the water-wheel inside bottle.
6 Pour water into the bottle over a sink and observe the water-wheel in action.

DISCUSSION

1 What form of energy does running water have?
2 Suggest a use for your water-wheel.

2 What is the original source of most of the Earth's energy?
3 List three uses of wind as a source of energy.
4 Describe four ways living things can be a source of energy.

Find out

1 How can tides be used as a source of energy?
2 What is geothermal energy? Where is this source of energy being used?

Activities

1 Find out if your school grounds are suitable for a wind turbine by conducting a wind survey. Use an anemometer to measure wind speed around your school. Keep records of date, time of day and location. (A steady wind over 10 kilometres per hour can be used to generate electricity.)
2 Select a form of energy and produce a visual display on it. Your display may take the form of a poster, collage, mobile or diorama. Research your chosen form of energy, collect information and pictures then construct your display. Present your display to your class with a short talk.
3 Design and build a vehicle powered by one standard mousetrap. The idea is to get it to travel as far as possible using only the mousetrap spring to change elastic potential energy into kinetic energy.

Web page

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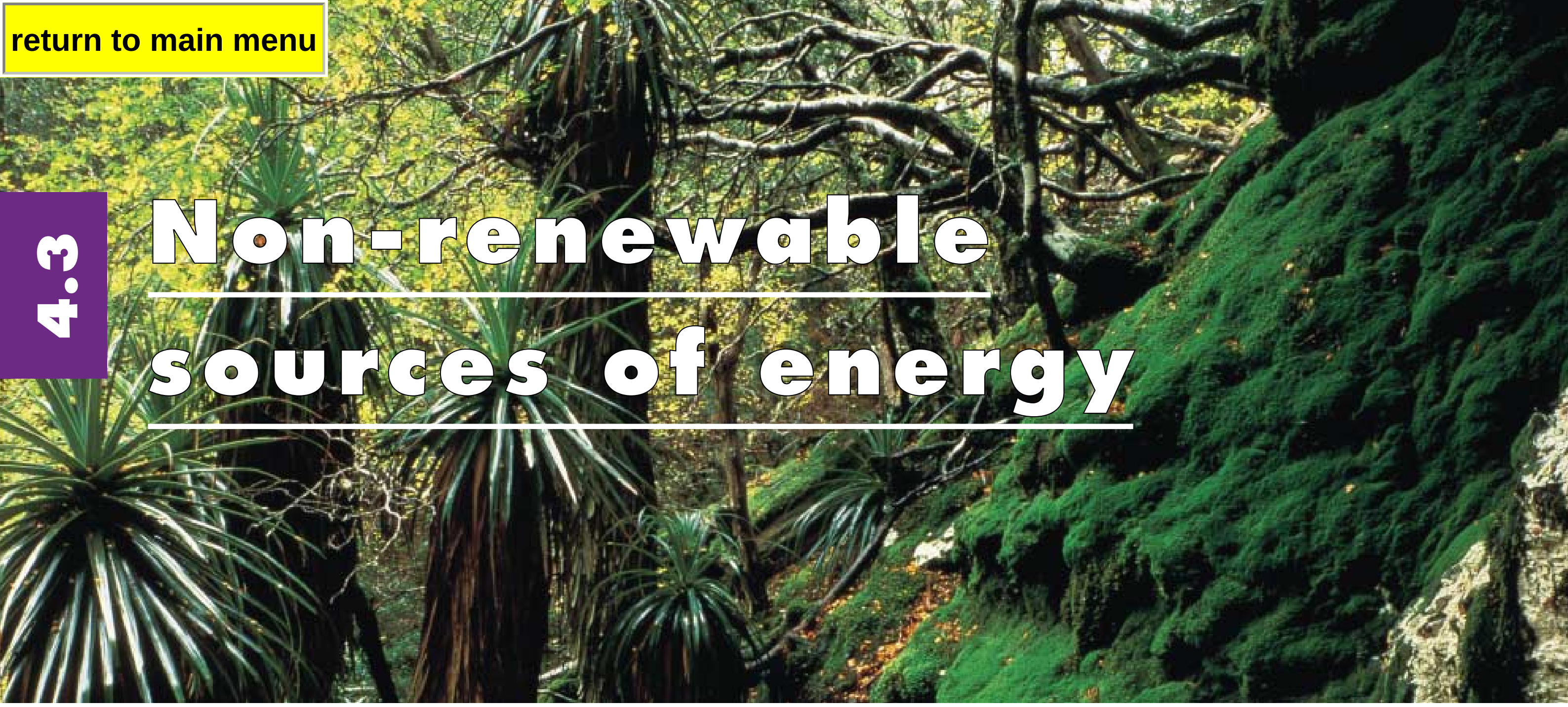

4.3

Non-renewable sources of energy

FIGURE 4.9
Swampy areas buried for millions of years may gradually turn into coal deposits.

Most of the world's energy comes from the burning of **fossil fuels**. Fossil fuels are formed from the remains of organisms (living things) that have been buried in the Earth for millions of years. The organisms rotted and became fossilised to form fossil fuels. Coal, natural gas, oil shale and crude oil are all fossil fuels.

Coal, for example, was formed millions of years ago, when most of the Earth was covered with plants growing in swamps. These organisms died and became submerged under the water, where they gradually decomposed. As time passed, layers of sand, mud and dirt settled over the remains. This created pressure under the ground which, along with movements in the Earth's crust, compressed and hardened the layers into coal. Geologists believe that most of the world's coal has already been discovered. This coal is rapidly being used. That means that if we are not careful, it may soon run out.

FACT FILE

Fossil fuels are non-renewable sources of energy because once we have used them all up it will take millions of years to make more. Non-renewable sources of energy should be saved or used wisely.

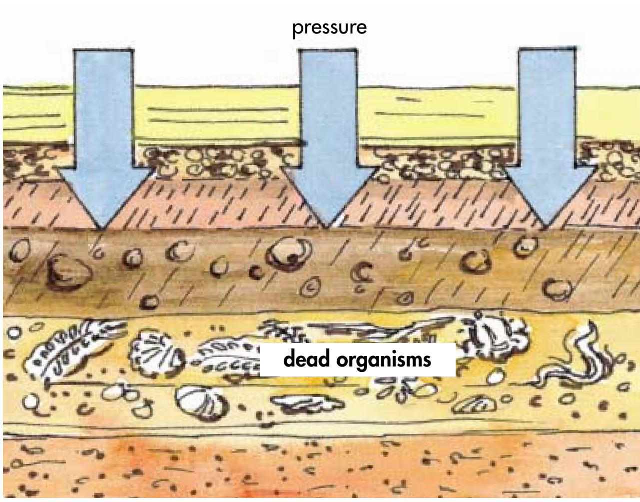

FIGURE 4.10
Fossil fuels were formed millions of years ago.

Most oil deposits are thought to have started forming at the bottom of the ocean. Millions of tiny sea creatures died and drifted to the bottom where they mixed with the sand and mud. If they were buried very quickly, lack of oxygen meant they did not decompose completely. Millions of years of squashing and heating due to the pressure of burial changed the animal and plant remains into oil, which seeped into the spaces between the sand and mud grains, by now hardened into rocks. If heated enough, some of the oil changed into **natural gas**, which was also trapped between the grains.

Coal, oil and natural gas are burned in vast amounts as fuels for our machines, cars, heaters and electricity generation.

FIGURE 4.11
A fossil and a fossil fuel, both millions of years old.

Glossary

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There are environmental costs for burning fossil fuels. Gases such as sulfur dioxide, carbon dioxide and water vapour are released into our atmosphere, where they contribute to problems such as acid rain and the increase of the greenhouse effect. The atmosphere is also polluted with solid particles such as ash and soot.

Uranium is another non-renewable source of energy. Uranium is used in nuclear power stations to generate electricity. An enormous amount of heat energy can be released from a very small amount of uranium. However, dangerous radioactive waste is also produced.

FIGURE 4.12
One day, all our fossil fuel resources will run out. What will we do then?

USING SCIENCE 4 ENERGY ALTERNATIVES

1 Choose a project to work on by selecting one item from each of the three columns below:

A	B	C
Write	Survey	Nuclear power
Produce	Poster	Using energy wisely
Draw	Poem	Uses of crude oil
Design	Cartoon	Fossil fuels
Research	Model	Australia's energy needs
Conduct	Pamphlet	Uses of natural gas
	Talk	Shale oil

Link each of your choices, one from each list, with a line. This, then, is your project.
For example, 'I will produce a poster about Using energy wisely'.

2 Use Figure 4.13 to answer the following questions.

a Why do you think we need so much more energy today than we did during the Stone Age (primitive society)?

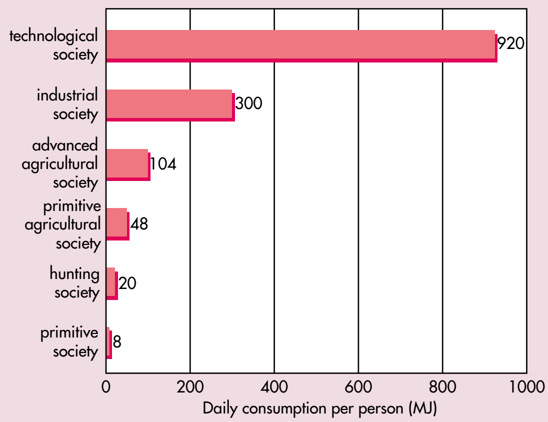

FIGURE 4.13
Energy consumption during human history.

b What percentage of energy do we use today in comparison with Agricultural Society?

c List what uses for energy we have today that Industrial Society, approximately 100 years ago, didn't have.

Questions

1 **Why are oil, coal and natural gas called fossil fuels?**

2 **What type of energy do fossil fuels contain?**

3 **Where did the energy in fossil fuels originally come from?**

4 **Why are fossil fuels considered to be non-renewable sources of energy?**

Find out

1 **Where in Australia can we find oil, coal and natural gas?**

2 **What causes the greenhouse effect?**

Glossary

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4.4

Heat energy

FIGURE 4.14
Heat is added to solid iron, so that the kinetic and potential energy of the iron particles (atoms) increases. Eventually the atoms move so much that they slide over one another and the iron melts.

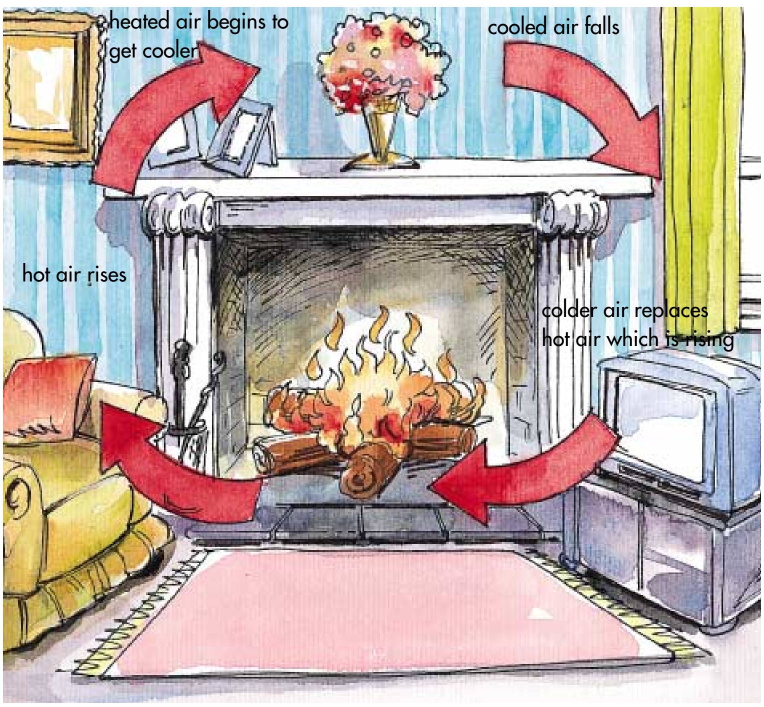

FIGURE 4.15
Convection currents are created as air is warmed then cools.

What is heat?

Early ideas about heat were of a fluid called ‘caloric’ that passed from hot to cold. A series of experiments by James Joule showed that heat was a form of energy. Any form of energy can be changed into heat. It is now known that heat is the energy transferred from a hotter object to a cooler object. Some of the transferred energy goes into increasing the kinetic energy of the particles of the object. Some of the transferred energy goes into increasing the potential energy of the particles which make up the object. The hotter something is the faster its particles move and the more kinetic energy they have.

Transferring heat

What happens when you leave a hot drink in a cold room? Of course, the drink will get cool. That is because heat moves from hot objects to colder ones. This transfer, or movement, of heat can occur in three ways. These methods are known as **conduction**, **convection** and **radiation**.

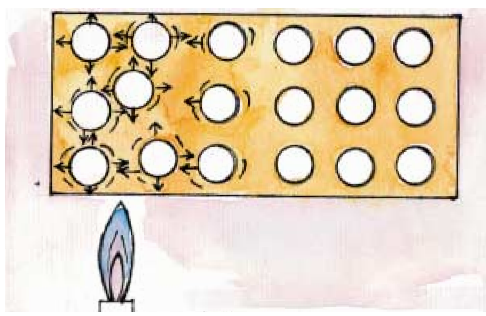

FIGURE 4.16
When a solid is heated, its particles vibrate more quickly and pass on or conduct their new-found energy to the other particles around them.

Datalogging

Glossary

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EXPERIMENT 1 CONVECTION HEATING

AIM
To observe the convection heating of a liquid.

MATERIALS
- tea leaves or potassium permanganate
- Bunsen burner, tripod and gauze mat
- large beaker
- water

METHOD
1 Begin heating water in the beaker.
2 Add the tea leaves or potassium permanganate and observe the path the coloured water takes.
3 Draw a diagram to represent your observations.

Conduction

Heat is transferred in some solids by conduction. When a solid is heated, the particles being heated absorb the heat energy and vibrate more quickly. These particles then pass this energy onto the particles next to them, which, in turn, pass it on, until the whole object is hot.

Convection

Liquids and gases transfer heat by convection. Think of a sauna. If you sit on the bottom seat in a sauna, it is far cooler than if you sit on the top row of seats. This is because hot air rises. Why does hot air rise? Because as air is heated, the particles move further and further apart. As a consequence, the air weighs less per cubic metre, i.e. the **density** of the air has decreased. Because this air is now lighter, it rises, while the surrounding cooler air falls. Convection of heat occurs in liquids and gases.

Radiation

Radiation is a process whereby heat travels through empty space in the form of **electromagnetic waves**. As air is a poor conductor of heat, radiation must also be the way heat passes through air. This form of heat transfer does not need the two objects involved to be in contact with one another. The heat from the Sun travels to Earth in this way. This is also how you may be warmed when standing in front of a fire.

Questions

1 What is heat?
2 Describe what would happen to the particles in a cooling cup of tea.
3 What are the three ways in which heat is transferred? Give an example of each.
4 Using your knowledge of convection, describe how a saucepan of water on a heating element becomes hot and boils. Ignore the initial heating of the saucepan itself.

Think about

Read the Fact File. Suggest how the amount of heat lost from an open fire could be reduced.

Activities

1 Stand as a group. When your teacher says 'cold', pretend that you are a water molecule with low kinetic energy. When your teacher says 'hot', pretend that you are now a water molecule with a high kinetic energy.
2 Stand in lines and do a role play to show how an object conducts heat. You could have races between your groups to see how quickly the 'heat' can get to the other end.
3 Conduct an experiment to find out which material is the fastest conductor of heat energy. Test a number of materials such as glass, plastic and metal. Use hot water as a source of energy. Time how long it takes the heat to travel through the material to melt a drop of wax. Write up your experiment as a scientific report.

FACT FILE

Most of the heat from an open fire goes up the chimney by convection. The heat we can feel comes to us via radiation.

Glossary

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APPLICATIONS AND USES OF SCIENCE

Harnessing solar energy

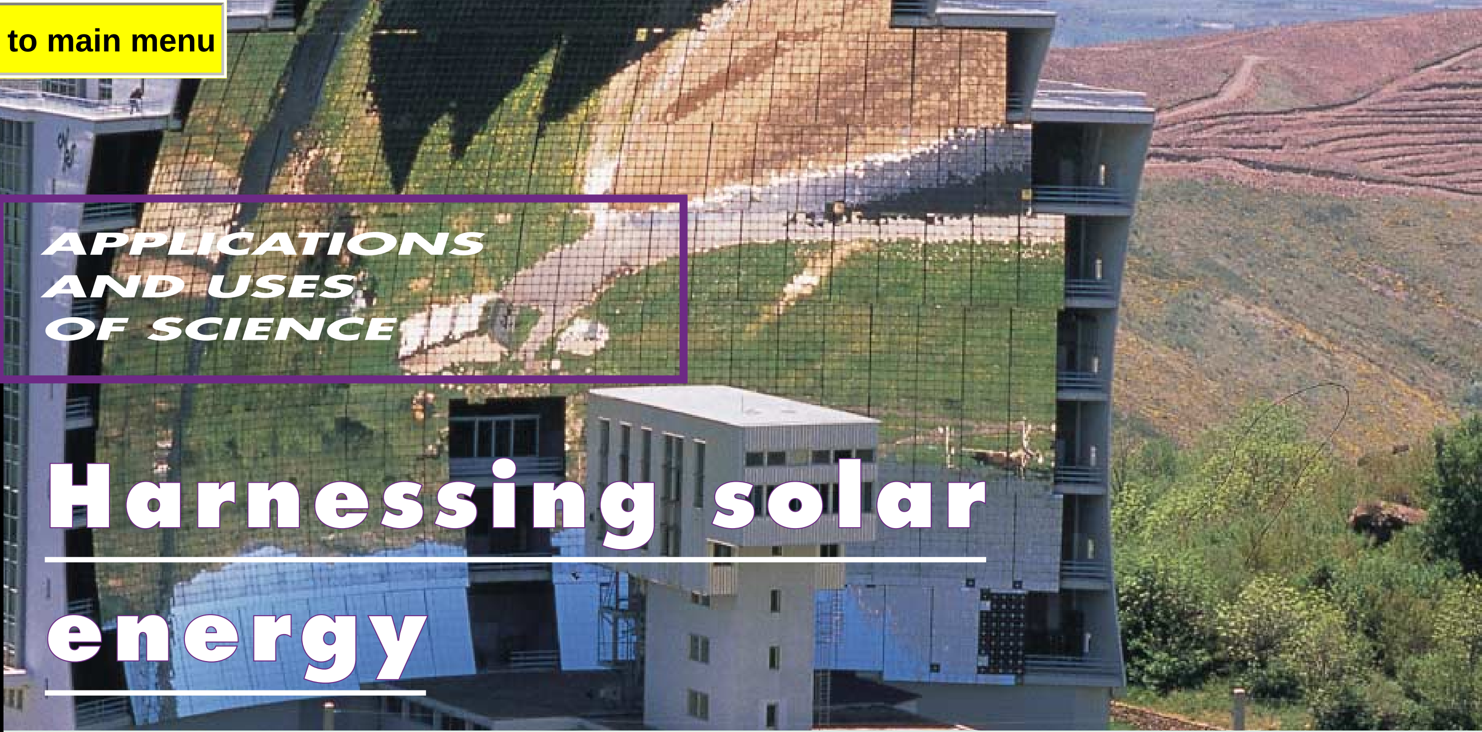

FIGURE 4.17
The solar furnace at Odeillo, Font-Romeu, France.

Solar energy is a collective term used to describe energy which reaches the Earth from the Sun. The Sun emits various forms of radiant energy which are received on Earth as heat and light energy.

Talk about

Have you ever sat in a car on a hot sunny summer's day and not been able to touch the seat or the dashboard? What colour was the seat cover? What colour was the car? Why should the colour of the car affect the temperature?

EXPERIMENT 2 HEAT GAIN AND LOSS

AIM
To compare the ability of dark and light coloured objects to absorb heat, and to compare the rate at which heat is radiated by light and dark objects.

MATERIALS
- 2 identical glass jars or cans, one painted white, one black, each with a hole in the lid
- 2 thermometers
- Plasticine or Blu-tack

METHOD: PART A
1 Seal a thermometer in each jar. Make sure it does not touch the bottom of the jar.
2 Record the temperature in each jar.
3 Place both jars in the sun.
4 Record the temperature in each jar every minute for 20 minutes.

DISCUSSION
1 Were the jars the same temperature initially?
2 Which jar heated up faster?
3 Which jar reached the higher temperature?

CONCLUSION
What conclusion can you make about the ability of light and dark objects to absorb heat?

METHOD: PART B
1 Stand the jars in hot water so the air inside each rises to approximately the same temperature, then place them somewhere out of the sun and away from heat. Record the temperature.
2 Record the temperature every two minutes for 20 minutes.

DISCUSSION
Which jar cooled down faster?

CONCLUSION
What conclusion can you make about the ability of light and dark objects to radiate heat?

Glossary

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Foundation worksheet 2

Solar hot water

The principle of absorption of heat is used in the construction of **flat plate solar collectors**. They are painted black (matt) so the collector will absorb as much heat as possible and so make them as efficient as possible.

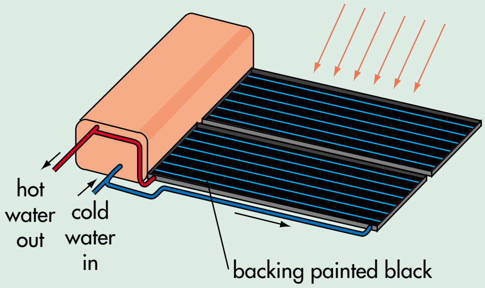

FIGURE 4.20
Solar hot water. As the black plate absorbs heat the water in the tubing is heated and transferred to the storage tank.

Solar still

The principle which is used to heat water so efficiently can also be used to purify salty water where electricity or another source of energy is unavailable. In outback Australia, artesian bores are often the only source of water. This water is frequently salty and unfit to drink. **Solar stills** can provide purified water on a scale large enough to supply a small town.

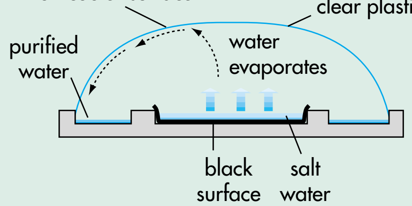

FIGURE 4.21
Solar still. The salty water is heated, evaporates, then condenses on the cooler top and sides of the still, running down into the side channels.

Solar reflector

FIGURE 4.18
The parabolic reflector concentrates the heat in this camper's solar cooker.

Solar furnace

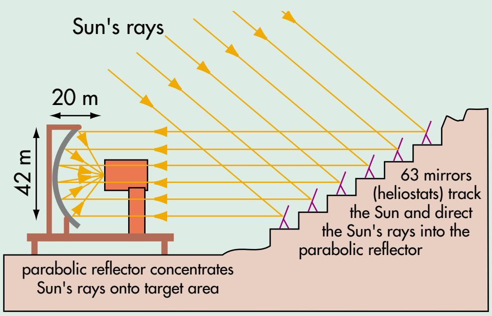

FIGURE 4.19
The Odeillo furnace. Heliostats, each an array of flat mirrors, focus onto the parabolic mirror which in turn focuses on the furnace. Solar furnaces such as this one in France are used to generate temperatures in excess of 3000°C and create pollution-free heat to conduct experiments on rare metals and materials to be used in spacecraft.

Questions

1 It is a hot summer's day and you walk off the concrete footpath onto the bitumen road. Which will be hotter now, and which will cool down faster when out of the Sun?

2 Why is matt black paint used to coat the tubing of solar hot-water heaters?

3 Describe a heliostat. What is it used for?

Think about

Can you think of any other ways we harness solar energy that have not been covered in this section?

Activities

1 Design and build a simple flat-plate collector and measure the maximum temperature reached after each hour in direct sunlight.

2 Design and build a solar still to purify salt water, or a solar cooker.

FACT FILE

Solar energy is used throughout the Sydney Olympic Village. Houses in the village use flat-plate solar collectors to heat water and solar cells to generate electricity.

Glossary

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4.6

Sound energy

USING SCIENCE 5 FEELING SOUND

1 Get a tape recorder or radio and turn it up as loud as it will go. Put your hand over the speaker and feel the sound with your hand.

2 Now hold a piece of paper in front of your mouth and shout. With your other hand you will be able to feel the paper vibrate.

FIGURE 4.22 (above) You can really feel the music!

Talk about

Clamp a ruler to the edge of a desk. Pull the end of the ruler down as far as possible and release it. Watch and listen. Describe the movement of the ruler and the sound produced.

FACT FILE

Sound travels at about 340 metres per second at sea level. Light travels almost a million times faster than sound. This is why you see lightning before you hear thunder during a storm.

Sound occurs when something vibrates. Something vibrates when it moves back and forth very quickly. Air, water, wood, rock and any other material can be made to vibrate. When this happens the particles that make up a material are moving back and forth with increased kinetic energy. Sound travels through materials when vibrating particles crash into each other and pass the energy along.

The loudness of a sound depends on how much energy goes into producing the vibration. A large amount of energy will cause a lot of vibration and a loud sound. A smaller amount of energy will cause a little vibration and a soft sound.

Usually sounds come to us as vibrations in the air, but we can also hear sounds that vibrate through other materials, as long as they can make our eardrums vibrate. Sound travels better through some materials than others.

In space there is no air to vibrate, so sound cannot travel through it. (A space that contains no air or other matter is called a **vacuum**.) Because light doesn't need air or anything else to travel through, it travels through space easily. That's why we can see the Sun but cannot hear it.

Questions

1 Explain why you hear a noise if a book is dropped onto a table. Draw a diagram showing the vibrations that are caused.

2 Explain the difference between a loud sound and a soft sound.

3 In science fiction movies such as *Star Wars*, spaceships flying through space always make a deep rumbling sound. What is wrong with this from a scientific point of view? Why do you think the film-makers do this anyway?

4a Astronauts on the Moon rely on radios to talk to one another. Why can't they just shout?

b Do you think it would make any difference if the astronauts touched their helmets together? Why?

Glossary

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EXPERIMENT 3 SOUND IN A JAR

AIM
To investigate whether sound will travel in a vacuum.

MATERIALS
- bell jar
- plastic tube
- fishing line
- alarm clock (one that ticks)
- rubber stopper
- vacuum pump
- sealant (such as silicone)

INTRODUCTION
Your teacher will demonstrate this experiment. The bell jar has an airtight seal: when the air is pumped out of it, no air can get back in.

METHOD
1 Your teacher will gradually remove the air from the bell jar.
2 Listen to the sound of the alarm clock as the air is sucked out.
3 Your teacher will gradually let the air back into the bell jar.

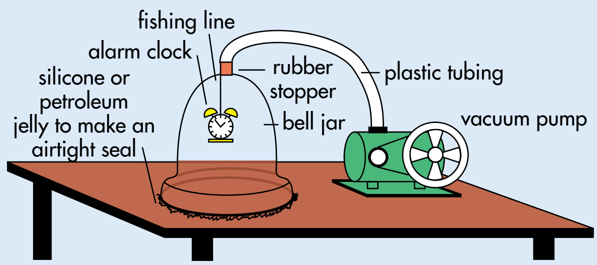


FIGURE 4.23
Does sound travel in a vacuum?

4 Listen to the sound of the alarm clock as the air is let back in.

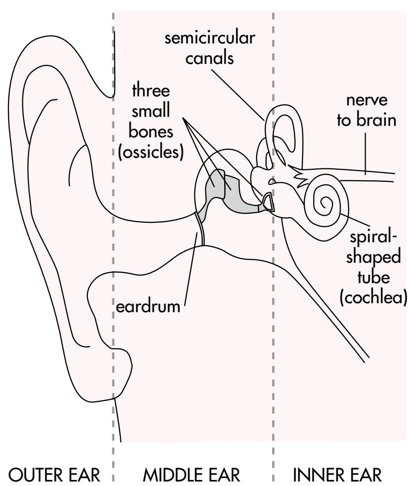
DISCUSSION
1 Draw a picture showing the alarm clock giving off sound, but there being no air for it to get out.
2 Explain why you can hear the sound again as the air is let back into the jar. You may use pictures in your explanation.
3 Why can you see the clock all the time, whether there is air inside the bell jar or not? What does this prove about light?

c Why can the astronauts still see each other?
5 How do you think it is possible to hear someone who is on the other side of a door?

Find out
How do we measure the loudness of a sound?

Activity
Make a string telephone by piercing a small hole in the base of two plastic cups. Thread string through the holes. Tie a large knot inside the cups so that the string will not pull out. Work with a partner and take turns speaking and listening.

Use the string telephone to find out:
- **which is best, a tight string or a loose string?**
- **will the vibration travel around corners?**
- **will the vibration travel through closed doors?**



FACT FILE
Supersonic planes travel faster than the speed of sound. They cause a sonic boom or shock wave to form when they overtake their own sound waves.

FIGURE 4.24
When an eardrum vibrates, the three small bones jiggle, sending vibrations through the fluid in the cochlea. The fluid moves small hairs along the side of the tube, which are connected to nerves that send signals to the brain. The brain then registers these nerve signals as sounds.

Glossary

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4.7

Electrical energy

FIGURE 4.25
Common electrical converters found in our homes.

Talk about

Newsflash! No electricity will be generated in New South Wales for one week!

How would this news affect you? How would you cope at home and at school?

Electrical energy is a very flexible form of energy. It can be easily changed into other forms of energy. Energy converters in our homes change it into heat energy, light energy, sound energy, kinetic energy and chemical potential energy.

There are many energy converters in our home used for lighting, heating, cooking, cleaning and entertaining. For every converter which changes electrical energy into another form of energy, there is a device which can convert that energy back into electrical energy.

Joules and watts

The unit of energy is the **joule** (J). However, when measuring the energy used by electrical appliances it is easier to measure the power instead. Power is the rate at which things use energy. One **watt** of power is one joule of energy used in one second. A 60-watt light globe uses 60 joules of electrical energy every second.

EXPERIMENT 4 ENERGY CONVERSION 1

AIM
To convert electrical energy into kinetic energy and change it back again.

PART A
MATERIALS
- small electric motor
- suitable power source
- leads
- string with small mass attached

METHOD
1 Attach the string to the shaft of the motor.
2 Use the leads to connect the power source to the electric motor.
3 Observe the energy change.

PART B
MATERIALS
- demonstration dynamo

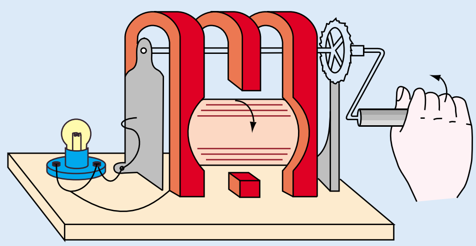

FIGURE 4.26
Demonstration dynamo.

METHOD
Turn the handle on the demonstration dynamo and observe the energy change.

DISCUSSION
1 Which device changes electrical energy into kinetic energy?
2 Which device changes kinetic energy into electrical energy?
3 Name three household appliances that contain electric motors.
4 Some cyclists have dynamos connected to the front wheel of their bikes. What are these used for?

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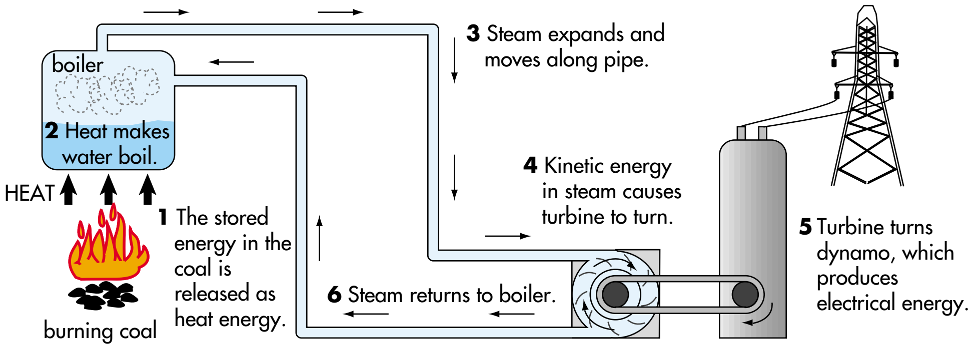

FIGURE 4.27
Over 90% of the electricity used in New South Wales is generated in huge coal-fired power stations. Coal is burned in air, changing chemical potential energy into heat energy. The heat is used to turn water into steam. The steam is used to turn the blades of large turbines. The turbines are connected to electrical generators.

EXPERIMENT 5 ENERGY CONVERSION 2

AIM
To convert electrical energy into heat energy and change it back again.

PART A
MATERIALS
- power pack (12-volt transformer)
- 150 mL beaker
- leads
- 40 cm nichrome wire
- thermometer

METHOD
1 Make a heating element by curling the nichrome wire around a pen, leaving 10 cm straight at each end.
2 Place the element in a small beaker containing 70 mL of water.
3 Use the leads to connect the element to the transformer.
4 Measure the water temperature each minute for 10 minutes.

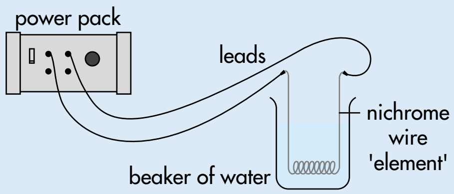

FIGURE 4.28
A heating element.

PART B
MATERIALS
- Bunsen burner
- microammeter
- 40 cm copper wire
- two 20 cm lengths of nichrome wire

METHOD
1 Twist the ends of the copper wire to the nichrome wire.
2 Connect the nichrome wire to the microammeter.
3 Heat one end of the twisted wire using the Bunsen burner and watch the microammeter.

DISCUSSION
1 Which device changed heat energy into electrical energy?
2 Which device changed electrical energy into heat energy?
3 Name three household appliances that contain a heating element.

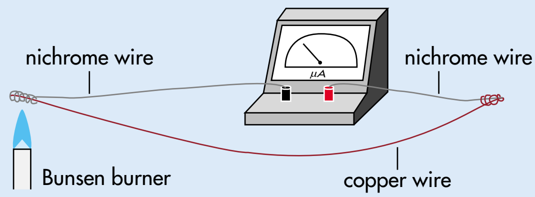

FIGURE 4.29
A thermocouple.

Questions

1 Use a flow diagram to show the energy change for each energy converter.
a microphone
b food mixer
c battery charger
d toaster
2 What is power?
3 Which electric iron uses the most power: one rated at 1200 watts or another rated at 1.5 kilowatts.
4 Write down all the energy changes which take place in a coal-fired power station.
5 Why is electricity such a useful form of energy?

Find out

1 What are thermocouples used for?
2 What is a kilowatt hour?

Glossary

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4.8

Light energy

FIGURE 4.30
The bright light used in the cowboy and cowgirl signs is produced by passing electrons through a gas contained in a thin glass tube. These lights are often called 'neon lights' because the gas neon can be used to produce bright red light. But other gases can also be used. Mercury vapour gives off a greenish-blue light, krypton gives a purple light, and helium produces yellow light.

Sources of light

If you can read this, you are relying on light. Light and our eyesight are the two things we need to be able to see: without one or the other there would be no sight.

It's easy to take light for granted, but can you imagine what life would be like without light? Well, quite simply, there wouldn't be any life at all. Plants need light to live, and if there were no plants, there would be no people.

Light can come from many sources: the sun, stars, light globes, fluorescent tubes, a television screen or a fire. It is all the same thing: there are just lots of different ways of making it.

Using light energy

Batteries produce **electrical energy**. You can use a battery to do different things by changing its electrical energy into other forms of energy. For example, when you connect a battery to a light globe, you change its electrical energy into light—so light is a form of energy too. Electrical energy can also be used to make a motor spin, which is another kind of energy. But would it be possible to turn light energy into motor spinning energy?

Glossary

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EXPERIMENT 6 LIGHT AND SOLAR ENERGY

Datalogging

AIM
To find out more about light energy and solar cells.

MATERIALS
- low-voltage electric motor
- torches and other light sources (such as microscope lamps, overhead projectors, reading lamps)
- solar cell
- connecting wires and alligator clips

METHOD
1 Connect two wires to the solar cell using alligator clips, as shown in Figure 4.31.

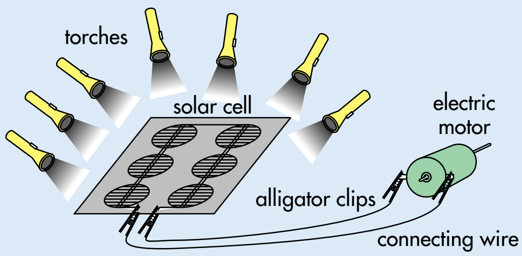

FIGURE 4.31
Experimental set-up for investigating the effect of light on solar cells.

2 Connect the other ends of the wires to the electric motor.

3 Shine one torch onto the solar cell and observe what happens.

4 Shine more torches onto the solar cell until the motor begins to spin. Record the number of torches that were needed to make the motor work.

5 Replace the torches with the other light sources and record the number of light sources needed to make the motor work.

6 Take the set-up out into the sunlight and record your observations.

DISCUSSION
1 Draw pictures to show each method you tried and record the results.

2 Draw up a table showing the number of each kind of light source that was needed to get the motor to spin.

3 Estimate how much energy was needed to get the motor to spin using the solar cell. How much energy would you need if you connected the motor directly to a battery?

4 Do you think solar cells are a worthwhile source of energy?

5 How did the amount of light energy from the sun compare with the light energy from the other sources you used?

Solar cells

Solar cells can only convert a small amount of the light energy that shines onto them into electrical energy. However, the sun can provide up to 1000 watts of light energy per square metre of ground. (A square metre is an area measuring 1 metre × 1 metre.) By comparison, the globe in the overhead projector gives off about 200 watts and the average light globe in your house would give off about 75 watts of light energy. So large solar panels can still produce a lot of electrical energy.

Questions

1a Write down 10 things you would not be able to do in the dark.

b How do you think blind people do these things?

2 Write down as many sources of light as you can think of.

3 If a solar cell converts one-twentieth of the light energy it receives into electrical energy, how many watts would it produce from 500 watts of light energy?

4a What are four problems with using solar cells instead of batteries?

b What are four advantages?

c How could you solve the problems you listed in part (a)?

Activity

Design an illuminated sign to advertise your school. Assume you have an unlimited supply of thin glass tubing; neon, krypton and helium gases; and mercury vapour.

FACT FILE

In 1994 Australian scientists invented a new kind of solar cell that converts much more light energy into electrical energy and can be made for one-tenth the cost of existing solar cells. The scientists believe that their cells may soon be powering whole towns.

Glossary

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4.9 IMPLICATIONS FOR SOCIETY AND THE ENVIRONMENT

SCIENCE IN FOCUS

Saving money and the environment

FIGURE 4.32 (above)
A compact fluorescent globe.
Life: up to 8000 hours
Cost: about $25
Power: 15 watts

FIGURE 4.33
(above right)
An incandescent (filament) globe.
Life: up to 1000 hours
Cost: about $1.50
Power: 75 watts

Think of three lights you use a lot in your home. If you replaced the conventional light globes in these lights with low-energy globes you would create nearly half a tonne *less* carbon dioxide in just one year. You would also save money. What does this handy hint mean to you? Is it important to save energy? How does our energy use affect the environment? Can one person make a difference to the world?

Standard **incandescent (filament) globes** are not very energy-efficient. They use a lot of electrical energy and much of it is wasted as heat energy. **Compact fluorescent globes** use only about one-third of the electrical energy to produce the same amount of light as an incandescent globe. Far less energy is wasted as heat energy.

Glossary

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Extension worksheet

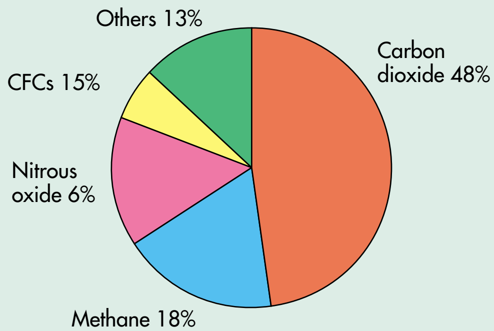
Using one compact 15 watt globe instead of one 75 watt incandescent globe reduces electricity consumption by about 480 kilowatt hours over the life of the globe. At a cost of 12 cents per kilowatt hour, this is a saving of $57.60 (minus the cost of the globe).

In addition, if your electrical energy comes from a coal-fired power station, using a compact fluorescent globe will save nearly half a tonne of carbon dioxide from being released into the atmosphere.

This gas is an important factor in the **greenhouse effect**. In the last 150 years the amount of carbon dioxide in the atmosphere has increased by 25 per cent and scientists believe that this is causing our atmosphere to warm up.

FACT FILE

At present prices, 1 kilowatt hour of electricity costs about 12 cents when supplied from the mains. To supply 1 kilowatt hour of electricity from non-reusable (disposable) batteries would cost about $100. It's the same amount of energy but at a much greater cost.



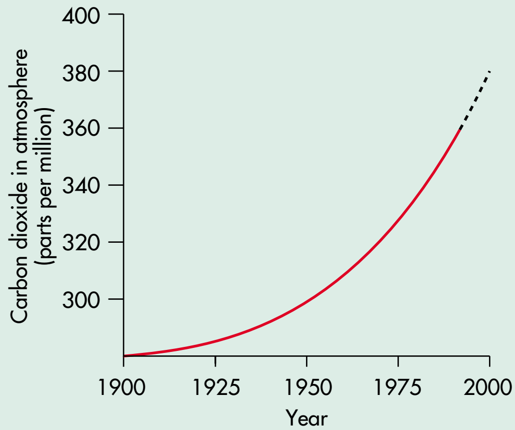


FIGURE 4.34
The composition of 'greenhouse gases' (above), and the increase in carbon dioxide in the atmosphere since 1900 (right).

USING SCIENCE 6 REDUCING ENERGY CONSUMPTION

REDUCING ENERGY CONSUMPTION AT HOME

1 In groups of five or six students, discuss ways in which you could reduce electricity consumption in your homes.
2 On a large sheet of paper, list the most commonly used appliances and identify those that consume the most electricity. Are some types of appliance used more in winter than in summer? Are some appliances too 'power hungry'? Are all the appliances you use necessary?
3 Share your findings with other groups then draw up a class action plan for homes in your area.
4 Publish your action plans in the school newsletter and discuss your findings with your parents.

REDUCING ENERGY CONSUMPTION AT SCHOOL

In many schools, lights, heaters and other electric appliances are left on when they are not needed. Turning them off would save money that could be put to other uses. Incandescent globes are often used instead of compact fluorescent globes.
1 Find out how much your school pays for electricity each year. Calculate how much this is for each school day (not counting weekends and holidays).
2 Conduct a survey around your school to identify any areas where energy is being wasted. Then calculate the cost savings that could be made if people acted more responsibly and energy-efficient appliances were used.
3 Draw up an Energy Savings Plan for your school.
4 Present your findings to your science teacher and to the school council. Can any of your suggestions be put into practice?

REDUCING ENERGY CONSUMPTION IN THE COMMUNITY

Debate the following topic:
That governments should encourage consumers to buy compact fluorescent globes by subsidising their price.

Glossary

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Using scientific language

Work in a small group to construct a crossword puzzle using the words listed below. Write clues for each word. Swap your crossword with one from another group and complete the puzzle.

elastic	electrical
energy	conduction
convection	radiation
generate	potential
kinetic	joule
turbine	hydroelectric
watt	fossil
vibration	fuel
heat	light
sound	

Check your knowledge

1 Sort the following list into two groups, forms of energy and sources of energy.

heat	oil
wind	sound
light	the Sun
coal	kinetic
methane	chemical
potential	wood

2 Copy and complete the following sentences.
   a Fuels such as petrol and coal contain __________ __________ energy.
   b A spring in a 'Jack in the box' toy ________ energy called elastic potential energy.
   c The ______ provides a continuous source of heat and light energy.
   d A child sitting at the top of a slippery dip has __________ __________ energy. When she slides ______ she changes this ______ kinetic energy.
   e __________ energy is produced when particles vibrate very quickly.

3 What is the name of the process by which heat energy moves through:
   a empty space
   b air and water
   c metal.

4 Explain the difference between a renewable source of energy and a non-renewable source of energy.

5 Sort the following list of energy sources into two groups, renewable and non-renewable.

wood	coal
solar	methane
oil	wind
tides	natural gas
shale oil	running water

Apply your skills

1 Draw a flow diagram to show how electricity is generated in New South Wales.

2 Give two advantages and two disadvantages of using solar cells to generate electricity.

3 Give three reasons why we should use fewer fossil fuels and more renewable sources of energy

4 Make a list of the things you could do personally to use energy more wisely.

Challenge yourself

1 Why can't heat energy from the Sun reach us by conduction or convection?

2 When a car is running not all the chemical potential energy in the burning petrol is changed into kinetic energy to move the car forwards. Some of the chemical energy is changed into other less useful forms of energy. What are they?

3 Look at Figure 4.35. It shows an energy rating label. Find out where they are found and what they are used for.

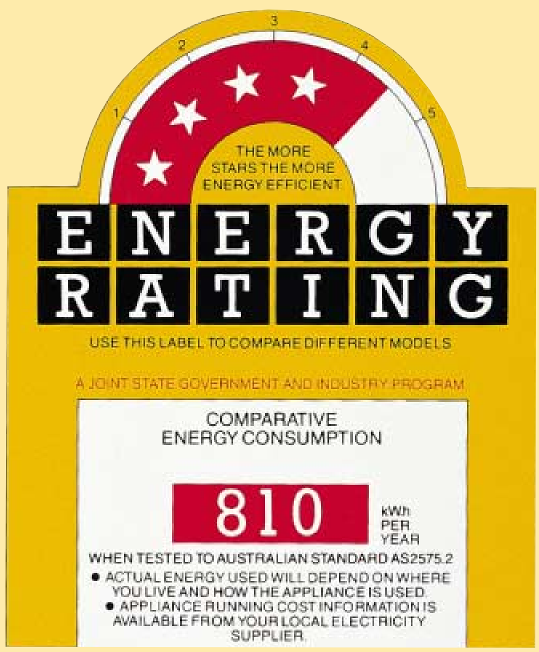

FIGURE 4.35

Glossary

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CHAPTER 5

FORCE

Late Sunday evening on 14 April 1912 the *Titanic*, a luxury liner, hit an iceberg while on its first voyage. At the time the *Titanic* was the biggest and supposedly safest vessel afloat. However, after hitting the iceberg, the ship quickly flooded, broke in two and plunged to the ocean floor.

The *Titanic* was designed to stay afloat if three or possibly four of the 16 watertight compartments in the hull flooded. A recent expedition to the wreck used sound waves to 'see' the damage caused by the iceberg. The expedition found a series of thin openings across six compartments. The total damage was quite small, but at around six metres below the water-line the seawater would have gushed in under high pressure. The ship would have filled quickly with 39 600 tonnes of water.

Before the 275-metre long *Titanic* hit the iceberg it had no trouble floating. Its hull was designed to displace a volume of water weighing the same as the *Titanic* while the upper part of the ship remained above the water. As the *Titanic* filled with water the force of gravity pulled it down until the upthrust force was overcome and the ship sunk.

In this chapter you will investigate a variety of forces including gravity and upthrust.

Web links

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Describe how forces act to change the shape or motion of objects.
- Classify forces as contact or non-contact (or field).
- Identify situations where friction acts to oppose motion.
- Recognise that all objects exert a force of gravity on all other objects.
- Outline the history of our understanding of gravity.
- Describe ways in which objects acquire an electrostatic charge.
- Describe the behaviour of magnetic poles and identify situations where magnets are used.

Glossary

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5.1

Let the force be with you

FIGURES 5.1, 5.2 & 5.3
You are constantly affected by some kind of force, whether it is a push, pull, twist or combination of these.

FACT FILE

The largest ship ever built is the oil tanker *Jahre Viking* weighing 564 763 tonnes.

Whenever you push, pull, twist or turn something you are exerting a **force**. A force can start a stationary object moving, or cause a moving object to come to rest or change its direction or speed. Forces can also change the shape of objects. Throwing a ball, riding a bike, walking, dressing and chewing all involve pushes, pulls, twists or turns.

There are many types of forces but they can be divided into two groups, **contact** forces and **non-contact** (or field) forces. Contact forces are exerted when objects actually touch one another. Examples of contact forces include:

- tension (the force in a rope during a tug of war)
- upthrust or buoyancy (the force that pushes back on gravity when an object floats)
- friction (the force between the road and the tyres of a car).

Non-contact forces can have an effect without objects touching. They can act from a distance. Examples of non-contact forces include:

- gravity (a pulling force between all matter)
- magnetic force (a force which can pull or push magnetic materials)
- electrostatic force (a force which can pull or push charged materials).

Glossary

EXPERIMENT 1 FORCES IN WATER

AIM
To show that water can exert a force.

MATERIALS
- thin wire
- dishwashing liquid
- large bowl

METHOD
1 Carefully add about a quarter of a cup of dishwashing liquid to an equal amount of water so that no suds are produced.
2 Make a rectangular frame (about 20 millimetres x 60 millimetres) using the thin wire. The frame should have a handle.

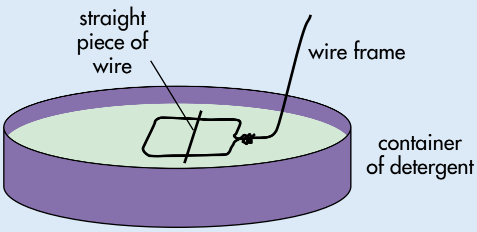

FIGURE 5.4
Frame made of thin wire. Be careful not to get any grease on the wire frame—it will ruin the experiment.

3 Holding the frame horizontally, place a straight piece of the thin wire across the centre of the frame. Gently dip the frame and wire into the dishwashing liquid.
4 Gently lift the frame out of the liquid; there should be a fine film of detergent stretching across the frame with the loose piece of wire in the middle.
5 Pierce one side of the detergent film and observe what happens to the loose wire. Record your results.

DISCUSSION
The force that caused the loose wire to move to the side containing the detergent film is called **surface tension**. Is it a pull or a push force in this case? Is there any way we could measure this force?

EXTENSION
MATERIALS
- straws
- long needles
- paper cake cups
- staples
- sticky tape
- pins
- cotton thread
- ice-cream container
- plastic wrapper clips (the sort used to seal plastic bags containing bread)

METHOD
1 Set up the simple balance shown in the diagram below.

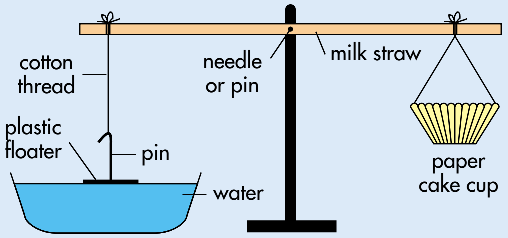

FIGURE 5.5
Experimental set-up. This activity deals with small forces, so do it very gently.

2 Half-fill the ice-cream container with water.
3 Attach the wrapper clip to the end of the straw using cotton thread, and float it on the water.
4 Measure the surface tension force that is holding the clip by adding staples to the paper cup until the clip is lifted off the surface of the water. Record how many staples were needed.

Questions

1 What is a force? What types of forces are shown in Figures 5.1, 5.2 and 5.3?
2 When a force acts on something it can cause changes. What sort of changes can occur?
3 What is the difference between a contact and a non-contact force? List examples of each.
4 What is surface tension?

Activity

You might have noticed that forces always act in a certain direction. For example, weight always acts towards the ground and the force of surface tension has a direction too. Choose one of the experiments you have just done and draw diagrams to show the directions of the forces involved.

Glossary

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5.2 Why do objects float?

FIGURE 5.6
Icebergs floating in the sea have two forces acting on them: the force of gravity, which acts downwards, and a buoyant force, or upthrust, which acts upwards. Only one-seventh of an iceberg is above the surface of the water.

FIGURE 5.7
When cargo is loaded onto a ship, the ship sinks deeper and deeper into the water. Special marks called 'Plimsoll lines' are painted on the hulls of ships as a safety measure. The ship should never be loaded with so much cargo that the Plimsoll line is submerged.

When an object floats in a liquid, the liquid provides an upwards force that is equal to the weight of water displaced (moved aside) by the object. This statement is called **Archimedes' Principle** after the person who first stated it. The upwards force is called the **buoyant force** or **upthrust** because it acts upwards against the weight of the object.

EXPERIMENT 2 FEELING THE FORCE OF WATER

AIM
To feel the force that water exerts on objects.

MATERIALS
- balloon
- basin or bucket big enough to contain the inflated balloon

METHOD
1 Blow up the balloon and tie off the neck.
2 Half-fill the basin with water. Place the balloon on the surface of the water so it floats.
3 Try to push the balloon into the water so that it is completely submerged.

DISCUSSION
1 How much of the balloon was above the surface of the water when it was floating?
2 What was resisting you when you tried to push the balloon completely under the water?
3 What happened to the level of the water in the bucket as you pushed the balloon further down?

Glossary

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EXPERIMENT 3 INVESTIGATING THE FORCE OF WATER

AIM
To investigate the buoyant force exerted by water on an object.

MATERIALS
- clean margarine tub and lid
- masses (5 grams, 10 grams, etc.)
- clean dry sand
- spring balance
- strong string
- large basin or bucket of water

METHOD
1 Float the open margarine tub in the basin of water.
2 Add masses to the tub until it is floating with its rim just above the surface of the water.
3 Remove the masses and weigh them with the spring balance. Record the result. Make sure no water enters the inside of the tub. If water does get in, dry the inside of the tub with a paper towel.

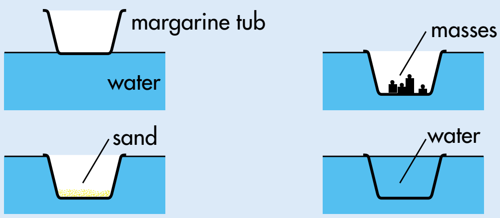

FIGURE 5.8
Experimental set-up for investigating the force of water.

4 Repeat steps 2 and 3, but this time using sand instead of the masses. Try to keep the sand dry.
5 Place the empty tub on the water again. Pour water into the tub until it is floating with its rim just above the surface.
6 Leave the equipment as it is and try the discussion questions.

DISCUSSION
1 What was supporting the tub, whether it was empty or carrying masses or sand?
2 Think about the tub with the masses in it. The water kept the tub and masses afloat.
a What was the size of the force exerted by the water? (Don't forget that the tub has weight too.)
b What was the direction of the force exerted by the water? Was it upwards, downwards or sideways?
3 Think about the tub with the sand in it.
a What was the size of the force supporting the tub and sand?
b What was its direction?
4 How does the weight of the sand compare with the weight of the masses?
5 Can you now work out the weight of the water inside the tub without weighing the water? If necessary, discuss this with the rest of your class. When you have worked it out, check your answer by weighing the water.

Spreadsheet

Questions

1 What do you think is the difference, in general, between the weight of something in water and in air? Try a simple experiment if you are unsure.
2 What happens to the level of the water as you lower an object into it? Why?
3 Why does a margarine tub completely full of sand sink?
4 Why does solid steel sink, but a steel boat float?
5 In general terms, why do some objects float and some sink? In your answer, mention the forces that act on objects in water, and their directions.
6 Look at Figure 5.6. Why is most of the iceberg's mass under water?

Activity

Devise a way to make a large lump of Plasticine float. Test your idea—why did or didn't it work?

Glossary

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5.3

Friction

FIGURE 5.9
Ice skaters glide smoothly over the ice.

FACT FILE

In a car engine, about one-fifth of the energy produced by the petrol is used to overcome the friction between the moving parts.

Wherever there is friction, heat is produced. Car brakes get very hot when they are used a lot.

Friction is a very important force that we often take for granted but rely on a great deal. Friction is a force that tries to prevent things sliding past one another. Friction tends to slow motion down or bring it to a stop. Without friction, however, you cannot have motion.

Friction acts when two solid surfaces meet and one is trying to move over the other, such as when a jogger's shoes hit the road. It also acts when a solid moves through a liquid or a gas, such as when a swimmer moves through water. Friction often acts in the opposite direction to the movement.

Talk about
When you walk, you push your feet against the ground. This creates friction. What would happen if there was no friction? (Imagine trying to walk or run on a very slippery surface.)

Sometimes we try to increase the forces of friction. For example, when a car is driven along a road there has to be some friction between its wheels and the road or it would skid. Treads are designed to increase the friction between the tyre and the road.

At other times we try to minimise friction. For example, we put oil in the engine of a car to reduce the friction between the moving parts so that maximum energy gets to where it's needed—the wheels.

EXPERIMENT 4 PRODUCING HEAT FROM FRICTION

AIM
To show that friction produces heat.

MATERIALS
- piece of rough wood
- coarse sandpaper

METHOD
1 Rub your finger backwards and forwards on the table. What do you feel? What is the effect of pressing down harder on the table as you move your finger?
2 Rub a piece of wood with some coarse sandpaper for several minutes. How does the sandpaper and wood feel?

EXTENSION
Research how fire is produced using a bow drill.

Glossary

Foundation worksheet 2

EXPERIMENT 5 SPIN OUT!

INTRODUCTION

Many toys and tricks involve spinning. The action of spinning involves force.

AIM

To find out what stops a block of wood spinning on a table.

MATERIALS

- small jar lid
- marbles
- Blu-tack or similar
- block of wood with smooth surfaces
- large jar lid
- stopwatch

METHOD

1 Spin the block of wood on the table top. Time how long it spins for. Record your results.

2 Stick the small jar lid onto the table with Blu-tack, and fill it with marbles. Place the larger jar lid on top of the marbles.

3 Stick the block of wood onto the large jar lid with Blu-tack. Carefully spin the block of wood. Time how long it spins for and record your results.

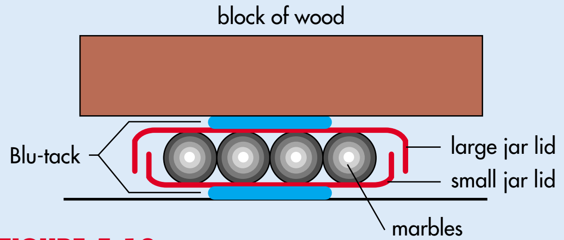

FIGURE 5.10
Experimental set-up.

DISCUSSION

1 What is the force that causes a block of wood to stop spinning in each trial?

2 What is the effect on this force of using marbles?

Starting and stopping

Motion cannot be started, altered or stopped except by a force.

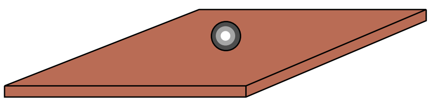

FIGURE 5.11
The ball is at rest on the table top: the forces on it are balanced.

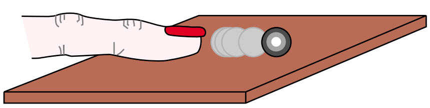

FIGURE 5.12
The ball starts moving if we give it a push. It moves because the forces on it are unbalanced. If we stop pushing it, it will slow down because of the friction between it and the table top. If we keep on pushing it, it will continue to move. If we push it harder, it will move faster.

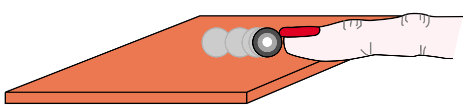

FIGURE 5.13
If we push a rolling ball in the opposite direction to its motion it will slow down. If we push it at an angle to its motion, it will change direction.

Questions

1 Look at the photo of the ice-skaters (Figure 5.9).

a What forces act on an ice skater?

b Why do the forces of friction need to be minimised in skating?

c How are these forces minimised?

2 Identify at least four places where friction would occur during a game of tennis. Explain the effects of friction in each case.

3 List at least three situations where it is desirable to:

a reduce friction

b increase friction.

4 From your everyday activities:

a list at least five situations in which motion is started.

b list at least five situations in which motion is stopped.

In each case, describe briefly how the motion is started, stopped and continued.

Glossary

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5.4

A matter of gravity

FIGURE 5.14
Two forces act as a skydiver falls through the air: friction (air resistance) and gravity. When the skydiver begins to fall, these two forces are unbalanced. The force of gravity is greater than the force of friction so the skydiver accelerates towards earth. When the force of friction and the force of gravity are equal, the forces balance and the skydiver falls to earth at a constant speed.

Talk about
Why do skydivers fall with their arms and legs stretched out as far as possible?

If you throw any object up into the air, it will fall back down again. (There are exceptions, of course, such as a balloon filled with a gas that is lighter than air.) Any object, whether it is a skydiver, an apple or a cricket ball, will eventually fall to the ground because there is a force of attraction between the Earth and the object. This force is called **gravity**. The force of gravity that attracts the skydiver, the apple or the cricket ball to the Earth also holds the Earth in its orbit around the Sun. The force of gravity is universal: wherever there is matter, there is gravity.

EXPERIMENT 6 INVESTIGATING GRAVITY

AIM
To investigate gravity by comparing the fall of different objects.

MATERIALS
- metal plate
- paper plate of similar size to the metal plate
- piece of paper of similar size to the metal plate
- two stopwatches (optional)

METHOD
In each of the following situations, release the two objects from the same height at the same time and compare the rate at which they drop. (You might like to assign two people with stopwatches to time the fall of each object.)
- Hold the metal plate and the sheet of paper horizontally, side by side.
- Place the sheet of paper on top of the metal plate, holding them horizontally.
- Hold the paper plate and the sheet of paper horizontally, side by side.
- Place the sheet of paper on top of the paper plate, holding them horizontally.
- Crumple the paper into a small ball. Hold the metal plate and the crumpled ball of paper horizontally, side by side.
- Hold the paper plate and the crumpled ball of paper horizontally, side by side.

DISCUSSION
1 Record your results in a table, and comment on your observations.
2 Why does the piece of paper keep up with the plate when it is crumpled or on top of the plate and not when it is a flat sheet?
3 If there were no air resistance, how do you think all objects would fall under the force of gravity?

EXTENSION
Investigate ways in which the air resistance of an object can be changed.

Glossary

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Extension worksheet

Force, mass and weight

Forces are measured in a unit called the **newton** (named after the seventeenth century English scientist Isaac Newton, who first described the force of gravity). The abbreviation for newton is N (without a full stop).

Weight is a measure of the force of gravity on an object. A person might weigh about 600 N, and an apple about 1 N. **Mass** is a measure of the amount of material in an object. It is measured in **kilograms**.

Sometimes, you may be asked the question: 'How much do you weigh?'. In everyday life, we often 'weigh' things in grams or kilograms. However, in science mass and weight are not the same. If someone says that they weigh 45 kilograms, they have actually told you their *mass* rather than their *weight*.

Your weight varies according to how far you are from a particular planet and how big the planet is. Your mass, on the other hand, does not depend on how close you are to a planet or even what planet you are on! The amount of matter in your body only changes if you add or lose some mass, for example by going on a diet or by building up muscles.

EXPERIMENT 7 MEASURING FORCES

AIM
To measure the force of gravity on various objects in newtons.

MATERIALS
- spring balance with scale in newtons
- various objects to be weighed

METHOD
1 Weigh the various objects.
2 Find the weight of 100 grams in newtons.
3 Present your results in a table.

DISCUSSION
1 How much does one kilogram weigh in newtons?
2 Work out how much you weigh in newtons.

Questions

1 What is the difference between mass and weight? What units are used to measure each?

2 If you drop a flat piece of paper and a flat piece of steel of the same size, why does the paper take longer to reach the ground?

3 What is the weight of a 60 kilogram mass in newtons?

4 On the moon the force of gravity is about one-sixth of Earth's gravity. Since weight is a measure of the pull of gravity, a person's weight on the moon would be one-sixth of their weight on Earth. On Jupiter the force of gravity is about 20 times that on Earth.

a What would be the weight of a 60 kilogram mass on the Moon?

b What is your weight in newtons (i) on Earth (ii) on the Moon (iii) on Jupiter?

c What is your mass in kilograms (i) on Earth (ii) on the Moon (iii) on Jupiter?

Spreadsheet

FIGURE 5.15
Neil Armstrong was the first person to walk on the Moon. This happened on 20 July 1969. His first steps were very careful since he didn't know what the Moon's surface was like. Would it be slippery? Would he sink into the moondust? Astronauts have found that walking on the Moon is like walking in flour. It is easier to leap and float *across* the Moon's surface. Astronauts can cover about 3 metres in a single leap. When astronauts tried to put a flag on the Moon, they found it difficult to put the flagpole into the lunar soil. When they finally managed to do it, the flagpole kept falling over. The lunar soil resisted downward forces but shifted sideways very easily.

Think about

How much do you weigh?

Glossary

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5.5

SCIENCE IN FOCUS

HISTORY OF SCIENCE

Changing ideas on gravity

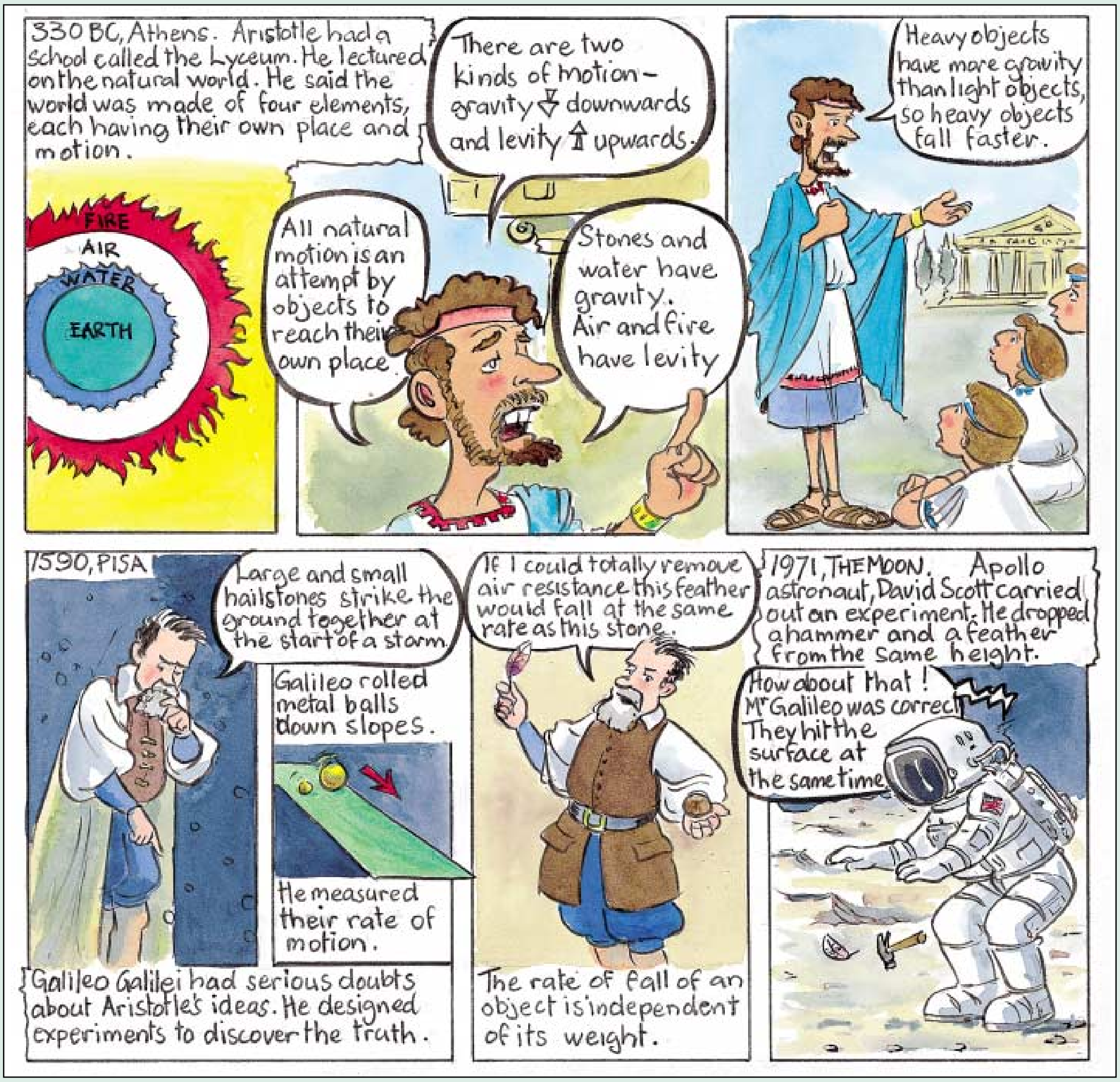

FIGURE 5.16

Glossary

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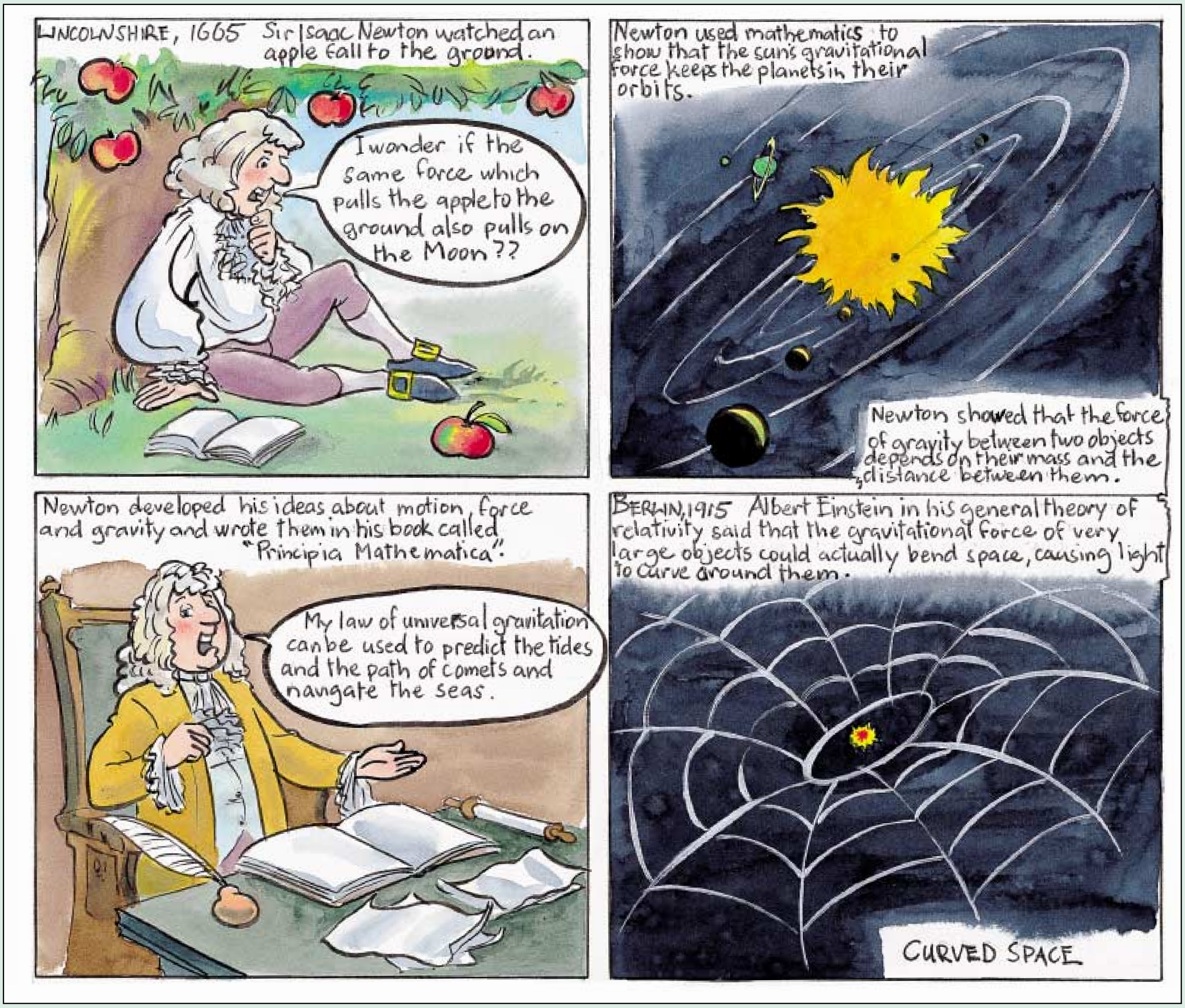

FIGURE 5.17

Questions

1 What was the difference between the old ideas of gravity and levity?

2 Aristotle was a philosopher; he thought about moving objects and gravity. How did Galileo work differently from Aristotle?

3 How have Newton's ideas about gravity been used?

Think about

1 Which do you think would produce the strongest gravitational force, a small planet or a large planet?

2 What would happen to the strength of Earth's gravity the further you move away from the planet?

Find out

What is a 'gravity assist' manoeuvre? Why is it used with spacecraft on long voyages?

FACT FILE

When a very large stars dies, it is crushed into a tiny sphere. In the space around it, gravity is so intense that nothing, not even light, can escape from it. This is called a black hole.

Glossary

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5.6 Static electricity

FIGURE 5.18
Static electricity can be used to remove soot particles from black smoke.

FACT FILE

In about 600 BC, a Greek called Thales described how small pieces of fluff were attracted to pieces of jewellery made from amber (a yellowish-brown resin). We now know this effect is caused by static electricity. The Greek word for amber was *elektron*, which is the origin of our word 'electricity'.

You may have noticed that you sometimes get a small shock when you touch a metal door knob after you have walked across a carpet. While brushing your hair you may have seen sparks fly between your hair and the brush. When taking off your jumper you may have seen small flashes of light (especially if you were in a darkened room) and heard crackling sounds. These effects are due to a build-up of electric charge, and are examples of **static electricity**.

Electricity is energy that results from the movement of electrons. In static electricity, however, the electrons are at rest. When electrons gather together in one place, a build-up of static electricity occurs. The build-up of static electricity can be caused in three ways.

Friction

Charging by **friction** occurs when objects are rubbed together causing electrons to move from one object to the other.

All materials may be given a charge by friction. However, not all materials can equally hold and build up a charge. Plastic and glass are easily charged by friction. Metals, however, are difficult to charge because the charge can move through it and escape to earth.

Conduction

Charging by **conduction** occurs when electrons are transferred from one object to another by direct contact.

FIGURE 5.19
This hair-raising experience is due to the electrical effects produced by a Van der Graaff generator.

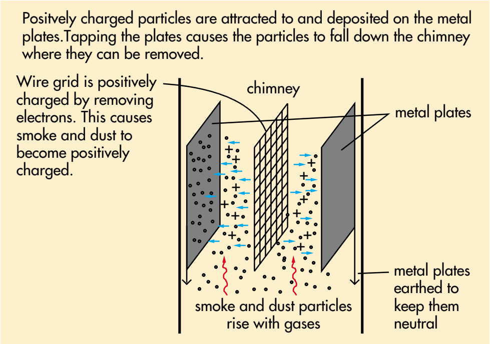

FIGURE 5.20
How a soot-removing precipitator works.

Glossary

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Induction

FIGURE 5.21
Lightning is a flow of charge between two oppositely charged regions in the form of a giant electric spark.

Charging by **induction** occurs when the charges on an object are moved around without it actually touching another charged object. During a thunderstorm, for example, the electrically charged water droplets in clouds can become separated so that the negatively charged particles build up in the lower part of the cloud. When the static electricity builds up sufficiently it discharges itself in the form of a giant spark, releasing a great deal of heat and light. The heat makes the surrounding air expand explosively, causing the sound of thunder.

Most of the charge in a lightning bolt flows between clouds, or between different parts of the same cloud. Since the earth also carries a charge, the electricity can sometimes flow to the ground in the form of a 'lightning strike'.

FACT FILE

Care must be taken to prevent charge building up and producing a spark when refuelling an aircraft and operating a drycleaning machine. Both situations involve the use of highly flammable liquids.

EXPERIMENT 8 BENDING WATER

AIM
To bend a stream of water using static electricity.

MATERIALS
- tap
- cloth
- plastic comb

METHOD
1 Turn on the tap to obtain a steady, gentle stream of water.
2 Rub the comb with the piece of cloth a number of times.
3 Hold the comb close to the stream of water.
4 Draw a diagram that shows what happened.

DISCUSSION
Try to explain what happened in the experiment.

EXTENSION
Design and perform an experiment to test which material can make the water bend the most. Check your procedure with your teacher before trying it.

Questions

1 **What is static electricity?**
2 **List three ways static electricity can be produced and give an example of each.**
3 **Draw a series of cartoons that explain how a lightning strike builds up and is discharged. Make sure you show the clouds, the build-up of static electricity, the lightning bolt and the boom!**

Activity

Vigorously rub an inflated balloon on your hair for 30 seconds. Now hold the balloon against a wall or the ceiling. The balloon will stick to the surface because of the static electricity you have produced. Who in your class can generate the most static electricity in a given time?

Find out

How does a Van der Graaf generator work?

Glossary

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5.7

Electrical charges and forces

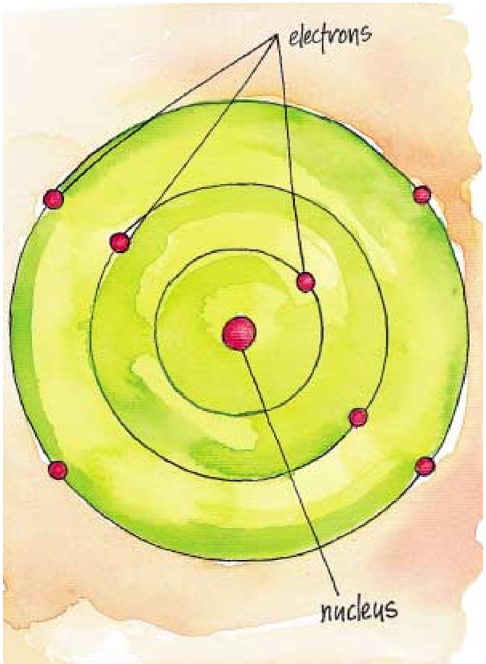

FIGURE 5.22
The structure of an atom helps us to understand how objects can become electrically charged.

All substances are made of tiny particles called **atoms**. At the core of each atom is a **nucleus**, which contains uncharged particles called **neutrons** and positively charged particles called **protons**. The nucleus is surrounded by a cloud formed by fast-moving, negatively charged **electrons**.

Usually, the number of protons in an atom is equal to the number of electrons. Since the positive and negative charges are balanced, the atom has no electric charge: it is neutral. When the atoms in an object have *more* electrons than protons, the overall charge of the object is negative. When the atoms in an object have *fewer* electrons than protons, the overall charge of the object is positive.

Sometimes when two neutral objects are rubbed together, electrons leave one object and move to the other. The objects are then no longer neutral: the one *receiving* the electrons will become *negatively* charged (since it has increased its total number of electrons) and the one *losing* the electrons will become *positively* charged (since it has decreased its total number of electrons).

The positive and negative electric charges in objects can produce a force between the objects. Objects **attract** each other when they have opposite charges. When objects have the same charge, they **repel** each other. For example, two positively charged objects will repel each other. Two negatively charged objects will also repel each other.

FIGURE 5.23 (below left)
What happens if you bring a balloon and a cloth close together? Nothing. The cloth and the balloon are both neutral objects. The cloth has an equal number of positive and negative charges. The balloon also has an equal number of positive and negative charges. They neither attract nor repel each other.

FIGURE 5.24 (centre)
What happens if you rub the cloth against the balloon? When the cloth is rubbed against the balloon, some electrons move from the cloth into the balloon. Since the two objects are now oppositely charged, they attract each other.

FIGURE 5.25 (far right)
What happens if you bring two 'rubbed' balloons close together? Since both balloons are negatively charged, they repel each other.

Animation

Interactive

Glossary

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EXPERIMENT 9 DETECTING STATIC CHARGE

AIM

To use an electroscope to detect static charge.

EQUIPMENT

- electroscope
- ebonite rod
- woollen cloth
- Perspex rod
- silk cloth

METHOD

1 Make sure the electroscope is discharged by touching the top plate with your finger.

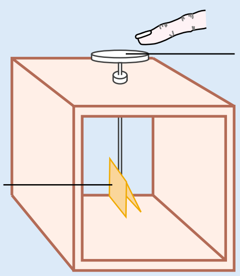

FIGURE 5.26
Discharging an electroscope.

2 Rub the Perspex rod with silk to give it a positive charge.
3 Bring the charged rod near the plate of the electroscope. Observe what happens. (The electroscope leaves becomes positively charged.)
4 Discharge the electroscope, then rub the ebonite rod with wool to give it a negative charge.

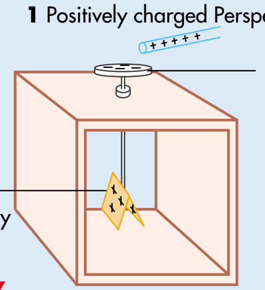

FIGURE 5.27
Charging the electroscope.

5 Bring the charged rod near the plate. Observe what happens. (The electroscope leaves becomes negatively charged.)
6 Again charge the Perspex rod with the silk; bring it near the already charged electroscope and observe what happens.

DISCUSSION

1 Record your observations for each step.
2 Are the rods charged by friction, conduction or induction?
3 Is the electroscope charged by friction, conduction or induction?
4 Draw a diagram showing what happens in step 5.
5 Explain your observations in step 6.

EXTENSION

Charge a variety of objects made from glass, metal or wood with wool. Use the electroscope to determine the charge on each object.

Questions

1 Name three types of particles found in atoms and describe how they are different.
2 Does the number of neutrons in an object affect its electric charge? Explain your answer.
3 Two balloons are each rubbed with a piece of cloth. When they are brought close together they repel each other. Draw diagrams to explain what has occurred.
4 If two charged objects repel each other, does this mean they are both negatively charged? Explain your answer.
5 Complete the statements.
a Objects with the same or like __________ attract.
b Objects with opposite or __________ charges ______.

Find out

1 Why is it difficult to do electrostaic experiments on humid or rainy days?
2 What happens when a charged object is brought near an uncharged object? (Try rubbing a pen and bringing it near very small pieces of paper.)

FACT FILE

An electroscope is a device that can be used to find out if an object is charged. It can also be used to determine if an object has a positive charge or a negative charge.

Glossary

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5.8

Magnetic force

FIGURE 5.28
All shapes of magnets have north and south poles.

FACT FILE

Some substances, such as gold, silver, lead and copper, even water, are actually repelled by magnets. This effect is called diamagnetism and involves much weaker forces than ordinary magnetic attraction, so it is easily missed.

What do magnets do?

A **magnet** is an object which is able to attract **magnetic** materials such as iron. Magnetic materials can be made into magnets.

If you hang a magnet from a piece of string one end will point towards the north pole. Because of this property magnets usually have their ends labelled as north and south **poles**.

Magnets can come in all sorts of shapes. The most common shapes are bar magnets and horseshoe magnets.

Magnetic fields

In the Using Science below, what you feel on the paper clip is a **magnetic force** caused by the paper clip being in the **magnetic field** of the magnet. The magnetic field is strong near the poles of the magnet, weaker in the middle, and very weak far away from the magnet.

You can feel how strong the effect can be from a magnetic field. In the next experiment, you will see how a magnetic field can be represented by '**magnetic field lines**'.

Internet assignment

USING SCIENCE 1 FEELING A MAGNETIC FORCE

Get a bar magnet and a paper clip. Circle the magnet with the paper clip and feel where the magnet's pull is strongest. Notice how hard it is to hold the paper clip only 1 mm away from one end (a pole) of the magnet, but not so hard to hold it 1 mm away from the middle.

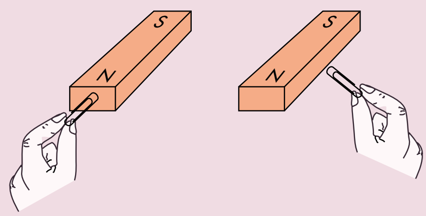

FIGURE 5.29
Feeling a magnetic force.

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EXPERIMENT 10 SEEING MAGNETIC FIELD LINES

AIM
To see the magnetic fields of different magnets.

MATERIALS
- bar, horseshoe and other magnets
- some thin books
- a sheet of stiff, transparent plastic
- some white paper
- some iron filings

METHOD
1 Lay the paper on your table and place the bar magnet in the middle.
2 Put the plastic sheet over the magnet, and support its edges with the thin books so that it is flat.
3 Sprinkle about a teaspoon full of iron filings from about 30 cm above the magnet.
4 Draw the pattern you see.
5 Lift up the plastic sheet and take off the iron filings.

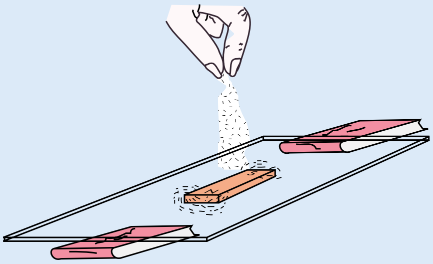

FIGURE 5.30
The experimental set-up.

6 Now repeat the above for the horseshoe and other magnets.

RESULTS
Notice how most of the iron filings are concentrated around the magnetic poles. This is where the field is strongest, as you would have noticed with your paper clip. Draw each magnet that you tested and show the pattern of the iron filings.

DISCUSSION
1 Identify the north and south poles of each of the magnets you tested.
2 What is the field like between the two poles of the horseshoe magnet? How easy do you think it would be to hold a paper clip in the very middle? Try it out!
3 How do the magnetic fields of each magnet you tested compare? In what ways are they similar? In what ways are they different?

EXTENSION
Do the same experiment but use two magnets this time. You may need Blu-tack to stop them from moving, but try pointing the north poles of the two bar magnets toward each other and draw the shape of the field. Try it with a north and south pole pointing to each other. What can you say about the fields? How are they different from when the magnets are by themselves?

Questions

1 How could you tell a magnet from an ordinary piece of metal?
2 What is a magnetic field?
3 How could you test for the presence of a magnetic field?
4 Suggest five things that magnets could be used for.
5 What is the difference between the magnetic fields of horseshoe and bar magnets?

Think about

You can feel the pull of magnets, and you can see that they hold onto things, but can you taste or smell or hear anything about magnets that makes them different from other bits of metal?

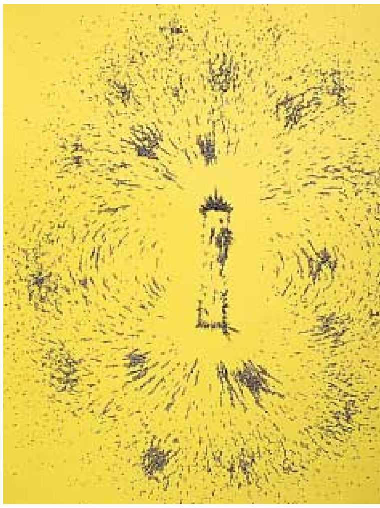

FIGURE 5.31
What pattern did your magnet give?

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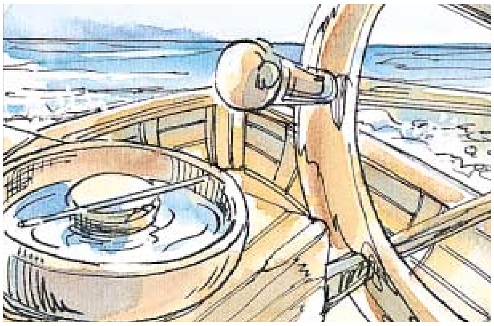
5.9

What can magnets do?

FIGURE 5.32
By the tenth century, the Chinese wrote about using compasses to navigate ships. Arab navigators are thought to have introduced the compass to Europe about two centuries later.

FIGURE 5.33
This was one of the earliest uses of magnets as compasses that worked reasonably well.



Hundreds of years ago ships could be steered across great oceans following the stars, but if there was a storm, or it was cloudy for weeks on end, the sailors could get completely lost. However, with magnets they could always tell which way was north and which way was south, and once they knew that they could stay on course.

EXPERIMENT 11 MAKE YOUR OWN COMPASS

AIM
To construct a compass.

MATERIALS
- bar magnet
- clamp and retort stand
- some string
- compass

METHOD
1 Tie the string around the middle of the magnet, using two loops so that it is balanced.
2 Attach the other end of the string to the clamp on the retort stand. Hang the magnet as far away from the stand as possible.
3 Note which way the magnet points after it stops swinging around.
4 Compare this to where a compass points (make sure it isn't near any other magnets when you do this!).

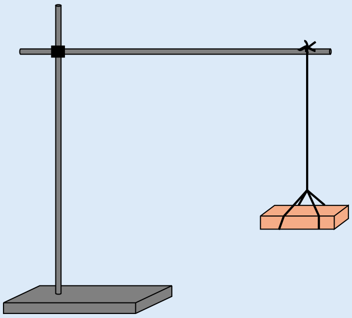


FIGURE 5.34
Setting up your own magnet.

RESULTS AND DISCUSSION
What can you conclude about magnets and compasses? What do they have in common?

EXTENSION
Bring the south pole of the bar magnet close to the compass. What do you notice? Now bring the north pole toward the compass. What happens this time?

Glossary

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Extra worksheet Multimedia

EXPERIMENT 12 HOW ATTRACTIVE IS IT?

AIM
To discover the rules of attraction (when magnets stick together) and repulsion (when magnets push away from each other).

MATERIALS
- 2 bar magnets
- compass
- clamp and retort stand
- some string

METHOD
1 Copy Table 5.1 into your book.
2 Now bringing the north pole of the free magnet toward the north pole of the hanging magnet. Tick the box labelled Attraction or the box labelled Repulsion depending on whether the two magnets were attracted or repelled by each other.

TABLE 5.1

Pole of magnet in hand	Pole of hanging magnet	Attraction	Repulsion
N	N		
N	S		
S	N		
S	S		

3 Stop the hanging magnet from swinging around and then continue to fill in the table for the other combinations of north and south poles.

RESULTS AND DISCUSSION
1 Which poles attract each other? Which poles repel?
2 Write down a rule that describes when magnets attract each other.
3 Write down another rule for when magnets repel each other.
4 Draw your experiment.

As you have discovered, magnets can attract and repel each other. Different (unlike) poles attract and like poles repel. Also, **compasses** are just magnets that are allowed to swing wherever they like. And they always point their north poles in the direction of magnetic north. This is because the Earth is like a giant magnet itself. So the north pole of magnets is attracted by the **magnetic north pole** of the Earth.

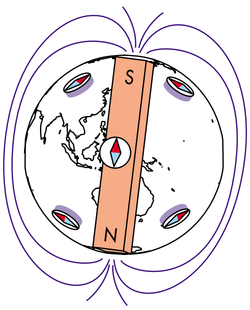

FIGURE 5.35
The north pole of the Earth is actually a magnetic south pole which attracts the north pole of compasses: that's why compasses point north.

The magnetic north pole of the Earth is not exactly at the geographical north pole, and compasses point to a place roughly 3000 km away from the north and south poles you see on maps. Magnetic north, for example, is located in northern Canada, although its exact position changes slightly over time.

The property of repulsion and attraction between magnets has been used in many ways. One way that magnets are used is in 'bullet' trains that float above their tracks, enabling them to go as fast as some planes.

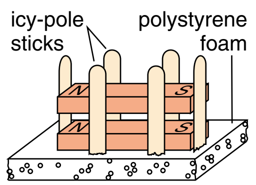

FIGURE 5.36
Levitating magnets in action.

Questions
1 What is the magnetic law of attraction and repulsion?
2 How can the North Pole also be a south pole?
3 Think of five other things, apart from magnetism, that can 'go through' substances without changing them.
4 In what way isn't it true to say a compass points north?

Think about
If you stood at the magnetic north pole, where would a compass point?

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APPLICATIONS AND USES OF SCIENCE

Using magnets

Mining with magnets

Think about

Why do you think mining companies are prepared to spend so much money on magnetometers?

Mining companies spend millions of dollars developing extremely sensitive magnets called **magnetometers** which they can use to find metals buried underground. You may be familiar with **metal detectors**, which work on the same

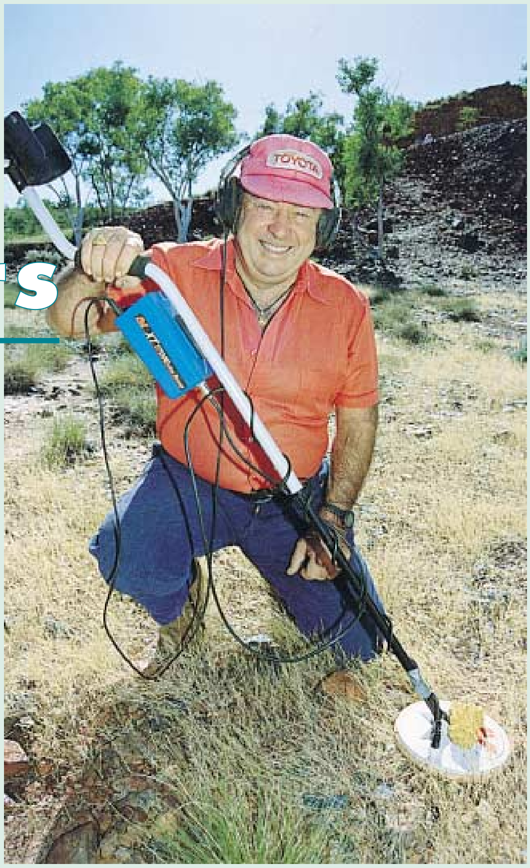

FIGURE 5.37 The largest nugget of gold ever found using a metal detector in Australia was worth over $10 000. It was found using a $300 metal detector.

EXPERIMENT 13 MINING FOR METALS

AIM

To find buried metals in a way similar to that used by mining companies.

MATERIALS

- compass
- 5 or more bar magnets
- large sandpit, or open area, newspaper and and tanbark (if you don't have a sandpit)
- 2 sheets of graph paper

METHOD

1 Both you and your partner should make a map on graph paper of the area in which you will be working.
2 While you are not watching, have your partner bury the 5 magnets at various depths (no deeper than 20 cm) in the sandpit in an area 1 m × 1 m. If you don't have a sandpit available, lay them on the ground and cover them with newspaper and tanbark. Your partner should mark where the magnets are on the map, but not let you see it.
3 Now hold your compass about 10 cm above the surface and slowly pass it over the area in straight lines to match the lines on your graph-paper map. (This is called 'sweeping'.) Watch your compass closely and make marks on your map to show where the compass seems to react to the presence of a magnetic field.
4 Once you have swept the area, compare your map with that of your partner and see if you have found all the magnets.
5 Now swap with your partner and repeat steps 1–4.

RESULTS AND DISCUSSION

1 How successful was your search?
2 What do you think might make it easier?
3 Did it matter how fast you moved the compass?
4 Did it matter how far above the surface the compass was?
5 How sensitive do you think magnetometers must be if they are swept over the ground at about 200 km/h and 1000 m above it?

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principle. A metal detector can tell you when there is a metal present because of the way it behaves in a magnetic field. Since magnetic fields can go through wood and soil, metal detectors can detect buried metals.

Magnetic imaging

MRI—Magnetic resonance imaging— uses powerful magnets to create pictures of the body using the magnetism of atoms inside the body. It is not thought to damage cells of the body, and no dangerous chemicals are needed. It can also show parts of the body that other methods can't, like the blood, arteries, brain cells etc., and it can show three-dimensional images of the body.

However, MRI machines are extremely expensive, and they work very slowly. Also, there is concern about the effect of magnetic fields on people.

Many scientists believe that exposure to some magnetic fields may cause cancer or other medical problems.

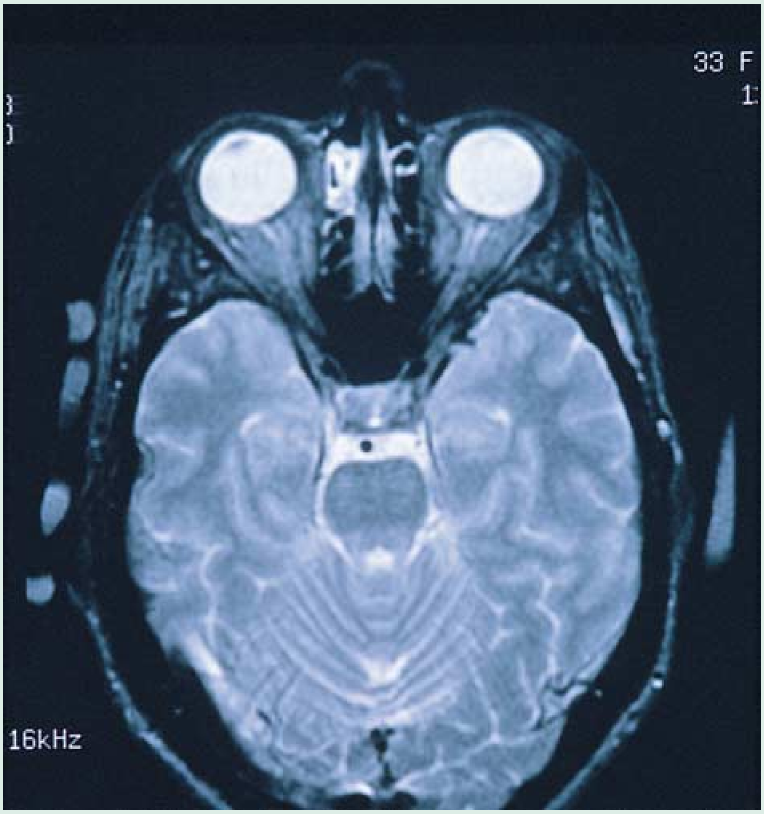

FIGURE 5.38
Magnetic resonance imaging (MRI) is used in the detection of disease. The patient is placed inside a machine with a large magnet. The magnetic field causes the magnetic fields of certain atoms in the body to line up. The machine then sends out a radio signal that causes the magnetic field of the nuclei to change direction. These changes create radio signals that a computer shows as an image. MRI is thought to be less dangerous than X-rays and radioactive dyes, and it can show up features of the body that other methods can't.

Activity A

Discuss the following possible scenarios. What would you do? Justify each decision you make. What extra information do you need?

Scenario 1

There are several MRI devices available in New South Wales. Each one costs 10 times as much as an X-ray machine, and can be used on only one tenth as many patients because it is so slow. A hospital is trying to raise funds to buy another MRI machine. If an X-ray machine can be used on 25 patients a day, how many patients could be examined each week if the hospital buys the MRI system? How many could the hospital examine if it bought the X-ray machines instead? Which should it buy?

Scenario 2

A doctor thinks her patient might have a disease that can only be detected by using an MRI device. The waiting list for MRI is three months and in that time it may be too late to treat the patient successfully. It is possible to jump the queue in urgent cases, but if the doctor is wrong, then the people who are forced to wait longer are at greater risk of not having their disease recognised in time. What should the doctor do?

Scenario 3

Someone dies after being inside an MRI machine. Nobody knows why. A few months later, someone else dies. These people represent only 1 per cent of the patients examined using MRI. Should doctors stop using it until they find out what happened? What if this will take years?

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Using scientific language

Give a brief explanation of each of the following terms.

charge	newton	force
surface tension	friction	electron
gravity	buoyancy	mass
weight	air resistance	poles

Check your knowledge

1 For each type of motion listed below, discuss how it might have been produced and whether the cause would have been a push, pull or twist.
   a The movement of the hands of a mechanical clock.
   b The flight of an arrow.
   c The circular motion of an egg-beater.
   d A bicycle freewheeling down a slope.
   e The upward movement of an elevator.
   f An artificial satellite orbiting the Earth.
2 Explain why you don't have to know the difference between mass and weight in order to run a supermarket on Earth. Would you need to know the difference if you were in charge of providing supplies to a colony on the Moon? Why?
3 a Explain how lightning occurs.
   b What is a 'lightning strike'?
4 'Friction opposes motion, but you can't have motion without friction.' Discuss this statement.
5 Explain why a wooden ship can be made to sink even though the ship is made of wood that floats.
6 Distinguish between a magnet and a magnetic object.
7 Why is the north pole of a magnet so called? Is this totally accurate?
8 Give two ways you could detect the presence of a magnetic field.
9 Explain how you could build your own compass.

Apply your skills

1 a Draw the magnetic field lines that you would find around a bar magnet and a horseshoe magnet. Indicate on each diagram where the magnetic field would be strongest.
   b Describe how you would determine what the field lines look like around a ring-shaped magnet.
2 You have two objects and you know that one of them is negatively charged. How can you find out whether the other object is negatively charged, positively charged or neutral?
3 Explain, using a series of cartoon pictures, why ships made of steel float.
4 Look at the photograph of skydivers in a free-fall descent on page 92. They are falling because the force of gravity is pulling them down.
   a What other force is acting on them and in which direction is it acting?
   b How do the skydivers control the speed at which they are falling?

Challenge yourself

1 a Take an empty plastic soft drink (PET) bottle and think of ways of crushing it. One way is to place increasing loads on the bottle until it gives way. Try this in two ways: applying the load on the side and on the top. Which requires the least force? Can you think of some way of measuring the force you used?
   b When you have some idea of the force required to crush the bottle, carry out the following activity. Put the bottle into very hot water for a few minutes, leaving the lid off. Screw the lid on tightly and plunge the bottle into a large basin of iced water.
   c What force crushed the bottle? Did the force come from inside or outside the bottle? Was the force greater or less than the force you applied to crush the bottle? Was it a push, pull or twist?
2 Fill a glass with water until it is overflowing. Slide a postcard over the top, making sure no air is trapped. Hold the glass in one hand and place the palm of the other on the card. Turn the glass upside down and carefully remove the hand placed against the card. What force is holding the water in the glass?
3 Devise and carry out an experiment to test whether the repulsion between two south poles is the same strength as the repulsion between two north poles. Your report should include a diagram of the experimental set-up and a table of results.

Tester

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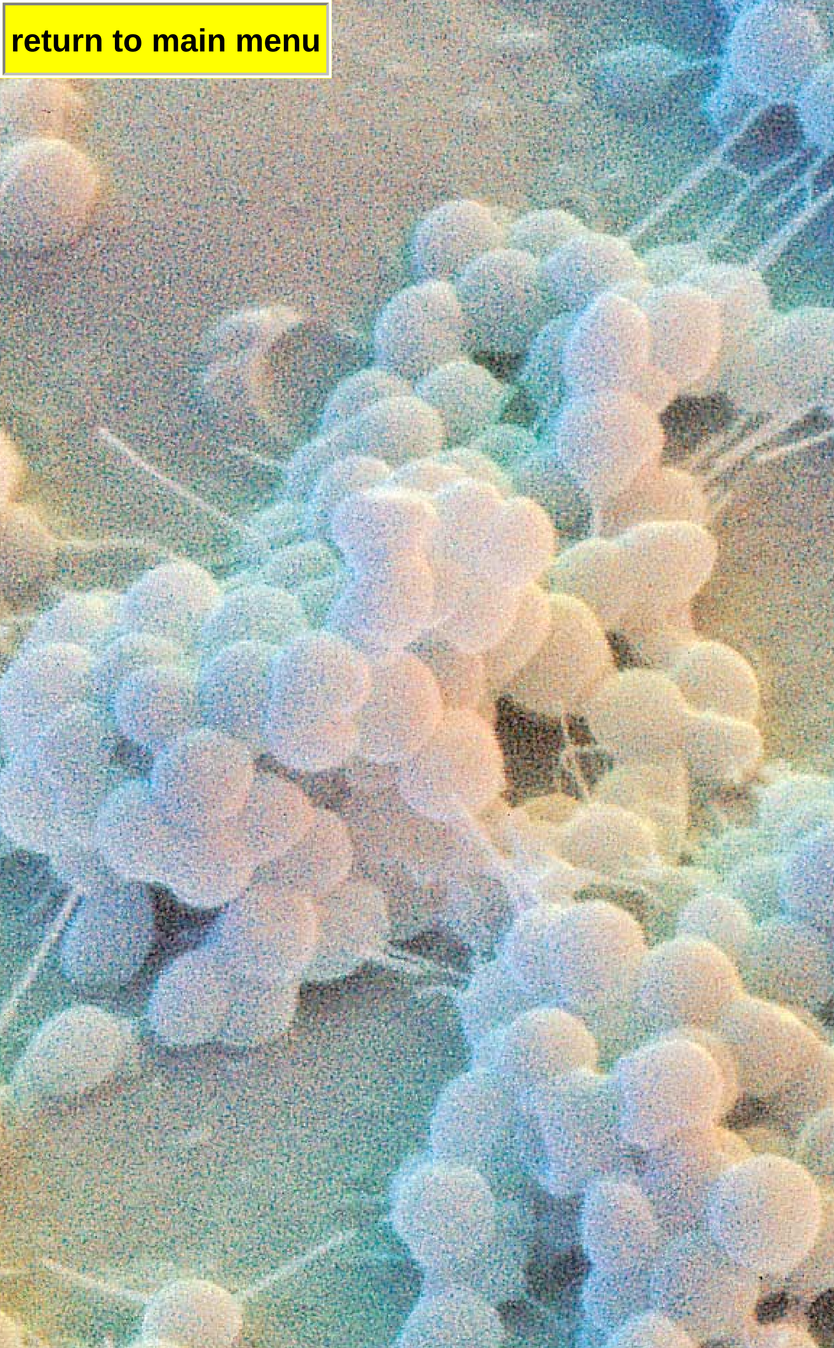

CHAPTER 6

CELLS—THE UNITS OF LIFE

No matter where we go we are never completely alone. Our skin provides a comfortable home for a wide variety of life forms. They are too small to see without the aid of a microscope.

The largest of these microscopic inhabitants are the hair follicle mites which live in the roots of our eyelashes and body hair. No one really knows why they live on us but they appear to cause us no harm. Growing in the moist regions of our skin are microscopic yeasts and fungi. These inhabit our skin soon after birth and stay with us until we die.

The smallest of our fellow travellers are the bacteria. These normally harmless creatures inhabit the oil and sweat glands in moist folds, underarms and between fingers and toes.

No amount of washing and scrubbing can completely remove the microscopic creatures which call us home. In fact we rely on them to destroy harmful micro-organisms which our skin may come in contact with.

In this chapter you will learn how to use microscopes and observe the microscopic building blocks which make up all life.

Web links

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Explain the cell theory and link its development to that of microscopes.
- Use a light microscope to observe cells and identify cellular structures.
- Draw diagrams of cells and tissues seen under the microscope.
- Identify and give the function of cell structures.
- Outline how specialised cells are organised in multicellular organisms into tissues, organs and systems.
- Recognise that cell division results in growth, replacement and repair of body tissues and that uncontrolled cell division can result in cancer.

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6.1 HISTORY OF SCIENCE

SCIENCE IN FOCUS

The discovery of cells

Every living thing on Earth is made up of **cells**. Small living things, like bacteria, may be made up of only one cell. Larger living things, such as trees and humans, are made up of billions of cells. Cells are the basic units of life.

There are many different types of cells, but they all have some things in common. Firstly, most cells are very small. Because we can only see them with a **microscope**, we say that they are **microscopic**.

FIGURE 6.1
Robert Hooke was the first person to describe cells after looking at thin slices of cork under a microscope in 1665. He thought the box-shaped structures looked like the cells (rooms) used by monks in monasteries, so he called them **cells**. The cork 'cells' that Robert Hooke studied were really the empty cell walls left behind after the cells of the tree had died.

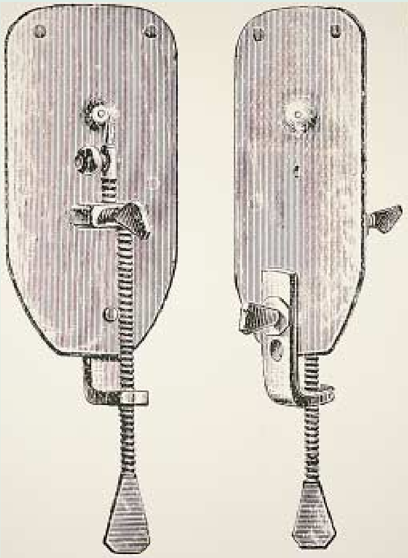

FIGURE 6.2
The Dutchman Anton van Leeuwenhoek was a highly skilled maker of microscopes and a careful and inquisitive observer. He was, in fact, the first person to observe bacteria under the microscope. His discovery opened up a whole new world of investigation to scientists.

Our knowledge of cells has been built up over hundreds of years. However, cells could not have been discovered until the invention of the magnifying glass (lens) and the microscope. These devices gave people the ability to see these tiny objects. The first microscopes were probably invented around 1600 by two Dutch spectacle makers, Hans and Zacharias Janssen. The first two-lens microscope was built in 1665 by an Englishman, Robert Hooke. Hooke's microscope could magnify 30 times. He used this microscope to look at many things including a thin slice of cork. He thought the box-shaped structures looked like the cells (rooms) used by monks in monasteries, so he called them cells. In 1675, another Dutchman, Anton van Leeuwenhoek, used a very simple microscope to find living things in ditch water. He described these living things as 'little beasties'. Today we call these creatures protozoa.

Anton van Leeuwenhoek's microscope could magnify 270 times so he was able to see creatures even smaller than protozoa. He found yeast cells and in 1683 he was the first person to observe bacteria.

Over the next 200 years many improvements in lenses and microscope design were made. Early scientists began to study plants and animals in detail. They found cells everywhere they looked. Soon scientists began to believe that all living things were made of cells. Around the same time two German scientists published their ideas about cells. Matthias Schleiden and Theodor Schwann developed the **cell theory** after making many careful observations and taking into account the work of other scientists.

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The cell theory states that:

- all living things are made up of one or more cells
- cells are the basic units of structure and function in living things
- all cells come from only other living cells.

By the 1860s Ernst Abbe had designed a microscope which is much the same as the modern microscopes in use today. New techniques to slice very thin sections of living things and colour them with dyes allowed further discoveries to be made. At the same time, Rudolf Virchow showed that 'all cells arise from other cells'.

The invention of the **electron microscope** in 1931 has allowed the greatest advances in our knowledge of cells. This type of microscope passes electrons instead of light through a very thin slice of an object. The electrons are 'seen' as a picture on a television screen. Another type of electron microscope called the scanning electron microscope was developed in 1965. This allowed objects to be viewed in three dimensions. With these microscopes scientists can study even the smallest details of a cell, and can discover things that have never been seen before.

FIGURE 6.3
The electron microscope.

USING SCIENCE 1 — A TIMELINE IN THE STUDY OF CELLS

Below is a list of some important dates in the study of cells.

TABLE 6.1 Milestones in the study of cells.

Date	Event
1590	H. Janssen invented the first microscope.
1665	Robert Hooke saw cells in cork. First used the name 'cells'.
1676	Anton van Leeuwenhoek saw bacteria in tooth plaque.
1838	Matthias Schleiden stated that 'all plants are made of cells'.
1839	Theodor Schwann proposed the cell theory.
1858	Rudolf Virchow found that cells were able to reproduce.
1860	Ernst Abbe invented the first modern microscope.
1865	Louis Pasteur found that bacteria caused disease.
1931	Knoll and Ruska made the first electron microscope.
1942	Viruses first seen under an electron microscope.
1973	First successful genetic engineering experiment.
1978	First baby born due to in vitro fertilisation (IVF).
1980 to date	Further advances in genetic engineering and IVF.

WHAT TO DO

1 Using A3 or poster-size paper, draw a timeline from 1500 to the present year and divide the line into 50-year intervals.
2 Place the events from the table along your timeline.
3 Find out more about some of the events or people listed and add the information to your timeline.
4 Add relevant pictures, drawings or newspaper clippings to your timeline.
5 Display your poster in your classroom when it is finished.

EXTENSION

See if you can find out about any other important dates in the study of cells and add them to your timeline.

Web page

Questions

1 What is the cell theory?
2 How did cells get their name? Who gave them this name?
3 Why do you think the history of the microscope is often linked to the history of cell theory?
4 Why do you think the scientists who first saw cells wanted more powerful microscopes?

Think about

1 A theory is an idea or explanation that is supported by a great deal of evidence. It is not a fact. Why do you think the cell theory is referred to as a theory? Do you know any other scientific theories?
2 Apart from hair and nails, can you think of any other parts of our bodies that are not made up of cells?

FACT FILE

The photographs produced from electron microscopes are called photomicrographs.

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6.2

Using a microscope

FIGURE 6.4
The modern light microscope is the type commonly used in school laboratories. These microscopes use a source of light to illuminate the object being studied.

Talk about

Collect a microscope. Compare it with the one in Figure 6.4. In what ways is it similar? In what ways is it different?

Today the microscope is one of the most important instruments used by scientists, particularly biologists. Microscopes have allowed us to discover many things: identifying which bacteria or viruses are responsible for a particular disease; examining evidence to determine whether a suspect is guilty of a crime; and enabling infertile couples to have children through in vitro fertilisation.

Most modern microscopes are **compound light microscopes**, which can magnify to approximately 1000 times. They work by shining light through the object.

For this reason objects viewed under a compound microscope must be very thin and flat. The object is placed on a glass slide, usually in a drop of water, then covered with a very thin piece of glass called a coverslip.

USING SCIENCE 2 GETTING TO KNOW YOUR MICROSCOPE

Microscopes come in various shapes and sizes. However, all microscopes are made of the same basic parts.

1 Collect a microscope. Make sure you carry it with both hands, one under the base and the other around the handle. Place the microscope on your bench away from the edge.

2 Examine your microscope carefully and use Figure 6.5 to find each of the labelled parts. Can you work out what each part is for?

3 Table 6.2 contains a description and a function for each part of the microscope but they are all mixed up. Unjumble the information and write the corrected table into your workbook.

DISCUSSION

Compare your completed table with another group. Discuss any differences.

TABLE 6.2

Name of part	Description	Function
Eyepiece lens	flat bottom surface	holds the slide in place, letting light pass through it
Objective lenses	flat platform to sit slide on, has a hole in its centre, may have clips	adjusts the position of the lenses so that the object can be seen clearly; can be coarse or fine
Focus knob	round with a shiny surface	bends the light to make the object appear bigger
Base	knob which can be turned to move the lenses	can be used to get different magnifications
Mirror	single lens closest to where the eye is placed	supports the microscope
Stage	lenses of different lengths which can be positioned above the slide	reflects light up through the slide into the lenses

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Foundation worksheet 1

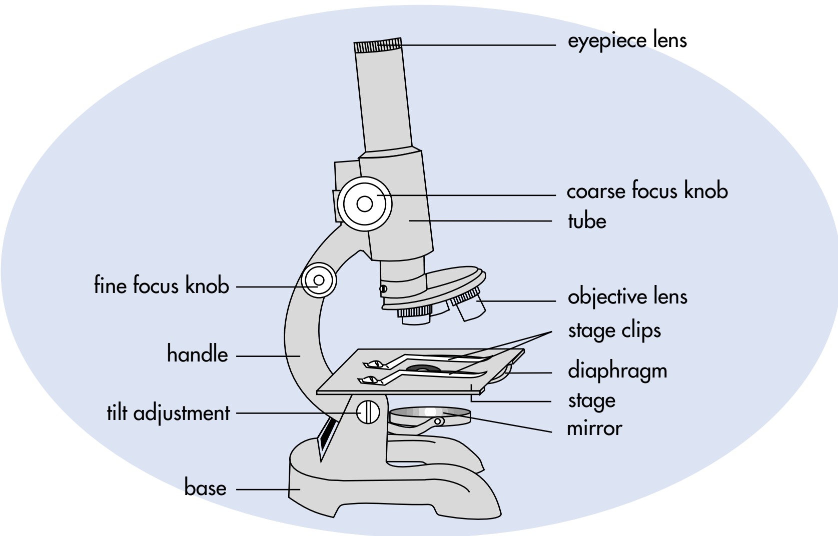

FIGURE 6.5
Microscopes vary. Some have more parts such as diaphragms and in-built lamps.

USING SCIENCE 3 — SETTING UP AND USING A MICROSCOPE

WHAT YOU NEED

- compound microscope
- prepared slide

PART A

1 Place the microscope near a light source. (Do not place it in direct sunlight.)
2 Rotate the objective lenses so that the smallest is in place above the stage.
3 While looking down through the eyepiece lens adjust the mirror so that bright light is reflected up into your eye. Your microscope is now ready to use.

PART B

1 Place the prepared slide so that the object on it is in the centre of the hole in the stage. Use the stage clips to hold it in place.
2 Watch from the side while you use the coarse focus knob to lower the objective lens over the slide until it almost touches it.
3 Look through the eyepiece lens and turn the coarse focus knob upwards until the object on the slide comes into focus.
4 Adjust the fine focus knob (if your microscope has one) until you have a sharp picture.
5 Draw what you see in your workbook.

Questions

1 Why are microscopes needed to study cells?
2 What are some of the things microscopes have allowed scientists to discover?
3 Why is it necessary to use both hands to carry a microscope?
4 What could go wrong if you lowered an objective lens downwards while looking through the eyepiece?

Find out

How can you use a microscope to view a slide using high-power magnification? Find out then try it.

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6.3

Size and magnification

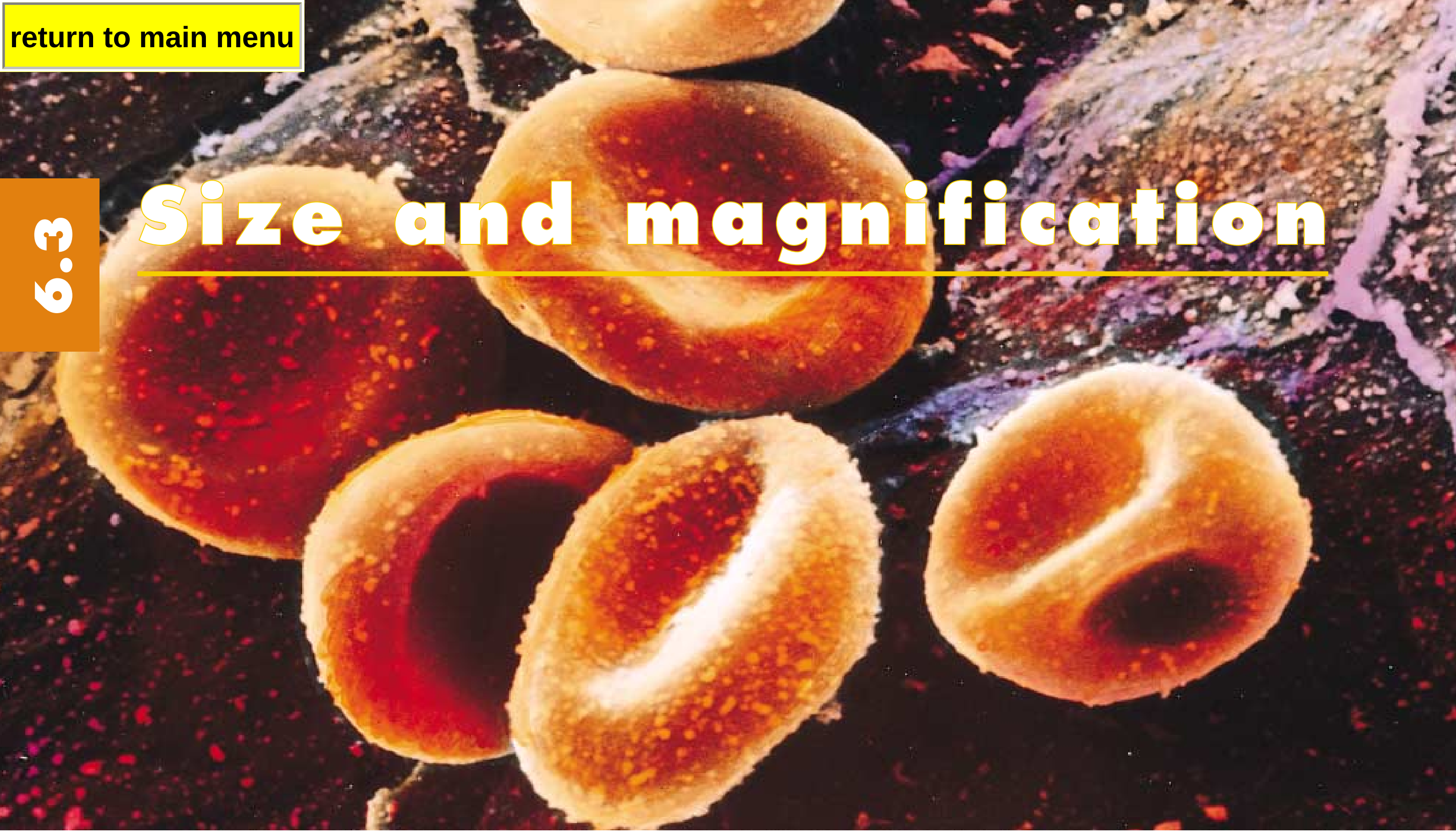

FIGURE 6.6
Red blood cells are quite small, about 5 µm in diameter. They are so small and numerous that there are about 5 000 000 in a millilitre of blood. An average adult has 6 litres of blood. How many red blood cells are there in an average adult?

FACT FILE

How small is the smallest object your eyes can see? The answer is about 0.1 millimetre (100 micrometres).

Cells vary in size from the smallest bacteria which are one-thousandth of a millimetre in diameter, to large nerve cells of over a metre in length. To measure cells, we use a unit called the **micrometre (µm)**. One micrometre is one-millionth of a metre, or one-thousandth of a millimetre. Bacterial cells are about 1 micrometre across; human skin cells are about 50 micrometres across.

Until microscopes were invented, people knew very little about the cells that make up all living things.

EXPERIMENT 1 MICROSCOPE MAGNIFICATION

AIM
To become familiar with the use of a microscope.

MATERIALS
- light microscope
- tweezers
- clear plastic ruler
- tissue
- writing paper
- 'mini grid' (optional)
- clean slides and coverslips
- hair
- newspaper
- cotton wool
- fabric

A HOW BIG IS IT REALLY?

METHOD
1 Place a clear plastic ruler on the stage of your microscope so that you can focus on the millimetre scale. Once you have focused your microscope, everything you can see is described as being in your **field of view**.

2 Using your low-power objective lens, measure the width of your field of view.

3 Using your high-power objective lens, measure the width of your field of view. How does it compare to your field of view using the low-power objective lens?

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EXPERIMENT 1 CONTINUED

4 Work out the magnification of your microscope when using the low-power and high-power lenses.
Note: To work out the magnification of your microscope, multiply the magnification of your eyepiece lens by the magnification of your objective lens. For example, if your eyepiece lens is labelled '×10' (meaning that it magnifies objects 10 times) and your objective lens is labelled '×20' (meaning that it magnifies objects 20 times), your total magnification is $10 \times 20 = 200$ times.

EXTENSION

Your teacher may have a 'mini grid' that you can use to estimate the size of what you see under the microscope. Learn how to use the mini grid and then estimate the width of a strand of your hair. If you don't have a mini grid, use the plastic ruler or the size of the field of view to make an estimate. Is it the same width as other people's hair? Is dark hair thicker than blonde hair?

B UPSIDE-DOWN OR BACK-TO-FRONT?

METHOD

1 Place a piece of newsprint on a microscope slide.
2 Using the low-power objective lens, focus on the letter 'e'.
3 Describe the image you see compared to the original letter. Is it bigger or smaller? Is it right-side-up, upside-down or back-to-front?
4 Draw what you see in a large diagram with pencil.

Note: When you draw something you have seen through a microscope, you should always label your diagram and include the magnification of the microscope. Things look very different under a microscope, and we may not always recognise them. An example is given below.

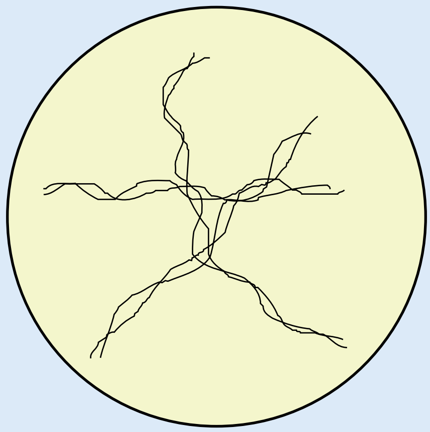

FIGURE 6.7
A sample diagram of cotton thread magnified 150 times.

EXTENSION

Now look at some other specimens such as tissue, cotton wool, coloured paper or fabric. Make neat diagrams of what you see.

Questions

1a How many micrometres are there in a millimetre?
b If a cell is 50 μm in diameter, how big is it in millimetres?
c Would we be able to see such a cell without a microscope?
2 List three ways in which the image seen under a microscope is different to the original object placed on the stage.
3 What is the 'field of view' of a microscope? How can it be used to estimate the actual size of objects placed under the microscope?
4 What was the greatest magnification you were able to obtain with your microscope in the experiment? Explain how you calculated it.

Think about

Explain how a microscope could help to solve a crime. You could present your answer in the form of a detective story.

Word process

Glossary

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6.4 Inside plant and animal cells

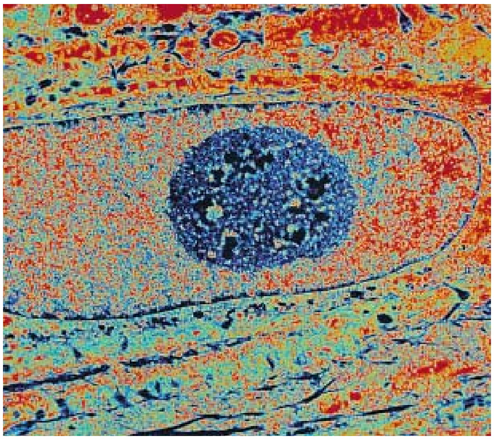

FIGURE 6.8
A photomicrograph of a human skin cell.

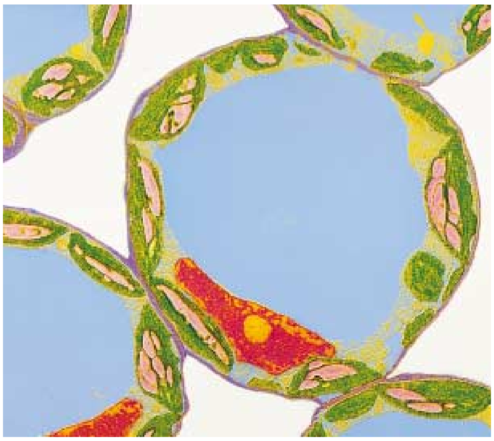

FIGURE 6.9
A photomicrograph of a plant cell.

FACT FILE

Red blood cells do not have a nucleus. This means that they only live for a short time (120–130 days), and die at the rate of 2 000 000 per second. New ones are made at the same rate.

Most cells can be classified as either animal cells or plant cells. Although cells are basically similar, there are some differences between animal and plant cells. This is because animals and plants do some things the same, but do many other things differently.

There are three main parts, or structures, in every cell which can be clearly seen using a light microscope:

- the cell membrane
- the nucleus
- the cytoplasm.

The **cell membrane** is the thin layer that surrounds each cell. It protects the contents of the cell and gives the cell its shape. A cell membrane controls what enters and leaves the cell.

The **nucleus** is the 'control centre' of the cell. It is surrounded by a **nuclear membrane** which holds the contents of the nucleus together. Inside the nucleus are **chromosomes**. These chromosomes are made up of smaller units called **genes**. The genes carry the inherited information that is needed by both the cell and the whole organism.

The **cytoplasm** is a jelly-like liquid that fills up most of the space in the cell. The cytoplasm contains many smaller structures that carry out special functions in the cell. **Ribosomes** manufacture complex substances called **proteins**. Storage areas for food, water and wastes in the cytoplasm are called **vacuoles**. The **mitochondria** are the parts of the cell where energy is produced in a process known as respiration.

Animal and plant cells

Plants make their own food using light, carbon dioxide from the air, and water. This process is called **photosynthesis**. Photosynthesis happens in structures called **chloroplasts** using a green chemical called **chlorophyll**. Plant cells also have tough cell walls surrounding their cell membranes. These **cell walls** give plants the strength to support themselves, since they do not have skeletons like some animals. Cell walls contain a tough, fibrous material called **cellulose**.

Glossary

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Foundation worksheet 2

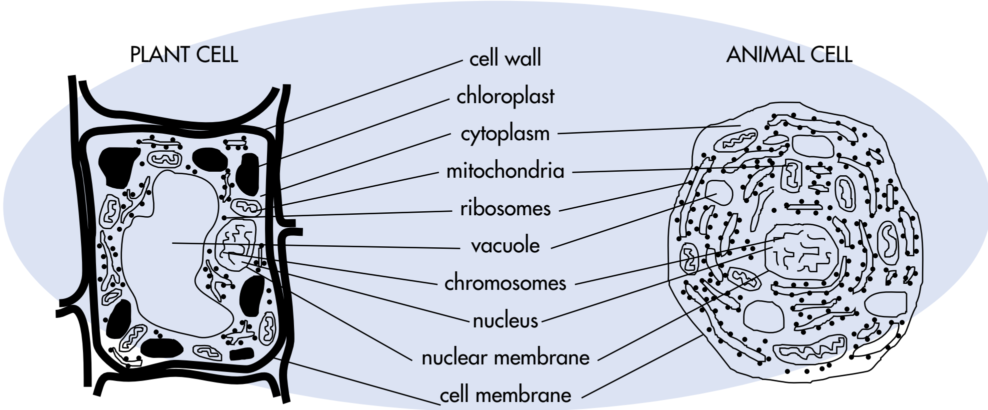

FIGURE 6.10
A typical animal cell and a typical plant cell contain many of the same structures. The parts of cells that can be clearly seen using a light microscope are the nucleus, cytoplasm and membrane. In plant cells the cell wall, chloroplasts and vacuoles can also be seen.

EXPERIMENT 2 COMPARING PLANT AND ANIMAL CELLS

AIM
To compare prepared slides of plant and animal cells under the microscope.

MATERIALS
- microscope
- prepared slides of various animal and plant cells (leaf, root, algae, bladder, blood, intestine)

METHOD
1 Look at two types of plant cells and two types of animal cells under the microscope.
2 Copy the table opposite into your book.
3 Based on the slides you have looked at, and using any pictures in this chapter, complete the table indicating the structures that are present in each type of cell.

Part	Animal cell 1	Animal cell 2	Plant cell 1	Plant cell 2
Cell wall				
Cell membranes				
Cytoplasm				
Vacuole				
Chloroplast				
Nucleus				
Mitochondria				

EXTENSION
Make a fully labelled, three-dimensional model of a cell using materials you can find at home. Present your cell to the class.

Multimedia

Questions

1 What cell parts are found in both animal and plant cells?
2 Name two cell parts found only in plant cells.
3 What substance gives plants their green colour? What does this substance do?
4 What is the function of each of the following parts of cells?
a mitochondria
b ribosomes
c vacuoles

Think about

1 What would happen to a cell if:
a its cell membrane burst?
b its nucleus was damaged?
2 Imagine that you have been made so small that you can fit through a hole in a cell membrane. Write a story called 'Journey to the Centre of the Cell' in which you describe what you see on such a journey.

FACT FILE

Cellulose is so 'chemically tough' that animals cannot digest it. Cows and other plant-eating animals need special bacteria in their intestines to do the job.

Glossary

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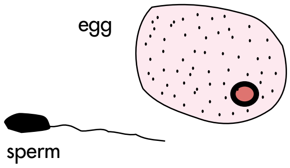
6.5

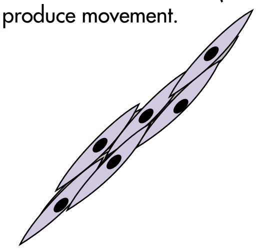
Animal cells in focus

FIGURE 6.11
Some of the cells found in our bodies, and in the bodies of many other animals.

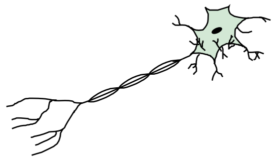
Sex cell
Male sex cells are called sperm. Female sex cells are called eggs or ova. Sex cells combine during reproduction to form a new organism.



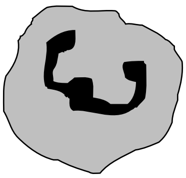
Muscle cell
A muscle cell can contract (shorten) to produce movement.



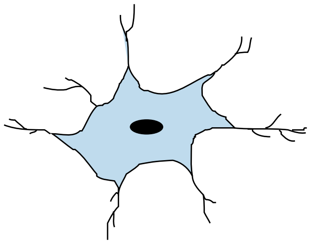
Motor nerve cell
A motor nerve cell controls movement. It passes a message from the brain to a muscle.



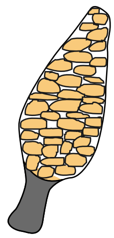
White blood cell
White blood cells help to fight disease. Some move about in the body to 'swallow up' bacteria.



Brain cell
A brain cell makes electrical messages which it passes to other cells through its many connections.



Goblet cell
Goblet cells are shaped like wine glasses, as the name suggests. They make mucus to lubricate and help protect our intestines, stomach and windpipe.



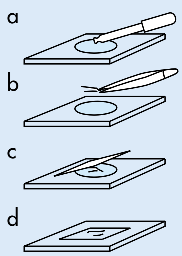
Animals are made up of many different types of cells. These cells have different functions, and generally look quite different.

EXPERIMENT 3 PREPARING A WET MOUNT

AIM
To investigate the animal (and plant) life in a sample of fish tank water, pond water or creek water by preparing a wet mount.

MATERIALS
- grass
- dropping pipette
- microscope
- slide and coverslip
- beaker
- threads of cotton wool
- microscope lamp
- tweezers
- water sample from fish tank, pond or creek

METHOD
1 Place the grass and water sample into a beaker.
2 Let the beaker and contents stand in a warm place for about two weeks.
3 Prepare a wet mount as shown in the diagram.
4 Look at your wet mount under a microscope.



a Clean slide well, then place a drop of prepared water on slide
b Place threads of cotton wool on the water drop (these trap the organisms, making observation easier)
c Gently lower coverslip so no air bubbles get trapped

FIGURE 6.12
Preparation of a wet mount.

5 Draw fully labelled diagrams of each organism you see.

DISCUSSION
1 Identify each organism as an animal or plant, giving reasons for your choice.
2 Use your library resources to identify the organisms you have collected.

Glossary

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Extra worksheet

What do cells do?

Cells are in fact quite complex things, and they can perform a wide range of tasks. Here is a list of some of the things they do.

- They take in nutrients and carry out chemical reactions.
- They produce waste products.
- They make useful substances such as hair and bone.
- They can reproduce by dividing in two.
- Some special cells can move. For example, muscle cells contract, while sperm cells (and many single-celled organisms) can 'swim'.
- They exchange gases with their surroundings. For example, cells take in oxygen and give out carbon dioxide.

Everything a living organism can do is a result of the activities of its cells.

CASE STUDY 1 BOX JELLYFISH

Many animals have some unusual and unique cells. Jellyfish have stinging cells (called **nematocysts**) in their tentacles. One type of stinging cell contains a thread with a barb at one end. The barb contains a paralysing poison to help the jellyfish catch its prey. The barbed thread is fired when the cell is touched. Box jellyfish , or 'stingers', are common in the warmer waters around northern Australia and their stings cause intense pain.

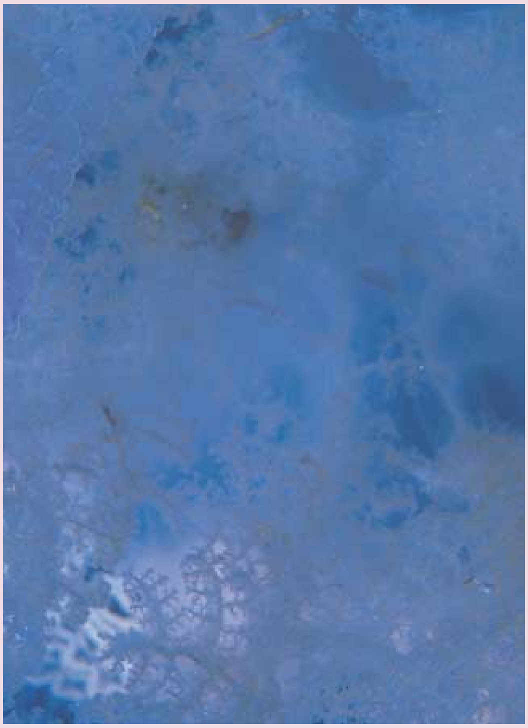

FIGURE 6.13
The stinging cells (nematocysts) from a box jellyfish.

Questions

1 Name six different types of cells in the human body and describe what each does.

2 How does the shape of a jellyfish's stinging cell help it do it's job?

3 How does a stinging cell help a jellyfish survive?

4 What is the function of white blood cells? How do some carry out this function?

Think about

1 What might there be inside muscle cells that helps them to contract?

2 Look at the picture of the motor nerve cell. How might its shape help it to carry out its function?

3 Why would there be many mitochondria in nerve and muscle cells?

Glossary

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6.6

Plant cells in focus

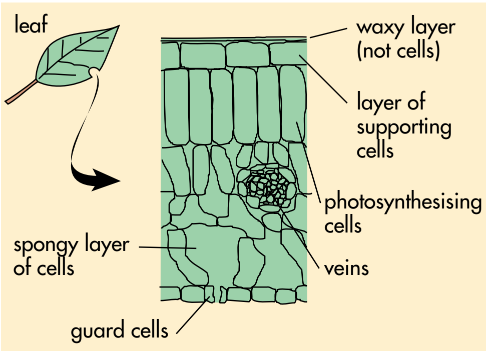
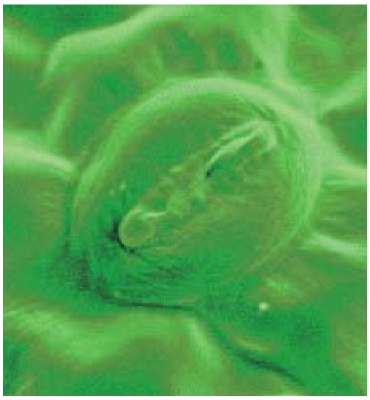
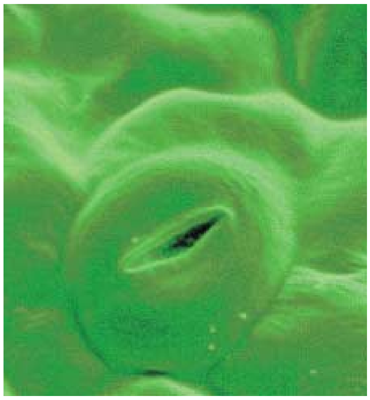


FIGURE 6.14
A cross-section of a leaf.





FIGURES 6.15 & 6.16
Closed (above) and open (above right) guard cells on the surface of a tobacco leaf. These cells control the amount of gases and water entering and leaving the leaves of the plant.

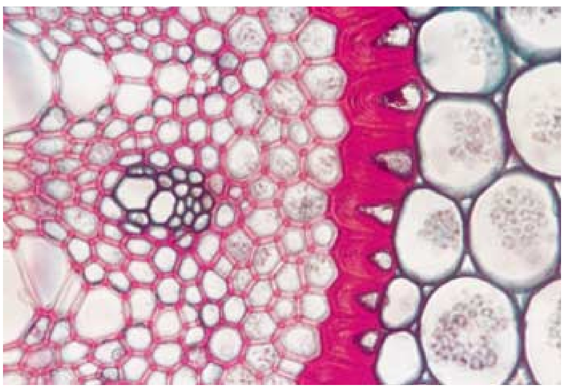


FIGURE 6.17
Small tubes, called the **xylem** and **phloem**, carry water and food around the plant. They can be seen in the leaves of the plant as veins.

Plants are made up of different cell types. Special cells in the leaves, stem, and roots help plants carry out different functions.

Leaf

The main function of the cells in a leaf is to make food by a process called photosynthesis. Most of the cells therefore have a large number of green chloroplasts.

Leaves also have special structures called **stomata**. These are openings found mostly in the lower layer of a leaf that allow gases to be exchanged between the leaf and the air. This is how the leaf obtains the carbon dioxide it needs for photosynthesis.

Two special cells called **guard cells** surround the opening of the stomata and control its size. When the stomata are open, the leaf can exchange gases but also loses water. When the stomata are closed, the leaf does not lose as much water but exchange of gases cannot take place.

Stem

In the stem of the plant are small tubes which carry water and food around. These continue into the leaves and are commonly called the **veins** of the leaf.

Roots

The function of roots is to take in water and nutrients from the soil. To help with this, some root cells are in the shape of fine hairs.

Plants also contain other special cells, such as the cells that make up the flower, and the plant's sex cells, called **pollen** and **ovules**.

Glossary

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Extension worksheet

EXPERIMENT 4 LOOKING AT PLANT CELLS

INTRODUCTION
Although onion cells do not photosynthesise, they clearly show many of the features of plant cells.

MATERIALS
- microscope slide and coverslip
- tweezers
- iodine
- onion

METHOD
1 Peel off a small piece of the clear 'skin' found between the layers of an onion.
2 Place the piece of skin on a microscope slide and add a drop of iodine. Lower the coverslip on top.
3 Look at the cells under the microscope.
4 Draw a few onion cells and label the parts that you can see.

DISCUSSION
1 Why is iodine used when observing onion cells?
2 What parts of the onion cell can you see clearly?
3 Write a report on how the onion cells look different to any of the animal cells you have seen.

EXTENSION
Examine other plant cells under the microscope. The following are some suggestions.
1 Cut a very thin cross-section of a plant stem and look at it under a microscope. Draw what you see.
2 Look at the underneath surface of a thin leaf under the microscope. Can you make out the guard cells?
3 Your teacher may have prepared a slice through a leaf. How many different cell types can you see?
4 Look at a small section of the root of a plant under the microscope. Can you see the root hairs?
5 Prepare a wet mount of 'pond slime' or another alga. Draw what you see. Can you find the nucleus?
6 Look at a variety of petals under the microscope.
a In what ways are the petals similar to each other?
b In what ways do the petals differ from each other?
c In what ways are the petals similar to other plant cells?
d In what ways are the petals different from other plant cells?

FIGURE 6.18
Roots help plants to survive by absorbing water and minerals from the soil.

Questions
1 What important function do most leaf cells carry out?
2 Describe the function of each of the following:
a xylem and phloem
b root cells
c chloroplasts
d guard cells.
3 Describe how you would make a wet mount of a strand of algae.
4 What are the advantages of staining cells prior to viewing them under a microscope? Can you think of any disadvantages in the use of stains? Make a list and compare it with that of another student.

Think about
Why do you think plants from hot, dry areas grow only very slowly?

FACT FILE
One centimetre of root can contain as much as 1000 centimetres (10 metres) of root hairs. This means the plant can absorb more water and nutrients from the soil.

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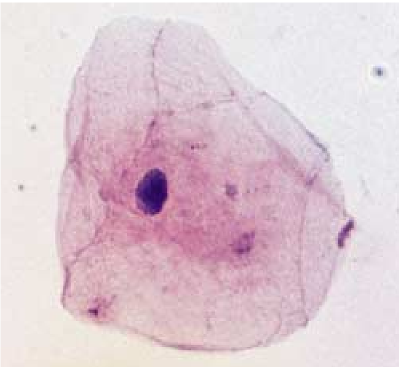
6.7

From cell to organism



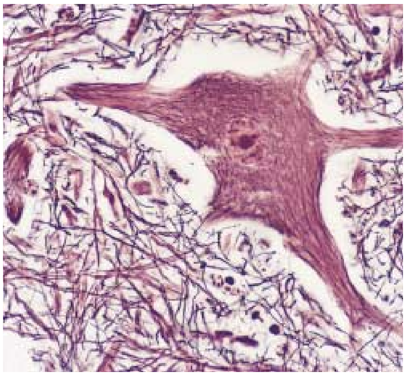


FIGURE 6.19 (above)
A human skin cell.

FIGURE 6.20
(above centre)
A human nerve cell.

FIGURE 6.21
(above right)
An onion 'skin' cell.

Cells

Most of the animals and plants you can see around you are made up of many, many cells. Some organisms, such as blue whales and kauri trees, contain billions of cells. Living things that are made up of many different types of cells are called **multicellular** organisms. Different types of cells have different structures which enable them to carry out specialised functions. We say that these cells are **specialised**.

Talk about

Compare the cells shown in the photomicrographs above. List the similarities and differences between them.

Tissues

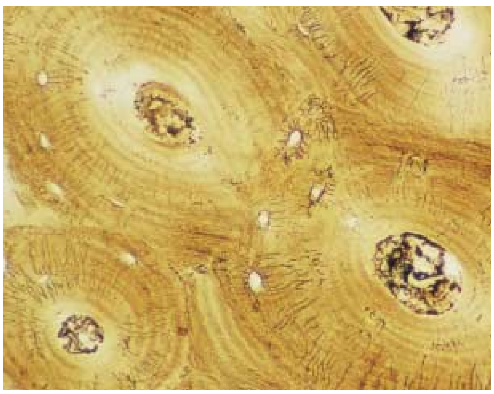
In multicellular organisms, similar cells work together in groups called **tissues**. The cells in a tissue all have a similar appearance and function. Animals, for example, have muscle tissue, nerve tissue, skin tissue and blood. In plants, special tissues transport water and minerals, and leaves contain a special skin-like protective tissue.

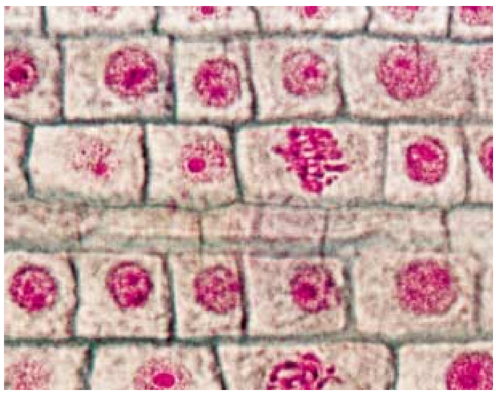
Talk about

Compare the animal and plant tissues shown in the photomicrographs below. List the similarities and differences between them.

FIGURE 6.22 (right)
A photomicrograph of human bone tissue.

FIGURE 6.23 (far right)
A photomicrograph of the root tip of a plant.





Glossary

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Organs

An **organ** is made up of different tissues working together to perform a particular function. For example, the stomach contains muscle tissue and gland tissue (to make the digestive juices), as well as tissues that form the outside lining. There are also blood vessels and nerves in the stomach lining. The brain, heart, liver and intestines are examples of other organs found in animals. Roots, leaves, stems and flowers are examples of the organs found in plants.

Systems

A **system** is made up of a group of organs that work together to perform a particular function or functions. One example, in animals, is the **circulatory system**. The function of the circulatory system is to move materials through the body. It consists of the heart, blood vessels, and the blood.

In plants, a transport system involving the roots, xylem and leaves moves water through the plant.

Organisms

The systems in an organism work together to help the organism survive. For example, the muscles (muscular system) cannot work unless they receive blood from the circulatory system. The blood supplies the muscles with oxygen, which has been taken in by the lungs (respiratory system). It also supplies nutrients that are used to make energy, and these have been obtained from the digestive system.

EXPERIMENT 5 LOOKING AT TISSUES

AIM

To investigate how cells group together to form tissues.

MATERIALS

Prepared microscope slides of any of the following:

- frog bladder
- intestine
- skin
- leaf
- plant stem sections

METHOD

1 Look at the animal and plant cell slides and try to count the number of different tissue layers.

2 Draw a fully labelled sketch of each prepared slide.

DISCUSSION

1 How did you tell the difference between the layers?

2 How difficult was it to identify the features of each slide?

3 Comment on any specialisations you noticed in any of the cells.

Questions

1 What is meant by saying a plant or animal is multicellular?

2 In multicellular organisms, cells display specialisation. Explain what is meant by cell specialisation, giving at least one example.

3 What is skin tissue?

4 What is an organ? Give examples.

5 What does a group of organs make up? Give an example.

Think about

1 What organs do you think make up the following systems in humans?

a the respiratory (breathing) system

b the digestive system

2 How do you think the tissues, organs and systems of a jellyfish would be (a) similar and (b) different to those of humans?

Glossary

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SCIENCE IN FOCUS

6.8

CURRENT ISSUES, RESEARCH AND DEVELOPMENT

Cancer: cells out of control

New body cells are made by one cell dividing itself into two. This is known as **cell division**. Our bodies continually make new cells for three main uses:

- **Growth:** The cells of an adult are no bigger than those of a newborn baby. Adults just have more of them.
- **Replacement:** Some cells (such as skin cells and red blood cells) grow old or wear out and need to be replaced.
- **Repair:** If the body is injured, the damaged cells need to replaced.

Normally, the body strictly controls the process of cell division: it only occurs where and when it is needed. Once the new cells have been made, the process 'switches off'.

In someone who has **cancer**, however, these controls do not operate. Cancer cells grow larger than normal cells, and divide more rapidly. They are abnormal and may have some parts missing or have unusual chromosomes. The cell surface is also altered. Cancer cells serve no useful purpose, and can spread throughout body tissues and whole organs. Some cells can break away from a cancer site, move through the body and set up cancers in other places. Eventually, healthy tissue becomes useless as the cancer invades. Some forms of cancer can be fatal.

Skin cancer

There are three main types of skin cancer. Basal cell carcinoma (BCC) accounts for 75% of skin cancers in Australia. They usually appear on areas of skin regularly exposed to the sun such as the face, neck and hands. Even though they are slow-growing cancers they should still be removed.

Squamous cell carcinomas (SCC) account for 20% of skin cancers in Australia. They occur mainly on the hands, forearms and upper parts of the face and are linked to too much exposure to the sun and certain cancer-causing chemicals called carcinogens.

Melanomas make up 5% of all skin cancers in Australia. This is the highest level in the world. Melanomas can appear on any part of the skin. This type of skin cancer is responsible for 80% of the deaths from skin cancer. Melanomas are linked to the overexposure to the UV radiation in sunlight, which occurs when people become sunburnt.

The only way to reduce your chances of getting skin cancer is to protect your skin by covering up with clothing, hats, sunglasses and sunscreen. It is also important to stay out of the sun in the middle of the day. Remember the 'SunSmart' message—'Slip, Slop, Slap'.

Internet assignment

Melanoma
- The most dangerous skin cancer.
- If untreated, cancer cells spread to other parts of the body.
- Grows over weeks to months, anywhere on the body.

Squamous cell carcinoma (SCC)
- Not as dangerous as melanoma but may spread to other parts of the body if not treated.
- Grows over some months.

Basal cell carcinoma (BCC)
- Most common and least dangerous skin cancer.
- Grows slowly, usually on the head, neck and upper trunk.

FIGURE 6.24
Common types of skin cancer.

Glossary

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EXPERIMENT 6 MAKE YOUR OWN ZINC CREAM

Caution: Zinc cream made in the laboratory should not be used on skin unless sterile equipment has been used.

AIM

To find out how chemists make the zinc cream we use on our noses to prevent sunburn.

MATERIALS

- 50 mL light liquid paraffin
- 10 g soft microwax
- 20 g zinc oxide
- large beaker
- thermometer (up to 100°C)
- hotplate
- stirring rod
- container with lid to store zinc cream
- non-toxic wax crayon (optional)

METHOD

1 Melt the paraffin and microwax in a beaker over a low heat. Use the thermometer to check that you don't go over 80°C. If you would like to make coloured zinc cream, add a small non-toxic wax crayon at this melting stage.

2 Remove the beaker from the heat when the wax is melted. Gradually add the zinc oxide, stirring well with the glass rod between each addition.

3 Allow the mixture to cool and transfer to a container.

USING SCIENCE 3 SUNSMART SURVEY

1 Design a survey form to find out who is being sunsmart and how people are protecting themselves. Decide which age groups you are going to survey, what type of questions you will ask and how you will collect this information.
You could investigate types of protection used, awareness of skin cancer and how to prevent it, understanding of the relationship between skin cancer and the sun.

2 After you have carried out your survey, display your results as tables and graphs.

EXTENSION

Encourage people to be 'sunsmart' by designing a colourful brochure showing how they can protect themselves from excess UV radiation. You may like to include pictures from magazines or newspapers showing well-known people using various forms of protection. You could include the latest in protective sunglasses as well.
Think about who you are aiming your brochure at. Is it for primary children, teenagers, or year sevens?

Questions

1 Why do cells divide? Give three reasons.

2 Describe in your own words what happens to cells when they become cancerous.

3 What is a carcinogen?

4 Look at Figure 6.24 then answer the following questions:

a Which type of skin cancer is the most dangerous? Why is it important to get this type attended to straight away?

b How long do each of the skin cancers take to grow?

c Which one grows most often where the skin is constantly exposed to the sun?

d Which skin cancer can grow anywhere on the body?

Find out

There are fears that the amount of UV radiation reaching the Earth's surface may be increasing because of damage to the ozone layer in the upper atmosphere. What is causing the ozone layer to be damaged and what are the long term consequences of increased UV radiation?

FACT FILE

Anyone with a suspicious skin marking should see his or her doctor immediately.

Glossary

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Using scientific language

Copy and complete these sentences.
A tissue is made up of a group of ___ ___ . An _____ contains a group of different tissues working together. Organs working together make up a _____ .

Check your knowledge

1 a Copy the following diagrams into your book and label the different parts.

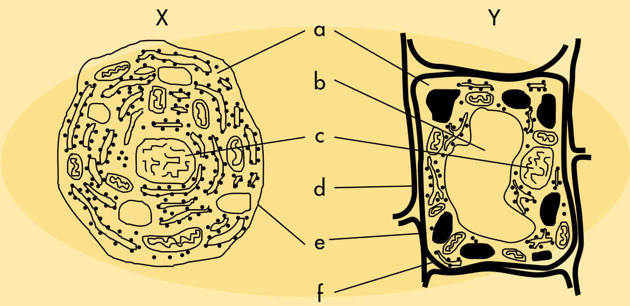

FIGURE 6.25
A plant cell and an animal cell.

b Which is the plant cell and which is the animal cell? Give reasons for your answer.

2 The part that controls what a cell does is the:
- a cytoplasm
- b membrane
- c nucleus
- d vacuole.

3 The process that happens in a chloroplast in a plant cell is called:
- a photosynthesis
- b growth
- c cell reproduction
- d movement.

4 Draw a light microscope and label its parts.

5 Answer the following questions as 'true' or 'false'.
- a Animal cells have cell walls.
- b A virus can be seen clearly only with an electron microscope.
- c Crystals are made up of cells.
- d Cells reproduce by dividing in two.
- e The average cell is about 1 millimetre across.
- f Light microscopes can magnify 3000 times.

6 Explain the differences between a cell, a tissue, an organ, a system and an organism.

7 Name the cell types shown in the following diagram.

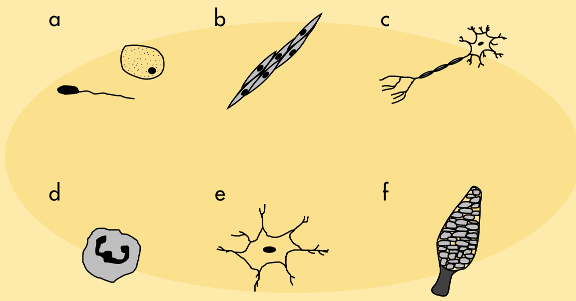

FIGURE 6.26

Apply your knowledge

1 A biologist was studying the parts of a cell. She removed the nucleus from a skin cell with a very fine pipette, and found that the cell died within a few hours.
- a What does this experiment show about the importance of the nucleus?
- b Could anything else have caused the death of the cell?

2 A certain type of cell is 50 micrometres wide. How many cells placed side by side would fit along a 2 centimetre line?

3 Why can the skin be described as an organ rather than a tissue or a system?

4 a If our eyes can see things as small as 0.1 millimetre, and a cell is one-tenth of this size, what is the size of the cell in micrometres?
b If the cell was magnified 1000 times, how big would it appear?

5 A student was using a light microscope to look at some plant cells. She was using a 5× eyepiece lens and a 40× objective lens.
- a How many times is she magnifying the plant cells?
- b If she changed to the 100× objective lens, would she see more or fewer plant cells? Explain your answer.

Challenge yourself

1 Some scientists (cytologists) study life processes by growing and observing cells in a laboratory. Find out how cell cultures are maintained and what scientists can learn by studying them.

2 Collect hydras, planarias and other small organisms from a pond or stream. Find out how to care for and feed them. Observe the organisms under a microscope. Keep a record of your observations.

e Tester

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CHAPTER 7

CLASSIFYING LIVING THINGS

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Distinguish between living and non-living things.
- Describe how scientists classify things into groups using different criteria.
- Recognise that living things are classified according to structural features and that they have patterns of similarity and difference.
- Devise and use a range of keys to identify living things.
- Recognise that living things can be divided into five major kingdoms: Plant, Animal, Fungi, Protista and Monera.
- Define the term species and explain the use of scientific names for species.
- Explain how micro-organisms can be both beneficial and harmful to humans.

Planet Earth is teaming with life. Scientists have described and named over 1.8 million species (different kinds of living things). However, they believe there are still millions of species not yet discovered. Imagine what it would feel like to discover a new species and maybe even have it named after you. This is exactly what happened to David Noble while bush-walking in the Wollemi National Park.

David Noble has a good general knowledge of Australian plants but he did not recognise the small group of trees growing in a dark narrow canyon. They looked prehistoric compared with the other trees in the area. The trees' trunks were covered with a brown knobbly bark similar in appearance to 'Coco Pops'. The foliage was also very different, with small leaves arranged in four rows along the length of each branch.

Plant experts soon realised that a unique find had been made. The only time scientists had seen plants that looked like this was in fossils over nine million years old.

In this chapter you will learn about the great variety of life on Earth and how scientists classify and make sense of the huge numbers of living things.

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7.1 Signs of life

FIGURE 7.1
The Great Barrier Reef is famous for its coral and huge variety of fish.

Talk about
Classify the things in this photograph as living or non-living.

All organisms are made up of one or more **cells**, and every cell comes from another cell. (See Chapter 6, Cells—The Units of Life.) Cells are found only in **living** things or things which were once living. **Non-living** things are not made of cells.

USING SCIENCE 1 COMPARING LIVING AND NON-LIVING THINGS

What do you already know about living and non-living things?

1 Copy this table into your book and use the symbols shown in the legend to indicate whether the feature is present or absent in each example.

Example	Needs food	Grows	Reproduces	Can move	Needs oxygen	Gets rid of wastes	Responds to changes in the environment
Feather							
Koala							
Wood							
Car							
Grass							
Crystals							
Pine cone							
Bacteria							

Legend ✔ = present ✘ = absent

2 Biologists call living things **organisms**. This could refer to an individual plant, animal or microbe. Which examples in your table do you think are living? Which do you think are non-living? How can you tell the difference?

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Foundation worksheet 1

What do living things do?

Living things can do certain activities that set them apart from non-living things. A living organism can move, respire (use oxygen), grow, reproduce, excrete wastes, be sensitive to changes in their surroundings and need food.

Non-living things may have only one or two of these characteristics.

Movement: People run, kangaroos hop, fish swim, birds fly, even sunflowers respond to sunlight by turning to face the sun as it moves across the sky. Most living things are capable of moving part or all of themselves.

Respiration: When an animal **respires**, its body uses the oxygen it takes in. It needs this oxygen to obtain energy from the food it eats. Like animals, plants also respire. Although they can produce their own food, plants still require oxygen.

Sensitivity: Animals and plants respond to changes in their environment in particular ways. These responses help the organism to survive.

Growth: All organisms grow. Sometimes growth simply means getting larger. A small palm frond will grow into a larger palm frond. In other cases, however, growth involves more substantial changes.

Reproduction: The process by which organisms produce more organisms like themselves is called **reproduction**. All organisms can reproduce.

Wastes: Excretion means getting rid of any wastes. Plants can do this through their leaves. Animals have special systems to do this for them.

Food: You, your dog, your favourite tree ... living organisms use their food by breaking it down into simpler substances. These provide the raw materials for growth and repair, and the energy to carry out all their daily activities.

FIGURE 7.2
Plants have feelings, too! Mimosa, a sensitive plant, curls its leaves up when you touch it.

Questions

1a What is an organism?

b How can you decide whether something is an organism?

2 Why are cells described as 'the basic unit of life'?

3 Is an apple seed living or non-living? Explain your answer.

4 Make a list of 10 objects which were once living or came from living things. For each object name the organism it came from.

5 A friend tells you that crystals are alive because they grow. How could you convince your friend that crystals are not living things.

Activity

Obtain an earthworm. Place it on damp paper. Examine it closely and write a description of its features. Carefully investigate the earthworm's response to touch (use tip of pencil), light (use a torch), and smell (use cloth soaked in vinegar). Test each end and the sides of the earthworm. Describe how the earthworm responds.

Which parts of the earthworm were most sensitive to touch, light and smell? Return the earthworm to a safe damp place when you have finished.

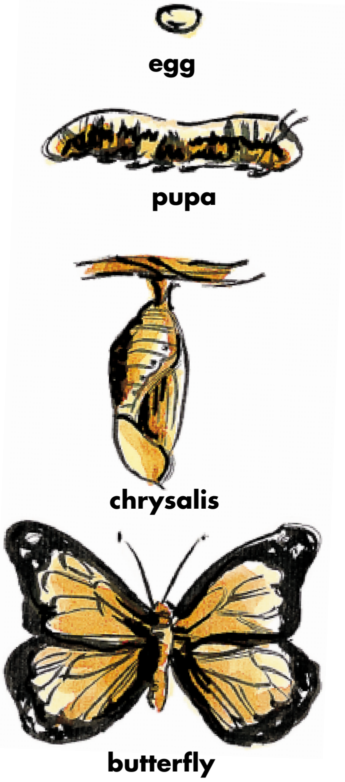

FIGURE 7.3
Butterflies grow and develop during their lifetime. As they develop, their appearance changes dramatically.

FACT FILE

Viruses cause diseases such as chickenpox and influenza. They are not made of cells. They can enter the cells of other organisms and multiply. Are they living?

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7.2 THE NATURE AND PRACTICE OF SCIENCE

SCIENCE IN FOCUS

Scientists classify

FIGURE 7.4
A geologist identifying rock types at Ross Island, Antarctica. Knowing the major features of different types of rocks helps place them into their correct group.

We are constantly trying to make sense of the world. We do this by making observations of the things around us. We try to organise our observations by looking for patterns, similarities and differences in things. It helps to group together things that are similar. This process of grouping together is called **classification**.

In everyday life many things are classified into groups for ease of use. The books in a library, the names in a telephone directory and the products in a supermarket are all organised so that similar items are together.

Scientists are always classifying. Whether it is rocks, clouds, stars, chemicals or living things, scientists sort things into groups. Classification is useful because all the members of a group have features (or characteristics) in common. Knowing the characteristics of one member of a group gives valuable information about the other members of the same group. For example, if we know that silver is classified as a metal because it is malleable, shiny and allows heat and electricity to travel through it, then we know something about all other metals.

Classification can also be used to help identify something. Scientists often use **keys** to help them sort and name things. A key can take the form of a branching diagram. At each branch a characteristic or question is given and the reader must make a decision about which direction to go next. When a key has a choice of only two directions at each branch it is called a dichotomous key.

USING SCIENCE 2 ORGANISING INFORMATION

1 Collect 20 different objects from around your school.
2 Combine your objects with those collected by three other people.
3 Look for similarities and differences in the collected objects. Choose one similarity or difference and sort all the objects into groups according to whether or not they have that characteristic.
4 Choose another characteristic and sort the objects according to it. How many different ways can you sort them?
5 List the characteristics you used to sort the objects. Compare them with those used by other groups.

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USING SCIENCE 3 ANALYSING INFORMATION

Taxonomists and biologists use **keys** to help them sort the objects they are studying into groups. Look briefly at the key below, then answer the questions.

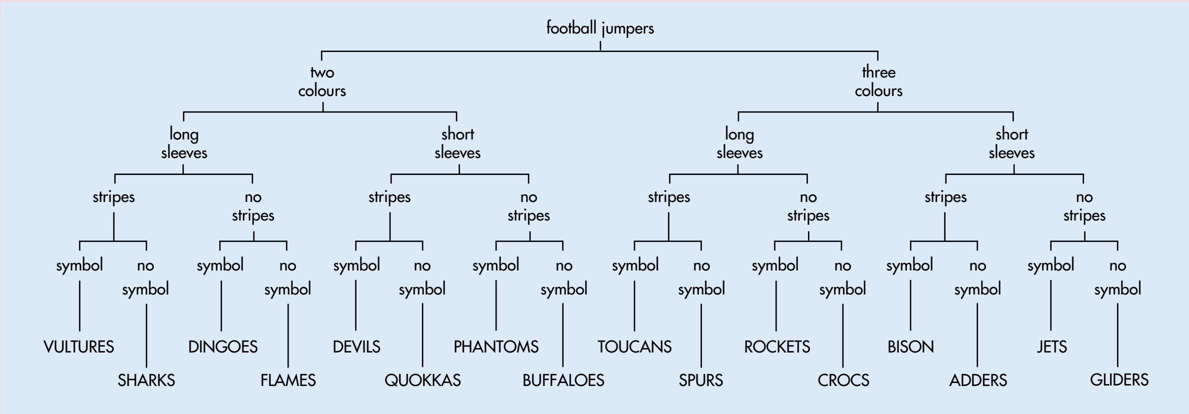

FIGURE 7.5
A key for football jumpers.

1 Use the classification key to identify each of the football jumpers in Figure 7.6.

2 Draw each of the following football jumpers:

a Dingoes **b** Bison **c** Jets
d Phantoms **e** Flames.

3 Choose 10 people in your class. Design a key like the one you just used so that each person can be classified individually.

FIGURE 7.6
Three football jumpers.

Questions

1 Write down three similarities and three differences between the following pairs of objects:

a a hot air balloon and a hang-glider
b a television and a telephone
c a paperclip and a staple
d a horse and a cow.

2 Which is the odd one out of each of these groups?

a length, mass, thermometer, time
b milk, lemonade, water, ice
c gold, diamond, emerald, sapphire
d waterfall, valley, lake, rapids

3 Look at Figure 7.7. Name all the types of cosmetics shown. Design a dichotomous key for identifying each type of cosmetic.

4 The following objects can be classified in a number of different ways. List the headings you would use to classify them. (There are at least three headings.)

soccer ball egg paper earth
marble Australian Rules football
book box football ground
computer monitor photograph
shot put coin rugby ball brick

Think about

1 Think of other examples where classification is used in everyday life.

2 What would life be like if we didn't classify things?

FIGURE 7.7

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7.3 Classifying living things

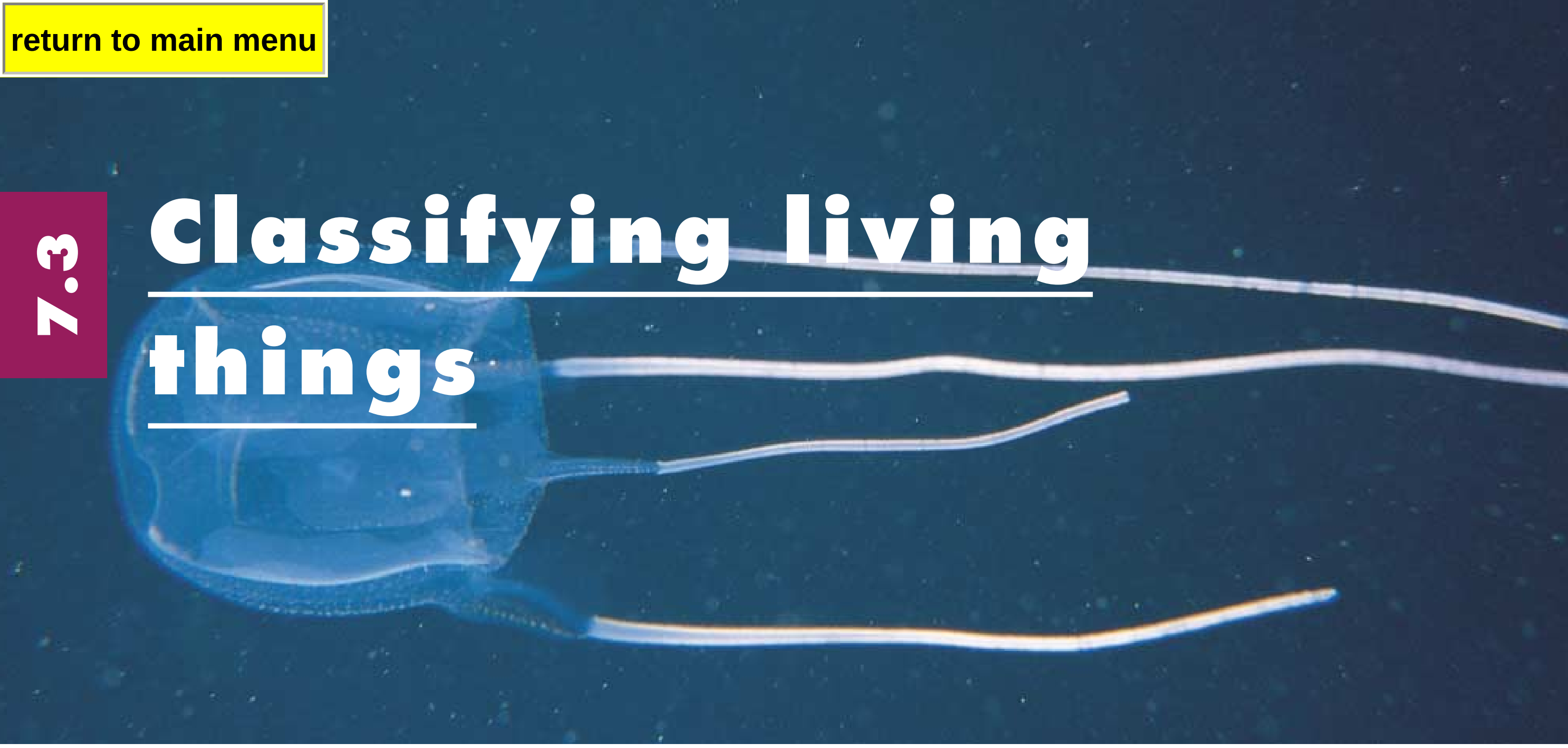

FIGURE 7.8 (above)
Jellyfish and worms are invertebrates that don't have an exoskeleton. They are supported by fluid that fills up the space under their skin. Puncture them and they'll deflate like a tyre.

FIGURE 7.9 (left)
Invertebrates such as beetles, crabs and spiders do not have backbones. They have an external shell or skeleton called an exoskeleton to provide them with support.

There is a great variety of organisms in our world. These organisms have some features in common but they also differ from each other in many ways. We can use these similarities and differences to arrange organisms into groups.

Taxonomists are scientists who classify living things into groups based on their similarities or differences. Classification enables taxonomists to summarise the common characteristics of a number of individuals.

TABLE 7.1

Kingdom	Characteristics	Examples
Animal	Feed on other living things for energy Cells have a nucleus but no cell wall	Jellyfish, dog, spider, human, magpie
Plant	Make their own food using light energy during photosynthesis Cells contain a green pigment called chorophyll and have cell walls	Grass, rose, moss, pine tree
Protista	Single-celled organisms which live in water Cells have a nucleus	Protozoa such as amoeba; algae such as diatoms
Monera	Single-celled organisms Cells have no true nucleus	Bacteria, blue-green algae
Fungi	Feed on other life forms for energy Cells contain a nucleus and a cell wall but they do not have chorophyll	Yeasts, moulds, mushrooms

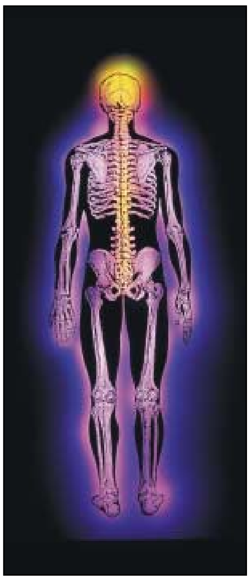

FIGURE 7.10
Humans are amongst the animals that have backbones (vertebrates). Less than 5 per cent of all animals are vertebrates.

The five kingdoms

Living organisms can be classified into five major groups, called **kingdoms**:
- animals
- plants
- monera (bacteria)
- protista (algae and protozoa)
- fungi.

To classify animals, taxonomists look at their structure; that is, how their body parts are arranged. The animal kingdom can be divided into two main groups:
- **invertebrates** (animals without backbones)
- **vertebrates** (animals with backbones).

Which group do you belong to?

To classify plants, taxonomists look at their structure and how they reproduce. The plant kingdom can be divided into two main groups:
- **bryophytes** (plants without true roots, stems and leaves)
- **tracheophytes** (plants with true roots, stems and leaves).

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USING SCIENCE 4 COMPARING PLANTS AND ANIMALS

WHAT YOU NEED

- a small flowering plant in a pot
- an animal such as a slater or a snail

WHAT TO DO

Draw a labelled diagram of each organism.

DISCUSSION

1 Compare the plant and animal as you answer each of the following questions.

a How do these organisms obtain their food, water and oxygen?

b How much movement is possible for the plant and the animal?

c How quickly can these organisms respond to changes in their environments?

2 Is the animal a vertebrate or an invertebrate?

3 Is the plant a bryophyte or a tracheophyte?

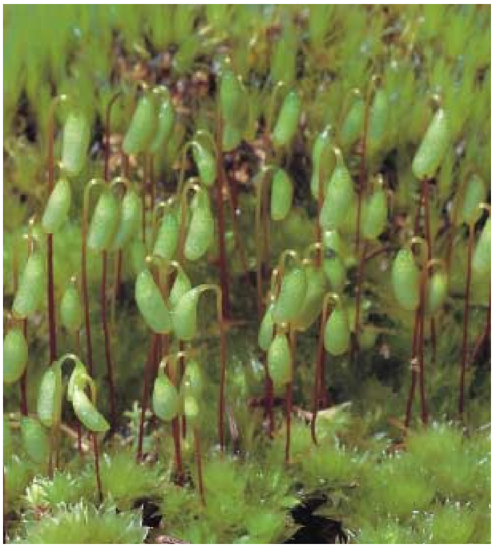

FIGURE 7.11
Moss has no true roots, stems or leaves. It is a bryophyte.

FIGURE 7.12
Trees have roots, stems and leaves so they are tracheophytes.

Questions

1 What do you think a taxonomist studies?

2 By placing the prefix ‘in’ before the word ‘vertebrate’ we change its meaning. Explain what is meant by the terms vertebrate and invertebrate?

3 Give two similarities and two differences between plants and animals.

4 Draw up a branching key to classify the following organisms into separate groups: a lizard, bread mould, a beetle, moss and a gum tree.

Think about

Why do we classify humans as animals?

FACT FILE

Carolus Linnaeus in 1737 suggested a system of classification where everything could be divided into the animal, vegetable and mineral kingdoms. The modern system of classification developed from his original idea.

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7.4

The animal kingdom

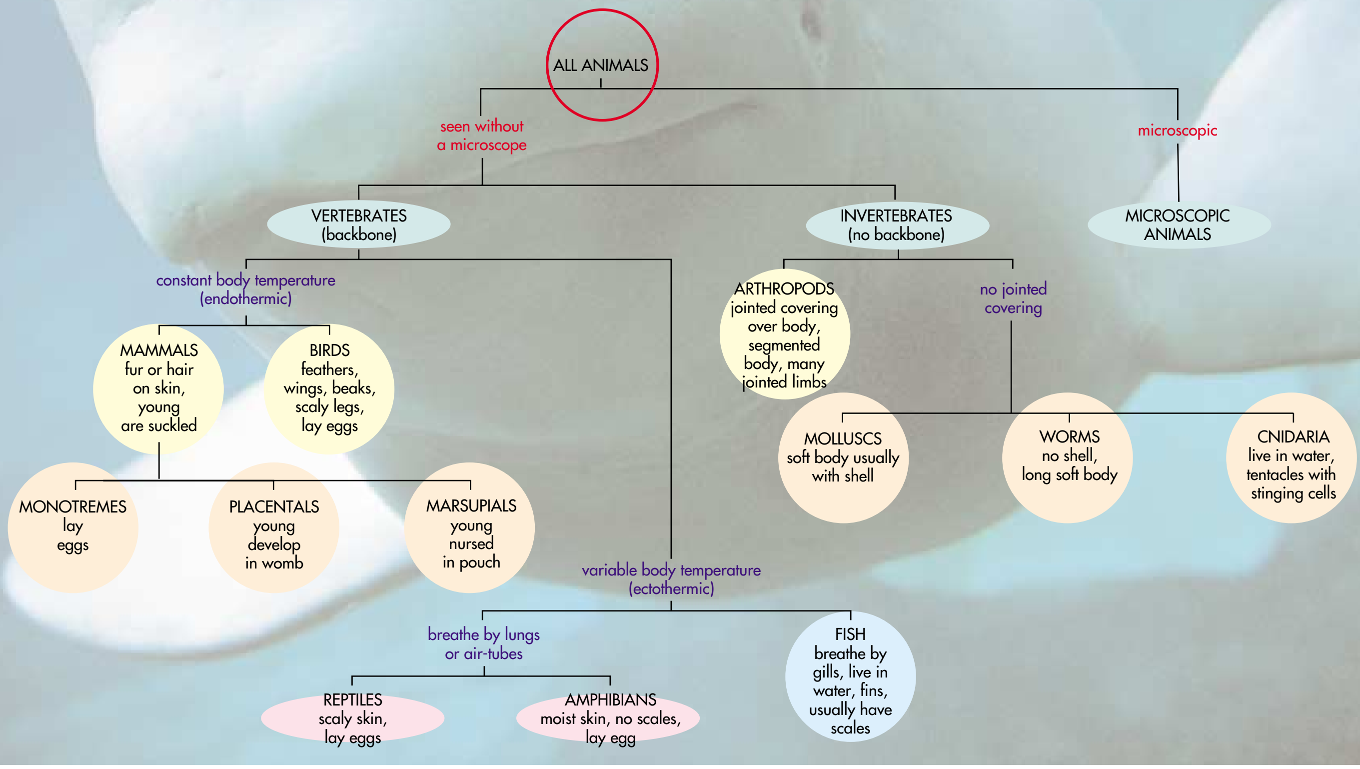

FIGURE 7.13
Using features based on structure and function, taxonomists have made a key for classifying animals.

Web page

USING SCIENCE 5 A KEY TO ANIMAL IDENTIFICATION

1 Use the classification key above to classify the following animals:

a elephant **b** whale **c** snail
d bee **e** lizard **f** frog
g hawk **h** jellyfish **i** protozoan.

Include the steps you followed, for example:
PELICAN: seen without a microscope → vertebrate → constant body temperature → feathers, wings, beak, scaly legs, lays eggs → BIRD.

2 Your teacher may have placed some animals around the room for you to observe. If so, repeat question 1 for these animals.

3 All animals reproduce to make more of their own kind. Taxonomists use the birth of the young to further classify the animal kingdom. What different ways for young to be born are listed in the classification key?

EXTENSION

One characteristic that all animals have in common is movement, but there are many different ways of moving. What headings would you use if you were classifying animals according to how they move?

Internet assignment

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Some characteristics of animals

Movement: Why do animals need to be able to move? Animals cannot make their own food, so they must eat other animals and plants. Therefore they must be able to catch it or roam for it.

Respiration: All animals need food and oxygen to provide them with energy.

sugar (food) + oxygen →
energy + carbon dioxide (waste) + water

All animals are adapted differently for this process. An earthworm absorbs oxygen through its moist skin. Fish have gills over which they pass water, which contains dissolved oxygen. All land-living vertebrates, including humans, have lungs. When they **inhale** (breathe in), their lungs take in oxygen from the air. When all these animals **exhale** (breathe out), they **excrete** carbon dioxide, a waste product.

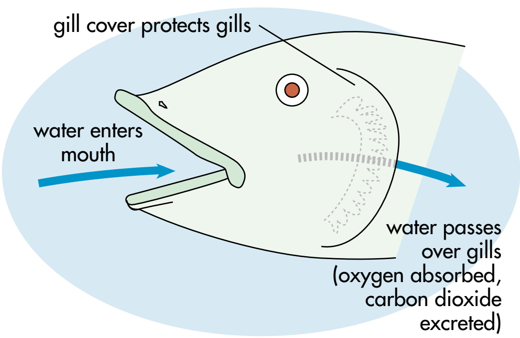

FIGURE 7.14
Fish have gills to enable them to take in oxygen and give out carbon dioxide.

Sensitivity: Another feature taxonomists use in classification is sensitivity to temperature. Birds and mammals, whose body temperatures are kept at fairly constant levels, are said to be 'warm-blooded', or **endothermic**. Even when the temperature of their surroundings changes, their body temperature stays the same. Fish, reptiles and amphibians are said to be 'cold-blooded', or **ectothermic**. Their body temperatures change with the temperature of their surroundings.

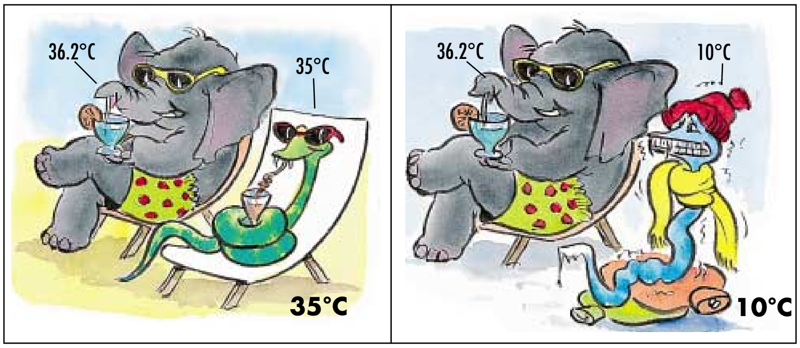

FIGURE 7.15
Elephants are endothermic and snakes are ectothermic. Why do you think ectothermic organisms often hibernate in winter?

Questions

1 Draw a labelled diagram that illustrates what happens during respiration in living things.

2 Explain what the terms 'endothermic' and 'ectothermic' mean. Give two examples of each.

3 Answer the following questions using the information provided in the table below, which shows the body temperature of certain animals at different environmental temperatures.

TABLE 7.2 Body temperatures and environmental temperature.

Animal	Body temperature (°C)	
	Environmental temperature = 35°C	Environmental temperature = 8°C
Wombat	35	35
Platypus	32	32
Dragonfly	20	10
Shark	27	12
Bat	33	33
Human	38	38
Snake	30	9
Pigeon	40	40

a Which animals are endothermic? Explain your answer.

b Why do the temperatures of some animals alter? What term is used to describe these animals?

c Predict the body temperature of the snake if the environmental temperature was 20°C.

4 Draw a column graph comparing the temperatures for each animal listed in question 3.

FACT FILE

Scientists who study animals are called zoologists.

FACT FILE

The most numerous animals on Earth are the insects. Over 950 000 species have been identified. They are members of an invertebrate group called the arthropods.

Spreadsheet

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7.5

The platypus: fact or fiction?

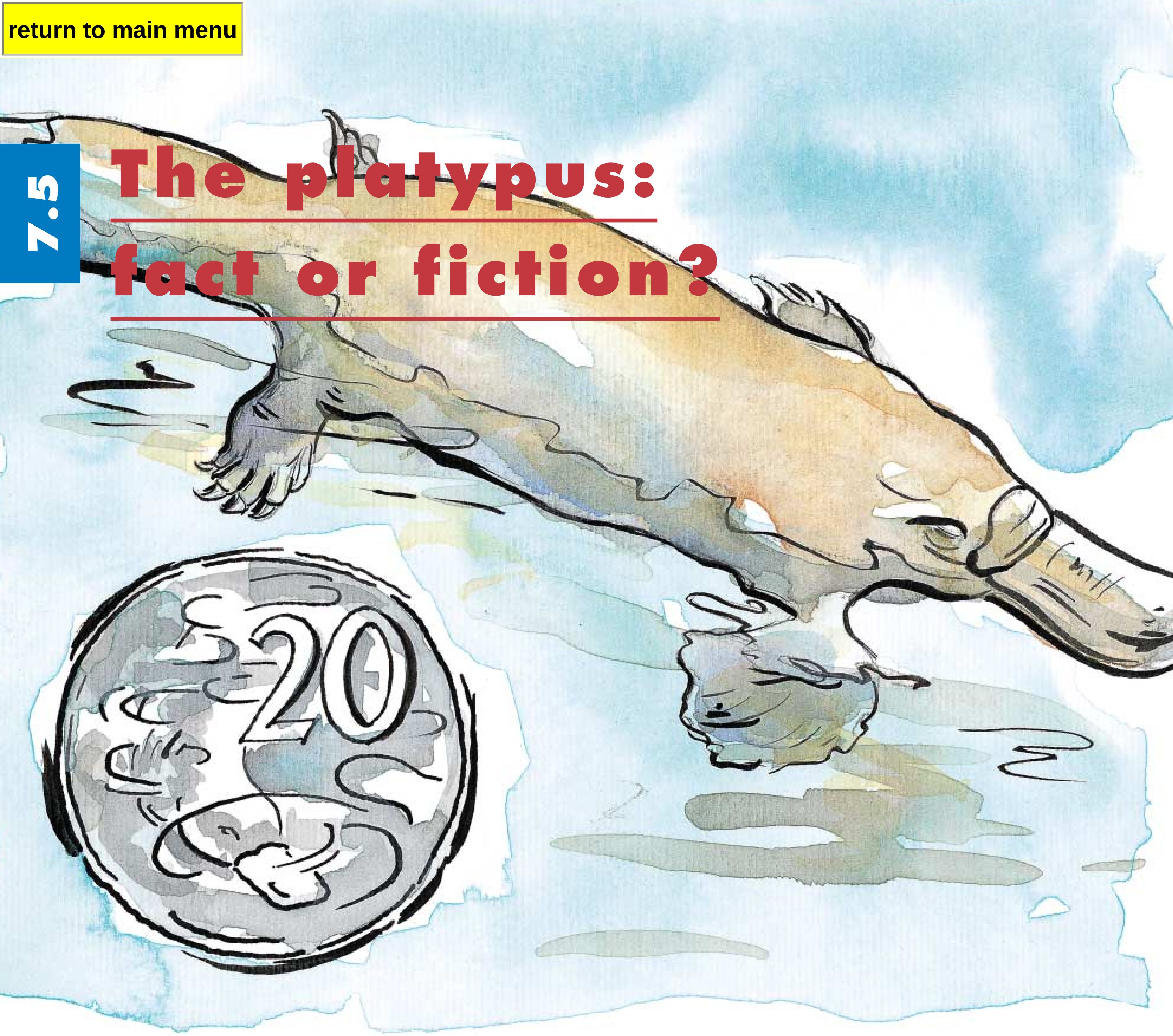

FIGURE 7.16
Most Australians still know remarkably little about the platypus, *Ornithorhynchus anatinus*, even though we handle it every day on our twenty cent coin.

A duck called Bill

One day Tharalkoo, an attractive girl duck, strayed too far from home. Biggoon, a nasty water rat, caught her and kept her as his mate. Much later, while Biggoon slept in the noonday sun, Tharalkoo escaped. She made it back to her family and friends just in time for the egg-laying season. Tharalkoo's eggs hatched. To her horror, out came a creature with a duck's bill and webbed feet but with fur and four legs like a water rat—the world's first platypus.

This is a legend from the Wiradjurie Aboriginal tribe. The Europeans also thought the platypus an odd mixture.

A dried platypus skin was sent to Britain in about 1798 by Governor John Hunter. He had preserved the skin of an animal speared by an Aborigine. As this was the first platypus ever seen by European scientists it was thought to be a hoax — the beak of a duck sewn to the body of a mammal. Even when it was found to be real, no one believed it was a mammal.

Glossary

FIGURE 7.17
The platypus is a **monotreme**, meaning one-holed. Excretion and reproduction occur through the same hole. Like the only other monotreme, the echidna, platypuses lay eggs instead of giving birth to live young as other mammals do. However, their young do suckle on the mother's milk.

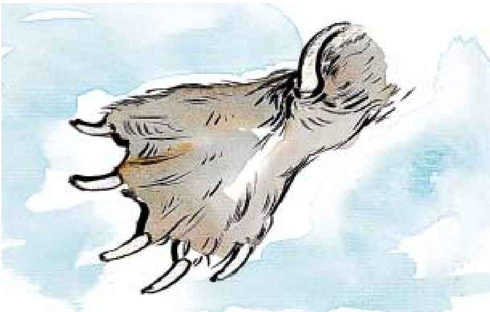

FIGURE 7.18
The adult male defends itself with a spur on the inside of each hindleg. It releases venom from the spur, being one of only a few venomous mammals in the world.

FIGURE 7.19
The platypus propels its streamlined body through the water using its webbed front feet. This webbing folds back when the platypus is on land.

FIGURE 7.20
The platypus's bill looks like that of a duck but is soft and rubbery. The tiny pores (holes) in the bill are used to detect electrical fields given off by its prey. A large network of nerves makes the bill touch-sensitive as well.

FIGURE 7.21
Here the platypus resembles a reptile. To help it use a sideways action, the shoulder girdle has extra bones.

Questions

1 Individual features of the platypus can be found among many different animal groups. In your book, list which of its features are commonly found among mammals, birds, reptiles, fish and amphibians.

2 With its odd combination of features, what makes the platypus a mammal?

3a Is the dolphin a fish or a mammal? Explain your classification.

b Is the penguin a bird or a mammal? Explain your classification.

Activity

1a In pairs, 'design' an animal. The first person draws the head and passes it on to the second person who draws the body. Label your drawing with information about the animal's structure, such as body covering, size, and body parts. Give details of how its systems function, such as respiration and reproduction.

b Now swap your animal with another pair. As zoologists, classify this new species using the information you have been given.

FACT FILE

When swimming under water the platypus closes its eyes and ears. Like other mammals, the platypus is covered with fur but its fur is waterproof. Only its feet and bill don't have fur. The platypus uses its tail to store fat, to act as a rudder and to protect its eggs until they hatch.

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7.6

The plant kingdom

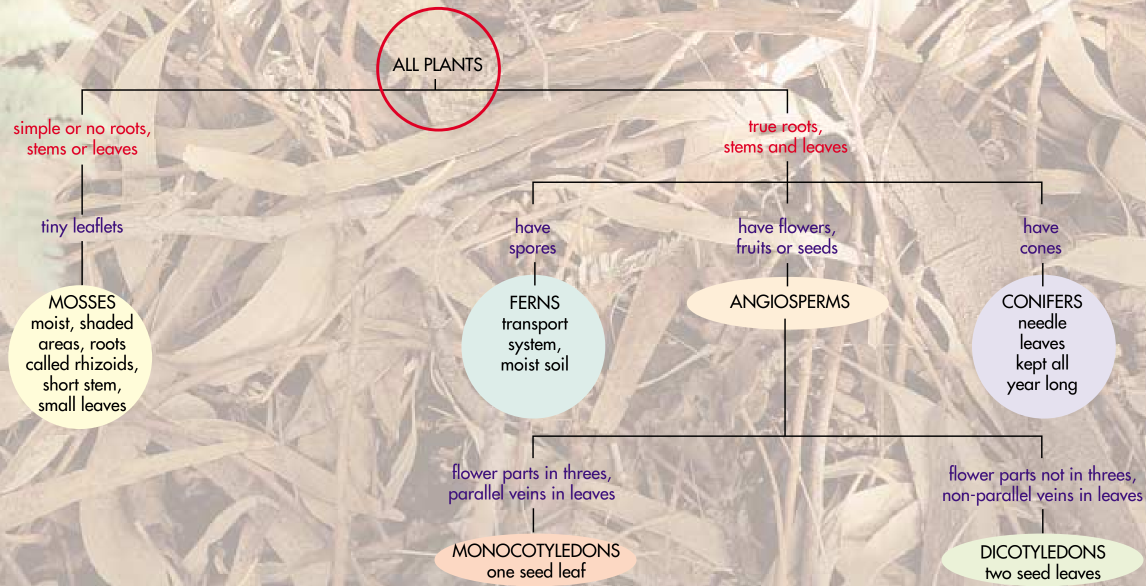

FIGURE 7.22
A classification key can be used to sort the plant kingdom into smaller groups with similar characteristics.

USING SCIENCE 6 A KEY TO PLANT IDENTIFICATION

1 In pairs, walk around the grounds of your school. Choose five plants to study. Pick a sample leaf from each plant.

2 In your book, sketch the whole plant and then use the above key to classify each specimen. For example: SPECIMEN 1: simple or no roots, stems or leaves → tiny leaflets → moist, shaded areas → roots called rhizoids → short stem → small leaves → MOSS.

3 You may have discovered some plants that we rely on every day. We use plants for food, building materials, clothing and fuel. Write these four headings in your book and list as many plants you and your partner can think of under each heading.

4 Can you think of other uses of plants in your everyday life?

FIGURE 7.23
Plants as food …

FIGURE 7.24
Plants as building materials …

FIGURE 7.25
Plants as clothing …

FIGURE 7.26
Plants as fuel …

Glossary

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Angiosperms: flowering plants

The type of plants you are probably most familiar with are flowering plants (**angiosperms**).

Each main part of the flowering plant has a specific function as shown in the following table.

TABLE 7.3 Plant parts and functions.

Part	Function
Roots	Anchor plant in the ground; absorb water and mineral nutrients (salts)
Stem	Supports leaves, flowers, etc.; allows for transport of water and food
Leaves	Manufacture food for the plant (photosynthesis)
Flowers	Reproductive part of the plant

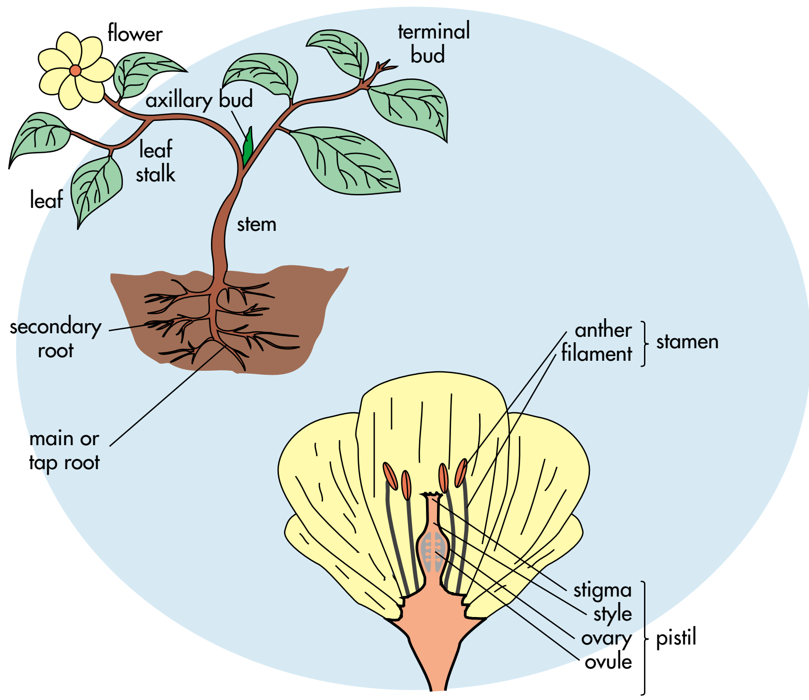

FIGURE 7.27
Which of the parts of the flowering plant in this diagram do you recognise?

The flower is the part of the plant responsible for reproduction. Most flowers have both male and female parts. The male part (**stamen**) produces **pollen** which pollinates the female part (**pistil**). **Pollination** can occur within a single flower or between two flowers. The beautiful colours and scents of flowers have a function too. They attract insects that transfer the pollen from one flower to another.

Plants without flowers

What about plants that don't have flowers? Using the classification key for plants, you can see that in some plants reproduction is carried out by spores or cones.

If you examine the back of a fern frond you may notice small reddish or brown spots. These spots are spore cases containing thousands of tiny spores, each of which is a potential fern plant. Like angiosperms, conifers have both male and female parts. The wind carries the male cells (pollen) from one cone to the female cells (eggs) in another cone. When the male pollen combines with the female eggs, **fertilisation** occurs and a new conifer can grow.

Questions

1 How are angiosperms different from other plants?

2a Why would light pollen be more useful to a flowering plant than heavier pollen?

b Can you think of any other ways that pollen could be transferred from one flower to another, or from the stamen to the pistil on the same flower?

3a Draw a diagram of a leaf of a (i) monocotyledon (ii) dicotyledon.

b Collect a sample of each type from your backyard or school ground.

4 What differences are there between the reproduction of angiosperms, ferns and conifers?

5 Draw and label a typical flower. Give the function of the labelled parts.

Think about

What effect might a bushfire have on a plant community?

FACT FILE

The Australian mountain ash is the tallest hardwood tree in the world, growing to a height of over 100 metres.

FACT FILE

A scientist who studies plants is called a botanist. New types of plants are constantly being discovered.

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7.7

CURRENT ISSUES, RESEARCH AND DEVELOPMENT

SCIENCE IN FOCUS

Prehistoric tree

FIGURE 7.29
The pine known as King Billy thrusts through the canopy, a Jurassic survivor locked in a time capsule.

Protecting the Wollemi Pine

Since the discovery of the Wollemi Pines in 1994, their location has been kept secret. Only a small number of people know the way to the remote canyon where fewer than 40 adult trees have been found. The trees are growing on wet ledges in a deep, sheltered rainforest gully. They are the last survivors of a species that existed in prehistoric times along with the dinosaurs. This species has survived ice ages, fires, droughts and floods while many other prehistoric plants have become extinct.

Can the Wollemi Pines survive people? Much is being done to try and save this very rare species. Scientists are collecting seeds and cuttings in order to find out how to grow these trees. If the Wollemi Pine can be grown in parks and gardens its numbers may increase and it will have more chance of survival. Also, scientists who visit the site first wash their shoes in a sterilisation solution to prevent disease spreading to the Wollemi Pines.

Classifying the Wollemi Pine

The classification system used for all living things is arranged in levels, see Figure 7.30. At the bottom of the classification system is the species. A species is a group of organisms of the same type which can successfully reproduce.

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Foundation worksheet 2

Extra worksheet

USING SCIENCE 7 IN THE NEWS!

Read the newspaper article and then answer the following questions.

1 How large is the Wollemi National Park?

2 How would you describe a 'wilderness'?

3 What activities are people allowed to do in a national park but not in a wilderness area?

4 Some people believe that national parks and wilderness areas belong to everyone and the general public should be allowed to visit them when they want. Others say we should have some natural areas which are closed to the general public. Write down a reason to support each view. What do you think?

5 Why is the location of the Wollemi Pines being kept a secret?

All species are given a two-part scientific name. The first part is the genus and the second part is the species. Organisms which are very closely related but not the same species will have the same genus name. In this system, humans are called *Homo sapiens*, the lemon-scented gum is called *Eucalyptus citrodora* and the honeybee is called *Apis mellis*. The Wollemi Pine has no close living relatives, so a new genus name was created. The Wollemi Pine's scientific name is *Wollemia nobilis*. This system of naming is used by scientists all over the world.

Questions

1 Which group would have more members, an order or a family?

2 In which group would the members have the most similarities, a class or a family?

3 Which animals are the most closely related? How can you tell?

a leopard (*Panthera pardus*)

a cheetah (*Acinonyx jubatus*)

a jaguar (*Panthera onca*)

4 Why don't scientists just use common names for living things?

Find out

What is the common name for the following familiar creatures?

a *Felis domestica*

b *Canis familiaris*

c *Musca domestica*

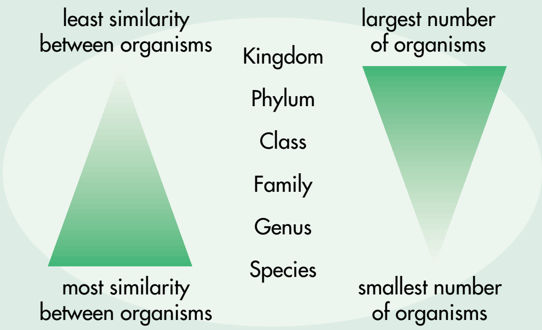

FIGURE 7.30
The levels of classification.

RARE PINE TREE LEFT OUT OF 'WILDERNESS'

THE rare Wollemi Pine tree will be endangered if the State Government fails to include it in a proposed wilderness area, an environmentalist has claimed.

Only 40 adult pines are known to exist in two groves within the Wollemi National Park boundaries; Environment Minister Pam Allen is expected to announce how much of the current 500 000 ha park will become wilderness next month.

But Colo Committee secretary Haydn Washington, claiming reliance on National Parks and Wildlife Service sources, said he believes Mrs Allen will announce 270 000 ha as wilderness—leaving the pine groves with national park protection only.

Four wheel drives, mountain bikes and horses are allowed in national parks, but not in wilderness areas.

Mr Washington said this sort of access should be thought of when formulating a protection plan.

'I've been bushwalking the Wollemi for 22 years and was part of a group which found the second grove of Wollemi Pines', he said.

'We're a bit concerned that the NPWS input to the wilderness plan is selling the pine a bit short.'

A spokesman for Environment Minister Pam Allen rejected the claims, saying the Wollemi is, and will stay, safe.

'How would these people know—they've never been to the area', the spokesman said.

'It's really a moot point. The pine has complete protection. It's already managed as an endangered species; if someone destroys the site they can face hefty fines or jail terms.'

Members of the Colo Committee have lobbied for the Wollemi's protection since 1974, Mr Washington said, and they were part of the 1986 working group which identified most of the national park for wilderness nomination.

'We believe that around 400 000 ha should be gazetted as wilderness', he said. 'But now it appears the pine groves won't be in the assessment area.'

The pine's protection prevented Mr Washington from identifying their location.

'The less said about the pine the safer it will be', he said. 'They were discovered only two or three years ago and are one of the most rare trees in the world. There are about 24 adults in one grove, and 12 in another...there could be other things undiscovered in the wilderness as well.

'It's like New South Wales' version of the Grand Canyon.'

Hawkesbury Gazette, 21 May 1997

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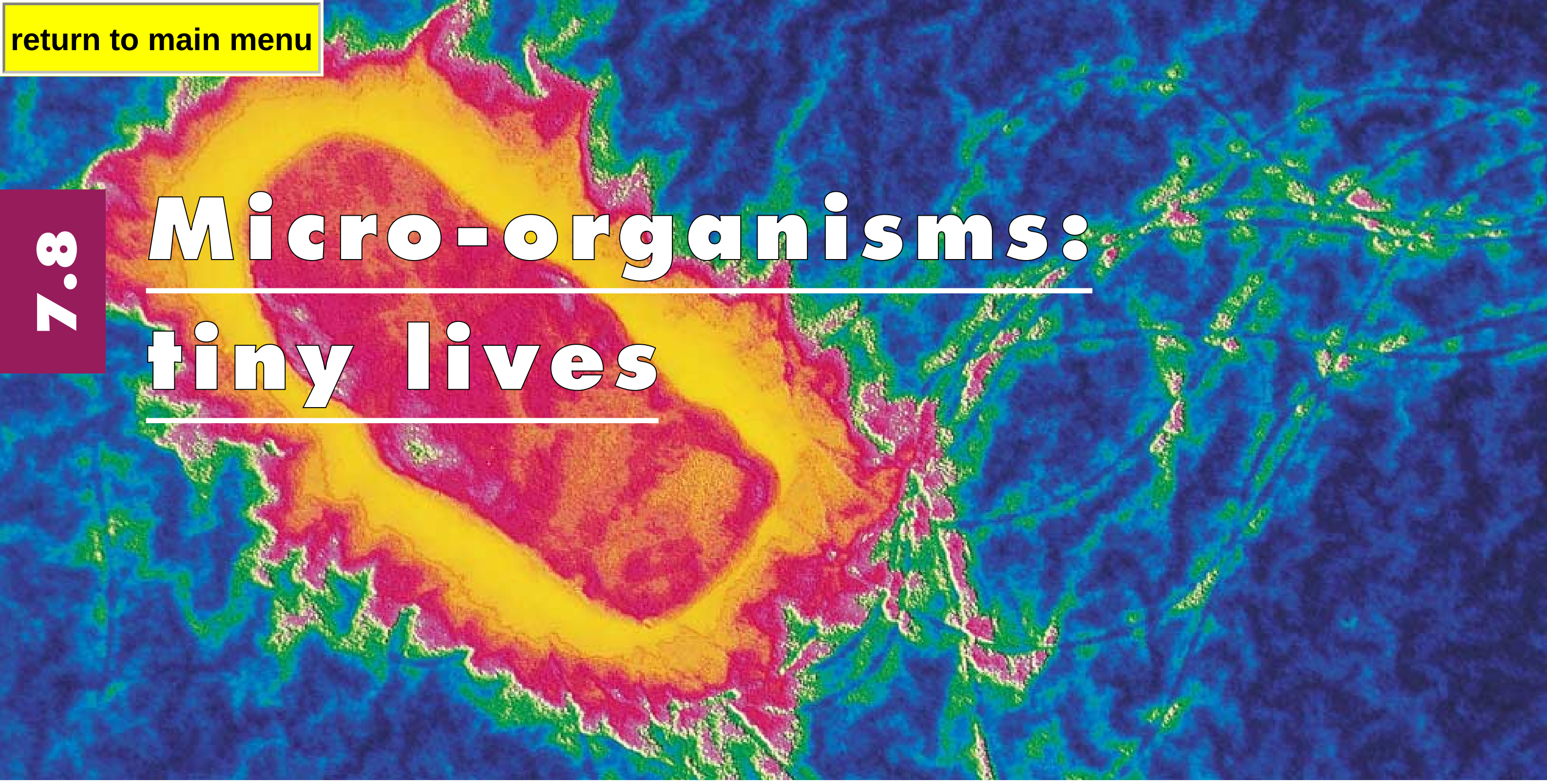
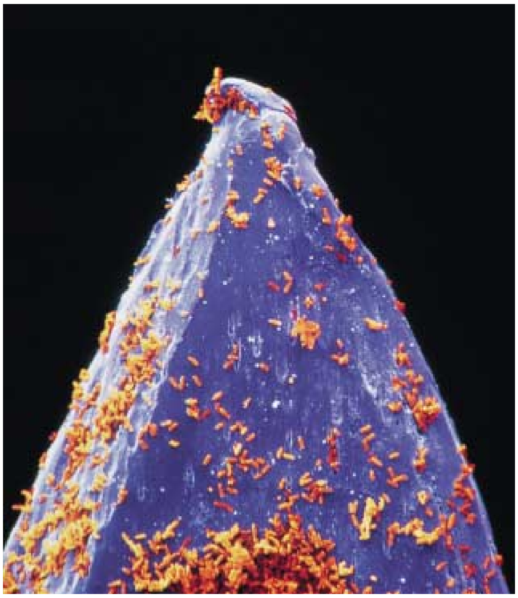


7.8

Micro-organisms: tiny lives

FIGURE 7.31 (above)
Bacteria magnified 20 000 times by an electron microscope.

FIGURE 7.32 (below)
Many bacteria can be found living in a pond environment.



Some organisms are so small they can only be seen by using a microscope. These are called **micro-organisms** or **microbes**.

Micro-organisms come in all shapes and sizes. There are bacteria, blue-green bacteria (cyanobacteria) and protozoa. Most micro-organisms are from the Monera and Protista kingdoms. Table 7.4 shows some of the features of common micro-organisms.

FIGURE 7.33
Bacteria on the tip of a hypodermic needle, magnified 500 times by a light microscope.

TABLE 7.4 Some of the features of common micro-organisms.

Kingdom	Micro-organisms	Structure	Shape	Habitat	Nutrition	Action	Example
Monera	Bacteria (singular = bacterium)	Single-celled organisms	Spherical, rod-like or spiral	Especially abundant in soil; live in or on dead and living organisms	Feed off dead or living organisms (parasitic)	May cause disease in living organisms; most are harmless or helpful	Tetanus, cholera typhoid; culture used in making, cheese and yoghurt
Monera	Blue-green bacteria	Single-celled photosynthetic organisms	Rod or chains of spheres	Generally live in water or in damp soil	Make own food	May cause toxic algal blooms	Pond slime
Protista	Protozoa	Single-celled animal-like organisms	Variable	Live independently, in water	Need a ready-made food supply; move around to catch food	Cause disease in tropical countries	Malaria
Protista	Algae	Mostly single-celled plant-like organisms	Variable	Generally live in water	Make own food via photosynthesis	Mostly harmless; very important part of marine food webs	Euglena, seaweeds

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EXPERIMENT 1 MICRO-ORGANISMS AROUND YOU

AIM
To grow colonies of micro-organisms.

MATERIALS
- 3 agar plates
- sticky tape
- 2 sterile cotton swabs
- marking pencil
- incubator

METHOD
1 Working in groups of three, collect three agar plates with their lids on. Do not remove the lids.
2 Label the agar plates 1, 2 and 3. Seal agar plate 1 with sticky tape around the sides. Write 'control' on its base.
3 Agar plates 2 and 3 are for the collection of micro-organisms. Try swabbing selected areas of the school, such as the canteen floor, benches, the blackboard, or inside lockers. Alternatively you could breathe or cough onto the agar plate.
4 Seal each agar plate immediately using sticky tape. On the base write where the sample was taken from.
5 Write your initials on all three agar plates.
6 Place the agar plates upside-down in an incubator at 25°C for 24–48 hours.
7 Examine the agar plates but do not open them.

Warning: Exposed agar plates must never be opened as they may contain millions of dangerous micro-organisms. Sealed plates must be returned to your teacher for correct disposal.

DISCUSSION
1 How many groups, or **colonies**, of micro-organisms have grown on each plate?
2 Describe the size, colour and shape of each colony you can see.
3 Compare your plates with those of other students. Which site produced:
a the most colonies?
b the least colonies?
4 What favourable conditions did you need to provide for the micro-organisms so that they could grow?
5 What was the purpose of the control plate?

TABLE 7.5 Some of the ways in which micro-organisms are helpful and harmful.

HELPFUL MICRO-ORGANISMS:	HARMFUL MICRO-ORGANISMS:
• help plants to grow	• cause diseases in plants
• make sewage pure and safe	• cause diseases in animals, including humans
• are used in medicine (penicillin)	• clog up rivers and lakes
• are used in brewing beer, wines and spirits	• make food go mouldy or rotten
• are used in baking bread	• make your body and clothes smell
• are used in making cheese and yoghurt	
• decompose dead plants and animals	
• make soil fertile	
• make compost	
• help cows and sheep digest grass	

Questions

1 What does single-celled mean?
2 Why must exposed agar plates never be opened?
3 List some of the helpful things that micro-organisms do. Why do you think an unknown micro-organism is always treated as harmful until proven otherwise?
4 You have just completed an experiment in which you have grown micro-organisms on an agar plate. Figure 7.34 shows the results.
a What type of micro-organisms are present in the greatest numbers?
b How many different kingdoms are represented in the data?
c How do you think the data was obtained?

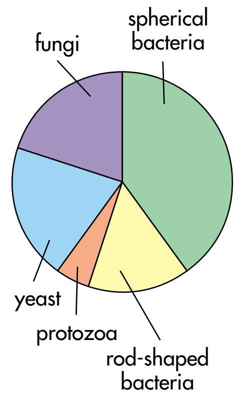

FIGURE 7.34
Pie graph of micro-organisms.

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7.9 Kingdom Fungi

FIGURE 7.35 (top left) The dry, scaly condition known as athlete's foot is caused by a fungus. Not all fungi are harmful, however.

FIGURE 7.36 (top right) The bread mould *Rhizopus* is a common example of a fungus.

What are fungi? Fungi can take many forms, ranging from the mould that grows on bread, to the mushrooms we eat. For many years fungi were classified as plants; however, there is one important ingredient missing from fungi that is present in all plants: chlorophyll. Chlorophyll is essential to plants for photosynthesis, the plant's food-making process. Fungi do not photosynthesise, so how do they obtain their food?

Some fungi live on dead organic matter. They are **decomposers** that break down the matter on which they are living. Other fungi are **parasites**, living on plants and animals.

Many fungi appear as a tangle of tiny threads called **hyphae**, which are responsible for feeding the fungus. Hyphae can grow quickly, spreading over the food which the fungus digests and absorbs. The absorbed food allows the fungus to grow and reproduce. The tiny black spots often seen in fungi are spore cases. Each contains hundreds of minute spores which are released and carried by air currents to land on other suitable sources of food. On what other types of foods have you seen fungi growing?

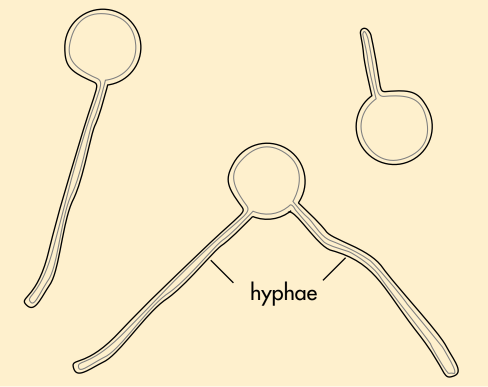

FIGURE 7.37 Hyphae are thin strands of tissue one cell thick. How does the thinness of the hyphae help the fungus to obtain food?

USING SCIENCE 8 LOOKING AT MOULD

1 Examine some mouldy bread or fruit with a hand lens or stereo-microscope. Draw and describe what you see.

2 Label your drawing of mould.

Glossary

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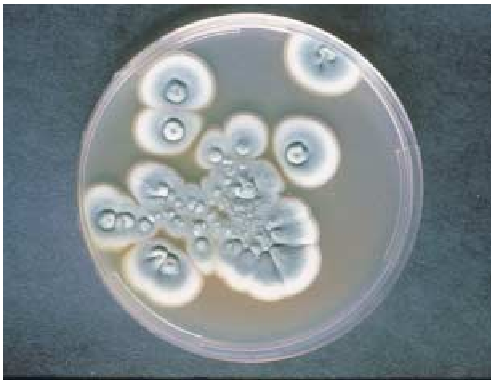
Fungi and medicine

Not all fungi are harmful to humans. In 1928 Alexander Fleming, a British scientist, discovered that a blue-green mould prevented the growth of a certain bacterium that was poisonous to humans. This was the birth of the antibiotic drug, penicillin. **Antibiotics** are drugs that inhibit or stop bacterial growth and they are widely used to treat infectious diseases. Since the success of penicillin, other scientists have prepared antibiotics from other moulds and soil bacteria.



Food fungi

Have you ever eaten a mushroom? If you have, then you have eaten fungi! Mushrooms consist of a mass of threads, like those in the bread mould, which provide the fungus with food as well as serving as an anchor.

Yeast is a fungus that is widely used in food production. Yeasts obtain the energy they need through a process called **fermentation**. During fermentation, sugar is broken down to produce energy for the yeast. Carbon dioxide gas and alcohol are formed as by-products. If yeast is added to bread dough, the carbon dioxide gas causes the dough to rise as the temperature increases. The alcohol vaporises and the yeast is killed at these high temperatures.

FACT FILE

30 grams of brewer's yeast contains about 5 billion cells.

FIGURE 7.38 (far left) The fungus *Penicillium* is the source of penicillin, an antibiotic drug used to treat bacterial infections.

FIGURE 7.39 (left) Many cakes and breads contain yeast, as do wines and beer.

USING SCIENCE 9 EXAMINING YEAST

WHAT YOU NEED

- sugar
- fresh yeast
- microscope
- glass or beaker
- dropping pipette
- slide and coverslip

WHAT TO DO

1 Dissolve a spoonful of sugar in a glass of warm water.

2 Break off a piece of yeast and place it in the sugar solution. Store the glass in a warm place for one hour.

3 Put a drop of the solution on the microscope slide and observe it under the low-power lens of the microscope.

4 Describe and draw what you see.

Questions

1 Give three examples of fungi that are used in everyday life.

2 What are antibiotics? What are they produced from?

3 Until recently, fungi were often classified as plants.

a Why would scientists have classified them this way?

b Why do you think taxonomists changed their minds and classified fungi as a kingdom on their own?

4 What is fermentation? In what processes is it important?

Find out

1 Who was Howard Florey and what was his connection with penicillin?

2 Some people are allergic to penicillin. What happens if they take penicillin? What do they do if they get a serious infection?

Multimedia

Glossary

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Using scientific language

Using the words listed below, complete the sentences by filling in the gaps.

angiosperms invertebrates pollen
taxonomist exoskeleton cold
chlorophyll monotremes phloem
without leaves animals green

1 _____ are mammals that reproduce by laying eggs.
2 A scientist who classifies organisms is called a _____ .
3 Flowering plants are called _____ .
4 Animals can be classified into vertebrates (with backbones) or _____ , (_____ backbones).
5 Some _____ have a shell known as an _____ .
6 When an animal's body temperature changes with its environment it is said to be _____-blooded.
7 _____ is the substance in a plant's leaves that makes it _____ and so allows for photosynthesis to occur.
8 The stamen of a flower produces _____ .

Check your knowledge

Unscramble the following sentences.

1 and sensitive Plants to environment animals changes are their in.
2 dioxide wastes excrete are things Carbon water and living that must all.
3 support skeleton A animal's an body provides with.
4 warm-blooded constant temperature have them Birds a body making.
5 uses and sugar dioxide Respiration water carbon produce oxygen and to water.
6 The monotremes only world the platypus two and echidna the in are.
7 kingdom members fungi are Mould of yeast the and.
8 as plant a well and salts ground to as water anchoring Roots the absorb.
9 Many a growing of colony known are micro-organisms together as.

Answer the following questions in full sentences.

10 What is a dichotomous key?
11 Describe two ways pollen can be transferred from one flower to another.
12 What is classification?
13 Describe the function of the stem of a plant.
14 Name three types of mammals and describe the main difference between them.

Apply your knowledge

1 What are the characteristics a biologist uses to identify living things?
2 The following diagrams show different types of bacteria.

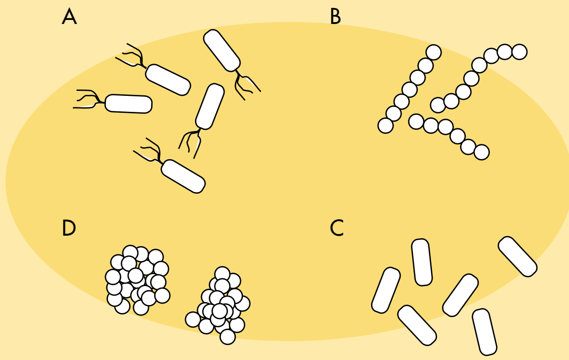

FIGURE 7.40

Which of the following choices (1, 2, 3 or 4) correctly classifies the four groups of bacteria?

Choice	Group A	Group B	Group C	Group D
1	Can move and are rod-shaped	Long chains	Singular and spherical	Clusters and spherical
2	Can move and are small	Long chains or spirals	Singular and rod-like	Clusters and spherical
3	Can move and are spiral-shaped	Spiral-shaped	Singular and rod-like	Singular and spherical
4	Can move and are long	Spherical	Singular and spherical	Singular and spherical

3 If an unknown 'thing' was discovered on a space expedition, how would biologists decide whether or not it was a form of life? If it was alive, how could they go about classifying it?

Challenge yourself

1 'Mike and Madge Microbe live in the sewage pipe on Greenvale Road. Madge is President of the Microbe Activation Club. Last night at their monthly meeting, Brad who lives in Professor Leo's laboratory, had some terrible news. Their number 1 enemy — humans — have discovered a way to kill all the micro-organisms in the world ...' Using this paragraph as your introduction, write a short science fiction story describing life in a world without micro-organisms.
2 Visit your library or supermarket. Design a key showing how the books or grocery items can be classified into groups with common characteristics.

eTester

Glossary

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CHAPTER 8

LIVING TOGETHER

A chemical is sprayed onto a cotton crop to kill a pest. The same chemical can turn up as part of a roast dinner. A plastic bag is dropped into a gutter then washed into a storm-water drain. The same plastic bag is found inside a dead dolphin lying on a beach. A developer clears a mangrove swamp to improve the view from a resort. Soil from the resort begins to cover and kill a coral reef.

Each of these examples shows us something very important about life on planet Earth. All living things from the smallest micro-organism to the largest whale are connected with one another and their surroundings. Living things depend on one another for their survival. The same is true for people. Our survival depends on the survival of all the other plants and animals we share this planet with.

In this chapter you will learn about how living things depend on each other and the places they live for their survival. You will also find out how the activities of people affect the natural world.

Web links

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- Relate the needs of a living thing to its natural habitat.
- Identify the features that make up an organism's environment.
- Define the term ecosystem.
- Describe the role of producers, consumers and decomposers in ecosystems.
- Construct food chains and food webs.
- Explain how plants produce food by photosynthesis.
- Describe how human activities can have an impact on ecosystems and give examples.

Glossary

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8.1 Habitats

FIGURE 8.1 Rabbits are found almost everywhere in the southern part of Australia.

What is a habitat?

A **habitat** is the place where a plant or animal lives. Every living thing has a place which can be called its habitat. For example, your habitat might include your home, your school and the places where you shop for all the items you require to live. Every living thing has particular requirements, and will only live in a place where these can be provided. Some of the things a habitat may need to provide for an animal or plant include:

- a source of food
- water
- shelter and living space
- mating partners for reproduction
- gases such as oxygen.

Talk about

Explain how a living thing would be affected if it was deprived of each of these five requirements.

A group of living things of the same species living in the same habitat is called a **population**. The size of any population may change over time depending on the availability of food, water, living space and mating partners.

To help living things survive in their habitats, they have special characteristics that help them to obtain food and water, protect themselves, build homes and reproduce. These characteristics are called **adaptations**.

How big is your habitat?

The size of a plant or animal's habitat can vary considerably. Some plants and animals seem to be happy to live almost anywhere; others have a very restricted habitat and may be found in only a very small area.

FIGURE 8.2 (right) Koalas are well adapted to their gum tree habitat. Look closely at the features of the koala. For each feature, describe how it helps the koala to survive in its habitat.

FIGURE 8.3 (far right) Pygmy possums have a very restricted habitat. They are only found in small patches of bushland near Mt Bogong (in northern Victoria) and in the Kosciusko National Park (in southern New South Wales).

Glossary

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EXPERIMENT 1 INVESTIGATING HABITATS

INTRODUCTION

Living things can often be found outside their natural habitats. They might have adapted well to their new environment and be flourishing, or they might not have adapted well and be in poor condition.

AIM

To find animals and plants living in your schoolgrounds that are not in their preferred natural habitats.

METHOD

1 Copy the table opposite into your book.

2 Conduct a search in your schoolgrounds to find plants or animals that are living in a number of different habitats.

3 For each plant or animal you find, record the relevant information in the table.

	Habitat 1	Habitat 2	Habitat 3
Name or drawing of animal or plant			
Sunny or shady habitat			
Wet or dry habitat			
Hidden or exposed habitat			
Number of the same type of plant or animal living nearby			
Possible food sources			
Possible water sources			
Possible dangers nearby			
Is the plant or animal helped to survive by humans (for example is it sprinklered, fed or fertilised)?			
Evidence that plant or animal is/is not well adapted to the habitat			

DISCUSSION

Comment on how well each type of living thing you found was surviving in each of the different habitats. In which habitat did each living thing seem to survive best?

How well a plant or animal survives in a particular habitat depends largely on how well adapted or suited it is to that habitat. For example, frogs are well adapted to their pond habitat. They can move easily both on land and in water, they lay their eggs and rear their tadpoles in the pond, and they are usually coloured to match their surroundings.

FIGURE 8.4 (far left) The marbled frogmouth is well adapted to its rainforest habitat. Its colouring matches its surroundings and it has large eyes for hunting at night. What other features can you see that show that the frogmouth is well adapted to its habitat?

Questions

1 What is a habitat?

2 How big is a habitat?

3 What are some of the important things a habitat must provide?

4 Some animals, such as grasshoppers, are very similar in colour to the plants or soil of their habitat. What is the advantage of this?

5 Choose a habitat and describe it in a paragraph. Create a plant or animal that would be well adapted to the habitat you have described. Draw a fully labelled picture that illustrates the characteristics of your new plant or animal.

Find out

Find out what the term ‘niche’ means and then describe a lizard’s niche in a desert. Can you think of some adaptations a lizard would have to help it survive in the desert?

Glossary

8.2 Looking at environments

The term **environment** is used to describe all the conditions that a plant or animal has to cope with in its habitat. Many factors can shape and change an environment, including:

- the temperature
- whether it is wet or dry
- whether it is windy
- the quality of the air
- the quality of the water
- the amount of sunlight
- the quality of the soil
- the plants and animals that live there.

The study of the interactions between living things and their environment is called **ecology**. **Ecologists** are scientists who study these interactions.

Talk about

Are all the things in your habitat also part of your environment?

USING SCIENCE 1 ENVIRONMENTAL POSTCARDS

1 Copy the following table into your book, leaving plenty of room under each heading.

Environment shown in postcard	Plants that could be found in the environment	Animals that could be found in the environment	Conditions that are characteristic of the environment

2 For each of the 'environmental postcards' shown below, complete the details in the table. You could develop a colour code to help you complete the fourth column, for example using yellow to represent a hot climate, blue to represent a wet climate, green to represent a forest area, and black to represent a well-populated area. Be sure to explain your colour code below your table.






FIGURE 8.5 (top) A 'hot spot' in South Australia.
FIGURE 8.8 Plain sailing across Bass Strait.

FIGURE 8.6 (top) Getting lost in Queensland.
FIGURE 8.9 The people in Victoria are going batty!

FIGURE 8.7 (top) Roughing it in Tassie.
FIGURE 8.10 Greetings from Flea's Paradise.

Glossary

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USING SCIENCE 2 MAKING INFERENCES

FIGURE 8.11
A small pool of water on a rock platform on the coast undergoes big changes in environmental conditions over 24 hours. At low tide on a hot, sunny day the water temperature can be quite high. As a result the amount of oxygen in the water would decrease, since hot water contains less oxygen than cold water. The heat might also cause some of the water to evaporate, which would make the remaining water saltier. If it rained, the water in the rockpool would become less salty. On the other hand, at high tide the rockpool might be completely under water, becoming part of the ocean and being subjected to strong ocean currents.

The following temperatures were recorded in a rockpool over one day.

Time	Temperature	Time	Temperature
6 a.m.	16°C	1 p.m.	16°C
7 a.m.	17°C	2 p.m.	20°C
8 a.m.	23°C	3 p.m.	24°C
9 a.m.	29°C	4 p.m.	22°C
10 a.m.	34°C	5 p.m.	25°C
11 a.m.	35°C	6 p.m.	28°C
12 noon	15°C	7 p.m.	21°C

1 Graph the temperatures recorded during the day.
2 Describe the environmental conditions that might explain the changes in temperature during the day.
3 Imagine being a creature that lives in the rockpool. Write a diary entry describing how you felt and what you did on this day.

Questions

1 List at least 10 factors that determine what an organism's environment is like.
2 Name an environment that:
a is very hot
b contains a number of human predators (animals that eat other animals or, in this case, humans)
c you would like to live in (give reasons)
d you would not like to live in (give reasons).
3 What makes Antarctica such a harsh place to live in?
4 What are some of the good things about your environment?

Activities

1 Work in pairs to measure and record the temperature of a number of different environments around your school. You could try measuring:
- the air temperature in an open, exposed place
- the air temperature in classrooms
- the soil temperature at different sites and at different depths of soil
- the water temperature in any ponds, creeks or puddles in your schoolgrounds or nearby.

Try to explain any differences between the temperatures you record. Suggest which living things (plants or animals) would be well suited to the different conditions.
2 Use a light meter to measure the light intensity of various locations around the school. Record the types of organisms found in each location. Do some living things prefer bright light while others live in the shade?

Datalogging

Spreadsheet

FACT FILE

Living things can be found surviving in the most hostile environment. A variety of bacteria has been found in superheated water (up to 300°C). The water comes from volcanic vents called 'black smokers' on the sea floor.

Glossary

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8.3

Ecosystems: living together

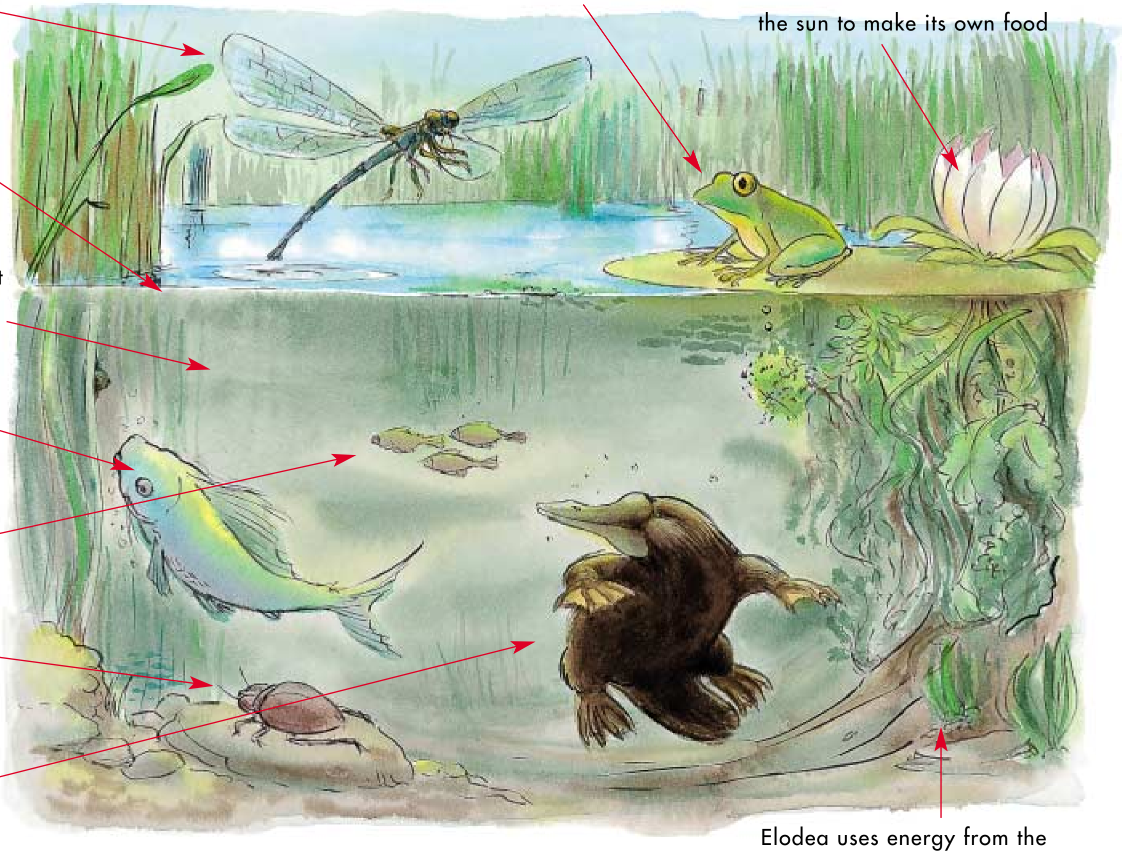

FIGURE 8.12
This pond ecosystem contains several types of plants and animals. Some of the basic requirements of the plants and animals in this ecosystem are listed. All the living things in an ecosystem depend on one another for survival. Changes in the number of one species can affect the whole community. What would happen to the pond ecosystem if all the large fish were caught by people fishing?

What is an ecosystem?

All organisms live in an environment with many other plants and animals. When two or more groups of different organisms live together and interact with each other in the same area, they are described as forming a **community**. The community of living things in a particular habitat, together with the non-living elements of the habitat (such as light, water, soil and air), is called an **ecosystem**.

The living things in an ecosystem are **interdependent**; that means they depend on one another for survival.

The ecosystem that most humans are part of is large because we move around a lot and get our food from distant places. Many animals and most plants live in the one place all their lives. A freshwater pond is an example of such a place. In and around the pond many of the plants and animals depend on one another for survival.

The plants and animals in an ecosystem have to survive constantly changing weather conditions such as changes in temperature, wind speed and direction, tides and the amount of rain or snow, as well as more extreme changes such as floods, bushfires and droughts.

Glossary

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Foundation worksheet 1

EXPERIMENT 2 MAKE YOUR OWN ECOSYSTEM

AIM

To find out how plants and animals interact in a model ecosystem.

MATERIALS

- large glass jar or plastic container with lid
- a range of animals and plants
- rocks or dead leaves to provide shelter

Suitable animals might include slaters, snails and ants. Suitable plants might include mosses, grasses and small weeds.

METHOD

1 Arrange the animals, plants and other materials in the container. Try to provide enough plant material for the animals to eat and also to ensure that enough oxygen is produced. Seal the container with an airtight lid.

2 Keep your container in a well-lit place but avoid direct sunshine, particularly during warm weather. You may need to do some library research to find out the requirements of the animals and plants in your ecosystem.

3 Keep a close watch over your ecosystem for several weeks and record your observations in diary form. An example entry is shown on this page.

DISCUSSION

1 Was your ecosystem successful? Did all the plants and animals survive? What would you change to improve your model ecosystem?

2 What will you do with your ecosystem after you have finished studying it?

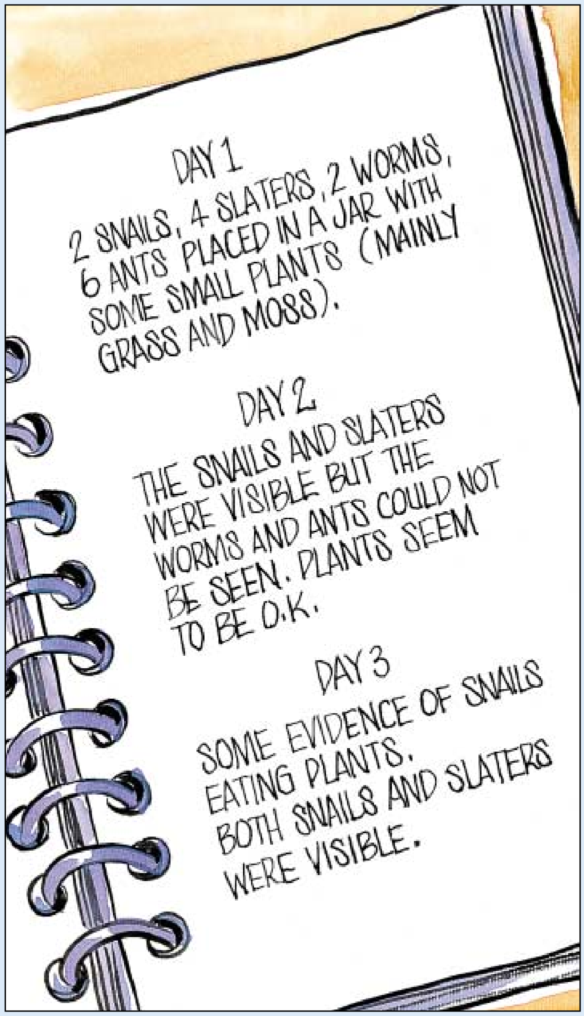

FIGURE 8.13
A sample diary entry.

Questions

1 **What is a community?**

2 **What is an ecosystem?**

3 **Why is the ecosystem that most humans belong to very large?**

4 **What are some of the changes an ecosystem may have to endure?**

5 **What environmental changes might affect a pond ecosystem such as that shown in Figure 8.12?**

6 **Draw a diagram of a rockpool ecosystem showing some of the plants and animals you might find in it and how they are interdependent.**

7 **Make a list of all the living and non-living parts of your ecosystem.**

Glossary

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8.4

Food chains

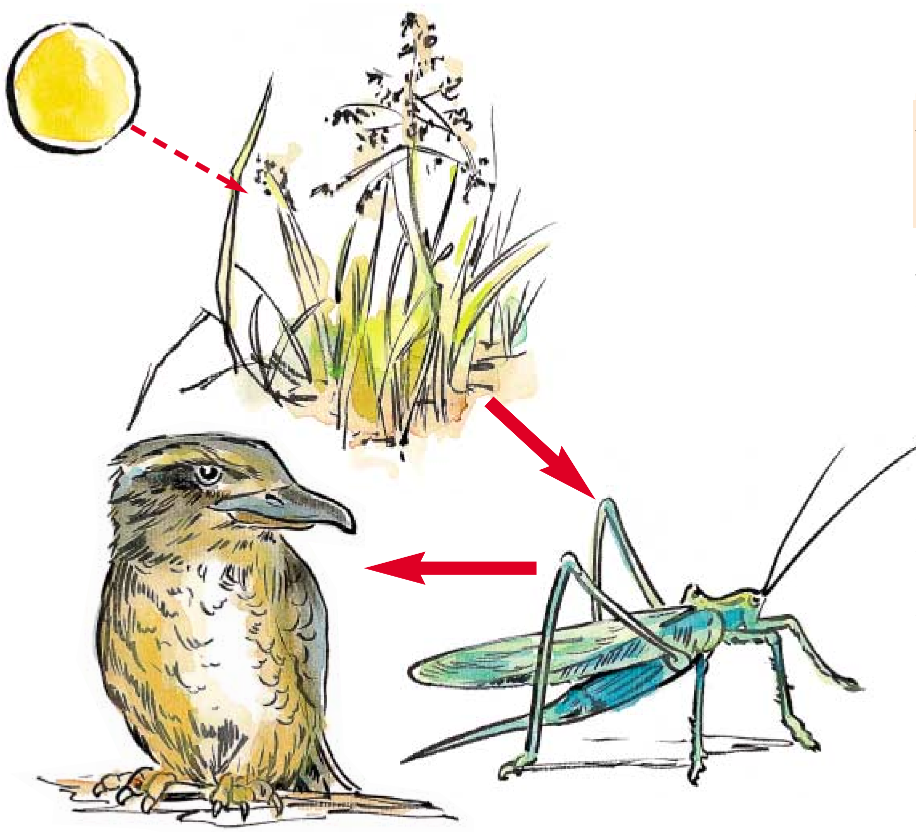

FIGURE 8.14
All food chains start with the sun and usually end with bacteria or fungi.

What is a food chain?

Plants and animals use up a lot of energy in growing and in day-to-day living. This energy has to come from somewhere. Plants get their energy from the sun; animals get their energy from eating food, such as plants and other animals. For example, grass uses the sun's energy to grow. A grasshopper might eat the grass to get the energy it needs, and a kookaburra might eat several grasshoppers to get the energy it needs. When the kookaburra dies, bacteria will help to decompose its body, enriching the soil and helping more grass to grow. This flow of energy is called a **food chain**.

Talk about
What would happen if there were no decomposer organisms such as bacteria and fungi?

A food chain is usually shown as a simple flow chart as follows:

sun → grass → grasshopper → kookaburra → bacteria

A food chain shows how when food is eaten energy is passed from one living thing to another. The direction of the arrows shows that the energy (or food) moves first from the sun to the plant, then to the grasshopper when it eats the plant, and then to the kookaburra when it eats the grasshopper.

Producers, consumers and decomposers

Food chains start with the sun. The sun gives out light energy that allows plants to make their own food from simple substances such as water and carbon dioxide. This process is called **photosynthesis**. Because plants can produce their own food they are called **producers**.

Animals are unable to make their own food and must consume (eat) plants or other animals to obtain food. Animals are therefore called **consumers**. If a plant or animal dies without being eaten its body is broken down by **decomposers**. Decomposers are living things such as bacteria and fungi that live off the energy in dead plants and animals. Decomposers are able to get the energy they need as they break down dead matter.

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Foundation worksheet 2

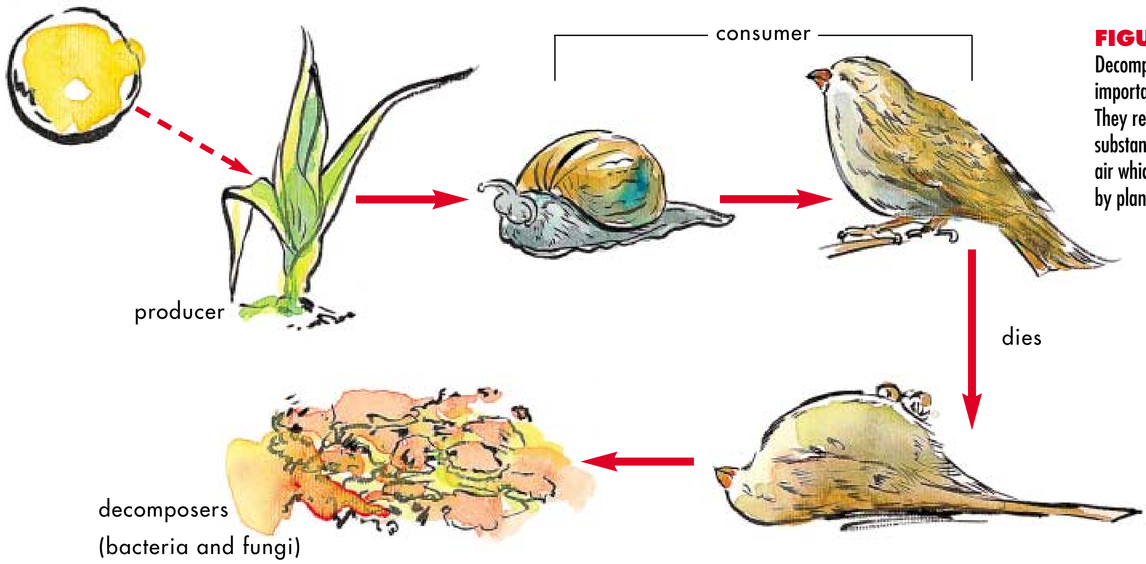

FIGURE 8.15 Decomposers are very important in a food chain. They return many important substances to the soil and air which can then be used by plants.

Questions

1 Write down the meanings of the following words:
producer   consumer   decomposer

2 What does the arrow indicate in a food chain?

3 Why do food chains begin with the sun?

4 Why is the first living thing in a food chain normally a producer?

5 In a particular pond environment, snakes are eaten by kookaburras. The snakes eat tortoises and the tortoises eat tadpoles. Tadpoles feed on algae, a type of water plant. The kookaburras often carry tiny creatures called lice which attach to their skin under the feathers. The lice suck out small amounts of the kookaburras' blood.
Which of the following food chains best describes these feeding relationships?

a algae → tadpoles → tortoises → snakes → lice → kookaburras
b lice → kookaburras → snakes → tortoises → tadpoles → algae
c algae → tadpoles → tortoises → snakes → kookaburras → lice
d snakes → kookaburras → tortoises → tadpoles → algae

Activities

1 For each of the diagrams below, copy and complete the food chains.

2 Identify the producers and consumers in each of the food chains.

3 Extend your food chain to include a decomposer and another consumer.

Sun → Tree → Grub → ______

Sun → ______ → Sheep

______ → Grass → ______ → Humans

FIGURE 8.16

FACT FILE

When food is eaten energy is not the only thing which can be passed along a food chain. Artificial chemicals such as some pesticides can also pass from the environment into plants. When animals eat the plants they consume the pesticides as well. As one animal is eaten by another the pesticide is passed along. If people are part of the food chain they can also consume the pesticide.

Glossary

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8.5

Plants: green machines

FIGURE 8.17
Plants get their energy by a process called photosynthesis. The green colour of the leaves of many plants is due to a substance called chlorophyll. Chlorophyll traps light energy from the Sun for photosynthesis.

FACT FILE

Scientists are trying to make a chemical which would work like chlorophyll to trap energy from the Sun. This energy would be used to make hydrogen, a fuel which could replace oil, coal and natural gas.

Photosynthesis

Plants have the amazing ability to trap energy from the sun to make food and oxygen. This process is called **photosynthesis** which means 'building from light'. To make food, plants need the raw materials carbon dioxide gas from the air and water from the soil. The carbon dioxide enters the plant through tiny holes in the leaves. The water is absorbed from the soil by the roots.

Photosynthesis mostly takes place in the cells which make up leaves. These cells contain a green coloured substance called chlorophyll. It is the **chlorophyll** that can absorb energy from sunlight. Because sunlight is needed, photosynthesis can only occur in daytime. The energy absorbed by chlorophyll is used to make glucose (a sugar) and oxygen from the carbon dioxide and water.

Plants use the glucose for energy to stay alive or they change it into other useful substances such as **protein** and **starch**. The oxygen gas which is formed can be used by the plant to produce energy or it can be released into the air.

As well as food and oxygen, plants provide other benefits to animals. They provide a habitat for numerous species of animals. They help hold moisture in the surrounding area. Plants also anchor the top soil in place and prevent soil erosion.

Glossary

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EXPERIMENT 3 SUNLIGHT AND PLANTS

AIM
To show that sunlight is needed for photosynthesis.

MATERIALS
- young geranium plant
- 250 mL beaker
- hot plate
- starch solution
- alcohol
- test-tube holder
- test-tube rack
- aluminium foil
- 500 mL beaker
- matches
- iodine
- water
- test-tube

METHOD
1 Secure a piece of aluminium foil to the front and back of part of a geranium leaf (with the leaf still attached to the plant). Leave the plant in sunlight for several days.

Note: The covered part of the leaf is the **control**. Any differences you find between the uncovered part and the control must be due to the effect of sunlight.

2 Boil some water in the 500 mL beaker.

3 Remove the leaf from the plant.

4 Remove the aluminium foil from the leaf and immediately plunge the leaf into boiling water. This will kill and soften the tissues.

FIGURE 8.18 Experimental set-up to investigate the effect of sunlight on plants.

5 Pour the alcohol to a depth of 1 cm into the 250 mL beaker.

6 Place the leaf into the alcohol. Place the 250 mL beaker into the 500 mL beaker containing the boiling water.

Note: This acts as a double boiler: you should never boil alcohol directly.

7 When the alcohol has turned green and the leaf has gone pale, wash the leaf in warm water. You have now extracted the chlorophyll from the leaf.

8 Place some starch solution into a test-tube. Add several drops of iodine. What colour does it turn? Starch (sugar) turns blue-black when tested with iodine.

9 Drop iodine on the leaf.

10 Draw the leaf in your book. Shade the area that turns blue-black.

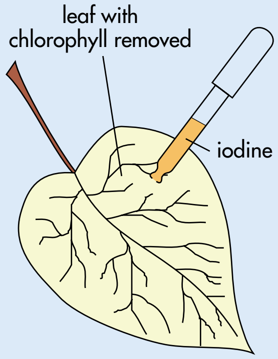

FIGURE 8.19 Testing a leaf for starch. Starch is made by joining many sugar units together.

DISCUSSION
1 Which area changed colour: the part exposed to sunlight or the part covered with the aluminium foil?

2 What substance is produced when a green leaf is exposed to sunlight?

Questions

1 **Complete the following sentences.**
_____ is necessary in the food-making process called _____ . In this process, sugar is made in the form of _____ to provide for the plant.

2 **'Without plants there can be no animal life.' Give two reasons to support this statement.**

3 **Make a list of as many different animals as possible whose habitats are trees.**

Think about

Many conservationists are concerned that the destruction of rainforests will lead to a lack of oxygen necessary for animal life.

a **Explain the relationship between the two.**

b **Suggest a solution to the problem. Discuss this with other members of your class.**

Glossary

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8.6 Food webs

FIGURE 8.20
While in most food webs the plants are eaten by animals, there are some exceptions. The Venus fly trap catches insects between two modified leaves. The insect is slowly dissolved and the plant uses some of the nutrients to help it grow.

Talk about

Why would plants like the Venus fly trap need to get extra nutrients by digesting insects?

Being among the smaller members of the pond ecosystem, small fish live in constant danger of being eaten. If they go too close to the surface, birds might catch them. If they wander too far away from the protection of the reeds or elodea, large fish such as redfin will have them for lunch. The edge of the pond also presents dangers: birds and frogs are always on the alert for an easy meal.

If you drew the food chains of every predator in and around the pond, the small fish would be included in many of them. This situation is common in ecosystems. Each animal eats a variety of different foods (other animals or plants) and is also the target of a number of different predators.

Joining a number of food chains together produces a **food web**, which outlines who eats whom in the whole ecosystem.

Changes often occur in food webs as the populations of the different animals and plants increase, decrease or move to another place. Some animals and plants might be in the pond only at certain times of the year. For example, tadpoles might be a good source of food for fish one week but if they become frogs the following week they will no longer be available.

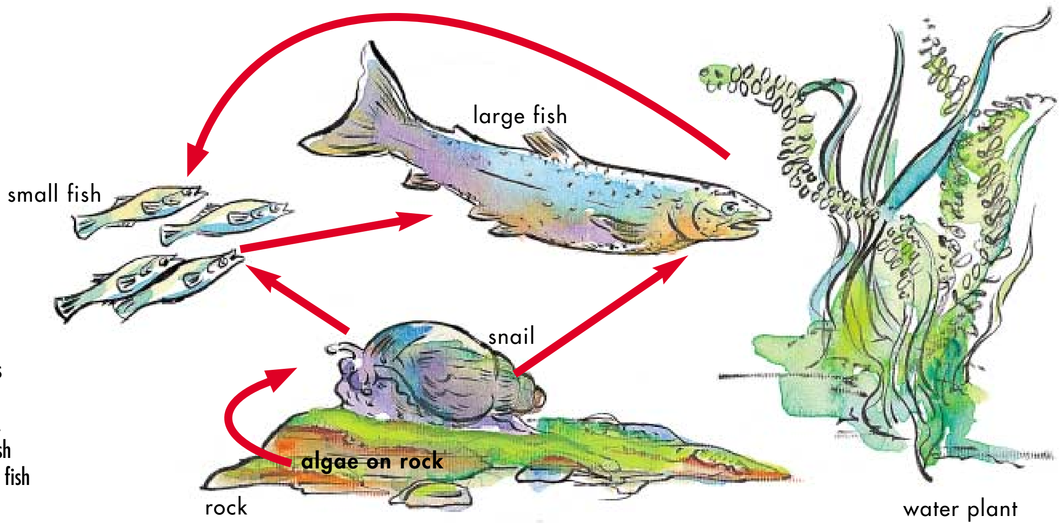

FIGURE 8.21
A food web clearly identifies who eats whom. From the above food web the following food chains could be drawn.
algae on rock → snail → large fish
water plant → small fish → large fish
algae on rock → snail → small fish → large fish

Glossary

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Extension worksheet

USING SCIENCE 3 A PERSONAL FOOD WEB MOBILE

WHAT YOU NEED

- cotton thread
- wooden skewers (shashlik sticks)
- cardboard
- scissors
- felt markers or paints (optional)

WHAT TO DO

1 Make a list of the food you ate yesterday. Identify at least 10 living things (plants or animals) that contributed to the food you ate. Include at least two producers and two consumers.

2 Use a piece of cardboard to represent each organism (don't forget to include yourself). You could simply write the name of each organism on a card, or you could cut out the cards in the shapes of the organisms and colour or paint them for a more decorative effect.

3 Identify any possible links (food chains) between the organisms and show these by joining the corresponding cards with cotton thread.

4 Construct your personal food web mobile by hanging the cards from the wooden skewers using cotton thread. (You may need to plan it on paper first, to work out the best arrangement for your web.)

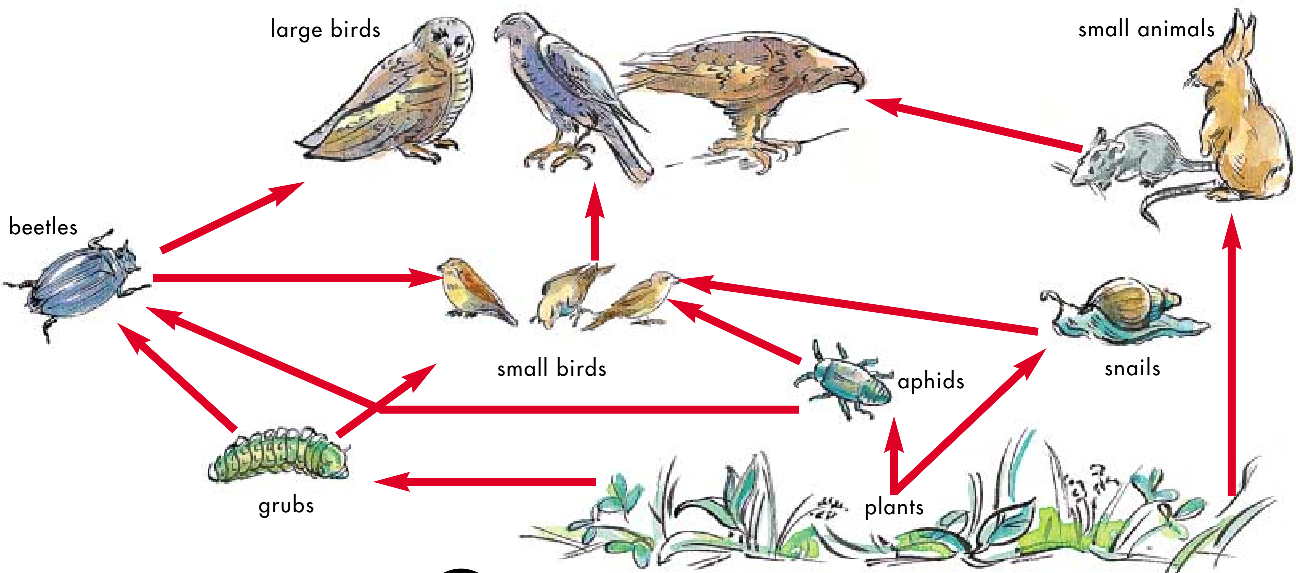

FIGURE 8.22 A large food web.

Questions

Use the food web shown in Figure 8.22 to answer questions 1, 2 and 3.

1 Which living things are:

a producers

b consumers

c decomposers?

2 Describe what you think would happen in the food web if the number of:

a small birds decreased

b foxes increased

c plants decreased.

3 Draw three food chains that are contained in the food web.

4 Why don't food webs always stay the same?

5 Draw a food web that includes the following animals and plants:

- **algae (a plant)**
- **snail (eats algae)**
- **small fish (eats algae and snails)**
- **water beetle (eats small fish)**
- **frog (eats beetles)**
- **snake (eats beetles and frogs).**

6 Draw a food web of a human eating a meal of chicken and chips. Include all the organisms that are likely to be involved.

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8.7

SCIENCE IN FOCUS

THE NATURE AND PRACTICE OF SCIENCE

The Biosphere project

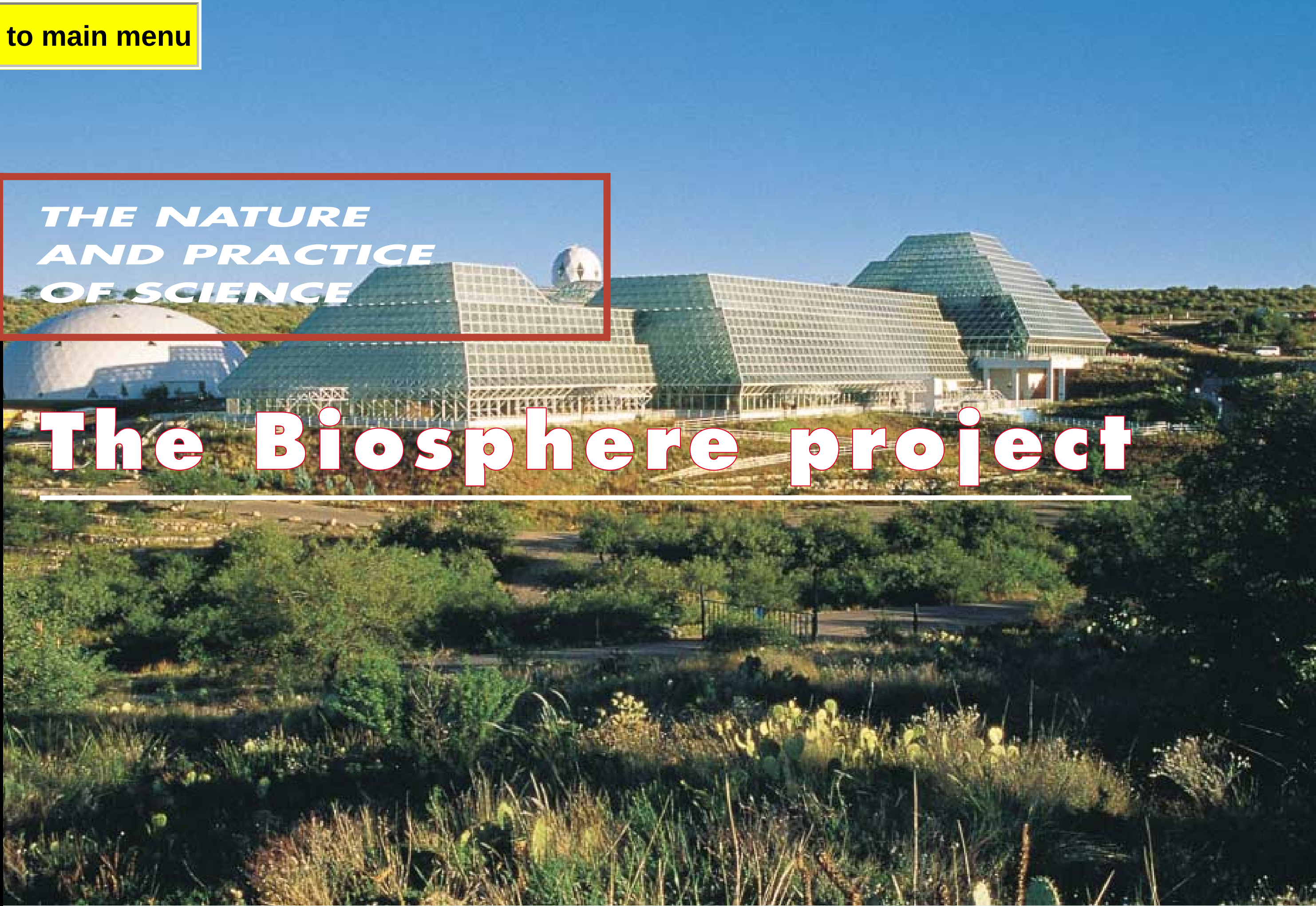

FIGURE 8.23 Biosphere 2—a complete indoor ecosystem.

In September 1991 four women and four men entered a giant glass bubble that was sealed off from the outside world. They would live inside the bubble for two years. The bubble was called Biosphere 2 and was part of an attempt to create an artificial ecosystem that could possibly be used in space exploration. The glass bubble was 1.2 hectares in area and was built in the Arizona desert in the USA.

Part of the area inside the bubble was set aside for agriculture. The inhabitants of Biosphere 2 had to grow their own food to eat, including chickens, pigs and goats as well as crops. All wastes were recycled to help grow more food. In the remaining area five wilderness habitats were set up. These included a rainforest, a grassy plain, a desert, a marsh and an 'ocean'. Into these habitats a total of 4000 species of plants and animals were introduced.

The scientists involved in the project expected that some of the 4000 species would die out because the bubble would not be able to provide the right living conditions for them. For example, animals may not have enough food, there may be too many predators, or there may not be enough oxygen to breathe.

The program did run into difficulties. A few months into the two-year experiment the level of carbon dioxide (the gas that humans and animals breathe out) was very high and had to be artificially reduced using chemicals. Some people argued that this was cheating and against the spirit of the whole investigation. However, many scientists believed that the project was a useful experiment and that much was learnt.

Web page

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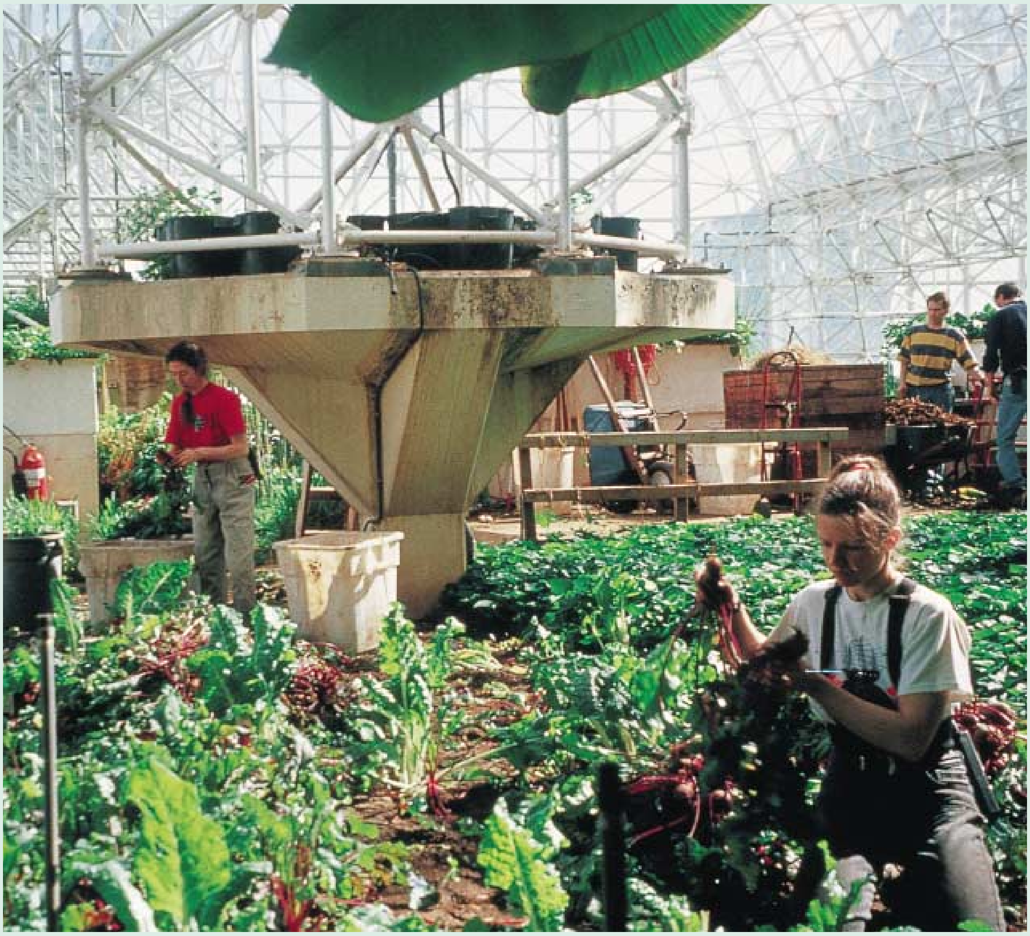

FIGURE 8.24
Growing food in Biosphere 2.

Questions

1 What were the five different habitats contained in Biosphere 2?

2 What were some of the foods that the people in Biosphere 2 could have eaten?

3 Why did the scientists expect that some of the 4000 species of plants and animals might die out?

4 Would it have been a good idea for the 'Biospherians' to have used a lawn mower or motor bike? Explain your answer.

5 Suggest a food web for the living things that were included in the experiment.

Activity

You are the director in charge of a project to build an Australian space station on a distant planet. You must design an ecosystem that can support a variety of Australian animals and plants as well as a team of 10 humans.

Choose three or four typical Australian animals that you will take with you and two or three types of plants. Think of their particular needs. You also need to provide food sources for the humans. Remember that decomposers are needed to break down dead animals and plants.

1 Draw a plan of your space station.

2 Draw a food web showing the relationships between the living things that will inhabit the space station.

FACT FILE

Currently scientists are using Biosphere 2 as a 'model Earth' to investigate the effect of environmental changes on life on Earth. Biosphere 2 will help scientists better understand the effect of increasing carbon dioxide levels on plant growth. Grasses are being grown in different levels of carbon dioxide and the effects are being measured. Carbon dioxide levels are increasing in Earth's atmosphere because of the burning of coal, oil and natural gas. There is great concern about how plants will respond to this change.

Glossary

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8.8

Human impact on ecosystems

FIGURE 8.25 (above)
A river in New South Wales has been used as a dumping ground for cars and other rubbish.

FIGURE 8.26 (right)
Dolphins are just one type of sea creature which can become tangled in plastic rubbish and die.

Internet assignment

FACT FILE

On Clean Up Australia Day, plastic objects have made up a major proportion of the rubbish removed from rivers, creeks and beaches. Plastic objects have included shopping bags, bottles, straws, six-pack holders and fishing line. These objects have choked and killed large numbers of sea mammals and birds.

Many things affect the plants and animals that live in an ecosystem. Changes in conditions associated with the seasons, and even more extreme changes such as drought, fire and flood, are familiar occurrences in most ecosystems. Organisms often develop ways of adapting to these changes and are able to survive. However, humans can cause very different sorts of changes with which the ecosystem may not be able to cope. Some human activities that can change or destroy ecosystems are shown on these pages.

Many human activities can affect ecosystems in some way. For example, fishing for just one type of fish can upset the balance in a marine food web. Using too much fertiliser on crops can lead to excess fertiliser being washed into rivers, causing algae to grow too quickly. Discharging hot water from factories into rivers can kill some types of fish and cause others to take over.

In Australia much damage has been caused to ecosystems by introduced animals such as rabbits and introduced plants such as boneseed. These have taken over the habitats of many native animals and plants. Other ways in which human activities affect ecosystems are not as noticeable and we are still learning about them.

Talk about

For each of the photographs in Figures 8.26, 8.27 and 8.28, explain how you think the ecosystem would be affected by the human activity shown. Discuss your responses with the rest of the class.

Glossary

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FIGURE 8.27 (far left)
Oil tanker spills.

FIGURE 8.28 (left)
Open-cut mining.

EXPERIMENT 4 POLLUTION AND PLANT GROWTH

INTRODUCTION

Humans use water for cleaning. When this water is returned to the environment it often contains pollution such as detergents.

AIM

To investigate the effect of detergent on plant growth.

MATERIALS

- 5 plant pots or tubs
- vermiculite or soil
- radish seeds
- 5 conical flasks or plastic bottles
- 4 different brands of detergent (such as dishwashing liquids and washing powders)
- felt marker

METHOD

1 Make up equal mixtures of the four detergents in flasks or plastic bottles. Fill the fifth container with tap water. Clearly label each container with a letter (A–E). Keep a record of which detergent is in which container.

2 Plant 10 radish seeds in each of the five pots. Label the pots A–E.

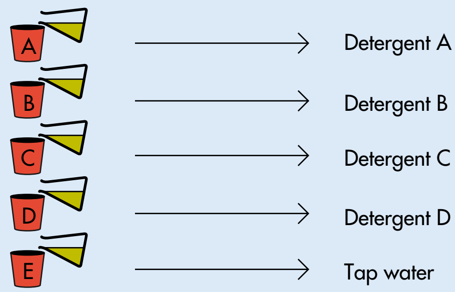

FIGURE 8.29
Set-up of pots and containers for the experiment.

3 Leave the pots in a warm, sunny spot. Water each pot with the mixture from the corresponding container. For example, water pot A with the mixture in container A, and so on (see Figure 8.29). Pot E should be given the tap water. It acts as the control in the experiment.

4 When the seeds have sprouted, remove all but the five healthiest plants in each pot. Continue to water them with the detergent mixtures. Measure their growth (height and leaf surface area) and observe their colour each week.

DISCUSSION

Write a paragraph to summarise your findings on the effect of detergents on plants.

Questions

1 What impact can introduced species have on ecosystems?

2 Water authorities ask people not to wash cars near gutters and drains. How could washing your car affect the environment?

3 What are three ways in which humans can affect ecosystems?

4 What are some of the things people do at school that could have a harmful effect on the environment?

5 What are some ways you could help to stop damage to the environment?

Extra worksheet

Glossary

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8.9

SCIENCE IN FOCUS

IMPLICATIONS FOR SOCIETY AND THE ENVIRONMENT

To log or not to log?

FIGURE 8.30
Bruno feels strongly about looking after the bush but also realises that the company and the town rely on logging. What would you do if you were Bruno?

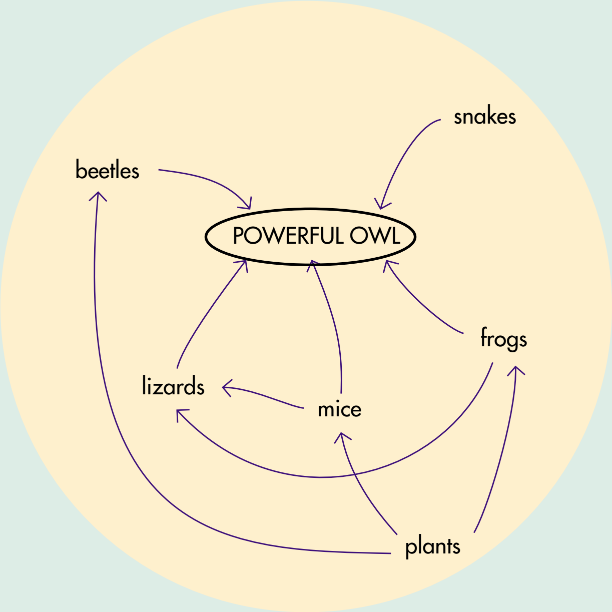
Bruno Rizzo has lived in the town of Barnard River for almost 30 years. He has seen the place grow from a small farming settlement into a large town thanks to the sawmill in which he is a part owner. Recently, however, trouble has been brewing in Barnard River. Studies by Wildlife Officers have indicated that a number of rare native animals are under threat of extinction due to logging carried out by Bruno's company.

Bruno enjoys bushwalking and has been a member of a walking club for many years. Some of his best friends are also members. The majority of the walking club members want the logging company to stop logging in areas where the powerful owl lives. They have also provided evidence to show that 14 other kinds of animals rely on the hollow trees found in the old-growth forests.

Bruno is sympathetic to the walking club members' concerns but knows that his company can only stay open if it is able to log in those areas. He also knows that more than half the town's population rely on the logging company for their income and many people would have to leave if the company closed.

FIGURE 8.31 (right)
One animal threatened with extinction by the logging is the powerful owl. It makes its home in the hollows of old trees that are destroyed when logging takes place.

FIGURE 8.32
(far right)
The destruction of a habitat affects many living things in a food web.



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USING SCIENCE 4 CLASS DEBATE

Topic: That the logging of Barnard River should continue unchanged.

Organise a class debate as follows:

1 Divide the class into two groups. One group will argue that logging should go ahead (the affirmative side) and the other group will argue that logging should not go ahead (the negative side).

2 Three students should be chosen from each side to be the speakers. They should each take on one of the roles outlined below.

3 Each team may need to do some further research to support their arguments. Those students who are not speakers should form the group's 'research team'.

4 Before the debate, decide as a class how the debate should be judged. You could bring in a guest judge or set up a judging panel of students who are not speakers. Scoring should be based on criteria such as: content and research; presentation; and strength of argument. The class should also agree on a strict time limit for each speaker.

5 During the debate, speakers from each side take turns in presenting their argument. Students who are not speakers can play the roles of Barnard River residents and ask questions of the opposing team's speakers.

Speakers (affirmative side)

Tim Burr (logger) is an outspoken, assertive person concerned about his job and the jobs of others in the timber industry. Dislikes 'greenies' who he says 'don't have real jobs'. Feels that people are more important than trees or owls. Argues that the town would become a ghost town if logging was stopped or reduced. Claims that a lot of owls have been seen in the bush.

Bill Scumming (local business person) firmly believes that logging must continue and that the owl is a small price to pay for the well-being of the town and its people. Suggests that the owl could be moved to other areas using artificial nesting boxes.

Barb Wyre (entrepreneur) believes that if people want to look at animals they should go to a zoo. She has already set up a commercial aquarium and organises a circus that visits the town each year. She would like to see more development in Barnard River: more people means more profits. She has plans to build the biggest zoo in the southern hemisphere.

Speakers (negative side)

Ima Walker (elderly resident and founding member of the walking club) is fiercely opposed to the operation of the logging company. She has obtained data to show that the population of owls has halved since 1985. She also claims that the logging cannot go on forever as the trees will eventually run out. She proposes that the town could take advantage of its pretty surroundings to promote tourism instead of logging.

Leah Vemmaloan (Wildlife Officer) has surveyed the area and found considerable damage caused by the logging company. Over 5000 hectares of owl habitat have been logged and only 2000 hectares remain. She claims that other species are also in danger, such as the squirrel glider and the tiger quoll. She claims that these animals could not be relocated because other areas do not provide the right kinds of food.

Phil Afformout (environmentalist) has collected 1000 signatures on a petition to stop the logging. He grows his own fruit and vegetables and has a 'back to basics' approach to life. He moved to the country to get away from the 'noisy rat race' of city life and enjoys living close to the bush.

Glossary

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Using scientific language

Produce a tourist guide that highlights the major features of the town or suburb you live in. Include the following words in your guide so that people who have not studied ecology will understand their meaning.

environment ecosystem community
habitat species population
producer consumer decomposer

Check your knowledge

1 Why do you think the habitat of a living thing is sometimes described as its 'address'?
2 Describe what you think would be the habitat of a mosquito.
3 What is an adaptation? Give one example.
4 What are some of the characteristics of worms that make them well suited to living in their particular habitat?
5 Consider the following list.

cat	gum tree	ant
magpie	sparrow	grass
rock	worm	daisy
rose		

a Divide the list into two groups: producers and consumers.
b Construct a food web using the words in the list. You may add others to make your web more complete.

Apply your knowledge

1 If an animal is taken out of its normal environment and placed in a new environment, it might not be very well adapted and might die. Some plants and animals, however, do very well in new environments. The rabbit is a good example. Its native environment was in Europe, around the Mediterranean Sea, but since being introduced to Australia it has flourished to the point of becoming a pest. Can you think of any reasons why the rabbit has been more successful in Australia than it was in its original environment?
2 Design a house that would make it possible for people to live in a very cold environment such as Antarctica.
3 Arrange the following groups of plants and animals into food chains.
a grass, snake, frog, grasshopper
b gum tree, kookaburra, caterpillar
c aphid, lemon tree, ladybird, spider
d human, shark, large fish, small fish, snail, water plants

4 Examine the following food web.

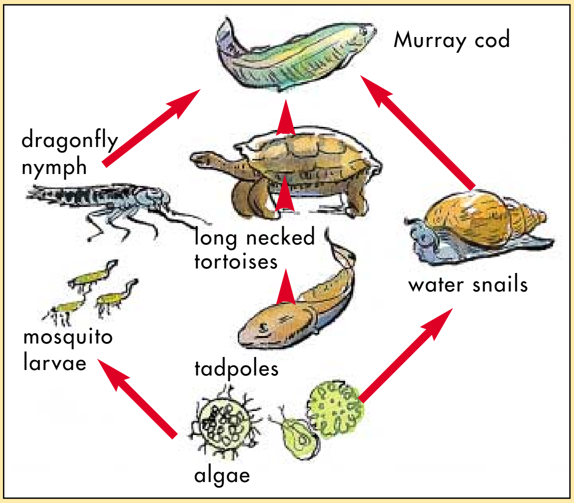

FIGURE 8.33

a If too many Murray cod were taken by anglers, what could happen to the number of long-necked tortoises?
b If the number of water snails decreased, would this have an effect on the number of mosquito larvae or tadpoles?

5 Examine the food web in question 4. List some of the ways in which human activities could have an impact on the animals and plants.
6 In groups of two or three, write down 10 things you know about dinosaurs and suggest why they might have died out.

Challenge yourself

Catch yabbies or other small animals to observe in your classroom. Yabbies normally eat decaying plants and animals. They survive quite well on meat but they can also be given raw carrot, apple, fish pellets or live worms. Feed the yabbies two to three times a week.

1 You can study the following aspects of yabbies:
   - their life cycle
   - moulting
   - their growth rate
   - their feeding habits
   - their preferred form of shelter.
2 Keep a diary of your observations about the yabbies and record the amount and type of food you have given them and how often.
3 When you have finished with your yabbies, return them to the place where you caught them.

Other suitable animals to study are worms, ants, butterflies, slaters and snails.

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CHAPTER 9

EARTH'S CHANGING SURFACE

Around 550 million years ago, there was a huge mountain range in what is now called central Australia. The mountain range rapidly eroded away. The sandy sediments formed were washed onto the surrounding plain to form a 2.5-kilometre thick structure called an alluvial fan.

By about 500 million years ago central Australia was covered by a shallow sea which covered the alluvial fan. More layers of sediment built up over the alluvial fan and pressure caused the sediments to turn into rock.

Around 430 million years ago the sea had completely disappeared and the many layers of rock which had formed began to be folded, faulted and uplifted. This continued for around 100 million years.

For 300 million years erosion has worn away the rock layers. Softer rocks have worn away faster than harder rocks. Uluru is the exposed tip of a huge layer of harder rock which has eroded slower than other rock layers surrounding it. This layer of rock extends several kilometres below the surrounding plain and is made from the sediments from the original 550-million-year-old mountain range.

In this chapter you will learn about the Earth and the forces that shape its surface.

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- **Recognise that the Earth's surface has changed over the history of the Earth.**
- **Describe features of the Earth's atmosphere.**
- **Distinguish between physical and chemical weathering.**
- **Describe erosion and demonstrate the eroding effects of water, wind and ice.**
- **Explain how weathering and erosion can lead to the formation of sediments.**
- **Describe how different types of rocks are formed and how they can be used.**
- **List the components of soil and discuss the environmental problems of soil degradation.**

Web links

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9.1 The home planet

FIGURE 9.1
Earthrise: 'Suddenly from behind the rim of the Moon, in long, slow motion movements of immense majesty, there emerges a sparkling blue and white jewel, a light, delicate sky-blue sphere laced with slowly swirling veils of white, rising gradually like a small pearl in a thick sea of black mystery. It takes more than a moment to fully realise this is Earth … home.'
Edgar Mitchell, astronaut, Apollo 14, 1971

Talk about
How would you describe how Earth looks from space?

Many of the people who have gazed down on Earth from space have expressed similar thoughts to those of Edgar Mitchell. As well as taking scientific measurements, they have often recorded their sense of wonder at the beauty of the blue and white planet.

Ancient philosophers thought a lot about our place in space, too. For a long time human beings could not imagine the Earth they stood on as a sphere. By 240 BC the Greek scholar Eratosthenes, certain that the Earth was round, had calculated the distance around the Earth (the circumference). He used the shadows cast by sticks and some reasonably simple mathematics to do this.

Despite this, it wasn't until 1961 that Yuri Gagarin, the famous Russian cosmonaut, confirmed with the human eye all those thoughts and calculations—he *saw* that the Earth was round!

Since that time, hundreds of electronic eyes—satellites—have monitored our planet closely. Today, a satellite takes a photo of the swirling clouds and rippling oceans of the planet's surface every half hour. They see other things too: storms brewing, volcanic ash clouds rising, fires raging, crops growing, forests falling, rivers flooding and cities expanding. All of these hourly, daily and yearly changes are being recorded. These images help us appreciate, more than ever, that our planet is alive.

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USING SCIENCE 1 — MAKING A MIND MAP

Work in groups of four to six students.

WHAT YOU NEED

- large sheet of poster paper (1 per group)
- thick felt marker or crayon (1 per person)

WHAT TO DO

1 Write the word EARTH in the centre of the paper.
2 Each group member contributes a word, group of words, or picture that he or she associates with the Earth. Add as many ideas as you can to build up a colourful 'mind map' about the Earth.
3 Explain to your group how your words and pictures are connected to the Earth.
4 Share your group's mind map with the rest of the class.

DISCUSSION

1 How many different ideas did your group have?
2 How many did the whole class have?

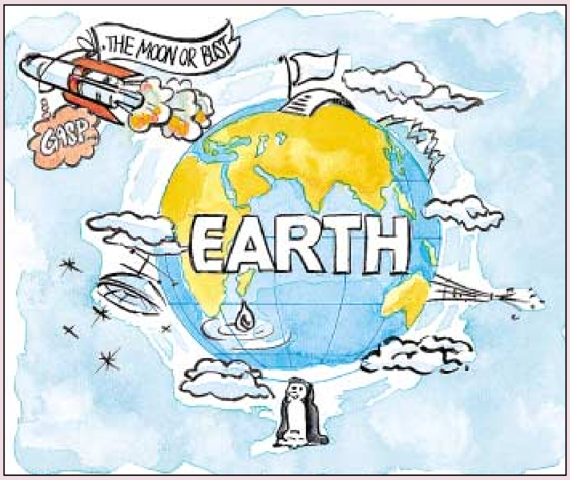

FIGURE 9.2
What does 'Earth' mean to you?

3 What features did most mind maps have in common?
4 What were some of the most unusual things people knew about the Earth?

Questions

1 What two colours do space travellers see immediately when they look down on Earth from space?
2 What features of the Earth give it these two colours?
3 Read Edgar Mitchell's words again. What do you think he meant when he wrote about 'slowly swirling veils of white'?
4a List three features or events on Earth that are observed by satellites.
b For each example, explain why it might be important for humans to monitor the feature as it changes.
c Estimate how long the satellite would have to monitor each feature to see a change (for example, hours, days, months or years).

Activity

Many cultures have their own legends about how the Earth began and how its features were formed. With a group of friends, make up your own legend about the formation of one of the Earth's features. You might choose clouds or oceans, or even volcanoes. Each group could choose a different feature.
Present your legend as a storybook, a painting, or a play.

FIGURE 9.3
Your legend could be about a feature such as a meandering river.

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When the rains came

How did the Earth begin?

Stories about the beginnings of the Earth as a planet have been told for as long as language has existed. The stories differ from culture to culture and through the generations. Scientists tell an exciting story based on centuries of gathered evidence. Imagine the Earth's early history as a novel—it might progress something like this:

Chapter 1. 4600 million years ago a swirling cloud of dust and gas surrounded our young Sun. Patches within the cloud became thicker as dust and gas clumped together, until huge solid dust balls had formed.

Chapter 2. The intense pressure that was created as the particles in the middle of the balls were squashed produced a lot of heat. Additional heat was provided by the decay of radioactive substances that formed much of the dust.

Chapter 3. Earth, one of these big, hot dust balls, was continually pounded by smaller dust balls (**meteorites**). These impacts further heated up the Earth until finally it melted.

FIGURE 9.4
The Earth is thought to have begun as a big ball of dust and gas which was being constantly bombarded by smaller dust balls called meteorites.

FIGURE 9.5
During the formation of the Earth, the cooling crust cracked again and again, and hot magma bubbled up from beneath.

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Chapter 4. The molten Earth began to separate into layers. Heavy substances such as iron and nickel sank to the centre. Lighter materials like silicon and oxygen rose to the outer surface.

Chapter 5. Eventually the top layer cooled enough to harden and a crust formed, but the centre was still fiercely hot. Great splits opened up in the new crust and lava flowed in huge quantities.

Chapter 6. The enormous amount of gas produced by these eruptions enveloped the steamy Earth. One of the heaviest of the gases in this early atmosphere was the most important ingredient for the future of the planet—it was water vapour.

Chapter 7. Eventually the Earth cooled enough for this water vapour to turn to liquid, and the rain came down in torrents. The first drops probably sizzled on hot lava 3500 million years ago. The rain didn't stop until most of the planet was covered in a shallow, muddy sea.

Chapter 8. There were many islands in the new ocean but, with no vegetation to hold them together, they were washed away by rain and eaten away by waves.

Chapter 9. Since that time, water has been continually wearing down, building up and reshaping the Earth's surface. But more importantly, this wonderful liquid has slowly transformed the barren, boiling, featureless surface into a blue and green, thriving planet that continues to change through time.

In theory

The scientific story of the beginning of the Earth is called a theory. A theory is not a fact, it is a useful way of thinking about a problem. Theories help scientists to make predictions and explain observations. Scientists continually design and conduct experiments to test theories.

The results of many experiments can support a good theory. Sometimes the results of experiments disagree with a theory. Over time the theory may be changed or replaced with a better theory.

Questions

1 How long ago did the Earth start to form from a huge dust cloud?
2 As the Earth formed, it heated up until it melted. What three things contributed to the heating?
3 Where would you expect to find the heaviest materials of the Earth? Where would the lightest ones be?
4 Read the Fact File. What does this tell you about the age of this part of Australia?
5 Earth is the only planet with liquid water. How has water shaped our planet?
6 What are theories and how are they used?

Activity

A

Make a children's book.

Imagine you are trying to explain the scientific story of the formation of the Earth to a young child. One effective way of doing this would be to tell the story in pictures. Your task is to make an illustrated story book using the text you have just read. Each 'chapter' in this story should be illustrated on a new page.

Do some research in a children's library to find out what makes a good picture book. To make your book really special you could:

1 Make it a pop-up book.
2 Use fabrics and textured papers to make your book interesting to touch.
3 Make a cassette and use your voice to tell the story, while the child just follows the pictures.

An important part of writing a book is trying it out on a target audience. Ask some young children to read, or look at, your book. Ask them what they think of it, and how it might be improved.

FACT FILE

Scientists in Western Australia have found crystals of the mineral called zircon that seem to have formed at the time when the Earth was first forming, 4150 million years ago.

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9.3

The blanket of air

FIGURE 9.6
A trip into the future?
A small aircraft, barely 3 metres in wingspan, boldly flies into the clutches of a powerful cyclone off the coast of northern Queensland. Howling winds and driving rain pound the tiny plane as it comes to the highlight of its four-day flight, 15 kilometres above the ground. Scientific instruments continue to take wind speed, temperature and air moisture readings, which they send back to scientists on the ground. The plane has no pilot.

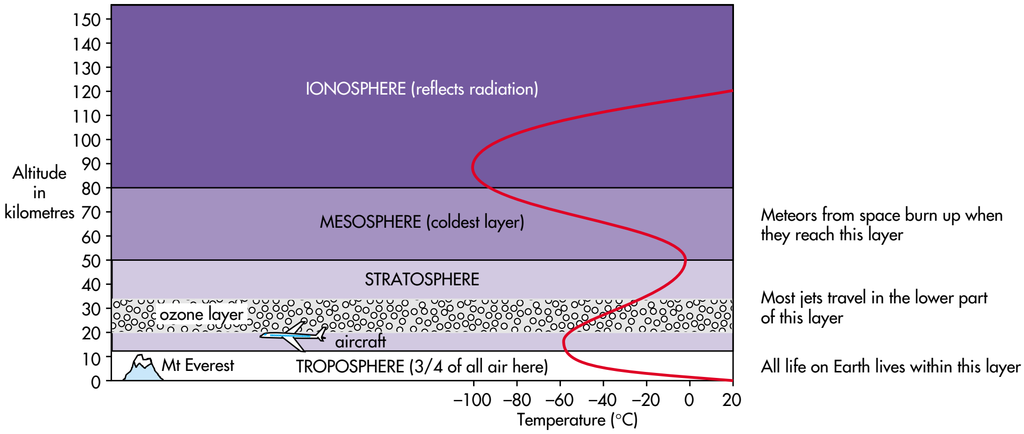
Talk about
Why wouldn't this aircraft have a pilot?

The caption at the left describes a possible scene from the not-too-distant future. Australian **meteorologists** (scientists who study the atmosphere) are leading the world in the development of this remote-controlled aircraft. They wish to improve their understanding of the complicated daily changes that occur in the blanket of air that surrounds the Earth.

The mixture of gases that surrounds a planet is called its **atmosphere**. The Earth's atmosphere is a mixture of gases approximately 145 kilometres thick. Nitrogen and oxygen, the most abundant gases, are essential for the life processes of all plants and animals. Carbon dioxide, though only accounting for 0.03 per cent of the atmosphere, is largely responsible for trapping heat close to the Earth, just as a blanket keeps you warm on a cold night.

Earth's atmosphere has several layers. It is within the lowest layer, the **troposphere**, that daily changes cause the patterns we call weather. All weather starts as energy from the Sun. This energy makes the air move (wind), and evaporates water from the Earth's surface to form clouds and, ultimately, rain.

FIGURE 9.7
The layers of the Earth's atmosphere.



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EXPERIMENT 1 WHY DOES THE WIND BLOW?

Spreadsheet

AIM
To show how the uneven heating of the Earth's surface and the air above it causes air to move, creating wind.

MATERIALS
- retort stand, boss head and clamp
- microscope lamp (or similar)
- 500 mL beaker and watchglass for a lid
- dry garden soil
- Plasticine
- glass stirring rod
- 2 thermometers
- matches

METHOD
1 Set up the equipment as shown in the diagram. Place the thermometers in the soil, but do not turn on the light yet. (Use the glass rod to make the hole in the soil: do not use the thermometer.)

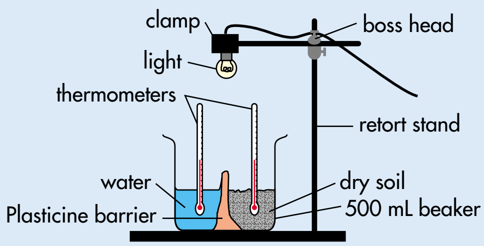

FIGURE 9.8
Experimental set-up.

2 While you wait for the thermometers to reach a steady temperature, draw up a table that will allow you to record temperature readings every 2 minutes for a total of 10 minutes. Your table could look like the one below.

Time	Soil temperature	Water temperature
Start		
2 minutes		
4 minutes		
…		

3 Take the starting temperature of the soil and the water. Switch on the light and let it heat the air. Take temperature readings every 2 minutes for the next 10 minutes.
4 Take the thermometers out.
5 Light a match, hold it down inside the beaker, and then gently blow it out so that it makes smoke.
6 Quickly place the watchglass over the beaker to trap the smoke inside.
7 Observe how the smoke moves immediately after the watchglass is placed over the beaker.

DISCUSSION
1 In this model the soil represents the land and the water represents the ocean. What does the light represent? What does it do in the model?
2 Which heated up more quickly—the land or the ocean? How do you think this affected the air above each area?
3 Which way did the air circulate (as shown by the smoke)? Show this pattern with a large labelled diagram of the beaker model. Try to explain this in terms of warm air and cool air.

Questions

1 **What is the atmosphere? Name the layers that make it up.**
2 **Look closely at Figure 9.7. Refer to the temperature graph on the right-hand side to help you answer the following questions.**
a **Give the temperature range (that is, the lowest and highest temperature) for each layer of the atmosphere.**
b **Where is the ozone layer?**
c **From the graph, try to explain what the ozone layer does to the temperature of the atmosphere.**
3 **Present the data in the 'Fact File' as either a column graph or a pie chart. The result should be large and colourful.**

FACT FILE

AVERAGE COMPOSITION OF EARTH'S AIR

GAS	Nitrogen	Oxygen	Carbon dioxide	Other gases
PERCENTAGE	78%	21%	0.03%	0.97%

The amount of each gas in the atmosphere varies slightly from place to place, and in the different layers.

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9.4 The crumbling crust

FIGURE 9.9
The effects of acid rain can often be seen in city limestone buildings. These buildings are slowly dissolved by the acid rain.

FACT FILE

Physical weathering is more common in very cold climates, or in dry environments like deserts. Chemical weathering is most extensive in tropical areas where it is warm and wet.

FIGURE 9.10
What has happened to the older headstone?

Weathering is the term used to describe all of the effects the atmosphere has on exposed rock materials. Uncovered rocks break down because of the action of wind, rain, ice and sunlight. Living things may contribute. Finally, gravity would make sure little pieces of the stone fall to the ground after they have been loosened in other ways.

There are two main types of weathering.

Physical weathering

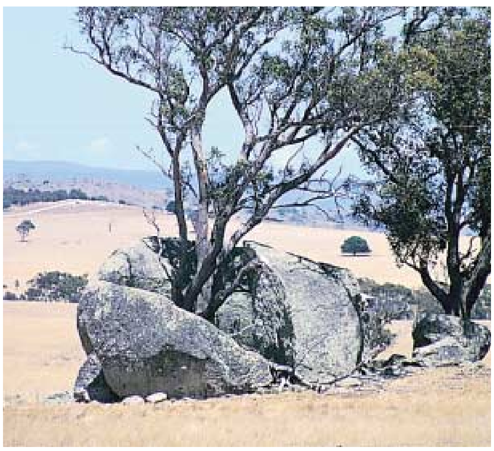

FIGURE 9.11
Living things can contribute to weathering. Here, a tree root grows in a crack in a rock, and will eventually split the rock.

Physical weathering is the breaking up of rocks into smaller and smaller pieces. When water in small cracks freezes it expands, making the crack larger. This is called **ice wedging**. Rocks may **expand** (get bigger), and **contract** (shrink) in areas of extreme daily temperature changes, such as deserts. Tree roots growing into cracks can split large boulders. Some organisms burrow into rocks for shelter, and their predators chip at the rock to eat them.

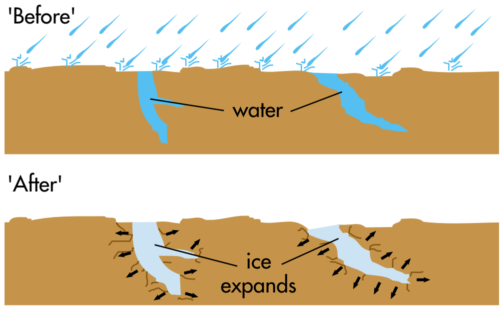

FIGURE 9.12
Ice wedging: Water collects in cracks in the rock. It expands as it freezes, widening the crack.

Chemical weathering

Chemical weathering involves the changing of the chemicals in the rocks to new chemicals by the action of water and air. The **minerals** (particles which make up rocks) often become very soft during this process, or may dissolve away entirely. Chemically weathered rocks are often very brittle, and may have distinctly different colours from fresh, unweathered rock. Oxygen from the atmosphere can combine with minerals in the rock and

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Foundation worksheet 1

Extension worksheet

EXPERIMENT 2 PHYSICAL WEATHERING

AIM
To discover how extremes of temperature affect the breakdown of rocks.

MATERIALS
- a small rock sample (granite is best)
- Bunsen burner
- small flat can (e.g. tuna can) filled with cold water
- tongs with heat-resistant handles

Warning: Safety glasses must be worn at all times.

METHOD
1 Hold the rock firmly with the tongs over a blue Bunsen burner flame for 2 minutes.
2 Drop the rock into the tin of cold water.
3 Check the contents of the tin to see any change (look for very small pieces of rock).
4 Repeat the heating, cooling and observing steps several more times with the same piece of rock. Record your observations.
5 Test the remaining rock for strength.

DISCUSSION
1 What did you observe happening to the rock?
2 Why do think this happened?
3 We used temperatures much higher than you would find in nature to demonstrate this effect. Why did we need to do this?

EXTENSION
Design an experiment to investigate **chemical weathering**. Find out what effect these three factors have on the extent of the weathering:
a strength of acid (vinegar is a safe acid to use)
b type of rock (you could compare marble and granite), and
c time.

change them to new minerals. Water can also change minerals or dissolve them completely. Carbon dioxide and other atmospheric gases can combine with rainwater to form acid rain which eats away at rocks.

Plants such as lichens growing on the surface of rocks may produce chemicals that eat into the rock surface.

It is not often that we find any one of these processes working on its own. The constant interaction between the atmosphere and rock surfaces ensures that the crust of the Earth is always crumbling, even if this process is too slow for us to notice.

Questions

1a What is weathering?
b What is the difference between physical and chemical weathering?
2 For each of the following statements, decide if the process described is an example of physical or chemical weathering, or a combination of both.
a Iron minerals become 'rusty' on contact with air and water, and change colour.
b Limestone is dissolved when acidic water gets into a crack in a rock caused by a growing tree root.
c Salt crystals grow bigger in a crack and make the crack wider.
3 List six structures made by people that would be affected by weathering.
4 The Pyramids in Egypt are in danger from several types of weathering. Given that they are near a big city, describe the human activities which might cause physical and chemical weathering of these ancient monuments.

Multimedia

Activity

Make a photo catalogue of weathering found around your own home or school ground.

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9.5

Erosion

FIGURE 9.13
Melbourne city dust storm, February 1983. Enormous quantities of soil eroded from Victoria's north were carried by the wind into the city of Melbourne, creating a huge dust storm.

Agents of erosion

Ever since the great downpour of rain 3500 million years ago, when the new atmosphere drenched the surface of the Earth until it was awash, the land has been at the mercy of running water. No other force has been as effective in shaping the land since that time.

Erosion is the wearing away of soil and rock materials. Erosion involves loosening material and transporting it to another place. The major agents of erosion are **water**, **wind** and **ice**.

Erosion by water

Even tiny amounts of **water** can start erosion. A raindrop can hit bare soil like a miniature meteorite, moving soil grains a few centimetres. Rivers, great or small, wear away their own banks and beds, making their course ever wider and deeper. Waterfalls deepen their pools below. The relentless sea pounds at the land forming cliffs, arches and stacks. (See Figure 9.15.)

FIGURE 9.14 & FIGURE 9.15
'London Bridge has fallen down'. The effect of erosion by water is clearly seen in these photographs. The sea has claimed another piece of land along the Victorian coast near Port Campbell.

FIGURE 9.16
A glacier is a river of ice. It can pluck out boulders as big as houses and transport them long distances, scouring the valley as it goes.

Erosion by ice

Ice is not a major source of erosion in Australia now, but it has been in the distant past. Our near neighbours, New Zealand and Antarctica, are good places to visit to see ice erosion in action. In both places **glaciers** (rivers of ice) grind their way slowly to the sea. Rocks plucked from the land and embedded in the ice scrape and scar the land further on. Evidence that this has occurred in Australia in the past can be found on ancient boulders in some localities.

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EXPERIMENT 3 SIMULATING EROSION

AIM
To demonstrate the eroding effects of water, wind and ice.

MATERIALS
- cake of soap
- hairdryer or fan
- handful of sand
- sponge
- safety goggles
- plain ice cube
- sink with overhanging tap
- poster size piece of black paper
- ice cube with gravel embedded in it
- piece of slate, or slab of dry clay

METHOD
1 *Waterfall*
Sit the cake of soap on the sponge, and place both under the tap in the sink. Have the tap dripping steadily for the whole lesson. Check the soap once or twice during the lesson.
2 *Windpower*
Place the sheet of black paper on a flat surface, and put the sand at one end of the paper. **Put your goggles on for the rest of this part of the experiment.** Holding the hairdryer or fan behind the sand, so as to blow it along the paper, turn it on for one minute. Try to find a relationship between the size of the sand grains and the distance they have travelled. Pile up the sand again and dampen it by shaking wet hands on it. Try the wind test again and note any changes.
3 *A miniature glacier*
Rub the plain ice cube over one part of the slate/dry clay slab as hard as you can. Now rub on a new spot with the ice cube containing gravel. Record your observations.

DISCUSSION
1 What happened to the soap? Could dripping water do this to solid rock? Explain.
2 What effect did dampening the surface have on the erosive power of the wind? In what sort of areas would wind erosion be most destructive?
3 Which ice cube is the most effective in eroding rock? How does this experiment mimic a real glacier?

Erosion by wind

In Australia wind is a very important agent of erosion because most of the continent has only a thin cover of vegetation to protect it. Once the wind has picked up grains of dust, soil and sand, this material ‘sandblasts’ other surfaces in a process that is far more effective at removing material than the wind by itself. Soil erosion is a big problem in Australia, especially in areas where drought, salt poisoning, overgrazing and clearing of the land have laid the soil bare.

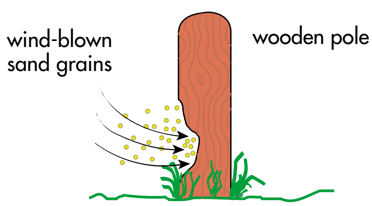

FIGURE 9.17

Questions

1a What are the three main agents of erosion?
b Describe an example of each in action.
2 Study Figure 9.17. Describe in detail what is happening to this pole. What will happen eventually?
3 What evidence is there that glaciers have been active in the past in Australia?

Think about

1 Why is soil erosion such a problem in Australia?
2 What problems would the Melbourne dust storm of 1983 have caused for:
a the farmers who lost the soil?
b the people in the city?
Write a paragraph for each.

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9.6

Dropping the load

USING SCIENCE 2 SETTLE DOWN!

Take a big coffee jar and put in it some sand, garden soil, and some fine clay. Fill the jar to the half-way mark with water, screw on the lid, and shake. Watch the contents settle when you stop shaking the jar.

Which particles fall to the bottom first? Which particles only settle when the jar has been still for some time?

To transport rock and soil, the agents of erosion (water, wind and ice) need to have energy. A glacier can move rocks the size of houses. Moving water has less energy, but can still move boulders in a river flood, or during a storm at sea. More often, water moves sand and mud. Wind can roll pebbles along the ground, but is mostly involved in transporting sand and dust. For ice to drop its load it needs only to melt. For water and wind to stop carrying eroded material, the energy level has to decrease. This means the wind has to drop, and the water has to slow down. The process of dumping the eroded material in a new place is called **deposition**.

When a pile of this deposited material comes to rest it forms **sediment**. The remains of plants and animals may be deposited with the rock particles, and some of these become fossils. Layer after layer of sediment builds up until the particles in the bottom layers become tightly packed. Water seeping through the sediment layers carries minerals which solidify in the spaces between the grains when the water evaporates. These processes, **compaction** (squashing) and **cementation** (gluing grains together) are the two main processes for changing loose sediment into **sedimentary rock**.

Sedimentary rocks can tell us a lot about the environments in which they were first formed. If the area of deposition was rough water, we would expect only large particles to be deposited, so the resulting sedimentary rock would be coarse grained. Finer particles would only be deposited when the water became very quiet, in a lake for example. Here we would expect to find rocks with small particles, a **fine grained sedimentary rock**.

FIGURE 9.18 Fragments of eroded rock of different sizes are deposited at different points along a river as the energy of the water drops.

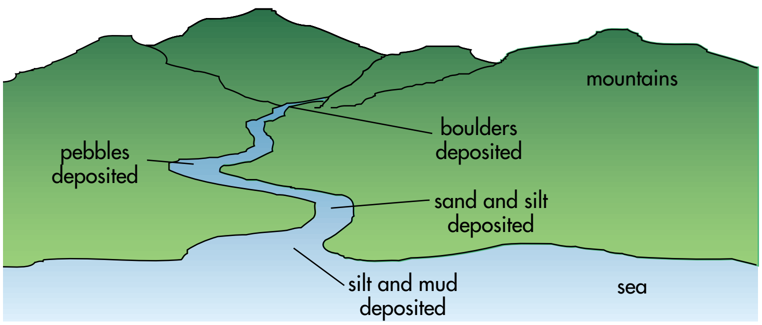
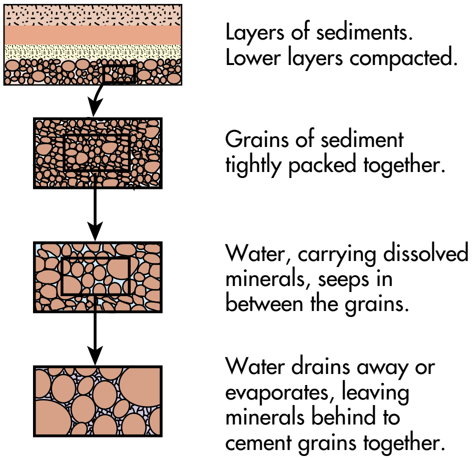


FIGURE 9.19 The compaction and cementation of grains in a pile of sediment gradually results in the formation of a sedimentary rock.



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Extra worksheet

EXPERIMENT 4 A MODEL RIVER

AIM

To make a model of a meandering (winding) river and discover where erosion and deposition occur due to changes in the energy of the current.

MATERIALS

- stream tray equipment as shown in Figure 9.20.

If your school does not have stream trays, you can use polystyrene fruit boxes, or large baking trays.

- an outdoor area with a water supply nearby
- damp sand to make the landscape
- talcum powder

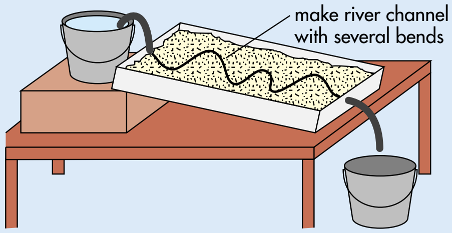

FIGURE 9.20

METHOD

1 Set up your stream tray river as shown, making sure your river has a number of bends in it.

2 Start a steady water flow.

3 Watch for places where erosion and deposition are occurring.

4 Sketch your river, marking those areas.

5 Puff a bit of talcum powder near the water source and watch it go down the river. Try this several times and note on your sketch the path it takes (it will follow the fastest part of the current).

DISCUSSION

1 What parts of the bends are most affected by erosion? What bank features form here?

2 Where on the bends does deposition occur? What would you call these areas of deposition?

3 How does the speed of the current relate to the areas of erosion and deposition in your model?

Questions

1 Explain how loose fragments of material could become sedimentary rock. Use these words in your explanation: weathering, erosion, deposited, sediments, compaction, cement, sedimentary rock.

2 What causes deposition to occur when sediment is being carried by wind or water?

3 How can sedimentary rocks tell us about past environments?

4 Joel and Judy did a shake-up-the-jar experiment. They observed a number of layers, and noticed that most of the largest grains were deposited on the bottom. They were able to sample each layer and analyse the grain sizes within each. Which of the graphs in Figure 9.21 shows the percentage of grain sizes found in the jar? Explain your answer.

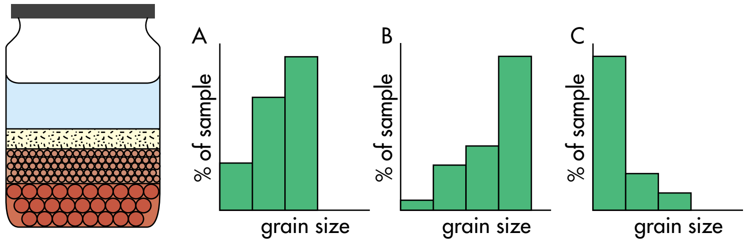

FIGURE 9.21

Find out

Find out what a delta is. Use an atlas or otherwise to find the location of some famous deltas such as the Nile and Mekong deltas.

Model a delta using your stream apparatus.

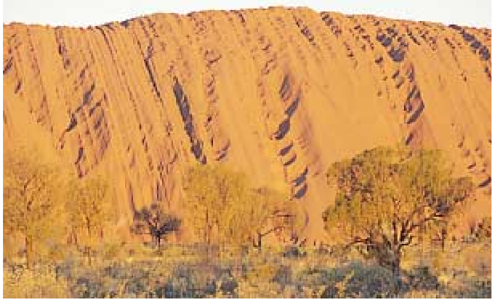

FIGURE 9.22
Uluru (Ayers Rock) is made up of sedimentary layers which have been tilted almost vertically by great forces in the Earth. Erosion has done the rest. Even though Uluru is in a dry, windy environment, the main agent of erosion is running water during desert storms.

Glossary

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9.7

The right rock for the job

FIGURE 9.23
Sandstone is often used as building material because it is easy to work with, it is strong and resistant to weathering, and it can be very attractive.

Sedimentary rocks

Sedimentary rocks cover 75 per cent of the Earth's surface in a thin covering. Layers of sediment are accumulating in the oceans, on river beds, in deserts, inside caves, at the bottom of lakes, and on beaches. They vary in thickness, colour, texture and hardness.

Sedimentary rocks are used in a wide variety of ways by humans. Stone for building often comes from sedimentary rock. The colours and textures available make sedimentary rock an attractive material, and it is also durable.

The calcium carbonate from **limestone** had many uses, but the most familiar is as an ingredient in cement for all of our concrete strutures.

The two other groups are the igneous rock group, and the metamorphic rock group.

FACT FILE

Even weathered rock has its uses. The white clay kaolin, used in the manufacture of paper and fine chinaware, is one of the chemical weathering products of granite.

Igneous rocks

Animation

Igneous rocks form by the cooling of molten material which originates deep in the Earth. As this molten material cools, interlocking crystals form and the liquid becomes solid. **Basalt**, which is used for road making, building blocks and slab paving, is a rock formed in this way.

Granite is an igneous rock which has large crystals. Its attractive appearance makes it a popular choice for headstones, table tops and for facing important buildings.

FIGURE 9.24
Basalt, or 'bluestone', is an igneous rock. It can be used for building and road making.

Metamorphic rocks

When igneous and sedimentary rocks are buried by overlying rocks, the heat and pressure they are subjected to may cause them to change significantly. Many of the original grains or crystals gradually recrystallise into new shapes, and the appearance of the rock may change completely. The beautiful white marble used for many statues is recrystallised limestone.

FIGURE 9.25
Marble, a metamorphic rock, has long been used for sculptures.

Mudstone which has been compressed and heated can change into **slate**, used for floor tiles and once a common roofing material. These changed rocks are called **metamorphic rocks**.

Rocks under the microscope

Under the microscope these three rock types look very different (Figure 9.27). The way the grains or crystals fit together is the key clue for deciding if a rock is sedimentary or igneous in origin, or if it has been altered by metamorphism.

Glossary

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Foundation worksheet 2

EXPERIMENT 5 MAKING SIMULATED SEDIMENTARY ROCKS

AIM

To imitate the rock-forming process of cementation to make some sedimentary rocks.

MATERIALS

- plaster powder
- petroleum jelly
- pebbles
- sand
- teaspoon
- icy-pole stick to mix with
- sedimentary rock key (Figure 9.26)
- 4 polystyrene cups
- margarine container
- gravel
- dry clay or fine soil

METHOD

1 Grease the inside of each cup with petroleum jelly.
2 Place 4 or 5 teaspoons of plaster powder in the margarine container and gradually mix in enough water to make a thin paste. Add pebbles, a bit of gravel and some sand. Mix, and pour into one cup.
3 Repeat step 2 with only gravel added to the plaster mix. Then repeat for other two rock types with sand and then clay/soil.
4 Allow your rocks a week to set, then peel away the cups to reveal your rocks.
5 Test your rocks for strength.

DISCUSSION

1 Which rock represents a conglomerate?
2 Which rock stayed together the best?
3 Could someone else identify your rocks using the key in Figure 9.26? Ask a friend to try.

EXTENSION

Use the key in Figure 9.26 to try to identify some sedimentary rocks in your local area. (Look for layered rocks.) Check first if sampling is allowed. If not, take some photographs instead. If natural outcrops of rock are not accessible, try looking at structures in your area which are built from rock materials.

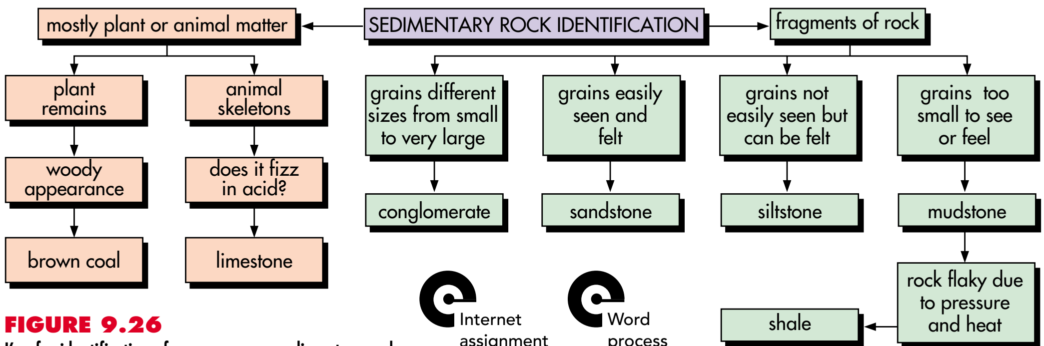

FIGURE 9.26
Key for identification of some common sedimentary rocks.

Internet assignment

Word process

Questions

1a What are the three main groups of rocks?
b How does each group differ from the other?
2 Match these rock types with the correct way they were formed.

Granite	Heat and pressure due to deep burial
Slate	Grains compacted and cemented together
Sandstone	Cooling liquid formed crystals

3 Using the information gained in this chapter and by looking at rocks in your local area, construct a table showing some common rock types, their properties, and their uses.

Think about

What qualities would you look for in the rock you would choose for a monument to a famous person or event?

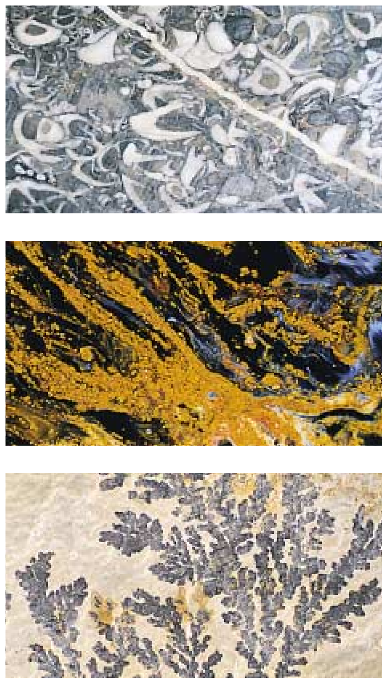

FIGURE 9.27
Limestone, thunder egg and slate. Under the microscope, sedimentary, igneous and metamorphic rocks are quite different in the way the mineral grains fit together.

Glossary

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9.8

What is soil?

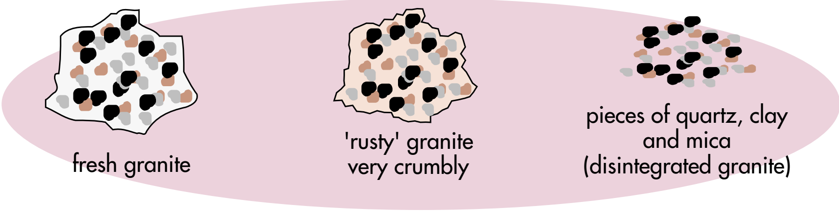

FIGURE 9.28
The physical and chemical disintegration of granite rock. The fresh granite is hard and distinctly coloured in grey, white and black. As the rock weathers, it changes colour and becomes soft and crumbly.

What would our lives be like without soil? We would have difficulty growing vegetables, there would be no grass for animals to graze, and forests could not survive to provide us with oxygen, timber and shade. Think of all of the wild creatures that would have no homes—wombats, centipedes, crickets and worms! **Soil** is important to all life on land, and to look after it properly we should know something about what it is, how it is made, and what it does.

The weathering of rock is the first step in the long process of making soil. The first stages in the physical and chemical disintegration of granite rock can take hundreds or even thousands of years. This process is shown in Figure 9.28.

But soil is more than just little pieces of rock. Water and air need to gather between the grains. Microscopic organisms such as bacteria and fungi move in and start to change the chemicals in the mixture. Eventually a whole community of tiny plants and animals take up residence in the new soil, adding their body wastes, and even their dead bodies, to make the soil rich in **nutrients**. These plant and animal wastes form a rich browny-black material called **humus**. Soils rich in humus are said to be **mature**, and they are usually very **fertile**, meaning they can support many plants.

Worms are very important to the health of a soil, because they take it in with their food. In so doing they alter the basic soil mixture both physically and chemically. Worms make burrows as they eat, which provide pathways for air and water to circulate underground to the roots of growing plants. Their excretions release nutrients such as iron, calcium, magnesium and potassium in a form that plants can readily absorb with water through their roots. Some scientists believe worms help prevent plant diseases.

FIGURE 9.29
Studying local worms. Through the Double Helix Club, under the direction of the CSIRO, 1500 children have collected data on worms in their local area. The information on species, numbers, soil types and climate these young Australians collected over seven months would normally have taken a few scientists five years to collect!

FIGURE 9.30
In East Gippsland, Victoria, Australia's largest worms grow to 2 metres long.

Questions

1 Pair up the following phrases to make sentences that make sense.

It can take many thousands of years . . .	change the chemicals in the pieces of rock.

Glossary

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EXPERIMENT 6 WHAT'S IN YOUR LOCAL SOIL?

AIM
To find out what soil in your local area contains.

MATERIALS
- fresh soil sample in a sealed jar
- stereo microscope, or magnifying glass
- tweezers
- graph paper
- gardening gloves

FIGURE 9.31
Wear gardening gloves when collecting and studying soil samples: you never know what you might find!

METHOD
1 Examine a small sample of your soil under the microscope. Try to identify rock fragments, plant roots, humus and small animals.
2 With tweezers, pick out samples of each type of soil particle. Put each one on the graph paper and try to estimate its size.
3 Record your findings, with pictures. Indicate the size of each type of soil particle (and animal) on the sketch.

DISCUSSION
What type of soil particle was most common?
How many species of animal did you find?

EXTENSION
Design your own experiment to find out how much water is in your soil.

As well as fragments of rock . . .

Microscopic organisms such as bacteria and fungi . . .

Worms alter the soil mixture . . .

The droppings of worms . . .

both physically and chemically.

contain many nutrients for plants to absorb.

soil contains air, water and other chemicals.

for soil to form.

2 **Draw a cartoon strip showing the formation of soil from hard rock to a nutrient-rich growth medium for plants.**

3 **8Z did an experiment which involved planting 10 seeds in each of 4 large pots. The pots contained various mixtures as shown, and the plants in each grew differently (Figure 9.32).**

a **What do you think was the aim of this experiment?**

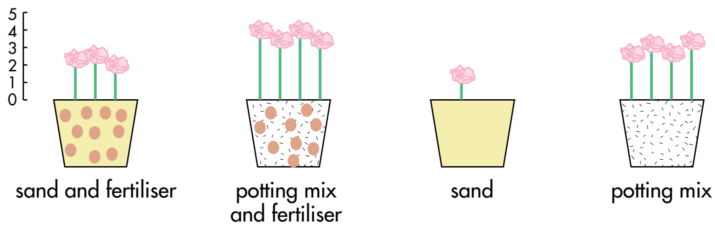

FIGURE 9.32

b **What hypothesis might the students have formed before starting the experiment?**

c **What variables did they need to control to make this a fair test?**

d **What results did they obtain? Display these results in a table or other suitable way.**

3 **What conclusion do you draw from these results?**

Think about

Fertile soil is soil that can support lots of living plants because it has lots of nutrients. Most of the nutrients come from rotting plant and animal material. Why, then, does soil quickly become less fertile if it is used repeatedly for crops, or if it is cleared of all vegetation?

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SCIENCE IN FOCUS 9.9

IMPLICATIONS FOR SOCIETY AND THE ENVIRONMENT

The vanishing soil

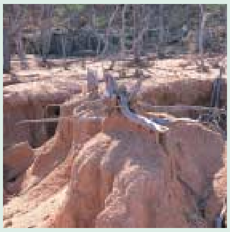

FIGURE 9.33
Gundaroo near Yass in New South Wales. Excessive clearing and tree loss can lead to deep gully erosion.

FIGURE 9.34
Massive machines compact the soil and lead to poor soil structure.

FIGURE 9.35
Soil erosion doesn't happen just on farms. It also occurs in towns and cities.

Australian soils are ancient, thin and infertile compared with soils in other countries. Until around 200 years ago, Aboriginal people were the only human inhabitants of Australia. They lived in such a way that they did not degrade (or damage) the soil. When European people arrived they cleared the land and cultivated the soil to grow crops and graze animals. The farming methods they used were disastrous for the fragile Australian soils. Soil that had taken up to 30 000 years to form was destroyed in a few decades. Through ignorance and greed the damage still continues today so that **soil degradation** is now **Australia's number one environmental problem**.

Soil can become degraded in four ways:

1 *Increased soil acidity*. This is caused by overusing fertilisers such as superphosphate. The soil becomes too acidic and plant growth slows or plants die.
2 *Loss of soil structure*. Soil with a good structure contains many spaces for air and water to penetrate. Continual ploughing and grazing leads to hard compact soil with poor structure. Water and air can no longer enter and plant growth is reduced.
3 *Increased soil salinity*. Salt originally found in lower subsoil layers rises to the surface dissolved in ground water. Most plants cannot survive in soil with high salt levels.
4 *Soil erosion*. When soil loses its protective plant cover, wind and moving water can easily strip away the top layer. The eroded soil eventually ends up being washed into waterways and then the ocean. The remaining under layer of soil is often not suitable for plant growth.

Twenty billion trees

There are many factors that contribute to soil degradation but the main cause is the removal of trees. Australians have not understood the role trees play in protecting the soil. It has been estimated that Australia has around twenty billion fewer trees than in 1788. Two-thirds of our rainforests have gone and one-third of our woodlands and shrub lands have been cleared. About 1200 trees have been axed, sawn, ringbarked, poisoned, bull-dozed, blown up and burnt for each person alive in Australia today.

Trees protect soil in a number of ways. The tree tops break the force of hard-hitting raindrops and reduce the force of the wind. Beneath the trees, a layer of dead leaves and twigs forms a protective blanket covering the soil. Tree roots help to bind the soil especially on slopes and riverbanks. Also, tree roots absorb water from deeper soil layers and prevent salt from rising to the top soil layer.

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Landcare

In an attempt to stop further soil degradation the 1990s has been chosen by the Federal Government as the 'Decade of Landcare'. Right across the country hundreds of community groups are working together to improve the long-term health of the land. Landcare groups are planting trees, repairing eroded riverbanks and gullies, protecting sand dunes and parks, investigating alternative farming techniques and planning for better land use.

FIGURE 9.36
Is there a landcare group in your local area? If there is, find out what they are doing to improve or protect the soil.

USING SCIENCE 3 MODELLING SOIL EROSION

WHAT YOU NEED

- large tray filled with sandy soil
- hose or watering can
- leaf litter, grass or straw

WHAT TO DO

1 Place the tray on a gentle slope outside.
2 Use the hose or watering can to allow water to gently wash over the soil.
3 Observe and draw the changes to the soil.
4 Repeat steps 2 and 3 but allow a heavy watering to wash over the soil.
5 Level out the soil in the tray then cover the surface with leaf litter, grass or straw and repeat the process.

DISCUSSION

1 Explain why most damage to soil occurs during storms and heavy downpours.
2 Explain why covered soil erodes less than bare soil.

Questions

1 What is the meaning of the term degradation?
2 List four ways soil can become degraded. For each one write down a cause and an effect.
3 Explain how trees protect soil.

Find out

1 Look around your local area for evidence of soil erosion. Draw or photograph each site and write down what you think is causing the erosion.
2 How did Aboriginal people survive for so long on this continent without degrading the soil?

Activity

Composting is one way everyone can help to improve the soil. Compost adds organic matter to the soil which improves soil structure, helps keep soil moist and slows down erosion. Build your own compost heap at home or your class could start one at school. Collect grass cuttings, vegetable scraps, shredded paper and garden waste such as weeds and clippings. Mix with soil and water then build a heap in a protected corner of the yard. Use a garden fork to turn the heap over each week until the compost is ready to add to your soil.

Glossary

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9.10 CHAPTER REVIEW

Using scientific language

Explain the difference between the following pairs of terms:

a weathering and erosion
b physical and chemical weathering
c deposition and sediment
d igneous rock and metamorphic rock
e sediment and soil

Check your knowledge

1 What is the atmosphere?
2 What causes wind in the atmosphere?
3 Where is the ozone layer found?
4 Copy Figure 9.37 into your workbook. Show on the diagram where you would find:
  a the fastest current
  b the slowest current
  c cliffs forming
  d sand deposits building up
  e maximum erosion
  f maximum deposition

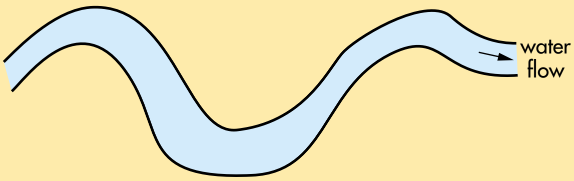

FIGURE 9.37

5 a What is deposition?
  b What causes deposition to occur when the transporting agent is wind or water?
6 What happens to soil which is repeatedly ploughed or grazed?
7 How do trees slow erosion?

Apply your skills

1 Where did the Earth's water come from? What had to happen before it became liquid water?
2 List the many things soil is needed for.
3 Look carefully at the footprints in Figures 9.38 to 9.40.
  a How long is each set of footprints likely to last?
  b What forces might destroy them?
  c What would have to happen in the environments that they are in for the footprints to be preserved as fossils?

FIGURE 9.38

FIGURE 9.39

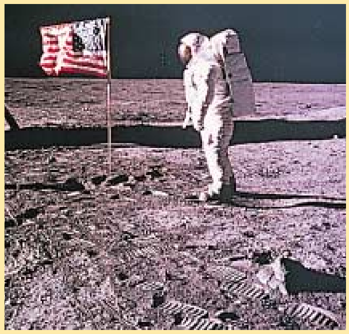

FIGURE 9.40

Challenge yourself

Use Figure 9.41 to help you set up your own wormery.

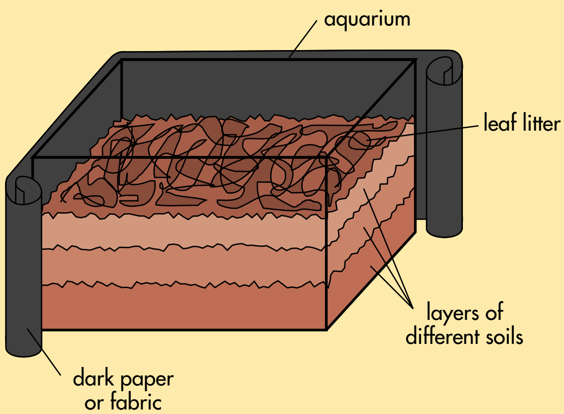

FIGURE 9.41

Make sure the different layers of soil are not too hard or lumpy. Put in about 10 worms. Cover the outside with dark paper or cloth, and keep the soil moist (not soaking wet). Check what is happening every few days, and note your observations in a log book. See if you can find out how to check for changes in soil quality, then experiment on the soil quality in your wormery. Present your findings in a poster.

Tester

Glossary

CHAPTER 10

THE STORY IN THE ROCKS

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- **Explain how fossils are formed and make a mould and a cast.**
- **Recognise that fossils are a record of past life forms which can be used to trace changes in life on Earth.**
- **Create a timeline of Earth's history which displays life forms and significant events.**
- **Research and present a report on a dinosaur.**
- **Recognise that a theory is a scientific explanation and that several theories exist to explain the extinction of the dinosaurs.**
- **Describe how scientists measure the age of fossils.**
- **Recognise that the surface of the Earth holds evidence of past events including impact with objects from outer space.**

The rocks which make up the crust of the Earth are like the pages of a book. Reading the rocks allows us to piece together the story of the Earth. The rocks tell an amazing story of upheaval, change and even impact with large objects from outer space.

Scattered over the Earth's surface are the remains of impact craters. Some craters like the one at Wolf Creek in Western Australia are clearly visible; others are long buried or are at the bottom of the sea. These hidden craters are only now being discovered as satellites photograph the Earth's surface from orbit.

The remains of a 195-kilometre wide crater have been discovered near the coast of Mexico. It is estimated to have been caused by an asteroid or comet at least 10 kilometres wide. The most recent collision with an object from space occurred in 1908 when a small asteroid or chunk of a comet about 60 metres wide exploded 8 kilometres above the Tunguska region of Siberia.

The rocks of the crust can also tell the story of life on Earth. Locked within them are the remains of past life forms preserved as fossils.

In this chapter you will learn how fossils are formed and about the most famous of the Earth's residents, the dinosaurs.

Glossary

Web links

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10.1

Old rocks and bones

FIGURE 10.1
Ammonites were thought to be snakes that had been turned into stone. To make them look more realistic heads were sometimes carved onto them.

FACT FILE

Leonardo da Vinci proposed over 400 years ago that fossils were remains of once living organisms. His views were not published for several hundred years because they were against the teachings of the church.

Talk about
What normally happens to a plant or animal when it dies in its natural habitat?

Fossils

A **fossil** is evidence of past life. It may be the remains of a plant or animal that died many years ago and has somehow managed to escape **decomposition**, or it may simply be a footprint or other imprint left by a living thing many years before. It may be the whole organism, or just a small part such as a single tooth. Fossils have caused considerable interest throughout history and in many cases people invented stories to explain them. Spiral fossils such as ammonites (Figure 10.1) were said to be 'snake stones' where the snakes had been turned into stone.

How fossilisation occurs

Usually when an animal or plant dies it will not form a fossil. The action of other organisms such as bacteria and fungi and the effects of erosion mean nothing remains. Very special conditions are required for **fossilisation** to take place. Anything which prevents the action of decomposer organisms may provide suitable conditions for fossilisation. This could include being frozen, preserved in tar or amber (fossilised tree sap), or sinking to the bottom of lakes where there is no oxygen.

Most fossils, however, have been formed following burial by sediments at the bottom of river, lake or sea.

Animation

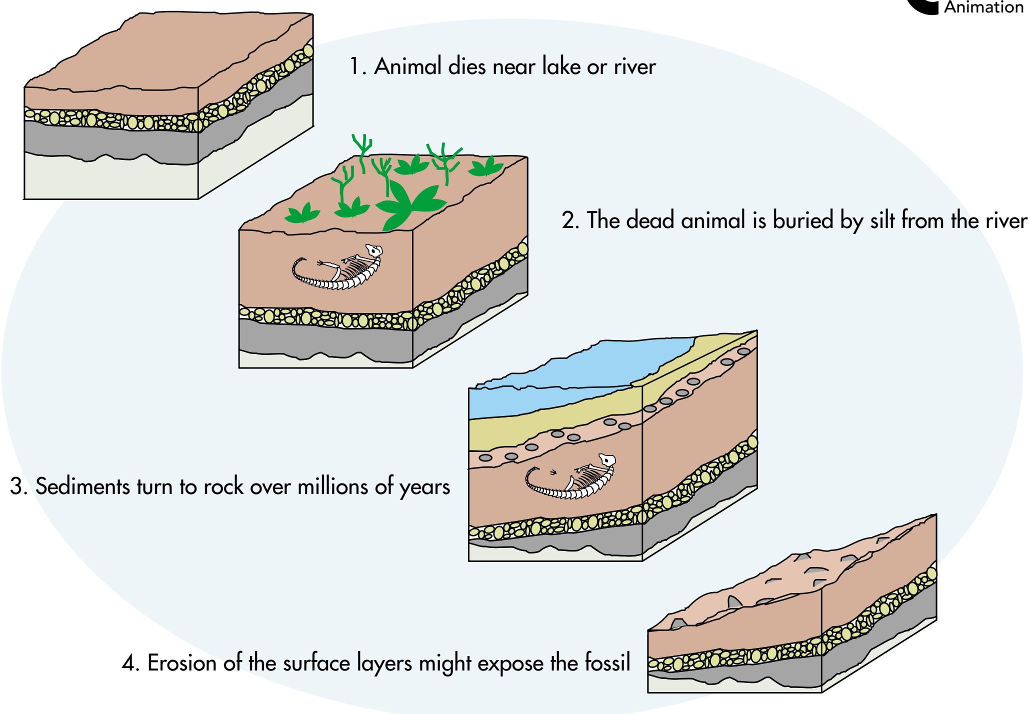

FIGURE 10.2
How most fossils form.

Glossary

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FIGURE 10.3
Insect trapped in amber. Amber is the resin or sap of a tree that has become fossilised. Insects trapped in amber were featured in the film Jurassic Park.

FIGURE 10.4
A baby woolly mammoth trapped in ice. Found in 1977, it is thought to be at least 40 000 years old.

Where to find fossils

Fossils can be found in many places but the best place to look is in **sedimentary rocks**. Sedimentary rocks are rocks formed in layers and fossils might be trapped between the layers. The layers might be exposed in a natural situation such as rocky coastal cliff or a gorge cut by a river. In some cases the layers of rock may have been exposed by humans, such as in a quarry or road cutting. (Check with conservation authorities before you remove any fossils you find.)

Questions

1 When an animal or plant dies does it always form a fossil? Explain.
2 In what sort of places do most fossils form?
3 What is amber?
4 What sort of rocks are most likely to contain fossils?
5 What parts of an animal that died millions of years ago are usually preserved as fossils?

Think about

1 Do you think it is still possible that fossils could form?
2 Normally when an animal dies it is the soft fleshy parts which disappear first, while bones and teeth are the last to go. Why do you think this is the case?
3 Is an animal that died on top of a hill likely to form a fossil? Explain.

Find out

Life in the past has been divided into pieces of time called eras and periods. Using references find out when the following periods occurred in time and what kinds of animals and plants existed during these times: Quaternary, Tertiary, Cretaceous, Jurassic, Triassic. You could present your work as a timeline poster or booklet if you wish.

Multi-media

Activity

A selection of different fossils have been placed around the room for you to observe. Each one may be accompanied by information such as where the fossil was found and its estimated age.
Observe each carefully then suggest:
1 What type of organism left the fossil.
2 How the fossil was formed.
3 How the fossil differs from the organism or part of the organism which created it.
Discuss your suggestions with at least one other class member, returning to look at the fossil if necessary.

FIGURE 10.5
This beetle has been preserved in tar and sand for thousands of years.

FACT FILE

Scientists who study fossils are called palaeontologists. Palaeontologists use their knowledge of geology to find the fossils and their knowledge of biology to piece together the fossil fragments. Using the evidence, they try to create a vision of the past.

Glossary

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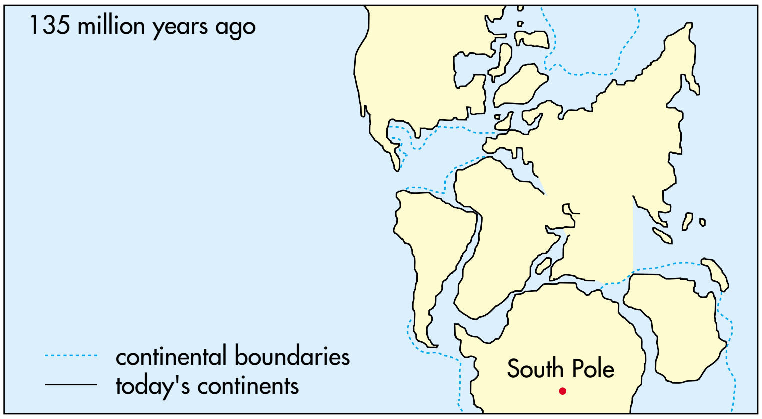
10.2

Making casts and moulds

Dinosaurs in the dark

It is about 100 million years ago. Australia is so far south of its present position, it lies within the **Antarctic circle**. The climate is much colder and it is dark for three to five months of the year. Not too many living things to be found here, right? Wrong!

FIGURE 10.6
100 million years ago Australia was far south of its present location and was part of the super continent Gondwana.



Dinosaurs the size of chickens scurry around searching for the right plants to eat; large reptiles hunt for prey; birds and flying reptiles are in the sky; fish, turtles and crocodiles are also found here.

The site is Dinosaur Cove near Cape Otway in Victoria, and an amazing amount of information is being put together to give a detailed picture of the unique life that was to be found here over 100 million years ago.

But how can scientists be so sure of their ideas?

The site at Dinosaur Cove is particularly rich in fossils. Many thousands have been found, including impressions or imprints left by former living things in what was later to become rock. These impressions can tell us much about the organisms which left them.

FIGURE 10.7
Imprint of a dinosaur's foot from Dinosaur Cove. Suggest how this might have been formed.

Imprints may have been left by a dinosaur running across muddy ground which later dried and hardened, by a marine worm slithering across the bottom of a shallow sea, or in soft ground by the whole body of an organism which later rotted away.

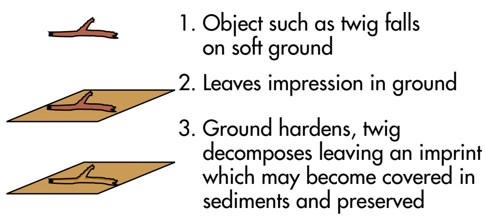


FIGURE 10.8
One of the many ways an imprint can be created.

Imprints are very important in the study of past life as they form natural **moulds** from which **casts** can be made.

Glossary

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EXPERIMENT 1 MAKING A SEASHELL MOULD AND CAST

AIM
To make a mould and a cast of a seashell.

MATERIALS
- modelling clay
- seashell
- paper cup
- plaster of Paris
- paper plate
- petroleum jelly
- plastic spoon

METHOD
1 On a paper plate, roll out a piece of modelling clay into a flat, smooth slab about 3 cm by 5 cm.
2 Coat the seashell with petroleum jelly. Press the seashell into the clay, making sure you have a definite imprint of the shell. Remove the seashell and observe the mould you have made. In what way does it differ from the original shell?
3 Use more clay to build a 2 cm wall around your seashell mould.
4 Prepare a paper cup full of plaster of Paris and pour it into your walled mould.
5 Wait for the plaster of Paris to harden, then carefully remove the clay. You have made a cast.

QUESTIONS
1a In what ways are moulds similar to, and different from, the original objects?
b In what ways are the casts similar to, and different from, the original objects?
2 What could the clay and the plaster represent?
3 Explain why an imprint would not form if:
a the seashell was just placed on the clay; or
b the clay was dried out or frozen.
4 What are some of the clues that the cast tells you about the object?
5 What information about the object cannot be determined from a cast?

DISCUSSION
Discuss how casts help scientists find out more about the Earth's past.

EXTENSION
Use a leaf, key, coin or other object to make a cast. Compare your cast with others in the class.
1 How easily can the object from which the casts were made be identified?
2 Which types of objects are easier to make casts from?

A mould can be thought of as a receptacle or container. It is the reverse structure of the object which formed the mould or is to be made from it. A cast is made by filling the mould with a liquid substance, such as plaster, plastic or molten metal (gold bars are made in this way), which later solidifies and so keeps its shape when it is removed from the mould. A cast will have the same structure as the object or organism which formed the imprint. Rather than trying to take large pieces of rock away from a fossil site, scientists may simply take casts of anything that they are interested in to study later.

Questions

1 Why were conditions much cooler in Australia 100 million years ago?

2 Describe at least two ways living things can create imprints.

3 Why are imprints described as natural moulds?

4 Why would scientists take casts at a fossil site rather than taking away the actual imprint?

Think about

Look at the illustration below of imprints found in rock dated at 80 million years old. Write a short story to explain what occurred here 80 million years ago.

FIGURE 10.9

Glossary

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10.3

Life in the past

FACT FILE

Moving plates. The Earth's surface is a solid crust floating on the still molten lava underneath. However the crust is not one solid piece covering all the Earth. It consists of a number of interlocking sections called plates. These plates can still move around slightly and these movements show up as volcanic eruptions or earthquakes.

FIGURE 10.10
Stromatolites. These creatures have existed on Earth for over 3400 million years.

The Earth is estimated to be about 4500 million years old. It was formed from a huge dust cloud that whirled around the Sun. The force of gravity compressed the dust into a solid ball. The Earth's atmosphere had a mixture of chemicals but no oxygen. It was a very hot place but as it cooled amazing reactions occurred and eventually living things arose.

Amongst the oldest fossils found are those of the **cyanobacteria** (blue-green bacteria). They formed into mounds called **stromatolites**. Some of these stromatolites still exist on the coast of Western Australia and are thought to be about 3400 million years old.

Plants and animals slowly became larger and more complex. Around 500 to 700 million years ago there were creatures resembling jellyfish and smaller shell-covered animals living in the sea. About 500 million years ago the first animal with an internal bony skeleton appeared. Having an internal skeleton was a great advantage as it made it easier to move around.

FIGURE 10.11
This fossilised fish shows an internal skeleton.

Around 400 million years ago the first animals invaded the land. They were fish-like creatures but were able to breathe air as they had lungs. These were the early amphibians, ancient ancestors of today's frogs. Although **amphibians** can survive on land they lack waterproof skin and must return to the water to reproduce.

Plants also started to grow on the land at this time. These plants had no leaves, flowers or roots and were quite small.

FIGURE 10.12
Eusthenopteron was a fish that had lungs and could breathe air. They were able to move around on muddy flats. It was the start of the animal invasion on land.

Over 300 million years ago the first reptiles appeared. They were better adapted to life on land than the amphibians as they did not have to live near water.

The dinosaurs had arrived by about 200 million years ago. They had evolved from earlier reptiles. They quickly dominated life on land. They consisted of giant plant eaters, powerful meat eaters and smaller agile pack hunters.

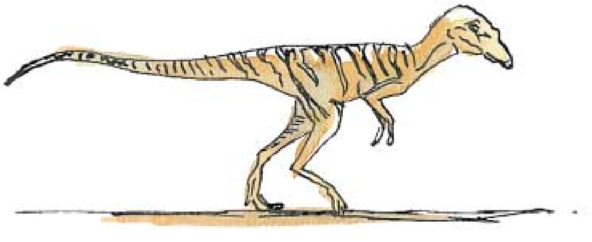

FIGURE 10.13
Herrasaurus lived about 228 million years ago. It is thought to be one of the first dinosaurs.

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Foundation worksheet 1

USING SCIENCE 1 MAKE AN EARTH CLOCK

Collect a 24-hour time wheel from your teacher. Make a 24-hour clock to represent the history of Earth since 3600 million years ago (just before life is thought to have begun). Each segment of the clock represents 150 million years. The last segment has been enlarged so you can try to include humans into the clock.

FIGURE 10.14
Hyaenodon was one of the early mammals that became a dominant predator. What advantages and disadvantages do you think it may have had in comparison to a dinosaur as a hunter?

The dinosaurs reigned for over 150 million years. They died out about 65 million years ago. After the dinosaurs died out a smaller group of animals that had been living in the shadows of the dinosaurs for millions of years took over as the dominant life form; these were **mammals**.

A variety of land dwelling, swimming and flying mammals spread all over the planet.

About 35 million years ago Australia became an isolated continent and so its plants and animals were able to develop in unique ways.

Modern humans seem to have appeared as little as 100 000 years ago, in Africa. The modern human is a descendant of ape-like creatures.

FIGURE 10.15
Homo habilis, one of the early forms which developed into the modern human. Why do you think the modern human has lost most of the hair covering?

Questions

1 **Where did life first occur, on land or in the sea? Give examples.**

2 **Why were the reptiles able to spread out and occupy a greater range of different habitats than the amphibians?**

3 **What was the dominant group of animals on Earth up until 65 million years ago, and what group of animals replaced them?**

4 **Why did Australia develop such a unique variety of animals?**

5 **According to the fossil record (history according to the fossils) how old was the Earth when the first signs of life appeared?**

Think about

If you were looking for fossils of present day organisms in 50 million years time, what sort of animals do you think would be most commonly found? Why?

FACT FILE

Living things which have disappeared are said to be extinct. More than 99.99% of all species that have ever lived are now extinct. Extinction is a natural process which has been going on steadily since life began. It usually happens to a small number of species at a time. It is of concern when it happens too quickly to too many species at the same time.

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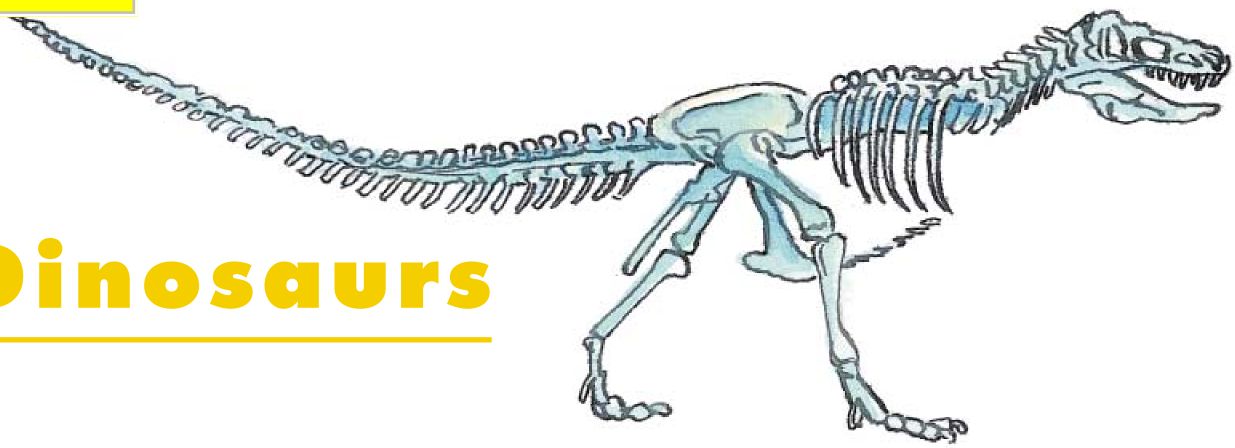


Dinosaurs

FIGURE 10.16 (above) Skeleton of *Tyrannosaurus rex*. Tyrannosaurus was the largest land-dwelling carnivore (meat eater). It lived about 70 million years ago. It grew up to 14 m in length and weighed up to 7 tonnes.

FIGURE 10.17 (below) Diplodocus was one of the large plant-eating dinosaurs. It grew up to 27 metres long and weighed between 10 and 11 tonnes.

FIGURE 10.18 (below right) Elasmosaurus was a large aquatic creature with a long whip-like neck which it most likely used to swing around in the water to catch fish.

Talk about

What do you know about dinosaurs? What were they like? When did they live? What did they eat? Work with a partner to make a list of what you know about dinosaurs. Discuss your list with your class.

We know about dinosaurs from studying the evidence in the fossil record. As new discoveries are constantly being made our ideas about dinosaurs are changing. The way we think about dinosaurs today is different from that of 20 years ago.

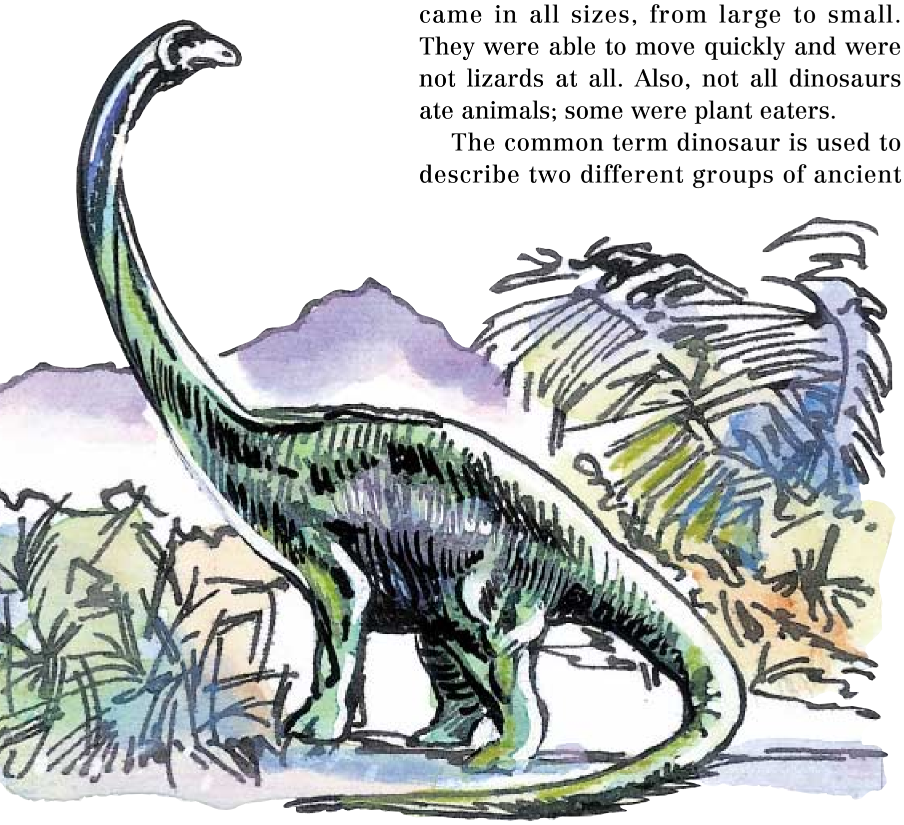
Early ideas about dinosaurs were of large, slow-moving, fierce creatures with brains too small for their bodies. In fact the name dinosaur means 'terrible lizard'. The evidence now shows that dinosaurs came in all sizes, from large to small. They were able to move quickly and were not lizards at all. Also, not all dinosaurs ate animals; some were plant eaters.

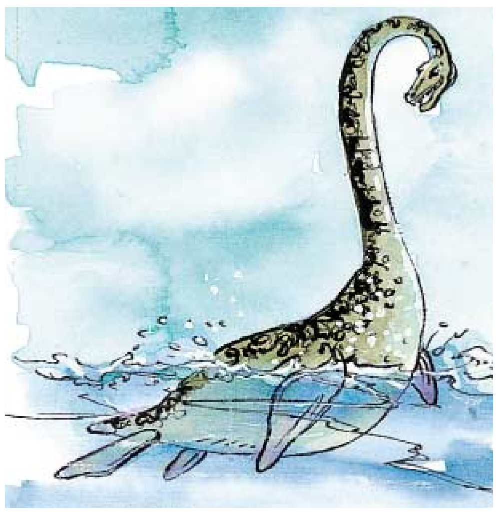
The common term dinosaur is used to describe two different groups of ancient reptiles. These are called the Saurischia (reptile-like dinosaurs) and the Ornithischia (bird-like dinosaurs). Dinosaurs lived on land, not in the water, and they could not fly. Plesiosaurs spent all their time in water and pterosaurs were able to fly, but neither were dinosaurs.

Dinosaurs were naked skinned animals that laid eggs and held their legs in an upright position (unlike modern reptiles with legs positioned at the side of their bodies). Some of their features are like modern reptiles, but they have similarities to birds as well.

How do we know?

Scientists have gathered most of their information about dinosaurs from examining their bones which have been preserved as fossils. From the skeleton of a dinosaur much can be learned about its size, shape, how it moved, what it ate, how it defended itself. Apart from size, however, most of what has been stated about dinosaurs has been inferred (educated guesses) as no one has ever seen a living dinosaur.





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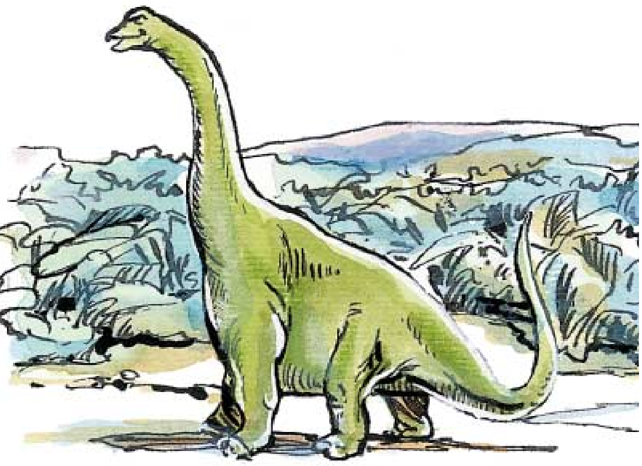

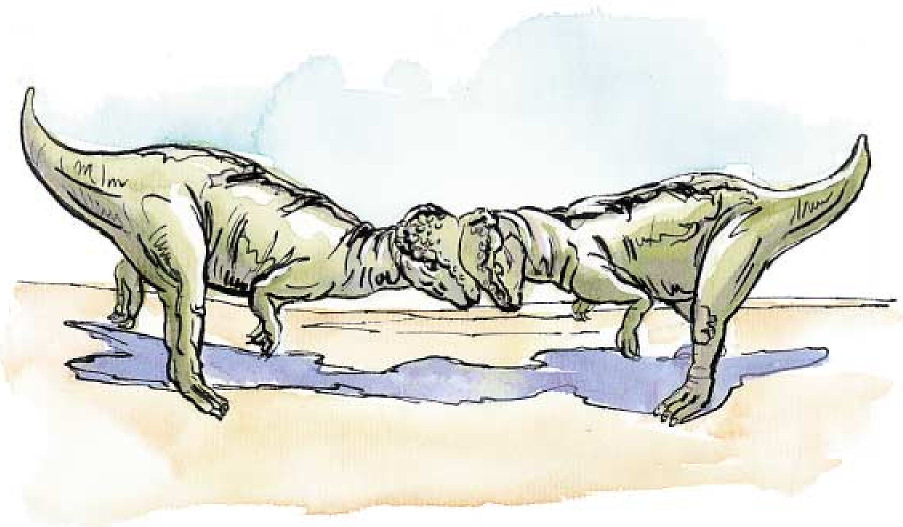

FIGURE 10.19 (above left)
Ultrasaurus. Only parts of this huge dinosaur have been found. It is a relative of the large plant-eating dinosaur Brachiosaurus. Ultrasaurus was possibly the biggest of all the dinosaurs. It could have weighed up to 130 tonnes and measured over 30 metres long.

FIGURE 10.20 (left)
Velociraptor was a small meat-eating dinosaur. It had 30 pointed teeth and each foot had a large curved claw which it used to slice open its prey.

FIGURE 10.21 (above)
Pachycephalosaurus (pak-ee-kef-al-oh-saw-rus) was a large plant-eating dinosaur which had a battering ram on top of its head. The top of the skull was up to 25 cm thick. No wonder they were called 'boneheads'.

USING SCIENCE 2 DESIGNASAURUS

Make a model or drawing of a creature that had some of the following features and lived in a habitat like the one described below. Label your diagram or model to explain the significance of some of its characteristics. **Features:** meat eater—will eat a range of smaller animals, large (10–15 m long), four powerful flippers, long neck and tail. **Habitat:** lives in the sea in warmer tropical waters (as are now found off Northern Queensland).

Questions

1 Where did the name dinosaur come from?

2 What are the similarities between modern lizards and dinosaurs?

3 What are the differences between modern lizards and dinosaurs?

4 Why can scientists be sure about the sizes of many types of dinosaurs but not so sure about how they moved or defended themselves?

5 A scientist discovered a fossil skeleton that had large pointy teeth. The scientist concluded that the skeleton belonged to a meat-eating dinosaur. How was this conclusion reached?

Think about

In most families over 100 years there might be four generations. The dinosaurs were on Earth for at least 160 million years. How many generations of your family would there be in 160 million years?

Activity

Library research. Choose a particular dinosaur that interests you and try to find out its size and shape, what it ate, during what period it lived, if it had any predators, and what they were. You could present your assignment as poster, booklet, class presentation or any other way as directed by your teacher.

FACT FILE

The smallest dinosaur was no bigger than a chicken and the largest was about as tall as a six-storey building.

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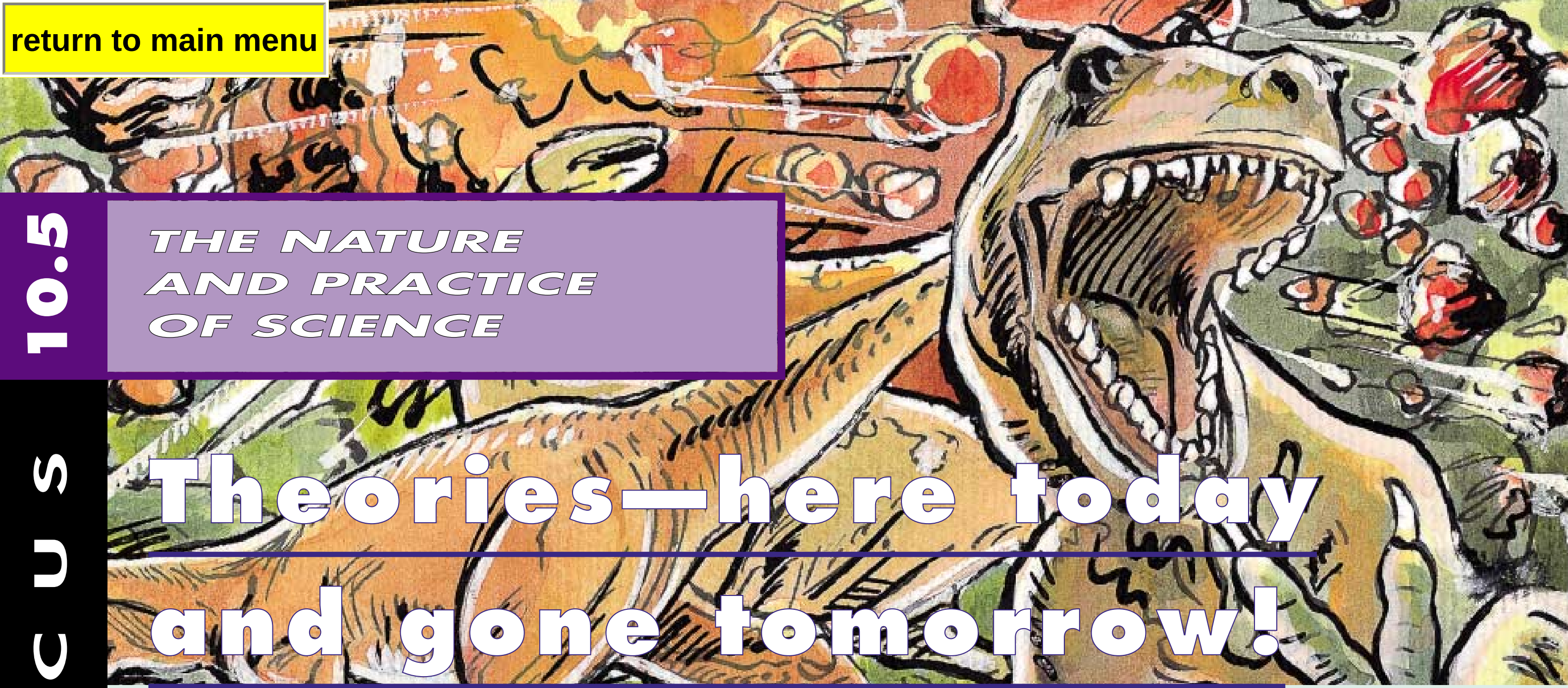

THE NATURE AND PRACTICE OF SCIENCE

Theories—here today and gone tomorrow!

FIGURE 10.22
Meteorite striking Earth and dust blocking out the Sun.

The dinosaurs died out about 65 million years ago when they were the dominant life form on Earth. Many other land and sea animals also died out. Why did this occur? Scientists have put forward several theories as to why the dinosaurs disappeared.

A **theory** is a scientific explanation of a problem. It must be based on all the available evidence. Theories are not facts. They cannot be proved beyond all doubt. As more evidence is collected theories often change. Some new evidence may support an existing theory and make it stronger. Some evidence can condradict a theory and scientists may develop a new explanation which fits the available facts. Sometimes scientists will stick to their theories even when evidence mounts up against them. Only when the negative evidence becomes overwhelming will scientists discard their theories.

The impact theory

A large object may have collided with the Earth. This would have caused an enormous explosion, filling the atmosphere with so much dust that the Sun would have been blotted out for several months. The Earth would have cooled and many plants would have died, resulting in a massive food shortage for the dinosaurs.

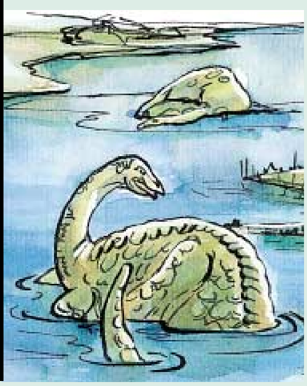

FIGURE 10.23
If the climate changed maybe the dinosaurs didn't like the cold?

The volcanic eruption theory

The Earth may have gone through a period of intense volcanic activity. The massive amount of gases sent into the atmosphere could have affected the climate and the ozone layer. Dinosaurs may have not been able to cope with the temperature changes or increased amount of UV radiation.

The continental drift theory

Scientists believe that when dinosaurs first appeared there was only one land mass located close to the warm equator. Over time forces within the Earth caused the land mass to break up and separate into the continents. As the continents drifted towards the cooler poles the dinosaurs could not have survived and gradually died out.

The changing vegetation theory

Around the time that dinosaur numbers were starting to fall, new types of flowering plants were replacing many existing plants. It is possible that these new plants may have been poisonous to the dinosaurs. Dinosaurs may have died out as a result of slow food poisoning.

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Foundation worksheet 2

USING SCIENCE 3 EVIDENCE FOR AND AGAINST

Form a group and discuss each of the following pieces of evidence. Use Table 10.1 to evaluate each of the four theories. Add a 'yes' if the evidence supports the theory, a 'no' if it condradicts the theory and an n/a if it gives no information to help you decide.

TABLE 10.1

Evidence	Theories			
	Impact	Volcanic eruption	Continental drift	Changing vegetation
a				
b				
c				
d				
e				
f				

EVIDENCE

a The fossil record appears to show that dinosaurs died out gradually over a period of several thousands of years.

b Sedimentary rocks formed around 65 million years ago contain a high level of a heavy element called iridium. This element is very rare on the crust of the Earth. It is believed to be present in material from deeper layers of the Earth and it is also found in extraterrestrial objects such as asteroids.

c Fossils of flowering plants have been found in rocks around 105 million years old.

d Fossil records show that some plants died out while others survived very well.

e Changes in the shape of plant leaves suggest that the average temperature around 65 million years ago fell slightly.

f Dinosaurs survived for around 160 million years, during which the Earth experienced different climates.

QUESTIONS

1 Does the evidence support one theory more than another or they all just as possible?

2 Write a report of your findings and share it with your class as a talk or a poster.

Questions

1 What are the four theories about how the dinosaurs died out?

2 If a large meteorite had crashed into Earth and caused plant growth to stop, why would this have been a problem for the meat-eating dinosaurs?

Think about

If the climate did change 65 million years ago, why would it affect the large dinosaurs more than smaller creatures?

Activity

Creative writing. What if the dinosaurs were alive today? Imagine if we still had dinosaurs. How would humans and dinosaurs get along? Would humans be just the next snack for a *T. rex* or could we domesticate them and have them on a farm or as pets? Write a short story to describe what you think it would be like.

Extension worksheet

Internet assignment

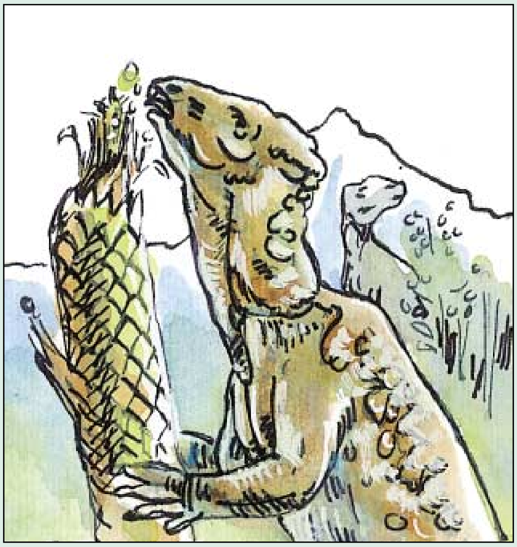

FIGURE 10.24
The arrival of new plant types poisonous to the dinosaurs may have caused their decline.

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10.6 How about a date?

FIGURE 10.25
Layers of sedimentary rock. The oldest rocks are at the bottom. Fossils in the lower layers would almost certainly be older than those in the upper layers. Can you think of any way the lower layers could contain younger fossils than upper layers?

How do you tell how much time has passed? Do you have a watch? Does your classroom have a clock on the wall? Can you tell that it is nearly lunchtime by the position of the Sun in the sky, or does your stomach rumble? How do we know when a month has passed, or a year? How does your body mark time? Is it by the length of your hair or fingernails, or the rate of your heartbeat, or the number of wrinkles on your face?

All of these ways of measuring time are called **clocks**. Some of these clocks are mechanical devices made by humans, but many others are natural clocks. A clock is a way of measuring the passing of time.

Geologists have always looked at sedimentary rocks for clues to the age of the Earth. If we assume that the layers have not been greatly disturbed, the layer on the bottom must be the oldest. It is also reasonable to assume that any **fossils** in the lower layers will be older than those in the layers at the top of the sequence. If we find the same fossils in different rocks in another area, we can often assume that the two rocks, even though widely spaced, are a similar age.

But this can only tell us relative ages, that is, we can only say that one rock or fossil is older than the other. These clues do not give us absolute ages, they do not tell us exactly what age a rock or a fossil is. To do this, geologists use **radiometric dating techniques**. These methods rely on the tiny amounts of radioactive material present in all things on Earth. Radioactive substances are continually changing or '**decaying**'. In so doing they change from one substance to another. The time it takes for half of the original radioactive particles to decay is called the **half-life** of the substance. Different radioactive substances have different rates of decay, or different half-lives.

TABLE 10.2 The half-lives of various radioactive elements found in nature.

Radioactive element	Half-life
Uranium-235	704 million years
Potassium-40	1251 million years
Uranium-238	4468 million years
Thorium-232	13 900 million years
Rubidium-87	48 800 million years

Scientists can often use these 'radioactive clocks' to find out when a living thing died (and became a fossil), or when a rock first formed. They measure three things:

1. the amount of radioactive substance still left;
2. the amount of decayed substance there is; and
3. the rate at which this particular radioactive substance decays.

From this, scientists calculate how long the decay process has been going on in this particular rock or fossil.

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EXPERIMENT 2 SIMULATING RADIOACTIVE DECAY

AIM
To demonstrate how radioactive decay progresses and to show how it can be used to give the ages of rocks and fossils.

MATERIALS
- 100 coins or counters with 2 different sides
- container for the coins/counters
- bench space
- graph paper and pencil
- notepaper and pen

METHOD
1 Decide which side of a coin or counter represents a radioactive particle, and which side represents a 'decayed' particle.
2 Put all of the coins/counters in a container, shake them up and tip tham all out on the bench.
3 Take away all of the 'decayed' particles and put them aside. Count how many 'live' particles are left, and record this number. This represents the percentage of radioactive material left after *one half-life*.
4 Put the remaining 'live' counters back in the container, shake, and tip them out.
5 Remove the decayed ones, count the remainder and record this number (percentage after two half-lives).
6 Repeat the process until no radioactive particles remain.
7 Plot your results on a graph. Your teacher may have to help you get this started.

DISCUSSION
For how many half-lives did your radioactive substance last? Did other people in the class get the same result? If you have time, run the simulation again and plot another graph. How do the two graphs compare? Why might they look a bit different?

EXTENSION
Use Figure 10.26 to answer these questions.
1 How long is one half-life for carbon-14?
2 How long (in years) does it take for 75% of the carbon-14 to decay?
3 Why can't this technique be used to date remains older than 50 000 years?

Spreadsheet

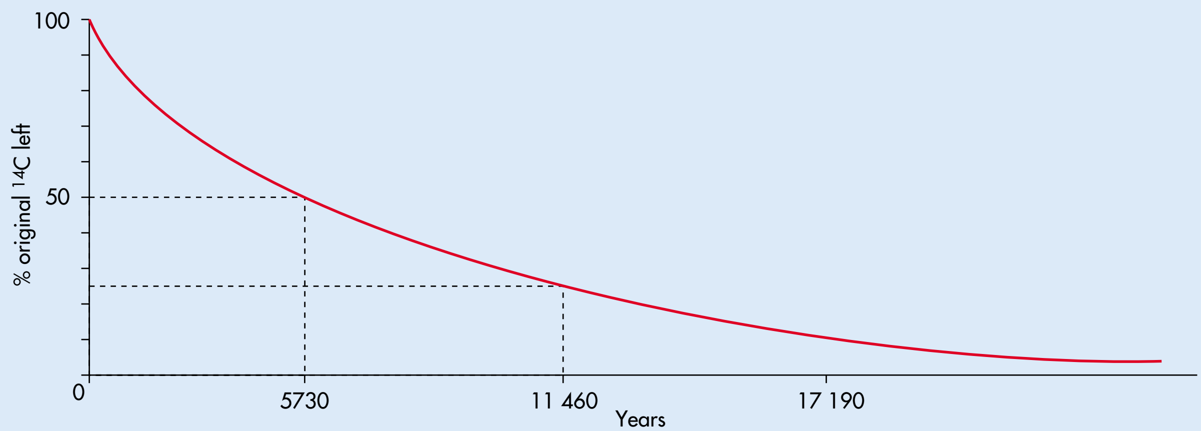

FIGURE 10.26
The decay curve for radioactive carbon-14 can be used to help date the remains of living things up to 50 000 years old.

Questions

1 **Explain how a fossil could be used to give:**
a **a relative age**
b **an absolute age.**
2 **Is it possible for a fossil to have a different age from the layer of sediment it is embedded in? Explain fully, giving an example. You may use a series of diagrams to illustrate your answer.**

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10.7

Large scars heal slowly

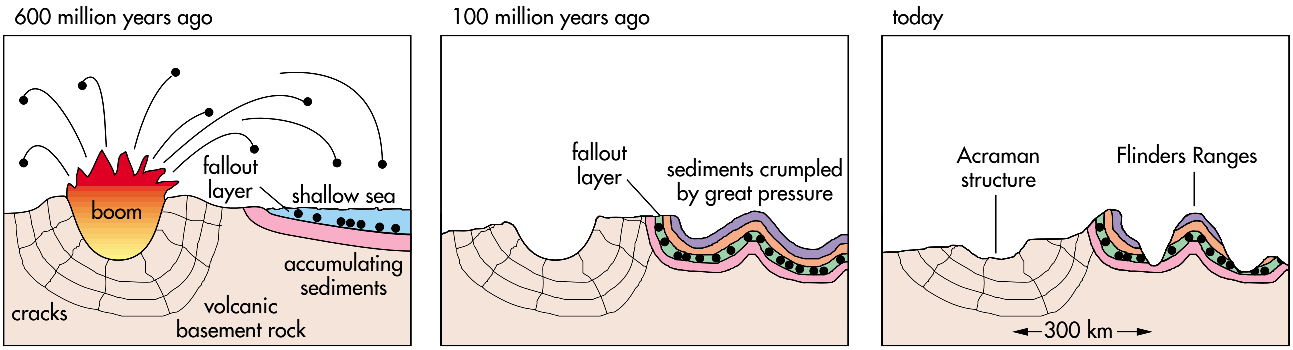

FIGURE 10.27
The Acraman Structure: sequence of events for layer of meteorite debris in the Flinders Ranges.

FACT FILE

On 30 November 1954, Mrs Hewlett Hodges, of Alabama, USA, was sitting on the couch after lunch when a meteorite weighing 8 kg crashed through the roof. It bounced off her radio and hit her on the leg.

It had all the makings of the greatest sound and light show ever. A huge fireball several kilometres across came hurtling to Earth trailed by a streak of multicoloured light as it plummeted through the atmosphere. Then it slammed into the Earth with a force 100 000 times larger than the biggest bomb we've ever built. The sound of the impact would have travelled hundreds of kilometres. This giant lump of space rock hit the Earth 600 million years ago, well before there was any life on land. The hard volcanic rock it hit was pulverised and hurled up into the air. A shallow sea 300 km away was showered with the fallout. This area, where fine-grained muddy sediments had been accumulating, was later to become the Flinders Ranges. Shattered rocks from the impact (some the size of footballs) were dropped in a layer which become one of the vital clues to this tremendous event.

The impact site itself is thought to be around Lake Acraman in South Australia, 500 kilometres northwest of Adelaide. It was only discovered when a satellite photograph revealed rings of cracks in the Earth around the lake, in a pattern too large to see from the ground.

The huge size of the 'Acraman structure' was not the only reason it was hard to detect. Weathering and erosion over 600 million years have all but obliterated the signs of this major event in the Earth's history.

FIGURE 10.28
Satellite image of the circular cracks around Lake Acraman, South Australia, thought to be the remnants of a huge meteorite crater.

A **meteorite** is the name given to a lump of rock that falls to Earth from space. When a big meteorite hits the Earth, it leaves big circular scars called **meteorite craters**.

Wolf Creek Crater in Western Australia is thought to be 15 million years old—a mere baby compared to Acraman. It is beautifully preserved, because it is young,

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and it is in an area where erosion is minimal.

If you wanted to visit meteorite craters that are even fresher, the Moon would be a good place to look.

But if the Earth is as old as the Moon, why hasn't our planet received as many scars from impacts? Most lumps of rock that enter our atmosphere travel so fast that they burn up from air friction. We see these as 'shooting stars' on a clear night. Only the really huge ones get through. Once they hit the Earth the agents of weathering and erosion immediately get to work to heal the scars.

FIGURE 10.29
Wolf Creek meteorite crater, Western Australia.

Questions

1 What is a meteorite?

2a Should we be spending money on protecting ourselves from meteorite impacts? Explain.

b Would it be possible to do so?

c If so, how would you go about it?

d Would your meteorite defences carry any risks of their own?

3 In what two ways does the Earth's atmosphere limit the number of meteorite craters we find on Earth?

4 Give two reasons why meteorite craters are clearly visible in large numbers on the Moon.

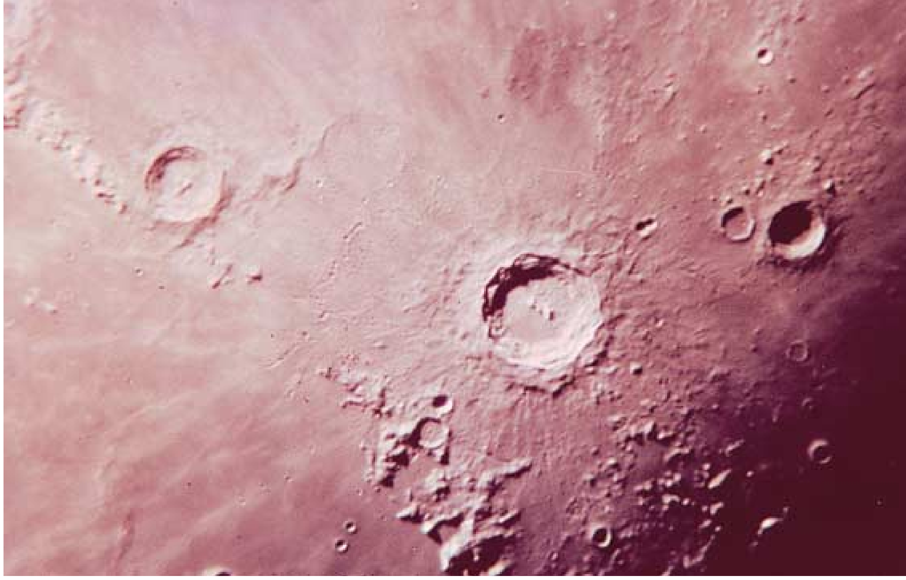

FIGURE 10.30
On the Moon, many craters are very old. Since there is no atmosphere on the Moon, there is no weathering.

Think about

How would each of these factors contribute to the making and preservation of an impact crater on Earth?

1 age of impact
2 size of meteorite
3 type of rock it lands on
4 climate of area
5 whether the impact is on land or at sea.

Activity

You be the reporter. Read the Fact File on page 198. Imagine you are a journalist reporting this event. You have interviewed Mrs Hodges, but you also have to do some background research for your report. Find out:

1 How often meteorites enter the atmosphere
2 How likely they are to hit the Earth
3 How much 8 kg is (compare the meteorite to an everyday object)
4 Other major impact sites and how big the meteorites were that made the craters.

Make the front page of a newspaper carrying the story as its lead article. Make sure you use an exciting headline, and include a big picture relevant to the story. The interview with Mrs Hodges and all of your background research should be used.

Word process

FACT FILE

Scientists are searching outer space for asteroids or comets that travel close to the Earth. They call these Near Earth Objects. In 1989, an asteroid 800 metres across passed within a million kilometres of planet Earth. If it had arrived only 6 hours later it would have collided with the Earth. More recently a 500-metre wide asteroid missed the Earth by just 450 000 kilometres. It was the largest object ever observed to pass that close to Earth.

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Using scientific language

Use a dictionary and the glossary to match each word with its correct meaning.

decomposition	made by filling a mould with a liquid which sets
fossilisation	compared with something else
cast	breaking down the remains of living things
mould	no longer in existence
preserved	saved or maintained
extinct	material which is breaking down and emitting radiation
theory	to reduce to dust or powder
radioactive	suggested explanation, not yet shown to be a fact
relative	the process of forming fossils
pulverised	imprint which is the reverse structure of the object which formed it

Check your knowledge

Copy the start of the sentences into your book and then choose the best endings.

1 When an animal dies it will turn into a fossil
   A over a couple of years.
   B if it is quickly covered by silt in a river and left for millions of years.
   C if it is left in the open for a while.
   D no matter where it is and what the conditions are like.

2 The parts of an animal that are usually best preserved are
   A the hair or fur.
   B the muscles.
   C the bones.
   D its internal organs.

3 As the Earth became older the plants and animals that evolved
   A became more varied and more complex.
   B moved from the land into the sea.
   C became less complex and smaller.
   D all lived in the one habitat.

4 According to the fossil record (the history of life according to the fossils)
   A humans must have first evolved during the dinosaur age.
   B animals started invading the land about 100 000 years ago.
   C the dinosaurs were around for about 160 million years.
   D animals with two legs evolved first, then three legs, and finally four-legged animals.

5 Copy and complete: Dinosaurs with huge sharp teeth like *T. rex* were most likely ___ eaters. Many other types of dinosaurs did not eat meat. These dinosaurs got their food from eating ___ . The dinosaurs lived on Earth for over ___ million years. During this time there were many different types of dinosaur; one of the earliest dinosaurs was ___ and one of the more recent dinosaurs was ___ .

Apply your skills

1 Explain why fossils of marine organisms are very common while those of organisms that lived on land are much rarer.

2 Examine Figure 10.31. What would be the advantages and disadvantages for Hylaesaurus to be shaped and structured in this way?

3 Fossilised leaves, wood and bark from trees 3–5 million years old have recently been discovered below the ice in Antarctica. The fossils are very similar to a type of southern beech tree growing in parts of Tasmania today. Suggest an explanation for this observation.

Challenge yourself

1 Which of today's animals most resemble dinosaurs? Which features of these animals are similar to dinosaur features?

2 Modern humans have only been around for less than 100 000 years whilst the dinosaurs ruled the Earth for over 160 million years. Do you think humans will be as long-lasting as the dinosaurs? Give reasons for your answer.

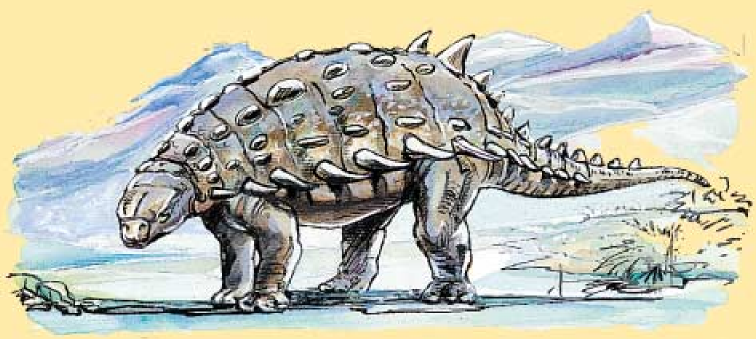

FIGURE 10.31
Hylaesaurus: a well-armoured animal.

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Tester

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CHAPTER 11

EXPLORING THE SOLAR SYSTEM

CHAPTER OUTCOMES

Successful completion of this chapter will allow you to:

- **Describe the major features of the solar system.**
- **Compare conditions on Earth with those on other planets.**
- **Relate the history of changing ideas about the solar system.**
- **Record the phases of the Moon and explain changes in phases.**
- **Explain the movement of Earth in space and relate this to night and day, the different seasons and eclipses.**
- **Model lunar and solar eclipses.**
- **Explain the relationship between tides and the lunar cycle.**
- **Research the history of unmanned exploration of the planets.**

People have been fascinated by the night sky since prehistoric times. They have been recording their observations of stars and planets for thousands of years, all the while trying to explain and understand what they saw. Many ancient observers believed that the movement of the stars and planets could affect human lives. If they could map this movement they could tell the future. The position of the planets and stars at the time of a person's birth was thought to influence their personality and the events that occurred during their life.

The planets can always be found in a narrow band of sky, behind which we can see 12 groups of stars called the zodiac constellations. Using the motion of the planets compared with the zodiac to tell the future is called astrology. Some people still believe in astrology even though there is no scientific evidence for it.

The careful observations of the early astrologers were not a waste of time because the information gathered was used for the scientific study of the night sky. This led to the beginning of astronomy, the oldest of all the sciences.

In this chapter you will learn about the objects that make up our solar system and how the study of astronomy has made advances.

Web links

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11.1

Our place in space

FIGURE 11.1
Solar system tours.

FACT FILE

Sunspot activity goes through a regular cycle. The number of sunspots increases over a period of about four years then decreases for about seven years. Increased solar flares and prominences also occur when sunspot activity reaches a peak.

Talk about

Imagine you could take a spacecraft on a journey through the solar system. What would you expect to see on this journey?

Although the **solar system** may seem a very large region of space, it is only a tiny part of the entire universe. Most of the solar system is empty space with the Sun at its centre. The Sun is an average sized star which emits energy. Revolving around the Sun are nine planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. We can see the planets because they reflect light. Many of the planets have moons (or satellites) revolving around them.

The solar system contains thousands of irregularly shaped chunks of metal and rock called asteroids. Many asteroids can be found in a broad band between Mars and Jupiter called the asteroid belt. Comets also revolve around the Sun. These are made of rock and ice and over 600 have been identified so far.

The solar system is full of dust and other debris called meteoroids. Occasionally these meteoroids collide with the Earth's atmosphere, burning up as they enter. This produces a streak of light in the night sky called a meteor or a shooting star. If the meteor survives its journey through the atmosphere and falls to the ground it is then called a meteorite.

How big is the solar system?

The various objects in the solar system are scattered over billions of kilometres of space but it is difficult to say where the solar system ends. Recently, small 'mini-planets' have been found beyond Pluto. Some astronomers think that at the furthest edge of the solar system is a huge halo of comets, called the 'Oort cloud'.

The Sun

The Sun is an average sized star with a diameter around 110 times bigger than the diameter of Earth. It is a massive ball of glowing gas which continually emits energy in the form of radiation, light and heat. The energy comes from nuclear reactions taking place in the core of the Sun, where the temperature reaches 15 000 000°C. The surface of the Sun is called the photosphere. It has an average temperature of 5500°C. The photosphere is sometimes marked with dark patches of slightly cooler gas called sunspots.

It is the immense pull of the Sun's gravity which holds all the planets and the other objects in the solar system in their orbits.

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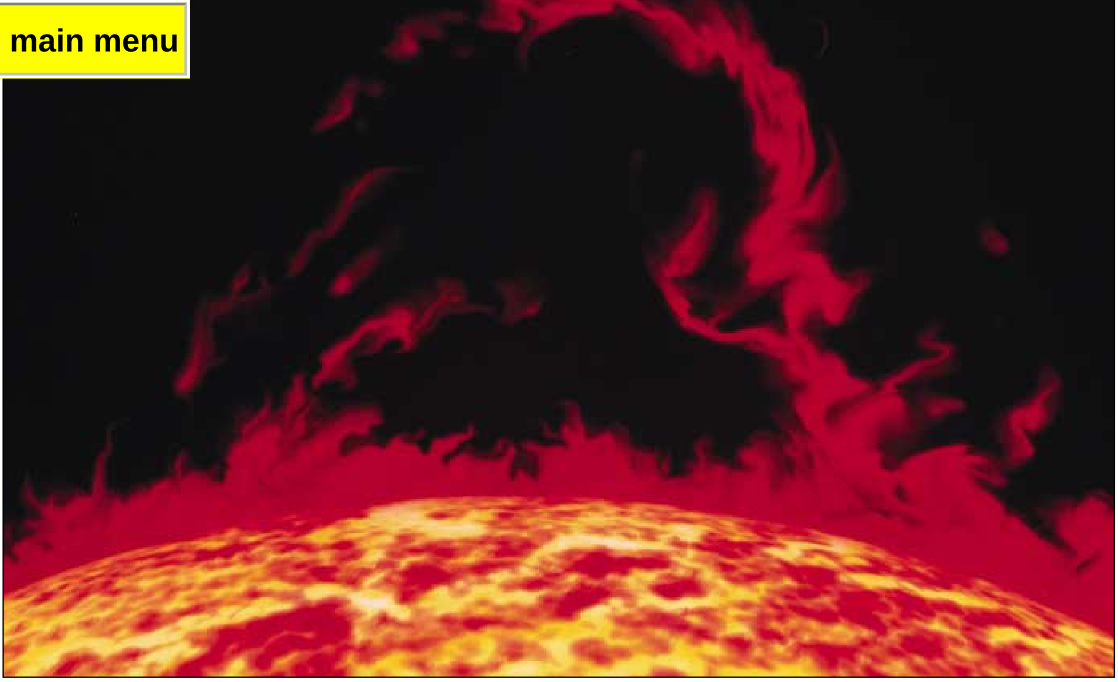

Foundation Worksheet 1

FIGURE 11.2
The surface of the Sun showing a sunspot and prominences.

USING SCIENCE 1 OBSERVING SUNSPOTS

Warning: never look directly at the Sun, with or without binoculars.

WHAT YOU NEED

- binoculars
- white cardboard 20 cm × 20 cm
- black cardboard 7 cm × 7 cm
- tape

WHAT TO DO

1 Use the tape and black cardboard to cover one lens of the binoculars.

2 Point the binoculars up at the Sun with the white cardboard behind them.

3 Move the binoculars until a bright circle shines on the cardboard, then focus them to obtain a sharp image.

4 Look for sunspots, which show as tiny dark spots.

DISCUSSION

1 How many sunspots were visible?

2 If you observe the sunspots for long enough you can see them slowly move across the image. Suggest what could cause this effect.

Questions

1 What is the difference between a star and a planet?

2 How are meteors different from meteorites?

3 The Sun is made of different layers. The innermost layer is the core, followed by the radiation zone then the convection zone. The surface of the Sun is the photosphere. The outermost part of the Sun's atmosphere is the corona, beneath which is the chromosphere. Draw a labelled diagram showing the internal structure of the Sun.

4 What do you think 'orbit' means?

5 Complete the following sentences. The Moon _____ the Earth while the Earth _____ the Sun. The Moon is a _____ of the Earth, just as the Earth is a _____ of the Sun. The other major satellites of the Sun are called _____ .

Think about

If the Sun is only a medium sized star why is it the biggest object we can see?

Find out

What are prominences and solar flares? What effect can these, along with sunspots, have on the Earth?

Glossary

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11.2 The inner planets

FIGURE 11.3
Mercury.

NAME:	Mercury
SATELLITES:	None
AVERAGE DISTANCE FROM SUN:	60 000 000 km (0.4 of the way to Earth)
DIAMETER:	4900 km (nearly 1.5 times as big as Earth's moon)
SURFACE TEMPERATURE:	–170°C to 350°C
TIME FOR 1 ROTATION (length of day):	59 Earth days
TIME FOR 1 ORBIT (length of year):	88 Earth days
ATMOSPHERE:	None

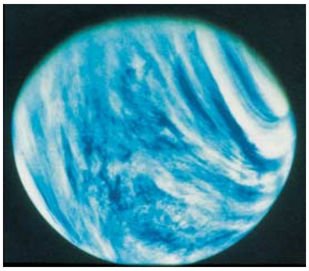

FIGURE 11.4
Venus.

NAME:	Venus
AVERAGE DISTANCE FROM SUN:	108 000 000 km (0.7 of the way to Earth)
DIAMETER:	12 100 km (nearly the same size as Earth)
SURFACE TEMPERATURE:	Around 500°C
TIME FOR 1 ROTATION (length of day):	224 Earth days
TIME FOR 1 ORBIT (length of year):	225 Earth days
ATMOSPHERE:	Dense smog-like clouds of carbon dioxide and sulfuric acid

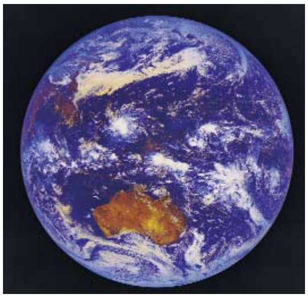

FIGURE 11.5
Earth.

NAME:	Earth
SATELLITES:	1 (3500 km in diameter)
AVERAGE DISTANCE FROM SUN:	150 000 000 km
DIAMETER:	13 000 km
SURFACE TEMPERATURE:	–30°C to 50°C
TIME FOR 1 ROTATION (length of day):	1 Earth day (24 hours)
TIME FOR 1 ORBIT (length of year):	365 Earth days (1 year)
ATMOSPHERE:	Nitrogen, oxygen, carbon dioxide and water vapour

FIGURE 11.6
Mars.

NAME:	Mars
SATELLITES:	2 (the biggest one only 27 km across)
AVERAGE DISTANCE FROM SUN:	228 000 000 km (1.5 times as far as Earth)
DIAMETER:	6800 km (about half the size of Earth)
SURFACE TEMPERATURE:	–120°C to 25°C
TIME FOR 1 ROTATION (length of day):	1.03 Earth days (around 40 minutes longer than Earth)
TIME FOR 1 ORBIT (length of year):	688 Earth days
ATMOSPHERE:	Thin and mainly carbon dioxide

The four planets closest to the Sun are small, compact planets made up of rock. They are often called the terrestrial (or Earth-like) planets.

Mercury is the second smallest planet in the solar system and it orbits very close to the Sun. It has virtually no atmosphere, so like Earth's moon its surface is heavily scarred from meteorites. The craters are sharp-edged but not as deep as those on the Moon. Mercury reaches extreme temperatures with one side begin scorched by the Sun and the other in frozen darkness.

Venus is only slightly smaller than Earth. It has a dense atmosphere of carbon dioxide which helps trap heat from the Sun. Although Venus is further away from the Sun it is actually hotter than Mercury because of its atmosphere. Thick clouds of sulfuric acid reflect three-quarters of the light from the Sun, making Venus the third brightest object in Earth's night sky. Venus rotates very slowly and in the opposite direction to most other planets.

Earth is the only planet that contains water in liquid form and a breathable atmosphere. These features mean that, unlike all other planets, Earth can support life. The Earth has few craters because most meteors burn up before impact. Also the water and the atmosphere are continually wearing down its surface. The Earth's moon has no atmosphere or liquid water so it remains covered in craters.

Mars is only half the size of the Earth. It appears as an orange-red object in the sky. Mars has a thin atmosphere of carbon dioxide. Its polar ice caps made of solid carbon dioxide melt and freeze with the changing seasons. The surface of Mars has volcanoes, dry dust plains and craters. Violent dust storms blow across its surface. Scientists have searched for evidence of life on Mars but as yet none has been found.

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EXPERIMENT 1 HOW FAR IS EARTH FROM THE SUN?

AIM
To estimate the distance from Earth to the Sun.

MATERIALS
- 2 pieces of thin cardboard or thick paper
- pin or needle
- ruler
- 1 metre of non-stretchy string
- sticky tape

METHOD
1 Work in pairs. Make a hole in the middle of one piece of cardboard with the pin.

2 Use the sticky tape to attach one end of the string to the cardboard near the hole. Be careful not to cover the hole at all.

3 One person holds the piece of cardboard with the hole in direct sunlight so that it makes a shadow on the second piece of cardboard. Move the first piece around so that the bright dot of light is in the middle of the shadow. Now move the pieces of cardboard as far apart as possible while still being able to make out the bright circle of the Sun.

4 The second person uses the ruler to measure the diameter of the circle of light. Make sure that the two pieces stay the same distance apart while you are measuring. You can use the string to do this by pulling it taut between the two pieces of cardboard. Mark the string to show how far apart the two pieces are. (The more carefully you measure, the more accurate your results will be.) Record both measurements.

5 You can calculate how far away the Sun is. The size of the Sun is represented by the size of the circle of light; the distance between Earth and the Sun is represented by the distance between the circle of light and the hole. Now since you know three of these measurements (including the size of the Sun), you can work out the fourth measurement using the following equation.

$$\frac{\text{distance between Sun and Earth (A)}}{\text{size of the Sun (B)}} = \frac{\text{distance between the pieces of cardboard (C)}}{\text{size of the circle of light (D)}}$$

$$\text{so } A = \frac{B \times C}{D}$$

DISCUSSION
Write up your report, explaining how you have estimated the distance from the Sun. Make sure you include diagrams and your calculations.

Questions

1 Compare Mercury with Earth's moon. What are the similarities and differences?

2 Why does Venus appear so bright in the night sky?

3 How many times does Mercury go around the Sun in the time it takes the Earth to go around once?

4 Explain why Venus is hotter than Mercury even though it is further from the Sun.

5 How could you tell the difference between Mars and Venus if you saw them at night?

6 Complete the following sentences. The ___ of Mars is similar in many ways to that of ___ . The major difference is that there is ___ on Earth, although the search for life continues on ___ .

Think about

1 If you lived on Mars for 10 Martian years, how many birthdays would you have missed back on Earth?

2 The gravity on Mars is much less than on Earth. On Mars you would weigh only one-third of your Earth weight. Write a story about how this might affect you.

Find out

Where did the names of the planets come from and what do they mean?

Animation

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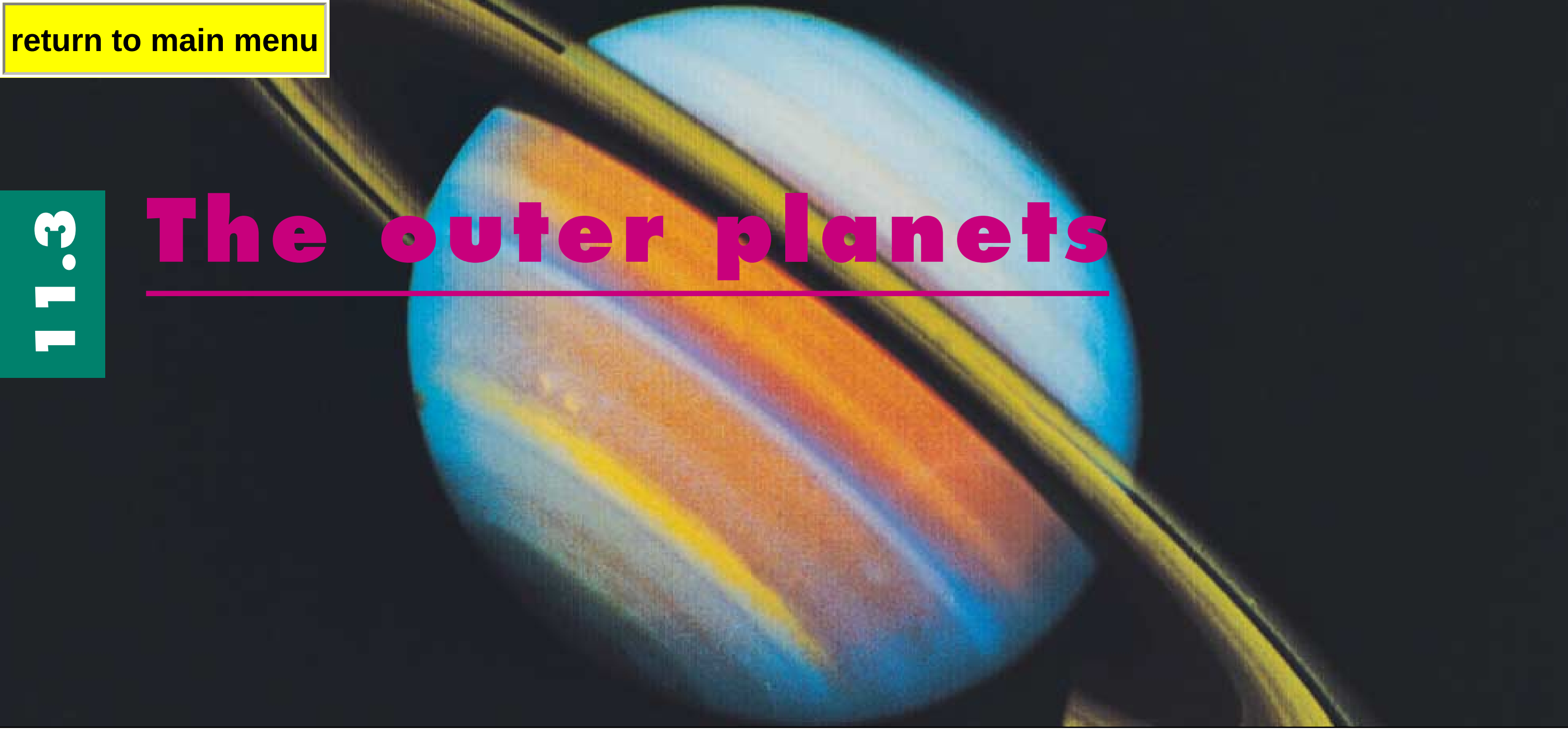

11.3

The outer planets

The next four planets in the solar system are large gaseous planets made of mainly hydrogen and helium. These planets are often called the gas giants. They all have rings around them and large numbers of moons. The fifth planet, Pluto, is a tiny frozen, rocky world.

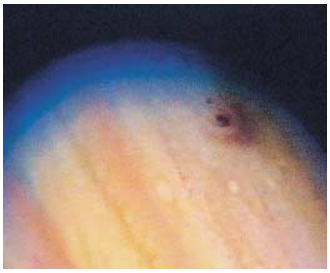

FIGURE 11.7
Jupiter.

NAME:	Jupiter
SATELLITES:	At least 16
	(4 bigger than Earth's moon, 1 bigger than Mercury)
AVERAGE DISTANCE FROM SUN:	778 000 000 km
	(5 times further than Earth)
DIAMETER:	134 000 km (11 times that of Earth)
SURFACE TEMPERATURE:	–150°C
TIME FOR 1 ROTATION (length of day):	10 Earth hours
TIME FOR 1 ORBIT (length of year):	12 Earth years
ATMOSPHERE:	Mainly hydrogen and helium

Jupiter is a huge planet, the largest in the solar system. It would take 1300 Earths to fill the same volume. Jupiter is rotating so quickly that it bulges in the middle. The atmosphere is thick and the pressure is so great that the gases condense into liquids. The high temperatures inside Jupiter cause clouds and storms on the surface of the planet. One such storm is called the 'Great red spot'.

FIGURE 11.8
Saturn.

NAME:	Saturn
SATELLITES:	At least 20 (1, Titan, is bigger than Earth's moon)
AVERAGE DISTANCE FROM SUN:	1 425 000 000 km
	(nearly 10 times further than Earth)
DIAMETER:	75 000 km (9.5 times that of Earth)
SURFACE TEMPERATURE:	–180°C
TIME FOR 1 ROTATION (length of day):	10 Earth hours
TIME FOR 1 ORBIT (length of year):	29.5 Earth years
ATMOSPHERE:	Very dense methane and ammonia

Saturn is the second largest planet, with a similar structure to Jupiter. It has the largest system of rings. These are made up of dust, rock and ice. The rings are almost five times as wide as the planet itself. Saturn is tilted on its axis so that as it revolves around the Sun our view of the rings changes. Over a Saturn year we can see a top, bottom and side-on view of the rings.

FIGURE 11.9
Uranus.

NAME:	Uranus
SATELLITES:	At least 17
AVERAGE DISTANCE FROM SUN:	2 878 000 000 km
	(19 times further than Earth)
DIAMETER:	51 000 km (about 4 times that of Earth)
SURFACE TEMPERATURE:	–220°C
TIME FOR 1 ROTATION (length of day):	17 Earth hours
TIME FOR 1 ORBIT (length of year):	84 Earth years
ATMOSPHERE:	Dense methane

Uranus was the first planet to be discovered with the use of a telescope in 1781. It is a unique planet because it revolves around the Sun on its side with its poles facing the Sun. At present the south pole of Uranus is facing the Sun. The atmosphere of Uranus contains methane which gives the planet a blue-green colour.

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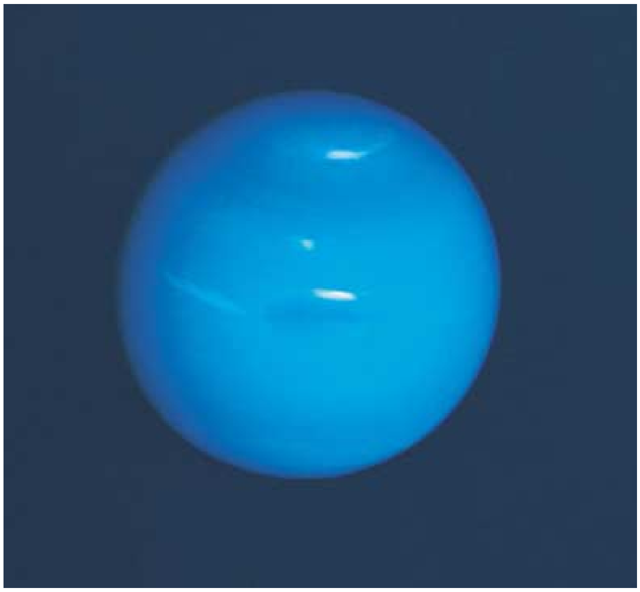
Neptune was the first planet whose existence was calculated (1822) before it was found by a telescope (1846). The orbit of Uranus was affected by the gravitational pull of another object further out. Neptune is almost the twin of Uranus but slightly smaller in diameter. It has a great dark spot on its surface, which is believed to be a storm. Neptune is deep blue in colour because of methane gas in its atmosphere.

NAME:	Neptune
SATELLITES:	At least 8 (1 nearly as big as Mercury)
AVERAGE DISTANCE FROM SUN:	4 497 000 000 km (30 times further than Earth)
DIAMETER:	49 000 km (nearly 4 times that of Earth)
SURFACE TEMPERATURE:	−230°C
TIME FOR 1 ROTATION (length of day):	16 Earth hours
TIME FOR 1 ORBIT (length of year):	165 Earth years
ATMOSPHERE:	Dense methane



Foundation Worksheet 2

FIGURE 11.10
Neptune.

Pluto is the smallest planet and the furthest from the Sun. From Pluto the Sun would look little more than a bright star. Pluto was discovered in 1930, after another search based on calculations about the orbit of Uranus. It has an orbit which is inclined 17° to the orbit of the other planets. Pluto actually passes inside Neptune's orbit and for a short time is closer to the Sun than Neptune.

NAME:	Pluto
SATELLITES:	At least 1 (about 1/3 the size of Earth's moon)
AVERAGE DISTANCE FROM SUN:	5 900 000 000 km (39 times further than Earth)
DIAMETER:	3500 km (0.25 times that of Earth)
SURFACE TEMPERATURE:	−260°C
TIME FOR 1 ROTATION (length of day):	6 Earth days
TIME FOR 1 ORBIT (length of year):	249 Earth years
ATMOSPHERE:	None in gaseous form, frozen methane

FIGURE 11.11
Pluto.

Questions

1 List all the planets in order of size from largest to smallest.

2 What are the major differences between the terrestrial planets and the gas giants?

3 Draw a column graph of the surface temperatures of the outer planets.

4 How many Pluto days are there in a Pluto year?

5 How many planets in the solar system have rings around them?

6 How many moons orbit the giant planets?

Think about

1 Why do you think Jupiter is sometimes called a 'mini solar system'?

2 What happens to the length of a year as the distance a planet is from the Sun increases?

Spreadsheet

Find out

Do other stars beside the Sun have planets?

Glossary

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11.4 SCIENCE IN FOCUS

HISTORY OF SCIENCE

Great moments in astronomy

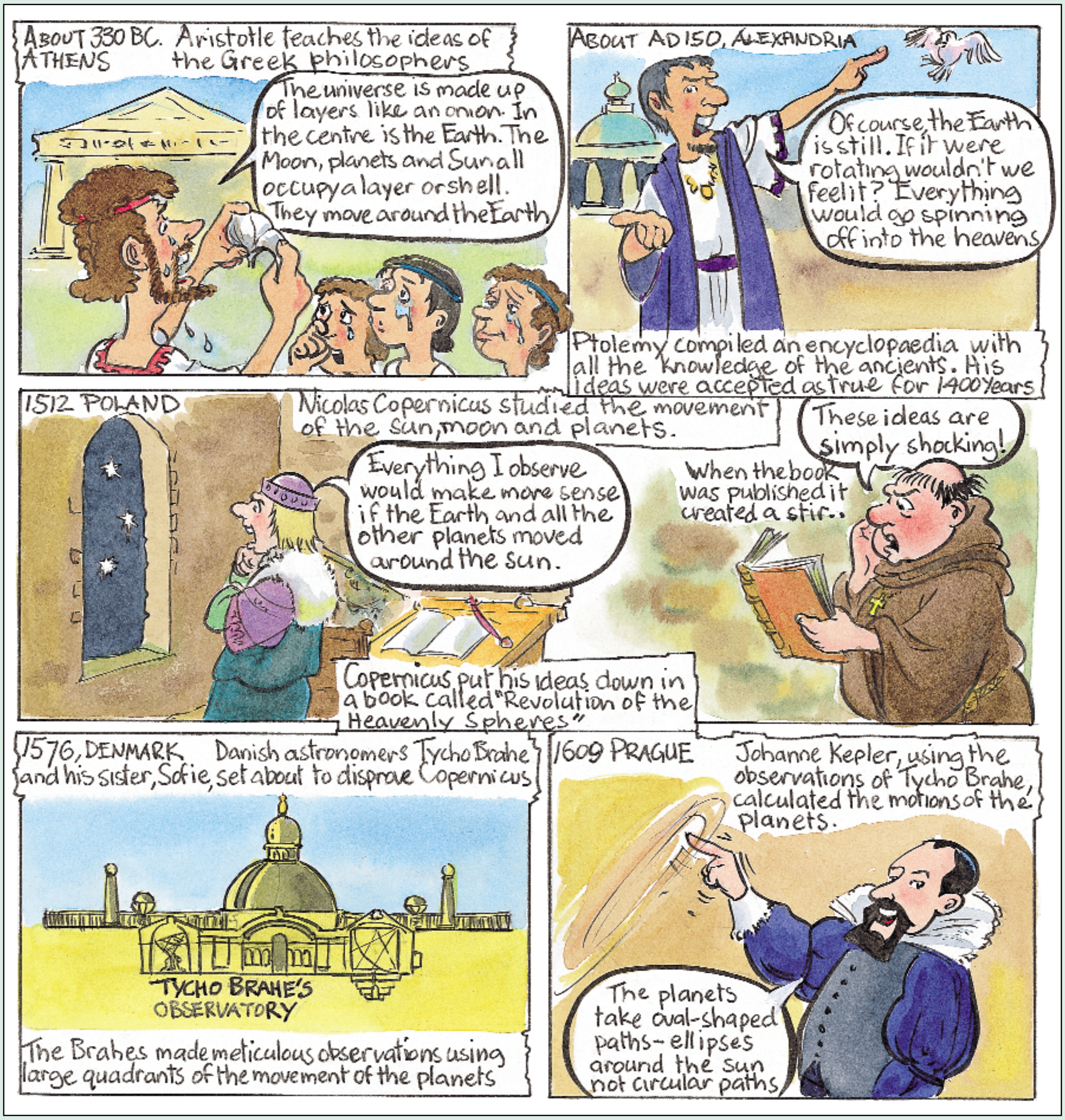

FIGURE 11.12

Glossary

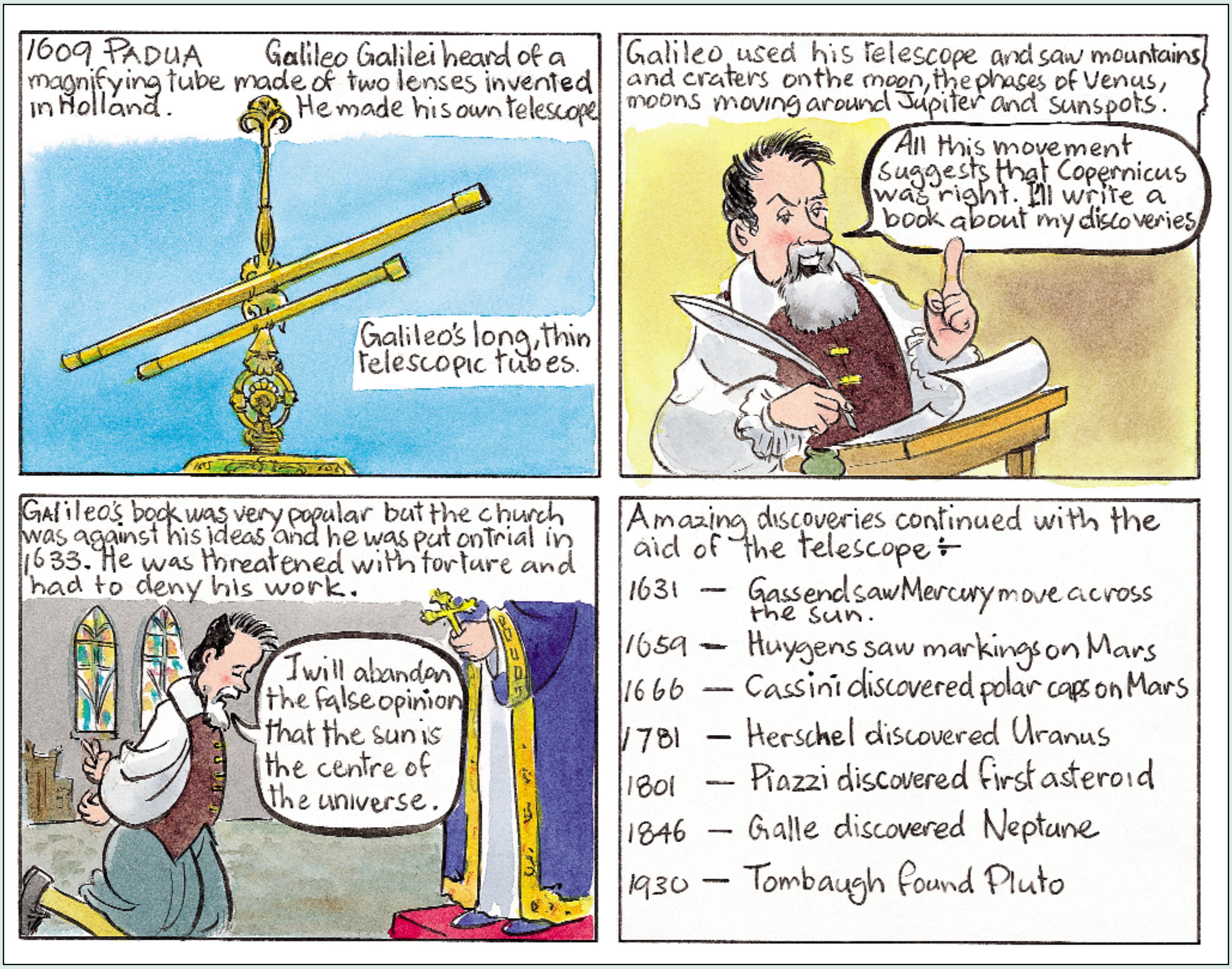

FIGURE 11.13

Questions

1 How were the ideas that Aristotle taught in ancient Greece different from those Nicolas Copernicus put in his book?

2 What contribution to astronomy did Tycho and Sofie Brahe make?

3 What did Galileo see with his telescope?

4 Over time, observations of more and more distant objects have been made. What do you think happened to allow this?

Think about

Why do many new ideas have such a difficult time being accepted?

Activity

A

Draw an ellipse.

1 Pin a sheet of paper to a piece of thick cardboard.

2 Pin two drawing pins 8 cm apart in the centre of the paper.

3 Tie a loop in a 20 cm length of string and pass it between the drawing pins.

4 Stretch the loop with a pencil. Draw an ellipse by moving the pencil around the pins, keeping the string taut.

What can you change to draw different shaped ellipses?

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11.5

How does the Earth move in space?

FACT FILE

The Earth is travelling through space at a speed of about 120 000 km per hour, spinning like a top as it moves. However, since the Earth is so large, and everything on it, including you, moves and spins with it, you don't feel it moving!

Talk about

What evidence is there that the Earth is moving in space?

The Earth moves in two ways. First, it spins, or rotates, like a spinning top. Second, while it is spinning, it orbits the Sun in an elliptical orbit.

Day and night

The Earth spins, or revolves, around its **axis** from west to east. The Earth's axis can be thought of as an imaginary line drawn from the North Pole down to the South Pole, around which the Earth spins. The axis always remains tilted. Earth makes one complete rotation in 23 hours and 56 minutes.

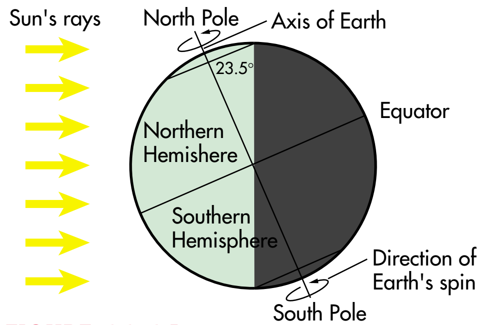

FIGURE 11.14
Day and night. Earth's rotation is responsible for the changing of day to night and night to day.

We get day and night because of Earth's rotation around its axis. As the Earth rotates, only one half of it faces the Sun at any one time. The side that faces the Sun experiences day and the side facing away from the Sun experiences night.

EXPERIMENT 2 MODELLING DAY AND NIGHT

AIM

To investigate how the rotation of the Earth causes day and night.

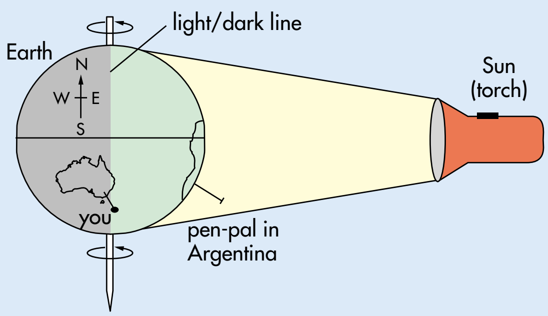

FIGURE 11.15
A model can help you understand how day and night occur.

MATERIALS

- polystyrene ball, about 10 cm diameter (to represent the Earth)
- bamboo skewer (the axis),
- torch (the Sun)
- two pins (you, and a pen-pal overseas).

(Note: Keep the polystyrene ball for the next activity.)

METHOD

1 Gently push the skewer through the centre of the ball. This represents the Earth's axis.

2 Draw in:

a the Equator (the imaginary line that divides the Northern and Southern Hemispheres);

b the directions north, south, west and east;

c Australia;

d another country where you may have a pen-pal, relatives or friend.

3 Place pins to represent where you and your pen-pal live.

4 Turn on the torch.

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EXPERIMENT 2 CONTINUED

5 Hold the ball in the light, turn the ball from west to east (anticlockwise) and observe from the side.

DISCUSSION

1 Do day and night occur at the same time at all places in Australia?

2 How would the times of the day differ between your place and your pen-pal's place?

3 Look down on the North Pole while you are spinning the Earth. Where does the Sun:

a rise? **b** set?

4 Look up at the South Pole while you are spinning the Earth. Where does the Sun:

a rise? **b** set?

5 Decide where dawn and sunset would occur on your rotating model.

The seasons

The Earth can be divided into two half-spheres, or **hemispheres**, separated by the **Equator.** It takes the Earth 365¼ days to complete one **orbit** of the Sun. As the Earth travels round the Sun, one hemisphere is always facing more towards the Sun than the other. This is because the axis of the Earth is tilted at an angle of $23^1/_2$ degrees to the Sun.

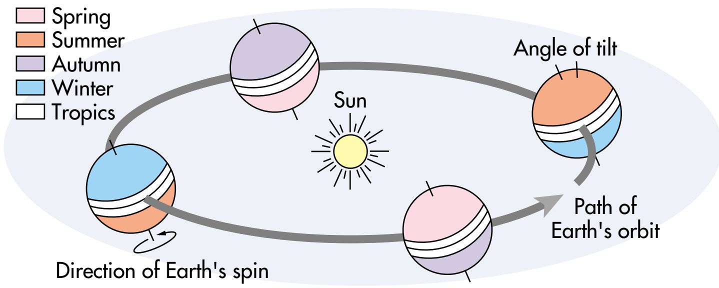

FIGURE 11.16
The seasons. The tilt of the Earth as it travels around the Sun is responsible for the changing seasons. A year is calculated by the time it takes the Earth to orbit the Sun. Since it takes $365^1/4$ days for the Earth to orbit the Sun, in our calendar there are 365 days every year apart from every fourth year (leap year), which has 366 days.

EXPERIMENT 3 MODELLING THE SEASONS

AIM

To investigate how the tilt of the Earth causes the seasons.

MATERIALS

- the prepared 10 cm polystyrene ball from the previous activity
- torch

METHOD

Work in pairs.

1 Hold the skewer at an angle of about $23^1/_2$ degrees to the path of the Earth's orbit.

2 Ask your partner to shine a torch on the ball.

3 Which hemisphere is facing more toward the Sun? Which season is this?

4 Which hemisphere is facing less toward the Sun? Which season is this?

5 Look at the position of the axis in Figure 11.16 and try to move the Earth through a cycle of a year. Compare your model with your partner's.

6 Copy these sentences and complete them using either 'towards' or 'away from':

In summer in the Southern Hemisphere, the top end of the axis is pointed ——— the Sun. In winter, the top end of the axis is pointed ——— the Sun.

Questions

1 **Explain how the Earth moves in space. You may use diagrams.**

2 **Why do dusk and twilight occur?**

3 **Explain why it gets hot in the summer months and much cooler in the winter months.**

4 **How many days make up one year? Where does this figure come from?**

Find out

Use library references to find out about the summer solstice, winter solstice and equinoxes. Present your findings as a poster or model.

Interactive

Web page

Internet assignment

Glossary

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11.6

Our connection to the Moon

FACT FILE

THE MOON
Distance from Earth: average distance 384 000 km (elliptical orbit)
Diameter: 3476 km
Temperature: 130°C at lunar noon to −175°C at night
Gravity: one-sixth that on Earth
Surface: covered with craters (circular indentations), mountains (bright areas also called highlands) and broad, flat plains (dark areas called mare or maria from the Latin for 'sea' because people once thought they were seas). Cutting across the maria are long, narrrow valleys called rilles.
Atmosphere: none. No wind disturbs footprints. No weather. Astronauts must carry their own air.

FIGURE 11.17
When you look at the Moon, you can clearly see areas of light (mountains) and dark (maria, or seas).

Which side of the Moon do we see?

The **Moon** has an elliptical orbit around the Earth. The Moon stays in Earth's orbit because the gravity of Earth and the gravity of the Moon pull on each other. The Moon's closest point to Earth is called the **perigee**. The furthest point in its orbit is called the **apogee**.

The Moon orbits the Earth once in about 28 days. During this time, it also rotates once on its axis. We say that the Moon's **period of revolution** is the same as its **period of rotation**. Therefore, we always see the same face of the Moon. In 1959, astronomers from the USSR photographed the back of the Moon for the first time, using a camera in a rocket ship. It looks similar to the front. Today, maps of the Moon are almost as accurate as maps of Earth.

Phases of the Moon

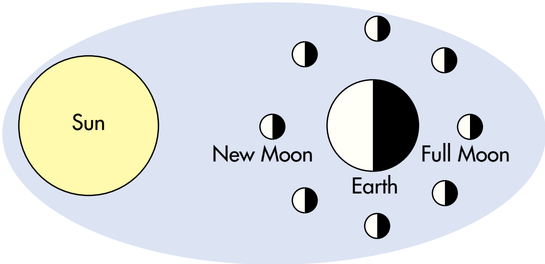

FIGURE 11.18
Phases of the Moon.

As the Moon orbits the Earth, it keeps the same side facing Earth all the time. Half of its surface is lit by the Sun, half is dark. The amount of the lit surface we can see from Earth changes as the Moon moves around the Earth. When the Moon is between Earth and the Sun, we cannot see the lit side at all; the side that we never see is facing towards

Glossary

the Sun. As the Moon moves around on the path of its orbit, we first see a small slice of the Moon, then a wider crescent, then a half-moon. This is called the **waxing** of the moon. At the point of the Moon's orbit when Earth is between it and the Sun, we see a full moon. The whole of the Moon's lit surface is visible from Earth. From then on the left hand side is more and more in shadow until, once again, we cannot see the Moon at all. This is called the **waning** of the moon. Like light from the planets, the light from the Moon is reflected light from the Sun.

USING SCIENCE 2 PHASES OF THE MOON

WHAT YOU DO

Work with a partner. You will need a basketball, overhead projector, notebook, pencil, darkened room.

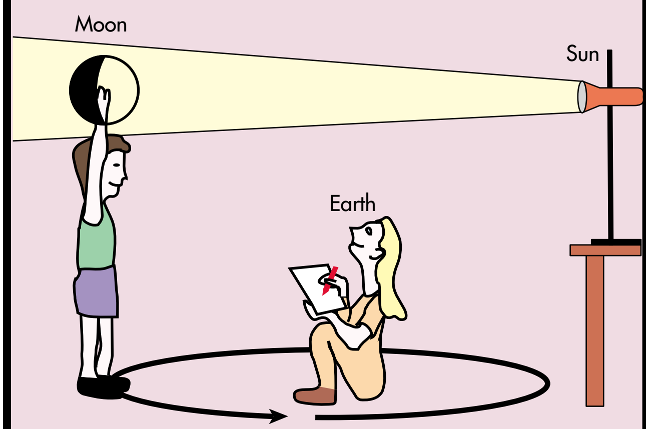

FIGURE 11.19
Role-playing the phases of the Moon.

PERSON A

You are the Earth. Sit in the centre of a darkened room, with a notebook and pencil. You will draw the shape of the lighted part of the basketball as your partner stops every 45 degrees.

PERSON B

You are the Moon. Stand about a metre away from the Earth. Hold a basketball above your head. Turn on an overhead projector so that it shines towards you and your partner. Walk slowly round your partner, always facing them, anticlockwise. Stop every 45 degrees so that your partner can draw the lit shape of the ball as it revolves.
Swap places with your partner and compare diagrams.

DISCUSSION

1 Where was the ball when you saw a full moon?
2 Where was the ball when you saw a new moon?
3 When did you see the waxing of the Moon?
4 When did you see the waning of the Moon?

Questions

1 Why do we always see the same surface of the Moon from Earth?
2 The side of the Moon facing away from Earth is often called the 'dark side of the Moon'. Do you think this is totally correct? Explain.
3 Draw and label a diagram which shows the phases of the Moon.

Activity

Keep a moon diary for a month. On an A4 sheet of paper, copy a calendar page for the current month. Draw the Moon each night as it goes through its phases. Try to draw it at the same time each night, and from the same position. Make brief comments about its size and colour, and any other observations you make.

a Why is it important to observe the Moon at the same time and from the same position each night?
b Where does the Moon rise each night?

Find out

What are the current theories on the origin of our Moon?

FACT FILE

During 1998 NASA's probe Lunar Prospector orbited the Moon and made an exciting discovery. Ice was found in deep craters near the Moon's poles.

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11.7 Eclipses: blocking the light

FIGURE 11.20
Solar eclipse.

FIGURE 11.21
Lunar eclipse.

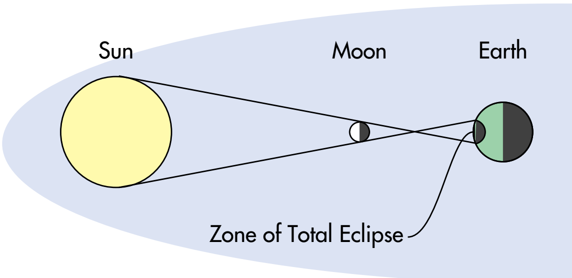

FIGURE 11.22
Solar eclipse.

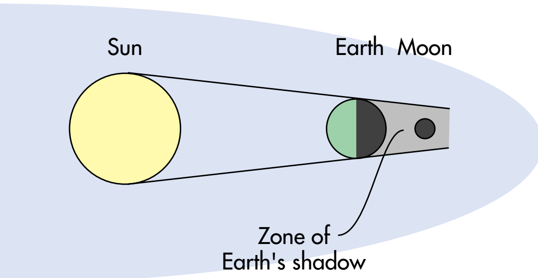

FIGURE 11.23
Lunar eclipse.

FIGURE 11.24
The early Chinese thought that a dragon eating the Sun caused eclipses.

The sight of an **eclipse** has always inspired wonder and often fear. During a total **solar eclipse**, the sky begins to darken, the temperature drops, birds go to roost, flowers close their petals. The first rays of sunlight peek out from behind the edge of the Moon. Finally, light from around the Sun blazes forth. Even today, when we know what is happening, an eclipse is an awesome sight. For the ancient Babylonians, every new moon (when the Moon is not visible) represented the temporary death of the Earth. The eclipses were even more fear-provoking, because they brought the risk of permanent death. Early astronomers used to believe the solar eclipses signalled the death of the Sun. Others believed a monster or wild animal had attacked the Sun or Moon and started to devour it.

What is an eclipse?

If you place your hand between a light source and your book, you will see a shadow on your book. This happens because your hand blocks the light. The same thing happens in space. If something passes between the Sun and another body, a shadow called an eclipse will be cast because the light from the Sun is blocked.

What happens during an eclipse?

As seen from the Earth, the Moon and the Sun appear to have nearly the same diameter. They look the same size, although the Sun is actually much bigger than the Moon. In space, the Sun, Moon and Earth change relative positions constantly.

When the Moon passes between the Sun and the Earth, a **solar eclipse** occurs.

Animation

Glossary

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The Moon's shadow falls on the Earth, but because the Moon is smaller than the Earth, only a small area of the Earth is covered by the shadow. This can only happen when the Sun, Moon and Earth are in a straight line, or aligned, at the time of the new moon. At least two and not more than five solar eclipses occur each year.

A lunar eclipse occurs when the Moon moves into the Earth's shadow. All or part of the Moon appears dark. This can only happen when the Sun, Earth and Moon are in a straight line, at full moon.

Eclipses can be either partial or total, depending on the position of the Sun, Moon and Earth.

Animation

USING SCIENCE 3 MODELLING AN ECLIPSE

WHAT YOU NEED

- torch (Sun)
- globe (Earth)
- tennis ball (Moon)

WHAT YOU DO

1 Darken the room.

2 Aim the torch at the globe.

3 Place the tennis ball between the torch and the globe as shown in Figure 11.25. Try not to let your body project a shadow on the globe. Draw your observations. Is the shadow darker in a certain place?

4 Rotate the globe a bit further. What happens to the shadow? How much of the Earth is in shadow?

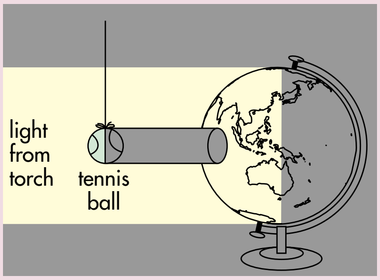

FIGURE 11.25
Modelling an eclipse.

5 Put the tennis ball on the opposite side of the globe. Move it so it is partly in the shadow of the globe. Draw what you see. What sort of eclipse is this?

EXTENSION

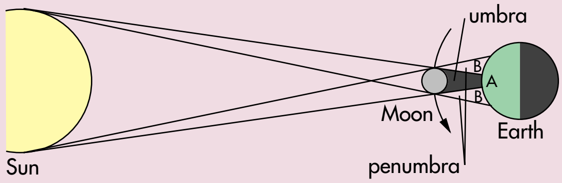

FIGURE 11.26
Solar eclipse.

Look at Figure 11.26. The darkest part of the Moon's shadow is called the **umbra**. You need to stand here in order to see a total solar eclipse. If you stand in the **penumbra**, you will see a partial solar eclipse. The darkest part of the Earth's shadow is also called the umbra. You need to stand here to see a total lunar eclipse. If you stand inside the penumbra, you will see a partial lunar eclipse.

DISCUSSION

What would you see if you stood at A? at B?

Questions

1 What is a solar eclipse? Draw a diagram to represent this.

2 What is a lunar eclipse? Draw a diagram to represent this.

3 Distinguish between a total and a partial solar eclipse.

Think about

1 Why do you think solar eclipses caused fear in ancient times?

2 Describe what you would see if you were on the surface of the Moon facing Earth during:

a a lunar eclipse

b a solar eclipse.

Glossary

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11.8

The tides: the rise and fall of the ocean

FACT FILE

It is not only water that shows a tidal effect. The atmosphere shows a clear tidal effect and even the solid parts of the Earth are deformed slightly by the Moon.

Tides happen because both the Moon and the Sun pull the Earth's seawater towards them, by the force of their gravity. The Moon is so close to the Earth that it pulls more strongly on the side of the Earth facing it than it does on the far side of the Earth. As the Earth rotates on its axis, each part of its surface faces the Moon about once in every 24 hours. The seas at that point are most strongly attracted by the Moon. They rise up and cause a bulge of water we call **high tide**. Another matching bulge of water, or high tide, rises up on the other side of the Earth. The water to make the high tides comes from the areas between the two bulges. These areas experience **low tides**. There are two high tides and two low tides on opposite sides of the Earth every day.

The Sun is so far away that the difference in its pull on opposite sides of the Earth is very small. However, twice a month, at full moon and new moon, the Sun and the Moon pull towards Earth in line and produce tides that are higher than normal. These are called **spring tides**.

When the Moon is at first and last quarter, it pulls at right angles to the Sun and produces small **neap tides**. At these times, the effect of the Moon's gravity on the oceans is partly offset by the Sun's gravity.

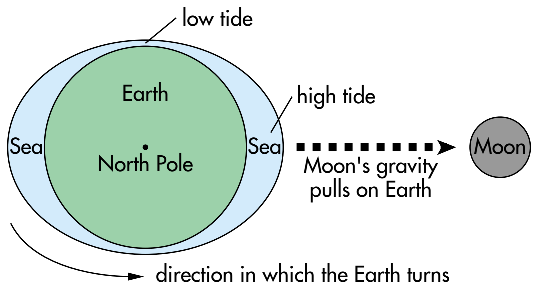

FIGURE 11.27
The Earth's tides.

USING SCIENCE 4 DO THE TIDES COME AT THE SAME TIME EVERY DAY?

Table 11.1 shows the times of high tide at Sydney, for one week in June 1997.

CALCULATE

1 The difference between one high tide and the next, on the same day.

2 The difference between one high tide and the next on different days.

3 Starting with Tuesday 3 June, complete the following tables then answer the following questions.

TABLE 11.1 High tide times, Sydney, June 1997.

Tuesday 3	6.32 a.m.	6.59 p.m.
Wednesday 4	7.26 a.m.	7.45 p.m.
Thursday 5	8.15 a.m.	8.28 p.m.
Friday 6	9.02 a.m.	9.10 p.m.
Saturday 7	9.48 a.m.	9.50 p.m.
Sunday 8	10.31 a.m.	10.30 p.m.
Monday 9	11.15 a.m.	11.15 a.m.

Spreadsheet

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Extra Worksheet

USING SCIENCE 4 CONTINUED

FIGURE 11.28

TABLE A
6.32 a.m. minus 6.59 p.m. = 12 hours 27 minutes
7.26 a.m. minus 7.45 p.m. =
TABLE B
6.59 p.m. minus 7.26 a.m. = 12 hours 27 minutes
7.45 p.m. minus 8.15 a.m. =

a Do the tides change in a regular way?
b What is the greatest length of time between high tides?
c What is the smallest length of time?
d What is the average length of time? (Add up results in both tables and divide by 14.)

The tides are separated by more than 12 hours because the tidal bulges follow the Moon as it travels round the Earth every month.

EXTENSION

TABLE 11.2 Moonrise and moonset, Sydney, June 1997.

	Rise	Set
Tuesday 3	4.18 a.m.	3.33 p.m.
Wednesday 4	5.21 a.m.	4.18 p.m.
Thursday 5	6.21 a.m.	5.06 p.m.
Friday 6	7.18 a.m.	5.57 p.m.
Saturday 7	8.11 a.m.	6.49 p.m.
Sunday 8	8.59 a.m.	7.43 p.m.
Monday 9	9.43 a.m.	8.38 p.m.

How much later does the Moon rise at night?

DISCUSSION

How long does it take for the Moon to return to the same place in the sky from one day to the next?

Questions

1 Explain why in any given location there are normally two high and two low tides per day.

2 What is a spring tide? A neap tide? Diagrams will help your explanation.

Activity

Read the article and write a brief account of how a day on Earth would be different if the Moon drifted out of the solar system.

Earth, moon are drifting apart

LONDON – The earth and the moon have drifted apart by one metre since astronauts landed on the moon, say American and French scientists.

They used a mirror, placed on the moon by Apollo astronauts Buzz Aldrin and Neil Armstrong 25 years ago this week, as a cosmic tape measure.

The scientists take precise measurements of the time it takes for a pulse of laser light to bounce off the mirror into a detector on earth, a round trip of about two and a half seconds.

The measurements show the distance between earth and the moon is increasing by almost 4 centimetres a year.

Experts said that was because energy was lost in our tides, 'affecting the motion of the earth–moon system'.

The Telegraph plc,
London 1994
from *Herald Sun* 23 July 1994

Glossary

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CURRENT ISSUES, RESEARCH AND DEVELOPMENT

Probing the planets

FIGURE 11.29 The view from Pathfinder shows Sojourner investigating Martian rocks in the distance.

FIGURE 11.30 NASA scientists checking Sojourner prior to launch.

Our knowledge of the planets comes from several sources. Different types of telescopes have been used to study the planets. However, for planets with thick atmospheres or at great distances from Earth, little detail can be seen. Since 1962 scientists have gathered information about planets using unmanned spacecraft. The spacecraft either do a fly-by or go into orbit around the planets. Missions to Mars, Venus and Jupiter have released probes into the planets' atmospheres. There have also been several landings on Venus and Mars. Robot probes contain cameras, measuring instruments, computers and radio transmitters. Information is collected then sent back to Earth using radio waves.

TABLE 11.3 Previous missions to Mars.

Mission to Mars	Year of launch	Outcomes of mission
Mars 1, USSR	1962	Failed, lost radio contact
Mariner 3, USA	1964	Failed, lost radio contact
Mariner 4, USA	1964	First fly-by, 22 pictures and data transmitted
Zond 2, USSR	1964	Failed, lost radio contact
Mariner 6/7, USA	1969	Both probes conducted fly-bys, returning about 200 pictures
Mariner 8, USA	1971	Failed, malfunctioned on launch
Mars 2/3	1971	Orbited planet; however, both landers failed to return data
Mariner 9	1971	Orbited planet, returned 7000 pictures and data on surface, clouds, atmosphere and moons
Mars 4/5, USSR	1973	Orbited and transmitted pictures and data
Mars 6/7	1973	Failed, Mars 6 at touch down, Mars 7 lost radio contact
Viking 1/2	1975	Both consisted of an orbiter and lander. Each one operated for several years, transmitting enormous amounts of data

Mars Pathfinder mission

Mars has been visited by numerous probes. The latest arrived after a seven-month voyage on 4 July 1997. The Pathfinder spacecraft was designed differently from previous probes. It used an 11-metre parachute, retro rockets and shock-absorbing airbags to touch down safely on the Martian surface. After bouncing 15 times it came to rest on an ancient flood plain. The airbags deflated, then the lander opened up and a robot rover called Sojourner rolled down the ramp.

For 83 days Sojourner explored the area around the lander. It took over 500 photographs, chemically analysed 15 rocks, measured the weather and transmitted all the data gathered back to Earth. The information received has greatly advanced our knowledge of this planet. We have more evidence that Mars once had running water which eroded the landscape and allowed sedimentary rocks similar to conglomerate to form. Scientists now have more information on the role of atmospheric dust in the Martian climate.

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USING SCIENCE 5 DESIGN AND BUILD A RECTRACTABLE CLAW

WHAT YOU NEED

- a variety of suitable materials such as wire, straws, cardboard cylinders, stick tape, glue etc.

WHAT TO DO

The robot probes which have landed on Mars all had devices to collect samples of rock and soil for testing. Design and construct a model retractable claw which can pick up and pull in a small rock. Demonstrate your working model to your class.

Questions

1 When are space probes more useful than telescopes in exploring planets?

2 How was Pathfinder designed differently from previous probes?

3 What achievements did the Pathfinder mission make?

Think about

1 Suggest a reason why more space probes have visited Mars and Venus than all the other planets put together.

2 How many Mars missions have been launched up to 1998? How many have failed? In your opinion, are space probes worthwhile?

Activity

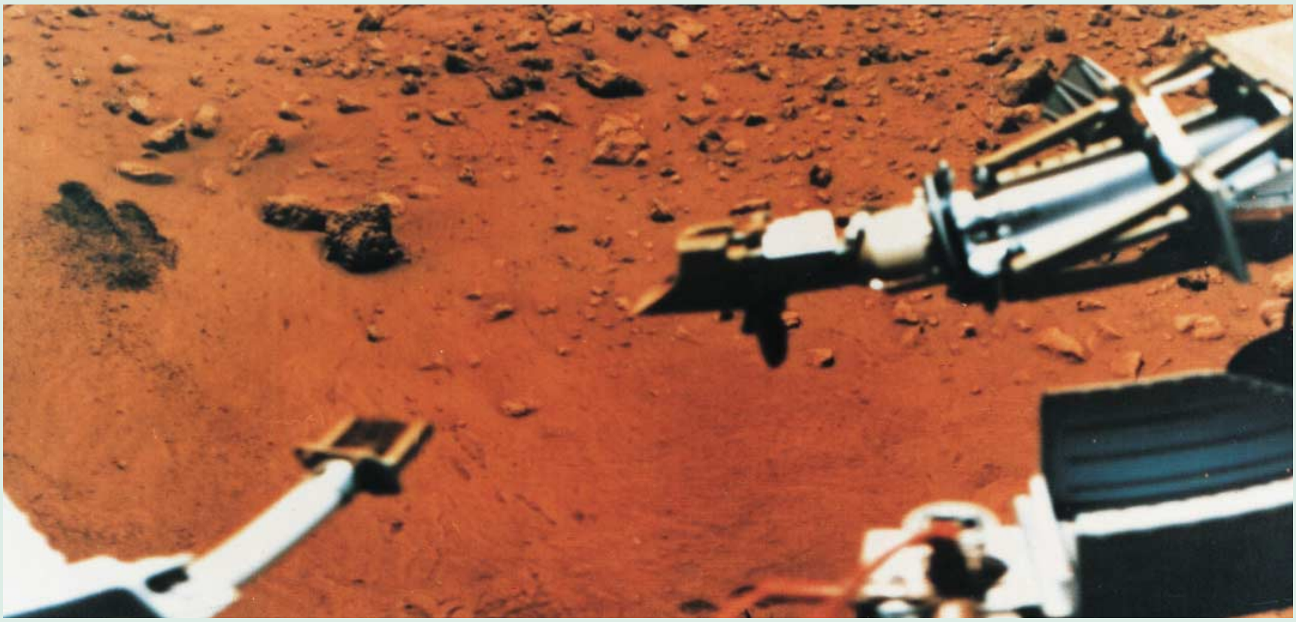
Start a scrap book of space exploration news. Look in newspapers, magazines and on the Internet for articles.

Find out

1 Select another planet and research the history of space probes to that planet. Present your findings as a poster.

2 Use the Internet to find out about future missions to the planets.

FIGURE 11.31
The view from Mars in 1975, taken by the Viking 1 lander.



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Using scientific language

1 Match the following words or terms to their correct meaning:

• solar system	• a feature that the giant gas planets have in common
• satellites	• smallish rocks and ice orbiting the Sun, between Mars and Jupiter
• planet	• the layer of gases surrounding a planet
• ring	• objects entering a planet's atmosphere from space
• meteors	• the name of the Sun and its satellites
• atmosphere	• a large satellite orbiting a star
• asteroids	• what the planets are to the Sun and the moons are to the planets

2 Fill in the missing words:

a The Earth rotates on its _____ once every _____ hours. It revolves around the Sun once in every _____ days.

b The light from the Moon is _____ light from the _____ , as is the light from the planets.

c A solar eclipse can only happen when the Moon is _____ .

d A lunar eclipse can only happen when the Moon is _____ .

e Stars in the sky appear to move from _____ to _____ due to the Earth's _____ .

Check your knowledge

1 List five different types of objects that can be found in the solar system.

2 How far around the Sun would the Earth get in 13 weeks?

3 How many moons are there (at least) in the solar system?

4 How many Saturn days are there in a Saturn year?

5 What sort of atmosphere does Venus have?

6 List at least five things all the planets have in common.

7 How would life on Earth be different if:

a Earth did not rotate on its own axis?

b Earth's axis was not tilted?

8 How would tides be affected if the distance between the Earth and the Moon was halved?

9 Which two planets in the solar system are most similar in size?

Apply your skills

1 Uranus's slightly wobbly orbit still isn't fully explained. Some astronomers think there is a tenth planet much further out than Pluto. From what you know about the nine planets, what would you predict a tenth planet would be like?

2 If Mars once had liquid on its surface, where is that liquid now?

3 If the Earth weighed 1000 kilograms, the other planets would have the following weights:

2 kg	815 kg	319 000 kg
107 kg	95 000 kg	55 kg
17 000 kg	15 000 kg	

• Pluto and Jupiter are the lightest and heaviest planets respectively.
• Venus weighs nearly the same as Earth; the next closest planet is Mars.
• Mercury is much lighter than the Earth.
• Uranus and Neptune are nearly the same weight.

Using this information, match each of the planets with its weight.

4 Suggest which planet in the solar system, other than Earth, could best support life. Justify your choice.

Challenge yourself

1 Draw two possible arrangements of the Sun, Moon and Earth that could cause a spring tide.

2 An astronomer discovers a new comet (a small lump of icy rock with a long tail of dust). In her excitement, however, she has forgotten where it was. Her notes show:

• it was between Uranus and Venus
• it was on the opposite side of the asteroid belt to the Sun
• it was beyond the seventh planet from the Sun.

Which neighbouring planets was the comet between?

3 The table below shows the temperature ranges on the four innermost planets.

TABLE 11.4 Temperature ranges on the four innermost planets.

W	X	Y	Z
80°C	0°C	145°C	520°C

Given that we know:

• Mars has a greater temperature range than the Earth
• the temperature on Venus is almost constant

identify the planets W, X, Y and Z.

4 Research one of the objects found in space mentioned in this chapter or one approved by your teacher. Prepare a poster on your topic which explains what is known about this object. Include diagrams and tables where possible. Use your poster to give a short talk to the rest of the class.

e Tester

Glossary

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GLOSSARY

adaptation a characteristic possessed by an organism that helps it to survive in its natural habitat or assists with its lifestyle 146
aerated has air pumped through 57
aim what you are trying to achieve from an experiment or activity 18
algae plant-like organisms usually found in water 130
amphibians class of ectothermic vertebrates with a moist skin lacking scales, e.g. frogs, toads, salamanders 190
analogue measurement displayed by a needle or pointer which moves along a scale 12
angiosperm plant that produces flowers 137
Antarctic circle parallel of 66.5° south 188
antibiotic chemical produced by a micro-organism that can kill other micro-organisms, e.g. penicillin 143
apogee furthest point from the Earth of the Moon's orbit 212
apparatus scientific equipment 7
asteroid small rocky object orbiting the Sun; most are found between Mars and Jupiter 202
atmosphere the air; the blanket of gases surrounding a planet 170
atoms small particles that make up all matter 34
axis imaginary line through the Earth, about which it rotates 210
bacteria simple, single-celled organisms which lack a true nucleus; most are harmless, some are beneficial and some cause disease 140
basalt igneous rock which has cooled rapidly 178
blood tissue composed of red blood cells, white blood cells and platelets floating in fluid plasma 120
Bunsen burner equipment used for heating in the laboratory by burning gas 6
buoyant force the upthrust or upwards force on an object placed in water 88
cancer disease in which cells become abnormal and grow out of control 122
cast made by filling a mould with liquid which sets; has the same structure as the object which formed the mould 188
cell smallest building block of living things that is itself living 108
cell membrane membrane surrounding the cytoplasm of cells 114
cell theory generalisation which states that all living things are composed of essentially similar structures, cells and the products of cells 108
cell wall cellulose wall surrounding the membrane of plant cells 114
cementation gluing of grains of sediment together; along with compaction forms sedimentary rock 176
centrifuge device used to separate part of a mixture by spinning 50
chemical weathering chemical changes in rock often leading to softness or dissolving 172
chlorophyll green pigment found in chloroplasts of plant cells 61, 114
chloroplast site of photosynthesis in plant cells 114
chromatography separation technique where substances dissolved in a solvent are carried at different rates along special paper 60
chromosomes long thread-like bodies of DNA found in the nuclei of cells; control the characteristics of an organism 114
circulatory system transport system composed of heart, blood and blood vessels 121
classification placing things into groups based on similarities they possess 3, 128
clock anything that can measure the passing of time 196
colloid liquid containing fine particles which do not settle out; unlike a solution, colloids are not clear 48
comet body which normally orbits the Sun on a large elliptical orbit 202
community living things living together in a particular habitat at a particular time 150
compaction squashing together of layers of sediment to form sedimentary rock 176
compass device used to find direction; includes a magnetised needle that points north 102
concentrated a concentrated solution has a large amount of solute added 48
conclusion final opinion, based on results of experiment 17, 18
condensation change of state from a gas to a liquid 32
conduction transmission of something from one place to another, e.g. electrons in the flow of electric current 72, 96
consumer organism that eats other organisms 152
controlled burning burning off of fuel during non-dangerous times to reduce the danger of bushfire 9
crystal solid substance in which the atoms are arranged in such a way as to produce definite shapes 54
crystallisation formation of crystals as solvent evaporates from solution 54
cubic metre unit of volume 15
cyanobacteria photosynthetic bacteria; also called blue-green bacteria and sometimes (incorrectly) blue-green algae 190
cytoplasm jelly-like liquid that fills the inside of a cell; site of most of the chemical reactions of the cell 114
decanting method used to separate an insoluble sediment from a liquid by carefully pouring off the liquid 50
decay break down of radioactive elements over time 196
decomposer micro-organism such as bacteria and fungi that break down the remains and waste products of plants and animals, thus returning important nutrients to the environment 142
decomposition breaking down of the remains and wastes of living things by bacteria and fungi 186
degrees Celsius unit of temperature (°C) 12
deposition dumping of eroded material 176
diffusion spreading out of the particles in liquids and gases due to the random movement of the particles; results in substance moving from areas of high to low concentration 38
digital measurement displayed as numbers or digits 12
dilute a dilute solution is one with little solute added 48
dinosaurs diverse group of reptiles which became extinct about 65 million years ago; ranging from about the size of a chicken to 30 metres in length and 130 tonnes 188, 190
discussion outlines what the results of an experiment show, whether the hypothesis is supported, problems encountered, possible improvements, etc. 18
distillate liquid recovered during distillation 58
distillation method used to separate and recover the solvent in a solution 58
eclipse the blocking of light as one body passes between the Sun and another body, casting a shadow 214
ecology study of living things and their interaction with their living and non-living surroundings 148
ecosystem system formed by living things interacting with each other and their non-living surroundings; the living things within an ecosystem are interdependent 150
ectothermic organism whose body temperature varies with that of the environment ('cold-blooded') 133
electricity the energy that results from the movement of charged particles 96
electrons fast-moving negatively charged particles that surround the nucleus of an atom 34
emulsion a colloid with tiny droplets of a liquid spread through another liquid 48
endothermic organism with a constant body temperature, normally higher than that of its environment ('warm-blooded') 133
energy the ability to do work or cause change 66
environment living and non-living things in an organism's surroundings which have an effect on it in its lifetime 148
Equator line which separates the Northern and Southern Hemispheres 211
erosion wearing away of rock and soil followed by removal to another location; the major agents of erosion are wind, water, and ice 174
evaporation change of state from liquid to gas at the surface of a liquid; can be used to separate a solvent from a solute in a solution 30, 54
experiment a carefully planned activity designed to answer a question or test a hypothesis 17, 18
extinction process of becoming extinct. A species is considered to be extinct if there has been no sighting of that species in the last fifty years 162

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fermentation conversion of sugar to alcohol and carbon dioxide by micro-organisms such as bacteria and yeasts; utilised in bread and wine making 143
fertile soil able to support many plants 180
fertilisation union of male and female sex cells (sperm and egg) 137
filter a fine mesh (e.g. special paper) that allows liquids through but retains insoluble substances 52
filter paper paper which is able to trap insoluble substances during filtration 52
filtrate liquid that passes through a filter 52
filtration method used to separate an insoluble substance mixed with a liquid by passing the mixture through a filter 52
fine-grained sedimentary rock sedimentary rock with fine grains, e.g. shale 176
fire triangle the three things necessary for fire—heat, oxygen and fuel 8
fluorescent globe electrons pass through a gas mixture and produce ultraviolet light. This hits a powder coating on the inside of the glass which absorbs it and re-emits the energy as white light 82
food chain organisms linked together by their feeding habits in a single series 152
food web series of interacting food chains within an ecosystem 156
force a pull, push or twist; forces can change the way things are moving 86
forensic science science which is used to help solve crime and in court 63
fossil any evidence of former life 186
fossilisation the process whereby fossils are formed 186
friction force that acts against a moving object 90, 96
fuel something that burns to release heat energy 9
gas state of matter with no fixed shape or volume 26
genes segments of chromosomes that control particular characteristics of an organism 114
glacier river of ice 174
gram unit of mass (g) 14
granite igneous rock formed from magma that has cooled slowly beneath the Earth's surface; contains large crystals 178
gravity the force of attraction between any two objects, e.g. the Earth and a person 92
gravity separation method used to separate parts of a mixture based on their weight 50
greenhouse effect trapping of heat energy by certain gases in the atmosphere known as greenhouse gases; carbon dioxide is a principle greenhouse gas 83
guard cells cells surrounding a stomatal pore that control its opening and closing 118
habitat the place where an organism lives 146
half-life time taken for half the radioactive material in a substance to decay 196
heat type of energy that can raise the temperature of things 9, 67, 72
hemisphere half sphere; the Earth is divided into the Northern and Southern Hemispheres 211
high tide pull of gravity by the Moon on the waters of the Earth causes the tides; the sides of Earth nearest to and furthest from the Moon experience a high tide 216
humus organic material found in top soil 180
hyphae tiny threads from a fungus that penetrate into its food supply and release chemicals to digest the food which is then absorbed by the fungus 142
hypothesis an educated guess based on observation or information; can be tested experimentally 3
igneous rock rock formed when molten magma solidifies, e.g. basalt, granite 178
incandescent globe light that shines due to a filament getting very hot and glowing brightly 82
induction process of charging an object by bringing a charged object close to it without touching it 97
inference suggestion based on observations 3
insoluble an insoluble substance will not dissolve in another; water-insoluble substances will not dissolve in water 46
invertebrate animal without a backbone, e.g. insect, jellyfish, worm 130
joule unit of measurement for energy (J) 78
kilogram basic unit of mass (kg); 1000 grams = 1 kilogram 93
kilowatt hour also known as unit; unit of measurement of the electrical power used in an hour (kWh) 83
kinetic energy the energy possessed by a moving object 67
kingdom the first sorting of living things into groups; there are five major kingdoms—animals, plants, fungi, monera and protista 130
laboratory place where experiments are conducted 4
limestone sedimentary rock composed of calcium carbonate 178
liquid state of matter that changes its shape but not its volume 26
logging cutting down and transporting timber 162
low tide pull of gravity by the Moon on the waters of the Earth causes the tides; the sides of Earth at right angles to the Earth–Moon line experience a low tide 216
lunar eclipse occurs when the Moon moves into the Earth's shadow 214
magnet an object which is able to attract magnetic materials such as iron 100
magnetic any object which is attracted by a magnet 100
magnetic field the region surrounding a magnet in which a magnetic object will experience a force 100
magnetic field lines pattern of the magnetic field around a magnet 100
magnetic force the force experienced by a magnetic object placed near a magnet 100
magnetic north pole region of the Earth which attracts the north pole of a magnet 103
Magnetic Resonance Imaging (MRI) technique which uses powerful magnets to create images of the internal structures of the body 105
magnetic separation use of magnets to separate magnetic parts of a mixture from non-magnetic parts 50
magnetometer very sensitive pieces of equipment for locating buried metals 104
mammals class of endothermic vertebrates; have hair and feed their young on milk, e.g. humans, dogs, dolphins, whales 191
marsupial mammal where the young is born after a very short gestation period and continues its development in a pouch 132
mass the amount of material in an object; measured in grams (g) or kilograms (kg) 14, 26
materials a list of equipment and requirements included in an experimental report 18
matter anything that takes up space and can be weighed 26
mature soil rich in humus 180
measurement using a scale to make accurate observations 12
measuring cylinder equipment for measuring volume 15
melanoma serious type of skin cancer that can be fatal 122
melting change state from a solid to a liquid 30
meniscus the curved surface of a liquid where it meets the side of a container 15
metal detector hand-held equipment for locating buried metals 104
metamorphic rock rock formed by the action of heat and pressure on sedimentary rock 178
meteorite an object that has reached the Earth's surface from space 198
meteorite crater scar left by the impact of a meteorite 198
method procedure to be followed in an experiment 18
metre basic unit of length (m) 14
micrometer instrument with screw scale for measuring very small distances 14
micrometre unit of length used to measure very small objects such as cells; one millimetre = one thousand micrometres 112
micro-organism (microbe) organism that can only be seen clearly with a microscope, e.g. bacteria, algae 140
microscope (compound light) an instrument that uses light and a system of lenses and mirrors to magnify objects up to 1000 times 108
microscope (electron) an instrument that uses a beam of electrons rather than light to magnify objects up to 500 000 times 109
microscopic something that can only be seen with the aid of a microscope 108
mitochondria site of respiration in cells 114
mixture a substance made up of two or more elements or compounds not chemically joined 50
model simple representation of a complex thing or idea 3, 34
monotremes egg-laying mammals, e.g. platypus 135

Moon, the Earth's natural satellite; orbits the Earth in an elliptical path 212
moulds (physical) imprint or depression that is the reverse structure of the object which formed it 188
multicellular (organism) made up of many cells 120
neap tide lower than normal tide when the Moon and Sun pull at right angles to each other 216
neutron uncharged particle found in the core of an atom 34
newton the unit of force (N); weight is measured in newtons 93
nuclear membrane membrane surrounding the nucleus of a cell 114
nucleation formation of snow by the grouping of ice crystals around a particle such as clay 42
nucleus (of atom) found at the core of an atom; contains protons and possibly neutrons 34
nucleus (of cell) found in most cells; controls the activities of the cell 114
observation information collected with your senses 10
orbit path followed by a planet or satellite around another body such as the Sun; normally elliptical 211
organ group of different tissues working together to perform a particular function, e.g. the heart 121
organism any living thing 126
ovules female sex cells, also called eggs 118
oxygen colourless, odourless gas found in air; needed by most living things to survive; also necessary for burning 9
ozone layer layer within the stratosphere that contains ozone gas; helps to screen out dangerous UV radiation 171
parasite living thing that feeds or lives on another organism at that organism's expense 142
perigee closest point to Earth of the Moon's orbit 212
period of revolution time for a planet or other body to complete a single orbit 212
period of rotation time for a planet or other body to complete a single rotation on its axis 212
permanent magnets materials which are permanently magnetised 135
phase (of matter) state (of matter) 30
photosynthesis process in which plants convert light energy to chemical energy (food) 114, 154
physical weathering mechanical breakdown of rock into smaller pieces 172
pistil female part of a flowering plant 137
placentals mammals that have a relatively long gestation period, during which the foetus is nourished via a placenta 132
pole the end of a magnet where the magnetic force is strongest; every magnet has a north and a south pole 100
pollen tough structures that contain the male sex cells (sperm) of flowering plants 118
pollination transfer of pollen from the male part of a flower to the female part 137
pollution contamination of the environment 161
population a group of the same species living in a particular habitat 146
potential energy stored energy 67
power how much energy something uses; measured in watts (W) or kilowatts (kW) 134
producer organism that can manufacture its own food; all plants are producers 152
proteins chemicals made up of long chains of amino acids; used by living things for growth and repair 114
proton positively charged particle found in the core of an atom 34
pure substance a substance made up of only one type of element or compound 50
push one type of force; the others are pulls and twists 86
radiometric dating techniques techniques used to date objects by measuring the amount of radioactive material remaining in them 196
reptiles class of ectothermic vertebrates with a dry scaly skin, e.g. lizards, snakes, tortoises 132
residue material which is trapped by a filter 52
respiration chemical reaction in living things that releases energy from food for life processes; requires oxygen 133
results data or information generated by experiments 18
ruler instrument with a scale for measuring length 14
saturated solution a solution that can dissolve no more solute 48
scientific diagram simple two-dimensional drawing of scientific equipment 19
scientist person who studies things in an orderly way 3
second basic unit of time (s) 12
sediment eroded material that settles following deposition 176
sediment insoluble substance that settles to the bottom of a liquid 46
sedimentary rock rocks formed by the build up, compaction and cementation of sediments 176, 178, 187
sense organ structure able to detect change and send a message to the brain, e.g. the eyes, nose and ears 10
senses allow us to make observations of our surroundings; the five main senses are sight, hearing, touch, taste and smell 10
septic tank underground tank containing bacteria for the treatment of sewage 57
sewage wastes put down sinks and toilet 56
sewerage system pipes or system for the removal of sewage 56
sieve device used to separate parts of a mixture based on their size 50
slate metamorphic rock formed by the heating and compression of mudstone 178
soil mixture of weathered rock, organic material and living organisms 180
solar eclipse occurs when the Moon passes between the Sun and the Earth 214
solar system consists of the Sun and all the things that orbit it including the nine planets 202
solid state of matter which has a fixed shape and volume 26
solidification change of state from a liquid to a solid 32
soluble a soluble substance will dissolve in a liquid; water-soluble substances dissolve in water 46
solute the substance that dissolves in a liquid to form a solution 46
solution a substance dissolved in another substance 46
solvent the substance that dissolves another 46
sonic boom loud noise produced as the sound barrier is broken 77
spring tide higher than normal tide when the Moon and Sun pull in a line 216
stamen male part of a flowering plant; produces pollen 137
starch energy-rich carbohydrate stored by plants 154
state (of matter) whether a substance is a solid, liquid or gas 30
static electricity build-up of charge in an object that remains at rest 96
stomata pores in a leaf that control the entry and exit of gases and control water loss 118
storm water run-off from roofs and ground which goes down storm water drains 56
sublimation change of state directly from a solid to a gas or gas to a solid with no liquid state 32
supersonic faster than the speed of sound 77
suspension a mixture with fine insoluble particles floating in it that eventually settle out to form a sediment 46
system group of organs working together to perform a function or functions, e.g. digestive system 121
temperature a measure of how hot something is; measured in degrees Celsius 12
tissue a group of similar cells working together, e.g. muscle tissue 120
title heading for an experiment or activity 18
troposphere layer of the atmosphere closest to the Earth; weather occurs within this layer 170
units divisions of a scale such as metres, grams, degrees, etc. 12
variable any factor which may affect the outcome of an experiment 17
vertebrate animal with a backbone, e.g. mammal, bird, fish 130
vibration rapid back-and-forth motion of particles 76
volume amount of space a substance or object occupies, usually measured in cubic centimetres 15, 26
waning visible part of the Moon's lit surface decreasing in size 213
watt unit of power (W) 78
waxing visible part of the Moon's lit surface increasing in size 213
weathering breakdown of rock 172
weight the force of gravity pulling on an object; measured in newtons (N) 93A

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