

MAMMALS » MACHINES » MIXTURES » FORCES

AMAZING

# SCIENCE?

PAUL HOLPER  
SIMON TOROK

IS THE  
EARTH'S CRUST  
RUNNING OUT  
OF FUEL?

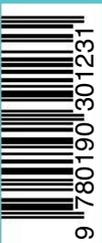
CLOSELY  
RELATED

The Platypus  
and the  
Echidna

\* 5 \*  
renewable  
energy  
resources

ASTRONAUTS  
FLOATING OR FALLING?

What's  
your  
cat's real  
name?



ECOSYSTEMS



Who eats who?

LIVING ON  
PLANET EARTH



What is moonlight?

FRICTION



Friend or enemy?



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AMAZING

# SCIENCE 7

PAUL HOLPER  
SIMON TOROK



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MAN  
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THE MOON  
92



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INSIDE  
VERTEBRATES



FILTERS  
70



RAMPS  
150

Lots more  
Experiments  
on the Teacher  
Dashboard!

AMAZING EXPERIMENTS

#1 EXAMINING SKELETONS

Examine the skeletal structures of three marine organisms.

Chapter 2, Page 34

#2 EXPLORING LEAF LITTER

Explore how tiny invertebrates work together to keep soil in good condition.

Chapter 3, Page 56

#3 STUDYING FOOD WEBS

Explore and study food webs in your local area.

Chapter 3, Page 57

#4 FILTERING MIXTURES

Separate the components of a mixture of sand and salt.

Chapter 4, Page 72

#5 QUICK ICE CREAM

Make your own ice cream at home.

Chapter 4, Page 79

#6 PHASES OF THE MOON

Identify the eight phases of the Moon.

Chapter 5, Page 98

#7 HOW DOES THE EARTH MOVE IN SPACE?

Demonstrate night and day, the seasons and a year.

Chapter 5, Page 99

#8 MODEL POWER STATION

Model the action of a coal-fired power station.

Chapter 6, Page 112

#9 MEASURING FORCE

Measure a variety of forces in common situation.

Chapter 7, Page 132

#10 REDUCING FRICTION

Investigate how friction may be reduced.

Chapter 7, Page 133

#11 INVESTIGATING LEVERS

Determine if various classes of levers are force multipliers or distance multipliers.

Chapter 8, Page 154

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# AMAZING SCIENCE 01

What  
to wear  
in the lab?

\*5\*  
RULES

WHAT DO  
SCIENTISTS DO?

What questions do  
scientists ask?

## SCIENCE IS AMAZING!



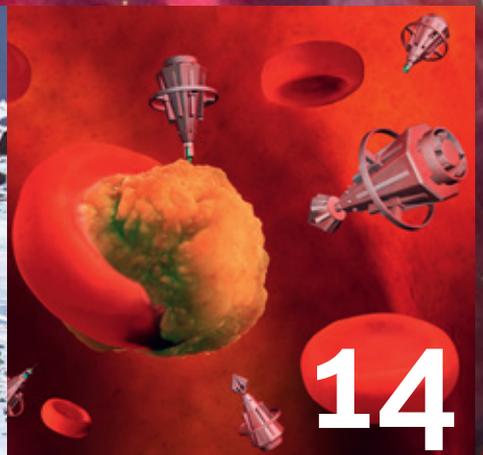
8

CURIOUS QUESTIONS



10

FIELDS OF SCIENCE



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HUMAN ENDEAVOUR

# SCIENCE IS AMAZING



**Science is the study of the physical and the natural world. It is vital to almost everything we do.**

A key part of science is asking questions about the world and using curiosity to find answers through observation and experimentation. It is human nature to be curious – many of the greatest discoveries and inventions in human history have been inspired purely by curiosity. Here are some of the amazing topics you will learn about in Science this year.

## CLASSIFYING LIFE

Chimpanzees are the closest relatives to humans. Both humans and chimpanzees are classified as primates. They have many physical features in common, including an opposable thumb. Scientists believe chimpanzees and humans share a common ancestor.

21

## ECOSYSTEMS

Chimpanzees live in a forest ecosystem where living things and non-living things in the environment work together as a system to support life. If any part of the ecosystem is changed, it has an impact on the other parts.

41

## MIXTURES

Most of the substances we use every day are mixtures. Air is a mixture because it is made up of oxygen, nitrogen, carbon dioxide and other gases. Fog is a mixture of water vapour and air. It is called a colloid.

61

## EARTH IN SPACE

The Sun is the centre of our solar system and is vital to life on the Earth. Without solar energy (heat and light), the Earth would be frozen and unable to support life.

83

## RESOURCES

This chimpanzee's rainforest home is in danger. Humans use the timber from the forests, and clear rainforests to build farms or mine the Earth beneath. The habitats of chimpanzees are quickly disappearing and chimpanzees are now an endangered species.

103

## FORCES

The force of gravity is pulling this chimpanzee towards the centre of the Earth. On Earth, gravity keeps the air, animals and us from drifting into space.

125

## MACHINES

147

Human and animal bodies work like machines, with levers to help us do work such as lifting and jumping more easily.

### CHECK IT OUT

- 1 What do scientists study?
- 2 How do scientists study the world?
- 3 How are chimpanzees like humans? How do scientists believe they are connected?
- 4 How is a chimpanzee's body like a machine?
- 5 Why is it important that scientists study and measure ecosystems?

# CURIOUS

# QUESTIONS

Questions are one of the most important tools available to scientists. They help scientists make decisions, solve problems, and invent things to change and improve our lives.

A 'big' question is a question that scientists ask when they are really curious about a more complex topic, such as 'How did the universe begin?'. Different kinds of scientists ask different big questions.

## ASTRONOMER

INVESTIGATES: Planets, stars and the universe



How did the universe begin?

## NANOTECHNOLOGIST

INVESTIGATES: Substances at the atomic (very small) scale



Can we design drugs to target individual cells?

## ENVIRONMENTAL SCIENTIST

INVESTIGATES: The environment



How is climate change affecting the Earth?

## MARINE BIOLOGIST

INVESTIGATES: Life in the oceans and seas



How can we catch fish without harming other animals?

## GENETICIST

INVESTIGATES: Features that are passed from parents to offspring



How can we predict genetic disorders?

## PHARMACOLOGIST

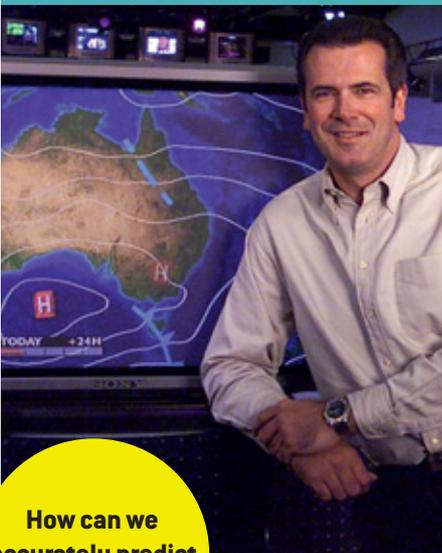
INVESTIGATES: Medicines and drugs



What is the best way to treat different types of cancer?

## METEOROLOGIST

INVESTIGATES: The atmosphere and weather patterns



How can we accurately predict cyclones?

## PALAEONTOLOGIST

INVESTIGATES: Prehistoric life



Why did dinosaurs die out?

# Meet some amazing Australian scientists



PHYSICIST  
Dr Niraj Lal  
(Page 12)



ENTOMOLOGIST  
Dr Aaron Stewart  
(Page 33)



ENVIRONMENTAL SCIENTIST  
Ms Jenny Powell  
(Page 67)



GEOLOGIST  
Dr Jo Whittaker  
(Page 109)

## CHECK IT OUT

- 1 Why are questions important in science?
- 2 Look carefully at the question that the meteorologist is studying. What might be the benefit of research into this question?
- 3 Which scientist might the pharmacologist work with to help test possible answers to her question?
- 4 Select a further two scientists who might work together at times to help answer a big question.

# FIELDS OF SCIENCE

All sorts of people are scientists: men, women, young people and old people. Scientists specialise in different fields of science such as biology, physics, Earth sciences and chemistry. Although some science takes place in the laboratory, a lot of it happens in other places – for example, in Antarctica, in space, near volcanoes and under the sea. Scientists can work alone or in teams, using their curiosity to ask questions. They answer questions by observing, recording and interpreting what they find.



*An entomologist picking through a group of three-week-old silkworms feeding on a bed of leaves.*



*A zoologist observing a colony of emperor penguins in Antarctica.*

## Biology

Biologists study living things. There are many different branches of biology. A zoologist studies animals and a botanist studies plants. An entomologist studies insects while a microbiologist studies small living things that can only be viewed under a microscope.

Scientists work on many unique projects in Antarctica, including the study of penguins, climate change, astronomy, volcanoes and ultraviolet radiation. Scientists in Antarctica also study themselves, researching how the human body adapts to cold and how humans react to extreme isolation.



## Chemistry

Chemists are scientists who are trained in the study of chemistry. Chemists study how substances form and what happens when they are mixed. Biochemists study the chemistry of living organisms.



Chemists use observations and models of the microscopic world to explain the composition and properties of matter.

### CHECK IT OUT

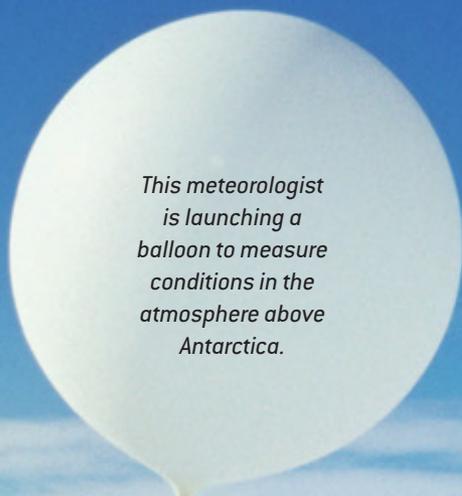
- 1 List some different places that scientists work.
- 2 What do scientists in Antarctica study?
- 3 Look at the photograph of the zoologist.
  - a How is the zoologist studying wildlife in Antarctica?
  - b In which field of science do zoologists work?
- 4 How is the microbiologist studying life in the geothermal field? Suggest how he might analyse what he has collected.
- 5 What do chemists study?



A microbiologist taking samples from a geothermal field.

## Physics

Physicists study movement and different forms of energy. Geophysicists investigate Earth's reaction to forces such as magnetic and gravitational fields. Astrophysicists deal with the physics of the universe. Meteorologists study weather and the atmosphere.



*This meteorologist is launching a balloon to measure conditions in the atmosphere above Antarctica.*

## Ask a scientist

Dr Niraj Lal



*Niraj studied physics at the Australian National University.*

A physicist is a scientist who studies energy and forces in the physical world. Physicists research how the universe works and look for practical ways to apply this knowledge across different areas of science and technology.

Dr Niraj Lal is a physicist working at the Australian National University in Canberra.

‘At school, I was interested in physics and maths at a fundamental level, but also wanted to do something useful,’ he explains. ‘I have always been keen on social and environmental issues.’

Niraj is currently doing research on solar-cell technology. The very first solar panels were only 2 per cent efficient. That is, for every 100 watts of sunlight that hit each panel, it generated only 2 watts of electricity.

Today, rooftop solar panels are close to 25 per cent efficient.

‘We’re trying to make light last longer in solar cells – trying to increase, even double, the efficiency of the cells,’ says Niraj.

‘The sky’s the limit!’



*A palaeontologist standing beside a sauropod skeleton.*



*A volcanologist shielding herself from the heat as she collects a sample of hot lava during a volcanic eruption.*



*A geophysicist is a type of geologist. This geophysicist is collecting data at different ocean depths in Antarctica.*

## Earth science

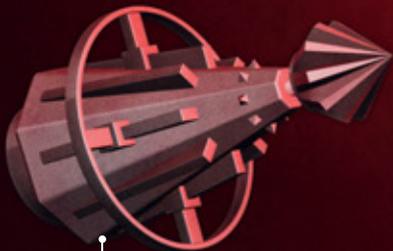
Earth scientists study the planet Earth. Geologists study the Earth and how it changes. A volcanologist studies volcanoes and a palaeontologist studies fossils.

### CHECK IT OUT

- 1 What does a physicist study?
- 2 Name two different types of physicists and explain what each one studies.
- 3 What kind of scientist studies volcanoes?
- 4 Why do you think scientists collect data as part of their research?
- 5 What does a meteorologist study?

# SCIENCE IS A HUMAN ENDEAVOUR

Through science, humans endeavour to improve their understanding of the world. Great scientific discoveries over time have come from the contributions of many different people. Science knowledge is continually added to as new evidence becomes available. Knowledge can also develop through connecting ideas across the different fields of science.



**NANOTECHNOLOGY** involves the use of tiny particles that measure between 1 and 100 nanometres. A nanometre is one billionth of a metre. Nanorobotics is an emerging field of science in which microscopic 'nanorobots' could travel through the blood system, targeting individual cells in the body to deliver drugs or undertake surgery.

**BLOOD CLOTS** — Nanorobots could remove blood clots that block arteries and cause heart attacks.

**THROUGH THE BODY** — Nanorobots would be small enough to travel through veins, arteries and capillaries.

#### ATTACK ROBOTS

Tiny blades could slice through tumours, destroying cancerous cells but leaving healthy cells untouched.

#### ENTRY

Nanorobots, the size of bacteria, could be injected into the patient.

*An agronomist checking the results of his experiment in a wheat field.*



Science understanding leads to changes in industry and agriculture, and in the way we work and live. It also contributes to finding solutions to social issues, such as obesity or disease, and ethical questions such as poverty or management of the Earth's resources.

#### VOLUME

Mass production would enable up to 100 billion nanorobots to be injected at a time to treat diseases.

#### CHECK IT OUT

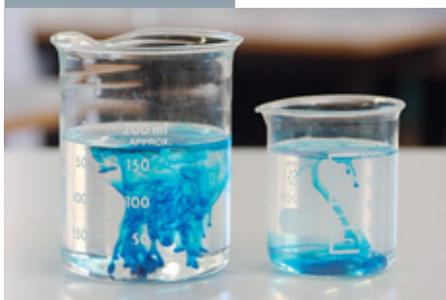
- 1 What do humans hope to achieve through the study of science?
- 2 How does scientific knowledge change over time?
- 3 How is scientific knowledge used in society?
- 4 What are nanorobots and how might they change the way we learn about the human body?
- 5 How else might nanorobots be used to increase scientific understanding?

# EXPERIMENTS IN THE LAB



You will have the opportunity to play the role of a scientist in the school science laboratory. You will soon get to know a whole range of equipment such as beakers, Bunsen burners, test tubes, stands and other items used in the laboratory. The equipment helps us to carry out experiments safely. Some pieces of equipment can be used together in an experiment. Equipment placed together for an experiment is called apparatus.

» Beaker



» Watch glass



» Conical flask



» Spatula



» Test tube



» Stirring rod



» Gauze mat



» Evaporating dish



» Metal tongs



» Filter funnel



» Thermometer



» Test tube holder



» Test tube rack



» Tripod stand



» Retort stand with boss head and clamp



» Measuring cylinder

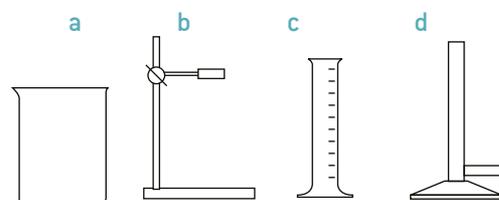


» Bunsen burner



### CHECK IT OUT

1 Identify the equipment shown in the scientific drawings below. Use the photographs on this page to help you.



- Give three examples of equipment used to hold objects.
- Give three different examples of stands used in experiments.
- What apparatus might you need for heating a solution?

01  
19 10

A worksheet is available on your obook / \_assess that will teach you how to use a Bunsen burner safely.

# SAFETY IN THE LAB

Good laboratories have special equipment and features that make them safe places to work. A science laboratory is not like a normal classroom – there are additional rules to follow. You will be using some chemicals that can be dangerous if not handled carefully. Doing experiments in science can be exciting, but you must follow the rules to ensure your safety and the safety of others.

## What to wear in the lab: 5 rules

It may not be the height of fashion, but clothing in the science laboratory is designed to keep you safe.

- 1 » **Long hair** should be tied back during experiments.
- 2 » **Safety glasses** protect your eyes from liquids or gases used or produced during experiments.
- 3 » The knee-length **lab coat** is worn buttoned up to protect your clothes.
- 4 » For some experiments, you will need to wear disposable **latex gloves** to protect your hands.
- 5 » Wear **solid shoes** to completely cover your feet.



*These students are modelling the correct safety clothing for working in a school science laboratory.*

### ✓ Do:

- ✓ Wear a lab coat for practical work.
- ✓ Keep your workbooks and paper away from heating equipment, chemicals and flames.
- ✓ Tie long hair back whenever you use a Bunsen burner.
- ✓ Wear safety glasses while mixing or heating substances.
- ✓ Tell your teacher immediately if you cut or burn yourself.
- ✓ Tell your teacher immediately if you break any glassware or spill chemicals.
- ✓ Wash your hands after any experiments.
- ✓ Listen to and follow the teacher's instructions.
- ✓ Light Bunsen burners with matches, never with paper or other materials.
- ✓ Wear gloves when your teacher instructs you to.

### ✗ Don't:

- ✗ Run in a laboratory.
- ✗ Push others or behave roughly in a laboratory.
- ✗ Eat in a laboratory.
- ✗ Drink from glassware or laboratory taps.
- ✗ Look down into a container or point it at a neighbour when heating or mixing chemicals.
- ✗ Smell gases or mixtures of chemicals directly. Instead, waft them near your nose, and only when instructed.
- ✗ Mix chemicals at random.
- ✗ Put matches, paper or other substances down the sink.
- ✗ Carry large bottles by the neck.
- ✗ Enter a preparation room without your teacher's permission.



These students are showing what **not** to do in the science laboratory.

### CHECK IT OUT

- 1 Why is it sensible to tie back long hair when working in a school science laboratory?
- 2 What purpose do a lab coat, solid shoes, safety glasses and gloves have?
- 3 Look carefully at the photograph of students in the lab (left) and list five things that you should never do in a science laboratory.
- 4 What safety tips should you follow when using a Bunsen burner?
- 5 What must you tell your teacher about if an accident happens?

## KEY IDEAS

1

Science is the study of the physical and the natural world.



6

Science understanding leads to changes in industry and agriculture, and in the way we work and live.



7

Science contributes to finding solutions to social issues such as obesity and disease.



8

Science contributes to finding solutions to problems such as poverty, or questions such as how to manage the Earth's resources.



2

Many of the greatest discoveries and inventions in our history have been inspired purely by human curiosity.



3

Scientists answer questions by observing, recording and interpreting what they see.



9

Questions help scientists make decisions, solve problems, invent things, and change and improve our lives.



4

Great scientific discoveries over time have come from the contributions of many different people.



10

Equipment placed together for an experiment is called apparatus.



5

Scientific knowledge can be developed through connecting ideas across the different fields of science.



11

When doing experiments in a science laboratory, you must follow the safety rules for your safety and the safety of others.

# CLASSIFYING LIFE 02

WHY DO THINGS NEED TO BE CLASSIFIED?

TOP  
\*5\*  
amazing plants

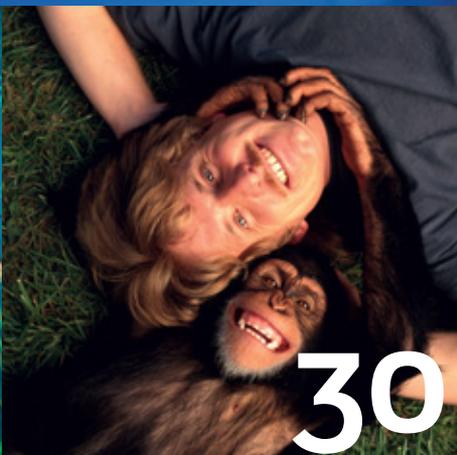
What do animals have in common?

## DOLPHINS: FISH OR MAMMALS?



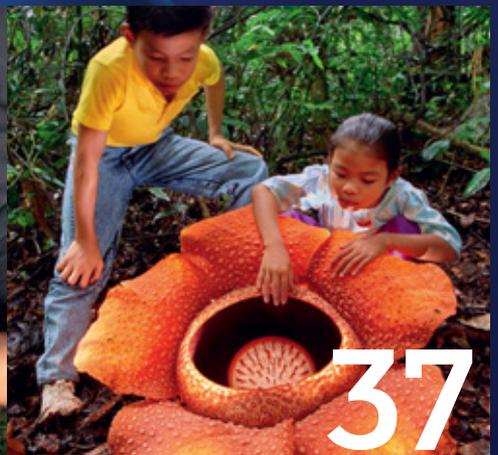
29

EGG-LAYING MAMMALS



30

ARE WE RELATED?



37

STINKY FLOWERS



The giant blue whale belongs to kingdom Animalia. It can grow up to 33 metres long!

# CLASSIFYING LIFE ON EARTH

Whales are often called giants of the deep, but apart from their size, how are they actually different from dolphins or even the tiniest cells? Scientists have asked these questions over many generations and tried to group living things with similar features. Scientists call this 'classifying'. Most animals grow over time so classifying them by size doesn't work. So, how do we classify life on Earth?

## Earth's five kingdoms of life

Scientists once only divided living things into plants and animals. Now, most scientists agree on classifying living things into five large **kingdoms** based on:

- » the features of their cells (small structures that make up every living thing on Earth)
- » how they eat
- » how they look.

### Kingdom Animalia (animals)

Animals get their nutrients (substances essential for life) from other living things – they are **heterotrophs**. All organisms (living things) in this kingdom are multicellular, which means they have more than one cell in their body. These cells come together to form tissues, organs and organ systems that help sustain the life of the animal. Scientists who study animals are called zoologists. Humans belong in this kingdom.

### Kingdom Plantae (plants)

Plants are **autotrophs** – they make their own food from sunlight. They have more than one cell (multicellular). Different types of plants include trees, grasses, flowers and some types of algae. Scientists who study plants are called botanists.

### Kingdom Fungi (fungus)

For many years it was believed that fungi were plants. We now know that fungi are different from plants in some very important ways. Unlike plants, fungi cannot make their own food. Instead, they feed on dead animals and plants. Fungi can have more than one cell (multicellular) or can have just one cell (unicellular). The kingdom Fungi includes mushrooms (including those you might find on a pizza), yeasts (used in bread), toadstools, and moulds. Some fungi grow in wood and in soil, and develop from tiny spores.

### Kingdom Protista

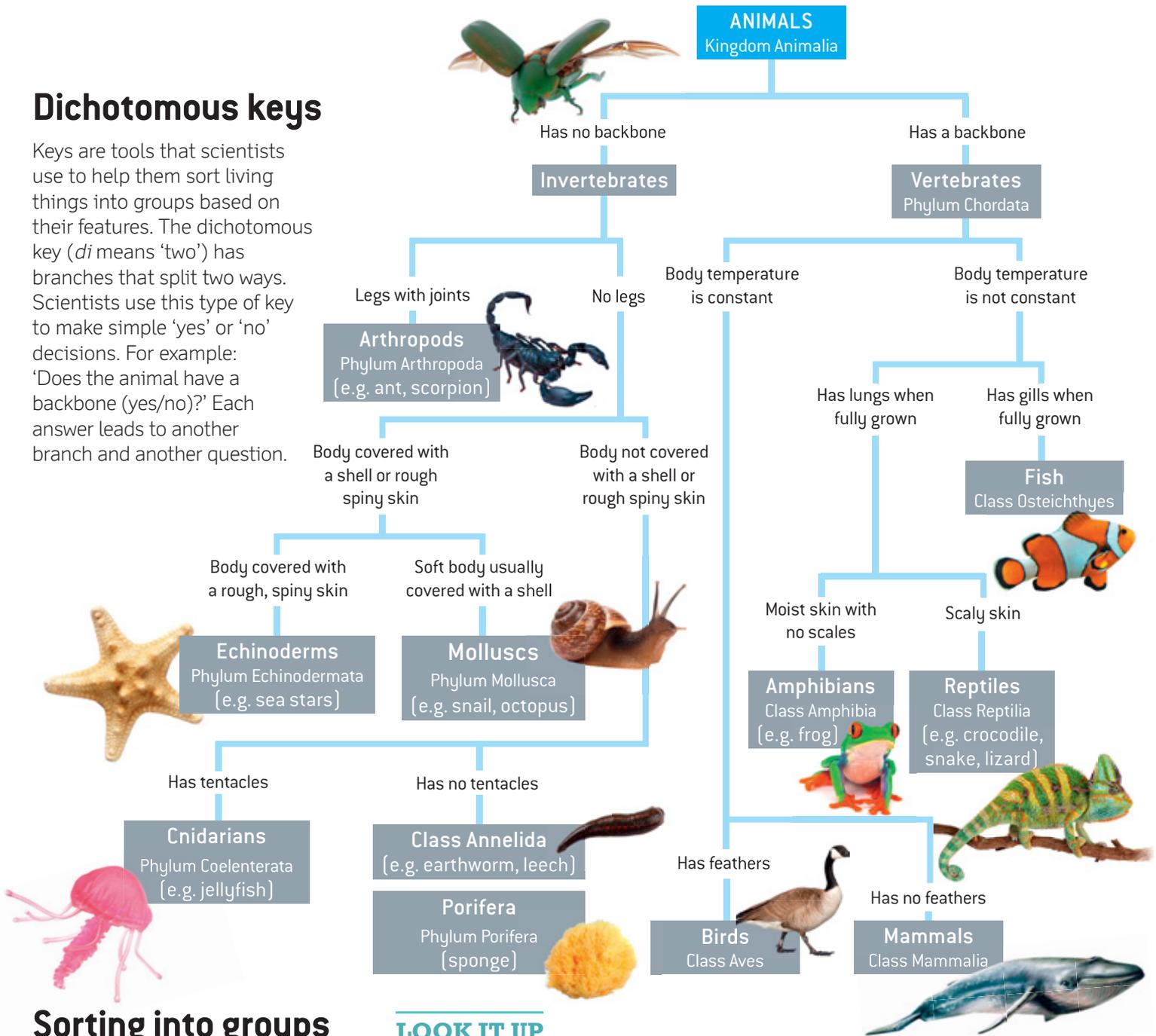
Most Protista are unicellular, and the multicellular ones (seaweed) exist like a colony of single cells so they can function on their own. Protista include algae and protozoans (animal-like single-cell organisms)

### Kingdom Monera (one cell)

This kingdom is made up of bacteria, the simplest and smallest living things. They are all unicellular (they have one cell) and are missing many of the parts of the cell commonly found in larger organisms. For this reason, scientists believe they were one of the first life forms on Earth and that all other organisms eventually evolved from them. Monera can only be seen under a microscope. Microbiologists study microorganisms (*micro* means 'small') in the kingdoms Monera and Protista.

## Dichotomous keys

Keys are tools that scientists use to help them sort living things into groups based on their features. The dichotomous key (*di* means 'two') has branches that split two ways. Scientists use this type of key to make simple 'yes' or 'no' decisions. For example: 'Does the animal have a backbone (yes/no)?' Each answer leads to another branch and another question.



## Sorting into groups

The Swedish scientist Carl Linnaeus (1707–1778) developed a system for classifying all living things. It starts with large groups called kingdoms, which are divided into smaller groups called phyla, which are divided into classes. The classes then divide into orders, and so on. There are seven different levels to get to the smallest grouping, called species. A species is a group of living organisms that are able to interbreed and produce fertile offspring.

### LOOK IT UP

**autotroph** an organism that makes its own food, such as a plant

**heterotroph** an organism that relies on other living things for food, such as an animal

**kingdom** the highest rank into which scientists classify living things; the most commonly used system of classification recognises five kingdoms: Animalia, Plantae, Fungi, Monera, Protista

### CHECK IT OUT

- 1 How do scientists separate living things into kingdoms?
- 2 What is an autotroph? Which kingdom is made up entirely of autotrophs?

- 3 To which kingdom do bacteria belong?
- 4 Look carefully at the dichotomous key.
  - a Kingdom Animalia is broken down into a number of phyla. To which phylum do snails belong?
  - b Each phylum contains a number of classes. What do animals in class Amphibia and class Reptilia have in common?
- 5 To which kingdom, phylum and class does the blue whale belong?
- 6 How is a blue whale different from a fish?

# WHAT'S IN A NAME?

Did you pat your *Felis catus* (cat) this morning? How about your *Canis lupus familiaris* (dog)? These are the kinds of names given to every living thing using Carl Linnaeus's classification system.

## Scientific names

In 1753, the Swedish scientist Carl Linnaeus created a way of naming organisms that is still used today. He changed the longer names given to organisms down to names with two parts. This name uses words from the Latin language. The first part of the name is the **genus** and the second part is the **species**. For example, humans belong to the genus *Homo* (Latin for 'man') and within this genus they belong to the species *Homo sapiens* (Latin for 'wise man').

### *Canis lupus*

The name *Canis* means 'dog' in Latin. Animals in this genus have large canine teeth, used for killing their prey. Wolves, dogs and dingoes all belong to the species *Canis lupus*. *Lupus* is Latin for 'wolf'. The dingo (*Canis lupus dingo*) from Australia and the domestic dog (*Canis lupus familiaris*) are subspecies of *Canis lupus*, but are not thought of as wolves.

*Canis lupus* is the scientific name for the wolf.

*Canis lupus familiaris* is the scientific name for the domestic dog.



## *Felis catus*

The name *Felis catus* means 'cat' in Latin. The animals in this genus are small cats with flexible bodies and a long tail. They are hunters with long claws and strong jaw muscles. Members of the genus are found worldwide and include the jungle cat (*Felis chaus*), the Chinese mountain cat (*Felis bieti*) and the domestic cat (*Felis catus*). Larger wild cats such as lions, tigers and leopards also belong to the cat family, Felidae.



*Felis catus* is the scientific name for the domestic cat. There are more than 500 million domestic cats in the world.

## The Linnaean classification system

The Linnaean classification system has seven different levels. It is used to give scientific names to living things such as the domestic cat. The first part of the scientific name always starts with a capital letter: this is the genus. The next words in the name do not have capital letters. This is the species name. The whole name is usually written in italics. For example, *Felis catus* (domestic cat).

**KINGDOM: ANIMALIA**

e.g. insect, fish, bird, lizard, kangaroo, fox, tiger, jungle cat, domestic cat

**PHYLUM: CHORDATA**

e.g. fish, bird, lizard, kangaroo, fox, tiger, jungle cat, domestic cat

**CLASS: MAMMALIA**

e.g. kangaroo, fox, tiger, jungle cat, domestic cat

**ORDER: CARNIVORA**

e.g. fox, tiger, jungle cat, domestic cat

**FAMILY: FELIDAE**

e.g. tiger, jungle cat, domestic cat

**GENUS: FELIS**

e.g. jungle cat, domestic cat

**SPECIES: FELIS CATUS**

e.g. domestic cat

The classification, from kingdom through to species, for the domestic cat. An easy way of remembering this classification is to use the first letters of the phrase, 'King Phillip Came Over For Good Soup'.

## LOOK IT UP

**genus** a subdivision of family in the classification of living things

**species** a group of similar organisms capable of breeding, such as *Homo sapiens*

## CHECK IT OUT

- 1 What might be some of the characteristics that domestic cats and tigers have in common?
- 2 *Panthera tigris* is the scientific name for which member of the family Felidae?
- 3 *Familiaris* is a Latin word for 'household'. Which animal shown here is it used to describe? Why?
- 4 Why do you think that Carl Linnaeus chose to name organisms by their genus and species rather than by their kingdom and phylum?
- 5 Why do you think it is helpful to have a scientific name for living things?

### Tiger (*Panthera tigris*)

**Common name:** Tiger

**Class:** Mammalia

**Order:** Carnivora

**Family:** Felidae

**Genus:** *Panthera*

**Species:** *Panthera tigris*

*Tigers and domestic cats belong to the same family (Felidae) and share many similar characteristics. The tiger (*Panthera tigris*) belongs to the genus *Panthera*, along with the lion, jaguar and leopard.*



# INSIDE VERTEBRATES

## 2 Amphibian (class Amphibia) characteristics

- » live on land and in water
- » moist skin
- » webbed feet
- » lay eggs
- » cold-blooded (blood temperature is not constant)

Mammals, reptiles, amphibians, birds and fish all have something in common – they all have a backbone that gives them structure and shape and helps them to move. All animals with a spine or backbone are known as **vertebrates**. Less than 10 per cent of all species on Earth are vertebrates. All other animals have no backbone. They are known as **invertebrates**.

## Five living classes of vertebrates

### 1 Mammal (class Mammalia) characteristics

- » mothers nurse their young with milk
- » give birth to live young
- » most have hair or fur
- » warm-blooded (blood temperature is constant)

#### Red-eyed tree frog (*Litoria chloris*)

**Class:** Amphibia

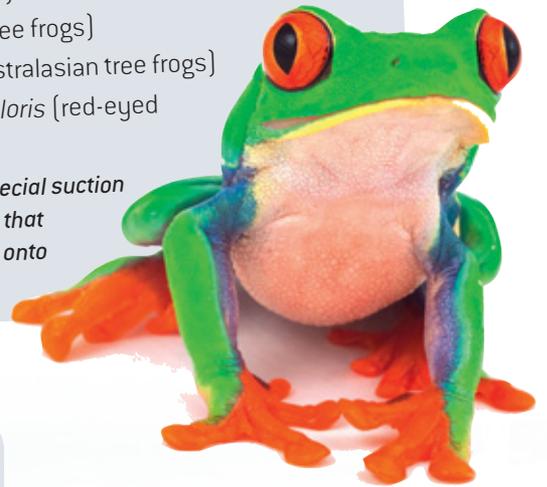
**Order:** Anura (frogs)

**Family:** Hylidae (tree frogs)

**Genus:** *Litoria* (Australasian tree frogs)

**Species:** *Litoria chloris* (red-eyed tree frog)

*Tree frogs have special suction pads on their toes that allow them to grip onto trees more easily.*



#### Common bottlenose dolphin (*Tursiops truncatus*)

**Class:** Mammalia

**Order:** Cetacea (large sea mammals)

**Family:** Delphinidae (ocean-living dolphins)

**Genus:** *Tursiops* (bottlenose dolphins)

**Species:** *Tursiops truncatus* (common bottlenose dolphin)

*Common bottlenose dolphins live in groups called pods. A pod usually contains up to 25 dolphins, but the group size can vary from a pair of dolphins to over 100 and occasionally as many as 1000.*



# 3 Fish (class Pisces) characteristics

- » scales and fins
- » breathe underwater using gills
- » lay eggs
- » cold-blooded (blood temperature is not constant)



Orange Clownfish  
(*Amphiprion ocellaris*)

**Class:** Pisces  
**Order:** Perciformes (bony, ray-finned fish)  
**Family:** Pomacentridae (damselfish and clownfish)  
**Genus:** *Amphiprion* (clownfish)  
**Species:** *Amphiprion ocellaris* (orange clownfish)

Blue and yellow macaw  
(*Ara ararauna*)

**Class:** Aves  
**Order:** Psittaciformes (parrots)  
**Family:** Psittacidae (true parrots)  
**Genus:** *Ara* (macaws)  
**Species:** *Ara ararauna* (blue and yellow macaw)



# 5 Bird (class Aves) characteristics

- » feathers and wings
- » lay eggs
- » warm-blooded (blood temperature is constant)

## LOOK IT UP

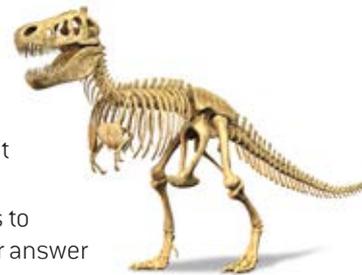
**invertebrate** an animal with no spine or backbone

**vertebrate** an animal with a spine or backbone

## CHECK IT OUT

1 Look carefully at the image of the skeleton of the *Tyrannosaurus rex* dinosaur.

- Was it a vertebrate?
- Suggest which class it belonged to.
- Give reasons to support your answer to 1b.



- Why is a backbone useful?
- Which is the only class of vertebrates that does not lay eggs? How do they reproduce?
- How do you think cold-blooded animals maintain their body temperature?

# 4 Reptile (class Reptilia) characteristics

- » scales
- » dry skin
- » lay eggs
- » cold-blooded (blood temperature is not constant)



Frill-necked lizard  
(*Chlamydosaurus kingii*)

**Class:** Reptilia  
**Order:** Squamata (scaled reptiles)  
**Family:** Agamidae (dragon lizards)  
**Genus:** *Chlamydosaurus* (frill-necked lizards)  
**Species:** *Chlamydosaurus kingii* (frill-necked lizard)

*Frill-necked lizards fan out their frills to frighten attackers.*

# MAGNIFICENT MAMMALS

Mammals are vertebrates that feed their babies milk. They usually have hair or fur. Their body temperature stays around the same level, whether the animal is a polar bear living in low temperatures or a kangaroo living in high temperatures. But this class gets its name from its **mammary glands**, which produce milk. It is usually the females that produce the milk to feed their young, but all mammals have mammary glands – even you!



*A koala joey peeking out of its mother's pouch.*

## Class Mammalia

Mammals are in the class Mammalia. Mammals can be divided into three groups: placental mammals, marsupials and monotremes. The main feature used to group mammals is where and how their young develop and grow. However, no matter the type of mammal, they all feed their young milk.

### 1 Placental mammals

**Placental mammals**, such as humans, give birth to babies that are well developed and are able to suckle milk from their mother. A placenta is a structure in the uterus that provides the developing baby with oxygen and nutrients from the mother's bloodstream.

- » Young develop inside mother's womb
- » Young are well developed when born
- » Mothers produce milk from mammary glands



*Tasmanian devil pups drinking milk from their mother.*



The brain in mammals keeps the body at an even temperature.

Most mammals are four-legged and live on land, but some have adapted for life in the air, in trees, at sea or on two legs.

Mammals usually have hair or fur.

Except for monotremes, all mammals give birth to live young.

All female mammals feed their young from mammary glands.

## 2 Marsupials

Marsupials, such as kangaroos, develop and grow inside their mother's pouch rather than in the womb.

- » Young are born very small and helpless
- » Further growth occurs in a pouch
- » Young receive milk from a mammary gland located in the pouch

## 3 Monotremes

Monotremes, such as platypuses, lay eggs. Once the young have hatched, they are able to suck milk from patches on their mother's stomach.

- » Young begin to grow in eggs
- » Young hatch and need to be sheltered in either a shallow pouch or burrow
- » Young suckle from milk patches on their mother's stomach

*A platypus hatching from an egg.*



## How are the platypus and the echidna related?

The echidna is a land animal covered in coarse hair and spines. It has a long snout that it uses to sense ants and termites, and a sticky tongue inside the snout for eating them. Echidnas have short, strong limbs with large claws for tearing open logs and anthills.

Platypuses live in water. They are covered in thick fur and have webbed feet to move through the water using their back feet and tails to brake and steer. The platypus has a snout like a duck's bill, with sensors to help it find prey such as insects, shellfish and worms.

So how can a spiky land animal and a duck-billed water animal be related? The answer is that monotremes are the only egg-laying mammals. The female lays a single leathery egg directly into her pouch. The young echidna or platypus hatches after 10 days. It sucks milk from two milk patches on its mother's stomach. The young monotremes stay in the pouch for 45 to 55 days.



*The echidna and the platypus are members of the order Monotremata. They are the only egg-laying marsupials.*



*A baby echidna is called a puggle.*

### LOOK IT UP

**mammary gland** the milk-producing gland of a woman or other female mammal

**placental mammals** mammals that possess a placenta to nourish a foetus (unborn baby)

### CHECK IT OUT

- 1 Name some of the main characteristics of mammals.
- 2 Look carefully at the photograph of the world's largest land mammal opposite.
  - a What is the baby doing?
  - b What type of mammal is it?
- 3 Describe how the birth and growth of a baby echidna is different from that of an elephant.
- 4 Bats can fly through the air like a bird but feed their young from mammary glands and are covered in fur. Which class do bats belong to – Aves or Mammalia? Explain your answer.



*Elephants are placental mammals.*

# ARE WE RELATED?

Chimpanzees are our closest living relatives. They share over 98 per cent of human **DNA**. Humans and chimpanzees are thought to share a common relative that lived between four and eight million years ago (mya). There are five key differences between humans and chimpanzees.

## 1

### Chimpanzees have opposable toes

Humans and chimpanzees have **opposable thumbs**. That is, thumbs that allow them to grab objects. Chimpanzees also have opposable big toes, allowing them to grab objects with their feet. The ability to grab and grip with both hands and feet allows chimpanzees to swing through trees, pick fruit and use tools.

## 2

### Chimpanzees are stronger than humans

Chimpanzees are stronger than we are – probably about twice as strong. Chimpanzees need to be stronger because they need to be able to climb trees.

*Chimpanzees communicate in ways similar to humans – by kissing, patting on the back, touching hands, laughing and tickling.*

## 3

### Chimpanzees can't swim

A chimpanzee's small legs and body makes it difficult for them to swim. Humans have more fat than muscle compared to chimpanzees, making it easier for us to float in water.

## 4

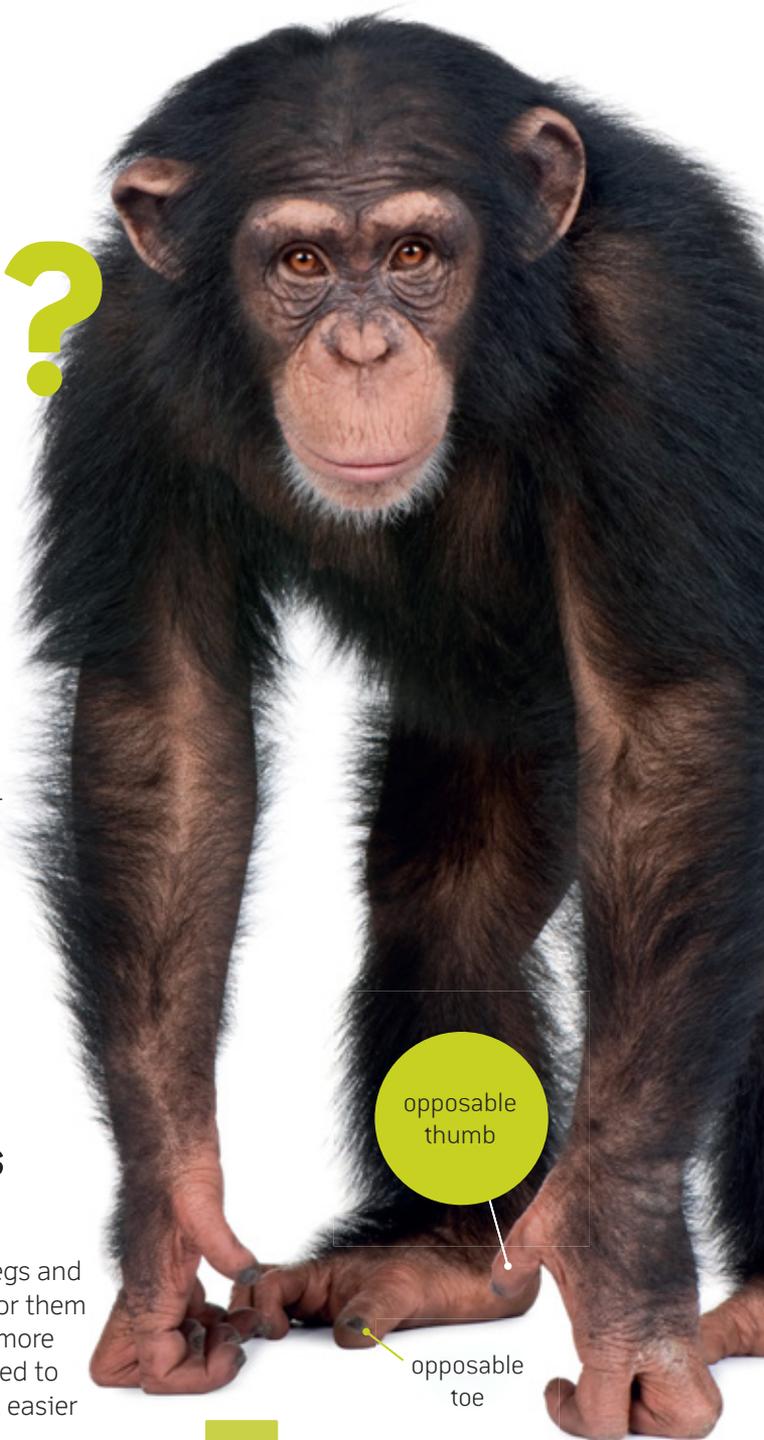
### Chimpanzees walk on their knuckles

Chimpanzees can walk upright on two legs, but they tend to walk crouched with their arms and legs on the ground. Chimpanzees walk on their knuckles and save their fingers for climbing.

## 5

### Chimpanzees have smaller brains

Both humans and chimpanzees have brains that are large compared to the rest of their body. The human brain is three times larger than the chimpanzee's brain. Human brains have more connections between their parts, allowing for complex thinking.



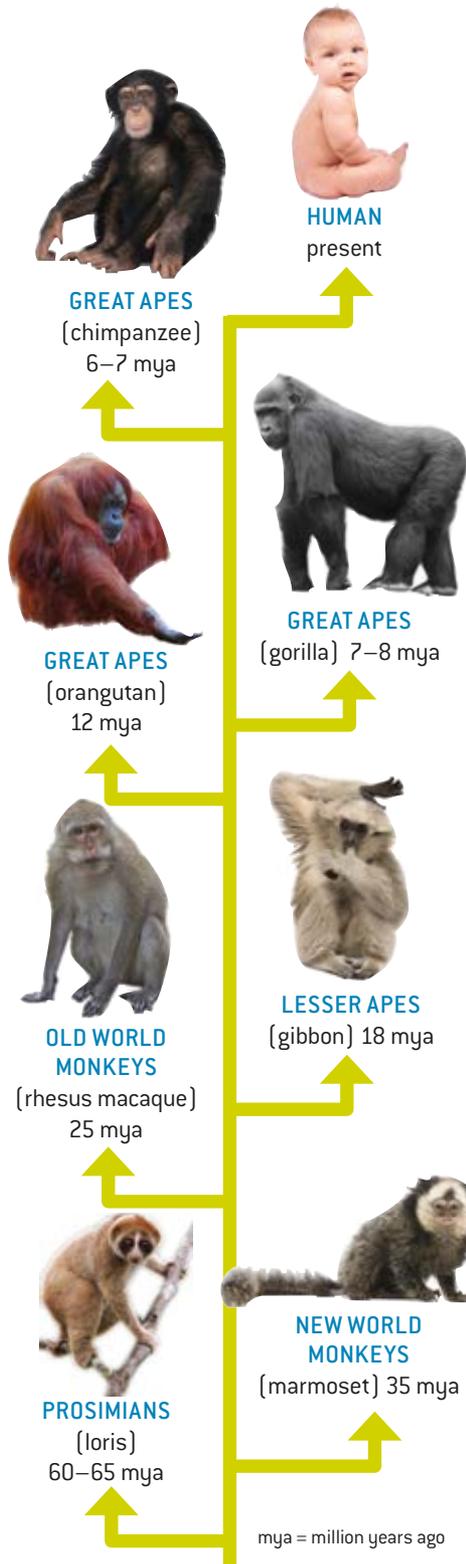


The human skull (left) is about three times the size of the chimpanzee's skull (right) because our brains are that much greater in size.

## Classification of humans and chimpanzees

Both humans and chimpanzees are mammals and they belong to the order known as **Primates**.

There are hundreds of species of primates, including humans, gorillas, chimpanzees and monkeys. The primates have many features in common and scientists believe they had a common relative. Mammals of this order are some of the smartest animals on Earth.



### EVOLUTION OF CHIMPANZEES AND HUMANS

#### Scientific classification of humans and chimpanzees

**Kingdom:** Animalia  
**Phylum:** Chordata  
**Class:** Mammalia  
**Order:** Primates  
**Family:** Hominidae

**Genus:** *Homo* (humans);  
*Pan* (chimpanzees)  
**Species:**  
*Homo sapiens* (human);  
*Pan troglodytes* (chimpanzee);  
*Pan paniscus* (bonobo)



Humans and chimpanzees are both members of the highly intelligent family of primates known as Hominidae. This woman is teaching this chimpanzee sign language so that it can communicate with her.



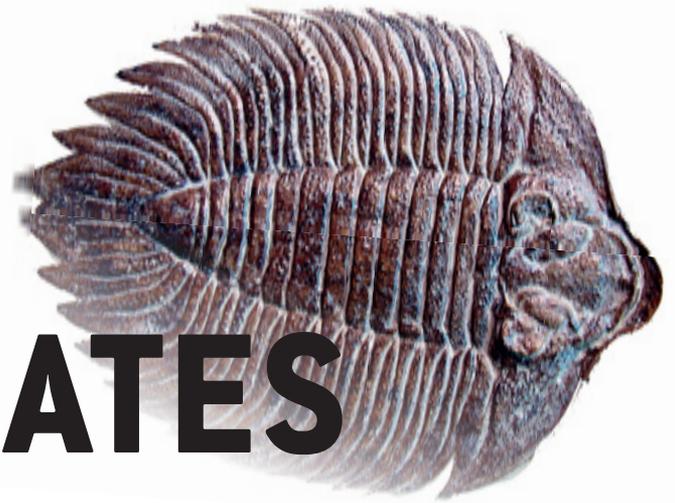
#### LOOK IT UP

**DNA** deoxyribonucleic acid; the carrier of genetic information  
**opposable thumb** a thumb that is capable of facing and touching the other digits on the same hand to enable the holding of objects  
**primate** a mammal of an order that includes monkeys, apes and humans; distinguished by having hands, hand-like feet and forward-facing eyes

#### CHECK IT OUT

- 1 How are humans and chimpanzees similar?
- 2 In what ways are chimpanzees and humans classified in the same way? Are they in the same kingdom, phylum, class, order, family or genus? Explain.
- 3 What are some key differences between chimpanzees and humans?
- 4 Make a sketch of a chimpanzee's foot and a human foot. Add labels to show the differences.
- 5 Look at the evolution diagram. Chimpanzees are our closest relatives. Which two other apes are we closely related to?

# INSIDE INVERTEBRATES



*Exoskeletons first appeared in the fossil record about 550 million years ago.*

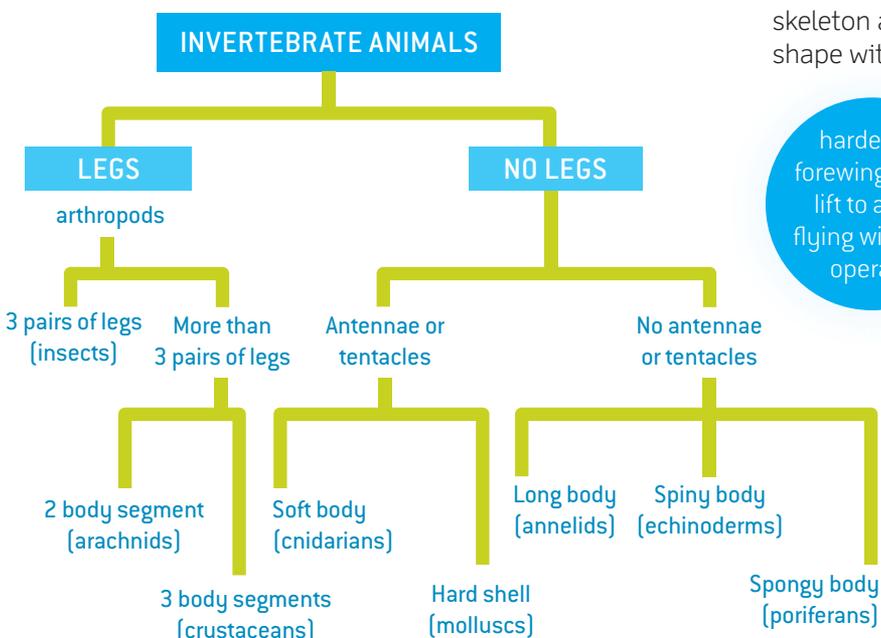
Invertebrates have either an external skeleton (**exoskeleton**) or no skeleton at all. More than 90 per cent of all animals are invertebrates. The 14-metre colossal squid, huge though it is, has no backbone. As well as enormous animals like this, thousands of tiny insects and sea creatures belong to the invertebrates group.

## Identifying invertebrates

In the same way that vertebrates are classified, invertebrates are also grouped by their characteristics. Characteristics used to classify invertebrates include:

- » the presence of a shell or exoskeleton
- » the number of legs
- » antennae or tentacles
- » spiny covering.

Organisms with similar features are placed in the same group. The dichotomous key below can be used to classify invertebrates.

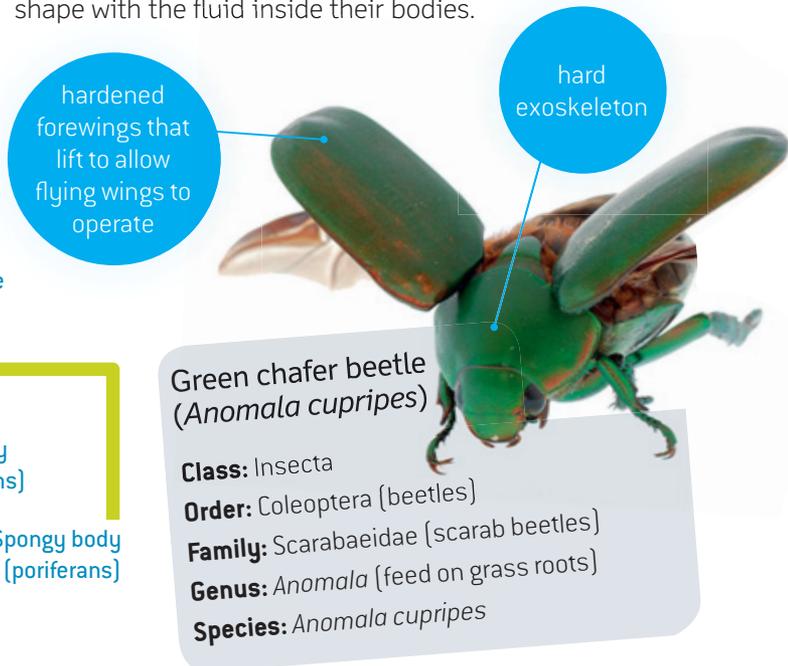


## Amazing exoskeletons

Many insects have exoskeletons around their bodies to support and protect them. The muscles of invertebrates are connected to the exoskeleton. Invertebrate exoskeletons may be hard like those of lobsters and crabs, or thin like those of flies and ants. The shells of molluscs such as snails and oysters are also considered exoskeletons. **Arthropods** are those invertebrate animals that have legs. Some arthropods shed an exoskeleton when it has been outgrown and a new exoskeleton is formed underneath the old one.

## No skeleton at all

Invertebrates such as worms and jellyfish have no skeleton at all. These creatures hold and change their shape with the fluid inside their bodies.



## THE SIX MAIN PHyla OF INVERTEBRATES



### 1 Arthropods

- » segmented body (body divided into parts)
- » paired and jointed legs
- » exoskeleton

**Examples:** insect, spider, scorpion, centipede

### 2 Poriferans

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

**Examples:** breadcrumb sponge, glass sponge



### 3 Molluscs

- » soft body
- » usually have a protective shell

**Examples:** snail, octopus, oyster, mussel, slug

### 4 Cnidarians

- » soft, hollow body
- » live in water
- » tentacles

**Examples:** coral, jellyfish, anemone



### 5 Nematodes, platyhelminths and annelids

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

**Examples:** leech, tapeworm, flatworm

### 6 Echinoderms

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

**Examples:** sea urchin, sea star



## Ask a scientist

Dr Aaron Stewart



*Aaron collecting insects from an ant mound, which could reveal whether there is gold underground*

An entomologist is a scientist who researches insects. Dr Aaron Stewart is an entomologist who has studied ants and termites.

Aaron's research has shown that termites and ants can find hidden treasure. Termite mounds contain lots of gold particles. This is evidence of more gold underground, covered by sand and dirt. Aaron says insects could help explore for valuable minerals in Australia in a cheap and environmentally friendly way.

Termites are essential for ecosystems and even human food production. 'Think of all the birds and animals that would have no nests without termites', Aaron says. 'Wood would sit on the ground without being recycled, without nutrients released for new plants to use!'

Aaron's advice to students is to feed your curiosity. 'It is never not cool to be curious', he says. 'Science is not about knowing something; it is about working out what you do not know!'



A video interview with Dr Aaron Stewart is available on your [obook](#) / [assess](#).

- 5 Design your own insect with an exoskeleton. Include its characteristics and how it would be classified.

### LOOK IT UP

**arthropod** an invertebrate with legs and an exoskeleton, such as an insect, spider or crustacean

**exoskeleton** a rigid external covering for the body in some invertebrates

### CHECK IT OUT

- 1 What characteristic do scientists use to classify animals as invertebrates?
- 2 Which characteristics do scientists use to further classify invertebrates? Use the dichotomous key to help you.
- 3 What does an exoskeleton do?
- 4 A new invertebrate was found to have three pairs of legs. Suggest which group it best fits into.

# EXAMINING SKELETONS

**AIM:** TO EXAMINE THE SKELETAL STRUCTURES OF THREE MARINE ORGANISMS

**MATERIALS**

- 1 fish (whole)
- 1 prawn
- 1 squid
- Newspaper
- Dissecting board
- Dissecting kit
- Vinyl or latex gloves

**SAFETY**

- Always wear gloves when handling the animals.
- The animals must always be on the dissection board when you are handling and dissecting them.
- Scalpels are extremely sharp. Use with great care.
- If you cut yourself, tell your teacher, and seek first aid.



**METHOD**



1 Observe the external features of the fish.



2 Carefully cut the fish in half lengthways so you can see the internal skeleton.

3 Observe the skeleton of the fish.

*Wear proper protective clothing [see page 18].*



- 4 Feel the outside of the prawn and then peel it.
- 5 Cut the prawn in half and observe how the skeleton covers the soft body of the prawn.



- 6 Feel the outside of the squid and then cut it in half.
- 7 Observe the inside of the squid. Can you locate a skeleton?

## RESULTS

Draw labelled diagrams of each specimen's skeleton.

## DISCUSSION

- 1 Consider the fish.
  - a Where is the skeleton of the fish located?
  - b What is this type of skeleton called?
- 2 Consider the prawn.
  - a Where is the skeleton of the prawn located?
  - b What is this type of skeleton called?
- 3 Does the squid have a skeleton? Suggest how it might hold its shape.
- 4 In which group of animals (vertebrate or invertebrate) would you place each of the organisms you observed? Why?
- 5 What are you – a vertebrate or an invertebrate?

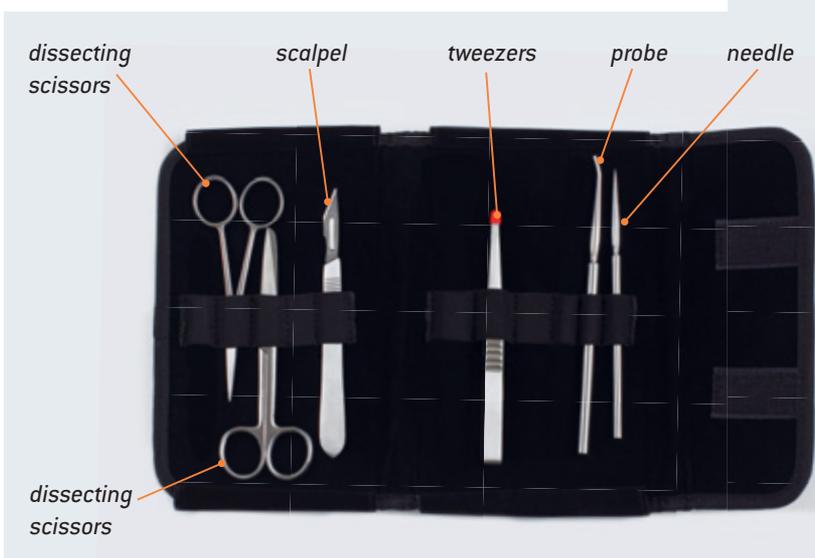
## CONCLUSION

What types of skeletons are possible?

## SCIENTIFIC EQUIPMENT DISSECTION KIT

A dissection kit has all the tools you will need for dissecting organisms in the school laboratory. Some of the key tools you will use are:

- » **probe** – to hold back sections to allow you to examine features
- » **scalpel** – a very sharp tool for cutting open the specimen
- » **dissecting scissors** – very sharp, thin scissors for accurate cutting
- » **forceps** – for clasping objects and holding them back to allow observation
- » **needle** – for piecing objects
- » **ruler** – for measuring features of the specimen



# TOP 5 AMAZING PLANTS

Plants are multicellular (have more than one cell) and belong to the kingdom Plantae. Green plants are able to change sunlight into energy. This is called **photosynthesis**. New plants are discovered each year, but there are around 300 000 different species of plants on Earth, including some of the most amazing living things on Earth.

## Classifying plants

Plants can be classified based on how they look, how they transport **nutrients** (food, vitamins and minerals) or how they reproduce (create more plants). Plants can also be classified based on whether or not they have tissues for transporting water and nutrients around the plant.

- » **Vascular** plants, such as ferns, conifers and flowering plants have tubes called xylem that carry water and minerals up from the roots. Phloem tubes carry food from the leaves to the rest of the plant.
- » Non-vascular plants, such as liverworts and mosses, do not have xylem and phloem and so must absorb their water and nutrients through the surface of their leaves.

More than 90 per cent of plants reproduce using seeds. A seed contains a **plant embryo** and some stored food inside a protective outer covering. To create a seed, a plant's flower must first be **pollinated**.

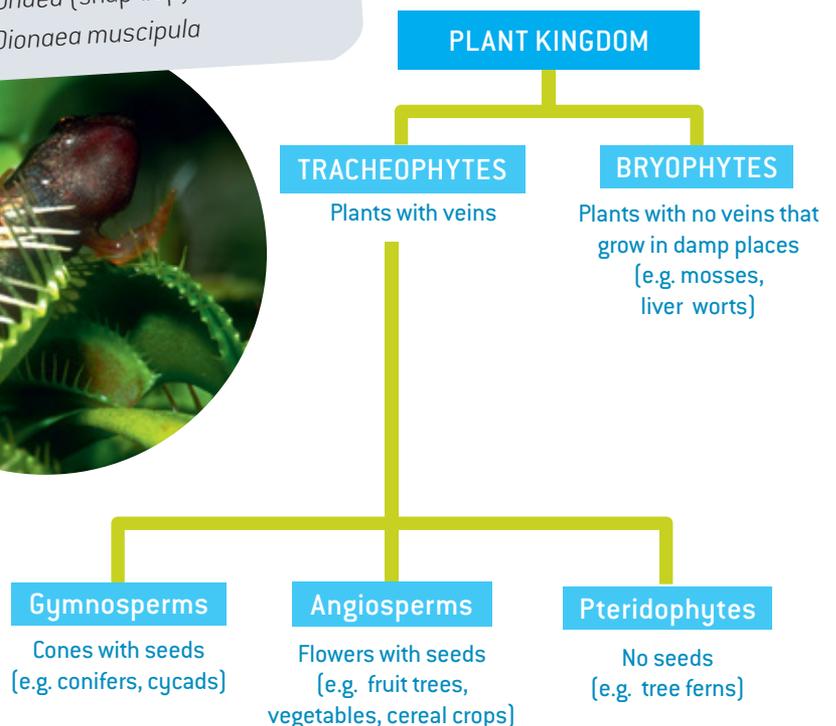
Venus flytrap  
(*Dionaea muscipula*)

**Kingdom:** Plantae (plants)  
**Phylum:** Anthophyta (flowering)  
**Class:** Eudicotyledons (pollen)  
**Order:** Caryophyllales (fleshy)  
**Family:** Droseraceae (sticky sap)  
**Genus:** *Dionaea* (snap trap)  
**Species:** *Dionaea muscipula*



## 1 What plant can eat frogs?

The leaves of the carnivorous (meat-eating) Venus flytrap plants ooze a sweet nectar that draws in insects and other small animals searching for food. When an animal crawls on the trap, it touches trigger hairs that make the leaves snap together to catch the prey within half a second!





## 5 What plant can grow on a car?

Moss has very shallow roots, just enough to hold on to the surface it lives on. It absorbs most of its nutrients, not through its roots, but through its small leaves.

## 2 What is the biggest plant in the world?

The General Sherman tree is a giant sequoia (*Sequoiadendron giganteum*) growing in California, USA. It is one of the largest known living things on the planet. This tree is 83.8 metres tall, with a diameter of 11.1 metres at its base. It is 2300–2700 years old, which also makes it one of the oldest living things on Earth.

Giant sequoia  
(*Sequoiadendron giganteum*)

**Kingdom:** Plantae (plants)

**Phylum:** Tracheophytes (vascular)

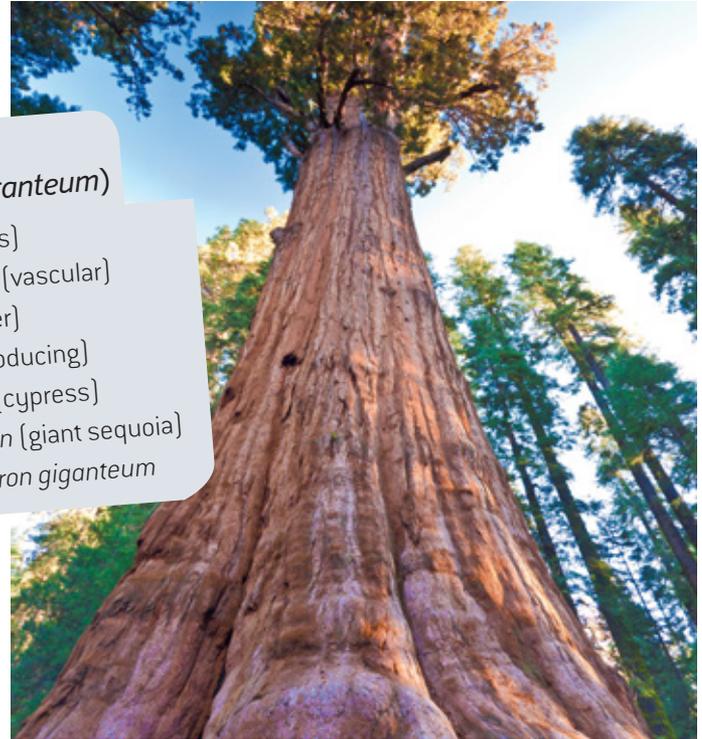
**Class:** Pinopsida (conifer)

**Order:** Pinales (cone producing)

**Family:** Cupressaceae (cypress)

**Genus:** *Sequoiadendron* (giant sequoia)

**Species:** *Sequoiadendron giganteum*



## What is the oldest plant grown from seed?

# 3

In 2012 scientists grew this white-flowering silene from the seeds of fruit frozen for 30 000 years.



# 4

## What is the largest flower?

The stinking corpse lily measures almost 1 metre in diameter and weighs 11 kilograms. It stinks like rotting flesh to attract flies, which pollinate the plant.

### LOOK IT UP

**nutrient** a substance that provides nourishment essential for maintenance of life and for growth

**plant embryo** the part of a seed that contains cells (for the leaves, stem and roots) that will develop into a plant

**photosynthesis** the process in which the energy of the Sun is used to convert carbon dioxide and water into oxygen and sugars

**pollinate** to deposit pollen on a plant to allow fertilisation

**vascular** plant tissues (xylem and phloem) that conduct water, sap and nutrients in flowering plants, ferns, and their relatives

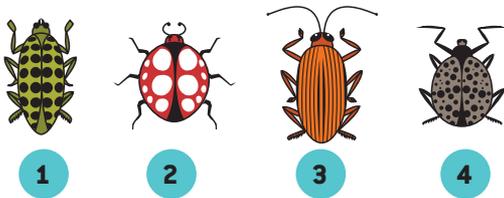
### CHECK IT OUT

- 1 What do all plants have in common?
- 2 Look carefully at the dichotomous key opposite.
  - a What do pteridophytes, gymnosperms and angiosperms have in common?
  - b How are they different?
  - c In which part of the key would each of the top five amazing plants be found?
- 3 How far does the xylem on the General Sherman tree need to go?
- 4 Choose either the Venus flytrap or the stinking corpse lily and, in your own words, describe how animals help them survive.

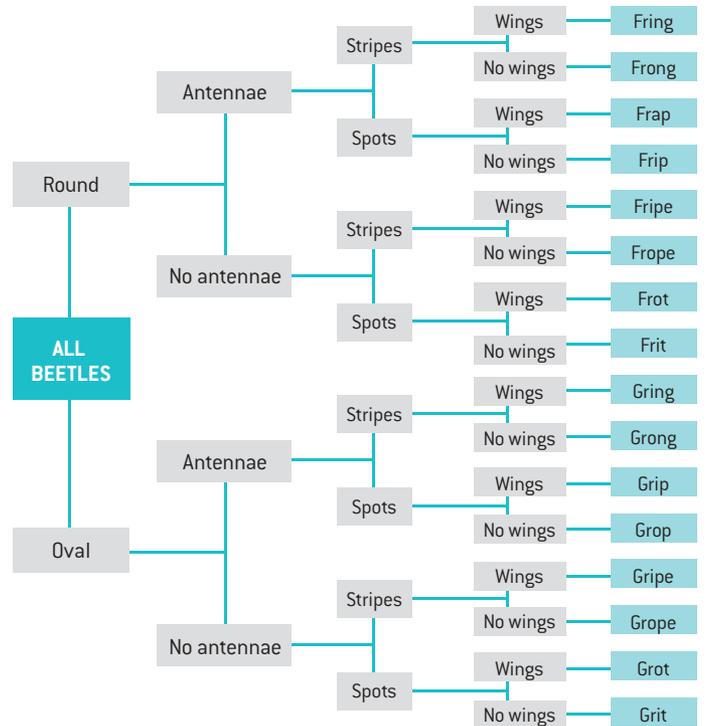
# CLASSIFYING LIFE

## CLASSIFYING LIFE ON EARTH (PAGES 22–23)

- 1 Arrange these terms in order from the level that contains the most number of organisms to the level that contains the least number of organisms: family, kingdom, species, class, phylum, genus, order.
- 2 Explain what a dichotomous key is.
- 3 Use the dichotomous key and the diagrams of four imaginary beetles below to:
  - a identify and name the beetles numbered 1 to 4.



- a draw a simple sketch of the following:
  - >> frope beetle
  - >> gring beetle
  - >> gripe beetle
  - >> frong beetle



## WHAT'S IN A NAME? (PAGES 24–25)

- 4 Apply the information in the table to match the scientific names of these five Australian animals with their common names: koala, frill-necked lizard, platypus, echidna, red kangaroo.
  - a *Macropus rufus*
  - b *Tachyglossus aculeatus*
  - c *Phascolarctos cinereus*
  - d *Ornithorhynchus anatinus*
  - e *Chlamydosaurus kingii*



### Some scientific words and their meanings

| LATIN/GREEK ROOT WORD | ENGLISH MEANING |
|-----------------------|-----------------|
| <i>Aculeat</i>        | Spiny           |
| <i>Anatinus</i>       | Duck-like       |
| <i>Arctus</i>         | Bear            |
| <i>Chlamy</i>         | Caped           |
| <i>Cinereus</i>       | Grey            |
| <i>Gloss</i>          | Tongue          |
| <i>Macro</i>          | Large           |
| <i>Ornitho</i>        | Bird            |
| <i>Phascol</i>        | Pouch           |
| <i>Pus</i>            | Foot            |
| <i>Rhynchus</i>       | Snout           |
| <i>Rufus</i>          | Red             |
| <i>Saurus</i>         | Lizard          |
| <i>Tachy</i>          | Fast            |

- 5 What do you think a *Macroglossus aculeatus* might look like? Sketch this imaginary animal, using the table above to help.

## INSIDE VERTEBRATES (PAGES 26–27)

- 6 Explain the difference between vertebrates and invertebrates.
- 7 Classify the animals shown opposite as vertebrates or invertebrates.

## MAGNIFICENT MAMMALS (PAGES 28–29)

- 8 Which of the living things shown opposite is a mammal? Explain your answer.
- 9 Describe the difference between placental mammals and marsupials, and give an example of each.
- 10 a Are the platypus and the echidna mammals?  
b Do you think they should be classified as mammals? Explain your answer.

## ARE WE RELATED? (PAGES 30–31)

- 11 What is an opposable thumb and why is it important to humans and chimpanzees?
- 12 What do chimpanzees, gorillas, humans and orangutans have in common?
- 13 What are some of the differences between chimpanzees and humans? Which do you think is the biggest difference?
- 14 The dugong (pictured below right) is the closest living relative of the elephant. Suggest some possible similarities.

## INSIDE INVERTEBRATES (PAGES 32–33)

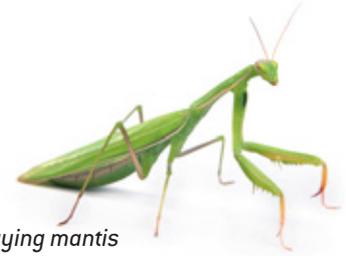
- 15 Name two animals that have an exoskeleton.
- 16 If an animal has no skeleton, what are some of the problems it may have?
- 17 What type of invertebrates are arthropods? Give four examples of arthropods.

## TOP 5 AMAZING PLANTS (PAGES 36–37)

- 18 What do all plants have in common?
- 19 How does pollination occur and why is it important? Explain your answer.
- 20 Identify the plant shown below.
- 21 How do you think this plant reproduces? Explain your answer.



*lizard*



*praying mantis*



*stingray*



*sea sponge*



*earthworm*



*sea anemone*

*bumble bee*



*lobster*



*sea star*



*snail*



*redback spider*



*galah*



*cow*



## KEY IDEAS

1

Life on Earth is classified by scientists into five kingdoms: Animalia (animals), Plantae (plants), Fungi, Protista (algae), Monera (bacteria).



2

Classification of living things is based on cell structure, what the organisms look like and how they absorb nutrients.



3

Different keys are used to help sort organisms into groups. The dichotomous key divides animals into two groups by making simple 'yes' or 'no' decisions. Each answer leads to another group and another 'yes' or 'no' decision.



4

Swedish scientist Carl Linnaeus designed a two-part naming system using Greek and Latin words. The first part identifies the genus and the second part identifies the species, e.g. *Homo sapiens* (human beings).



5

Animals are sorted into vertebrates (with a backbone) and invertebrates (no backbone).



6

Vertebrates are sorted into five classes – mammals, amphibians, fish, reptiles and birds.



7

Mammals have mammary glands to feed their young with milk. Placental mammals are well developed at birth, whereas marsupials develop in a pouch. Monotremes hatch from eggs and the young are fed milk from patches on the mother's abdomen.



8

Humans and chimpanzees come from the family Hominidae – the great apes. They share over 98 per cent of the same DNA.



9

Invertebrates make up over 90 per cent of all animals. They are classified into those with legs (e.g. insects, spiders, lobsters) and those without legs (e.g. snails, worms, starfish). The majority of invertebrates are insects.



10

Plants are generally classified according to how they transport nutrients (vascular plants transport through conducting tissues), or how they reproduce.



# ECOSYSTEMS 03

WHY is the flow of energy important in an ecosystem?

HOW has human activity changed the surface of the land?

## WHO EATS WHO IN A FOOD CHAIN?

\* 5 \*  
WAYS  
to protect  
ECOSYSTEMS  
\*



47

CARNIVORES



50

FRAGILE FOOD WEBS



52

CLINGING TO LIFE

# ECOSYSTEMS

An **ecosystem** is the short name for an 'ecological system'. An ecosystem includes all of the living things in a specific area and their interactions with the environment around them. Each living thing in an ecosystem is linked to the others, meaning all living things depend on each other for survival.

## The biosphere – home to all ecosystems

When we need to talk about the ecosystem of the entire planet, we use the word **biosphere**. The term 'biosphere' refers to our living world and includes all living creatures such as plants, animals, fungi, bacteria and complex celled organisms. The biosphere stretches to the upper layers of the atmosphere, where bacteria and tiny organisms can be found. It stretches down deep into the ground, into dark caves and to the bottom of the ocean. The biosphere includes any place on Earth where life of any kind can exist.

The biosphere includes the interaction of the water (hydrosphere), the land (lithosphere) and the gases in the atmosphere, such as nitrogen and oxygen. The water, land and air interact to influence our weather. The land interacts with the energy coming to the Earth from the Sun. All of these interact together to create our living world.

A **biome** is a large natural community of plants and animals that are adapted to particular conditions. Deserts, grasslands, shrublands, forests, tundras and

ice caps are examples of different biomes. Organisms living in the same type of biome have similar features. The plants and animals living in Australia's deserts have similar features to living things in deserts in other parts of the world. This is because they have adapted in similar ways to life in dry areas with very high temperatures.

## WORLD BIOMES

**Deserts** occur in areas with less than 250 millimetres of rainfall per year. Deserts are some of the hottest and coldest areas in the world.

**Grasslands** are big, open grassy areas with very few trees. There are many different names for grasslands around the world.

**Shrublands** are generally found in areas of higher rainfall than grasslands, where more trees and shrubs are able to grow.

**Forests** are areas covered by trees. There are many different kinds of forests found throughout the world.



A coral reef ecosystem is a community of living organisms. It is made up of populations of many different sea creatures such as corals, fish, crabs, sea worms and sea turtles. The biotic factors in a coral reef ecosystem rely on abiotic factors such as sunlight and warm sea temperatures.

## Ecosystems and habitats

Ecosystems vary in size, from as small as the smallest puddle to as large as the Earth itself. Animals such as mammals, birds, reptiles, worms and bacteria are some of the **biotic** (living) things in an ecosystem. Ecosystems also include **abiotic** (non-living) things such as water, soil and air, and factors such as temperature and light. In an ecosystem, biotic things such as animals and abiotic things such as water are always interacting. Likewise, living things interact with each other and non-living things interact with each other.

**Habitats** are found within ecosystems. 'Habitat' is the term for where a group of organisms (plants or animals) live. Habitats can be larger or smaller depending on the amount of food, water and shelter they provide. Sand dunes, spinifex grass and rocky areas are all examples of habitats in a desert biome.

The habitat must supply all the needs of the population of organisms, such as food, water, temperature, oxygen and minerals. If, for example, there is not enough food or water, the population's needs are not met and organisms will move to a better habitat or die out.

### LOOK IT UP

**abiotic** the non-living things in an ecosystem, such as water

**biome** a large natural community of plants and animals adapted to particular conditions

**biosphere** all the plants and animals, from the upper areas of the atmosphere to deep underground or in the ocean

**biotic** the living things in an ecosystem, such as plants and animals

**ecosystem** a community of living and non-living things that depend on one another for survival

**habitat** a place where a population of organisms lives

### CHECK IT OUT

- 1 Explain the terms biosphere, atmosphere, hydrosphere and lithosphere.
- 2 What conditions might animals in an ice cap biome need to be adapted for?
- 3 What are the terms for living and non-living things found in an ecosystem?
- 4 What does a habitat supply for its population?
- 5 Name three events that may threaten the survival of a population.

**Tundras** are very cold, treeless areas of the Arctic, Antarctic and alpine regions. Here, the ground is always frozen.

**Ice caps** are permanently covered with ice and snow. They can be found at the North and South poles.



# AT HOME IN THE DESERT

Life in a desert biome is difficult. Desert plants and animals experience hot days and cold nights, and shortages of water and food. Over time, native plants and animals have adapted to life in the harsh desert environment.

Princess parrots feed mainly on native seeds. These nomadic birds follow the rain and flowering cycles through the desert. They nest in the hollows of desert trees.

The perentie lizard shelters in underground burrows. It is a very efficient digger and can burrow a shelter in minutes with its powerful legs.

The fat-tailed dunnart can store fat in its carrot-shaped tail – a clever adaptation to ensure a source of energy.

Paper daisies germinate, grow, flower, produce seeds and then die within a very short time period. They are called 'ephemerals'.

The mulga has upward-facing leaves and branches that channel rain to the base of the trunk. Its roots grow deep into the soil searching for underground water.

Red kangaroos concentrate their urine to minimise water loss and can tolerate severe dehydration. During the hottest part of the day they rest in the shade, grazing at dusk and dawn.

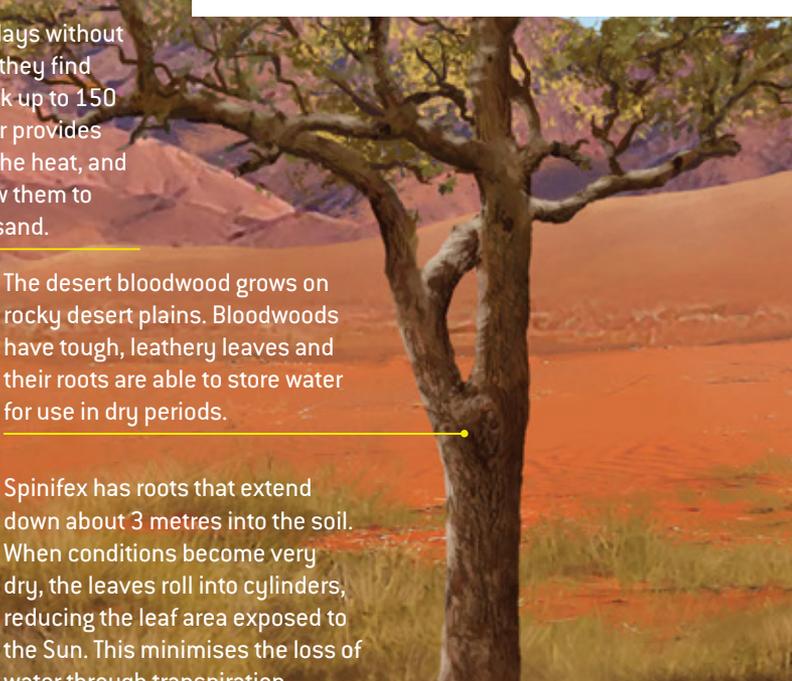
The marsupial mole spends most of its life in burrows up to 2.5 metres below the surface. They have backwards-facing pouches so that they do not fill with sand.



The carnivorous wedge-tailed eagle uses currents of hot air created by the desert heat to rise up to 2000 metres. Wedge-tailed eagles can hunt in groups and have been known in rare cases to kill large animals such as kangaroos.



Camels can go for days without drinking, but when they find water they can drink up to 150 litres! Their thick fur provides insulation against the heat, and their wide feet allow them to walk easily on the sand.



The desert bloodwood grows on rocky desert plains. Bloodwoods have tough, leathery leaves and their roots are able to store water for use in dry periods.



Spinifex has roots that extend down about 3 metres into the soil. When conditions become very dry, the leaves roll into cylinders, reducing the leaf area exposed to the Sun. This minimises the loss of water through transpiration.



The thorny devil's orange, yellow and black skin creates a great camouflage in the desert. Early in the morning, they brush against dewy grass and collect moisture on their bodies. This moisture runs between their spikes, directly into their mouths!



Wombats live in burrows in sandy desert plains and can grow to 3 metres in length. They feed on lizards, birds and small marsupials.



Bilbies shelter in burrows where the temperature is up to 10 degrees cooler than on the surface. Their large ears provide them with excellent hearing, as well as helping to keep them cool.



Spencer's burrowing frogs shelter in burrows to avoid drying out. When it rains, they surface to feed and reproduce. They absorb water, storing it between their muscles and their skin, giving them a round shape.



Narrow-banded sand swimmers have pointy snouts that help them 'swim' through the sand below the surface, where temperatures are cooler.

## CHECK IT OUT

- 1 What conditions do desert animals face?
- 2 Give three examples of animals that shelter from sunlight.
- 3 Give three plant adaptations to desert life.
- 4 Give three animal adaptations to desert life.
- 5 Design your own desert animal and label its adaptations to life in the desert.

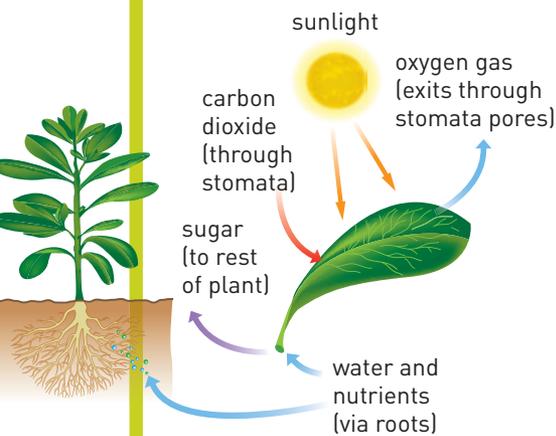
# ENERGY FOR LIFE

Everything organisms do in ecosystems – growing, running, breathing, burrowing – requires energy. The flow of **energy** is the most important factor influencing how an ecosystem works. The Sun is the source of virtually all energy on Earth, but where do organisms get their energy and how does it move within an ecosystem?

## Producers

Life exists on Earth because **photosynthesis** makes it possible to capture some of the light energy from the Sun and transform it into food. Plants, green algae and a number of microorganisms make a type of sugar known as glucose through photosynthesis.

Organisms that produce their own food are known as **producers** or autotrophs. In plants, sunlight provides the energy to convert carbon dioxide and water into glucose.



## Consumers (herbivores)

**Consumers** or heterotrophs cannot make their own food, so these organisms eat other organisms to get their energy. All animals and fungi, and many bacteria, are heterotrophs.

Animals that eat only plants are known as herbivores. In an ecosystem they are also referred to as the primary consumer. The zebra is a herbivorous animal. All of the zebra's diet comes from the different grasses, leaves, buds and other plant matter it consumes. Much of the grass has little nutritional value, so zebras spend up to 80 per cent of their day grazing.

### CONSUMER – HERBIVORE



Zebras and giraffes are herbivores. They are primary consumers in the savannah grassland ecosystem.

### PRODUCER



Savannah grassland ecosystems provide food and open areas for grazing animals.

## LOOK IT UP

**consumer** an organism, such as an animal, that obtains energy by eating other organisms; a heterotroph

**decomposer** an organism, such as a maggot, that feeds on dead organisms

**energy** a resource that allows organisms to survive

**photosynthesis** the process in which the energy of the Sun is used to convert carbon dioxide and water into oxygen and sugars

**producer** an organism that produces its own food, such as a plant; an autotroph

## CHECK IT OUT

- 1 Where do the following organisms get their energy?  
a plants                      b herbivores                      c carnivores
- 2 How do plants make their own energy?
- 3 How are herbivores and carnivores the same? How are they different?
- 4 What role do decomposers play in an ecosystem? In what way are they similar to scavengers?
- 5 Draw a diagram to show how producers, consumers and decomposers interact with one another.

## Consumers (carnivores)

Animals that only eat other animals are known as carnivores. Lions are carnivores, and they get their energy and nutrients from a diet consisting exclusively of animal meat. In the savannah grassland ecosystem, lions are predators that hunt prey such as zebras. In this case, the lion is a secondary consumer (an animal that eats a primary consumer). Some carnivores, such as hyenas and vultures, scavenge dead animals or the remains of prey left over from other predators.

An omnivore derives its energy and nutrients from a diet including a variety of food sources that may include plants, animals, algae, fungi and bacteria. Humans are omnivorous, and so are most bears, wolves, orangutans, rats, chickens, pigs, worms, piranhas, possums and rats.

### CONSUMER – CARNIVORE



Lions are carnivores that prey on primary consumers such as zebras in the savannah grassland ecosystem.



Vultures are scavengers that feed on the remains of dead animals.

## Decomposers

Some living organisms, called **decomposers**, get the food they need by feeding on dead things. Decomposers recycle dead organisms by making the nutrients in the organisms available to living plants and animals. Decomposers are usually bacteria, fungi or invertebrates such as slugs and worms. The fly larvae (maggots) crawl over the flesh of a dead animal. In a matter of days, these decomposers can reduce the dead carcass to almost nothing.

The nutrients that pass through the decomposers as waste end up in the soil in simpler forms that plants can take up by absorption through their roots.

### DECOMPOSER



The carcass of this dead zebra has been reduced to almost nothing by decomposers such as fly larvae.

# FOOD CHAINS: WHO EATS WHO?

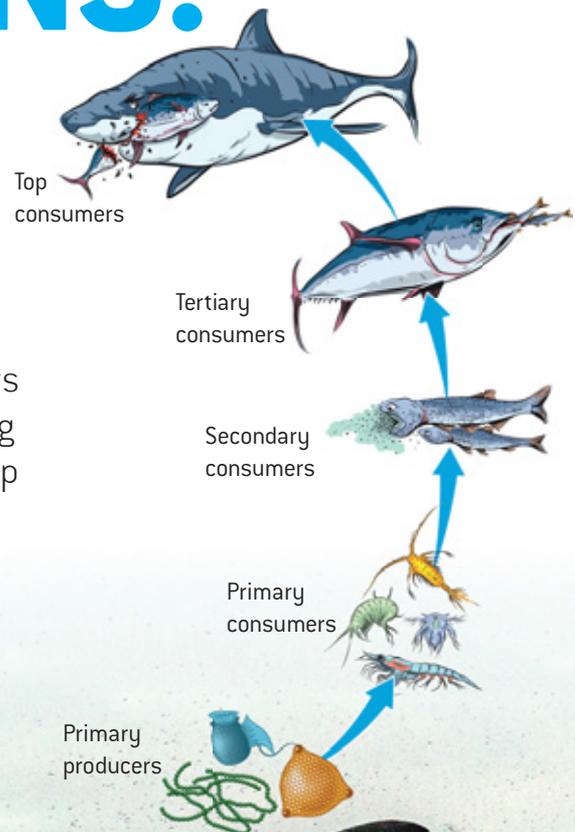
All consumers get energy from food. A food chain shows who eats who and how energy is passed from one living thing to another. Carnivores such as sharks sit at the top of their food chains, food webs and food pyramids.

## Food chains

A **food chain** shows the flow of food in an ecosystem. The arrows in a food chain show the movement of energy and always point towards the consumer. Energy in the form of food must be available for an environment to sustain life.

Sharks are the top consumer in the ocean ecosystem. Consumers cannot make their own food, so they eat other organisms or their products for energy. Sharks play a key role in controlling populations of species lower in the food chain. Without sharks controlling the balance of the food chain, the population of algae or other small organisms could increase. This might cause damage to the ecosystem, affecting many of the plants and animals within it.

Plants and plant-like organisms such as algae are always found at the start of food chains because they only need air, water, sunlight and a few minerals in small amounts (trace minerals) to live and grow. These organisms are known as the producers in the ecosystem because they make their own food from the non-living (abiotic) features of the ecosystem.



*This simple food chain shows who eats who in an ocean ecosystem.*



A great white shark launching into the air to catch a seal.

# Food webs

Like humans, most animals will eat more than one type of food. This can be represented in a **food web**, which shows several food chains intertwined. Some consumers will consume a variety of foods. Food webs show how living things in the environment are connected.

# Food pyramids

A **food pyramid** shows the numbers of organisms at each level of a food chain. The food pyramid below shows hundreds of millions of plankton (producers) at the bottom of the food pyramid. The plankton are the food for the hundreds of thousands of consumers at the next level, such as crabs, lobsters and shrimps. The number of consumers gets smaller towards the top of the food pyramid, with very few top consumers, including the shark.

More energy is available to organisms at the bottom of the food pyramid. Producers need to generate enough energy to sustain all the consumers above them in the pyramid. Only 10 per cent of a producer's energy is passed on to primary consumers.



### LOOK IT UP

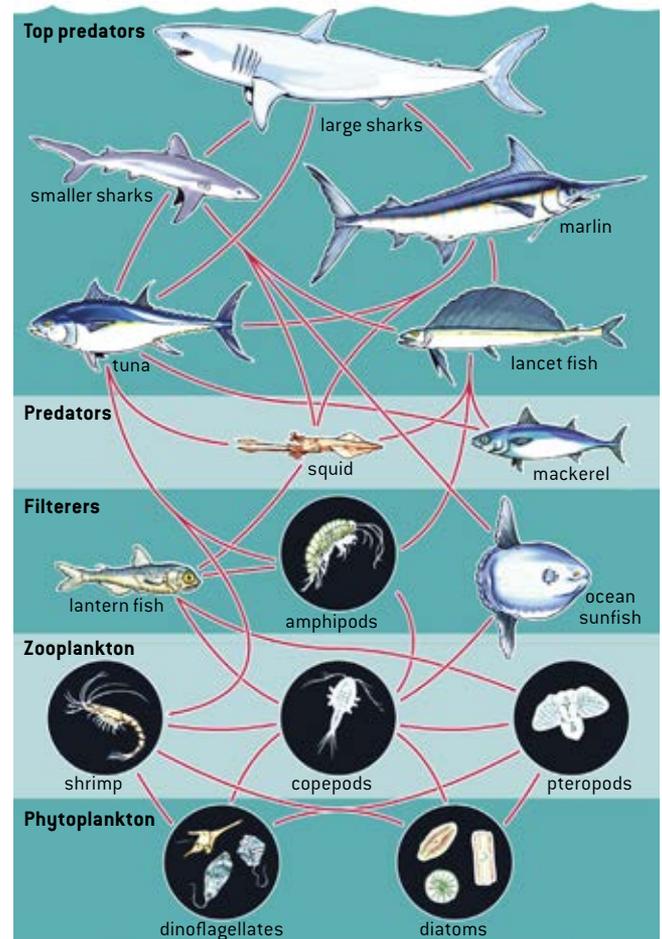
**food chain** a chain of organisms arranged to show the flow of food in an ecosystem, from producers to herbivores to carnivores

**food pyramid** a diagram showing the numbers of all organisms at each level of a food chain

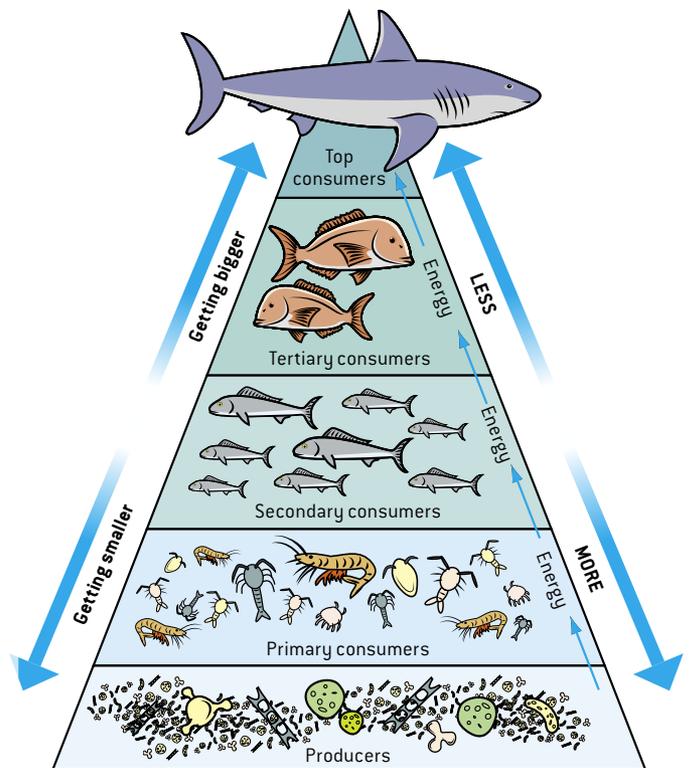
**food web** a diagram showing several food chains intertwined

### CHECK IT OUT

- 1 What does a food chain show?
- 2 What is a producer? Give an example from an ocean ecosystem.
- 3 Will there be more primary or secondary consumers in a food chain?
- 4 Who are the consumers in an ecosystem?
- 5 Give an example of a primary consumer and a secondary consumer from the food pyramid and suggest what they eat.
- 6 What role do sharks play in the ocean ecosystem and what might happen if their numbers were to decrease?



Food webs connect together a number of food chains to show how many organisms in an ecosystem are connected.



Food pyramids show the types, size and numbers of organisms in a food chain and the amount of energy available.

# FRAGILE FOOD WEBS

Food webs show how the balance is maintained between producers and consumers. Ecosystems and the food webs within them can be surprisingly fragile. Food webs can become unbalanced when predators are removed from the environment or when new organisms are introduced. Even the smallest of changes can disrupt the flow of food and energy.

## Introduced species

**Introduced species** such as the fox and the rabbit are a major threat to the food webs in ecosystems across Australia. Such animals invade areas that are not their natural habitat. Often, introduced species have no natural predators in their new environment. This means they can multiply quickly. Introduced species have led to many Australian animals and plants becoming **extinct**.

Some introduced species in Australia are domestic animals (kept as pets) that escaped into the wild, such as feral cats. Others were introduced for sports such as hunting (the fox) or as pack animals (camels and horses). A few, such as the cane toad, were introduced to eat (control) insects or other species thought of as pests.

*Foxes threaten a number of Australia's endangered species, including orange-bellied parrots, numbats and western swamp tortoises.*

## Foxes in Australia

Foxes were introduced into Australia in the mid-1800s for recreational hunting. They are now found across most of the country. These predators have played a major role in the decline of a number of native species. They are a particular threat to small mammals such as numbats and bilbies, as well as reptiles and ground-dwelling birds. Foxes wiped out numbat populations throughout most of Australia, and now less than 1000 numbats remain in two small populations near Perth.



*European wasps are a threat to many Australian ecosystems.*



*Cane toads were introduced into Australia in 1935 to control cane beetle populations.*



## Southern corroboree frog

The tiny southern corroboree frog is one of Australia's most endangered species. Until the late 1970s, tens of thousands of southern corroboree frogs were found in mountain areas in the bogs of Australia's Snowy Mountains. Then, within only a few years, the population suddenly dropped by 90 per cent. Just 218 frogs were counted in a 1999 survey and only 64 could be located in a survey in 2004. In 2013 there were believed to be fewer than 50 in the wild.

The main reason for the southern corroboree frog's decline is the chytrid fungus that kills frogs by eating away their protective skin. This fungus is believed to have been accidentally introduced to Australia in the 1970s.



*The tiny southern corroboree frog is in danger of becoming extinct.*

## European wasps

The first European wasp recorded in Australia was in Tasmania in 1959. Wasps quickly increased because they faced few predators, no diseases and no competition for nest sites.

So how does this affect a food web? By the end of an Australian summer, each European wasp nest may have several thousand individuals. The larvae are fed a diet that consists mainly of other insects that the workers catch and kill. This means that each European wasp nest is fed several thousand native insects, often the caterpillars of moths and butterflies. This can have a large negative effect on local animal populations.

## Loss of amphibians

Loss of organisms from an ecosystem can have large negative effects. Amphibians such as frogs are an important part of the biosphere. Amphibians have been on Earth for millions of years, but today almost a third of the world's amphibian species face extinction. As many as 165 amphibian species may already be extinct and almost half of all amphibian species are decreasing in population.

The thin skin of amphibians helps them drink and breathe. But their thin skin means that they absorb air pollution and water pollution. Chemicals dumped into the water,

such as those from crop sprays and factories, have played a major role in harming frog populations. Frogs are like 'canaries in a coal mine', which means a decline in their population may indicate polluted waterways.

Amphibians feed mainly on insects and other invertebrates. A single population of about 1000 frogs could consume almost five million invertebrates in one year. In areas of the world where amphibians have declined, there has been an increase in invertebrate pests (mostly insects) that damage crops and carry human diseases.

### LOOK IT UP

**extinct** a family, class or species that has died out

**introduced species** any species of plant or animal that has been moved by humans to an environment where it did not occur naturally

### CHECK IT OUT

- 1 Why can introduced species have such an impact on the food web?
- 2 Give an example of the impact of an introduced species in Australia.
- 3 What are the main threats to amphibians and what is happening to food webs as their numbers decrease?

The Amazon rainforest is the largest in the world. One in three of all plant and animal species live here. Since 1970, over 600 000 square kilometres of this rainforest has been cleared.

The habitat of these birds is destroyed.

Trees are cut down and burned.

Gold mining destroys the forest and pollutes the river.

The river is brown. It carries away topsoil that is no longer protected by trees.

Land is cleared for agriculture and cattle grazing.

Land is cleared for a village.

Trucks take logs to the paper mill.

# HABITAT DESTRUCTION

The destruction of habitats can change an ecosystem instantly or over time. Habitat destruction, such as the clearing of land, can wipe out a whole species instantly. Humans clear forests to build roads, farms and towns, as well as for logging and mining. Clearing the Earth's forests is called **deforestation**. Trees protect the land from erosion and provide homes, habitats and shelter for animals and plants. When there is deforestation, these habitats are destroyed.

## Changing ecosystems

Habitats, such as forests, swamps, deserts and rivers, are the homes of animals. They provide shelter, food and water for animals and plants. When ecosystems are changed and parts of them are destroyed, trees and other plants die and, with them, the living area of many species. When this happens, breeding cycles of the species that rely on the habitat are also interrupted.

Changes are made to habitats in many ways, including:

- » the clearing of native trees and plants for homes or farms
- » the building of roads that split habitats
- » mining or logging, which removes vegetation
- » changes to rivers through the building of dams and irrigation
- » introduction of pollution into the air, land and water through industrial activities
- » change to the climate through increasing greenhouse gases
- » introduction of foreign (non-native) animal and plant species into natural habitats.



Orangutans are now endangered due to rainforest destruction in Indonesia.

## Rainforest habitat

The tropical rainforest biome is found close to the equator where it is warm and wet. All through the year the rainforest is humid, and plants flourish in this climate. Rainforests are home to at least half of all known plants and animals on Earth. Yet rainforests cover less than 7 per cent of the Earth's land surface.

Rainforests play a major role in keeping our climate stable. Their leaves release water vapour, which creates clouds and rainfall. Without rainforests, the planet would become drier and warmer.

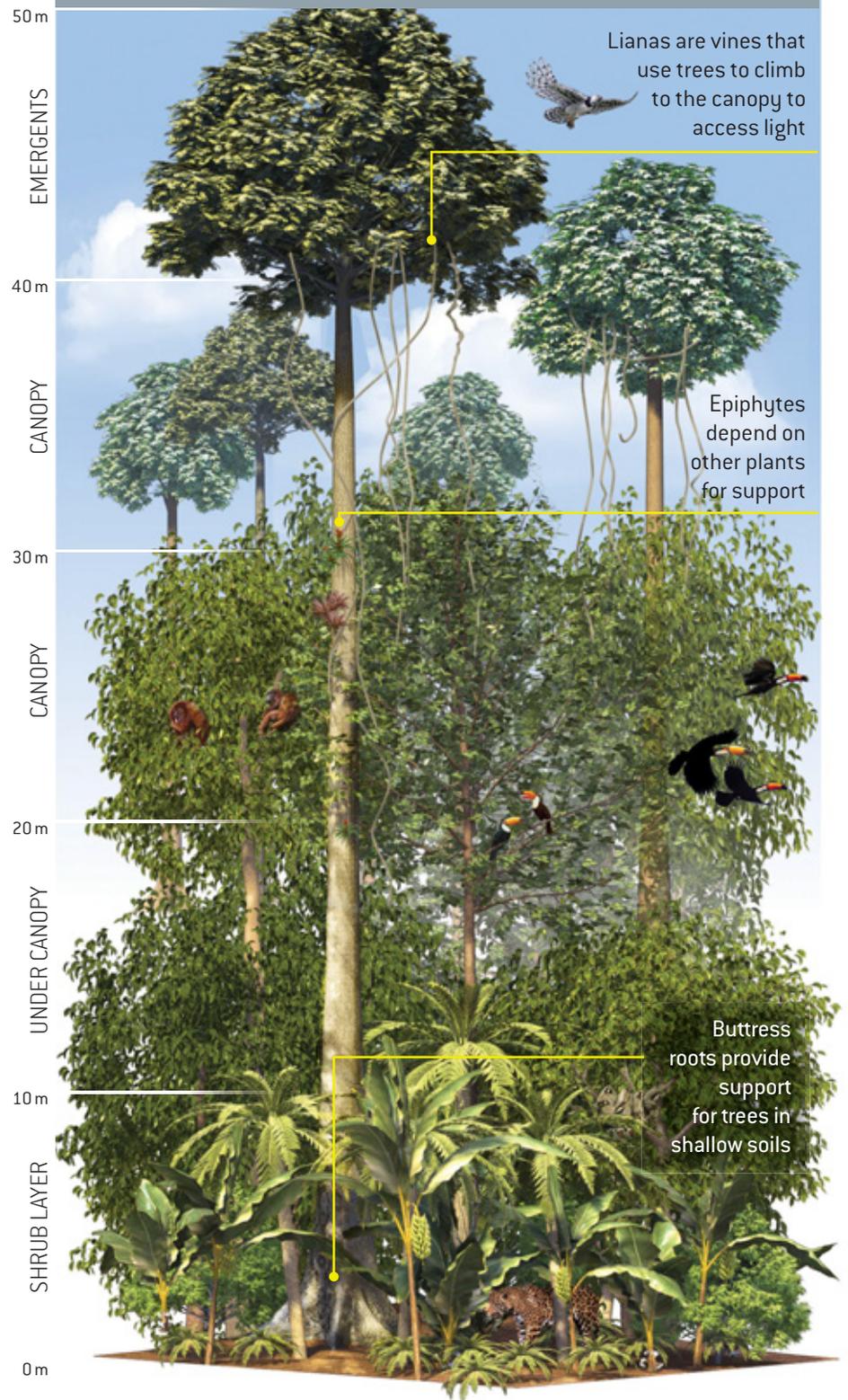
About 20 per cent of the world's oxygen is produced by the Amazon rainforest alone. When rainforests are destroyed, carbon trapped in the wood is released into the atmosphere, which adds to global warming.

## Orangutans in danger

The orangutan is the largest tree-living mammal in the world and the only large ape that lives in Asia. The trees of the rainforest supply the orangutan with leaves, fruits and nuts for food. Orangutans build nests from leaves and branches in the rainforest trees.

More than half of the orangutan's rainforest habitat has disappeared in the past 20 years. This destruction is due to growth in the human population. Land has been cleared and logged for building. Forest has been replaced by palm oil plantations. Palm oil is used in foods and items such as cereals, biscuits and washing powders. Rainforest habitats have decreased greatly due to clearing for palm oil plantations. In fact, so many rainforests have been destroyed that rainforests themselves are now **endangered**.

### CROSS-SECTION OF A TROPICAL RAINFOREST



### LOOK IT UP

**deforestation** clearing of forests that leads to loss of habitat

**endangered** in danger of becoming extinct

### CHECK IT OUT

- 1 List five ways in which habitats can be changed.
- 2 What dangers exist for rainforests around the world?
- 3 How has the orangutan been affected by habitat change?
- 4 If all of the rainforests were lost, what might be the impact on humans?

# 5 WAYS TO PROTECT ECOSYSTEMS

## 1 Plan and provide 'green belts'

Many cities in Australia have planned for 'green belts' or 'green wedges' as a way of ensuring there are green areas with plants and animals within suburbs and cities. These active, living areas protect a city's open spaces and natural areas from too much building (overdevelopment). Green belts provide important habitats for animals. These areas can act as green corridors to allow animals to move from one place to another.

Melbourne has a number of green belts set aside to conserve the natural environment.

## 2 Protect habitats

**National parks** and reserves are one of the best ways to help ecosystems and protect endangered species such as bilbies and numbats. These controlled ecosystems and the animals and plants within them can live safely without habitat destruction.

Introduced species such as feral cats and foxes are predators of native species such as bilbies, numbats and wallabies. The 20-square-kilometre bilby fence at Currawinya National Park keeps out bilby predators and enables the species to breed and grow in number.

The bilby fence at Currawinya National Park in south-west Queensland.



## 3 Conduct fieldwork surveys

The starting point for the management of species in an ecosystem is to accurately measure the numbers and habitat of the species and the threats to their survival. Scientists use a wide range of methods to count and monitor species. These include aerial and ground surveys, listening for calls, trapping, tagging and filming.



*This scientist is listening for the call of the male Baw Baw frog during the breeding season.*

## 4 Protect plants and animal populations

The Pavlovsk Experimental Station in Russia was established in 1926 by Nikolai Vavilov. He is credited with creating the concept of **seed banks** to classify and store seeds of important crop plants. These seeds could then be used to breed new varieties of crops, retain 'copies' of existing crops, and provide a backup plan in the face of threats to food production. Today, the Pavlovsk Experimental Station contains over 5000 seed varieties. Its crop collections are thought to possess traits that could be crucial for productive fruit harvests in many parts of the world as the climate changes and disease, pests and droughts weaken the varieties that farmers are now growing.



*Seeds are classified and stored at the Pavlovsk Experimental Station.*



*Waterwatch volunteers monitor a creek.*

## 5 Monitor environmental quality

Pollution occurs when waste products are released into streams, oceans and the atmosphere. Waterwatch Australia is a community program that connects local communities and schools with river health and water management issues. Thousands of Australians volunteer many hours monitoring, planting, communicating about and caring for their local creeks, wetlands, groundwater, rivers and estuaries.

### LOOK IT UP

**green belt** undeveloped land set aside within a city

**national park** a park set aside by a government for conservation

**seed banks** places for the classification and storage of seeds of important crop plants

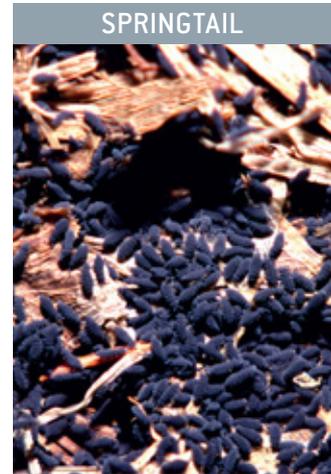
### CHECK IT OUT

- 1 List five ways to protect ecosystems.
- 2 What is the purpose of the bilby fence at Currawinya National Park?
- 3 What methods do scientists use to monitor the populations of ecosystems?
- 4 What problem can you see for animals moving along the green corridor in the first example. What action might you take to improve this?

# FOOD CHAINS

Knowing who eats who in a food chain can be very useful information, particularly when looking at how human activities have impacted on the natural environment. Scientists use a food chain to show the flow of food in an ecosystem. A possible food chain for a backyard ecosystem is shown here.

Note that the arrows in a food chain always point towards the animal that is doing the consuming. These arrows illustrate the movement of energy in the system. Energy in the form of food must be available for an environment to sustain life.



SPRINGTAIL

## EXPERIMENT #2

# EXPLORING LEAF LITTER

Leaf litter is the dead and rotting leaves that lie on the ground under trees and in gardens. Leaf litter helps protect soil and is home to many tiny, fragile invertebrates that work together to keep soil in good condition.

**AIM:** TO FIND AND IDENTIFY SOME OF THE CREATURES IN LEAF LITTER

### MATERIALS

- Old newspaper
- Gloves
- Plastic test tubes or specimen tubes with lids
- Wet paintbrush
- Hand lens
- Pen and paper

### SAFETY

- Before you start, ask your teacher about any bull ants, poisonous spiders or centipedes that are found in your area.
- There may be some animals that could bite or sting you. If in doubt, leave the animals alone and ask your teacher.



LEAF LITTER

### METHOD

- 1 Work in an undisturbed area about 50 cm long by 50 cm wide.
- 2 Lift up the leaves slowly. Use your brush to pick up the tiny animals and make sure not to crush them.
- 3 List the animals you find. Include as a separate list any eggs, cocoons, larvae or types of fungi.
- 4 Return the animals to the place where you found them.

GROUND BEETLE



CENTIPEDE



MUDLARK



### EXPERIMENT #3

# STUDYING FOOD WEBS

**AIM:** TO INVESTIGATE FOOD WEBS IN A LIMITED AREA

### MATERIALS

- Metre-long sticks
- Metric rulers
- Poster board
- Markers
- Photographs of ecosystems

### METHOD

- 1 Think about what you know about food webs in your area. Come up with a list of at least 20 biotic and abiotic components within these food webs. Do some areas support more life than others?
- 2 Select two 1-metre-square areas in your backyard, schoolyard or neighbourhood to study. The study areas should be near each other (adjacent) but in two different habitats (e.g. on a footpath and on some grass, or just inside a forest and in a clearing).

- 3 Observe and record all organisms in the area above and within this study area.
  - Which organisms are producers?
  - Which organisms are consumers?
  - Which organisms are decomposers?
  - How do the numbers (of individuals and species) of producers, consumers and decomposers compare?
- 4 Devise a system for estimating the number of something too great to count, such as the number of grass blades in your study area.
- 5 Make predictions about which study area might depend more on food energy from adjacent habitats.
  - Which study area will produce more energy for adjacent habitats?

- 6 Devise methods to test your predictions. You might like to group organisms into 'visitors' and 'residents'.
- 7 Are the 'visitors' bringing food energy into a study area or taking it away?
  - How will you measure the flow from decomposed matter?
- 8 After you have collected data, graph your findings and write about what you learned.

### CHECK IT OUT

- 1 Why is it important to know something about the animals you are likely to find before looking for them?
- 2 Why should you return animals to the place where you found them?
- 3 A leaf litter community doesn't contain any producer organisms, such as healthy green plants. What is the energy source for this community?
- 4 How does this leaf litter community help the soil?

# ECOSYSTEMS

## ECOSYSTEMS (PAGES 42–43)

- 1 What is the main reason for studying ecosystems?
- 2 Apply your knowledge to list three different habitats you might find within a forest ecosystem.
- 3 Draw an example of an ecosystem. Make sure you include a range of plant and animal species and label your diagram.

## AT HOME IN THE DESERT (PAGES 44–45)

- 4 List three adaptations of desert plants.
- 5 Name three desert animals that live in burrows. Suggest why burrows are important for some animals that live in desert habitats.
- 6 How have red kangaroos and camels adapted to prevent dehydration in the hot desert climate?

## ENERGY FOR LIFE (PAGES 46–47)

- 7 Explain how decomposers help the environment.
- 8 What role do you think the three animals opposite play in their ecosystems?
- 9 Using the terms 'producer', 'consumer' and 'decomposer', explain how the savannah ecosystem below provides a flow of energy.



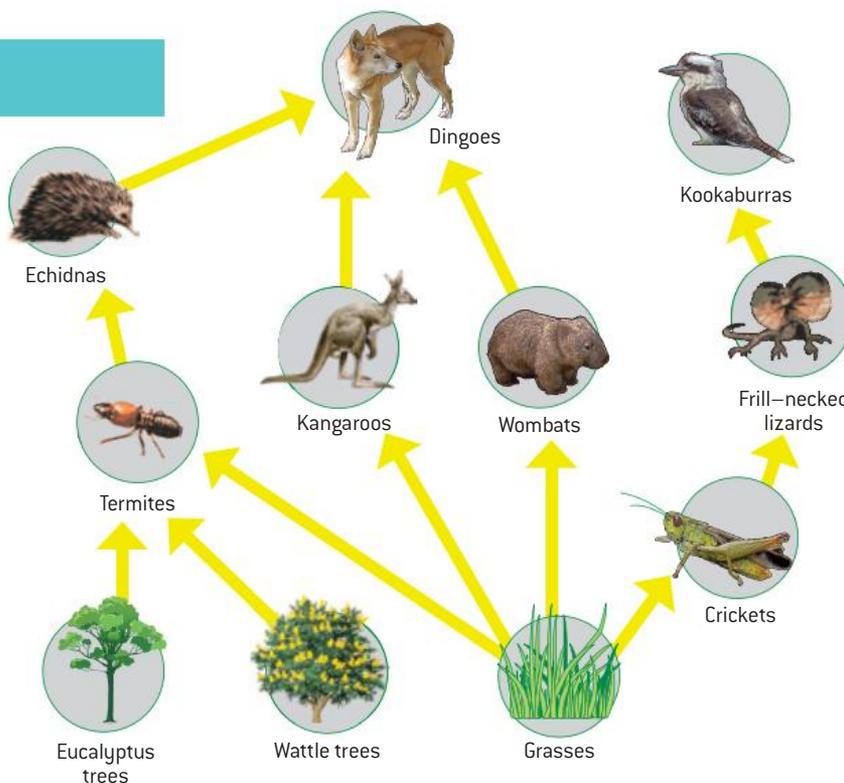
## FOOD CHAINS: WHO EATS WHO? (PAGES 48–49)

10 Look at the food web (right) and identify:

- a producers
- b primary consumers
- c secondary consumers
- d the top consumer.

11 What do you think would happen if all of the producers in a food chain died?

12 Use your knowledge of food webs to draw a food web of a rainforest ecosystem. Include at least six species and label the diagram.



## FRAGILE FOOD WEBS (PAGES 50–51)

- 13 Explain in your own words why many frog species are becoming extinct.
- 14 In what way are European wasps impacting on Australian ecosystems?
- 15 The cane toad's population has skyrocketed since it was introduced to Australia in 1935. What impact do you think this introduced species might have on the ecosystems it lives in?
- 16 What is your opinion about introducing new species to Australia? Apply your new knowledge of introduced species and write a short paragraph to explain your answer.



## HABITAT DESTRUCTION (PAGES 52–53)

- 17 Draw a labelled diagram of a rainforest, including how it controls the climate and affects the atmosphere.
- 18 What motive is there for habitat destruction and who do you think would want to do this? Write a short paragraph to explain your answer.

## 5 WAYS TO PROTECT ECOSYSTEMS (PAGES 54–55)

- 19 Do you think that green belts in cities are a good idea? List the advantages and disadvantages, and give your opinion.
- 20 Why do you think it is important to do research and fieldwork surveys on animals?
- 21 What are some other ways you can think of to protect ecosystems?

## KEY IDEAS

1

A biosphere is our living world and it extends from the upper layers of the atmosphere to the bottom of the ocean. It includes plants, animals, fungi and bacteria.



2

A biome is a place within the biosphere where the climate, soil type and plants are similar. Forests, grasslands, deserts and ice caps are all biomes.



3

Ecosystems contain a community of living and non-living organisms, and can be as small as a puddle or as large as the Earth itself. Animal and plant habitats are found within ecosystems.



4

Plants and animals adapt to the climate and conditions of the habitat where they live. For example, many desert animals shelter in burrows away from the hot Sun so they can keep cool.



5

Food chains show the flow of food and energy in an ecosystem, from the smallest microorganism (such as algae) to the carnivores (such as sharks).



6

Animals within a food chain can be classified according to their position within it. Food webs show relationships between several food chains. These are constructed to show how organisms relate within an environment.



7

Food pyramids show the numbers of all organisms at each level of the food chain. For example, the ocean contains millions of plankton on the first level, thousands of crustaceans (such as crabs and prawns) on the next level, and so on. The number of consumers gets smaller with every level, finishing with very few top consumers.



8

Human activity can impact on food webs and habitats. Introduced species, such as foxes, have in many cases reduced the numbers of native wildlife.



9

Deforestation and agriculture have destroyed habitats and ecosystems, in some cases leading to plants and animals becoming endangered or even extinct. One example of human impact is palm-oil harvesting in Borneo and Sumatra. More than half of the orangutan habitat has been destroyed and as a result, orangutans are now endangered.



10

Strategies have been put in place to try to protect ecosystems. These include green belts within cities and suburbs, national parks to protect habitats from deforestation and introduced species, research and fieldwork to monitor species numbers, seed banks to preserve plants, and pollution monitoring in different environments.

# MIXTURES 04

**3\***  
WAYS  
to SEPARATE  
SOLUTIONS  
\*

IS IT  
PURE  
OR A  
MIXTURE?

How do you  
separate blood?

WHAT IS  
SMOKE?



66

PARTICLES IN  
SUSPENSION



70

FILTERING OUT NASTIES



77

THE SCIENCE OF DRUG  
TESTING

# IS IT A MIXTURE OR IS IT PURE ?

Mixtures are everywhere you look in nature. The rocks, the ocean and even the atmosphere are all made up of mixtures. Most of the substances we use every day are mixtures. Mixtures contain a combination of pure substances that can be separated. Some mixtures, such as the air, look like just one substance because the particles they are made from are so small.

## Mixtures

A **mixture** is made of different substances that are not chemically joined. Mixtures can be separated into simpler substances by methods such as filtering and evaporating.

Sulfur and iron filings is an example of a mixture. A mixture of sulfur and iron filings can be separated with a magnet. The magnet will attract the iron particles, leaving behind the solid yellow sulfur. Salt and sand is another mixture. Adding water will dissolve the salt, making it easy to filter out the sand.

A solution of sugar dissolved in water is a mixture. The relative amounts of the substances in a mixture can vary. You can have a dilute solution of sugar in water, in which very little sugar is dissolved. You can also add lots of sugar to water, forming a sweet, concentrated solution.

Solutions, suspensions and colloids are different types of mixtures.

These colourful paints are an example of a mixture.

# Pure substances

Elements and compounds are examples of **pure substances**. Pure substances cannot be separated into simpler substances by physical methods such as filtering and evaporation.

» An **element** is a pure substance because every **atom** within the substance is the same. Gold is an example of an element. The smallest particles that make it are gold atoms. Carbon is also an element. It contains only carbon atoms.

» A **compound** is formed when different atoms bond together. An example is water, in which two hydrogen atoms bond with an oxygen atom to form  $H_2O$ . A sample of water, no matter how small, will always contain two hydrogen atoms joined to one oxygen atom.

Other examples of compounds are common salt (sodium chloride), table sugar (sucrose), carbon dioxide, methane and octane.



## PURE SUBSTANCES

*These balloons contain the element helium (He).*



*Gold is a chemical element with the symbol Au.*

*Salt is sodium chloride, a compound of two elements: sodium and chlorine.*

## MIXTURES



*A cup of tea is a mixture of tea, water and sugar.*



*Milk is a mixture of fats, oils and water.*

*Fog is a mixture of water droplets and air.*



## LOOK IT UP

**atom** the smallest particle of a substance that can exist

**compound** a substance made up of two or more different types of atoms bonded together, such as water

**element** a pure substance made up of only one type of atom, such as oxygen or carbon

**mixture** something made up of two or more pure substances mixed together

**pure substance** a substance that is not combined with anything else

## CHECK IT OUT

- 1 What is a pure substance? Give three examples.
- 2 What is a mixture? Give an example.
- 3 Explain why muddy water is an example of a mixture.
- 4 A compound contains more than one substance. Why are compounds considered pure and mixtures are not?
- 5 When sugar dissolves in water, it forms a solution. Is a solution an example of a compound, a mixture, an element, or a pure substance?

# SOLUTION

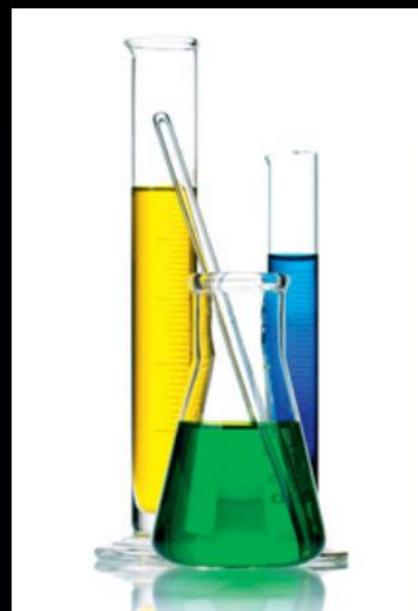
Add salt to water and stir. Soon the salt will disappear. It has dissolved, forming a solution. A solution contains tiny particles spread evenly throughout it. The salt particles have become so small that they cannot be seen. The salt is **soluble**.

## Looking for solutions

A cup of coffee is a good example of a solution. Coffee granules dissolve in hot water to create a brown solution. A solution may be coloured, but you can usually see through it.

A substance (such as salt or coffee granules) that is able to dissolve in a liquid is considered to be soluble, and is called a **solute**. The liquid it dissolves into is called the **solvent** (such as water). An **insoluble** substance (such as sand) cannot dissolve.

*Sugar dissolves easily in a cup of hot coffee to form a solution.*



*Solutions contain a solute dissolved in a solvent.*



*A soft drink is a solution of sugar, colourings and flavourings.*

# SOLUTIONS

Water is a good solvent because it dissolves many substances. If you add sugar to water, the sugar particles become so small that they cannot be seen. Because they are so small they will not fall to the bottom or float on the top, but will remain evenly spread through the liquid. The resulting mixture will be clear – light will shine through it. We say that the sugar has dissolved in the water to form a solution.

Sometimes a solute may need help to dissolve. Warming and stirring are the most common ways of making a solute dissolve faster. For example, when making a hot chocolate, more hot water may have to be added to help dissolve the chocolate, and it may need to be stirred to further help it dissolve.

Most solutions are formed with a liquid solvent (such as water) and a solid solute (such as sugar). However, this is not always the case. Gases can also dissolve in liquids. Carbonated drinks contain carbon dioxide gas dissolved in water. The mixture also contains sugar, flavouring, food colouring and preservatives.

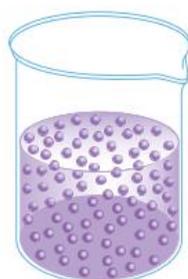


*The Dead Sea has a high concentration of salt. When people try to go under the water, they float instead!*

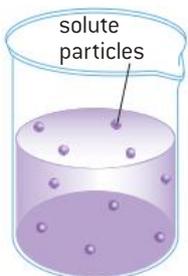
## Concentration

How strong do you like your hot chocolate? If you enjoy just a small amount of cocoa (just a little solute), then you like your hot chocolate dilute (low concentration). If, however, you enjoy a large amount of cocoa, the hot chocolate solution you like is described as concentrated (high concentration). If you enjoy your chocolate so much that you keep on adding cocoa (solute) until no more cocoa will dissolve, your hot chocolate solution is described as being saturated. If you add too much cocoa, it will begin to form lumps on the bottom. A solution is saturated when no more solute can be dissolved.

*A concentrated solution contains more solute than a dilute solution.*



concentrated solution



dilute solution

## LOOK IT UP

**insoluble** a substance that cannot dissolve

**soluble** a substance that dissolves in water or another solvent

**solute** a substance that dissolves in a liquid (solvent)

**solvent** any liquid that dissolves another substance or substances

## CHECK IT OUT

- 1 What is a solution?
- 2 Give three examples of soluble and insoluble substances.
- 3 What gas gives the fizz to soft drinks?
- 4 Look at the three glasses of cordial.



- a What is the solvent in this mixture?
  - b What is the solute in this mixture?
  - c Explain why they are different colours.
- 5 Do you like your cordial concentrated or more dilute? Explain why.
  - 6 What is the gas dissolved in water that is helpful to fish?

# SUSPENSIONS

In a **suspension**, very small pieces of solid are spread through a liquid but do not dissolve. The solid particles are **dispersed** throughout the liquid and will often settle and separate over time if left alone. Dirty water, like the floodwaters opposite, is an example of a suspension.



## Examples of suspensions

The **particles** in a suspension are much bigger than those in a solution. Some everyday examples of suspensions are dust and soot floating in air, a shaken mixture of oil in water, and flour in water.

*Chocolate milk is a suspension. It must be shaken or stirred to spread the powdered chocolate throughout the milk (see image a). Over time, some of the solid particles will separate and settle at the bottom of a glass (see image b).*



*If river water is left to settle, less dense solids such as wood float to the top. Denser solids such as sand will sink to the bottom.*

A dust storm is a suspension of fine particles floating in air.



Floodwaters of the Ovens River in Victoria carrying sediment in suspension over the flood plain in 1993. As the water slowed, it deposited the sediment onto the land.

# Ask a scientist

Ms Jenny Powell



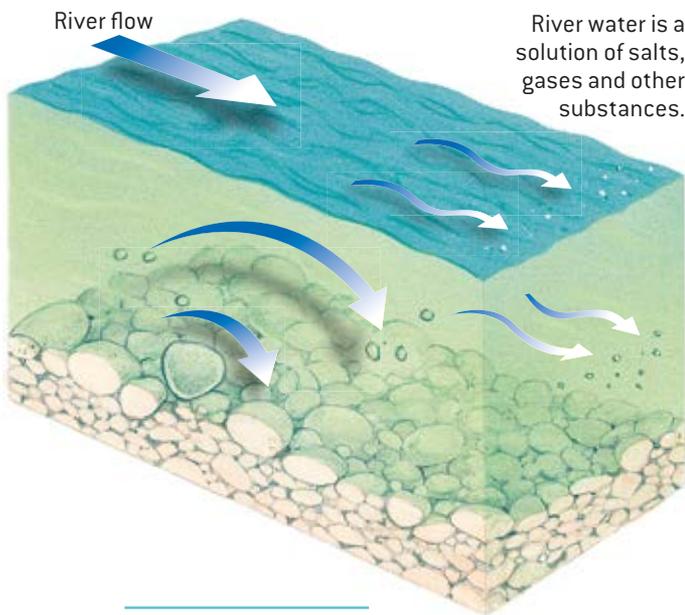
Ms Jenny Powell with air-quality measuring equipment.

## Depositing sediment

Rivers and floodwaters get their brown appearance from suspended particles in the water. The power of the moving water removes soil and rocks from the riverbanks and carries them downstream. Suspension sees loose, fine pieces of rock and

minerals, carried downstream. When the land becomes flatter, the river slows and can **deposit** sediment (soil and rocks). A delta is an area of sediment that forms near the mouth of a river.

*Rivers transport eroded rocks. Small particles are carried in solution or suspension.*



Water movement picks up insoluble particles from the river floor and banks, and holds them in suspension.

### LOOK IT UP

**deposit** a natural layer of sand, rock or coal

**dispersed** distributed in different directions or over a wide area

**particle** a building block of matter

**suspension** a mixture in which insoluble particles are spread through a fluid

### CHECK IT OUT

- 1 What is a suspension?
- 2 How is a suspension different to a solution?
- 3 When making a chocolate milk drink from powdered chocolate, what action do you need to take to mix the solid powder with the liquid milk?
- 4 Why do some insoluble particles in the chocolate milk drink float to the top?
- 5 Is a river an example of a pure substance or a mixture? Explain your answer.
- 6 If you shone a light through a solution, what would happen? Compare this to shining a light through a suspension.

An environmental scientist is a scientist who measures and records features of the environment. Environmental scientists also study and develop ways of controlling or minimising the harmful effects of pollution.

Ms Jenny Powell is an environmental scientist who works for CSIRO (Commonwealth Scientific and Industrial Research Organisation), Australia's largest science agency. Jenny studied chemistry, geography and environmental science before joining CSIRO as a laboratory technician. Today, she is a researcher and is finishing a PhD in chemistry.

Jenny specialises in monitoring pollutants in the air, both outdoors and in people's homes and workplaces. She recently completed a study of the tiny particles in Sydney's air. Some of these particles get into people's lungs and can affect their health. The results will help the New South Wales government develop ways to reduce pollution.



A video interview with Ms Jenny Powell is available on your [obook](#) / [\\_assess](#).

# COLLOIDS

Sometimes suspensions don't separate out over time. Suspensions that don't separate easily are called **colloids**. Colloids can be formed in a number of different ways. Colloids can be formed by a solid in a liquid. Paint and blood are examples of this kind of colloid. Colloids can also be formed by a liquid in a liquid, in which case they are known as emulsions. Mayonnaise is an emulsion. Colloids can even be formed by a solid suspended in a gas. Smoke is an example of this kind of colloid. Milk, shaving foam, hair gel and fog are all examples of different kinds of colloids.

## Emulsions

An **emulsion** is a colloid of two or more liquids. Usually one liquid is the 'base' and the other is broken into tiny droplets spread throughout the base liquid. Milk is an example of an emulsion, with tiny droplets of milk fats and oils spread throughout water (the base). Proteins in the milk act as an emulsifier. They coat the fat droplets, allowing them to stay dispersed in the water.



## Foam

Foam is a colloid of gas mixed with a liquid. Shaving foam is an example of a useful colloid.



## Gels

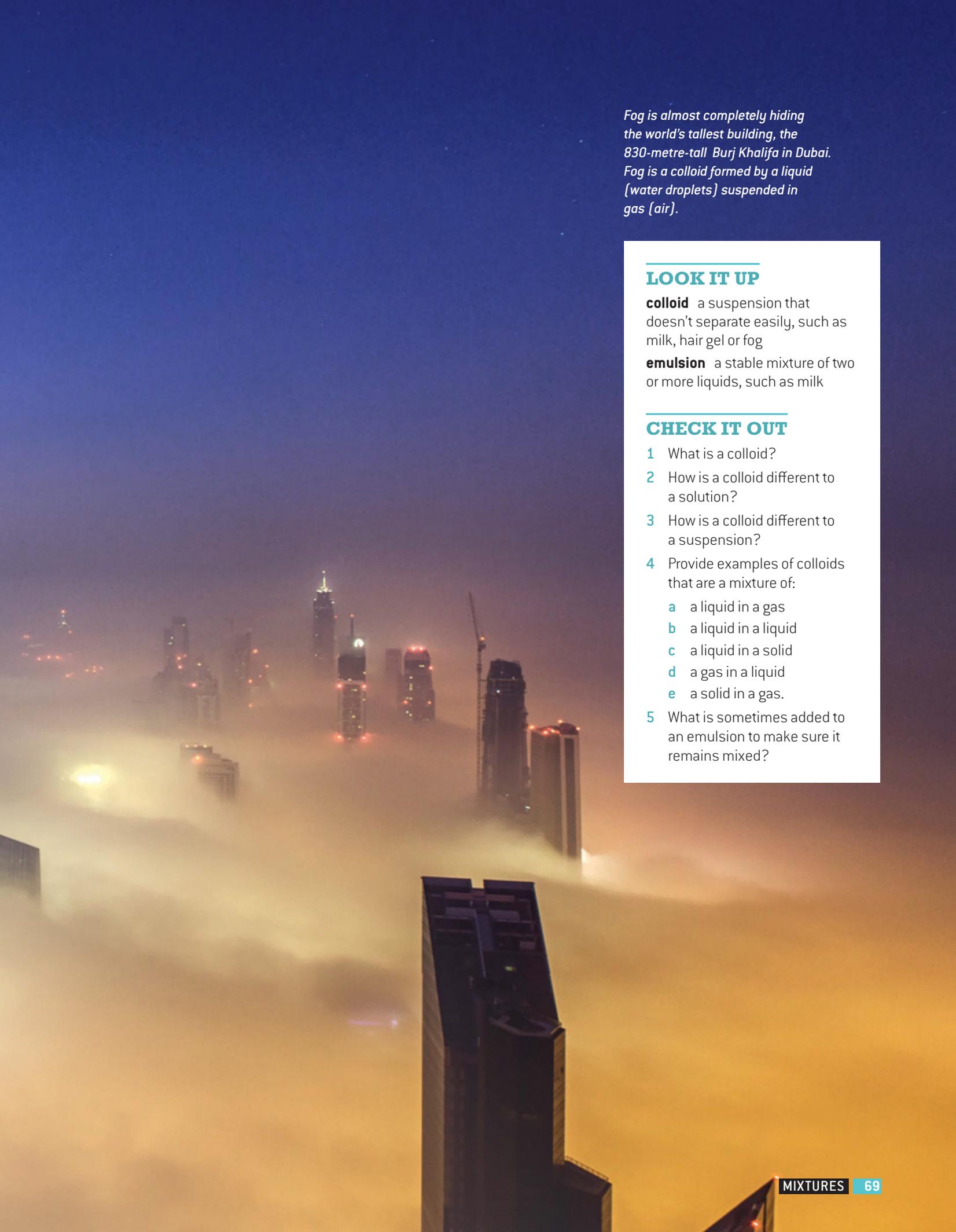
A gel is a colloid in which liquid particles (such as water) are held between solid particles (such as gelatine). Jelly is a mixture of water and gelatine. Hair gel and skin gels are other examples of gels.



## Smoke

Smoke is a colloid with solid particles, such as soot (carbon), spread through air.





*Fog is almost completely hiding the world's tallest building, the 830-metre-tall Burj Khalifa in Dubai. Fog is a colloid formed by a liquid (water droplets) suspended in gas (air).*

### LOOK IT UP

**colloid** a suspension that doesn't separate easily, such as milk, hair gel or fog

**emulsion** a stable mixture of two or more liquids, such as milk

### CHECK IT OUT

- 1 What is a colloid?
- 2 How is a colloid different to a solution?
- 3 How is a colloid different to a suspension?
- 4 Provide examples of colloids that are a mixture of:
  - a a liquid in a gas
  - b a liquid in a liquid
  - c a liquid in a solid
  - d a gas in a liquid
  - e a solid in a gas.
- 5 What is sometimes added to an emulsion to make sure it remains mixed?

# FILTERS

Flyscreens on our windows filter bugs and leaves from the air, tea bags filter tea leaves, and sieves filter the lumps out of flour so that you can have a smooth cake mixture. Filters are used everywhere in daily life for many different purposes.

## Filtration

Filters separate mixtures by controlling what can pass through using holes of different sizes and shapes. Grates on stormwater drains filter water from leaf matter and rubbish, but the holes need to be big enough to cope with heavy rain. The holes in a tea bag are small to make sure that people don't drink tea leaves.

In the process of **filtration**, the **filtrate** passes through the filter and the **residue** is left behind in the filter. For example, a colander or sieve will separate boiling water from the cooked pasta. The holes in the colander or sieve let the water flow through them, leaving the pasta in the sieve. In this case, the residue is the pasta.

Most filters separate mixtures by size. The smaller the holes in the filter, the fewer substances get through. HEPA (high-efficiency particulate air) filters are used in vacuum cleaners, air conditioners and dust masks to remove tiny dust particles.

A tea bag is a filter. The tea leaves remain inside the filter and the flavoured water (tea) passes through.



*Gas masks use charcoal to filter out smoke particles, bacteria and other microbes.*



## Filtering dust with vacuum cleaners

A vacuum cleaner sucks air, dirt and other particles from the floor into the intake port. A woven bag inside the vacuum cleaner catches the large particles. The smallest particles and the air push through the bag and travel through a filter. The remaining particles are then trapped before the air is pushed out through the exhaust port.

Clean air is pushed through the exhaust port.

### INSIDE A VACUUM CLEANER

The filter traps the finest dust particles.

Intake port

Exhaust port

Filter

Vacuum cleaner bag

A mixture of air, dirt and other particles is sucked up from the floor and into the hose.

The vacuum cleaner bag acts as the first filter and traps the larger particles. Small holes in the bag allow air and the smallest dust particles to pass through.

*Cross-section of a vacuum cleaner.*



Coffee filters and the filters found in vacuum cleaner bags are both made of paper. Coffee filter paper allows the coffee granules to stay in the paper and the dissolved coffee to travel through.

### LOOK IT UP

**filtrate** the substance that passes through a filter

**filtration** the removal of impurities or solids from a liquid or gas

**residue** the substance that is trapped in a filter

### CHECK IT OUT

- 1 What are the following examples trying to stop and what are they trying to let through?
  - a flyscreen
  - b drain grate
  - c kitchen sieve
  - d gas mask
- 2 Identify three further filters around your home or school. What substances do these filters allow to pass through them and what substances do they collect?
- 3 What is the residue and what is the filtrate when you use a tea bag to make a cup of tea?
- 4 What two filters operate inside a vacuum cleaner? Explain the role of each.

# FILTERING MIXTURES

**AIM:** TO SEPARATE THE COMPONENTS OF A MIXTURE OF SAND AND SALT

## MATERIALS

- Mixture of sand and salt
- Beaker
- 100 mL conical flask
- Small funnel
- Filter paper
- Stirring rod
- Water

## METHOD

- 1 Follow the steps in the 'Scientific equipment' section to set up the filter paper and conical flask.
- 2 Add the sand and salt mixture to the beaker. Half-fill the beaker with water and use the stirring rod to help dissolve the salt.
- 3 Pour the mixture slowly into the filter paper at the top of the funnel to filter the sand from the remainder of the mixture.

## RESULTS

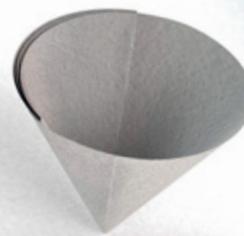
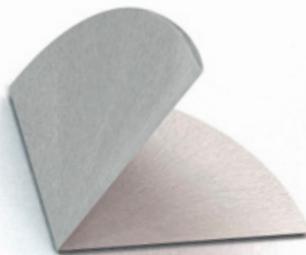
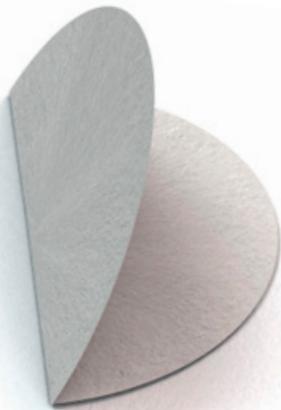
Describe what happens. Use scientific terms such as 'soluble', 'insoluble', 'sediment', 'filtrate' and 'residue'.

## DISCUSSION

- 1 What happened when you added water and stirred the mixture?
- 2 Which parts of the mixture could pass through the small holes in the filter paper?
- 3 Which parts of the mixture remained inside the filter paper?
- 4 What mixture remained in the conical flask? How do you think this mixture might be separated?

## CONCLUSION

What do you know about using filtration to separate sand from salt?



## SCIENTIFIC EQUIPMENT

### FILTER PAPER

Filter paper is a paper sieve with holes that are too small to see. Solutions can flow through because the particles in solutions are small enough to fit through the holes in the paper. Most solid particles in suspensions are not able to fit through the paper. Different filter papers come with different-sized holes. Filter paper with finer holes is used in laboratories to separate out fine suspensions.

## Preparing filter paper for filtration experiments



- 1** Fold a round filter paper in half, then in half again to get quarters, then in half again to get eighths.



- 2** Unfold the filter paper and lay it flat.



- 3** Re-fold back and forth over the creases to obtain a fluted shape.



- 4** Set up the funnel and flask as shown.



- 5** Place the filter paper in the funnel.



- 6** Dampen the filter paper with some extra water to help it stick to the sides of the funnel.



- 7** Slowly pour a mixture from a beaker into the funnel. Don't overfill the funnel. Keep adding the mixture slowly until it is all used up. Extra water can be added to the beaker mixture to pour out the last solid particles.

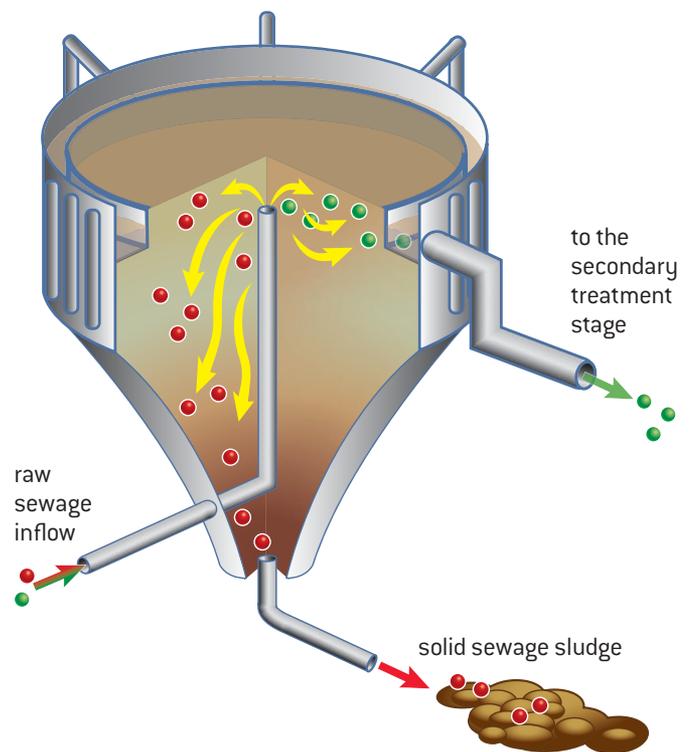
# SEPARATING SUSPENSIONS

In a suspension, small pieces of solid particles are spread through a liquid, but they do not dissolve. If a suspension is left still, the solid pieces may separate from the liquid and either fall to the bottom or rise to the top. Filtering can separate the components of a suspension, as can **centrifuging** and **sedimentation**.

## Sedimentation

An easy way of separating a suspension, such as muddy water, is to wait for the suspended material to settle to the bottom of a container. This is called sedimentation. The clear water left can then be collected in a process called decanting.

Sedimentation is used in sewage treatment. Sewage is left in settling ponds to allow the denser sediment to settle to the bottom. Chemicals called flocculants can be added to a mixture to make suspended particles clump together. Once the particles clump together, they are heavy enough to settle to the bottom. This part of the process is called **flocculation** and is regularly used to separate substances from water.



*Suspended solid sewage sinks to the bottom of the settling pond.*



*Melbourne's Western Treatment Plant removes solids and harmful products from sewage. Following a process that takes around 30 days, the plant releases water into the sea or recycles the water for irrigation.*

# Centrifuging

A centrifuge is a machine that spins mixtures at a very high speed. The spinning results in the larger and heavier components of a mixture moving to the outside of the centrifuge. The solid particles in a suspension can quickly be separated using a centrifuge.

## Washing machines

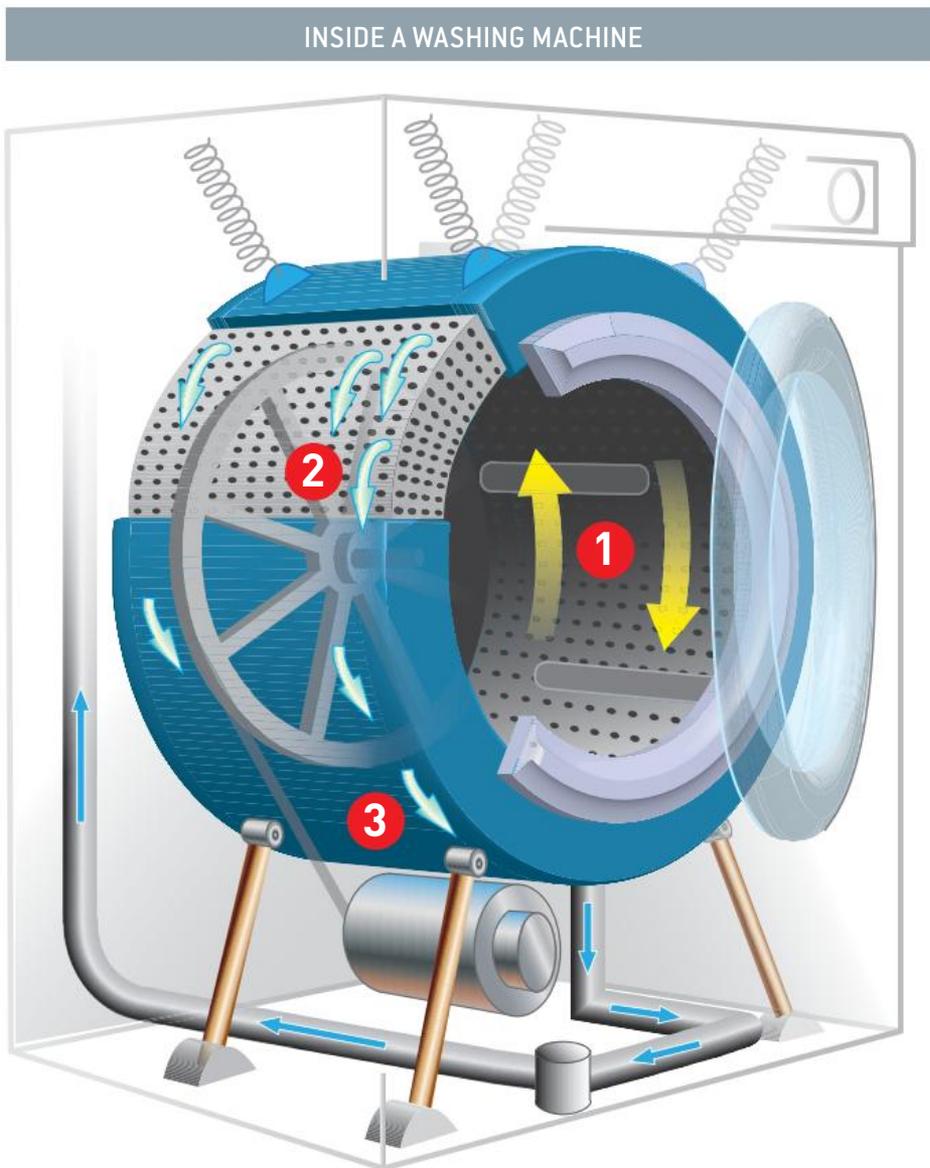
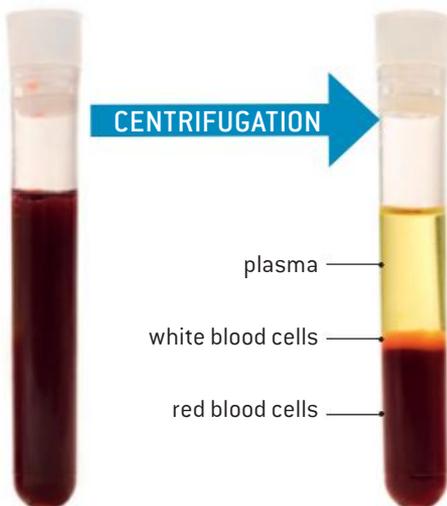
An example of a centrifuge is a washing machine. Washing machines separate liquids (water) from solids (clothing) during the spin cycle.

## Centrifuges in the laboratory

In a laboratory, small glass tubes of mixtures are attached to the inside of the bowl of a centrifuge. The spinning motion causes the heavier particles to move to the outside of the centrifuge and into the bottom of the tubes.

Centrifuges are used to separate blood for medical research and for donation at blood banks. The blood bank uses this method to separate blood into its components – plasma, red and white blood cells and platelets. When blood is spun in a centrifuge, the red blood cells, which are heavier, sink to the bottom of the tube, leaving the yellowish liquid part of blood (plasma and platelets) at the top.

*Inside the centrifuge the tubes spin rapidly, forcing the heavier particles to the bottom of the tubes.*



- 1 During the spin cycle the drum rotates very quickly.
- 2 The fast spinning pushes the wet clothes to the edge of the drum.
- 3 The water passes through the filter, leaving behind drier clothes.

## LOOK IT UP

**centrifuging** a technique used to separate light particles from heavy particles by spinning a mixture

**flocculation** a process in which chemicals added to a mixture make particles join together and settle on the bottom

**sedimentation** a separation technique in which the sediment settles to the bottom and can be separated from the mixture

## CHECK IT OUT

- 1 How is a suspension separated in:
  - a a sewage settling pond?
  - b the blood bank?
- 2 What are flocculants and why are they added to suspensions?
- 3 How is a centrifuge used to separate mixtures?
- 4 What is the mixture in a washing machine and how is it separated?

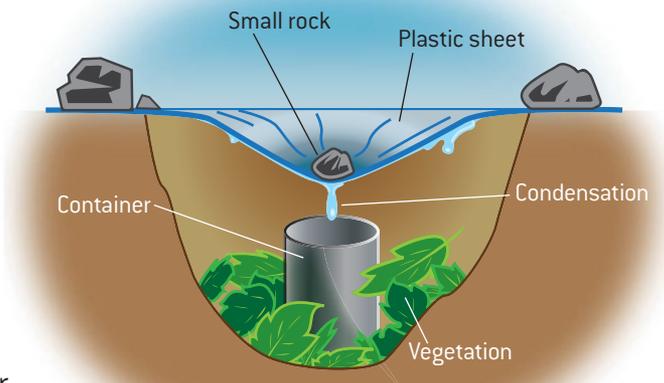
# 3 WAYS TO SEPARATE SOLUTIONS

Filtration, sedimentation and centrifuging are useful for separating the components of a suspension. Scientists must use other methods to separate the components of a solution.

## 1 Evaporation

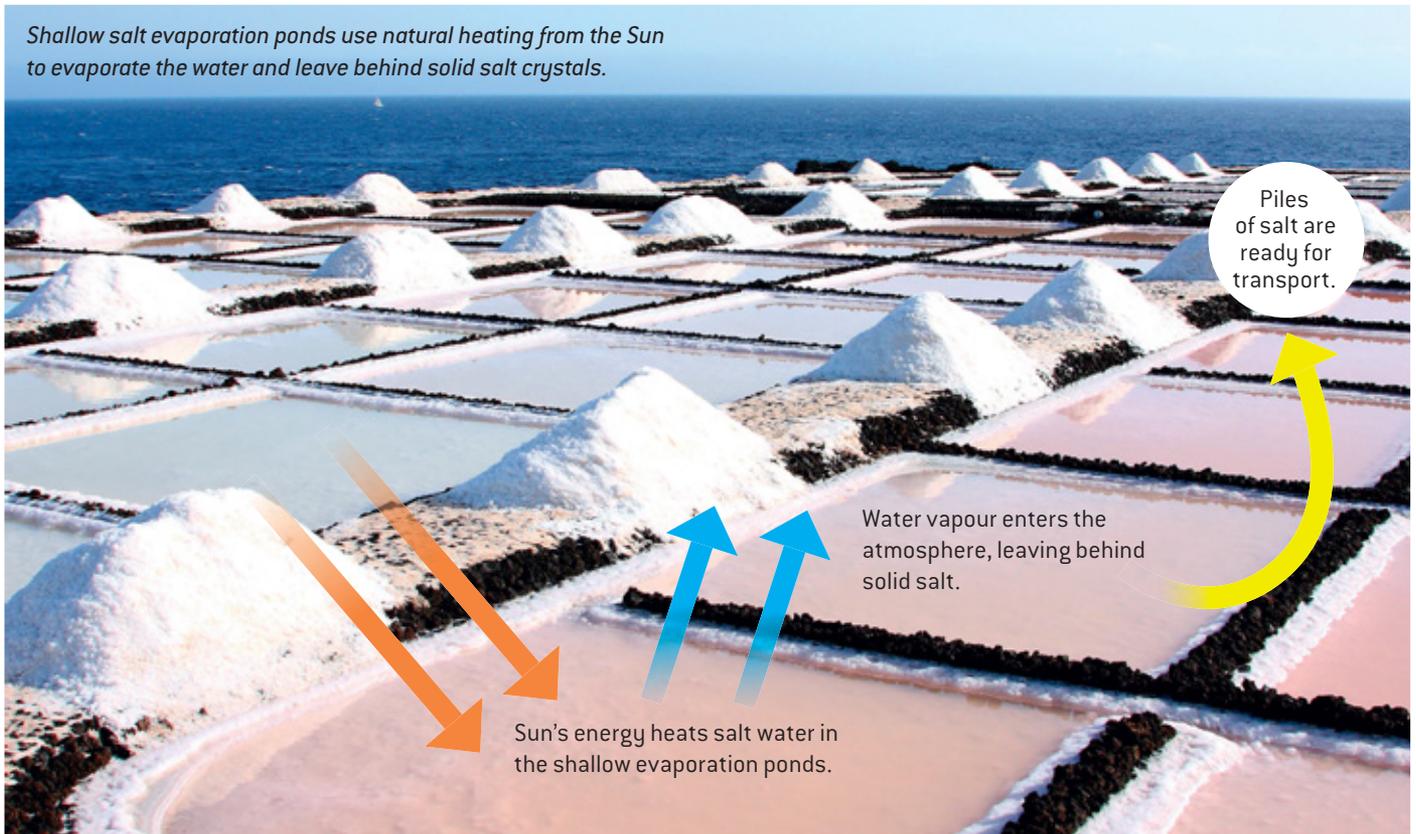
**Evaporation** ponds contain salty water, which the Sun heats up. As the water is heated, some of it evaporates (changes to a gas), eventually just leaving salt behind. Heating the salty water has separated the mixture into salt and water.

Evaporation separates the substances in a solution by removing the solvent, such as water, leaving behind a solid (solute) such as salt.



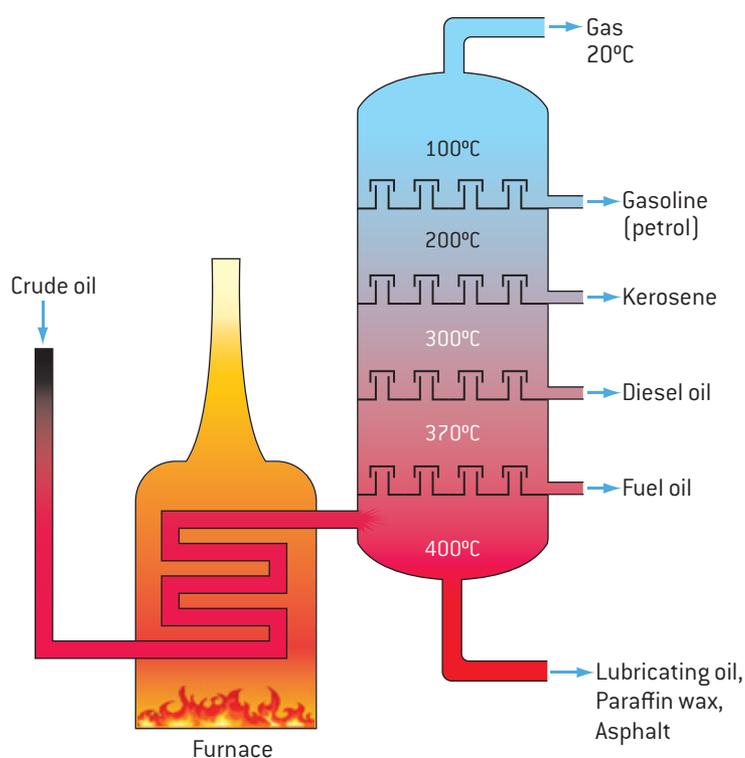
*A solar water still. Moisture evaporates from vegetation and is trapped by a plastic sheet. The condensed liquid drips down into a pot, ready for drinking.*

*Shallow salt evaporation ponds use natural heating from the Sun to evaporate the water and leave behind solid salt crystals.*



## 2 Distillation

**Distillation** also uses evaporation, but this time the evaporated liquid is collected, such as the components of crude oil in the diagram below. The solar water still in the diagram opposite shows how distillation can be used to create fresh water in the bush. The evaporated water is cooled and changed back into a liquid by a process called **condensation**.



*Crude oil is separated into different parts using fractional distillation. This type of distillation can be used to separate different liquids from a mixture because each boils at a different temperature.*

### LOOK IT UP

**chromatography** a method of separation and analysing mixtures of chemicals

**condensation** the change of state from a gas to a liquid

**distillation** a separation technique that uses evaporation and condensation to separate a solid and the solvent in which it has dissolved, such as obtaining pure water from salt water

**evaporation** a change of state from liquid to gas

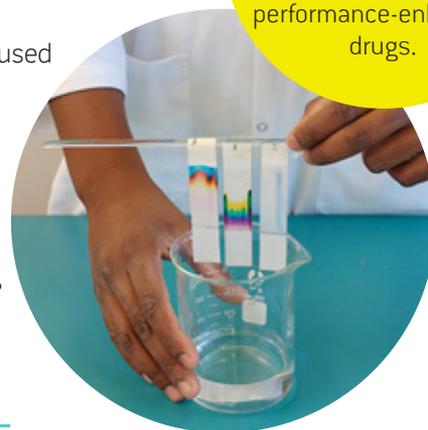
## 3 Chromatography

**Chromatography** can separate dissolved substances that have different colours, such as inks and plant dyes. Some of the coloured substances dissolve better than others, so they travel further up the chromatography paper. Chromatography works because different substances in a mixture flow at different speeds over a solid surface.

You can see paper chromatography in action. Draw small dots with different coloured water-soluble felt tip pens near the bottom of a strip of filter paper. Suspend the paper in a beaker or glass with the dots above a little water. The water starts to creep up the paper, carrying the ink colours with it at different rates. The dried paper is called a paper chromatogram.

More complex and sensitive chromatography instruments can be used to detect even one gram of a substance present in thousands of litres of solution. Chromatography is used to test the urine or blood of athletes for banned substances (such as drugs).

*Paper chromatography can be used to separate samples such as inks and dyes.*



Advanced chromatography techniques are used to test the urine samples of athletes for banned performance-enhancing drugs.



### CHECK IT OUT

- 1 Which separation techniques are used for suspensions and which are used for solutions?
- 2 Which techniques require heating for separation of a solution?
- 3 Explain two different ways in which evaporation is used to separate solutions.
- 4 What is the water extracted from in a solar water still?
- 5 What is chromatography and how is it used to separate mixtures?

# MAKING ICE CREAM

Ice cream is made from milk. Milk is a mixture of fats, water and other substances. It is an example of a suspension that does not easily settle. This is called a colloid, and because milk involves liquid particles suspended in another liquid, milk is a special type of colloid called an emulsion. Combine milk, cream, flavouring and sugar and freeze the mixture, and you have ice cream.

## Making milk and cream

Whole milk from a cow is a mixture of water, protein, carbohydrate, fat, vitamins and minerals. If whole milk is left still, the fat globules separate and rise to the surface as a layer of cream. The skim milk (without cream) sits below.

Milk-processing factories use centrifuges (see page 75) to separate milk and cream. As the centrifuge spins, the heavier milk moves to the outside, and the cream, which has a lower **density**, remains on the inside of the centrifuge.

A different process in the milk-processing factory helps spread the cream evenly throughout the milk so that it won't separate. During **homogenisation**, pumps force whole milk through small holes in a filter. The globules of milk fat are greatly reduced in size and mixed evenly throughout the milk.

Homogenised milk is a suspension that doesn't separate easily.



*Cows' milk is an emulsion (a colloid of two or more liquids). It contains milk fat spread throughout water.*

## Ice-cream science

Like milk, ice cream is an emulsion. In ice cream, molecules of fat are suspended in a water-sugar-ice structure along with air bubbles. The air bubbles mean that you can also call ice cream a foam.

Ice cream contains many ingredients. There is milk fat, which can be added as cream, butter or pure milk fat. The more fat, the creamier the taste.

There are other milk solids, sugar, and air. Stabilisers such as vegetable gums help hold the air-bubble structure together and give the ice cream a better texture. Emulsifiers keep the ice cream smooth and help keep the milk fat evenly spread.

Ice-cream factories combine milk, cream and sugar in huge vats. They heat (**pasteurise**) the mixture to kill any harmful bacteria. Next they add flavour. The mixture is cooled and

whipped by rotating blades. This adds air bubbles. The mixture is frozen, but still soft. Fruit, choc chips and other ingredients are added. The mixture is poured into containers for sale and cooled to around  $-25^{\circ}\text{C}$ .



## EXPERIMENT #5

# QUICK ICE CREAM

**AIM:** TO MAKE YOUR OWN ICE CREAM

### MATERIALS

- 1 tablespoon caster sugar
- $\frac{1}{2}$  cup full-cream milk
- $\frac{1}{4}$  teaspoon vanilla extract (or other flavouring)
- 6 tablespoons rock salt or common salt
- 4-litre sealable bag
- 500-mL sealable bag
- enough ice to half fill the 4-litre bag
- oven mitts or small towel

### SAFETY

Do this activity at home as you must never taste anything that you use or make in a laboratory.

### METHOD

- 1 Half fill the 4-litre bag with ice. Add the salt.
- 2 Pour the milk, sugar, and vanilla extract into the 500-mL bag.
- 3 Carefully seal the bag.
- 4 Place the sealed 500-mL bag into the 4-litre bag with the ice. Seal the 4-litre bag.
- 5 Put on oven mitts or wrap the bag in a small towel and then shake it for five minutes.
- 6 Remove and open the 500-mL bag.
- 7 Try your ice cream.

### DISCUSSION

- 1 Describe the appearance and taste of your ice cream.
- 2 How does the ice cream differ from the initial mixture in the 500-mL bag? Would it taste different if air were not mixed through it?
- 3 Do some research to find out why the procedure requires salt to be added to the ice.



### LOOK IT UP

**density** the mass per unit volume

**homogenisation** making a uniform mixture from two liquids that don't dissolve in each other; for example, making milk fat globules small so that they mix throughout the rest of the milk

**pasteurisation** heating a liquid to kill bacteria without significant change to the food

### CHECK IT OUT

- 1 What are the components of milk?
- 2 What properties of milk does a centrifuge rely on to separate key ingredients?
- 3 Describe why ice cream is referred to as an emulsion.
- 4 What is pasteurisation and why is it done?

# MIXTURES

## IS IT A MIXTURE OR IS IT PURE? (PAGES 62–63)

- 1 What is a pure substance?
- 2 What are the two different types of pure substances?
- 3 Explain what an element is and give an example.
- 4 Explain what a compound is and give an example.
- 5 Look at the following image.



- a Which two elements combine to form water?
  - b How many atoms of each element combine to form a molecule of water?
  - c Is water a pure substance or a mixture? Why?
- 6 Why do you think the components of a compound might be difficult to separate?
  - 7 Give three examples of compounds you might find in your home.
  - 8 What is a mixture?

## SOLUTIONS (PAGES 64–65)

- 9 A soft drink is described as a solution. Why?
- 10 In a cup of coffee, what is the solute and what is the solvent?
- 11 'My mother likes strong tea.'
  - a Explain what this sentence means and how you would make your mother's tea.
  - b What scientific term would you use to replace the word 'strong'?
- 12 Which of the following solutions has the greatest concentration?
  - a a cup of water with one teaspoon of coffee
  - b a cup of water with half a teaspoon of coffee
  - c half a cup of water with one teaspoon of coffee
- 13 Why is water described as a good solvent?

## SUSPENSIONS (PAGES 66–67)

- 14 List three suspensions that you might find in daily life.
- 15 How do the particles in a suspension differ from those in a solution?
- 16 Explain why muddy water is an example of a suspension.

## COLLOIDS (PAGES 68–69)

- 17 Place the following words in the appropriate spaces to complete the table below:

gel   smoke   fog   foam

| COLLOID | TYPE            |
|---------|-----------------|
|         | gas in liquid   |
|         | liquid in gas   |
|         | solid in gas    |
|         | liquid in solid |





### FILTERS (PAGES 70–71)

- 18 Explain why it is important to fold filter paper before putting it inside a filter funnel.
- 19 What might happen if the holes in a vacuum filter were bigger?
- 20 Flyscreens are a type of filter. Explain what the residue and the filtrate would be when using a flyscreen.
- 21 Explain what is happening in the image above. Use the terms 'filtrate' and 'residue' in your response.

### SEPARATING SUSPENSIONS (PAGES 74–75)

- 22 Explain where sedimentation occurs in everyday life.
- 23 What is the function of a centrifuge?
- 24 Explain how flocculation might help clean the swimming pool shown below.

### 3 WAYS TO SEPARATE SOLUTIONS (PAGES 76–77)

- 25 Explain how a solution can be separated into its components by evaporation. Use the terms 'solvent' and 'solute' in your answer.
- 26 What is the difference between the techniques of evaporation and distillation?
- 27 Chromatography is used in forensic science to investigate crimes. What kinds of substances do you think forensic scientists would use chromatography on?

### MAKING ICE CREAM (PAGES 78–79)

- 28 Explain why milk needs to be homogenised.
- 29 Why are milk and ice cream classified as emulsions?



## KEY IDEAS

# 1

All matter can be classified as either a pure substance or a mixture. A pure substance is made up of all of the same particles and can be an element (such as hydrogen, carbon or gold) or a compound (such as water or salt). A mixture is made up of two or more pure substances.



# 2

A solution is usually transparent as the tiny particles are spread evenly throughout it. A solution contains a solute, such as sugar, which dissolves into a solvent, such as water.

# 3

Suspensions contain insoluble particles and will often separate if left still. Cocoa in milk is an example of a suspension. It needs to be stirred or heated to prevent sediment forming on the bottom.

# 4

Colloids are suspensions that don't separate easily. Colloids take many forms including foam, fog, gels and smoke.

# 5

An emulsion is a colloid of two or more liquids. Milk is an example of an emulsion, with tiny droplets of milk fats and oils spread through water.

# 6

Filters are used to separate suspensions by using holes of different sizes. In filtration, the filtrate passes through the filter and a residue is left behind.

# 7

Two other methods for separating suspensions are centrifuging (spinning) and sedimentation (settling).

# 8

The components of a solution can be separated by evaporation, which vaporises the solvent (such as water) and leaves behind the solute (such as salt). Distillation involves evaporating the solvent and then condensing and collecting it. Chromatography separates dissolved substances that have different colours, such as inks and dyes.



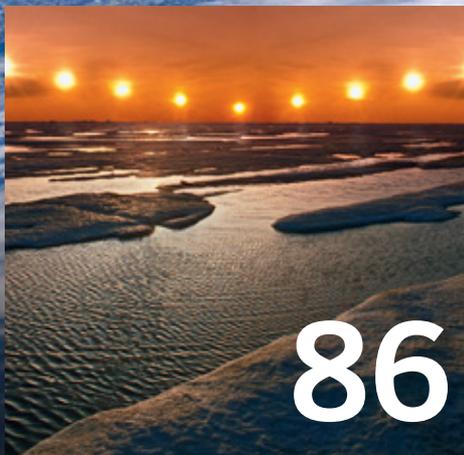
# EARTH IN SPACE 05

HOW DO WE  
EXPLORE  
SPACE?

WHY  
do we have  
\*4\*  
SEASONS?

WHAT CAUSES  
NIGHT AND DAY?

What causes high  
and low tides?



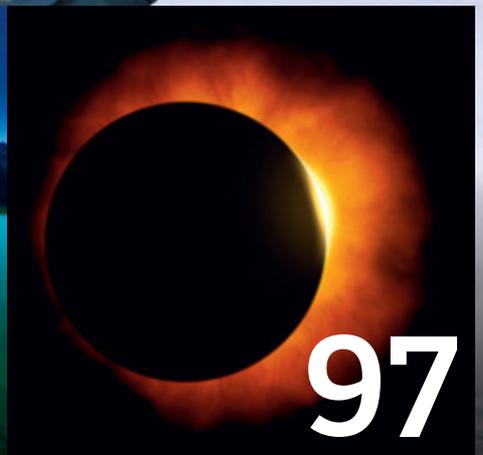
86

WHERE THE SUN  
NEVER SETS



90

MYSTERIOUS  
MOONLIGHT



97

ECLIPSING  
THE SUN

# LIVING ON PLANET EARTH

## Planets in our solar system

- ☀ Distance from the Sun
- Diameter
- 🕒 Time to orbit the Sun

**Mercury**  
☀ 57.9 million km  
● 4900 km  
🕒 88 days

**Venus**  
☀ 108.2 million km  
● 12 100 km  
🕒 224.7 days

**Earth**  
☀ 149.6 million km  
● 12 800 km  
🕒 365.25 days

**Mars**  
☀ 227.9 million km  
● 6800 km  
🕒 686.97 days

**Jupiter**  
☀ 778.3 million km  
● 143 000 km  
🕒 4331.57 days

Earth is one of the eight **planets** in our solar system. The solar system also contains moons, asteroids, comets, minor planets and many other objects. The Sun is at the centre of our solar system and the planets revolve around it.

The oval path travelled by the planets and the moons is called an **orbit**. The planets orbit around our closest star, the **Sun**. The four inner planets – Mercury, Venus, Earth and Mars – are sometimes called **terrestrial planets** because of their rocky surfaces. The four outer planets – Jupiter, Saturn, Uranus and Neptune – are known as **gas giants** because they don't have a solid surface. There are several dwarf planets beyond Neptune, including Pluto, Eris, Haumea, and Makemake, plus several others thought to be dwarf planets, and hundreds of minor planets.

## The Earth in space

The Earth orbits around the Sun, our nearest star. The Sun's **gravitational pull** holds the Earth, and all the other objects in our solar system, in its orbit.

The Sun is the centre of our solar system and is vital to life on Earth. Solar energy from the Sun provides both heat and light.

Different parts of the Earth heat up by different amounts, creating changes in air pressure in the atmosphere. These differences in air pressure drive our

weather systems. A low pressure system may bring moist air, clouds, stormy weather and strong winds, whereas a high pressure system may bring dry air, light winds and fair weather.

Plants capture energy from the Sun in a process known as photosynthesis to survive and grow. As they do so, plants give out oxygen into the atmosphere. Oxygen is necessary to sustain most life on Earth.



**Saturn**  
☀️ 1427.0 million km  
🌀 125 000 km  
🕒 10 832.33 days

**Uranus**  
☀️ 2871.0 million km  
🌀 51 100 km  
🕒 30 799.09 days

**Neptune**  
☀️ 4497.1 million km  
🌀 49 500 km  
🕒 60 189.55 days

## The Sun

Our Sun is a star. It is only an average-sized star, but it is still a huge ball of hot gas that is 110 times as wide as the Earth. Our Sun is mainly yellow and has a temperature of about 5500°C at the surface. Stars make light of different colours because of their different temperatures. Cool stars are red or orange. Medium-hot stars like the Sun are yellow, and blue stars are the hottest of all.

The energy that the Sun gives out is released in the core of the Sun. Here, hydrogen is converted to helium in nuclear reactions. A massive amount of energy is released in the process.

### LOOK IT UP

**gas giant** a large planet, such as Jupiter, that is made up mainly of hydrogen and helium

**gravitational pull** the invisible force that causes objects to pull towards each other

**orbit** to revolve around; planets in our solar system orbit the Sun

**planet** a large object that orbits a star such as the Sun

**Sun** the yellow star that is the centre of the solar system; provides heat and light to sustain life on Earth

**terrestrial planet** a planet, such as Earth, that is made of rock and metal

### CHECK IT OUT

- 1 What holds the planets in our solar system in orbit around the Sun?
- 2 How does solar energy sustain life on Earth?
- 3 How are the four planets that are closest to the Sun different from the next four planets from the Sun?
- 4 How much larger than Earth is the Sun?
- 5 How long does it take for Neptune to orbit the Sun?

# NIGHT AND DAY

The Earth spins once every 24 hours. This causes night and day. The part of the Earth that faces the Sun experiences day, while the part of the Earth that faces away from the Sun experiences night. People see the Sun rise in the east when the face of the Earth where they are located spins towards the Sun. People see the Sun set in the west when the Earth spins away from the Sun.

## Night and day

Night and day are caused by the Earth spinning on its **axis**. The Earth's axis is an imaginary straight line that runs from the North Pole to the South Pole. The axis is tilted at an angle of  $23.5^\circ$  from the vertical. All parts of the Earth experience day and night, but they experience it at different times because the Earth rotates. Only half of the Earth is in sunlight at a given time. The other half is in shadow. The part that faces the Sun is having daytime and the part facing away from the Sun is having night.

## How does the Sun rise and set?

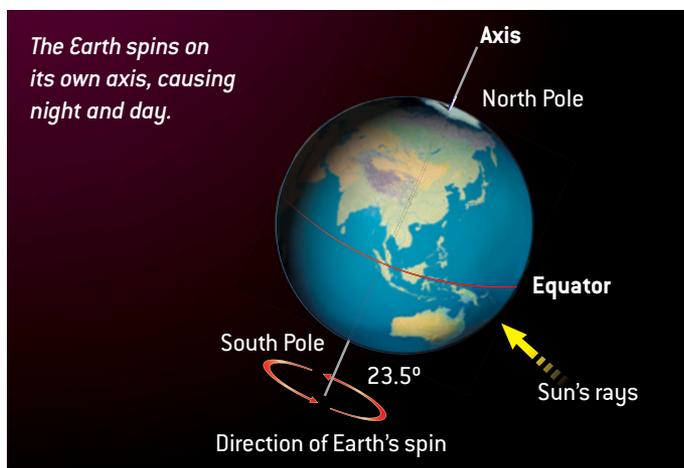
The Earth rotates from west to east. We know this because, as the Earth spins towards the Sun, we see the Sun rise above the horizon in the eastern sky. Sunset occurs when your part of the Earth rotates away from the Sun. Australia's east coast capital cities of Hobart, Melbourne, Sydney and Brisbane see sunrise each day before Perth on the west coast. During the day, the Sun appears to move across the sky. In fact, it doesn't move at all. As the Earth rotates, it looks as though the Sun is moving.

## The Earth's rotation

As the Earth spins, we are also moving with it. If you were standing on the **equator** you would actually be travelling at 1670 kilometres per hour! However, because gravity holds us tight to the surface of our planet, we move with the Earth and don't even notice its rotation. Locations further from the equator move more slowly. In Brisbane, for example, you will move at 1480 kilometres per hour; in Hobart, 1230 kilometres per hour. If you were at the North or South Pole you wouldn't move – you would just turn on the spot, completing one rotation in 24 hours.

## Long polar nights and days

The Sun doesn't rise and set every day at the poles. It rises just once a year at the spring **equinox** and sets at the autumn equinox. If you lived at the North or South Pole, you would have six months of daytime, starting in spring. The Sun would then set at the autumn equinox and you would have six months of night. An equinox is a time when the Sun is directly over the equator. This occurs twice a year: on 20–21 March (autumn equinox) and on 22–23 September (spring equinox) in the southern **hemisphere**. During an equinox, day length and night length are equal.





The Earth rotates 15 degrees every hour. It rotates a full circle (360 degrees) every day.

The side of the Earth facing the Sun experiences day.

The side of the Earth facing away from the Sun experiences night

The Earth rotates towards the east.

### LOOK IT UP

**axis** an imaginary line running through the centre of an object such as Earth

**equator** an imaginary line around the Earth dividing the Earth into the northern and southern hemispheres

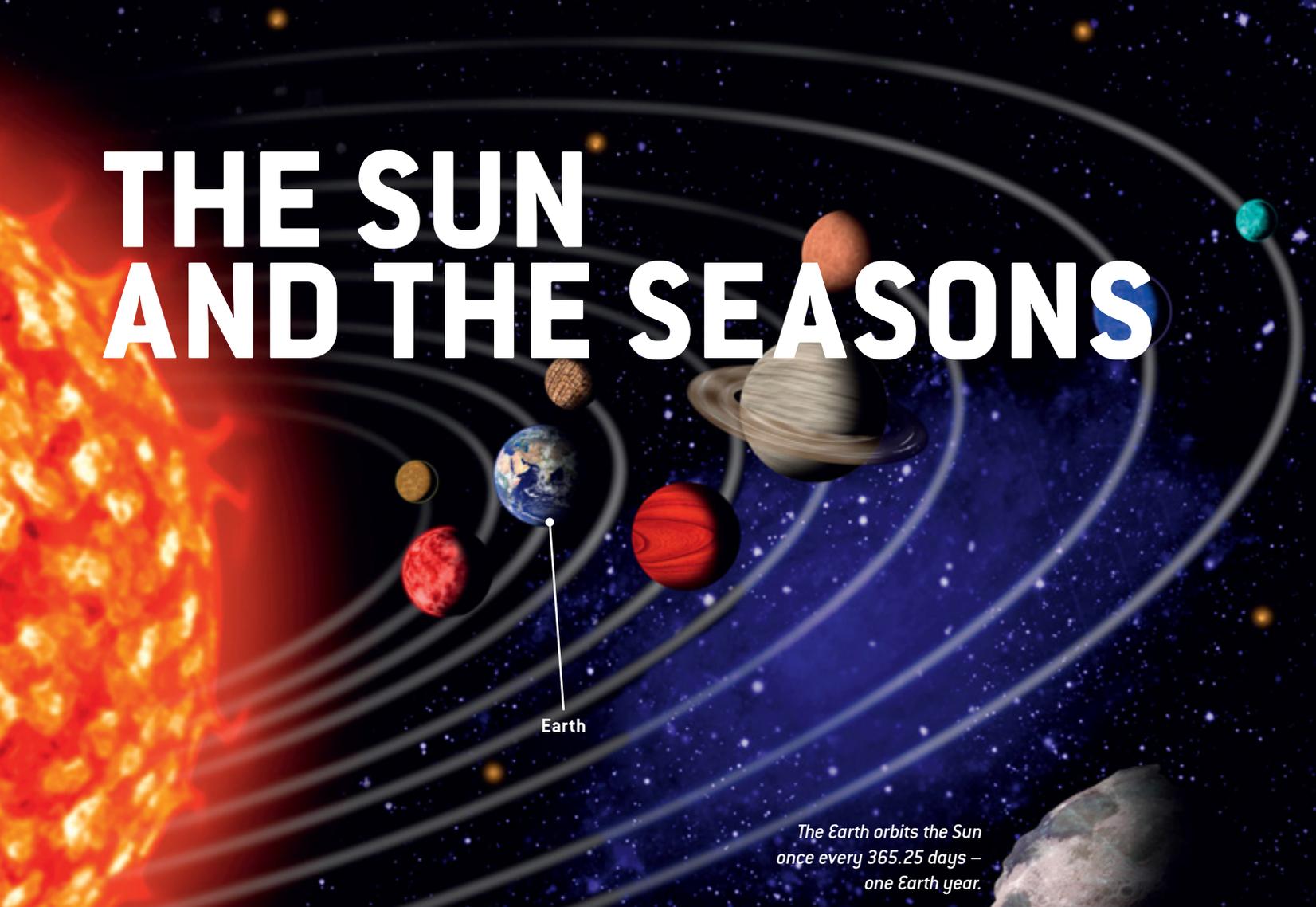
**equinox** the time (twice a year) at which the Sun is directly over the equator; when day and night are of equal length

**hemisphere** half the Earth as divided by the equator

### CHECK IT OUT

- 1 How quickly does the Earth spin at the equator compared to the poles?
- 2 Explain what causes sunrise.
- 3 Does the Sun move across the sky each day? Explain your answer.
- 4 Why do we see the Sun rise in the east and set in the west?
- 5 Describe the motion of the Sun at the South Pole during the middle of summer.

# THE SUN AND THE SEASONS



Earth

*The Earth orbits the Sun once every 365.25 days – one Earth year.*

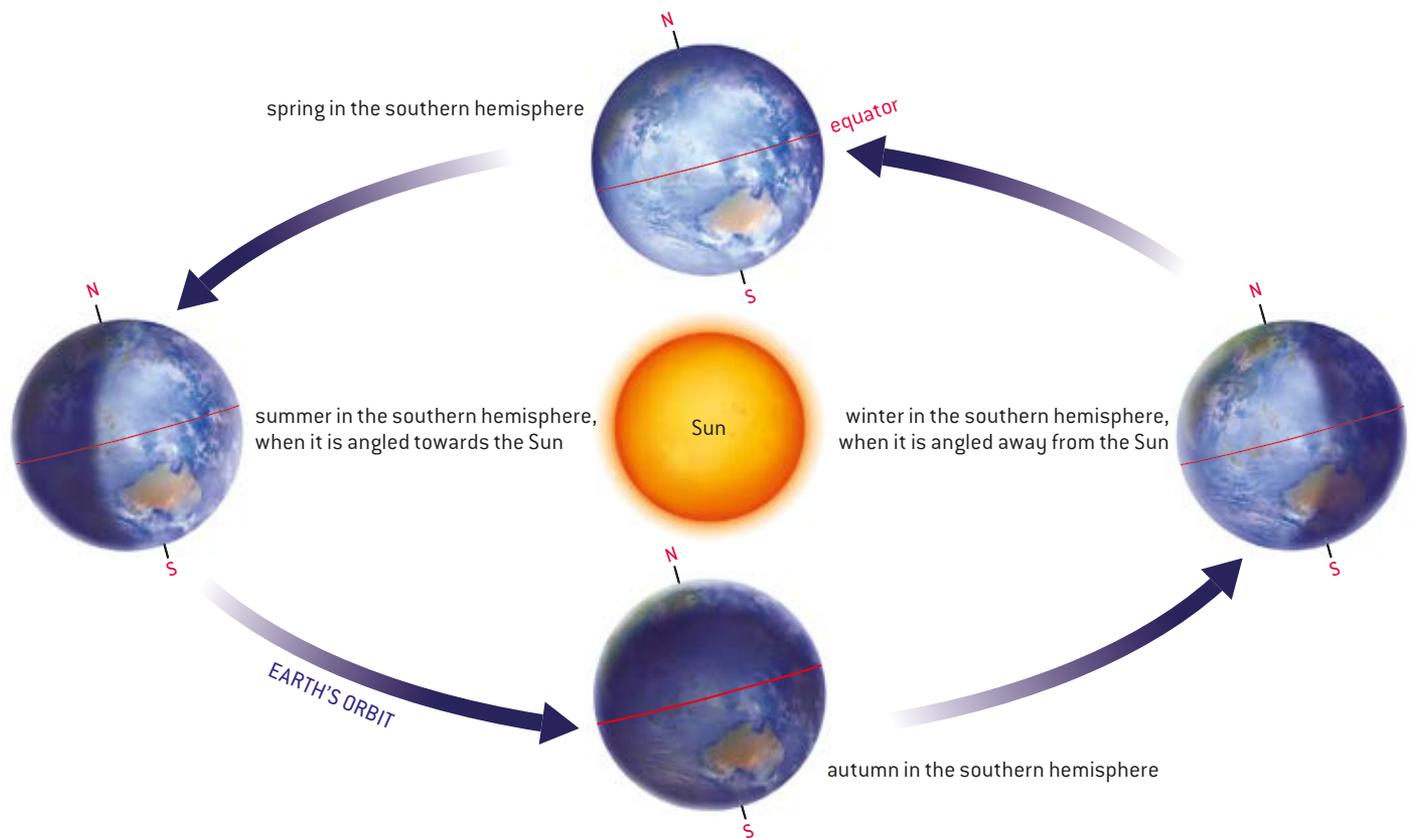


*Deciduous plants change with the seasons.*

The Earth takes a little more than 365 days (one year) to orbit the Sun. During this orbit, the amount of sunlight reaching Australia changes. This causes changes in our seasons. When it is summer in Australia (in the southern hemisphere) it is winter in the northern hemisphere.

## A year on Earth

The ancient Egyptians developed calendars that recognised the change of seasons in one year. A year is also the time it takes a planet to make one orbit around the Sun. The Earth does this in about 365.25 days. Our calendar is set up so that a year has an exact number of whole days: we usually have a 365-day year. An extra day is added to the month of February every four years to make up the difference. This is known as a leap year. Mars takes about twice as long as the Earth to orbit the Sun; therefore, a year on Mars is twice as long as an Earth year. A year on Mars is about 687 days.



The tilt of the Earth on its axis causes the northern and southern hemispheres of the Earth to point towards or away from the Sun as the Earth orbits the Sun. This causes different parts of the Earth to experience seasons. The northern hemisphere experiences winter when the southern hemisphere is experiencing summer.

## The seasons

The seasons are caused by the tilt of the axis around which the Earth rotates each day. The tilt of the Earth on its axis causes the northern hemisphere or southern hemisphere to face towards or away from the Sun as the Earth orbits the Sun.

In the middle of the year, the northern half of the Earth's sphere experiences summer when it is tilted towards the Sun, while the southern hemisphere experiences winter because it is tilted away from the Sun. Six months later in January, the southern hemisphere experiences summer because the Earth moves along its orbit to the other side of the Sun.

Australia experiences summer when the southern hemisphere is tilted towards the Sun. At this point of the Earth's orbit around the Sun, Earth is closer to the Sun. This results in a warmer summer than the northern hemisphere summer. Countries closer to the North and South Poles experience greater changes in the seasons than countries closer to the equator. In places near the equator, which have no winter, summer, spring or autumn, the year is divided into alternating wet and dry seasons.

### CHECK IT OUT

- 1 How do the Earth and the Sun interact to create the seasons we experience on Earth?
- 2 Explain the difference between the Earth's rotation on its own axis and its orbit around the Sun.
- 3 How long does the Earth take to complete:
  - a one rotation on its axis?
  - b one complete orbit of the Sun?
- 4 What season does the northern hemisphere experience when the southern hemisphere is experiencing summer?
- 5 During which season is Australia tilted away from the Sun? What type of climate does Australia experience at this time and why?
- 6 What is a leap year and why do we need them?



*Moonlight is light reflected from the Sun. The Moon does not produce its own light.*

# EARTH AND MOON

The Moon is the Earth's natural **satellite** (an object that orbits a planet). It is a ball of rock about a quarter of the size of the Earth. It slowly spins as it orbits the Earth. The Moon rotates only once as it orbits the Earth every 27.3 days. For this reason only one side of the Moon can be seen from the Earth.

## Viewing the Moon

The Italian **astronomer** Galileo Galilei was the first scientist to describe mountains and craters on the Moon, in 1609, based on his observations through a **telescope**. Before the invention of the telescope, people had thought the Moon was smooth. Scientists in the 1600s even described large flat plains called *maria* (Latin for 'seas') because they look like dark oceans. We now know these plains to be solidified lava.

Unlike the Sun, the Moon does not create its own light. Instead, it reflects sunlight. The amount of reflected light that we can see from Earth varies greatly with the different phases of the Moon. We always see the same side of the Moon from Earth because its orbit takes the same time as its rotation. The other side of the Moon, which we cannot see from the Earth, is often called the 'dark side of the Moon' even though it experiences a period of light every lunar day.

The Moon rises and sets on the horizon, just like the Sun. The Moon rises about 50 minutes later from one day to the next. During the day, the sky is bright so the Moon is harder to see than at night.

### MOON PHASES: SOUTHERN HEMISPHERE ORIENTATION

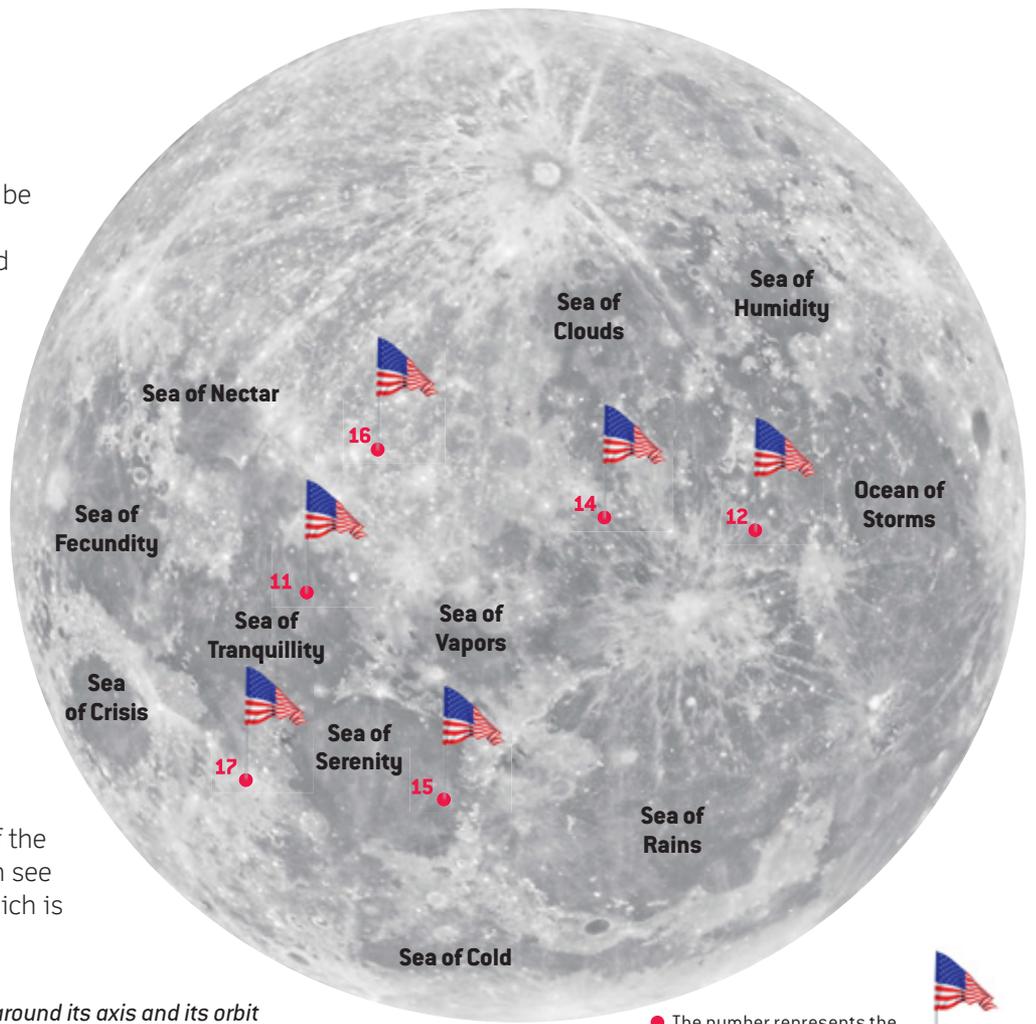


# Phases of the Moon

Sometimes only part of the Moon can be seen in the night sky. You might see half a Moon, a crescent or a fully round Moon. Sometimes the Moon can't be seen at all. These changes in the appearance of the Moon are called phases of the Moon.

Of course, the Moon does not change shape – it is always round. The apparent change in shape is caused by changes to how much of the Moon lit by the Sun can be seen from the Earth. We are really looking at the day and night parts of the Moon.

When the Moon is in the sky but not able to be seen it is called a new Moon. It will then appear to become fuller over a few days, which is called waxing. When we can see the whole of the Moon we call this a full Moon. We then see less of the Moon over several days, which is called waning.



*The Moon's rotation around its axis and its orbit around Earth are about the same, so we see the same side of the Moon all of the time. Using an early telescope, Galileo Galilei described the Moon's surface in 1609. Scientists had earlier described the large flat plains as 'seas' because they looked like dark oceans.*

● The number represents the mission, for example, **Apollo 11**

## LOOK IT UP

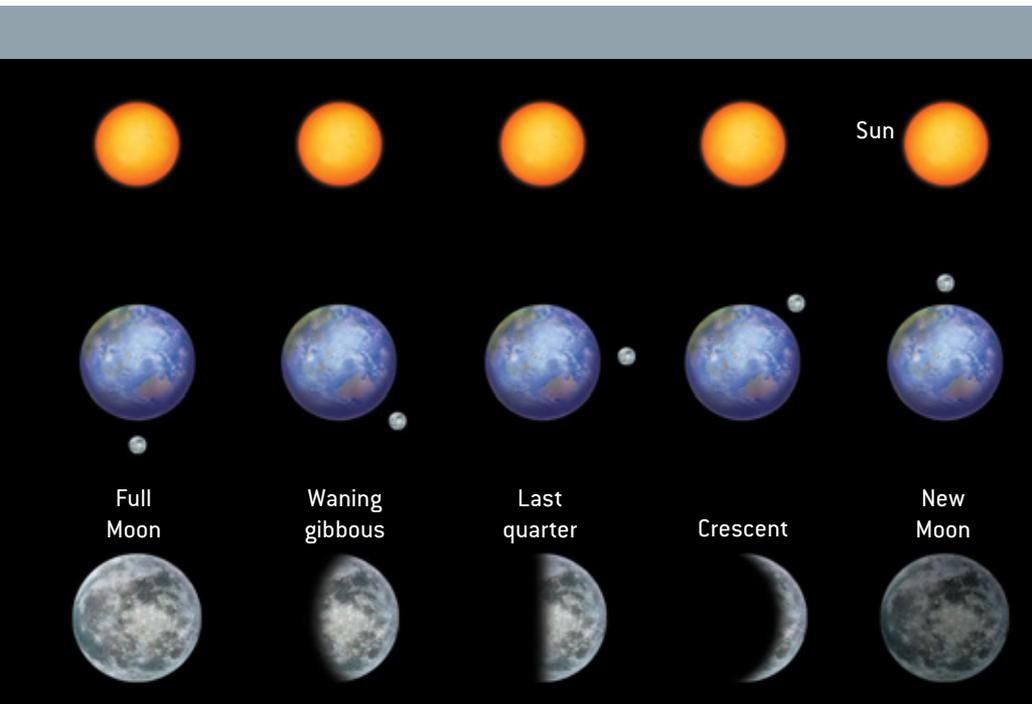
**astronomer** a scientist who studies planets, stars and all the other objects in the universe

**satellite** an object that orbits (revolves around) a planet

**telescope** an optical instrument used to view distant objects

## CHECK IT OUT

- 1 Why do we always see the same side of the Moon when we view it from the Earth?
- 2 What is moonlight?
- 3 Does the Moon change shape as it moves through its different phases?
- 4 What phases of the Moon come directly before and after a full Moon?
- 5 What are the 'seas' on the Moon that scientists in the 1600s observed?



# MAN LANDS ON THE MOON

**‘That’s one small step for man, one giant leap for mankind.’**

Astronaut Neil Armstrong spoke on television to a live audience around the world as he descended the steps of the *Eagle* lunar module to be the first person to set foot on the Moon.

21 July 1969

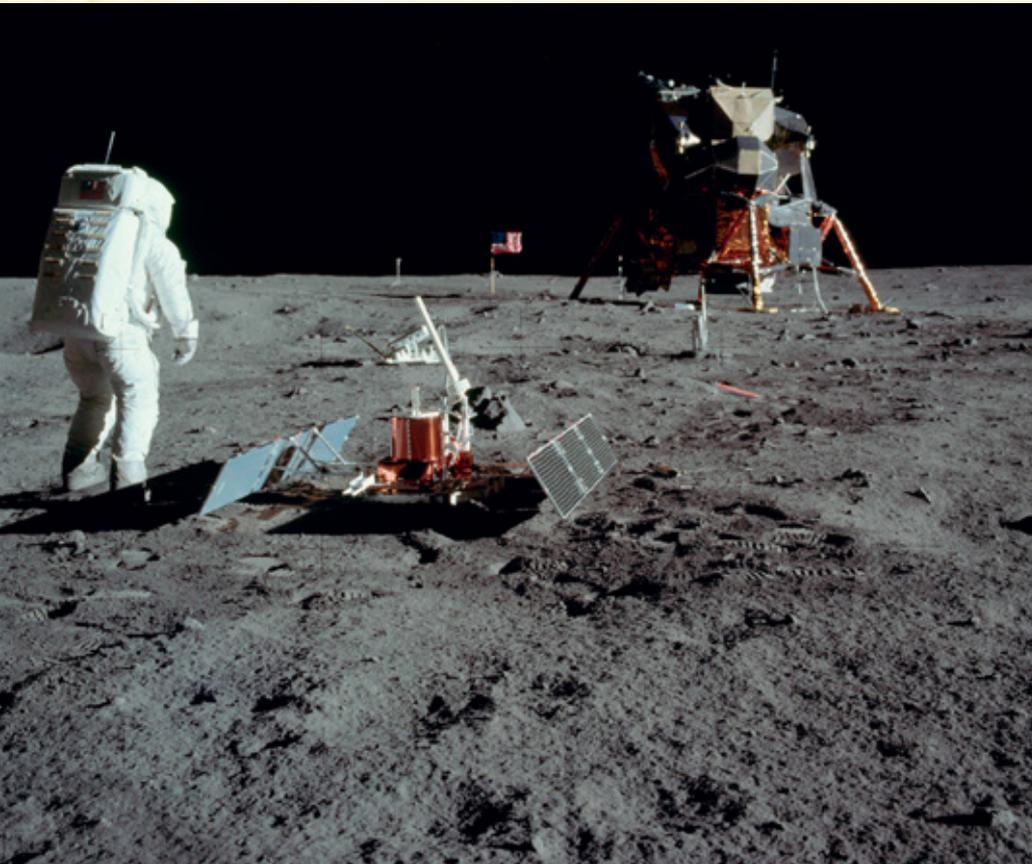
Buzz Aldrin walking on the surface of the Moon during today’s historic Moon landing. Neil Armstrong, the first person on the Moon, can be seen in the reflection on Aldrin’s visor, along with the *Eagle* lunar module.

THE HISTORIC MOON LANDING caps off an epic week that had the world on the edge of their seats. *Apollo 11* astronauts Neil Armstrong, Buzz Aldrin and Michael Collins blasted off from Kennedy Space Center at 9.32 am on 16 July in the *Saturn V* three-stage rocket.

In today’s historic Moon landing, Collins orbited the Moon in the *Columbia* command module while Armstrong piloted the *Eagle* lunar module to the surface of the Moon with Buzz Aldrin on board. He

needed to manually pilot the ship past a boulder field, before setting down the lunar module in the Sea of Tranquillity. The lunar module landed at 8.18 pm, Universal Time, with only 30 seconds of fuel remaining.





Aldrin setting up an experiment on the Moon's surface.

Armstrong contacted mission control with the news everyone had been waiting for: 'Houston, Tranquillity Base here. The *Eagle* has landed.' Mission Control celebrated as a controller replied to Armstrong and Aldrin, 'You got a bunch of guys about to turn blue, we're breathing again'.

At 2 am Universal Time, Armstrong climbed down the ladder of the lunar module and, with more than half a billion people watching on television, he proclaimed, 'That's one small step for man, one giant leap for mankind'.

Twenty minutes later, Buzz Aldrin joined Neil Armstrong, and the two NASA astronauts explored the Moon's surface for two and a half hours, taking photographs and collecting soil and rock samples.

The astronauts planted an American flag and left a plaque on one of *Eagle's* legs. It reads, 'Here men from the planet Earth first set foot upon the Moon. July 1969 A.D. We came in peace for all mankind'.

Armstrong and Aldrin detached the top of the *Eagle* module from the bottom to get ready for the trip back to the *Columbia* command module. While preparing for lift-off the astronauts found that they had broken the ignition switch. Instead they used a pen to push the circuit breaker in to start the launch sequence.

Fuel was critically low in the lunar module, but there was enough to leave the lunar surface. Armstrong and Aldrin then docked with *Columbia*.

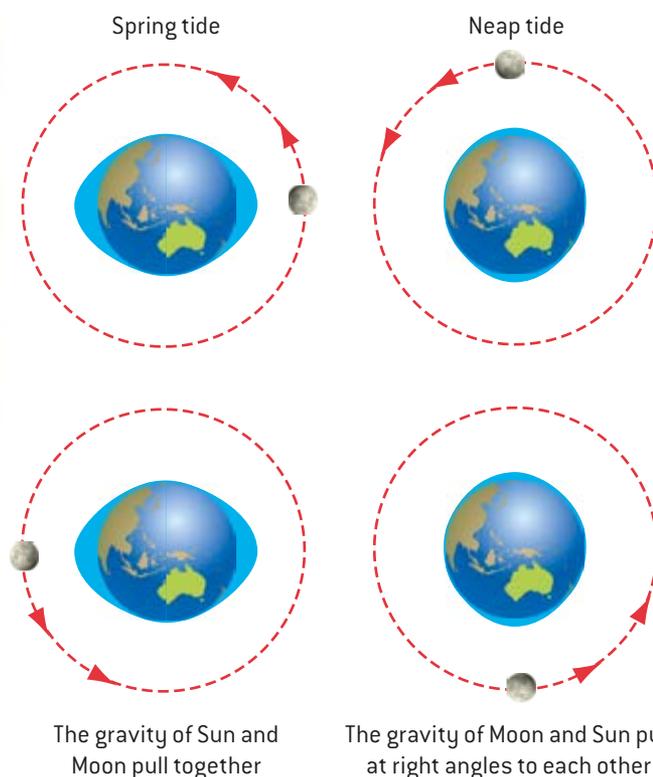
The *Saturn V* rocket carrying the *Apollo 11* spacecraft blasted off on 16 July 1969. The spacecraft had three parts: the command module, with a cabin for the astronauts; a service module, with power, oxygen and water for the command module; and a lunar module for landing on the Moon.

### CHECK IT OUT

- 1 Where on the Moon did humans first land?
- 2 What did Neil Armstrong and Buzz Aldrin collect on the Moon? Why do you think they did this?
- 3 Why do you think Mission Control were so excited that *Apollo 11* had landed safely on the Moon?
- 4 The news report finished with the astronauts returning to the command module. What stages of the mission were yet to come?
- 5 Why do you think people thought it was important to visit the Moon?

# CHANGING TIDES

**Tides** are the rise and fall in ocean levels that happen along the world's sea shores twice every day. The gravitational pull of the Moon as it orbits Earth causes a bulge in the water on the side of the Earth facing the Moon, leading to a high tide. The gravitational pull of the Sun also contributes to tides. On the other side of the Earth, the water also bulges due to a force that counterbalances the gravitational pull, called **inertia**.



Small high tide

*The Sun adds to the Moon's gravitational pull to create spring and neap tides.*

## Tides

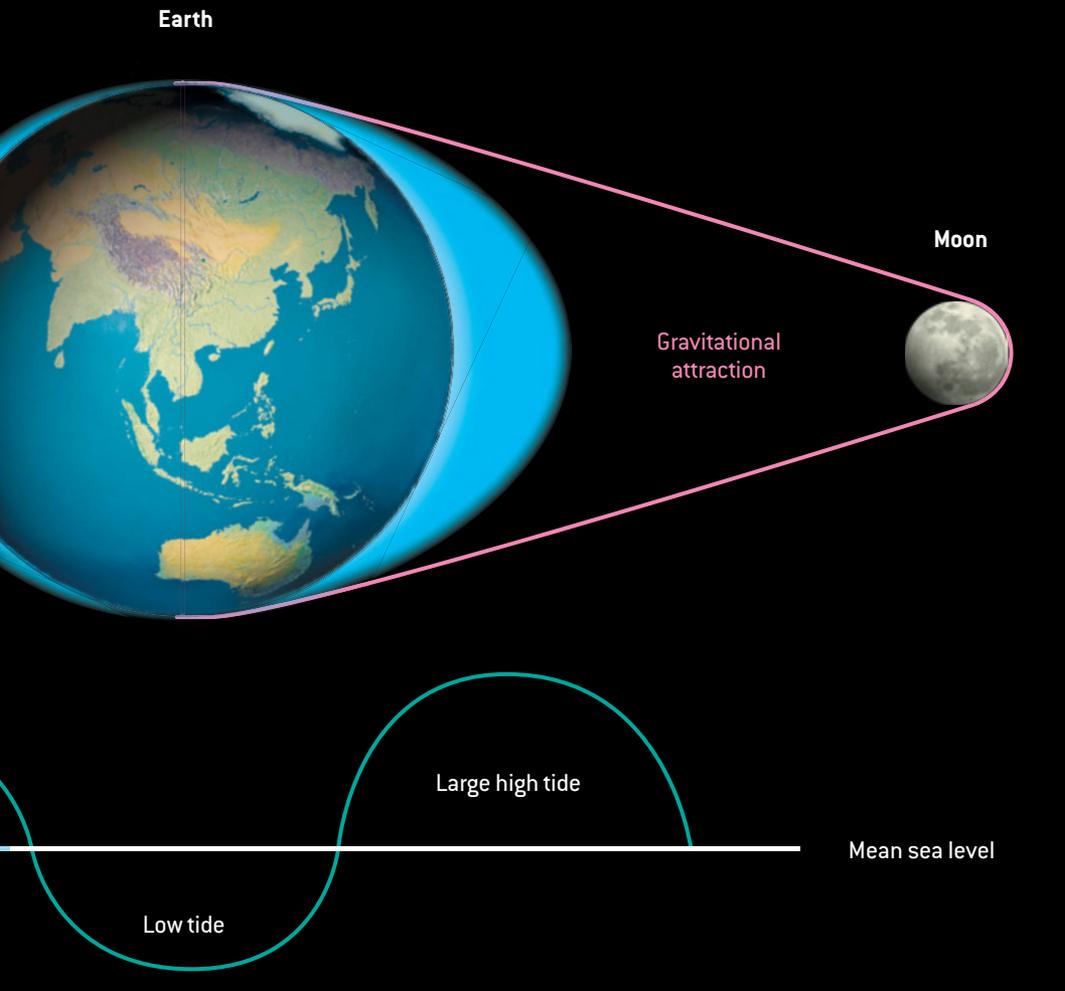
The Earth's **gravity** (gravitational pull) holds the Moon in orbit. The Moon has its own gravity, even though it is far less than that of the Earth. Gravity is related to the size and mass of an object, and also to how far away it is from objects on which it acts. The Moon is about 27 million times smaller than the Sun so its gravity is much weaker, but it is about 400 times closer to the Earth than the Sun, so its gravitational pull affects our tides more than the Sun does.

As the Moon travels around the Earth, and as both bodies travel around the Sun, the change in the force of gravity causes the world's oceans to rise to high tides and fall to low tides. The Earth takes 24 hours to make one rotation around its axis, but at the same time the Moon is orbiting the Earth, so the time it takes for the

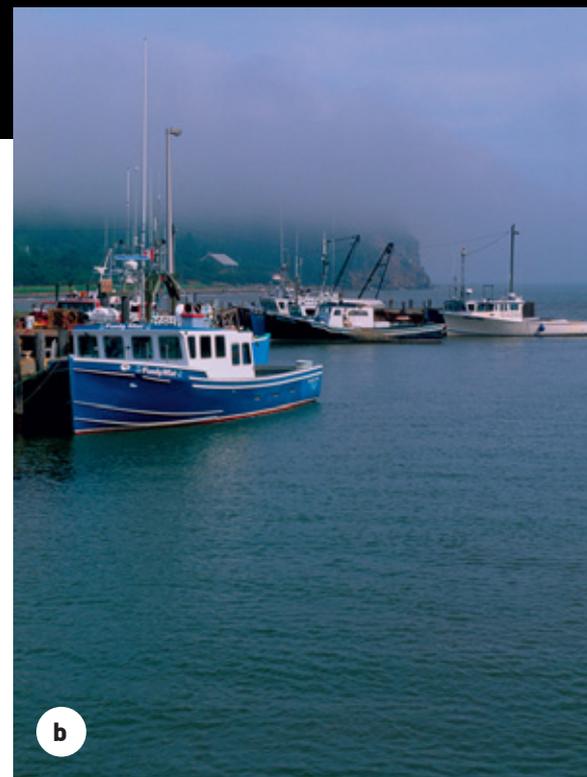
Moon to return to the same point above the Earth is 24 hours and 50 minutes. This means that two high tides occur each day, about 12 hours and 25 minutes apart. High tides happen when the Moon's gravitational field is pulling on the seas facing the Moon, and on the opposite side of the Earth due to the inertia effect. Low tides occur on the other sides of the Earth.

When the Sun, the Moon and the Earth are aligned during a full or a new Moon, the gravitational pull of the Sun and Moon act together to cause very high and very low tides, known as **spring tides**. Smaller **neap tides** happen during the Moon's quarter phases. At these times, the Sun and the Moon are at right angles to the Earth and the gravitational pull of the Sun counteracts the pull of the Moon.

The Moon's gravitational pull on the Earth and its oceans causes high and low tides.



The biggest change in the depth of water between (a) low and (b) high tide occurs at the Bay of Fundy in Nova Scotia, Canada. The narrow, funnel-shaped inlet causes changes in depth of up to 17 metres.



## LOOK IT UP

**gravity** the force of attraction that objects have towards one another due to their masses

**inertia** the tendency of an object to resist changes in its motion while either at rest or in constant motion

**neap tide** smaller tides that occur when the Sun is at right angles to the Moon

**spring tide** very high and low tides when the Sun, Moon and Earth are in a line

**tide** the rise and fall in water level that occurs on sea shores twice a day

## CHECK IT OUT

- 1 How does the Moon cause a high tide to occur on both sides of the Earth at once?
- 2 The Sun is much larger than the Moon, but it doesn't have the same impact on tides. Why is this the case?
- 3 Why are there two high tides and two low tides each day?
- 4 What is a spring tide and when does it happen?
- 5 What difficulties do you think changing tides might cause people on the Bay of Fundy in Canada?

# ECLIPSES

An **eclipse** happens when the light from the Sun is blocked by a body, such as the Earth or the Moon.

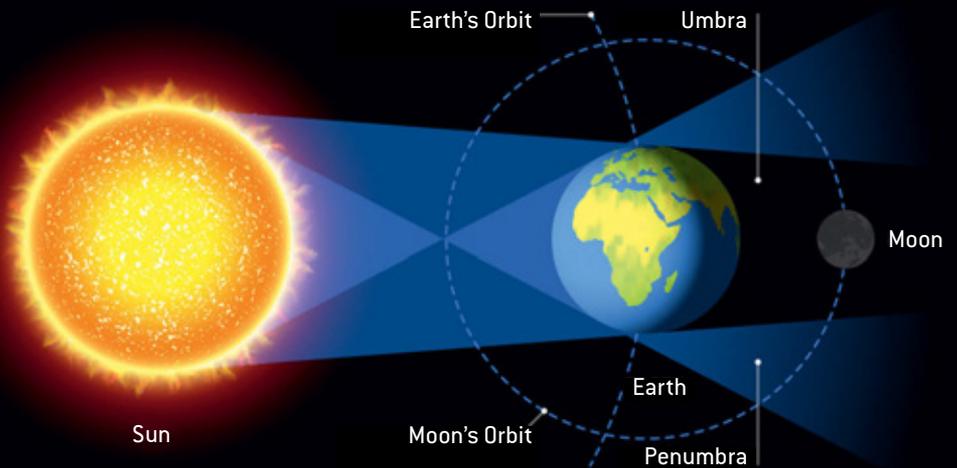
## Lunar eclipse

A lunar eclipse happens when the Earth moves between the Moon and the Sun. The Moon passes into the Earth's shadow and appears dark.

A lunar eclipse can only happen during a full Moon. However, they don't happen every full Moon because the angle of the Moon's orbit around the Earth is slightly different to the Earth's orbit around the Sun. An eclipse only happens when all three celestial bodies are lined up.

When the Moon passes completely into the Earth's shadow, it doesn't go completely dark. Some light still reaches the Moon from around the edges of the Earth, because it is bent and made red by the Earth's atmosphere. This light reaches the Moon and is reflected by it, and this is what causes the eclipsed Moon to appear red.

A total lunar eclipse lasts up to one and three-quarter hours while a total solar eclipse can last just over 7 minutes. This is because the Earth casts a much bigger shadow on the Moon than the Moon can on the Earth.



*A lunar eclipse occurs when the Moon passes into the Earth's shadow.*



*The stages of a lunar eclipse gradually reveal a red Moon as some of the Sun's light bends around the Earth and is reflected from the Moon's surface.*

# Solar eclipse

The Moon passes between the Sun and the Earth once every 29.5 days. Sometimes, the Moon will be in a position where it blocks some of the light from the Sun. This is known as a solar eclipse. During a total solar eclipse, the Moon blocks the whole disk of the Sun. This causes the sky to go dark for a short time during the day.

A solar eclipse is only visible on the part of the Earth on which the Moon's shadow is cast. Those parts of the Earth within the **penumbra** see a partial eclipse of the Sun, while those within the central path of the Moon's shadow, or **umbra**, experience a total eclipse.

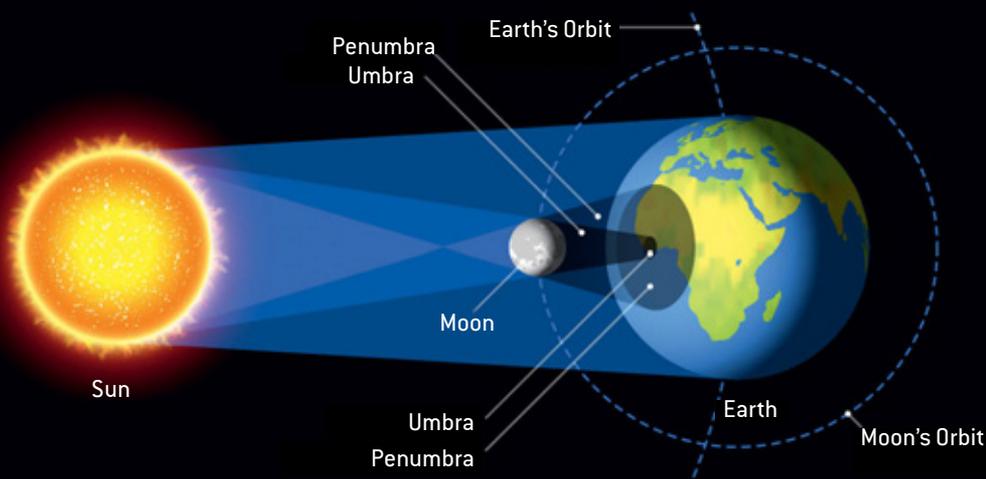
When a total eclipse is visible in Australia, people somewhere else in the world may only see a partial eclipse. During a partial solar eclipse, only a section of the Sun's light is blocked. The Earth and the Moon are always moving along their orbits, so an eclipse takes a few minutes. It then gradually passes as the Earth and the Moon continue their motion.

Scientists have used total solar eclipses to learn more about the Sun. When a solar eclipse occurs, some details around the edges of the Sun, such as the **corona**, can be seen from the Earth.



*The corona is too faint to see when the Sun is shining. When there is a total solar eclipse, the faint structures of the corona can be studied.*

**WARNING!** Never look directly at the Sun, even during a solar eclipse, because it can cause permanent damage to your eyes, even through sunglasses.



*A solar eclipse occurs when the Moon is directly between the Sun and the Earth. A solar eclipse will only last for a few minutes.*

## LOOK IT UP

**corona** lines of light that surround the Sun or Moon during an eclipse

**eclipse** passing of an astronomical body through the shadow of another or when a body passes between it and the viewer; usually referring to solar or lunar eclipses, which can be partial or total

**penumbra** the shadow of the Moon or Earth in an eclipse

**umbra** the total shadow cast on the Earth by the Moon during a solar eclipse or on the Moon by the Earth during a lunar eclipse

## CHECK IT OUT

- 1 How are lunar and solar eclipses similar?
- 2 How are lunar and solar eclipses different?
- 3 Draw a diagram with labels to show a penumbra and umbra.
- 4 What is the corona and when is the only time for scientists to view it?
- 5 Why should you never look at the Sun, even during an eclipse?

# PHASES OF THE MOON

**AIM:** TO IDENTIFY THE EIGHT PHASES OF THE MOON

**MATERIALS**

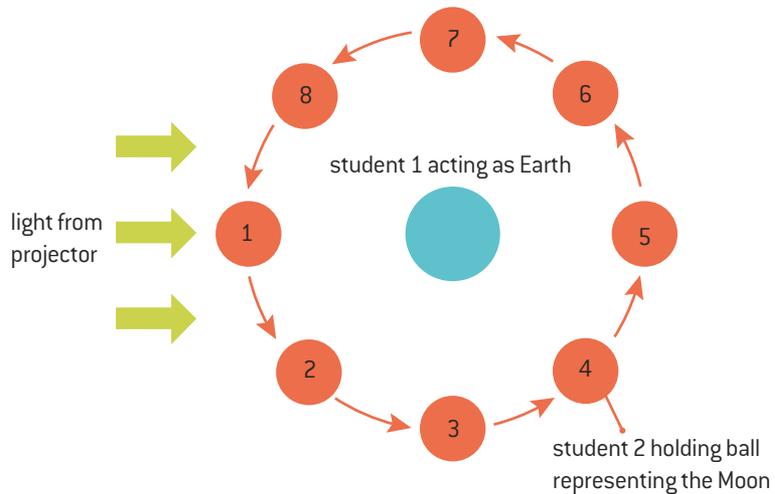
- Large ball
- Projector or a powerful torch

**SAFETY**

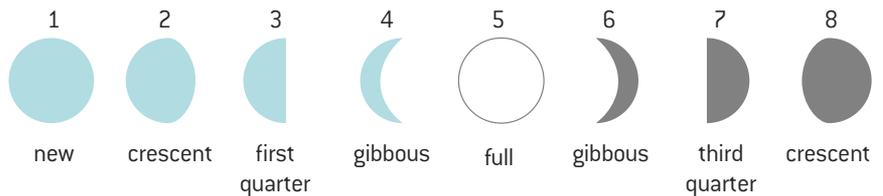
**Warning:**  
A projector can become very hot. Handle with care to avoid serious burns.

**METHOD**

- 1 Draw a large circle (lunar orbit) on the floor.
- 2 Student 1 should switch off the lights. Aim the projector (Sun) at the ball (Moon) in student 2's hands.
- 3 Student 1 (Earth) stands in the middle of the circle.
- 4 Student 2 walks around the circle holding the ball (Moon) still.
- 5 Student 1 (Earth) observes how much of the lit face of the Moon can be seen from Earth.



**The 8 phases to identify**



**DISCUSSION**

Record the positions of the projector, the ball/student 2, and student 1. Draw the eight phases of the Moon that occur at various positions of the projector, student 2, and student 1. Draw a diagram that explains the positions of the Earth, Sun and Moon.

**CONCLUSION**

How does the amount of the Moon's face that we see from Earth change through the Moon's cycle?

# HOW DOES THE EARTH MOVE IN SPACE?

**AIM:** TO DEMONSTRATE NIGHT AND DAY, THE SEASONS AND A YEAR

This is a whole-class activity. Night and day, the seasons and a year can be demonstrated using a simple model.

## METHOD

### NIGHT AND DAY

- 1 Make your classroom as dark as possible and shine a light from a torch or a projector onto the model of the Earth. This shows the model Earth in night and day. It is daytime on the part of the Earth with the light shining on it, and it is night on the part of the Earth in shadow.
- 2 Rotate the globe so that dawn, then dusk, then dawn appear.

In which direction should the Earth spin? (Hint: it is dawn in Melbourne before the Sun comes up in Perth.)

### MATERIALS

- Model of the Earth (this can be a globe, an Earth ball or a balloon with the continents drawn on it with a marker pen)
- Torch or projector
- Light bulb on a stand

### A YEAR

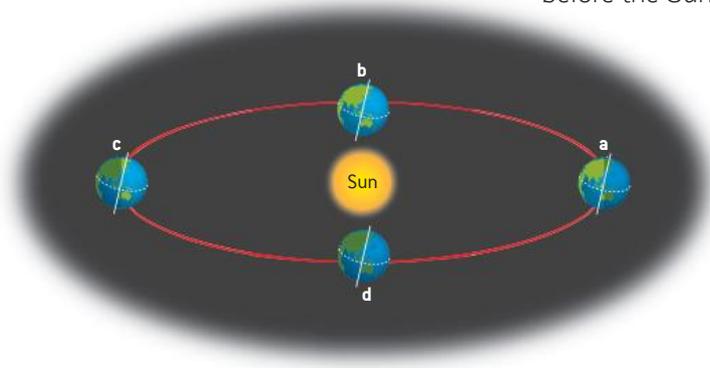
- 1 Darken your classroom and set a single light bulb on a stand in the middle of the room. This is a model of the Sun, which shines light in all directions.
- 2 Hold your model of the Earth and walk in a circle around the lamp. This is the Earth going around the Sun. One circle or orbit is one year. To model the Earth accurately, you should spin the Earth as it orbits the Sun.

How many times should the Earth spin in one orbit?

### SEASONS

- 1 The Earth is tilted as it orbits the Sun. Hold your model Earth so that it is tilted slightly. Imagine the axis is tilted to point towards 1 and 7 on a clock face. Do not change this tilt during the activity.
- 2 Walk slowly in a circle around the lamp, at the same time rotating the model Earth about its own axis. Make sure the tilt always points in the same direction. Freeze or pause the model Earth in this position so the class can examine its orientation.

When you have walked half a circle around your Sun, stop and look at the model Earth. How has it changed from the starting position? Which part of the Earth is experiencing summer? What is the orientation of the Earth? Continue walking back to the starting position. Which part of the Earth is having summer now?

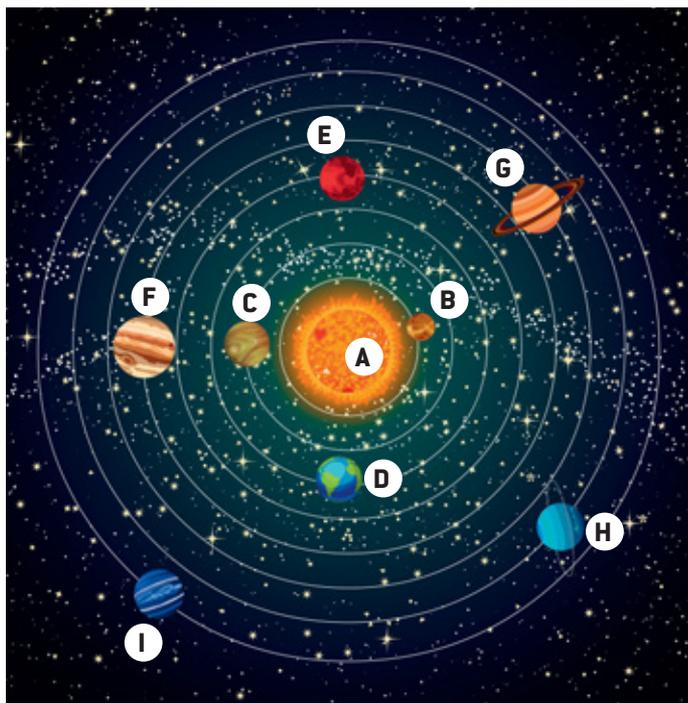


*The Earth's rotation and orbit cause day and night and the seasons.*

# EARTH IN SPACE

## LIVING ON PLANET EARTH (PAGES 84–85)

- 1 Look carefully at the diagram of the solar system below.
  - a Identify the celestial bodies labelled A–I.
  - b Divide your list of planets into terrestrial planets and gas giants.
  - c What is the difference between a terrestrial planet and a gas giant?
  - d Which are the largest and smallest planets in the solar system?
  - e Which planets have the longest and shortest orbits around the Sun?



- 2 What objects other than the Sun and the planets can be found in the solar system?
- 3 How is the Sun the centre of the solar system?
- 4 Why is the Sun so important for life on Earth?

## NIGHT AND DAY (PAGES 86–87)

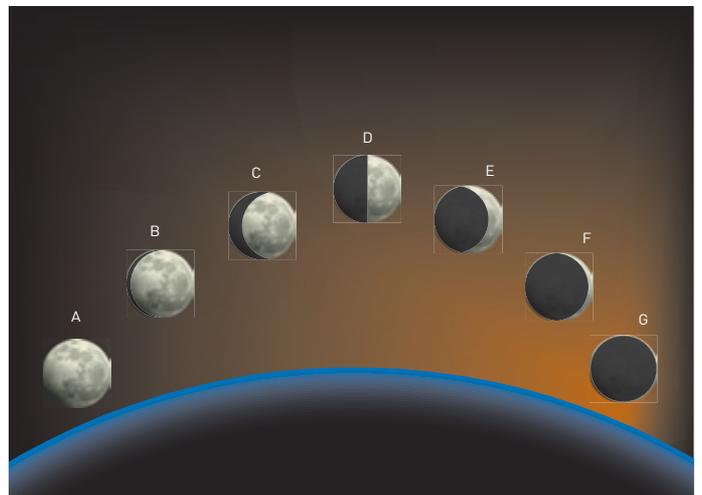
- 5 How long does it take for the Earth to complete one rotation around its axis?
- 6 When does your location experience daytime?
- 7 'The Sun moves across the sky each day from east to west.' Explain why this statement is misleading.
- 8 On 22–23 September (spring equinox), the Sun dips below the horizon for six months at the North Pole. What happens at the South Pole?

## THE SUN AND THE SEASONS (PAGES 88–89)

- 9 How long does the Earth take to orbit the Sun?
- 10 What is a leap year?
- 11 How does the tilt of the Earth's axis influence when we experience summer in Australia?
- 12 When the southern hemisphere experiences summer, what happens in the northern hemisphere?

## EARTH AND MOON (PAGES 90–91)

- 13 How did Galileo and scientists in the 1600s come up with such detailed observations of the Moon?
- 14 'Moonlight is light produced by the Moon.' Say whether this statement is true or false, and explain your answer.
- 15 Look at the diagram below.



Identify the phases of the Moon labelled A–G.

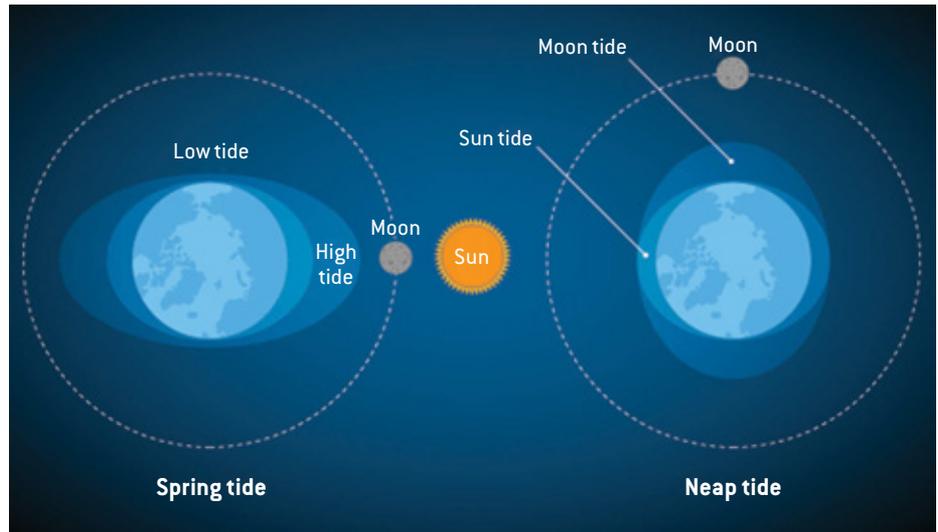
- 16 Where does the Moon go during the day?

## MAN LANDS ON THE MOON (PAGES 92–93)

- 17** Which Apollo mission was the first to land on the Moon and which astronauts first stepped onto the Moon's surface?
- 18** Use the map of Apollo landing sites on page 91 to answer the following questions.
- Where did *Apollo 11* land?
  - Where did *Apollo 15* land?
  - What are the areas labelled as 'seas' on the surface of the Moon?
- 19** Once they reached the Moon, astronauts explored the lunar surface. Why do you think they did this?
- 20** Why do you think more than half a billion people were watching television to see Neil Armstrong walk on the Moon?
- 21** What possible reasons could there have been for fuel to be critically low in the lunar module?

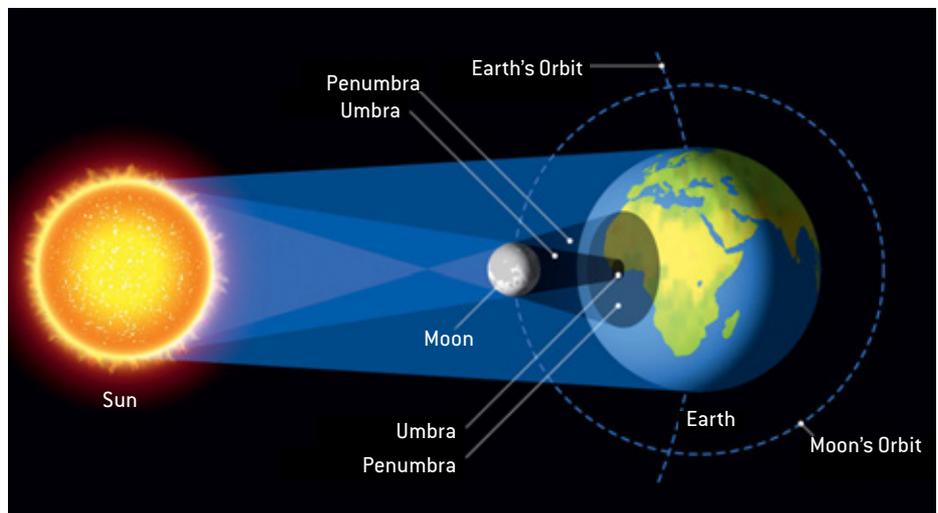
## CHANGING TIDES (PAGES 94–95)

- 22** The Moon is much smaller than the Sun. Why does the Moon's gravitational pull cause the Earth's tides?
- 23** Look carefully at the diagram below.
- Outline why very high and very low tides occur with a spring tide.
  - How does the position of the Moon influence a neap tide?



## ECLIPSES (PAGES 96–97)

- 24** Look carefully at the diagram below.
- Is this an example of a solar or a lunar eclipse?
  - What is an umbra and which celestial body is causing it to occur in this case?



## KEY IDEAS

1

The Earth is one of the eight planets that orbit around the Sun. The Sun is a star that is 110 times as wide as the Earth.



2

The Earth rotates once every 24 hours, causing day and night. The part of the Earth facing the Sun experiences day while the part of the Earth facing away from the Sun experiences night.



3

The Earth takes 365.25 days to orbit the Sun. The tilt of the Earth causes a change in climate, which we know as the seasons. When the southern hemisphere is tilted towards the Sun, it experiences summer, whereas when it is tilted away from the Sun, it experiences winter.



4

The Moon is a satellite that slowly orbits the Earth. The Moon reflects sunlight. We see different phases of the Moon such as the crescent Moon and the full Moon according to how much of the Moon lit by the Sun we can see from Earth.



5

In 1969, Neil Armstrong was the first person to walk on the Moon. He and astronaut Buzz Aldrin landed in *Apollo 11's Eagle* module and explored the Moon's surface. The historic event was televised around the world.



6

The gravitational pull of the Moon causes the tides. The gravitational pull of the Sun also contributes to tides.



7

A lunar eclipse occurs when the Earth moves between the Moon and the Sun.



8

A solar eclipse occurs when the Moon passes between the Sun and the Earth. The shadow cast on Earth during a total solar eclipse is known as an umbra.

# RESOURCES 06

**\*5\***  
**RENEWABLE  
ENERGY  
RESOURCES**

**CAN FOSSILS  
BE CONVERTED  
TO ENERGY?**

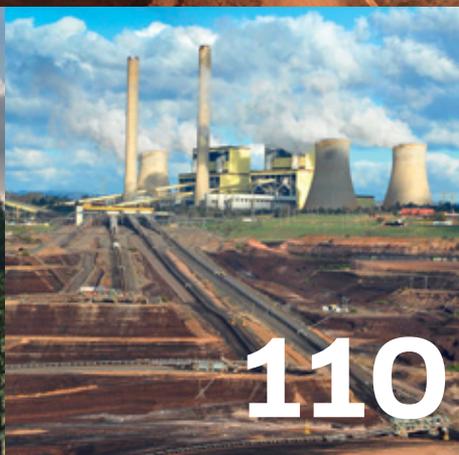
**WHY ARE  
MINERALS AND OIL  
LIMITED  
RESOURCES?**

**Why is water  
a precious  
resource?**



**108**

**FOSSIL FUELS**



**110**

**GENERATING POWER**



**116**

**WIND ENERGY**

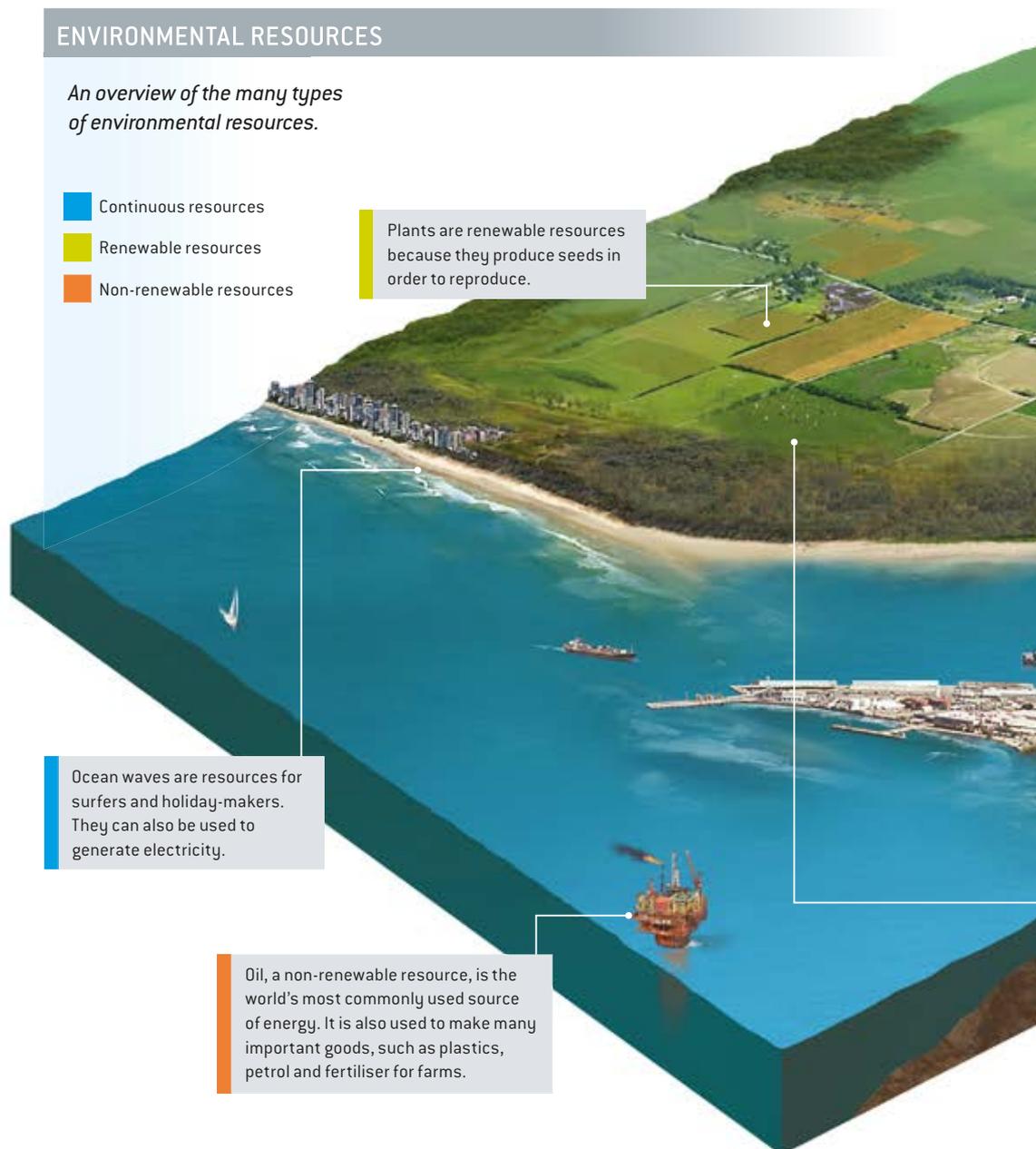
# ENVIRONMENTAL RESOURCES

Humans use many environmental resources found on Earth. Water from rainfall, minerals from rocks, food from the land and oceans, and other natural resources have allowed us to survive. We use resources to build homes, farms, cities and highways.

Some resources are taken from the Earth and are finite (limited). If we keep using them, one day they will run out. These kinds of resources are called **non-renewable resources**. Minerals (such as coal and uranium) are examples of non-renewable resources.

**Renewable resources** are those that can be replaced. Fresh water is a renewable resource, but we need to take care how we use it. Trees that we cut down can be replaced by new ones over time, but we need to carefully manage forests.

Energy from the Sun and wind will not run out no matter how much we use them. These are known as both renewable and **continuous resources**.





The amount of oxygen in our atmosphere stays about the same because it is constantly recycled through plants, animals and oceans.

Wind is used to turn turbines that produce electricity.

In some parts of the world, electricity is generated from heat deep within the Earth. This is known as geothermal energy.

The Sun provides energy for plants and animals, and forms the basis of everything we eat. It also provides solar power.

Forests are a renewable resource that are under threat. Much of the world's natural forest cover has been cleared or logged.

Most of Australia's electricity comes from the burning of coal. Coal is an important energy resource in many countries.

Fresh water is vital for life on Earth.

Minerals are used as a resource in many ways. Uranium is just one of the many minerals mined around the world. It is used at nuclear power stations to produce electricity.

Soil is formed when rocks break down. We use soil to grow the crops we eat and feed the animals we farm for food.

### LOOK IT UP

**continuous resource** a resource that will not run out

**non-renewable resource** a resource that is limited; once used, it is gone forever, such as coal, oil or natural gas

**renewable resource** a resource that is made naturally and is available in an almost unlimited amount, such as wind, solar and hydro-electric power

### CHECK IT OUT

- 1 What are the three main types of resources? Give two examples of each type.
- 2 Why is the Sun a resource that we rely on?
- 3 Why is it important to look after renewable resources such as fresh water?
- 4 Describe how you may have used a non-renewable resource in the past hour.
- 5 What problems might societies around the world face if people continue to rely heavily on non-renewable resources?

# AUSTRALIA'S RESOURCES

Almost everything we do requires energy and minerals. Having a shower, making toast and travelling in a car – all of these use energy and resources. Nearly all of Australia's **energy resources** come from limited, non-renewable **fossil fuels** buried in the Earth's crust. Use of renewable energy sources has become more urgent as it becomes clear that fossil fuels are running out and harming our environment.

## Australia's mining industry

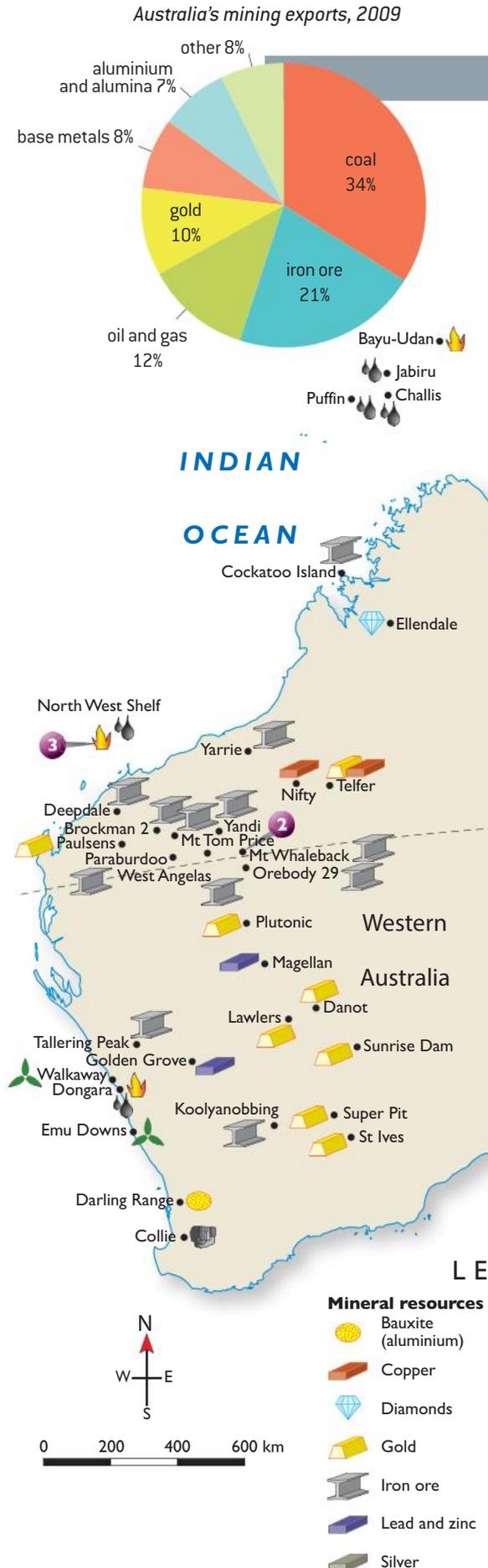
Australia mines large amounts of mineral resources. It is one of the world's leading extractors of mineral resources. Australia is one of the largest producers of industrial diamonds, lead, zinc, gold, iron ore (used to make steel), bauxite (used to make aluminium), uranium, nickel, silver and manganese. Australia is one of the world's largest energy producers. The main fuels used in Australia are coal, oil and natural gas.

Mining makes up a significant amount of Australia's total exports. That is, a large proportion of Australia's money comes from mining – which is why it is an important industry. Renewable resources, such as the wind and the Sun, are likely to be used to generate more of our energy in the future.

2 Located in the Pilbara, Western Australia, Mt Whaleback is the world's largest single pit open-cut iron ore mine.



3 Situated on the North West Shelf off the coast of Western Australia, the Goodwyn Platform is one of Australia's largest natural gas rigs.



## AUSTRALIA'S MINERAL AND ENERGY RESOURCES

1 Argyle Diamond Mine in Western Australia's Kimberley region is the world's largest supplier of diamonds.



4 The Bowen Basin in Queensland is the largest coal deposit in Australia and has many operating mines.

5 Wattle Point in South Australia is a wind farm that supplies electricity to 52 000 homes.



### LOOK IT UP

**energy resource** a substance or method used for generating energy, such as coal, petrol, gas, wind, solar or hydro-electric

**fossil fuel** a fuel such as coal, oil and natural gas that is produced from ancient organisms (mainly plants) that lived millions of years ago

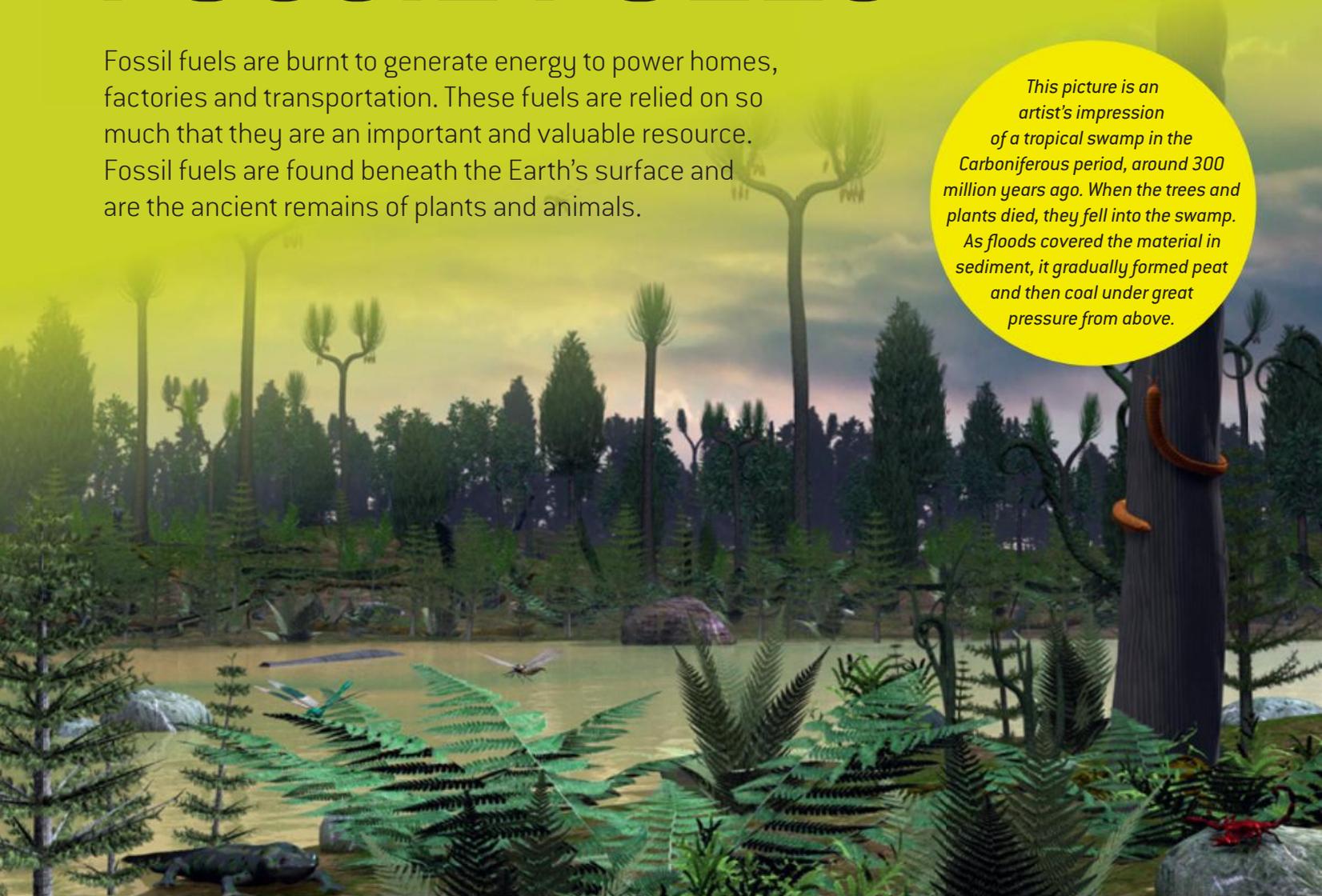
### CHECK IT OUT

- 1 List three minerals and three energy resources mined in Australia.
- 2 Use the map to list the names and locations of:
  - a three gold mines
  - b three coal mines
  - c three wind farms.
- 3 List the main fuels used in Australia.
- 4 Find the gas fields on the map. What other energy resource is found in the same regions?

# FOSSIL FUELS

Fossil fuels are burnt to generate energy to power homes, factories and transportation. These fuels are relied on so much that they are an important and valuable resource. Fossil fuels are found beneath the Earth's surface and are the ancient remains of plants and animals.

*This picture is an artist's impression of a tropical swamp in the Carboniferous period, around 300 million years ago. When the trees and plants died, they fell into the swamp. As floods covered the material in sediment, it gradually formed peat and then coal under great pressure from above.*



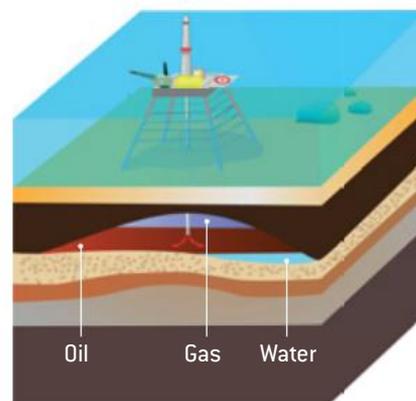
## Formation of oil and gas

The coal, oil and gas we use today take millions of years to form. Fossil fuels began as microscopic plants and animals living on the land and in the ocean millions of years ago. The plants absorbed solar energy and stored it as carbon compounds in their bodies. When they died, they sank to the bottom of the ocean, or became covered in layers of sediment.

The pressure of the water and layers of sediment on top caused **chemical reactions** that changed

the dead material into fuels: coal (solid), oil (liquid) and natural gas. The oil and gas travelled out through **porous** rock, until it was trapped by a layer of non-porous rock that would not allow it to travel any further.

Australia's largest oil and natural gas reserves are the trapped deposits beneath the oceans. They are mostly found under the seabed on the North West Shelf off the coast of Western Australia and in Bass Strait off Victoria.



*This diagram shows a giant oil rig drilling through layers of rock under the sea to reach pockets of oil and gas reserves.*

# Ask a scientist

## Dr Jo Whittaker

A geologist is a scientist who studies rocks and minerals. Geologists' knowledge of rock formations helps us understand the Earth.

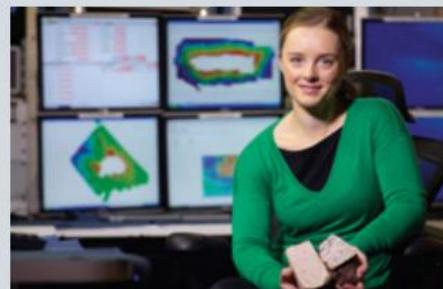
Dr Jo Whittaker is a type of geologist called a marine geoscientist. She studies how rocks form and move beneath the ocean.

After leaving secondary school, Jo finished a science degree with honours in geology at the University of Sydney,

completed a Master of geophysics in New Zealand, and then earned a PhD in geophysics back in Sydney.

Jo now works at the University of Tasmania, studying rocks beneath the ocean. She says it is a bit like fitting together the pieces of a complicated jigsaw puzzle, but the pieces are huge and are millions of years old.

Her research increases our understanding of how the planet works and how the Earth's geography has changed over millions of years.

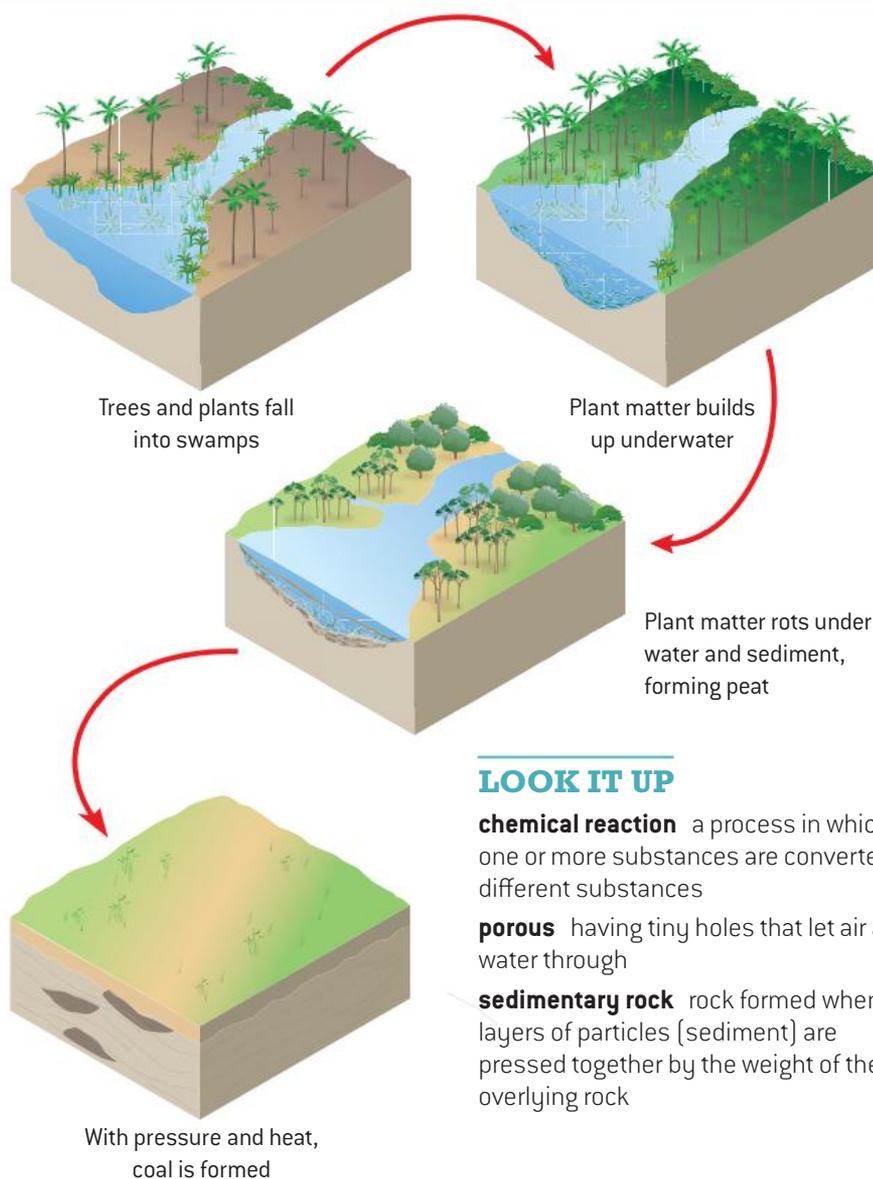


Jo is a geologist who studies rocks beneath the ocean.



A video interview with Dr Jo Whittaker is available on your [obook](#) / [assess](#).

## THE FORMATION OF COAL



### LOOK IT UP

**chemical reaction** a process in which one or more substances are converted to different substances

**porous** having tiny holes that let air and water through

**sedimentary rock** rock formed when layers of particles (sediment) are pressed together by the weight of the overlying rock

## Formation of coal

Coal forms from the remains of trees and other plants that grew in tropical swamps millions of years ago. When the trees and other plants died, they fell into swamps. The partly rotted plant material gradually built up, forming a layer of peat. Floods brought sediments of sand, mud, gravel and silt to cover the peat. Over time, these sediments formed rocks, known as **sedimentary rocks**.

The pressure from the rocks on top and the heat from the Earth's crust underneath caused chemical reactions that gradually changed the peat into coal. These chemical reactions removed most of the oxygen and hydrogen atoms from the sugar molecules in the plant material, leaving mainly carbon atoms. Coal is rich in carbon. When it is burnt, the chemical energy originally stored in the plants is released.

### CHECK IT OUT

- 1 Give three examples of fossil fuels.
- 2 How long do fossil fuels take to form?
- 3 Make a list of the steps involved in the formation of fossil fuels.
- 4 Describe how oil and gas move and become trapped.
- 5 Where are most oil and gas reserves found in Australia and how are they mined?
- 6 Why is coal a useful fuel?

# MINING AND USING FOSSIL FUELS

*An open-cut coal mine and power station in Victoria's Latrobe Valley.*

Some of the Earth's resources take millions of years to form. Once these resources are used by humans, they cannot be replaced by natural processes. These resources are called non-renewable resources.

## SENDING ELECTRICITY TO YOUR HOME

Electricity is produced at the power station.

Electricity travels through thick transmission wires to a substation.

Transformers in the substation reduce the voltage, and it travels down suburban power lines.

The voltage is reduced again at a local substation for use in homes and businesses.

Electricity is supplied to your house so you can turn on the lights, and use appliances such as washing machines and computers.



## Fossil fuels

The mineral and energy resources that are mined from the Earth's crust are non-renewable. In Australia, most of our electricity comes from burning coal and almost all of our transport is fuelled by petrol and diesel, which are refined oil.

Oil and coal, along with natural gas, are called fossil fuels because of the way they are formed. They are the decomposed remains of ancient plants and animals trapped in the Earth's crust over millions of years. There is only a finite (limited) supply of fossil fuels.

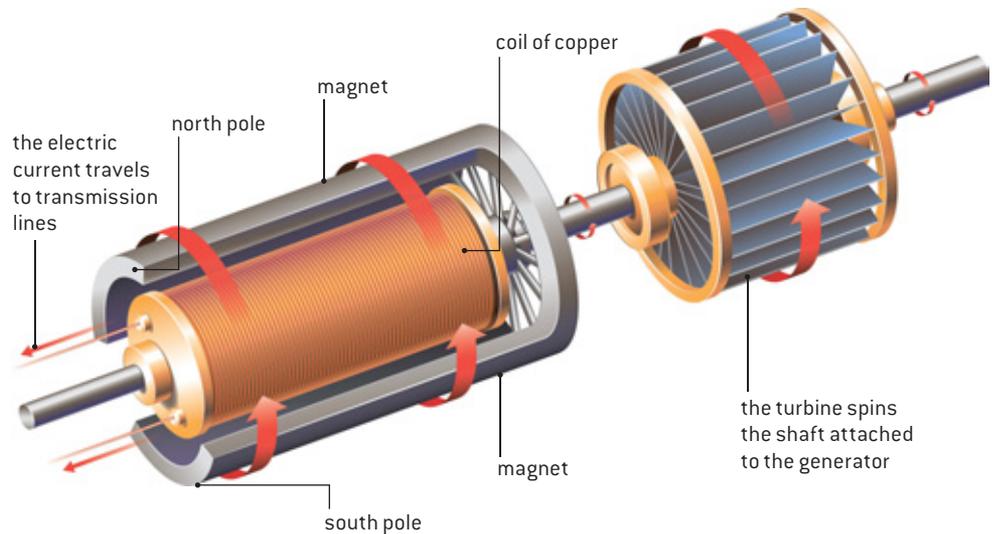
### Coal

Coal is a black or brownish-black substance that is mined from the Earth. It is mostly burnt in power stations to create electricity. It is also used to make fertilisers, tar and plastics. Coal takes millions of years to form.

Coal is mined in open-cut mines if it is close to the surface, or in underground mines if it is deep beneath the surface. Australia is the world's fourth-largest producer of black coal. While most Australian coal is exported, black and brown coal are also used to create more than three-quarters of Australia's electricity.

Coal-fired power stations burn coal to produce electricity. When coal is burnt, heat is released. This heat is used to boil water and make steam. The steam is used to make a **turbine** spin. The spinning turbine rotates a strong magnet that is surrounded by coils of wire. This generates electricity.

**Electrical energy** is transported from the power station to homes and factories by electrical wires.



### Oil

Oil is refined (changed) into fuel such as petrol and diesel to run cars, buses and trucks. It is one of the world's most used non-renewable resources. When mined, **crude oil** is usually a thick, black liquid that is piped or shipped to a refinery.

At the refinery, impurities are removed and the various parts of the crude oil are separated from each other. This produces several new materials. Some of these are used as **lubricants**, and others are further refined into fuels such as petrol and diesel.

Some oil products are added to other substances to create plastic, one of the world's most used consumer products.

### LOOK IT UP

**crude oil** a naturally occurring, unrefined petroleum product that can be refined to produce usable products such as gasoline, diesel and various forms of petrochemicals

**electrical energy** energy associated with electric charge, either stationary (static) or moving (current)

**lubricant** a substance used to reduce friction

**turbine** a large wheel with angled sections similar to a fan's blades; steam, water, gas or air can push on the blades to spin the turbine and turn a generator

### Gas

As ancient plants and animals decompose deep underground, they produce a gas, which can be trapped by layers of rock. This gas is highly flammable (bursts into flames easily) and, when mined, is used as a source of energy. Some of the largest amounts of natural gas in the world are buried deep in the seafloor near the Western Australian coast.

Offshore platforms (known as rigs) are used as a base to drill for oil and natural gas in the Australian seabed. Gas can also be obtained by drilling into the Earth, or by forcing a water mixture into the ground in a process called fracking.

Natural gas is commonly used for cooking and for heating our homes and hot water supplies. Methane is the main component of natural gas.

### CHECK IT OUT

- 1 What are fossil fuels?
- 2 Why is coal described as a non-renewable resource?
- 3 Explain how coal is used to make electricity.
- 4 How is electricity transported to homes and businesses?
- 5 What products are made from crude oil?
- 6 What is an oil rig and why are they needed?

# MODEL POWER STATION

**AIM:** TO MODEL THE ACTION OF A COAL-FIRED POWER STATION

## MATERIALS

- Square paper, 15 cm × 15 cm
- Ruler
- Pencil with an eraser on the end
- Scissors
- Pin
- Bunsen burner
- Tripod
- Gauze mat
- 150 mL beaker
- Aluminium foil – 10 cm × 10 cm
- Large nail

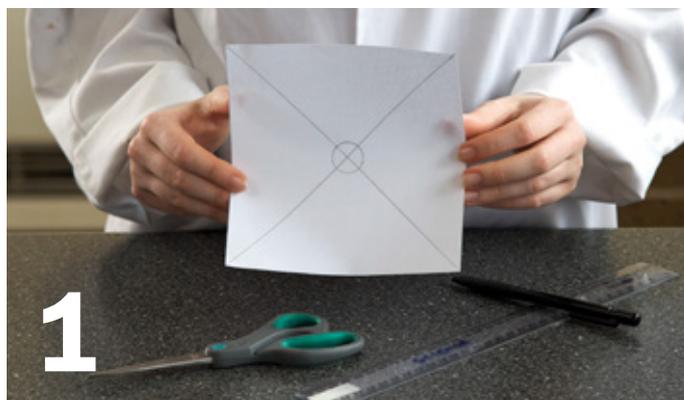
## SAFETY

Part 2 involves using a Bunsen burner:

- Be careful of naked flames.
- Ensure that long hair is tied back and loose clothing such as a tie is tucked away.
- Do not leave flames unattended.
- Handle hot sample with tongs.
- Ensure you follow laboratory safety procedures and wear safety glasses and a lab coat.
- The apparatus will be very hot at the end of this experiment. Leave it to cool before packing it away.

## METHOD PART 1: THE TURBINE

- 1 Mark the square paper as shown below using a pencil and a ruler. Draw a circle about the size of a 5 cent piece in the centre.



- 2 Cut in from the corners along the lines you have drawn, but stop at the circle.
- 3 Fold all four corners in towards the centre and hold them in place.
- 4 Insert the pin through the four corners and into the tip of the pencil's eraser.
- 5 Blow on the pinwheel to see if it spins. If not, pull the pin out slightly to create room. The pinwheel will act like the turbine of the power station.



## METHOD PART 2: THE BOILER



NOTE: Before operating a Bunsen burner, complete the worksheet on your [obook](#) / [\\_assess](#).

- 1 Set up your Bunsen burner, tripod and gauze mat. Place the beaker on top.
- 2 Use the nail to punch a small hole in the centre of the aluminium foil.
- 3 Carefully place the aluminium foil over the top of the beaker and fold it over and down the sides.
- 4 Light the Bunsen burner and boil the water.
- 5 Steam should come out of the hole in the foil. Hold your pinwheel over the hole and let the steam spin the 'turbine'.

## RESULTS

Include photographs or diagrams of what occurred.

## DISCUSSION

- 1 Describe what happened to your pinwheel when it was placed in the steam flow.
- 2 What else would you need to add to make your 'power station' generate electricity?
- 3 What is the fuel in your power station?
- 4 Will your power station run out of fuel?

## CONCLUSION

What do you know about the action of a power station?

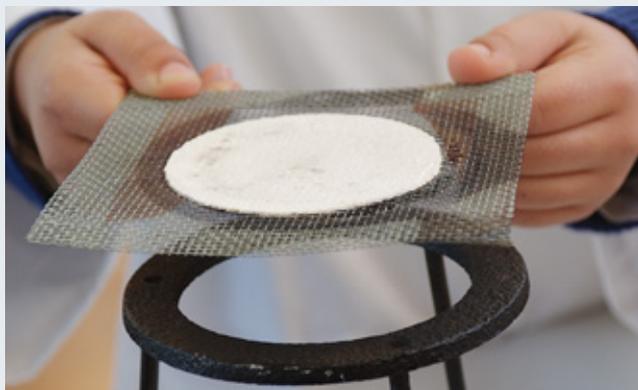
## SCIENTIFIC EQUIPMENT



*Bunsen burner*



*Tripod*



*Gauze mat*



*Beakers*

# 5 RENEWABLE ENERGY RESOURCES

**Renewable energy** is generated (created) from resources that are continuous, or can be replaced if we don't use them too quickly. About 20 per cent of the world's electricity but just a fraction of the world's total energy use comes from renewable resources such as the Sun, the wind, the ocean's tides, running water and heat stored beneath the Earth's surface.

## 2 Solar energy

Solar panels turn the Sun's light into electricity. The panels contain light-sensitive material as part of a photovoltaic cell that allows the sunlight to energise electrons, forming electricity. Solar energy can also directly heat water stored in, or flowing through, black pipes that absorb the Sun's heat.

## 1 Wind energy

Wind is moving air. Some places are windier than others because they are more exposed.

The wind turns large, windmill-like blades. As the blades turn they cause a turbine to spin and produce electricity. The turbines are fixed onto tall poles in areas where there is reliable wind. Groups of these wind-powered turbines are called wind farms.

## 3 Geothermal energy

Heat stored below the Earth's surface can be used to generate power. Large wells, some as deep as 5 kilometres, are drilled into the Earth's surface. Water is pumped underground and heated by the Earth. It is then piped to the surface as steam. The steam is used to drive large turbines and generate electricity.

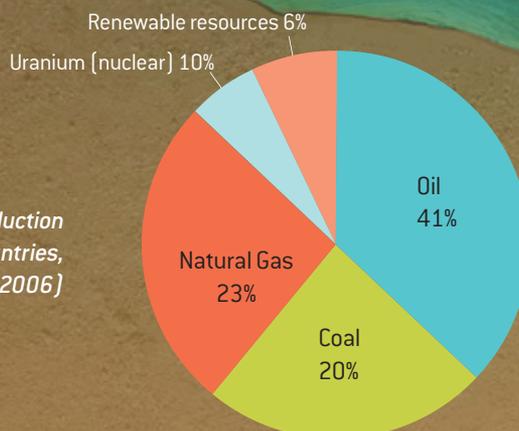
## 4 Hydro energy

Water flows from a dam over turbines. This causes the turbines to spin and generate electricity.

## 5 Tidal energy

A dam or barrage is built across a river mouth. Water is then pushed through tunnels as the tide comes in and out, driving turbines that produce power. Ocean waves can also be used to create electricity.

*Energy production  
(developed countries,  
2006)*



### LOOK IT UP

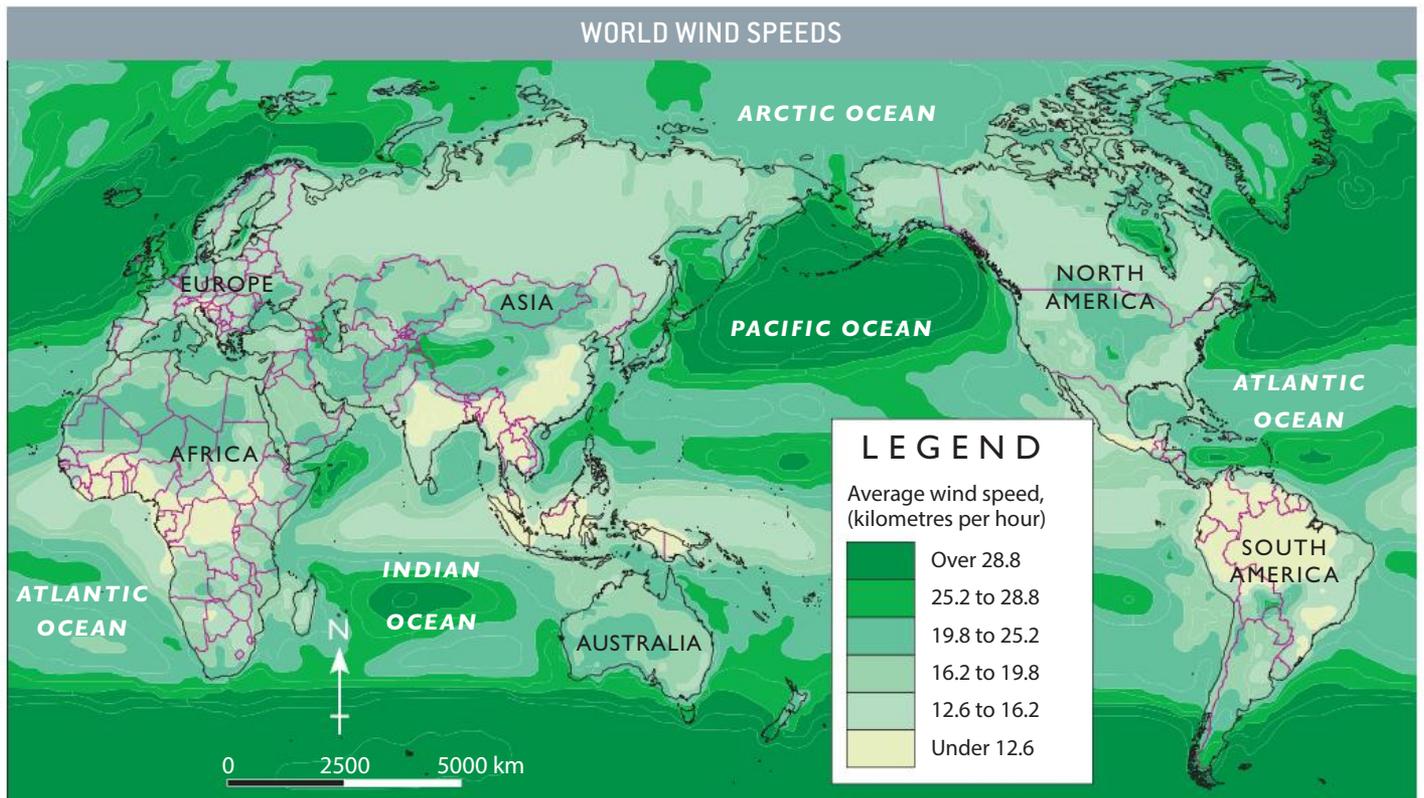
**renewable energy** energy from a continuous resource that will never run out, such as wind or solar power

### CHECK IT OUT

- 1 What is renewable energy?
- 2 What is a turbine and what role do they play in generating renewable energy?
- 3 Give three different examples of turbines producing energy.
- 4 A country uses the following renewable energy resources: hydro (63%), bioenergy – mainly from burning wood (21%), solar (8%), wind (5%), geothermal (3%). Draw a graph to show the break up. How do these figures compare with the latest information you can find for Australia's renewable energy consumption? Where did you find your information?
- 5 Look at the pie chart below.
  - a What type of energy is most commonly used?
  - b What percentage of the world's energy comes from renewable resources?

# WIND AND SOLAR ENERGY

Improvements in the technology that enables energy to be produced from renewable resources have helped us use energy from the Sun and wind more easily. These continuous resources will not run out, regardless of how much we use them.



## Using wind energy

Wind is moving air. Air moves between areas of different pressure and heat in the atmosphere. Places near the coast or the beach are often windier than those inland as they are more exposed to strong winds.

Wind energy has been used as a resource for thousands of years. More than 5000 years ago, Persians began to use wind energy to power their sailing ships. Wind is also used in recreation. Sailboarders, kite flyers and glider pilots all rely on the wind, as do balloonists and hang-gliders.

*Sailors, such as those in the annual Sydney to Hobart Yacht Race, use the wind's energy as a resource.*



## Wind power

Wind has been used as a source of energy for centuries. Windmills were used to perform jobs such as grinding flour. Windmills have been in use in Australia for many years to draw water from under the ground. Wind turbines are now being used to generate electricity. This provides an alternative to non-renewable resources (such as coal, oil and gas).

In an electricity generator, a turbine needs to be turned. Fossil fuels turn a turbine when they are burnt to produce steam. Wind can turn a turbine without the need to produce steam, and without emitting **carbon dioxide** as a waste product.

To generate large amounts of energy, many wind turbines are placed on a wind farm. Wind farms need to be in places that experience a lot of wind. The stronger the winds, the more energy is produced.

Wind speeds differ depending on which part of the world you are in. In the southern hemisphere, strong winds blow almost constantly in a belt around the globe, with only South America to interrupt their flow. These winds are known as the roaring forties because they are found between 40°S and 50°S latitude. Tasmania is in the path of the roaring forties, making it a great location for wind farms.

## Solar power

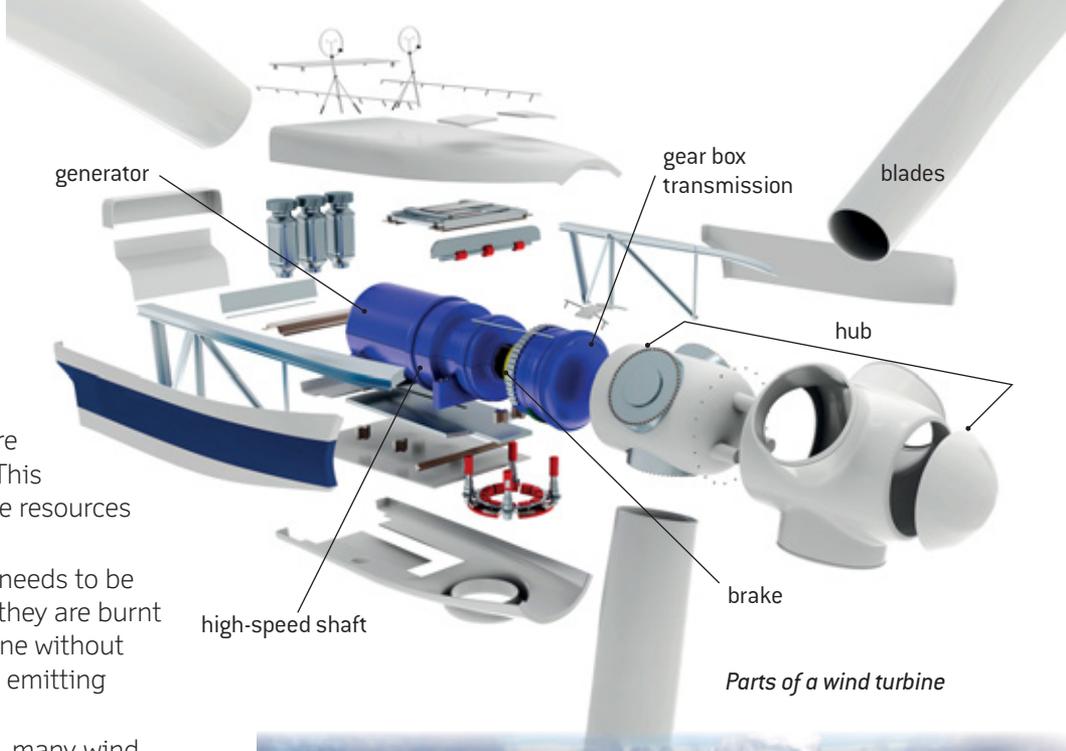
Australia is one of the world's sunniest countries, so it makes sense for Australia to use the energy from the Sun.

A **photovoltaic cell** converts sunlight into electricity. The word 'photovoltaic' is a combination of two words, *photo* meaning light and *voltic* referring to electricity. The cells are made of glass covered with a thin layer of silicon, the most common element in the Earth's crust other than oxygen (for example, most sand is silica, or silicon dioxide). When photovoltaic cells are exposed to sunlight, electrons break free from silicon atoms and move through a wire as electricity. The cells have no moving parts, so they don't wear out, and produce no pollution or greenhouse gases once they are made.

### LOOK IT UP

**carbon dioxide** a colourless, odourless gas with the formula  $\text{CO}_2$

**photovoltaic cell** a device that converts visible light into electricity



Parts of a wind turbine



One of Australia's largest wind farms, Woolnorth, is located on the north-western tip of Tasmania.

Solar panels contain photovoltaic cells that turn the Sun's light into electricity. Energy from the Sun can also directly heat water in black pipes on roof tops.

### CHECK IT OUT

- 1 List the ways in which wind is used as a resource. Can you add more ways that are not listed on these pages?
- 2 How is wind energy used as a power source?
- 3 Why are wind farms often located near the coast?
- 4 How do photovoltaic cells convert energy into electricity?

# WATER FOR ENERGY AND OTHER USES

## Hydroelectricity

**Hydroelectricity** is electricity produced using water. The word comes from *hydro*, meaning water.

Water is stored in large dams. It flows through tunnels, falling due to the force of gravity. As it flows over large turbines, the force of the falling water causes the turbines to spin. These spinning turbines generate electricity, just as a turbine spun by steam in a coal-fired power station generates electricity.

Hydroelectricity produces about 8 per cent of Australia's electricity. In Tasmania, hydro power and wind power combined provide more than 90 per cent of the state's electricity needs.

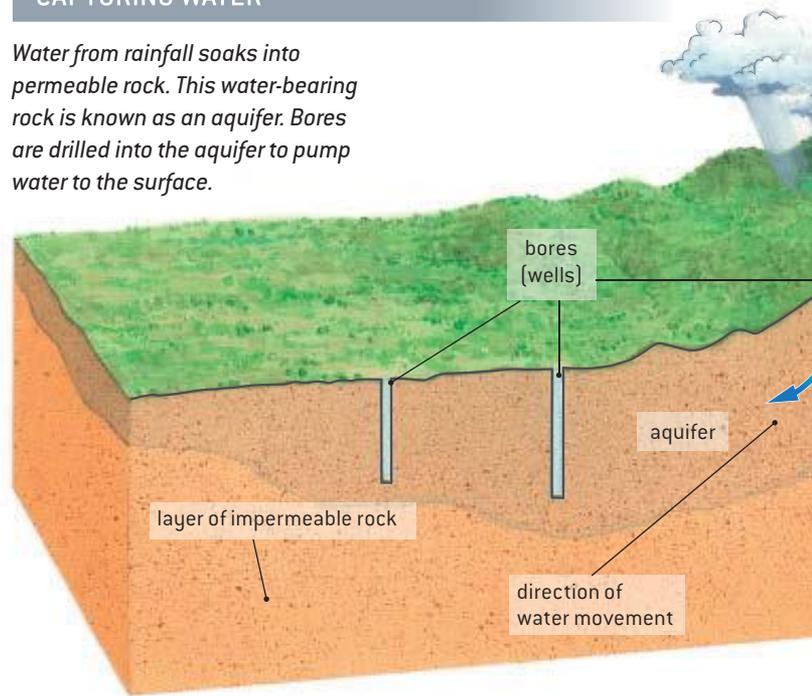
The Snowy Mountain Hydroelectric Scheme in New South Wales was completed in 1974. It is made up of 16 large dams, seven power stations, a pumping station, 145 km of mountain tunnels and 80 km of aqueducts.



When water is let through a hydroelectric power plant's dam wall, it turns turbines to create electricity.

## CAPTURING WATER

Water from rainfall soaks into permeable rock. This water-bearing rock is known as an aquifer. Bores are drilled into the aquifer to pump water to the surface.



## Capturing water

As well as being used to create hydroelectric power, dams create a reliable water supply for our growing population. In Australia, we use more water per person than most other countries.

Stormwater can be collected from pipes and gutters before it flows into rivers and the sea. Rainwater tanks capture some fresh water but cannot collect large amounts. It is possible to capture stormwater through existing pipes and treat it in the city's water treatment plants to add to the city's drinking water.

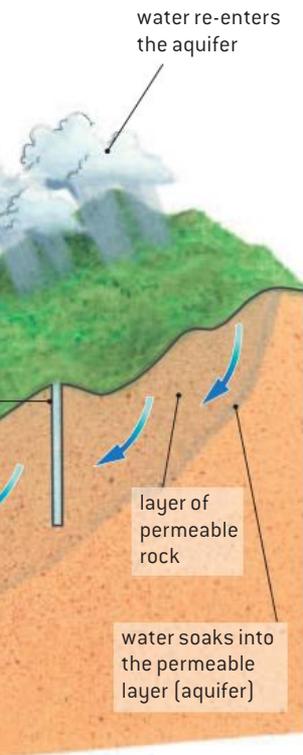
Water can also be obtained from underground. Drilling water bores is a common method used on Australian farms to supply water for irrigating crops, and for animals. Many Australian cities have started to use this method to add to their freshwater supplies. Deep holes, called bores, are drilled down into a layer of rock under the ground that holds water. This layer of rock is called an **aquifer**. The water is then pumped to the surface. It is also possible to replace the water in the aquifers during wet periods by pumping the water back underground.



# Making water

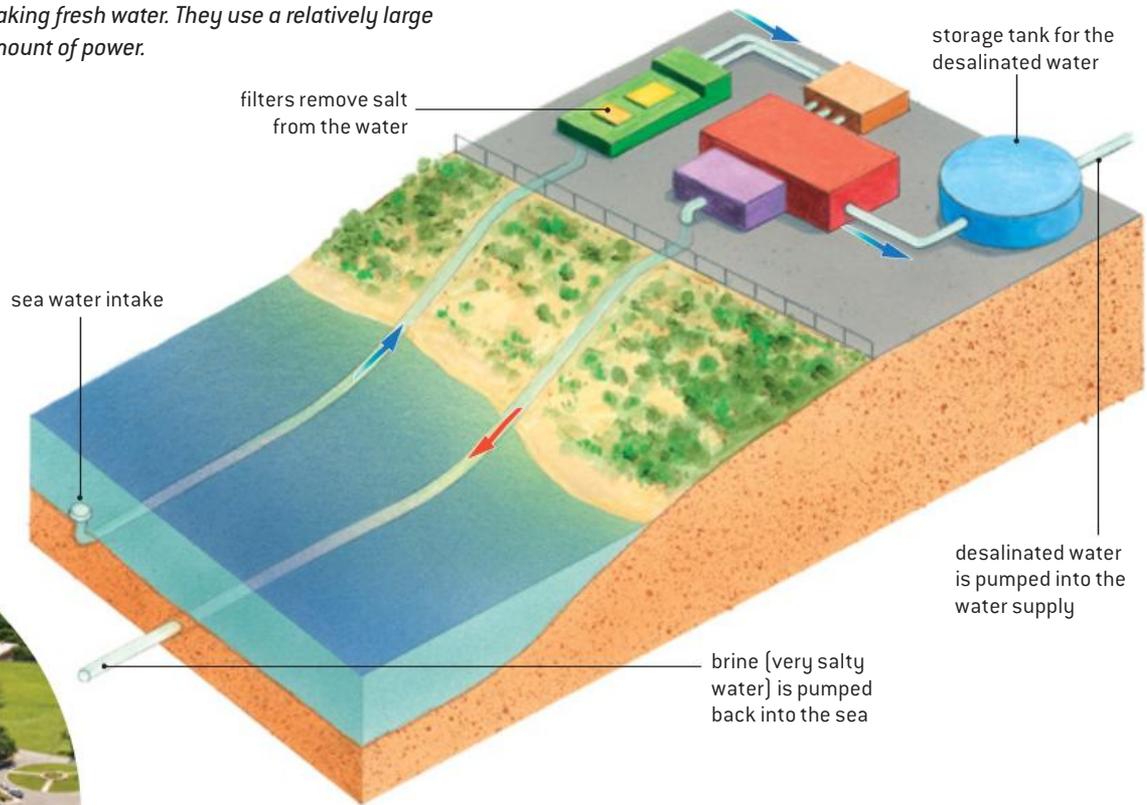
In using water to clean clothes, dishes and ourselves, and to flush toilets, we have polluted it. This water (known as **sewage**) is usually piped to a treatment plant where it is cleaned and then released back into rivers and bays. Scientists have developed ways to purify waste water to such an extent that it can be used for drinking. Some countries, such as Singapore, use this method to produce water.

Desalination plants produce fresh water from sea water. However, they can be very expensive, use a large amount of energy and impact on the environment. A common method for turning salt water into fresh water is a process known as reverse osmosis. This involves pushing sea water through super-fine filters at extremely high pressure. It can remove up to 99 per cent of the dissolved salts and inorganic matter.



## HOW A DESALINATION PLANT WORKS

*Desalination plants remove the salt from sea water, making fresh water. They use a relatively large amount of power.*



*A sewerage treatment water reclamation plant, where water is removed from sewage before being used in factories and businesses.*

### LOOK IT UP

**aquifer** permeable rock that stores or allows the flow of groundwater

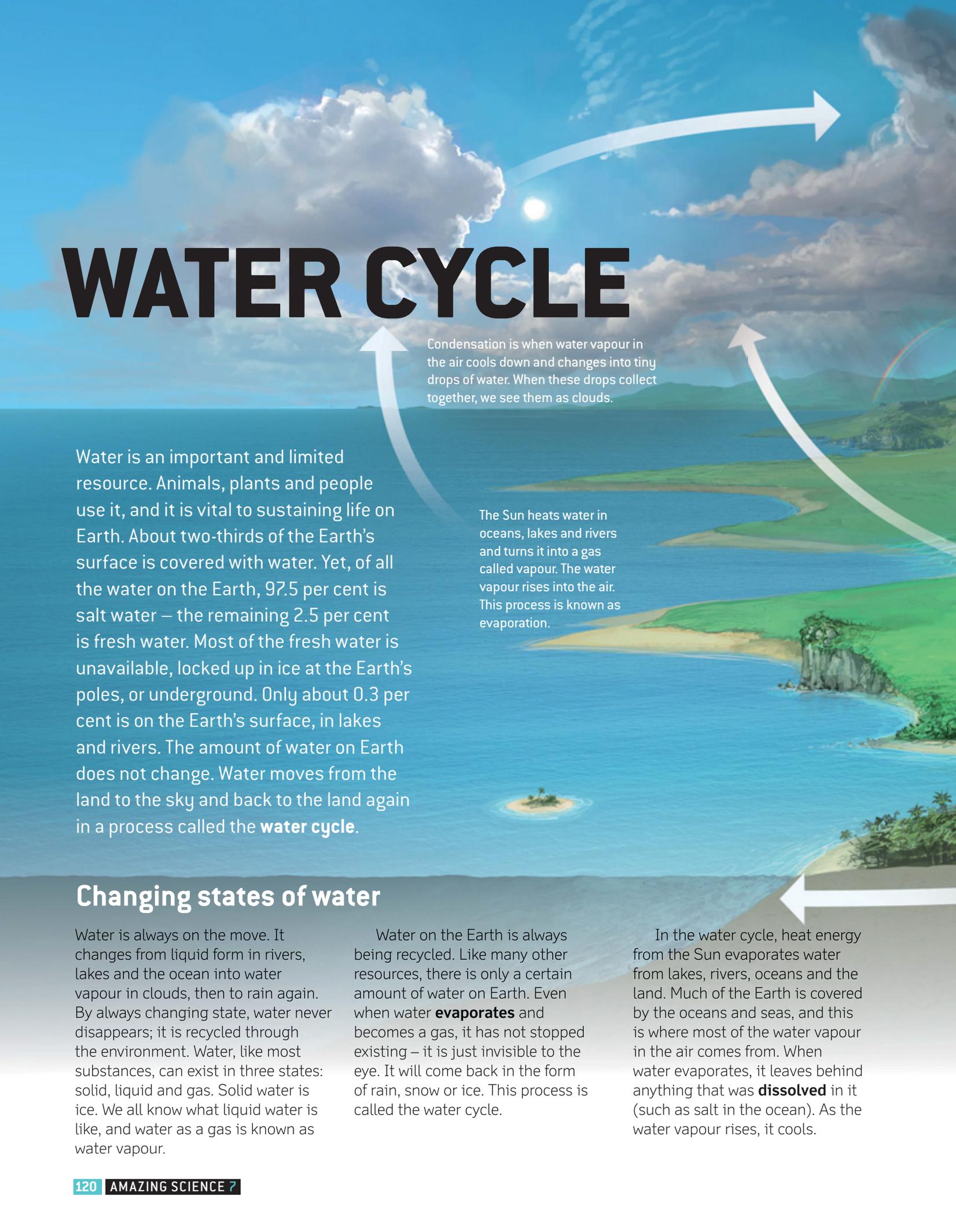
**hydroelectricity** the production of electrical power from falling or flowing water

**sewage** liquid and solid waste released into sewers

### CHECK IT OUT

- 1 How can water be used to provide electricity?
- 2 How can aquifers be used to both provide and store water?
- 3 What are the advantages and disadvantages of desalination?
- 4 Suggest five ways in which we can reduce the amount of water we use in the home.

# WATER CYCLE



Water is an important and limited resource. Animals, plants and people use it, and it is vital to sustaining life on Earth. About two-thirds of the Earth's surface is covered with water. Yet, of all the water on the Earth, 97.5 per cent is salt water – the remaining 2.5 per cent is fresh water. Most of the fresh water is unavailable, locked up in ice at the Earth's poles, or underground. Only about 0.3 per cent is on the Earth's surface, in lakes and rivers. The amount of water on Earth does not change. Water moves from the land to the sky and back to the land again in a process called the **water cycle**.

Condensation is when water vapour in the air cools down and changes into tiny drops of water. When these drops collect together, we see them as clouds.

The Sun heats water in oceans, lakes and rivers and turns it into a gas called vapour. The water vapour rises into the air. This process is known as evaporation.

## Changing states of water

Water is always on the move. It changes from liquid form in rivers, lakes and the ocean into water vapour in clouds, then to rain again. By always changing state, water never disappears; it is recycled through the environment. Water, like most substances, can exist in three states: solid, liquid and gas. Solid water is ice. We all know what liquid water is like, and water as a gas is known as water vapour.

Water on the Earth is always being recycled. Like many other resources, there is only a certain amount of water on Earth. Even when water **evaporates** and becomes a gas, it has not stopped existing – it is just invisible to the eye. It will come back in the form of rain, snow or ice. This process is called the water cycle.

In the water cycle, heat energy from the Sun evaporates water from lakes, rivers, oceans and the land. Much of the Earth is covered by the oceans and seas, and this is where most of the water vapour in the air comes from. When water evaporates, it leaves behind anything that was **dissolved** in it (such as salt in the ocean). As the water vapour rises, it cools.



A cloud is a large collection of water drops or ice crystals. The drops are so small and light they can float in the air.

Precipitation occurs when so much water has condensed that the air cannot hold it any longer. If the clouds have enough water drops, the drops join together and form even bigger drops. The drops get so heavy that they fall back to Earth as rain, hail, snow or sleet.

When water falls back to Earth as precipitation, it will either fall into the oceans, rivers or lakes or on land. Water that ends up on land will become part of the water in the ground that plants use, or it will run over the land back into the oceans, rivers or lakes.

Transpiration occurs when the Sun's heat causes plants to lose water through leaves, moving it into the air.

## LOOK IT UP

**condensation** the change of state from a gas to a liquid

**dissolve** to change from a solid to part of a solution when placed into a solvent

**evaporate** to turn from liquid into vapour

**precipitation** liquid (rain) or solid (hail, sleet and snow) forms of water that fall to Earth

**transpiration** the process by which plants take up water from the soil through their roots and up into their leaves and then release it into the air

**water cycle** the continuous movement of water on the land and in the atmosphere

## CHECK IT OUT

- 1 What is the gaseous state of water and how does it form?
- 2 What is condensation?
- 3 What causes precipitation?
- 4 What roles do plants play in the water cycle?
- 5 How does water from rainfall on the land find its way back to the ocean?
- 6 Where on Earth might you find water stored in its solid form?

When this happens, some of the water vapour (gas) will change into tiny water droplets (liquid) in a process known as **condensation**.

The water droplets rise in the atmosphere and form clouds. The droplets then combine to form larger droplets, and they fall as rain, hail or snow (the different forms of **precipitation**). In this way, water is returned to the land, where some of it runs off the hills, flows into rivers and

returns to the oceans. Sometimes the water solidifies, or freezes, into a solid. We see this as snow or ice.

Animals and plants are also part of the water cycle. Animals and humans expel water as waste or via evaporation from sweat. Plants take in water from the soil through their roots and up into their leaves. During **transpiration**, water evaporates from the leaves of plants and joins the water cycle.

# RESOURCES

## ENVIRONMENTAL RESOURCES (PAGES 104–105)

- 1 What are renewable and non-renewable resources? Give three examples of each resource type.
- 2 List five resources you would use over the course of a day and classify them according to whether they are renewable or non-renewable resources.
- 3 What is a continuous resource?

## AUSTRALIA'S RESOURCES (PAGES 106–107)

- 4 List three resources that Australia produces more of than most other countries.
- 5 Explain why fossil fuels are a non-renewable resource.
- 6 Australia uses more non-renewable resources than renewable resources. Why do you think that this is the case?

## FOSSIL FUELS (PAGES 108–109)

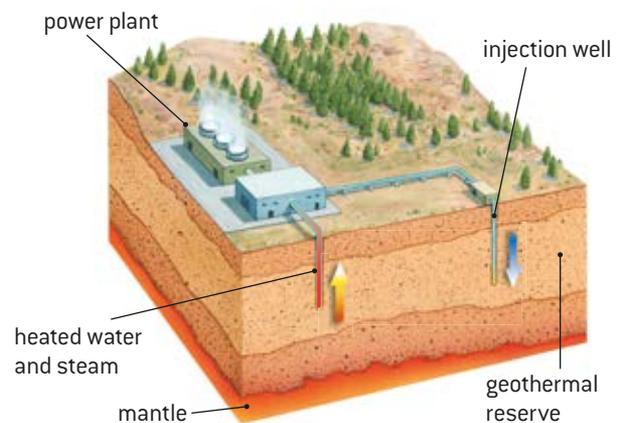
- 7 Give examples of fossil fuels in their solid, liquid and gaseous forms.
- 8 Look carefully at the photograph below left.
  - a What is this structure called?
  - b Which two fossil fuels is it mining?
  - c Where are these fossil fuels found?
- 9 Where does the carbon in coal come from?

## MINING AND USING FOSSIL FUELS (PAGES 110–111)

- 10 Name two ways that natural gas is used in the home.
- 11 How is the energy stored in coal changed to electrical energy at the power station?
- 12 Explain how high-voltage electricity is reduced for safe use in the home.
- 13 What is the difference between the crude oil mined from the ground and the petrol used in cars?

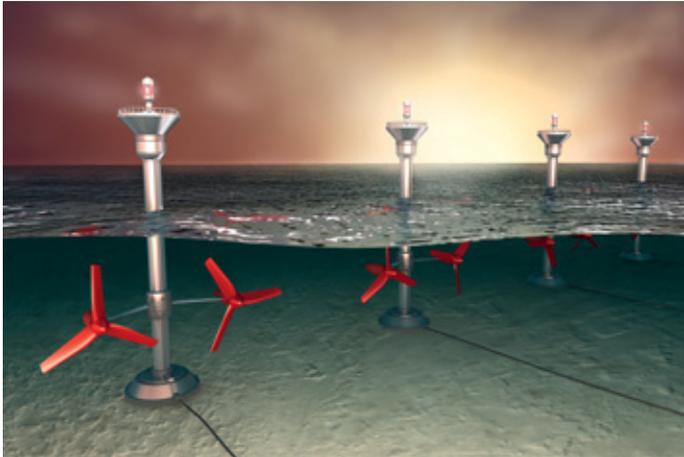
## 5 RENEWABLE ENERGY RESOURCES (PAGES 114–115)

- 14 Look at the diagram below.
  - a Which renewable energy resource is shown here?
  - b What is being pumped down the injection well?
  - c What is pumped up into the power plant?
  - d What happens in the power plant?



15 Look at the illustration below.

- What type of renewable energy is shown here?
- What role do the propellers play?
- How is the electrical energy transported once it is produced?



16 Why do you think only a fraction of the world's energy production is from renewable sources?

### WIND AND SOLAR ENERGY (PAGES 116–117)

- Explain the difference between what turns wind turbines and what turns turbines in a power station powered by fossil fuels.
- Discuss the advantages of wind turbines.
- Explain the location of the wind farm in the picture below.



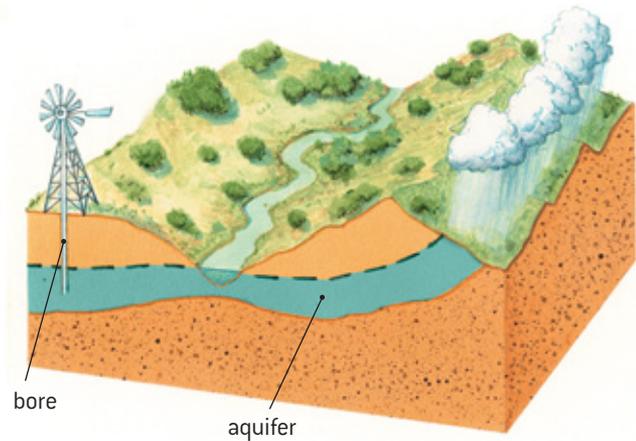
20 How is solar energy converted into electrical energy?

### WATER FOR ENERGY AND OTHER USES (PAGES 118–119)

- The places where water is recycled are often called treatment plants. Why do they have that name?
- Why does Australia store great volumes of water in dams?

23 Look at the diagram below.

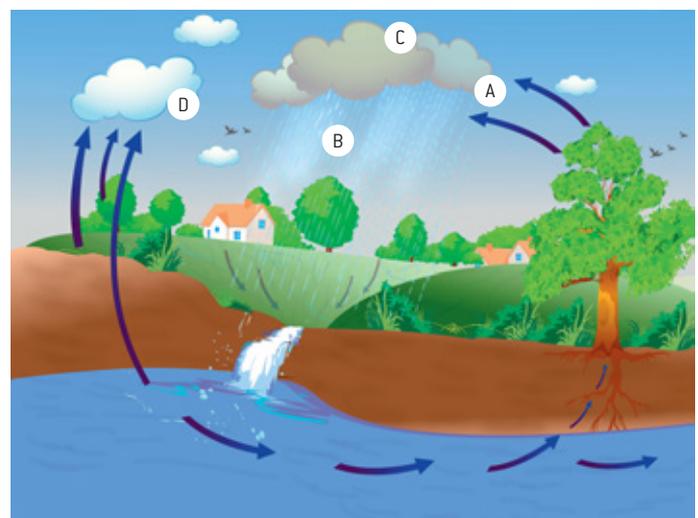
- What is an aquifer?
- Explain what role the windmill plays.



24 New buildings have the potential to capture rainwater for reuse. Draw a diagram to illustrate a way that a new building could capture and reuse rainwater.

### WATER CYCLE (PAGES 120–121)

- How much of the world's total water is fresh water found in lakes and rivers?
- Match the following terms to the letters A–D on the diagram below:
  - >> evaporation
  - >> condensation
  - >> transpiration
  - >> precipitation.



## KEY IDEAS

1

People use many environmental resources. They include renewable, non-renewable and continuous resources.



6

Fossil fuels such as coal, oil and gas are non-renewable energy resources mined from the Earth's crust. Coal is used for electricity, and oil is used for products such as petrol and diesel. Natural gas is used for cooking food, heating our homes and water, and as fuel for transport.



2

Non-renewable resources are resources such as coal and oil that will one day run out. Renewable resources, such as fresh water and trees, will not run out if they are carefully managed.



7

Renewable energy resources include wind energy, solar energy, geothermal energy, hydro energy and tidal energy. Renewable energy supplies about 20 per cent of the world's electricity and less than 10 per cent of the world's total energy production.



3

Nearly all energy resources used in Australia come from non-renewable fossil fuels, which are running out.



8

Wind energy has been used in the past for grinding flour and sailing ships. More recently, wind energy has been used for generating electricity through turbines placed in windy locations.



4

Australia's resources include fuels such as coal, uranium and natural gas. Mining is Australia's biggest export industry.



9

In Australia, we manage water resources by using underground water and water from dams, capturing stormwater and reusing waste water. We also get clean water from desalination plants.



5

Fossil fuels take millions of years to form. Oil, gas and coal were formed from the remains of plants and animals by great pressure and heat.



10

The water cycle is the movement of water from land to sky and back to land again through the processes of evaporation, transpiration, condensation and precipitation.

# FORCES 07

HOW DOES FRICTION SLOW US DOWN?

**\*5\***  
key facts about FORCES

Does an elephant sink or float in water?

## GRAVITATIONAL FORCE



127

USING FORCE



138

MAGNETIC LEVITATION



143

HAIR-RAISING FORCE

# 5 KEY FACTS ABOUT FORCES

**Forces** change motion. When we think of motion we think of things that move, such as cars, bikes, scooters and planes. For something to change its motion it must be pushed or pulled. These pushes and pulls are forces. More than one force is acting on everything around us all of the time. The changes in motion and shape shown here are examples of **contact forces**, where one object is in contact with another. Objects can also be changed by **non-contact forces**, such as gravity, and magnetic and electrostatic forces.

*The spinnaker sail on maxi-yacht Wild Oats XI has an area of 880 square metres. The yacht has a top speed of 28 knots (52 kilometres per hour).*



## 1 Forces can move objects

When you play golf, the golf club is used to push the ball. The club puts a force on the ball, causing it to begin to move along the ground or through the air. The golf tee and the grass also move. If you miss, there is no extra force on the ball from the club and the ball stays still.

## 2 Forces can increase speed

The force of the wind on the sail of a yacht causes the yacht to move. The greater the speed of the wind, the faster the yacht goes. The air consists of tiny invisible particles that rapidly move about. When there is a wind, the particles mostly move in the direction of the wind. When they hit objects in their path, the air particles push the objects. Yachts have a very large area of sail so that as many air particles as possible are able to hit the sails and give them a push.

### 3 Forces can decrease speed

Think about a car and the use of brakes. To slow down, the driver applies the brake pedal, which pushes on the brake pads. These, in turn, put a force on the wheels, causing the car to slow down. In drag-racing, cars can reach speeds of 530 kilometres per hour. At the end of the 400-metre run, the driver releases a parachute. Air particles hitting and pushing on the huge area of the parachute slow the drag-racing car down so the driver can safely bring it to a stop. The force of the air particles on the parachute is called air resistance.

### 4 Forces can cause objects to change shape

A tennis racquet provides the force to change the motion of a tennis ball. When a tennis player hits a ball, the ball is compressed by the racquet. The racquet strings bend and stretch a little under the force of the ball. As the ball leaves the racquet, both the ball and the strings return to their normal shapes and sizes.

### 5 Forces can cause a change in direction

The purpose of a tennis racquet, or a cricket or softball bat, is to change the direction of the ball. The force of the racquet or bat causes the ball to speed up and change direction.



#### LOOK IT UP

**contact forces** forces occurring when two objects are touching each other

**force** a push or a pull on an object to change its motion

**non-contact forces** a force that operates between two objects when they are not touching each other, such as gravitational force



*The fastest recorded serve in tennis is by Australian player Samuel Groth at 263 kilometres per hour.*

#### CHECK IT OUT

- 1 List five key facts about forces.
- 2 Explain how force is used to change the shape of the clay sculpture shown to the left.
- 3 Sails and parachutes have large areas of material.
  - a What are sails and parachutes designed to do?
  - b Explain how they can cause objects to speed up and slow down.

# BALANCING FORCES

Forces are acting on us all the time, whether we are still or moving. We say forces are balanced when there are two forces of the same strength working in opposite directions. That is, they balance each other, and there is no change. We say forces are unbalanced when two forces acting on an object are not equal in size. That is, one force is bigger than the other, causing an object to change its motion.

If the forces on an object are equal and opposite, there will be no change in movement. These are known as **balanced forces**. The forces on an object are balanced if it does not:

- » change direction
- » change shape
- » speed up
- » slow down or stop.

If one force is bigger than all of the other forces acting on an object, then the forces are said to be **unbalanced forces**, and the object may:

- » change direction
- » change shape
- » speed up
- » slow down or stop.



As this weightlifter moves and lifts the barbell, there are unbalanced forces in action. The upward force raising the bar is greater than the downward force of gravity. Once the barbell is lifted and held, balanced forces are in action. The upward and downward forces balance each other and the barbell remains still.



Unbalanced forces make the tractor move faster.



## Forces can be added together

If you tried to move a heavy object, such as a car, you probably would not succeed because the force you could exert on the car would be too weak. But if several strong people were to exert a force on the car, they could move it. This is because their combined forces would be stronger than the other forces on the car. The **net force** is the force that results when all the forces acting on an object are combined. If the people pictured (right) are able to move the train, there is a net force on the train toward one side.

## Forces on an aircraft

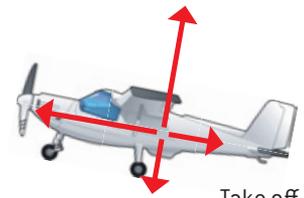
When an aeroplane is cruising at a constant speed, the forces of lift (upward force from the wings), gravity (the downward force), thrust (the push force provided by engines) and drag (air resistance) are balanced. When it takes off, the thrust and lift forces are dominant and the aircraft rises into the air. When a plane comes in to land, the lift and thrust reduce and the plane slows and descends. When a plane takes off or lands, the forces acting on it are unbalanced.



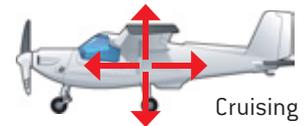
In 2014, train passengers in Perth used their net force to push an entire train onto an angle to free a commuter whose leg became trapped between the train and the platform edge.

## Drawing force diagrams

A force diagram uses arrows to show the direction and strength of a force. A short arrow shows a weak force and a long arrow shows a strong force. We use a separate arrow to represent each different force. The direction of the arrow shows the direction of the force and the length of the arrow indicates the relative strength of the force.



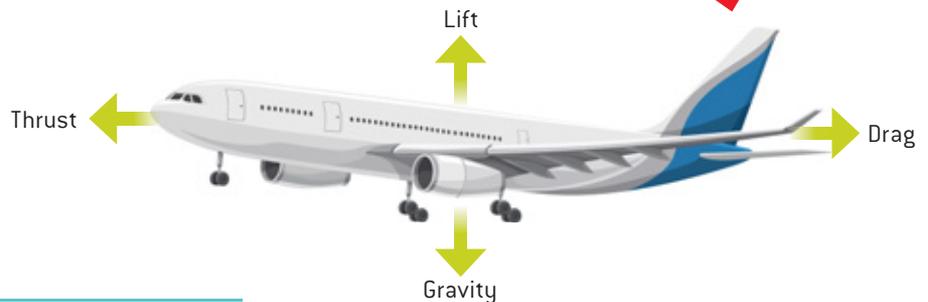
Take off



Cruising



Landing



## CHECK IT OUT

- 1 What are the features of balanced and unbalanced forces?
- 2 The weightlifter pictured is lifting a heavy mass. Explain what happened to the forces before and after this picture.
- 3 Explain how you might combine forces to move a heavy piano.
- 4 Draw a diagram to show the main forces acting on an aircraft cruising at a constant speed.
- 5 Draw a force diagram to represent the movement of the parachutist shown here.



## LOOK IT UP

**balanced forces** two forces that are equal in size and opposite in direction

**net force** the combined effect of all the forces acting on an object

**unbalanced forces** two forces, not equal in size, acting on an object

# FRICTION: FRIEND OR ENEMY?

**Friction** is found everywhere that objects come into contact with each other. Friction is a contact force applied to the surface of an object when it contacts the surface of another object. Friction always slows a moving object down.

If a car needs to stop, it slows because of friction between the brakes and the wheels. Without friction, your feet would slip over the ground, like trying to walk on ice. The rough surfaces on your shoes and on the ground provide the friction you need to push you forward.

This type of friction is known as **traction**. Without traction, a car's wheels would spin and it couldn't start moving. Moving cars could not turn corners or stop without friction. Less friction on wet and icy roads makes it difficult to control a car.

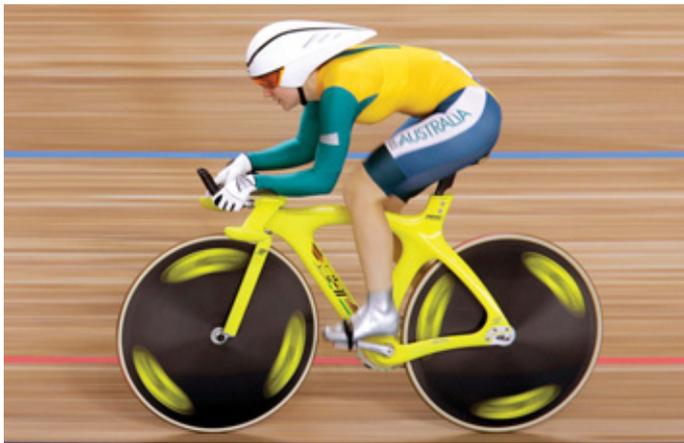
A simple way to experience friction is to rub your hands together as fast as you can. You can feel the friction and the heat it generates. All friction forces generate heat because the energy that was causing the movement is converted into heat.



*This woman has slipped on the ice. Less friction is produced on smooth surfaces such as ice.*

## Friction slows you down

Friction slows everything that is moving. The more friction there is, the more quickly the movement slows. Friction happens because objects rub together. A moving bicycle is pushing through the air and against the road, and the wheels are rubbing against the axles. When you are swimming, you are pushing against water. The water slows you down. With less friction, you could ride further and swim faster with less effort. Friction acts opposite to the direction that the object is moving in, so it will always slow you down.



*This Australian Olympic cyclist reduces air resistance by wearing a smooth, curved helmet and smooth, tight clothes. The rider bends down to let the air flow over her. The wheels are closed in to help the air flow around them.*



### LOOK IT UP

**friction** a force that acts to oppose the motion between two surfaces as they move over each other

**lubrication** decreasing friction by applying a substance between the surfaces, such as oil or grease

**traction** the grip an object exerts on a surface

### CHECK IT OUT

- 1 Why have the cars and trucks shown in the image above crashed?
- 2 What is friction?
- 3 Explain how the orange car pictured has been designed to reduce friction.
- 4 Look at these two bike tyres and suggest what each is designed to do.



*Ice on the surface of a road reduces friction and makes it difficult for vehicles to get the traction they need to steer and stop.*

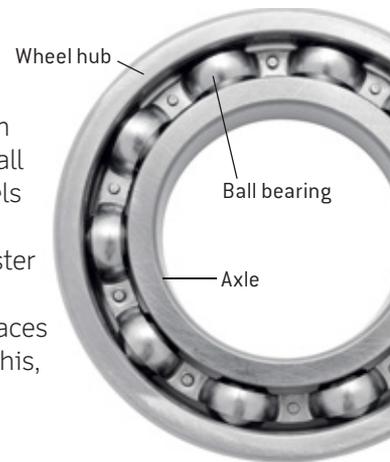
## Reducing friction

Oil and grease are used to reduce friction. They are known as lubricants, and reducing friction in this way is known as **lubrication**. Lubricants work by coating a surface with an oily or waxy substance, which makes them slippery. Putting oil on bicycle chains and grease on wheel axles makes the moving parts move against each other more easily, with less friction.

Objects travelling through air slow down because of air resistance. Cars and aeroplanes have smooth, streamlined shapes to reduce the drag of air resistance. Air resistance is the friction between a moving object and the air it is moving through. Streamlining makes the surface smooth and rounded, and helps reduce air resistance.

## Ball bearings

One way of reducing friction between objects is by using rollers or balls. Ball bearings reduce the friction on wheels as they spin around an axle. Ball bearings allow the wheels to turn faster as the tiny metal balls inside them reduce the contact between the surfaces of the wheel and the axle. By doing this, they reduce the amount of friction.



*Ball bearings reduce friction on wheels as they spin around the axle.*



# MEASURING FORCE

**AIM:** TO MEASURE A VARIETY OF FORCES IN COMMON SITUATIONS

## MATERIALS

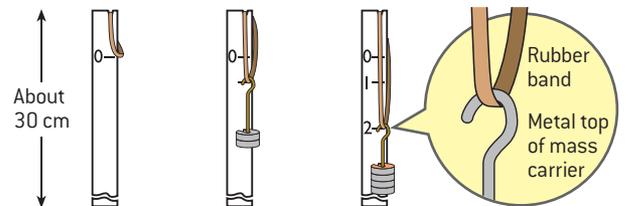
- Rubber band
- Thin wooden strip (or a ruler)
- Mass carrier and masses
- Pen

## METHOD

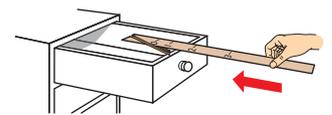
A rubber band can measure the sizes of forces in a similar way to a spring balance. But before it can, it must be calibrated. This means matching the stretch of the rubber band to the number of Newtons (a measure of force) pulling on it.

- 1 Calibrate the rubber band on the wooden strip, as shown.

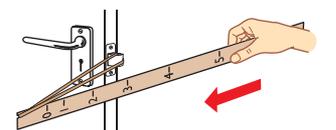
*Calibrating the force measurer.*



- 2 Mark the distance that the rubber band is stretched on the wood when the carrier holds a 100 g mass.
- 3 Repeat for masses of 200 g, 300 g, 400 g and so on, marking the wood each time. Note: The weight force of 100 g equals 1 Newton of force.
- 4 Use your force measurer to measure the size of the force needed to:
  - a open the door to the room
  - b drag a chair across the floor
  - c close a drawer in the laboratory
  - d move your pencil case
  - e pull up your sock
  - f do three other movements of your choice.



*Measuring the force needed to close a drawer.*



*Measuring the force needed to open a door.*

## RESULTS

Include a neat, labelled and accurate diagram of the rubber band force measurer, and set out your measurements in a table.

## DISCUSSION

Write a sentence for each of the measurements you made, as well as several sentences comparing the measurements.

## CONCLUSION

What have you learned about a variety of forces in common situations?

# REDUCING FRICTION

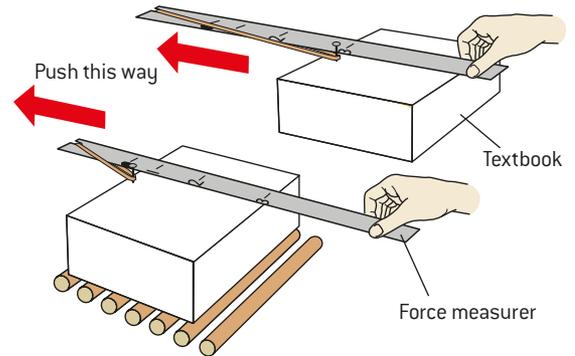
**AIM:** TO INVESTIGATE HOW FRICTION MAY BE REDUCED

**MATERIALS**

- Force measurer (see experiment 'Measuring force')
- Thick textbook
- Wooden rollers (or round pencils)
- Book
- Sand

**METHOD**

- 1 Use your force measurer to measure the friction created by dragging your textbook across the table. (Hint: Drag the book at constant speed.)
- 2 Place a second book on top of the first book and measure the friction.
- 3 Place rollers under the book and measure the friction.
- 4 Place sand under the book and measure the friction.



*Measuring the friction of a textbook.*

**RESULTS**

Record your results in a table.

| OBJECT                            | FORCE NEEDED TO MAKE IT MOVE (N) |         |         |         |
|-----------------------------------|----------------------------------|---------|---------|---------|
|                                   | TRIAL 1                          | TRIAL 2 | TRIAL 3 | AVERAGE |
| Textbook                          |                                  |         |         |         |
| Textbook with a second book on it |                                  |         |         |         |
| Textbook with rollers under it    |                                  |         |         |         |
| Textbook with sand under it       |                                  |         |         |         |

**DISCUSSION**

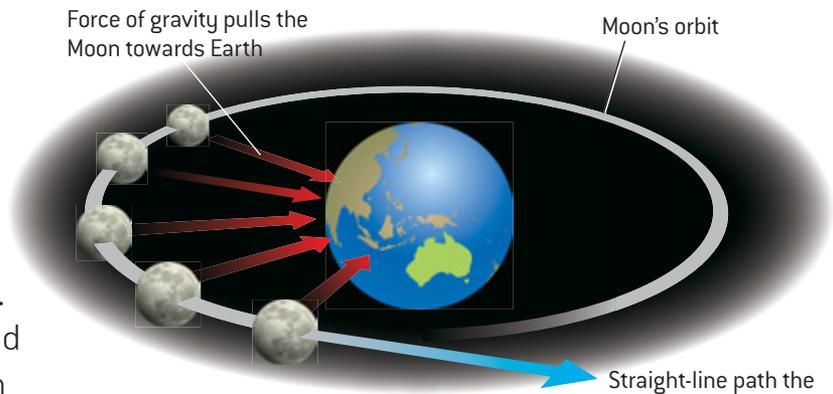
- 1 What was the best way to reduce friction?
- 2 Would five rollers be better than two for reducing friction?
- 3 Would ten rollers be better than five for reducing friction?
- 4 Would bigger or smaller rollers be better for reducing friction?
- 5 What are some problems with using rollers?
- 6 Write down a practical example of rollers being used to reduce friction.
- 7 Why wouldn't square rollers work?
- 8 Would fine sand or coarse (large-grained) sand be better to increase friction?
- 9 Write down a practical example of sand being used to increase friction.
- 10 What are some problems with using sand for this purpose?

**CONCLUSION**

What do you know about how to reduce friction?

# GRAVITY

Gravity is a non-contact force of attraction between two objects. Non-contact forces push and pull objects without touching them. Gravity keeps the planets orbiting the Sun and keeps our Moon orbiting the Earth. It holds an atmosphere of gases and stops you drifting into space.



The Moon is held in its orbit by the gravitational field of the Earth.

## How gravity works

Gravity is the force that causes two objects to pull towards each other. These BASE-jumpers are being pulled towards the centre of the Earth. On Earth, gravity keeps the air and everything else from drifting into space.

*BASE-jumpers are pulled towards the ground by the influence of gravity.*

## Gravity and mass

Gravity is affected by the mass (amount of material) of objects. The greater the mass of an object, the stronger its **gravitational force**. The Sun has such a large mass that its powerful gravity attracts all other objects in the solar system and keeps them orbiting around it.

Each planet has a different mass, so each has a different pull of gravity. Mercury, the smallest planet in our solar system, has just 38 per cent of the gravity of the Earth. Jupiter, the largest of all the planets, has 254 per cent of the gravity of the Earth.





*In space, astronauts appear to float. The astronauts and their spacecraft are in fact both falling. They are falling at the same rate, so the astronauts appear to be floating.*



*A rocket leaving Earth has to accelerate to a speed of 40 000 kilometres per hour (the 'escape velocity') before it can break free from the force of Earth's gravity.*

## Gravitational fields

We cannot see gravity, but it is real. We feel the effects of gravity every day. Gravity causes a force field around the Earth. A **gravitational field** is an area around an object in which the object's gravity attracts anything that has mass. People, cars, mountains, even the Moon, all feel a force when they are in the gravitational field of the Earth. Gravitational fields only attract; they never repel. Usually, the closer you are to the centre of the gravitational field, the stronger the force.

When you jump, the gravity of the Earth brings you back to the ground. The Moon has less gravity than the Earth. If you could jump 1 metre high on Earth, on the Moon you would be able to jump more than 6 metres!

For an object to leave the Earth, it has to overcome the pull of the Earth's gravitational field.

### LOOK IT UP

**gravitational field** a region near a particular mass where a gravitational force is experienced

**gravitational force** the force of attraction between all masses in the universe

### CHECK IT OUT

- 1 Look at the photographs of the BASE-jumpers and the astronauts. Why do the BASE-jumpers fall and the astronauts appear to float?
- 2 Define the following terms:
  - a gravity
  - b gravitational field
  - c escape velocity.
- 3 What keeps the planets in our solar system in orbit around the Sun?
- 4 Why can you jump higher on the Moon than on Earth?
- 5 Why do you think rockets are needed to allow travel from Earth into space?
- 6 Where do you think these scientists (pictured) are located? What might they study there?



# STAYING AFLOAT

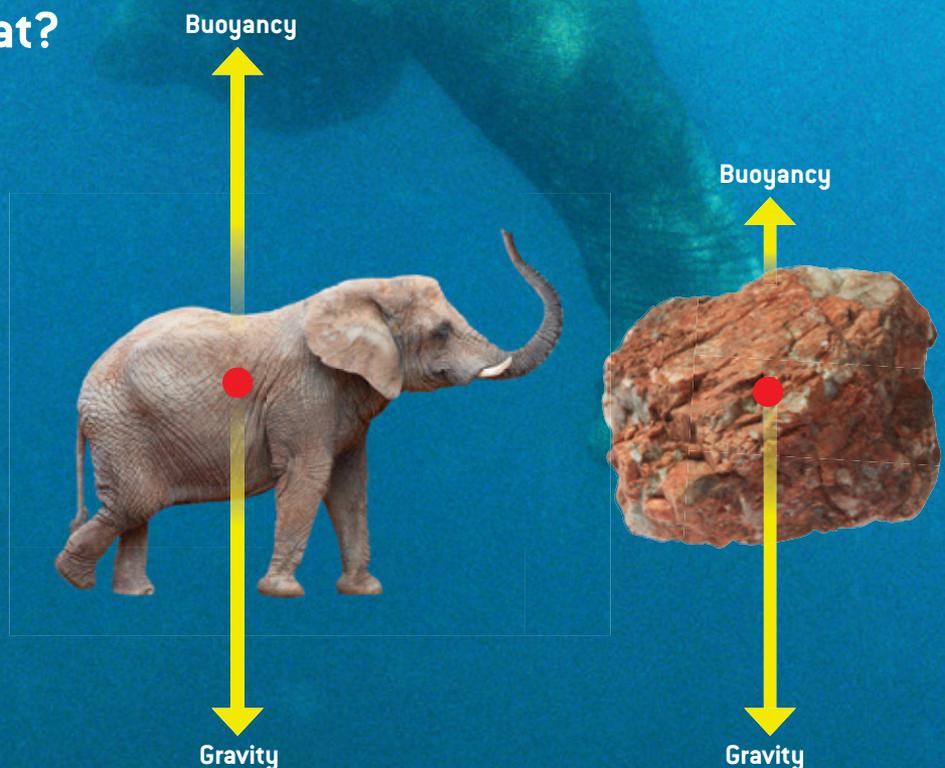
How can very heavy animals such as elephants float in water and very small animals such as insects walk on water?

The answer is in two very special forces that operate when objects are placed in water: **buoyancy** and **surface tension**.

## How do elephants float?

Elephants can float and swim in water. The elephant is helped by the force known as buoyancy – the upward push on an object either floating on the top of a liquid or submerged in it.

As an object floats in water, it moves water aside according to how much it weighs. Archimedes, an ancient Greek mathematician and inventor, found that the water will push upwards against the object with a force equal to the weight of water moved. A rock that was the same size as the elephant would sink because rock is denser than water. The elephant contains air and fat that is less dense than the water it floats in. The weight of the elephant is less than the weight of the water it has pushed aside. This means that there is an upward buoyancy force acting on the elephant that balances the downward force of its weight.



*The elephant is buoyant and floats.*

*The rock is denser than water and sinks.*



To make the air inside the balloon less dense than the air outside, the air inside the balloon is heated. Air in a hot-air balloon is typically heated to 100°C.

## How do spiders walk on water?

Water can create a skin on its surface that is strong enough to allow some insects and other small creatures such as spiders to walk on water. Water particles have a force of attraction, known as **cohesion**. Cohesion is a force that sticks things together. Cohesion at the surface of water is referred to as surface tension. The small weight of the spider pictured is spread out over the surface and is not great enough to push the water particles apart. The force of cohesion forms a 'skin' on the water that allows the spider to walk across it.



*Thanks to surface tension, this spider can walk on the surface of water.*

## How do hot-air balloons fly?

Hot-air balloons rise because the hot air inside the balloon is less dense than the cold air outside the balloon. Buoyancy acts in liquids and in gases, and is related to the differences in **density** of the two objects.

### LOOK IT UP

**buoyancy** upward force of a liquid or gas on an object

**cohesion** attractive forces that hold part of a substance together

**density** the mass per unit volume

**surface tension** the force existing in the surface of a body, especially a liquid, that makes it behave as an elastic sheet

### CHECK IT OUT

- 1 Explain which forces act on you when you float on your back in a swimming pool.
- 2 Why do you think underwater divers wear weight belts?
- 3 Solid steel is denser than water.
  - a Why do large steel ships float?
  - b Use a force diagram (see page 129) to show why a ship floats.
- 4 How can insects walk on water?
- 5 How do hot-air balloons fly?

# MAGNETIC FORCE

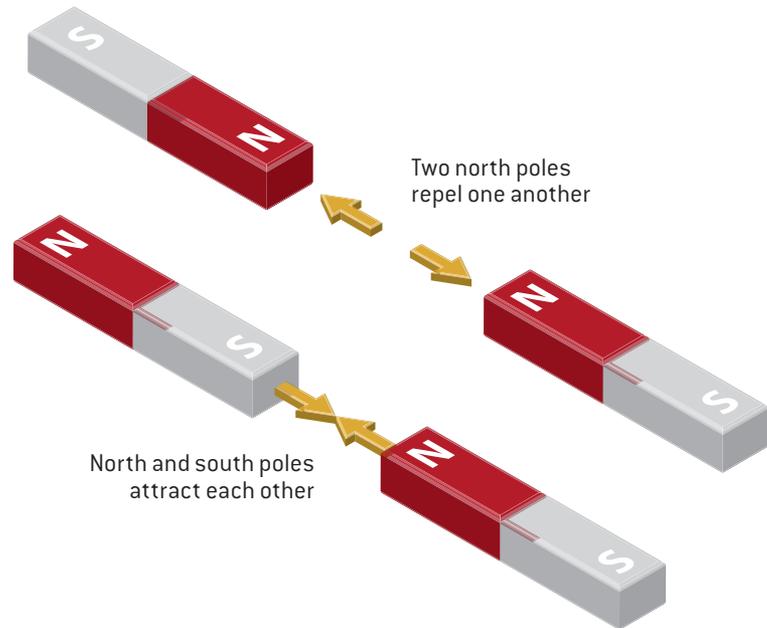


**Magnets** produce an invisible force that can pull or push objects without touching them. Magnets attract and repel each other. They are used to help operate computers, speakers, motors and the fastest trains in the world.

*Researchers test a hoverboard that uses magnetic force to levitate above a rail. The Magsurf is a skateboard that rides a few centimetres above a magnetic track. Super-cold liquid nitrogen turns the material on the bottom of the board into a superconductor, which repels the magnetic field in the track.*

## How magnets work

**Magnetic** force is a non-contact force. Magnetic forces are strongest when the magnets are touching, but most magnets have the ability to push and pull from a distance. The forces are strongest at the ends of the magnets, called the **poles**. Magnets have a north pole and a south pole. Magnets push away from one another (repel) when the same poles are brought close together. Magnets pull towards each other (attract) when different poles are brought together.



## Magnetic materials

Magnets attract magnetic metals – iron, nickel and cobalt. They also attract **alloys**, such as steel, that contain some magnetic materials (steel contains a large amount of iron). Magnets do not attract non-magnetic metals such as gold, tin or copper.



### LOOK IT UP

- alloy** a metallic substance made by mixing two or more metals
- magnet** material or object that produces a magnetic field
- magnetic** able to be magnetised or attracted by a magnet
- poles** the ends of a magnet where the magnetic field is strongest



*The horseshoe magnet shown attracts an iron nail as well as steel paperclips and screws. It does not attract the plastic building block, the wooden pencil, the coin (zinc and copper) or the brass hose fitting.*

### CHECK IT OUT

- 1 Why is magnetism considered to be a non-contact force?
- 2 When magnets are together, which two poles:
  - a attract each other?
  - b repel the magnets from one other?
- 3 What objects have been picked up by the horseshoe magnet opposite? Why?
- 4 How does magnetic force help maglev trains travel much faster than other trains?
- 5 What magnetic experiment are the scientists on the opposite page conducting?

Maglev (magnetic levitation) trains, such as this one in China, are the fastest trains in regular service.

Magnets on the rail pull on magnets on the train to help it levitate just centimetres above the track surface.

By floating above the track, the train avoids friction with the surface. This reduces wear and tear and increases the speed of the train.

# MAGNETIC FIELDS

Magnetism and other non-contact forces operate through an invisible force field to push and pull.

A **magnetic field** is the area around a magnet where magnetic force is felt.

## Earth is a giant magnet

All magnets, no matter what their size or shape, have a north pole at one end and a south pole at the other. Even if you cut a magnet in half, each half will still have north and south poles.

The Earth itself is a giant magnet, with north and south poles like the two ends of a bar magnet. A **compass** needle is a small magnet and will always point to the Earth's North Magnetic Pole.

The North Magnetic Pole isn't a fixed point – it wanders according to the magnetic field of the Earth. The Earth is surrounded by a magnetic field that extends way beyond the atmosphere into space, where it is called the **magnetosphere**.

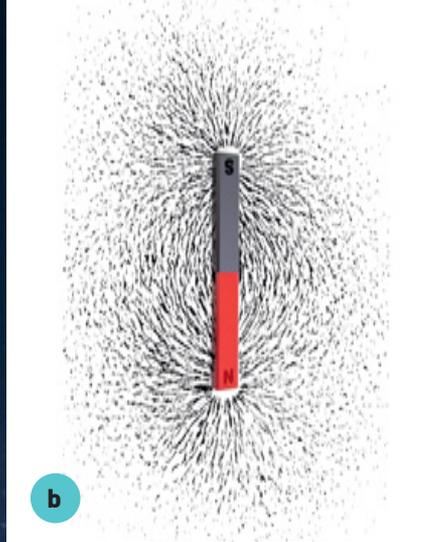
The magnetosphere changes the direction of charged particles from the Sun so they do not hit the Earth.

This produces displays of light in the sky called **auroras**. In the southern hemisphere this display is called the aurora australis, and in the northern hemisphere it is called the aurora borealis. The auroras are mostly seen in the night sky near the Arctic and Antarctic regions.

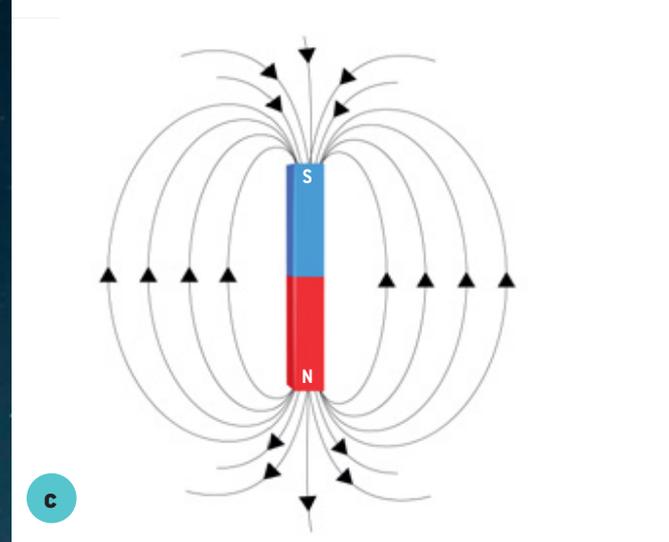
*Auroras are light shows in the sky caused by the Earth's magnetic field.*



a



b



c

Invisible magnetic fields can be shown by (a) compasses and a magnet; (b) iron filings; (c) magnetic field lines on a map.

## 'Seeing' invisible magnetic fields

### a Using a magnet and compasses to show the invisible magnetic field

A compass is a small magnet used to point towards the North Magnetic Pole of the Earth. Compass needles line up with the Earth's magnetic field, but if a magnet is brought near a compass, the north pole of the compass will point towards the south pole of the magnet. If you place many compasses near to the magnet, the compass needles draw a map of the magnetic field.

### b Using iron filings to show the invisible magnetic field

Magnetic metals such as iron are attracted to magnets. We can use iron filings to 'see' the magnetic field. If you put iron filings near a strong magnet, they become temporary magnets. The iron filings line up like tiny compass needles around the strong magnet. This lets us see what a magnetic field looks like.

### c Drawing magnetic field lines to make a map

We can draw lines to clearly see the invisible magnetic field. Where the lines are close together, the magnetic force is greatest, and where they are further apart, the magnetic force is weakest. Magnetic field lines never cross, and they always point away from the north pole of the magnet and towards the south pole. We use arrows to show the direction of the field.

### LOOK IT UP

**aurora** bands of coloured light in the night sky due to charged particles interacting with the Earth's magnetic field

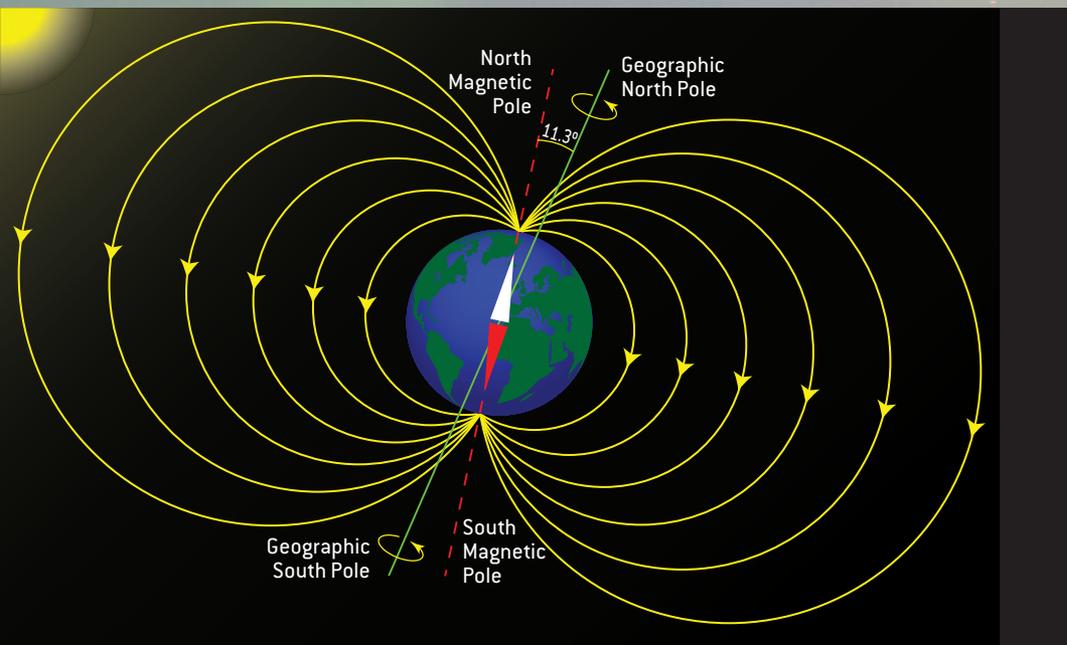
**compass** an instrument showing the direction of magnetic north

**magnetic field** region around a magnetic material or a moving electric charge within which the force of magnetism acts

**magnetosphere** the magnetic field surrounding planets, stars, etc.

### CHECK IT OUT

- 1 How is the Earth like a giant magnet?
- 2 How does a compass work and why is it useful?
- 3 How can people in the Arctic or Antarctic 'see' the invisible magnetic field around the Earth?
- 4 How can we 'see' the magnetic field around a bar magnet?
- 5 In which direction do magnetic field lines flow?





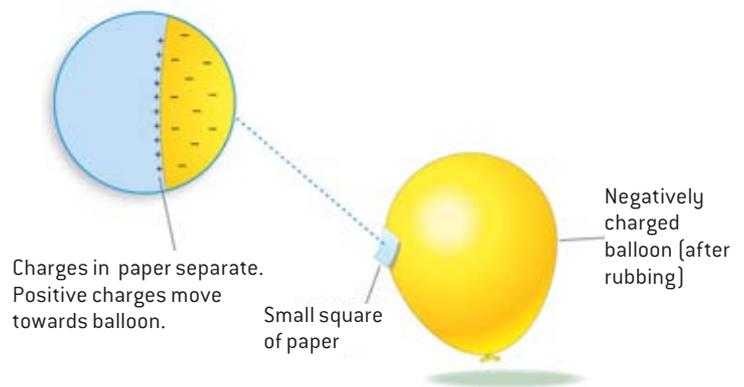
Lightning is the result of rapid charge movements in storm clouds.

# ELECTROSTATIC CHARGES

Substances become charged with the addition or removal of **electrons**. This can happen by friction, when materials are rubbed together. It can also happen when an object comes into direct contact with another.

## Creating charge

Matter is made of atoms. At the centre of each atom is a nucleus containing protons and neutrons. Each proton carries a positive electric charge. Electrons have a negative charge and constantly move around the nucleus. Atoms have equal numbers of electrons and protons. Atoms have no overall charge. If you remove electrons from a substance, it will become positively charged.



*A negatively charged balloon can attract a neutral object such as paper by causing its charges to separate.*

*A Van de Graaff generator creates static electricity. Standing on an insulated rubber surface, the girl touching the metal dome of the generator is receiving a positive charge from it as the negative charges leave her body. Her positively charged hairs are trying to repel each other and stand on end.*



## Static electricity

**Static electricity** refers to the charge on the surface of an object. The electricity is not flowing. 'Static' means staying still or remaining unchanged. Static electricity can also be neutralised or discharged by a spark or movement of electrons.

### Friction

When some objects are rubbed together, such as a balloon and someone's hair, electrons may move between them. The rubber balloon removes electrons from the hair. This leaves the balloon with a negative charge. The shortage of electrons on the hair leaves it with a positive charge.

### Contact

As well as charging an object by

friction, objects can be charged by contact. The girl touching the Van de Graaff generator (pictured) has become positively charged because she has lost electrons to the generator.

## How do charged objects behave?

Charged objects behave in a similar way to magnets. Like (or similar) poles of two magnets will repel, and unlike poles will attract. In the same way, like charges repel and unlike charges attract. So two negatively charged objects will repel each other, as will two positively charged objects. A positively charged object and a negatively charged object will attract. The girl's hair is positively charged. Each hair is repelling the next one,

leading the hairs to separate from each other and stand on end.

When a balloon is rubbed on your jumper, it becomes negatively charged with electrons. If the same balloon then touches a piece of paper, the negative charges in the paper are repelled and the positive charges are attracted. This causes the paper to stick to the surface of the balloon. Neutral objects such as paper will attract charged objects such as the balloon.

Static electricity is used in an inkjet printer, where the positively charged ink is attracted to areas of negative charge on the paper to form the required pattern. Static electricity can sometimes be unhelpful. It can cause some light objects such as dust to 'stick' to other objects such as television screens.



### LOOK IT UP

**electron** a negatively charged particle found in atoms

**static electricity** a stationary electric charge that builds up on a material

### CHECK IT OUT

- 1 How do substances become positively charged?
- 2 Why is the hair of the girl in the photograph standing on end?
- 3 Explain how friction causes a balloon to be able to attract a piece of paper.
- 4 How are charged objects similar to magnets? Give an example.
- 5 How can static electricity be both helpful and unhelpful?
- 6 How is lightning a good example of discharging static electricity?

# FORCES



## 5 KEY FACTS ABOUT FORCES (PAGES 126–127)

- 1 Give three examples of how forces change motion.
- 2 Look at the photograph of the BASE-jumper above. Explain how the shape of his suit is changing his motion.
- 3 Explain how force can change the shape of a tube of toothpaste.

## BALANCING FORCES (PAGES 128–129)

- 4 What is the term for forces on an object that do not change direction or speed?
- 5 What is the result when several forces act on an object in the same direction? What is the name for this?

## FRICITION: FRIEND OR ENEMY? (PAGES 130–131)

- 6 What is friction?
- 7 Look carefully at the racing car below.
  - a Why do racing cars have a streamlined shape?
  - b Why has grease been used to lubricate the wheel axles?
  - c Look at the tyres. Why is there not a lot of tread on these racing car tyres?
  - d In what weather conditions might a racing car be fitted with tyres that give greater traction?
  - e What does the smoke from the tyres tell you about friction and heat energy?



## GRAVITY (PAGES 134–135)

- 8 Why is gravity a non-contact force?
- 9 How does gravity hold the Moon in its orbit around the Earth?
- 10 Look at the photograph of the BASE-jumper opposite. How is the force of gravity acting on this BASE-jumper?
- 11 Are astronauts who are spacewalking in orbit around the Earth floating or falling?

## STAYING AFLOAT (PAGES 136–137)

- 12 How do hot-air balloons become buoyant enough to fly?
- 13 How can a spider walk on water?
- 14 The *Oasis of the Seas* (pictured below) is one of the world's largest cruise ships. It is 20 storeys high, 362 metres long, and weighs 100 000 tonnes.
  - a Explain how buoyancy helps such a heavy object to float.
  - b The *Oasis of the Seas* displaces (moves aside) the equivalent of 100 000 tonnes of water. How does this allow it to float?
  - c If the *Oasis of the Seas* was just a block of dense, solid steel, would it float? Explain your answer.

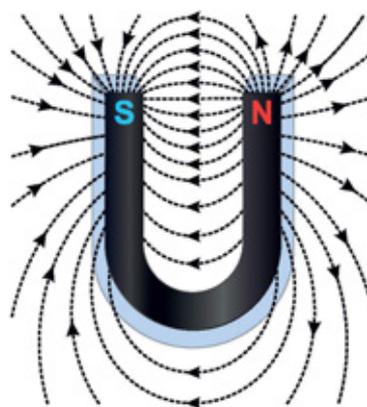


## MAGNETIC FORCE (PAGES 138–139)

- 15 Why is magnetism a non-contact force?
- 16 What objects do magnets attract?
- 17 Explain how magnets can attract and repel one another.
- 18 What is the effect of magnets on a maglev train? Why is this an advantage?

## MAGNETIC FIELDS (PAGES 140–141)

- 19 Explain why a compass needle always points towards the North Magnetic Pole (when it is away from other magnets).
- 20 What happens when auroras occur?
- 21 Look carefully at the diagram below and complete the following sentences.
  - a Magnetic field lines point away from the [north/south] pole of the magnet towards the [north/south] pole of the magnet.
  - b When magnetic field lines are close together the magnetic force is [weak/strong] and when magnetic field lines are further apart the magnetic force is [weak/strong].



## ELECTROSTATIC CHARGES (PAGES 142–143)

- 22 Describe how friction can separate positive and negative charges.
- 23 When the soles of your shoes rub on some types of carpet, your body becomes negatively charged. Explain what will happen to the additional negative charge if you:
  - a immediately touch a metal door handle
  - b place your hand near a negatively charged balloon
  - c place your hand near a positively charged balloon.

## KEY IDEAS

1

Forces change motion. They make objects speed up, slow down or change direction.



5

Buoyancy is a force that allows objects to float. The less dense the object, the more likely it is to float.



2

When the forces on an object are balanced, the object stays still. An example is a book resting on a table.



6

Surface tension is the force created by the cohesion of particles on the surface of the water, giving water a type of 'skin.' Some insects are able to walk on the 'skin' of the water.



3

Friction is a contact force that causes objects to slow down.



7

Magnets have an invisible force that allows them to attract and repel each other. Opposite poles of a magnet attract and like poles repel.



4

Gravity is the force that causes two objects to pull towards each other. The greater the mass of an object, the stronger is its gravitational force.



8

A magnetic field is the area around a magnet where magnetic force is felt. The Earth is like a giant magnet with north and south poles.



9

Electrostatic charges can be positive or negative. Substances become charged with the addition or subtraction of negative charges (electrons).



10

Like charges repel each other and unlike charges attract. A positively charged object will attract one that is negatively charged and will push away another positively charged object.

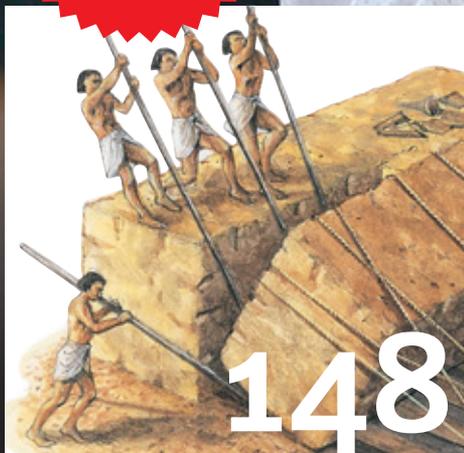


# MACHINES 08

How can an object be moved with little effort?

**\*5\***  
**AMAZING  
WHEELS**

## AMAZING BODY LEVERS



**148**

EARLY MACHINES



**152**

USING LEVERS



**160**

SHIFTING GEARS

# MACHINES MAKE TASKS EASIER

A force is needed to change an object's speed or direction. Machines increase the force we can apply. They can make jobs easier and allow us to do things that we couldn't possibly do without them.

A ramp was built to help move the large blocks

Blocks moved on wooden sleds

## Machines in Ancient Egypt

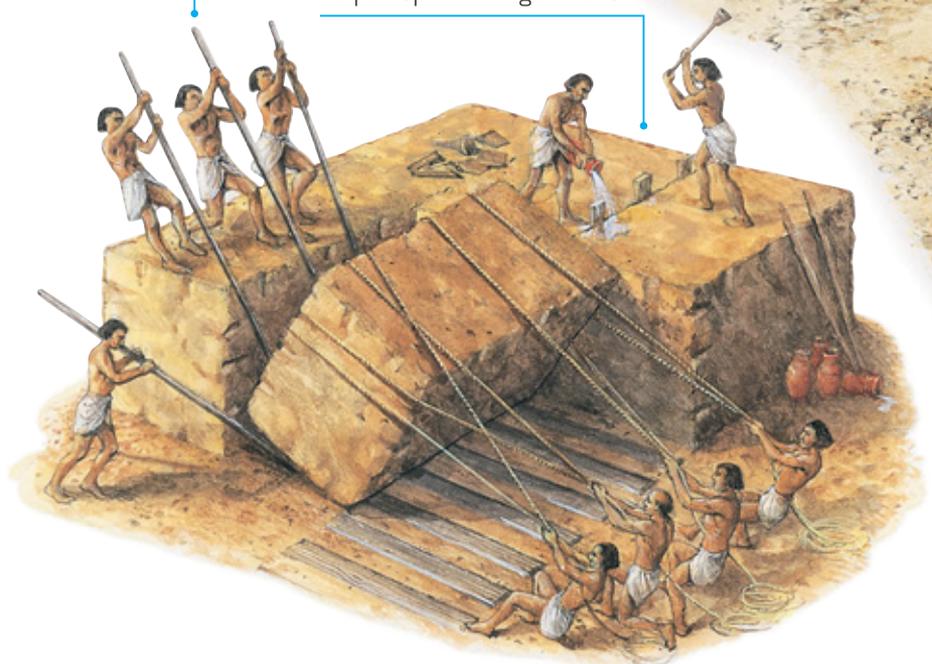
The Great Pyramid at Giza was built around 2580 BCE as the tomb of the pharaoh Khufu. Most of the Great Pyramid's 2.3 million blocks weigh 2.5 tonnes or more.

For years, scientists and historians did not understand how the Great Pyramid was built. After much research, they now believe that the Ancient Egyptians used simple machines such as **ramps**, **wedges**, **levers**, wheels and **pulleys** to cut and move the huge blocks of stone.

They used huge wooden sleds pulled by ropes, using water to wet the sand at the front of the sled to reduce friction, to transport the stone.

Long levers helped increase the force to move the blocks

Wedges hammered into rock helped split the large blocks





## LOOK IT UP

**lever** a solid rod or bar that is supported at the fulcrum and can be used for moving a load

**pulley** a rotating wheel with a grooved circumference, used with a rope or cable to lift heavy loads

**ramp** a flat, tilted surface used to help raise or lower a load; also known as an inclined plane

**wedge** an object with a thick end tapering to a thin end that can be pushed between two objects to separate or secure them

## CHECK IT OUT

- 1 How do machines help humans do jobs?
- 2 What simple machine was used to cut the blocks used to make the Great Pyramid? Can you think of tools around the home that use a wedge shape?
- 3 How were long levers used to increase the effort? What tools might you use to move a heavy load, such as a rock in the garden?
- 4 How did the ramp help in the construction of the pyramid?
- 5 What simple machines were used to move the heavy blocks over a distance?

The force applied to an object is called the effort. The load is the object, such as a rock, that is moved. Simple machines reduce the amount of effort needed by humans because they increase the force on the load.



# RAMPS

*A skateboard ramp is an inclined plane. The greater the angle on the ramp, the more speed can be gained. The skateboarder crouches down to increase speed as he exits the ramp so he can perform more tricks while airborne.*

Ramps, wedges and screws are all examples of **inclined planes** – each with a surface that is set at an angle to the horizontal.

## Ramps

A ramp is a machine because it reduces the amount of **effort** required to lift a **load**. Although a greater distance is travelled, a much lower effort is required to move an object along a slowly rising ramp than to lift it straight up. Think about when you walk up a ramp compared with the stairs.



*A ramp takes longer, but needs less effort.*

## Wedges

A wedge is made up of one or two inclined planes or surfaces. Wedges can be used to split objects or to stop them moving.

An axe is a wedge with two inclined planes, and is used for splitting logs. The axe reduces the effort needed to split the timber by forcing the wood to travel up the wedge. As the axe is forced into the wood, it pushes the two parts of the log apart.

Humans discovered the benefits of the wedge when they used the jagged edges of rocks to cut animal flesh and skin. Heavy-duty wedges were soon to follow, which made work easier and weapons more powerful. You have probably used a wedge today: a knife is a wedge, and so are your teeth.

A wedge can also be used as a **force multiplier**. Nails are an example of wedges. They concentrate the force of a hammer so that the nail is driven deep into a wooden object with little effort.

A chisel is a wedge that is used to concentrate the force of a hammer. A chisel is a single inclined plane used for cutting.



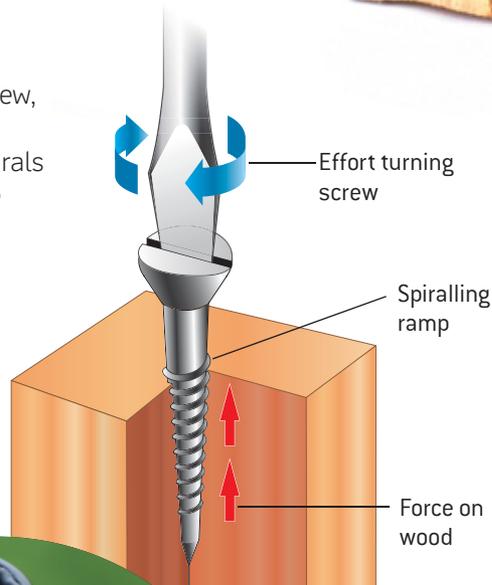
The head of an axe is a wedge used to split timber.

## Screws

You might be surprised to know that a screw, like a wedge or a ramp, is also an inclined plane. In the case of a screw, the ramp spirals around a metal cylinder. The thread of the screw looks almost like a road (a ramp) spiralling up the side of a mountain.

Instead of the object being pushed up the ramp, the ramp of the screw is pushed down into the object. Screws penetrate materials such as wood by using the turning effect of a force. When a screw is turned by a screwdriver, it moves the timber along the spiral ramp. The effort needed to insert a screw into an object is much less than it would take to hammer a screw into the same object.

*A corkscrew being pushed into the cork in a wine bottle.*



### LOOK IT UP

**effort** a force that is applied to make an object move or change position

**force multiplier** a simple machine that allows a small force to move a large object

**inclined plane** a ramp that reduces the effort to move a load

**load** a force, such as the weight of an object, that is in opposition to an applied force

### CHECK IT OUT

- 1 List three different types of inclined planes.
- 2 Why is less effort required to move a load when a ramp is used?
- 3 Look at the large ramp used to construct the Great Pyramid [see page 148]. Draw a sketch to show how the ramp reduced the effort of moving the blocks.
- 4 How does an axe make splitting timber easier?
- 5 How is a screw an example of a ramp?

# 3 LOAD-SHIFTING LEVERS

A lever is a simple machine that allows you to use a small effort to lift a heavy load. Like ramps, levers reduce the force needed to lift a load.



These men use a lever to help move a large, heavy rock. The small rock acts as a fulcrum and the timber pole is the lever.

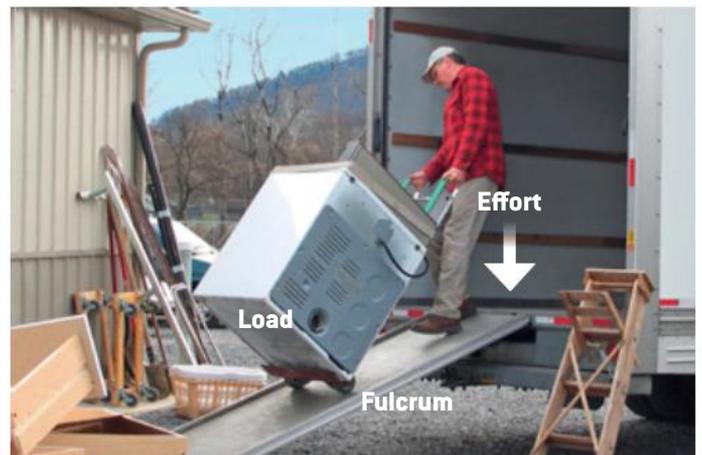
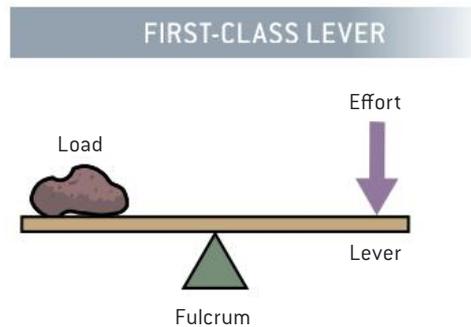
## How levers work

A lever is a solid rod or bar that is supported at a turning point, called the fulcrum. The force used to operate the lever is known as the effort, and the force it overcomes is known as the load.

Levers allow us to lift much heavier loads than normal. We can apply a small force at one end and get a larger force out of the other end. The position of the fulcrum can be changed depending on what you want a lever to do, giving three different classes of lever.

### 1 First-class levers

In a first-class lever, the fulcrum is between the load and the effort. First-class levers are force multipliers that multiply your effort. With first-class levers you apply the effort (such as pushing down) at one end of the lever. The load to be moved is at the other end of the lever. The lever pivots on the fulcrum to lift the load. A seesaw is an example of a first-class lever.



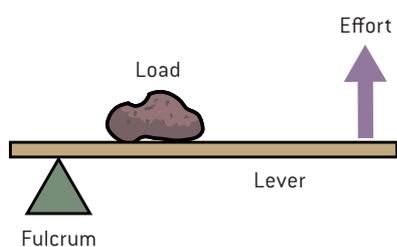
A trolley is a first-class lever. You apply the effort (pushing down) at one end of the lever and it lifts the load at the other end of the lever. The lever pivots on the fulcrum (wheel) between the effort and the load.

# 2

## Second-class levers

Second-class levers are also force multipliers. This time the load is between the effort and the fulcrum. Bottle openers, doors and wheelbarrows are second-class levers.

### SECOND-CLASS LEVER



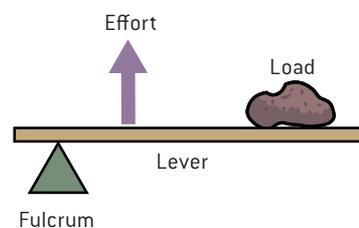
A wheelbarrow is a second-class lever. You apply the effort (lifting) at one end of the lever. The load to be moved is in the middle and the fulcrum (wheel) is at the other end of the lever.

# 3

## Third-class levers

Third-class levers are **distance multipliers**. The effort is between the load and the fulcrum. Third-class levers are designed to move a small load quickly with a large effort. Tennis racquets, brooms and the heads of hammers can be used as third-class levers.

### THIRD-CLASS LEVER



The hammer head acts as the lever. The claw at one end of the hammer head grabs the load (nail). The load is lifted by applying strong force (effort) to the handle in the middle of the lever. The neck of the hammer is used as the fulcrum, at the other end of the lever.

### LOOK IT UP

**distance multiplier** a simple machine that increases the speed or distance travelled by an object

### CHECK IT OUT

- 1 What is the purpose of a lever?
- 2 How do levers work?
- 3 What class of lever is a wheelbarrow? Explain how a wheelbarrow helps to lift a heavy load.
- 4 Look at the photograph of the workers moving the large rock opposite. Draw a diagram to show how they are using a fulcrum and a lever to lift the rock.
- 5 Draw a labelled picture of opening a tin lid with a spoon and show why it is a first-class lever.
- 6 Explain which class of lever is a distance multiplier and give an example.

# INVESTIGATING LEVERS

**AIM:** TO DETERMINE IF A FIRST-CLASS LEVER IS A FORCE MULTIPLIER OR A DISTANCE MULTIPLIER

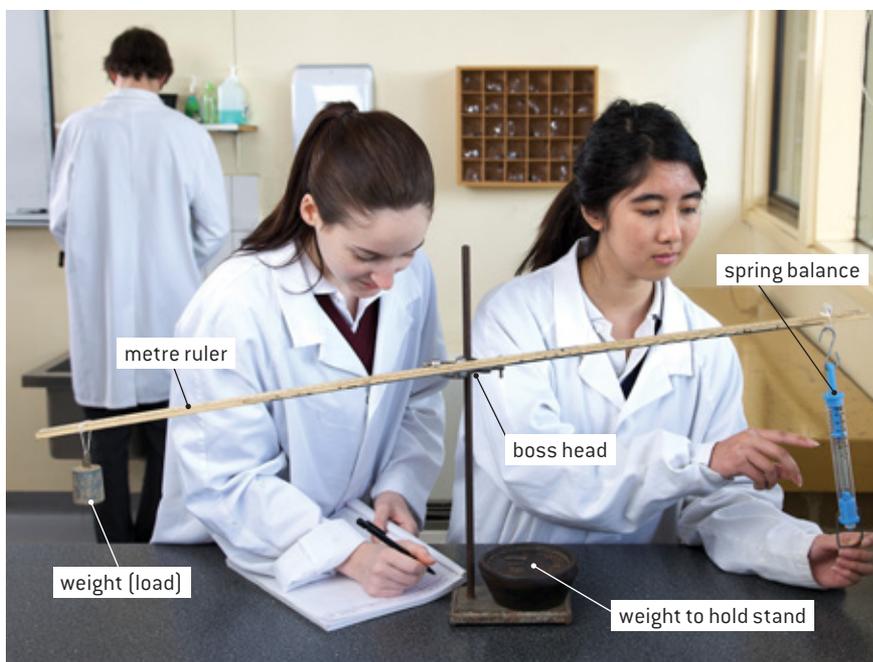
## MATERIALS

- Retort stand
- Boss head
- Large nail
- Metre ruler (with small holes drilled at every 10 cm and close to both ends)
- 2 string loops (to fit over the ruler)
- 500 g mass on mass hanger (as the load)
- Spring balance (to measure the effort force)
- Heavy weight or pile of books

## STATION 1: FIRST-CLASS LEVERS (fulcrum in the centre)

### METHOD

- 1 Use the spring balance to determine the size of the load (i.e. weigh the 500 g mass).
- 2 Mount the nail in the boss head so that the pointed end protrudes about 5 cm.
- 3 Mount the boss head on the retort stand.
- 4 Place a pile of books or a heavy weight on the base of the retort stand to prevent it from tipping over.
- 5 Slip the string loops over both ends of the metre ruler and position them at the 5 cm and 95 cm marks.
- 6 Mount the metre ruler on the nail at the 20 cm mark.
- 7 Hang the load from one string loop and measure the effort required to balance the load by pulling the spring balance on the other string loop.
- 8 Repeat when the nail is positioned at the 30 cm mark, then at 40 cm, 50 cm, 60 cm, 70 cm and 80 cm.
- 9 Find out if the lever makes the load easier to lift when the:
  - a effort arm is longer than the load arm
  - b load arm is longer than the effort arm.



## RESULTS

Record your results in a suitable table with the following headings: 'Load (N)', 'Load arm (cm)', 'Effort (N)', 'Effort arm (cm)'.

## DISCUSSION

Examine your results and comment on when the first-class lever acts as a force multiplier and when it acts as a distance multiplier.

**AIM:** TO DETERMINE IF A SECOND-CLASS LEVER IS A FORCE MULTIPLIER OR A DISTANCE MULTIPLIER

### MATERIALS

Same as for station 1.

## STATION 2: SECOND-CLASS LEVERS (load in the centre)

### METHOD

- 1 Set up your apparatus as for station 1.
- 2 Mount the metre ruler on the nail through one of the end holes in the ruler.
- 3 Slip the string loops over the other end of the metre ruler and position them at the 5 cm and 80 cm marks.
- 4 Add the load to the string loop at the 80 cm mark and measure the effort required to balance the load.
- 5 Repeat when the load's string loop is positioned at the 70 cm mark, then 60 cm, 50 cm, 40 cm, 30 cm and 20 cm.

### RESULTS

Record your results in a suitable table with the following headings: 'Load (N)', 'Load arm (cm)', 'Effort (N)', 'Effort arm (cm)'.

### DISCUSSION

Examine your results and comment on when (if ever) the second-class lever acts as a force multiplier and when (if ever) it acts as a distance multiplier.

**AIM:** TO DETERMINE IF A THIRD-CLASS LEVER IS A FORCE MULTIPLIER OR A DISTANCE MULTIPLIER

### MATERIALS

Same as for station 1.

## STATION 3: THIRD-CLASS LEVERS (effort in the centre)

### METHOD

- 1 Set up your apparatus as for station 1.
- 2 Mount the metre ruler on the nail through one of the end holes in the ruler.
- 3 Slip the string loops over the other end of the metre ruler and position them at the 5 cm and 80 cm marks.
- 4 Add the load to the string loop at the 5 cm mark and measure the effort required to balance the load.
- 5 Repeat when the effort's string loop is positioned at the 70 cm mark, then 60 cm, 50 cm, 40 cm, 30 cm and 20 cm.

### RESULTS

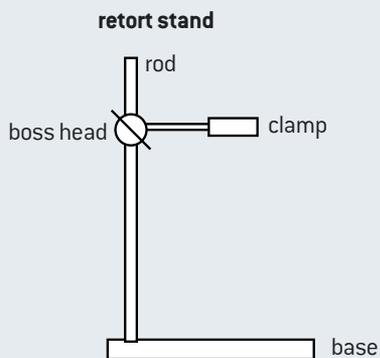
Record your results in a suitable table with the following headings: 'Load (N)', 'Load arm (cm)', 'Effort (N)', 'Effort arm (cm)'.

### DISCUSSION

Examine your results and comment on when (if ever) the third-class lever acts as a force multiplier and when (if ever) it acts as a distance multiplier.

### CONCLUSION

Write a statement for each experiment that responds to each aim.



## SCIENTIFIC EQUIPMENT RETORT STAND

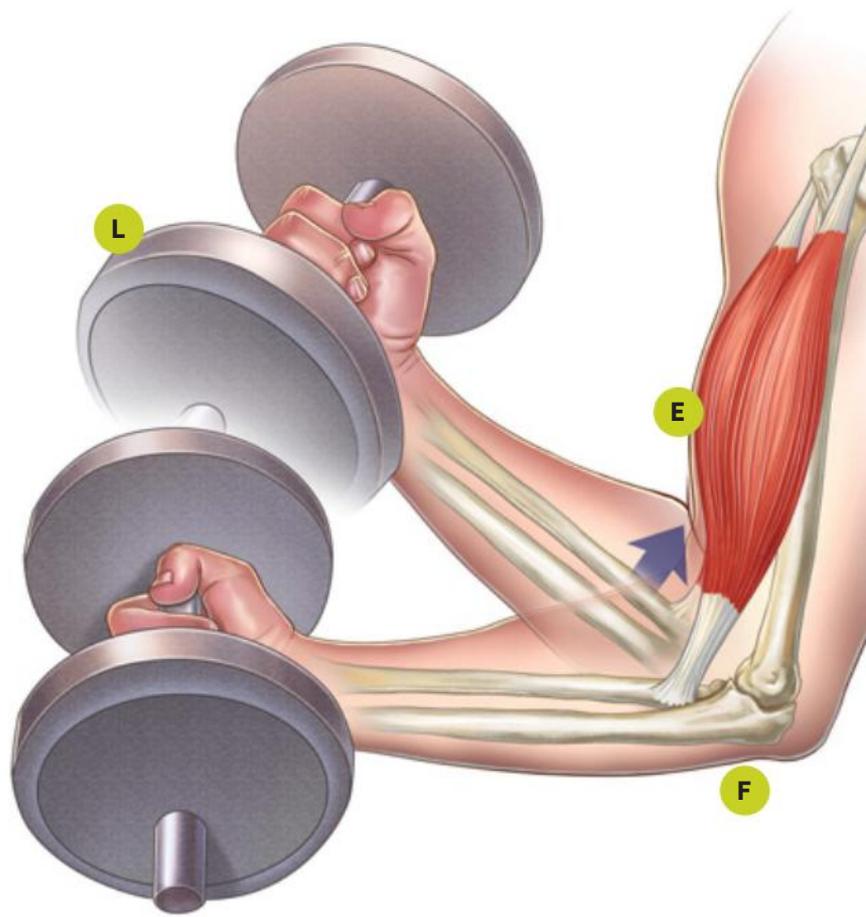
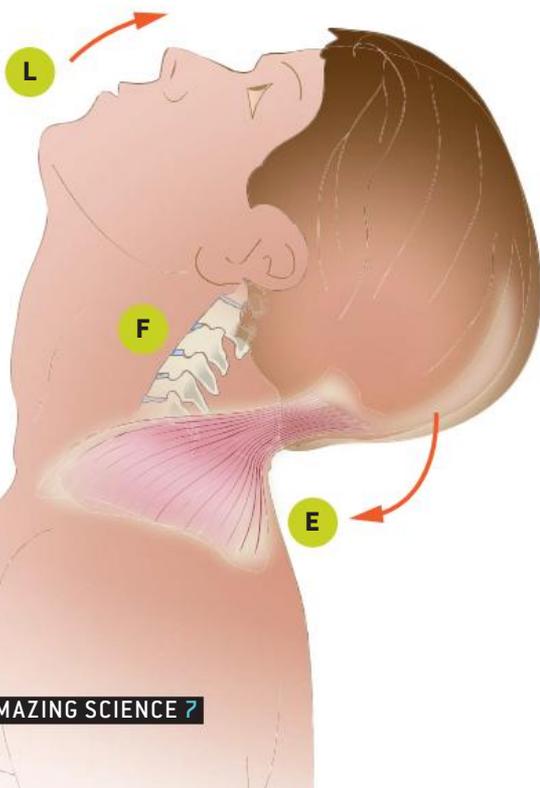
A 50 cm retort stand, to which clamps can be attached to hold test tubes and other equipment. A boss head is attached to the rod to adjust the height and to keep the clamp in place and adjust its height.

# BODY LEVERS

The bones in our bodies are used as levers and fulcrums to help reduce the effort in moving a load. The long bones in our arms and legs are examples of levers, and our knees and elbows act as fulcrums. In sport we use bats and racquets to extend the levers in our arms and deliver a greater force.

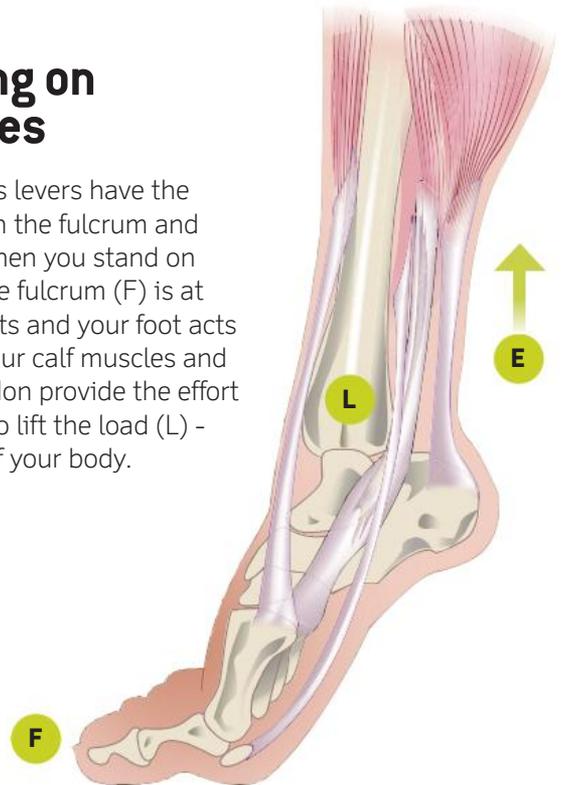
## FIRST-CLASS LEVER: nodding your head

The fulcrum lies between the effort and load in first-class levers. When you nod your head, the fulcrum (F) is the place where your skull meets the top of your spine. The skull is the lever and the neck muscles at the back of the skull provide the effort (E) to lift the load (L) of your head. Your head nods forward when the neck muscles relax.



## SECOND-CLASS LEVER: standing on your toes

Second-class levers have the load between the fulcrum and the effort. When you stand on your toes, the fulcrum (F) is at your toe joints and your foot acts as a lever. Your calf muscles and Achilles tendon provide the effort (E) needed to lift the load (L) - the weight of your body.



## THIRD-CLASS LEVER: bending your arm

Third-class levers are distance multipliers. The effort is between the load and the fulcrum. When you lift a weight, the fulcrum (F) is the elbow and the forearm acts as the lever. The biceps muscle provides the effort (E) and bends the forearm against the load (L) of the forearm and any weight held in the hand. The effort is larger than the load, and the speed of movement of the hand is greater.

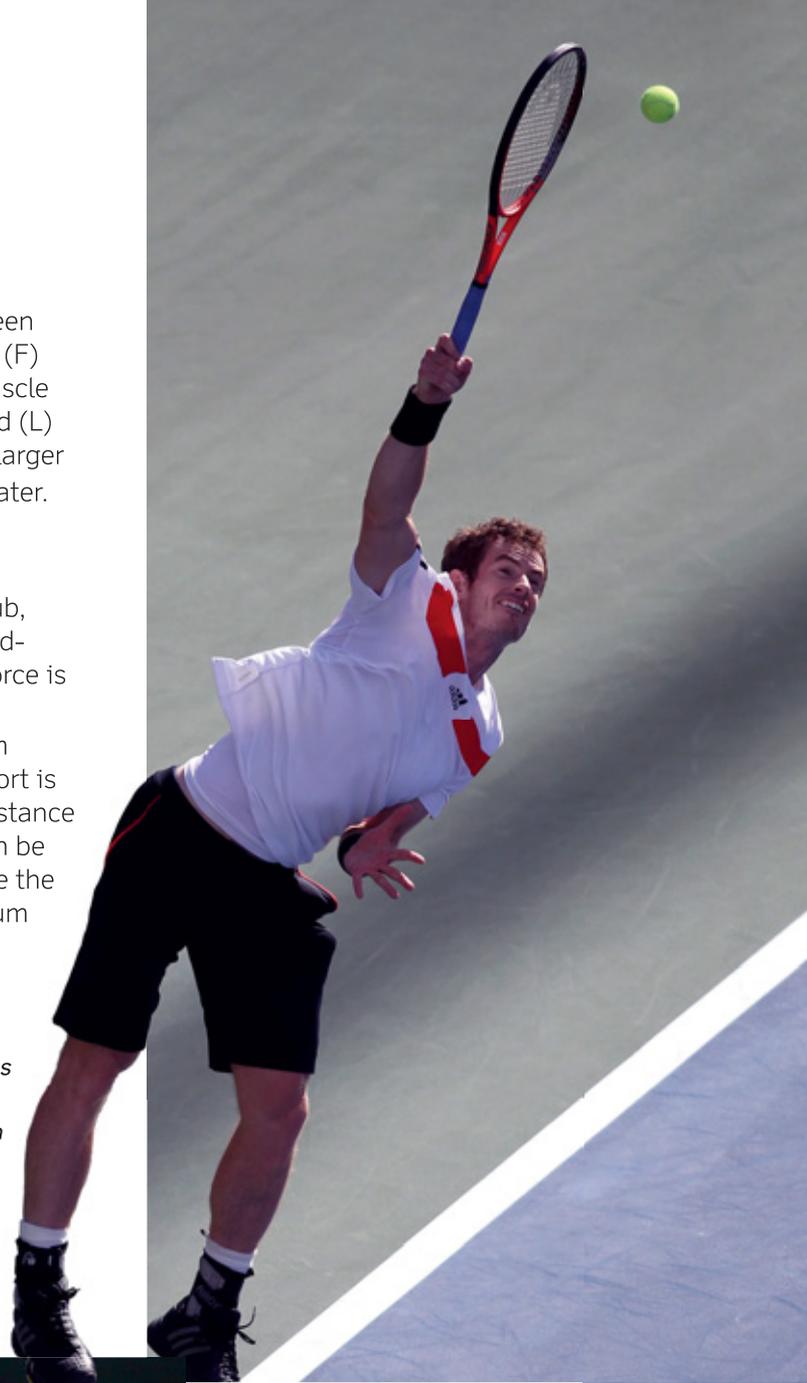
### Third-class levers in sport

The lever in our forearm can be extended using a bat, golf club, tennis racquet or hockey stick. Increasing the length of a third-class lever means a greater speed is possible. The greatest force is created at the end of the lever.

When a softball (the load) is hit, the lever is the whole arm and the softball bat. The fulcrum is your shoulder and the effort is provided by the muscles in your upper arm. The larger the distance between the load and the effort, the greater the force that can be created. In a tennis serve, a fully stretched arm will make sure the racquet head is moving at its top speed and that the maximum force is given to the ball.

*A straight arm ensures the longest lever and the maximum force in a tennis serve.*

*A softball bat extends the lever of the arm to produce greater speed and force.*



### CHECK IT OUT

- 1 Which body parts act as levers?
- 2 Which body parts act as fulcrums?
- 3 Which body parts provide the effort?
- 4 When you perform a push-up:
  - a what acts as the lever?
  - b where is the fulcrum?
  - c what is the load?
  - d what provides the effort?
- 5 How do racquets and bats help produce greater speed and force?
- 6 Sketch the softballer opposite and add labels to show the load, effort, fulcrum and lever.

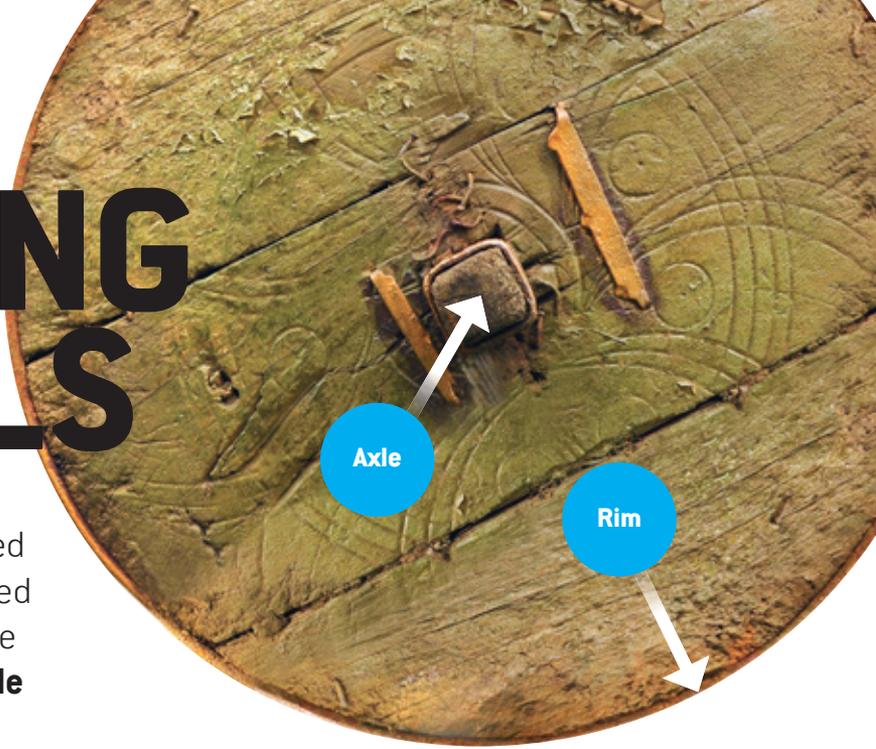
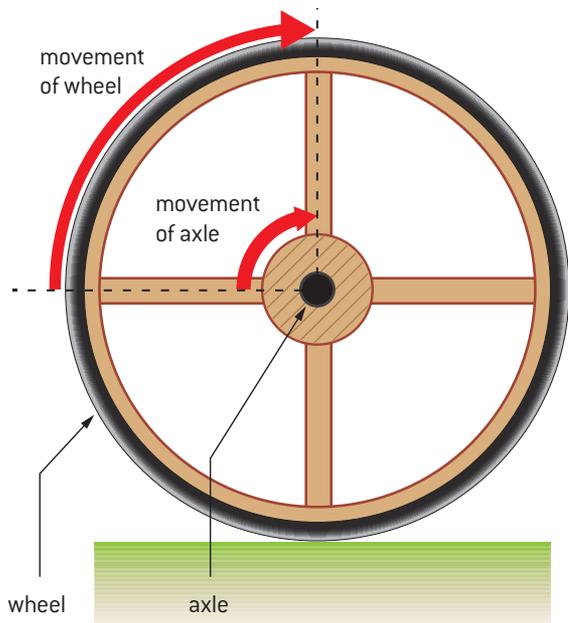
# 5 AMAZING WHEELS

Wheels are simple machines that can be used to make tasks easier. A greater force is needed to slide an object than to use a wheel to move it. Wheels are a type of lever because the **axle** in the middle of the wheel acts as a fulcrum and the rim of the wheel is similar to the other end of the lever.

## Amazing wheels

If you've used a circular door handle or travelled in a car, bus or train today, then you've used a wheel and axle. A wheel and axle is sometimes a force multiplier. For example, you apply a small effort to a doorknob to move a larger load, the latch.

Wheel and axle machines can also act as distance multipliers. This happens when the smaller axle on the inside of a wheel, turns the larger wheel, as in the case of a bike wheel or a ceiling fan. The axle turns through a small distance when there is a large force applied, and the wheel turns much faster, covering a larger distance.

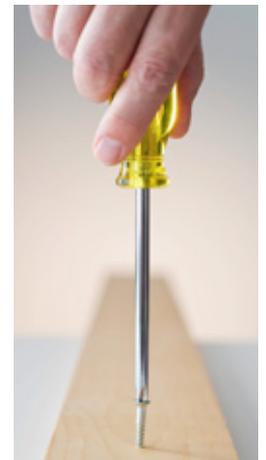


## 1 World's oldest wheel

The oldest wheel ever found is the Ljubljana Marshes Wooden Wheel. It is thought to be 5150 years old. Earlier wheels are known to have existed from paintings and other records. The log roller was first used in ancient civilisations. This was eventually replaced by the wheel and axle.

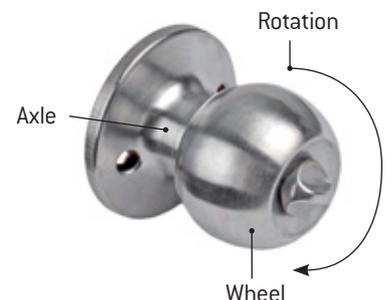
## 2 Screwdriver

The handle of a screwdriver acts as a wheel, while the metal rod plays the role of the axle. Screwdrivers are force multipliers. The force you apply in turning the handle of the screwdriver is travelling a greater distance than the metal rod.



## 3 Doorknob

Doorknobs are force multipliers. When you turn a doorknob, you apply an effort to the wheel of the knob and the axle exerts a force on the load (the latch), which opens the door. The fulcrum is the centre of the doorknob.



# 4 London Eye Ferris wheel

The London Eye is a 135-metre-tall Ferris wheel that gives people amazing views over London. It attracts more than 3.5 million passengers every year. The 32 passenger carriages sit on the rim of a wheel that is 120 metres in diameter.

The London Eye rotates around its axle much like a bicycle wheel. However, unlike a bike wheel, which is driven by a chain that applies force at the axle, the London Eye is driven from the rim. Motors drive opposing pairs of rubber tyres that grip the rim and provide the large effort required to turn the wheel.



# 5 Helicopter

A helicopter moves air over rotor blades that spin to create lift. The tips of the rotor blades are like the rim of the wheel. Rotor blades need to be distance multipliers to spin the blades quickly. As the blades spin, the helicopter moves up. The rotor (axle), in the middle of the blades, spins at a slower speed than the outside of the blades. The rotor only travels a short distance around in a circle but the large force provided by the rotor allows the blades to travel faster over a greater distance.



## LOOK IT UP

**axle** a rod in the middle of a wheel; the axle turns a small way and the rim of the wheel covers a larger distance

## CHECK IT OUT

- 1 How are wheels types of levers?
- 2 Identify the wheel and axle on a doorknob.
- 3 Is a circular doorknob a force or distance multiplier?
- 4 Draw a diagram to show how a screwdriver acts like a force-multiplying wheel.
- 5 How do the rotors on a helicopter act as a distance multiplier?

# SHIFTING GEARS

Gears are simple machines that make work easier. A **gear** is a wheel with teeth around the rim that connect into another gear. An axle turns the **driving gear**, which in turn creates rotation on attached gears.

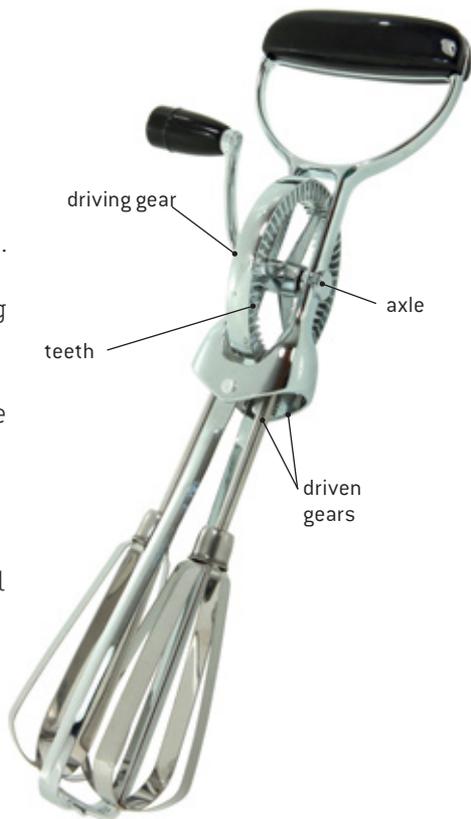
*Tiny interconnected gears in a watch allow the hour, minute and second hands to move at different speeds around the face of the clock.*

## How gears work

Gears are wheels with teeth around the rim that mesh with the teeth of other gears to make them turn. Gears are used to change speed or the direction of rotation.

A gear is a type of wheel and axle. An axle turns the driving (input) gear. The teeth of the driving gear mesh with other gears, known as driven (output) gears. The **driven gears** will also turn, but in the opposite direction. The speed of the driven gear depends on its size in comparison to the driving gear.

If two gears are the same size, they will turn at the same speed in opposite directions. Larger gears turn more slowly than small gears. When the driven gear is smaller than the driving gear, the driven gear will rotate faster. This distance-multiplier effect is useful when high-speed rotation is required, as in kitchen beaters or a power drill.



*When the handle of an egg beater is turned, the driving gear connects with two smaller driven gears, causing each beater to rotate.*

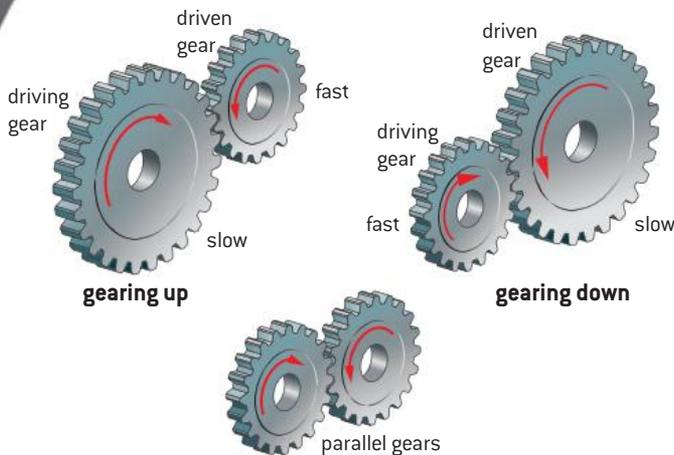


# How car gears work

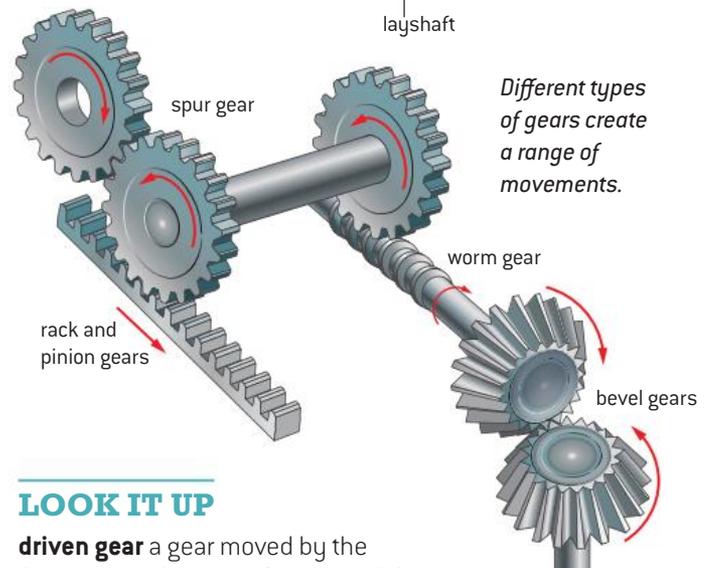
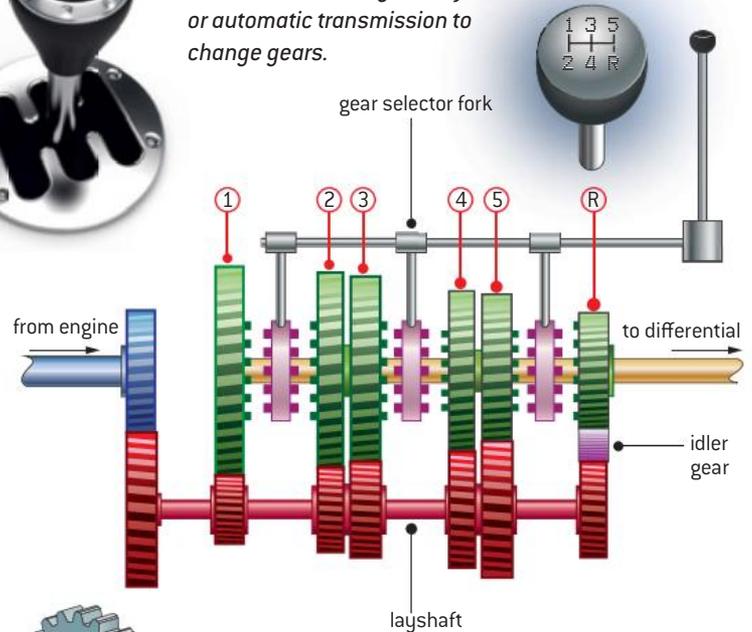
The driver of a car uses the gear shift (or automatic transmission) to change gears. Car engines need to generate more force or more speed in different situations, depending on whether hill-climbing power or speed is required.

The gearbox transmits force from the engine to the wheels. When a stationary car starts moving, the driver chooses a low gear to transmit the huge amount of force the car needs to get going. A small driving gear turns a larger driven gear to move the car's wheels at low speed but with great force. Once the car is moving, the driver switches to a higher gear. 'Gearing up' involves a larger driving gear turning a smaller driven gear at higher speed to make the car go faster.

*Gearing up for high speed and gearing down for strong force.*



The driver uses the gear shift or automatic transmission to change gears.



*Different types of gears create a range of movements.*

## LOOK IT UP

**driven gear** a gear moved by the interconnecting teeth from the driving gear

**driving gear** a toothed wheel that moves other gears

**gear** a toothed wheel that transmits a rotational force to another gear when they are meshed together without slipping

## CHECK IT OUT

- 1 How is a gear like a wheel?
- 2 What extra advantages do gears offer over wheels?
- 3 How do egg beaters use gears to make the beaters spin quickly?
- 4 Look at the different types of gears illustrated above.
  - a What do they have in common?
  - b How are bevel gears different to spur gears?
- 5 How do cars use gears to increase the force needed to climb a steep hill?
- 6 Look at the illustration of car gears at the top of the page. Describe how fifth gear produces greater speed.



*Cars 'gear down' where strong forces are required, such as on steep slopes or in slippery conditions.*

# PULLEY POWER



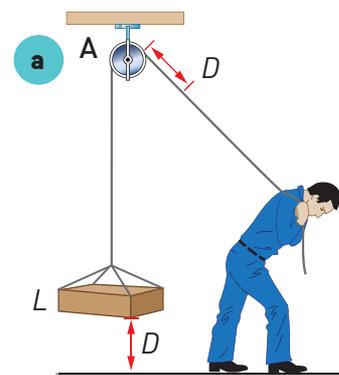
Exercise machines in gymnasiums use pulleys to make heavy objects easier to lift. The load to be lifted remains the same, but it is easier to pull down on a cable than it is to directly lift a heavy load.

A pulley is a rotating wheel with a grooved rim. The groove usually guides a rope or a cable. A pulley makes lifting an object easier because it changes the direction you need to pull.

## How do pulleys make it easier to lift?

Simple pulleys are used to lift blinds at home or in exercise machines at the gymnasium. The simplest pulley system is made of one pulley. In this system, the direction of the force is changed but the size of the force remains the same. It is easier to pull a rope down to lift a load than it is to push the load up. As a person pulls down on the rope, the load on the other end moves up but still weighs the same amount. This makes lifting easier because the person can use his or her weight to assist in lifting.

Pulleys can also be used as force multipliers to allow you to lift heavier loads. Bigger loads can be lifted with the same effort if two or more pulleys are strung together. By adding a second pulley, double the load can be lifted with the same effort. However, you will need to pull the rope double the distance. A system with more than one pulley is called a **block and tackle**. The block is the frame around the pulleys and the tackle is the rope or cable.



**[a]** Pulling a rope that passes over a single pulley lifts a load [L] a distance [D] off the ground.

Pulleys are used by workers in high places, such as this electrician working on a transmission tower. They are also used by mountaineers to safely take the weight of a climber as they ascend or descend a steep slope. Pulleys are used in rescue helicopters to lift injured or stranded people to safety.

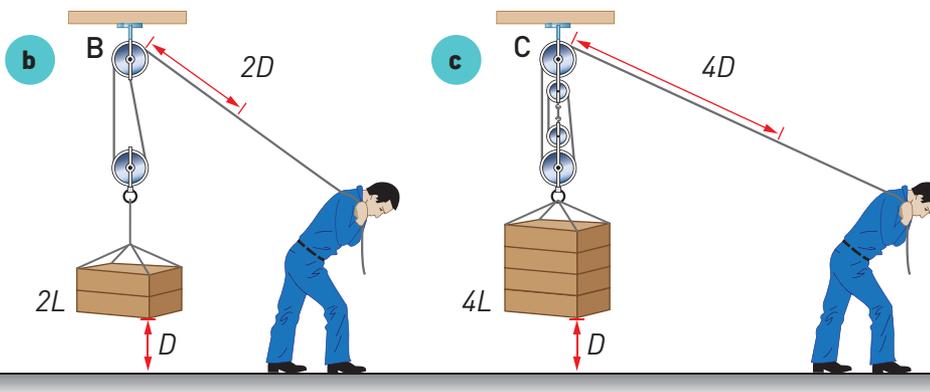


## LOOK IT UP

**block and tackle** a group of pulleys mounted together in a frame or block; gives a greater mechanical advantage than single or double pulleys

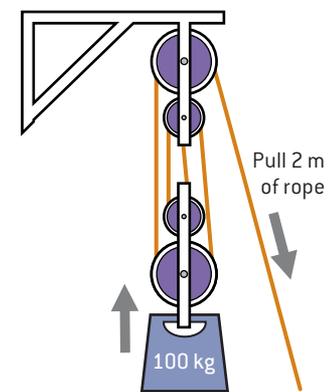
## CHECK IT OUT

- 1 How does a pulley make it easier to lift things?
- 2 What are some examples of pulleys used in everyday life?
- 3 Look at the illustration of the weight machine.
  - a Do the pulleys change the amount of weight to be lifted?
  - b Explain how the machine changes the direction of force needed to lift the weights.
- 4 Are pulleys distance multipliers or force multipliers? Explain your answer.
- 5 Look at the diagram below right. If a person pulled the rope through 2 m to lift the 100 kg mass, how far would the mass be raised?



**(b)** If a second pulley is added, the same effort can lift twice the load ( $2L$ ) the same distance ( $D$ ) off the ground. However, the effort must be exerted over twice the distance.

**(c)** If a system is set up with four pulleys, the same effort can lift four times the load ( $4L$ ) the same distance ( $D$ ) off the ground. However, the effort must be exerted over four times the distance.



# ON YOUR BIKE

Bicycles are **compound machines** made up of many simple machines. The levers, wheels, pulleys and gears on a bicycle are all designed to get the maximum benefit from the effort of pedalling.

## Wheels and axles

Bicycles are designed around two wheels – the front and back wheels – and their axles. However, it is another wheel that causes the effort used to move the bike forward: the pedals. The axle of the pedals is joined to the rear wheel axle by a chain.

The rear wheel is a distance multiplier. The axle turns through a small distance when there is a large force applied to it. The rear wheel then turns much faster, covering a larger distance. The front wheel is simply pushed along by the movement created by the pedals and the rear wheel.

## Gears

Bicycle gear wheels are called **sprockets**. The teeth of the sprocket at the axle of the pedals interlock, via the chain, with the teeth on another sprocket at the axle of the rear wheel. They cause the gear on the rear wheel to rotate as well.

When riding quickly along a flat road, a larger front sprocket is combined with the smallest rear sprocket. This distance multiplier is useful when high-speed rotation is needed.

rear sprockets

axle

guide pulley

When riding up a steep slope, a smaller front sprocket is used with the largest rear sprocket. The small front sprocket turns the large rear sprocket at low speed, but with the great force needed to climb the hill. You need to make more turns of the pedals to turn the small front sprocket.



## Pulleys

On a bicycle, a pair of pulleys guides the bike chain around the sprockets on the rotating rear wheel. These pulleys, known as the chain guide, are used in the bicycle's gear system to make the chain change direction. When a rider uses the gear lever while pedalling, the chain guide moves from side to side. Known as **derailing**, this action moves the chain onto a different sprocket, changing the gear.

## Handbrake

Handbrakes are first-class levers. In a first-class lever, the fulcrum is between the load and the effort.

First-class levers are force multipliers – that is, they multiply your effort. With a bike handbrake you apply the effort by squeezing the handle. The handle is attached to a cable that transfers the effort to the brake pads. The brake pads then push against the wheel to slow it down.

### LOOK IT UP

**compound machine** a machine made up of a number of simple machines

**derailing** the action of gear-shifting on a bike that moves the chain from one sprocket wheel to another

**sprocket** a toothed wheel that engages with the links of a chain

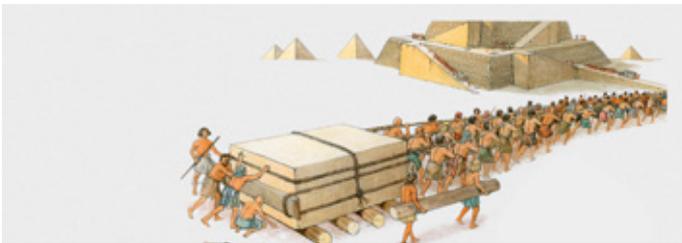
### CHECK IT OUT

- 1 What simple machines are joined together to make a bike?
- 2 What sprocket combination will the rider in the photograph be using to climb the steep hill?
- 3 Why are pulleys needed on a bicycle?
- 4 Where are levers used on a bicycle and how do they work?
- 5 Think of another compound machine and list the simple machines it uses.

# MACHINES

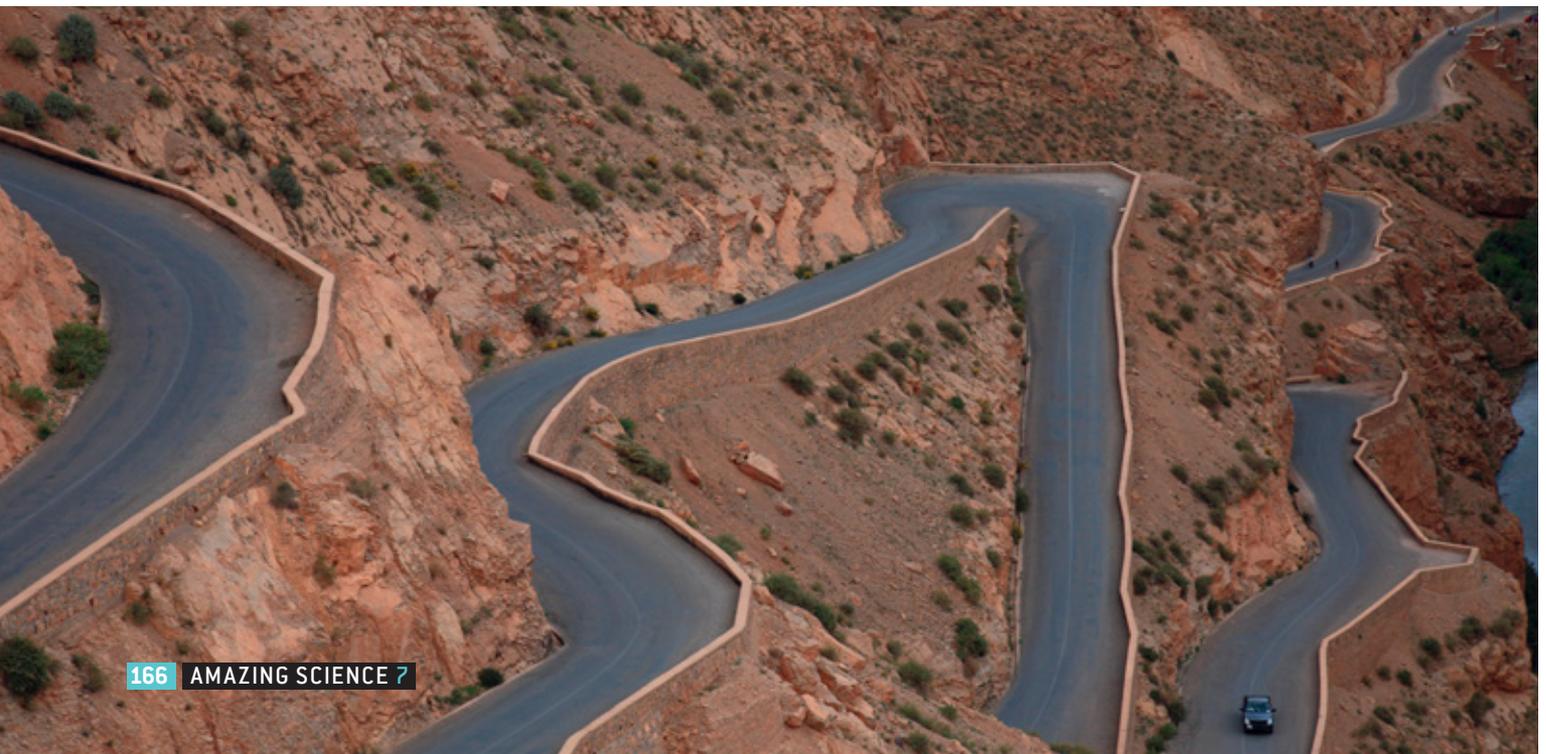
## MACHINES MAKE TASKS EASIER (PAGES 148–149)

- 1 Consider how the Ancient Egyptians built the pyramids.
  - a Why did they use ramps?
  - b How did they use wedges to split large blocks?
  - c How was friction reduced when dragging sleds with heavy stone blocks?
- 2 Look carefully at the following illustration. Describe how the Ancient Egyptians might have used this simple machine to move heavy loads.



## RAMPS (PAGES 150–151)

- 3 What is the purpose of ramps?
  - 4 List three examples of inclined planes.
  - 5 Describe how teeth are like wedges and how they help us.
  - 6 How does an inclined plane within a screw help you drive it into a piece of timber?
- 7 A slide is a type of ramp. What factors do you think would affect how far and how fast an object would slip down a slide?
  - 8 Explain why this winding mountain road is an example of an inclined plane.



### 3 LOAD-SHIFTING LEVERS (PAGES 152–153)

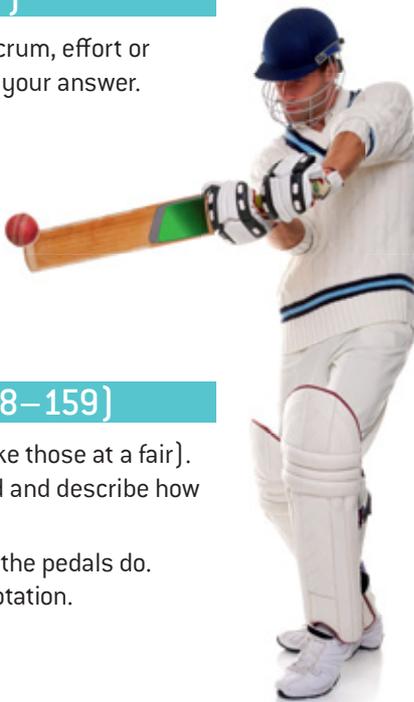
- 9 Draw a labelled diagram of a seesaw, showing the load, fulcrum, lever and effort. What class of lever is it?
- 10 Look at the image of the paint can below.
- Sketch a diagram of the scene and add labels to show load, fulcrum, lever and effort.
  - Is the screwdriver being used as a first-, second- or third-class lever? Explain your answer.



- 11 What is the difference between force multipliers and distance multipliers?

### BODY LEVERS (PAGES 156–157)

- 12 What role do the neck muscles play (fulcrum, effort or load) when you nod your head? Explain your answer.
- 13 Explain which parts of the body would be acting as levers on someone doing chin-ups on a bar.
- 14 Draw a diagram of a cricket player hitting a ball with a bat. Label the fulcrum, load and effort. What class of lever is this?



### 5 AMAZING WHEELS (PAGES 158–159)

- 15 Explain how a merry-go-round works (like those at a fair). Label where the axle and rim are located and describe how it increases speed.
- 16 Draw a diagram of a bike and label what the pedals do. Include the terms axle, wheel, rim and rotation.
- 17 Explain how the object pictured is a wheel and outline why it is a distance multiplier.



### SHIFTING GEARS (PAGES 160–161)

- 18 What is a gear?
- 19 What determines the speed of the driven gear?
- 20 Refer to the picture of the gears at the bottom of the page.
- How many teeth do the larger and smaller gears have?
  - If the larger gear rotated three times, how many rotations would the small gear make?
  - If the small gear is the driving gear, will the driven gear turn fast or slow? Why?

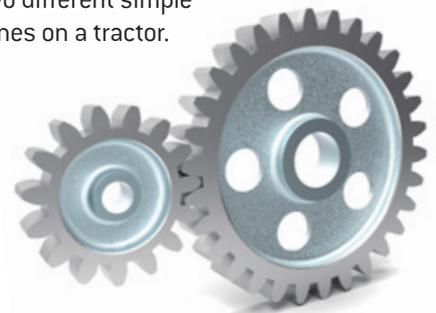
### PULLEY POWER (PAGES 162–163)

- 21 What is a pulley?
- 22 Look at the picture below.
- How many pulleys are on the part of the exercise machine that the woman is using?
  - Why is it easier for the woman to move the load using a pulley?
  - If the machine had just one pulley, how much load could she lift using the same effort?



### ON YOUR BIKE (PAGES 164–165)

- 23 Explain why a bicycle is a compound machine.
- 24 Describe how the gears on a bike work.
- 25 List two different simple machines on a tractor.



## KEY IDEAS

1

It is believed that machines such as ramps, wedges, levers and wheels were used during Egyptian times to move huge stone blocks.



2

Ramps (inclined planes) reduce the amount of effort needed to lift a load. Wedges, which include teeth and knives, concentrate force. Screws have an inclined plane that spirals around their outside to penetrate materials more easily.



3

Lever are classified as first-class, second-class and third-class levers. First- and second-class levers are force multipliers. Third-class levers are distance multipliers.



4

Our body has many natural levers. Our bones act as levers, joints such as our knees and elbows are fulcrums, and our muscles provide the effort to move loads. In sport, we use bats and racquets to extend the levers in our arms and deliver a greater force.



5

Wheels, in which the axle on the inside of the wheel turns a smaller distance than the rim on the outside of the wheel, can be force multipliers or distance multipliers. Door handles, ceiling fans and screwdrivers are all examples of wheels that serve as machines.



6

Gears are toothed wheels that mesh with other gears to make them turn. Gears are used to change speed or direction.



7

A pulley is a wheel with a grooved rim that is used to make lifting objects easier. Pulleys can be force multipliers.



8

Bikes are compound machines that include many simple machines. Gears are used as distance multipliers. Pulleys guide the bike chain onto different sprockets. Handbrakes are first-class levers and are force multipliers used to slow the bike.

# GLOSSARY

**abiotic** the non-living things in an ecosystem, such as water

**adaptation** physical or behavioural characteristics that help an organism to survive in a particular area

**air resistance** friction between a moving object and the air it is moving through; also known as drag

**alloy** a metallic substance made by mixing two or more metals

**amphibian** a cold-blooded vertebrate; such as a frog or salamander

**angiosperm** a plant that has flowers and produces seeds

**aquifer** permeable rock that stores or allows the flow of groundwater

**arthropod** an invertebrate with legs and an exoskeleton, such as an insect, spider or crustacean

**astronomer** a scientist who studies planets, stars and all the other objects in the universe

**atmosphere** the layer of gases surrounding the Earth and other planets

**atom** the smallest particle of a substance that can exist

**aurora** bands of coloured light in the night sky due to charged particles interacting with the Earth's magnetic field

**autotroph** an organism that makes its own food, such as a plant

**axis** an imaginary line running through the centre of an object such as Earth

**axle** a rod in the middle of a wheel; the axle turns a small way and the rim of the wheel covers a larger distance

**bacteria** unicellular microorganisms that have cell walls but no nuclei (singular: bacterium)

**balanced forces** two forces that are equal in size and opposite in direction

**biome** a large natural community of plants and animals adapted to particular conditions

**biosphere** all the plants and animals, from the upper areas of the atmosphere to deep underground or in the ocean

**biotic** the living things in an ecosystem, such as plants and animals

**block and tackle** a group of pulleys mounted together in a frame or block; gives a greater mechanical advantage than single or double pulleys

**bore** a well drilled into an aquifer to pump water to the surface

**buoyancy** upward force of a liquid or gas on an object

**carbon** a non-metallic element occurring in a pure form as graphite and diamond; present in all organic compounds

**carbon dioxide** a colourless, odourless gas with the formula  $\text{CO}_2$

**carboniferous** producing coal

**carnivore** an organism that obtains its energy by eating meat

**centrifuging** a technique used to separate light particles from heavy particles by spinning a mixture

**chemical reaction** a process in which one or more substances are converted to different substances

**chromatography** a method of separating and analysing mixtures of chemicals

**class** a biological grouping that ranks above order and below phylum, such as Mammalia or Insecta

**classify** to arrange things into categories depending on the properties they share

**climate** the long-term weather conditions of an area

**coal** a black or brown mineral substance formed from the remains of plants that grew in ancient swamps

**colloid** a suspension that doesn't separate easily, such as milk, hair gel or fog

**cohesion** attractive forces that hold part of a substance together

**compass** an instrument showing the direction of magnetic north

**compound** a substance made up of two or more different types of atoms bonded together, such as water

**compound machine** a machine made up of a number of simple machines

**concentrated** describes a solution with a large amount of solute

**condensation** the change of state from a gas to a liquid

**consumer** an organism, such as an animal, that obtains energy by eating other organisms; a heterotroph

**contact forces** forces occurring when two objects are touching each other

**continuous resource** a resource that will not run out

**corona** lines of light that surround the Sun or Moon during an eclipse

**craters** bowl-shaped cavities

**crude oil** a naturally occurring, unrefined petroleum product that can be refined to produce usable products such as gasoline, diesel and various forms of petrochemicals

**crystal** a solid with its atoms organised in a regular pattern with flat surfaces; the structure of a crystal influences a mineral's properties

**decomposer** an organism, such as a maggot, that feeds on dead organisms

**deforestation** clearing of forests that leads to loss of habitat

**dense** closely compacted in substance

**density** the mass per unit volume

**deposit** a natural layer of sand, rock or coal

**derailing** the action of gear-shifting on a bike that moves the chain from one sprocket wheel to another

**desalination** removing salt from sea water to produce fresh water for human consumption

**dichotomous key** a diagram used in classification; each 'arm' of the key contains two choices

**dilute** describes a solution with a small amount of solute

**dispersed** distributed in different directions or over a wide area

**dissolve** to change from a solid to part of a solution when placed into a solvent

**distance multiplier** a simple machine that increases the speed or distance travelled by an object

**distillation** a separation technique that uses evaporation and condensation to separate a solid and the solvent in which it has dissolved, such as obtaining pure water from salt water

**DNA** deoxyribonucleic acid; the carrier of genetic information

**drag** friction between a moving object and the air it is moving through; also known as air resistance

**driven gear** a gear moved by the interconnecting teeth from the driving gear

**driving gear** a toothed wheel that moves other gears

**eclipse** passing of an astronomical body through the shadow of another or when another body passes between it and the viewer; usually referring to solar or lunar eclipses, which can be partial or total

**ecosystem** a community of living and non-living things that depend on one another for survival

**effort** a force that is applied to make an object move or change position

**electrical energy** energy associated with electric charge, either stationary (static) or moving (current)

**electron** a negatively charged particle found in atoms

**electrostatic force** the force of attraction or repulsion between two point charges

**element** a pure substance made up of only one type of atom, such as oxygen or carbon

**emulsifier** a substance that stabilises an emulsion

**emulsion** a stable mixture of two or more liquids, such as milk

**endangered** in danger of becoming extinct

**energy** (physics) the ability to do work; (biology) a resource that allows organisms to survive

**energy resource** a substance or method used for generating energy, such as coal, petrol, gas, wind, solar or hydro-electric

**environmental resources** natural systems that produce services of potential benefit to people, such as clean air or clean water

**equator** an imaginary line around the Earth dividing the Earth into the northern and southern hemispheres

**equinox** the time (twice a year) at which the Sun is directly over the equator; when day and night are of equal length

**evaporate** to turn from liquid into vapour

**evaporation** a change of state from liquid to gas

**exoskeleton** a rigid external covering for the body in some invertebrates

**extinct** a family, class or species that has died out

**family** a biological grouping that ranks above genus and below order, such as Hominidae (the family including humans)

**filtering** a separation technique used to separate different-sized particles in a mixture using a sieve or filter

**filter** a porous device for removing impurities or solids from a liquid or gas

**filtrate** the substance that passes through a filter

**filtration** the removal of impurities or solids from a liquid or gas

**first-class lever** the class of lever in which the fulcrum is between the load and the effort

**flocculant** a chemical that can be added to a mixture to make suspended particles clump together

**flocculation** a process in which chemicals added to a mixture make particles join together and settle on the bottom

**flotation** a separation technique in which a substance will float to the top of a liquid because the substance is less dense

**food chain** a chain of organisms arranged to show the flow of food in an ecosystem, from producers to herbivores to carnivores

**food pyramid** a diagram showing the numbers of all organisms at each level of a food chain

**food web** a diagram showing several food chains intertwined

**force** a push or a pull on an object to change its motion

**force multiplier** a simple machine that allows a small force to move a large object

**fossil** the remains or imprints of an animal, plant, bacteria or other living organism preserved in rock

**fossil fuel** a fuel such as coal, oil and natural gas that is produced from ancient organisms (mainly plants) that lived millions of years ago

**friction** a force that acts to oppose the motion between two surfaces as they move over each other

**fulcrum** a pivot or turning point (usually part of a lever)

**gas giant** a large planet, such as Jupiter, that is made up mainly of hydrogen and helium

**gear** a toothed wheel that transmits a rotational force to another gear when they are meshed together without slipping

**generator** a machine that converts movement energy (usually from a turbine) into electrical energy

**genus** a subdivision of family in the classification of living things

**geothermal energy** the heat generated and stored in the Earth

**global warming** the rise in the average temperature of Earth's climate system

**gravitational field** a region near a particular mass where a gravitational force is experienced

**gravitational force** the force of attraction between all masses in the universe

**gravitational pull** the invisible force that causes objects to pull towards each other

**gravity** the force of attraction that objects have towards one another due to their masses

**green belt** undeveloped land set aside within a city

**gymnosperm** a non-flowering plant with seeds, such as conifers or cycads

**habitat** a place where a population of organisms lives

**hemisphere** half of the Earth as divided by the equator

**herbivore** an organism that obtains its energy by eating plants

- heterotroph** an organism that relies on other living things for food, such as an animal
- high tide** when the ocean level is at its highest point at a particular place on Earth
- homogenisation** making a uniform mixture from two liquids that don't dissolve in each other; for example, making milk fat globules small so that they mix throughout the rest of the milk
- hydroelectricity** the production of electrical power from falling or flowing water
- hydrosphere** the waters of the Earth's surface
- inclined plane** a ramp that reduces the effort to move a load
- inertia** the tendency of an object to resist changes in its motion while either at rest or in constant motion
- insoluble** a substance that cannot dissolve
- introduced species** any species of plant or animal that has been moved by humans to an environment where it did not occur naturally
- invertebrate** an animal with no spine or backbone
- kingdom** the highest rank into which scientists classify living things; the most commonly used system of classification recognises five kingdoms: Animalia, Plantae, Fungi, Monera, Protista
- lever** a solid rod or bar that is supported at the fulcrum and can be used for moving a load
- Linnaean classification system** naming system designed by Swedish scientist Carl Linnaeus to identify the genus and species of a living organism, such as *Homo sapiens*
- lithosphere** the layer including the Earth's crust and upper mantle
- load** a force, such as the weight of an object, that is in opposition to an applied force
- low tide** when the ocean level is at its lowest point at a particular place on Earth
- lubricant** a substance used to reduce friction
- lubrication** decreasing friction by applying a substance between the surfaces, such as oil or grease
- lunar eclipse** passing of the Moon into the shadow of the Earth; can be total or partial
- magnet** material or object that produces a magnetic field
- magnetic** able to be magnetised or attracted by a magnet
- magnetic field** region around a magnetic material or a moving electric charge within which the force of magnetism acts
- magnetic separation** a process in which magnetic material is removed from a mixture
- magnetosphere** the magnetic field surrounding planets, stars, etc.
- mammal** a warm-blooded vertebrate with hair or fur; female mammals secrete milk for the nourishment of their young
- mammary gland** the milk-producing gland of a woman or other female mammal
- marsupial** a mammal born incompletely that is typically carried and suckled in a pouch on the mother's belly
- microbiologist** a scientist who studies microorganisms
- microorganism** a microscopic organism such as a bacterium that can be viewed under a microscope
- mineral** naturally occurring solid substance with its own chemical composition, structures and properties
- mixture** something made up of two or more pure substances mixed together
- monotreme** an egg-laying mammal, such as a platypus or echidna
- multicellular** consisting of many cells, such as animals or plants
- national park** a park set aside by a government for conservation
- neap tide** smaller tides that occur when the Sun is at right angles to the Moon
- net force** the combined effect of all the forces acting on an object
- non-contact force** a force that operates between two objects when they are not touching each other, such as gravitational force
- non-renewable resource** a resource that is limited; once used, it is gone forever, such as coal, oil or natural gas
- non-vascular** plants without veins that must absorb water and nutrients through the surface of their leaves
- nucleus** {chemistry} positively charged central part of the atom, contains protons and neutrons {plural: nuclei}
- nutrient** a substance that provides nourishment essential for maintenance of life and for growth
- omnivore** an organism that obtains its energy by eating plants and flesh
- opposable thumb** a thumb that is capable of facing and touching the other digits on the same hand to enable the holding of objects
- orbit** to revolve around; planets in our solar system orbit the Sun
- order** biological grouping that ranks below class and above family, such as Primates
- oxygen** a colourless, odourless, reactive gas; life-supporting component of air
- particle** a building block of matter
- pasteurisation** heating a liquid to kill bacteria without significant change to the food
- peat** vegetable matter decomposed in water and partly carbonised; used for fuel and growing plants
- penumbra** the shadow of the Moon or Earth in an eclipse
- phloem** the vascular tissue in plants that conducts nutrients from the leaves
- phylum** a biological grouping that ranks above class and below kingdom, such as phylum Mollusca
- photosynthesis** the process in which the energy of the Sun is used to convert carbon dioxide and water into oxygen and sugars
- photovoltaic cell** a device that converts light into electricity
- placental mammal** mammals that possess a placenta to nourish a foetus (unborn baby)
- planet** a large object that orbits a star such as the Sun
- plant embryo** the part of a seed that contains cells (for the leaves, stem and roots) that will develop into a plant
- plasma** {biology} the colourless liquid part of blood
- platelet** part of blood that helps with clotting to stop bleeding
- poles** the ends of a magnet where the magnetic field is strongest

**pollen** fine grains discharged from the male part of a flower; each pollen grain contains a male gamete that can fertilise the female ovule

**pollinate** to deposit pollen on a plant to allow fertilisation

**population** a group of the same kind of organisms that live in the same place at the same time

**porous** having tiny holes that let air and water through

**precipitation** liquid (rain) or solid (hail, sleet and snow) forms of water that fall to Earth

**predator** an animal that naturally preys on others

**preservatives** substances for preserving perishable food and food products

**primary consumer** an animal that feeds on plants

**primate** a mammal of an order that includes monkeys, apes and humans; distinguished by having hands, hand-like feet and forward-facing eyes

**producer** an organism that produces its own food, such as a plant; an autotroph

**proton** a positively charged particle found in atoms

**pulley** a rotating wheel with a grooved circumference, used with a rope or cable to lift heavy loads

**pure substance** a substance that is not combined with anything else

**radiation** emission or transmission of energy in the form of waves through space or through material

**ramp** a flat, tilted surface used to help raise or lower a load; also known as an inclined plane

**refinery** a place where oil is refined

**renewable resource** a resource that is made naturally and is available in an almost unlimited amount, such as wind, solar and hydro-electric power

**renewable energy** energy from a continuous resource that will never run out, such as wind or solar power

**residue** the substance that is trapped in a filter

**satellite** an object that orbits (revolves around) a planet

**secondary consumer** a carnivore that feeds only upon herbivores

**second-class lever** the type of lever where the load is between the effort and the fulcrum

**sediment** matter that settles to the bottom of a liquid

**sedimentary rock** rock formed when layers of particles (sediment) are pressed together by the weight of the overlying rock

**sedimentation** a separation technique in which the sediment settles to the bottom and can be separated from the mixture

**seed banks** places for the classification and storage of seeds of important crop plants

**separating techniques** techniques used to purify substances or to isolate them from other substances

**sewage** liquid and solid waste released into sewers

**solar eclipse** when the Moon passes between the Earth and the Sun

**solar energy** energy obtained from the Sun's radiation

**solar system** the Sun is the centre of the solar system and is surrounded by eight planets, several dwarf planets (such as Pluto) and many moons and asteroids

**soluble** a substance that dissolves in water or another solvent

**solute** a substance that dissolves in a liquid (solvent)

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

**solvent** any liquid that dissolves another substance or substances

**species** a group of similar organisms capable of breeding, such as *Homo sapiens*

**spring tide** very high and low tides when the Sun, Moon and Earth are in a line

**sprocket** a toothed wheel that engages with the links of a chain

**static electricity** a stationary electric charge that builds up on a material

**streamlined** a design that produces the least resistance to the flow of fluids

**subspecies** a biological classification that ranks below species; usually a geographically isolated group

**Sun** the yellow star that is the centre of the solar system; provides heat and light to sustain life on Earth

**surface tension** the force existing in the surface of a body, especially a liquid, that makes it behave as an elastic sheet

**suspension** a mixture in which insoluble particles are spread through a fluid

**telescope** an optical instrument used to view distant objects

**third-class lever** the type of lever where the effort is between the load and the fulcrum

**terrestrial planet** a planet, such as Earth, that is made of rock and metal

**tide** the rise and fall in water level that occurs on sea shores twice a day

**traction** the grip an object exerts on a surface

**transpiration** the process by which plants take up water from the soil through their roots and up into their leaves and then release it into the air

**turbine** a large wheel with angled sections similar to a fan's blades; steam, water, gas or air can push on the blades to spin the turbine and turn a generator

**umbra** the total shadow cast on the Earth by the Moon during a solar eclipse or on the Moon by the Earth during a lunar eclipse

**unbalanced forces** two forces, not equal in size, acting on an object

**unicellular** organism consisting of just one cell, such as bacteria

**vascular** plant tissues (xylem and phloem) that conduct water, sap and nutrients in flowering plants, ferns, and their relatives

**vertebrate** an animal with a spine or backbone

**water cycle** the continuous movement of water on the land and in the atmosphere

**wedge** an object with a thick end tapering to a thin end that can be pushed between two objects to separate or secure them

**wheel and axle** an outer wheel and a smaller inner wheel (the axle); a type of simple machine

**wind farm** a collection of wind turbines in one location

**xylem** vascular tissue in plants that conducts water and dissolved nutrients upwards from the roots; helps to form the woody element in the stem

**zoologist** a scientist who studies animals

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