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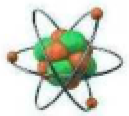
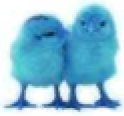
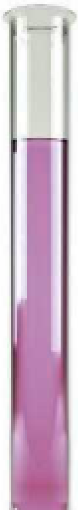
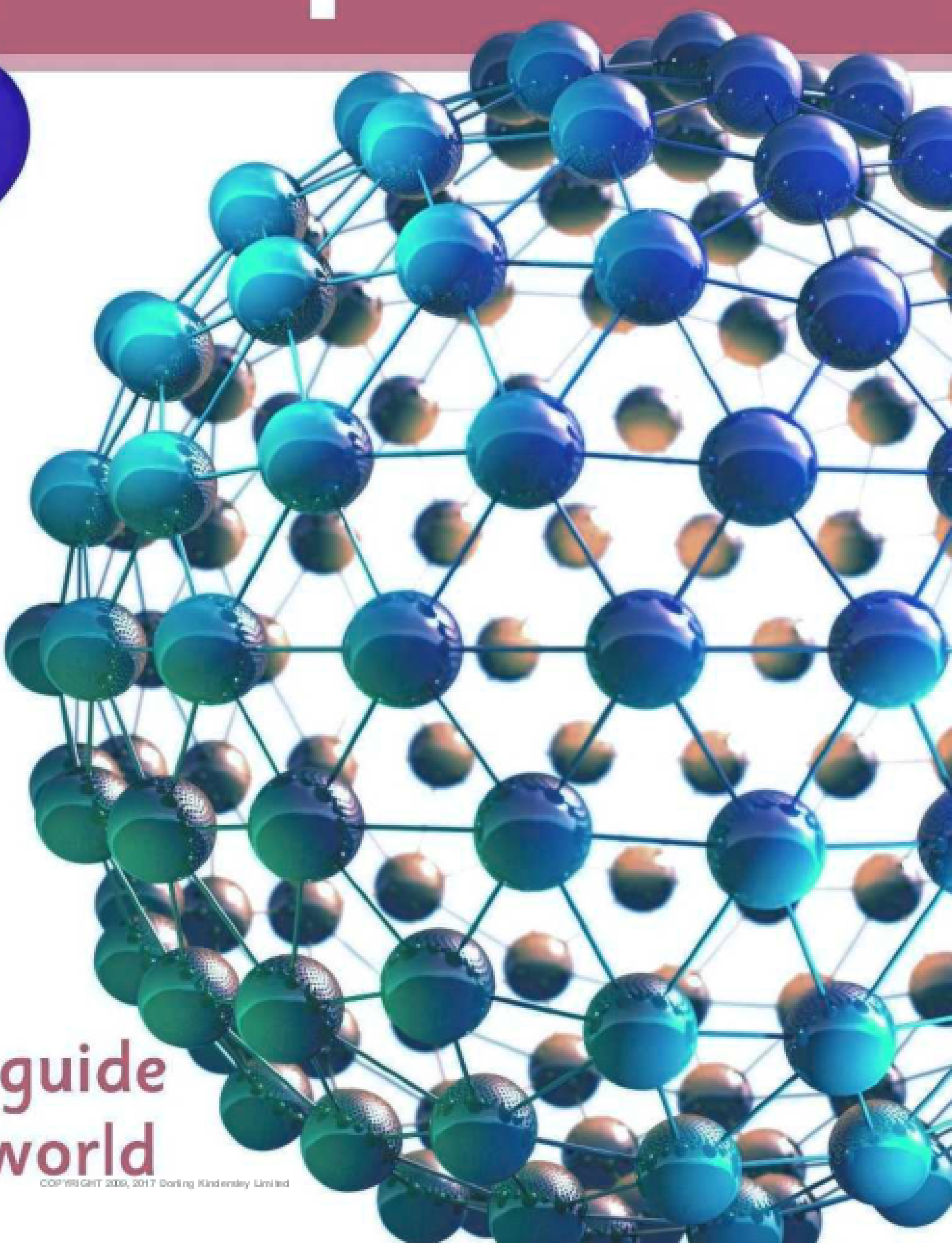



First Science Encyclopedia



A first reference guide to the scientific world

First Science Encyclopedia

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Project editor Suneha Dutta
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First American Edition, 2009
This edition published in the United States in 2017 by
DK Publishing, 345 Hudson Street, New York, New York 10014
DK, a Division of Penguin Random House LLC

17 18 19 20 21 10 9 8 7 6 5 4 3 2 1
001–280449–Jun/2017

A catalog record for this book is available from the Library of Congress.
ISBN 978-1-4654-4344-1

DK books are available at special discounts when purchased in bulk for sales promotions, premiums, fund-raising, or educational use. For details, contact: DK Publishing Special Markets, 345 Hudson Street, New York, New York 10014 or SpecialSales@dk.com.

Printed and bound in Hong Kong

A WORLD OF IDEAS:
SEE ALL THERE IS TO KNOW

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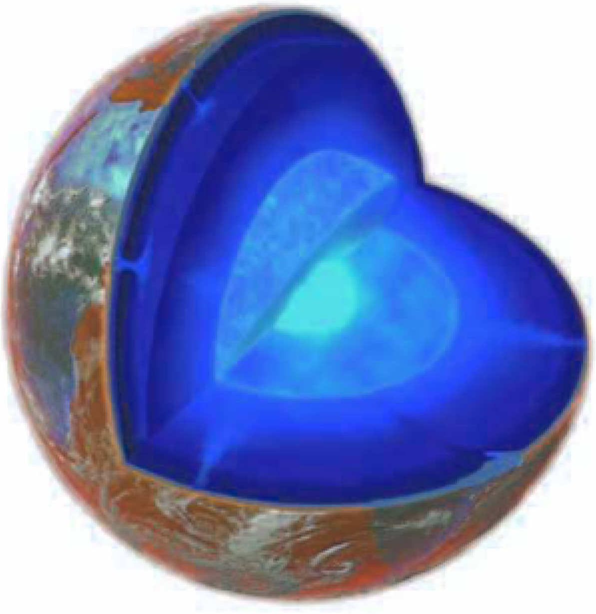
Contents



What is science?

Life science

There is a question at the bottom of each page...

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Contents

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Materials science

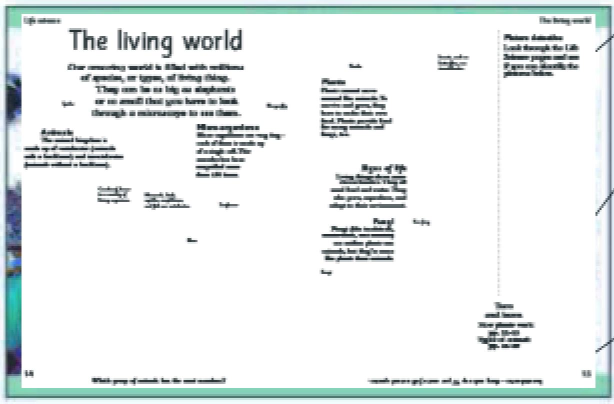
Physical science

Earth and space science

Reference section

About this book

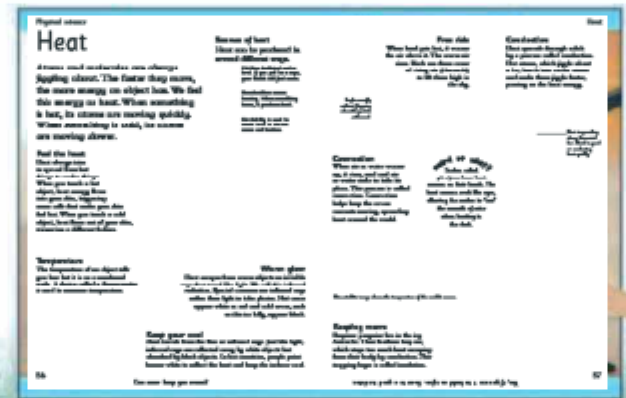
The pages of this book have special features that will show you how to get your hands on as much information as possible! Look out for these:



The Picture Detective will get you searching through each section for the answers.

Turn and Learn tells you where to look for more information on a subject.

Every page is color-coded to show you which section it is in.

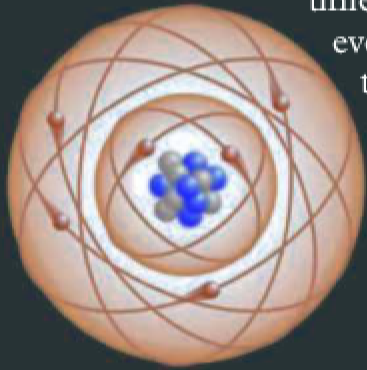


What is science?

Science is the search for truth and knowledge. Scientists suggest explanations of why things are as they are, and then they test those explanations, using experiments. Some of what science discovers can be applied to our everyday lives.

From atoms to space

Scientists study a huge variety of things—from the tiniest atoms that make up everything around us to the mysteries of space.



Everything you see is made up of minuscule atoms.

Life science

How do living things survive and grow, where do they live, what do they eat, and how do their bodies work? Life science seeks to answer such questions about the living world, from microscopic bacteria to plants and animals—including you!

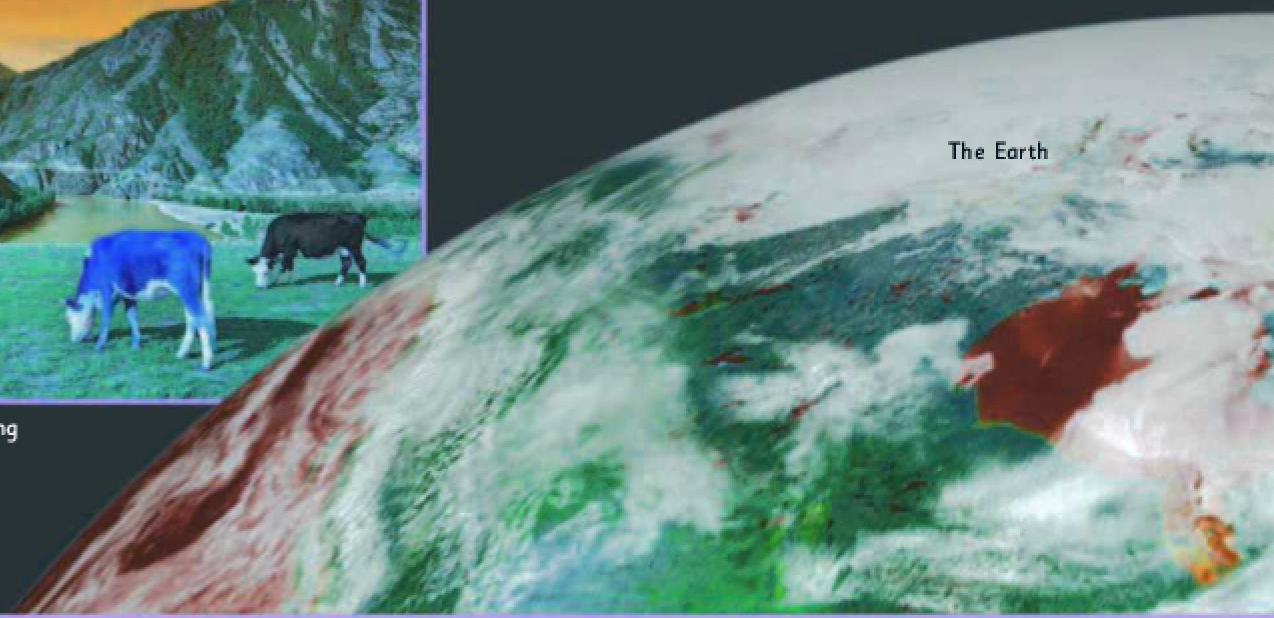
The scientific study of plants is called botany.

Life science studies the living world around us.

Physical science

This science looks at energy and forces. There are different types of energy, including light, heat, and sound. Forces are the things that hold everything in place in our world. Without the force of gravity, for example, you would fly off into space!

The study of electricity is part of physical science.



The Earth

What is the study of animals called?

This is NASA's Atlantis orbiter—part of its Space Shuttle program, which ended in 2011.

Earth and space science

The Earth is a dot in a vast universe filled with planets and moons, stars and galaxies. As far as we know, the Earth is special because it is the only place that supports life. Earth and space science is the study of the structure of our planet—and everything that exists beyond it.

Volcanology is the scientific study of volcanoes.

One branch of science studies how materials can change.

Materials science

Our universe is filled with atoms and molecules, which make up elements, compounds, and mixtures. Materials science is the study of these things, how they behave, how we use them, and how they react with one another.

All about change

People always want to make life better, and that's what puts us on the road to scientific discovery. Whether it's finding cures or sending rockets into space, science drives us onward, changing the world in which we live.

Pictures of the Earth from space help scientists understand the Earth better.

Advances in science

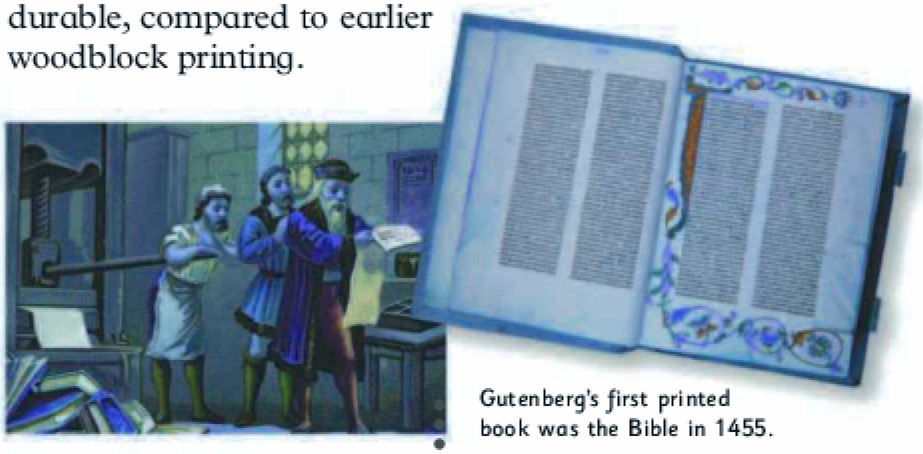
Great scientists are thinkers who understand the world around us, provide solutions to problems, and create new things. This has led to many great inventions and discoveries.

A falling apple probably inspired Newton to think about gravity.

In a rainbow, white light breaks up into seven colors.

Johannes Gutenberg (c.1398–1468)

Gutenberg played a key role in printing. Experts believe he invented metal-type printing in Europe. Gutenberg's press was quick, accurate, and durable, compared to earlier woodblock printing.



Gutenberg's first printed book was the Bible in 1455.

Isaac Newton (1642–1727)

Newton investigated forces and light. He realized there must be a force that keeps the planets in orbit around the Sun. This force is known as gravity. Newton also discovered that white light is a mixture of lots of different colors.

1400 — 1500 — 1600

Wooden replica of da Vinci's Ornithopter

Leonardo da Vinci (1452–1519)

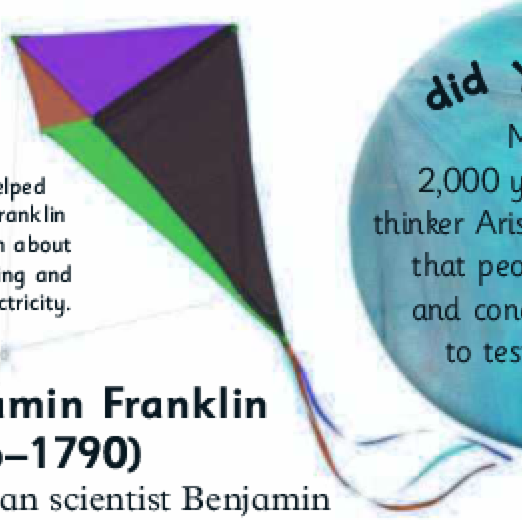
Da Vinci was a painter and inventor. He drew plans for helicopters, airplanes, and parachutes. Unfortunately, the technology of the time was not good enough to build a working model for any of these.

Galileo Galilei (1564–1642)

Galileo proved that the Earth moves around the Sun by looking at the solar system through a telescope. A few wise thinkers had always suspected the truth, but most people at the time believed that our Earth was the center of everything.

Replica of a 17th-century telescope

Who invented the bifocal lens?



A kite helped Benjamin Franklin learn about lightning and electricity.

Benjamin Franklin (1706–1790)

American scientist Benjamin Franklin experimented with lightning and electricity. His work in the 1700s laid the foundations for today's electrical world.

Franklin risked his life flying a kite—he could have been struck by lightning.

did you know?

More than 2,000 years ago, Greek thinker Aristotle recommended that people study nature and conduct experiments to test the accuracy of ideas.

Louis Pasteur (1822–1895)

Pasteur is known for discovering pasteurization—a process that uses heat to destroy bacteria in food, particularly milk. He also found that some diseases are caused by germs and encouraged hospitals to be very clean to stop the spread of germs.

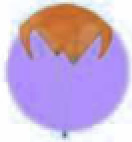
Super inventions!

Inventions and discoveries have changed the course of our history.

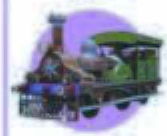
The first known **wheel** was used in Mesopotamia around 3500 BCE.

Paper was invented in China around 105 CE, but kept secret for many years.

The magnetic **compass** was first used by the Chinese. It was invented around 247 BCE.

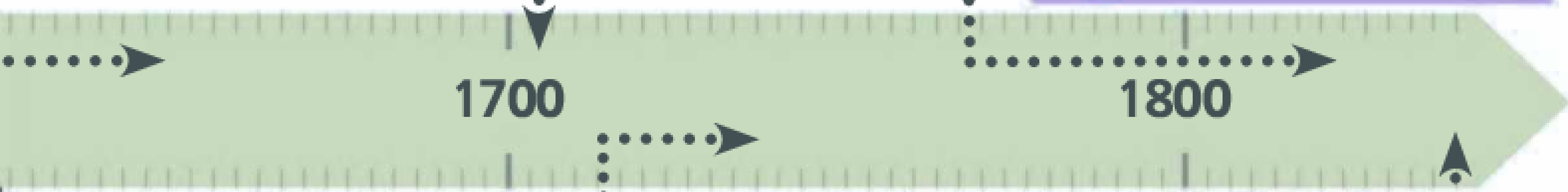


The **parachute** was first tested in 1617 by Faust Vrancic, centuries after da Vinci made his drawings.

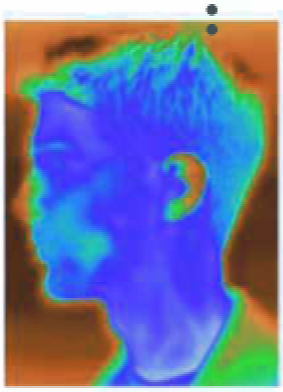


The **steam engine** was invented in 1804. The earliest successful model reached 30 mph (48 kph).

The **color photo** was first produced by physicist James Maxwell in 1861.



William Herschel (1738–1822)



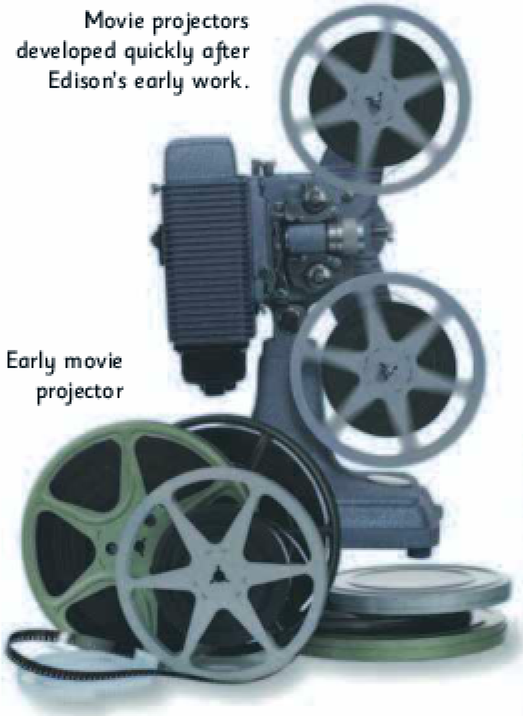
Herschel is well known for his work in astronomy (he was the first to identify the planet Uranus). He also discovered infrared radiation—this technology is used today for wireless communications, night vision, weather forecasting, and astronomy.

Wilhelm Conrad Röntgen (1845–1923)

Röntgen discovered electromagnetic rays—today known as X-rays—on November 8, 1895. This important discovery earned him the first Nobel Prize for Physics in 1901.

X-rays allow doctors to look inside the human body.

Benjamin Franklin.



Movie projectors developed quickly after Edison's early work.

Early movie projector

Thomas Edison (1847–1931)

Thomas Alva Edison produced more than 1,000 inventions, including long-lasting lightbulbs, batteries, and movie projectors.

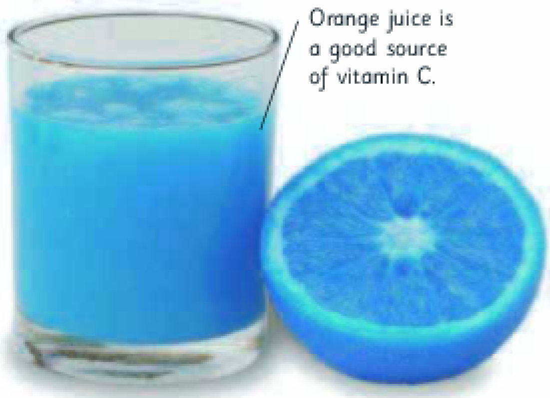
Karl Landsteiner (1868–1943)

Austrian-born physiologist Landsteiner discovered that human blood can be divided into four main groups—A, B, AB, and O. This laid the foundation of modern blood groupings.

Blood transfusions play an important part in modern medicine.

Red blood cells

You inherit your blood type from your parents.



Orange juice is a good source of vitamin C.

Albert Szent-Györgyi (1893–1986)

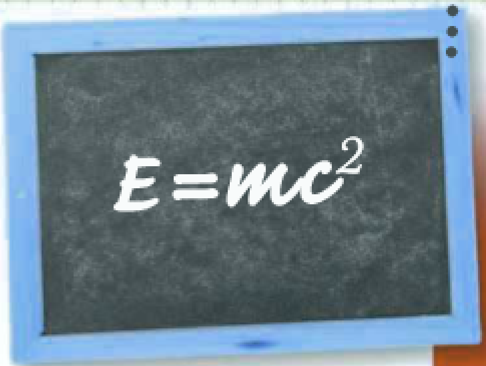
The Hungarian scientist Albert Szent-Györgyi is best known for discovering vitamin C. He also pioneered research into how muscles move and work. In 1937, he won the Nobel Prize for physiology and medicine.

1800

1850

Albert Einstein (1879–1955)

German-born physicist Albert Einstein's famous equation $E=mc^2$ explained how energy and mass are related. It helped scientists understand how the universe works.



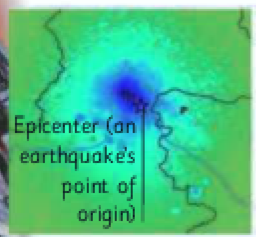
Einstein's equation

Earthquakes destroy homes and office buildings.

A "great" earthquake (8–9.9 on the Richter scale) strikes on average once a year.

Charles Richter (1900–1985)

Richter developed a way to measure the power of earthquakes. He worked on his scale with fellow physicist Beno Gutenberg.



Epicenter (an earthquake's point of origin)

Who was the father of the frozen food industry?

Alan Turing (1912–1954)

During World War II, Alan Turing, a brilliant mathematician, helped develop code-breaking machines that eventually led to the invention of modern computers.

The English used Turing's machine to break German codes that were sent through the Enigma machine during World War II.

Tablet

An Apple smartphone

Modern inventions

Imagine the world without these fantastic inventions!

The first **antibiotic**, penicillin, was discovered accidentally.

Modern **cars** are driven by internal combustion engines that run on gas or diesel.

Nuclear power is efficient, but some people think it could harm us.

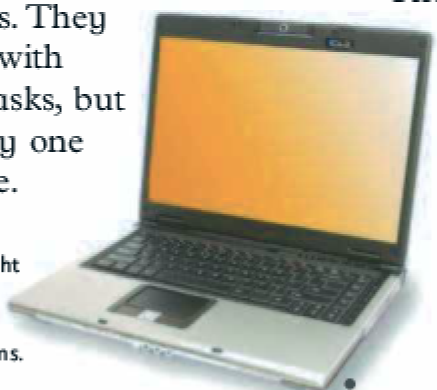
Plastics technology is used to make many of the things in your home.

Compact discs are small and light, and they store lots of information.

Energy-efficient lightbulbs help save energy in your home.

Computers (1941)

The first computers were huge machines. They couldn't cope with complicated tasks, but worked on only one thing at a time.



Today's laptops can be lightweight and portable. Early computers filled whole rooms.

Cell phones and tablets (1980s)

The first cell phones were large and heavy, weighing about 77 lb (35 kg). Tablet technology has also improved drastically since its invention in the late 1980s.

1900

1950

DNA profiling (1986)

The discovery of DNA (which holds information in human cells) led to DNA profiling, a huge help to the police—criminals can now be identified by a single hair or spot of blood.

Nuclear bombs (1945)

The US dropped two nuclear bombs on Japan in World War II, killing nearly 300,000 people. It is the only time nuclear weapons have been used in war.

The Internet (1990s)

With its roots in the 1960s, the internet (short for internetwork) became public during the mid-1990s, and is now used for fun and education by about 2.5 billion users—70 percent of whom are online every day.

Before DNA profiling, police identified criminals by their fingerprints. This system was developed in the 1890s.

Clarence Birdseye, who started a frozen food company in 1924.

Being a scientist

Experiments can involve toxic fumes or chemicals that might explode, so scientists wear protective goggles.

Scientists study the world around us. They look for gaps in existing knowledge and try to find the answers. Not all scientists study the same things—they specialize in different areas.

Testing, testing

Scientists explore their ideas and theories using tests called experiments. In this book, there are lots of experiments you can try out for yourself.

Mixing it up

Experimenting with chemicals and their reactions can produce some mixed results. Some mixtures can be dangerous, while others can be the answer the scientists are after.

A closer look

The microscope was developed by two Dutch eyeglass makers in around 1610, and then refined by Robert Hooke in England. Early models revealed tiny organisms in water, while modern versions can look inside a single cell.


Hooke's microscope

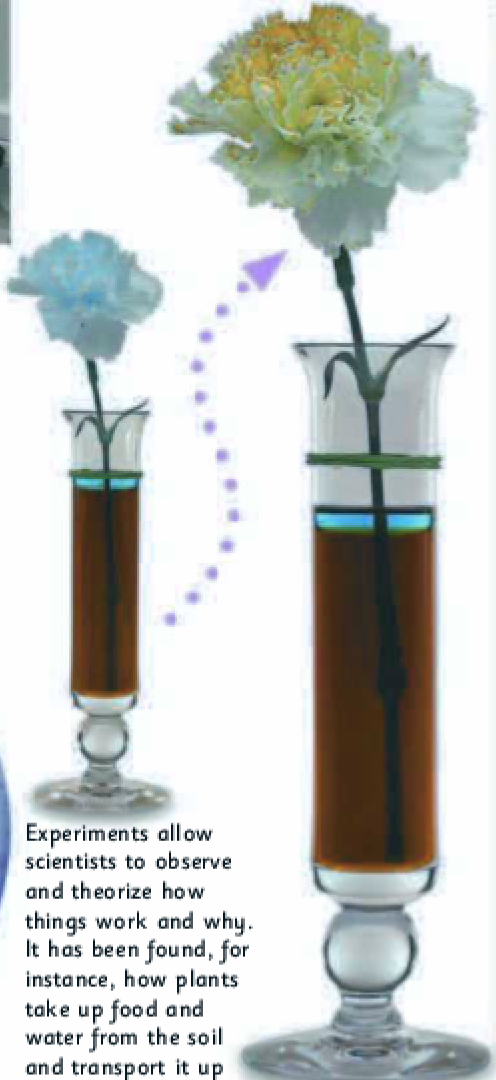

Modern microscope

Inside view

When you go to a hospital, the doctor may send you for a body scan. Using a powerful machine, the medical team can see what's going on inside you.

hands on

Fill a cup or vase with water and add a few drops of food coloring. Cut the end off the stem of a flower and put the flower in the water. The petals turn the color you mixed in the water.


Experiments allow scientists to observe and theorize how things work and why. It has been found, for instance, how plants take up food and water from the soil and transport it up the stem.

Types of scientist

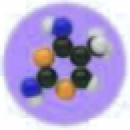
Almost everything in the world is the subject of study by a scientific specialist.


Zoologists study animals of all kinds except human beings.

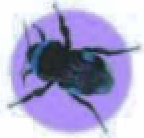

Biologists are interested in everything about life and living organisms.


Paleontologists are experts on fossils and try to learn about organisms from them.


Botanists learn about the world of plants, plant types, and plant groups.


Chemists study elements and chemicals, and they help make new substances.


Astronomers are experts on space, planets, stars, and the universe.


Entomologists are a special kind of zoologists who learn about insects.


Geologists find out about our Earth, particularly by studying rocks.


Archeologists are interested in the remains of past peoples and lives.


Ecologists study the relationship between living things and their environment.


Oceanographers know all about oceans and ocean life.

Some microscopes can magnify objects up to 2,000 times!

Science and everyday life

Science is not just used by experts working in laboratories. It is part of all our lives. From brushing your teeth to setting your alarm, science is with you all day, every day, in the form of technology.

Teflon

Invented in 1938, Teflon was used in space suits. In everyday life, it stops stuff from sticking to hot surfaces.

Iron

Teflon pan

Electricity

Electricity lights up the world and gives us the energy to run machines and gadgets with which we can cook, travel, work, and play.

Plastic building blocks

Plastic fantastic

Look around you and you will see dozens of things made of plastic. From containers to toys, plastic is a versatile and durable material. Many plastics can now be recycled.

Some medicines come in plastic bottles. Sometimes tablets are contained in plastic packets and sold in strips.

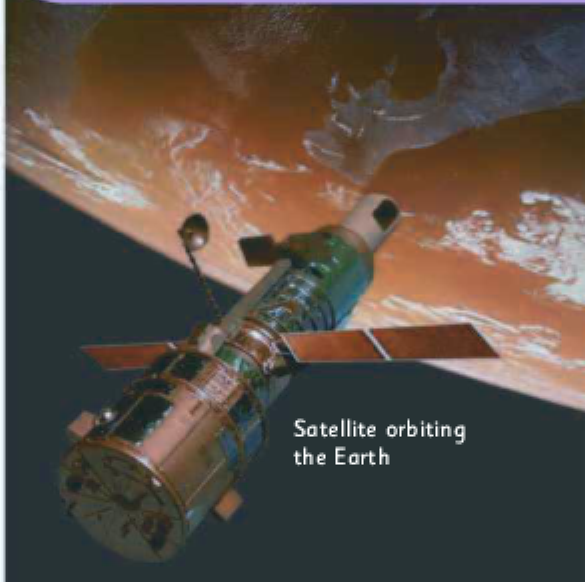
Cities at night are bright places, lit up by offices, houses, and street lights.

Surgeons get a helping hand from computers.

Masks, aprons, and gloves help doctors keep operating rooms free from infection.

In the best of health

Long ago, people relied only on herbs to cure diseases. Thanks to modern science, many illnesses, including those that were once untreatable, can now be cured or prevented.



Satellite orbiting the Earth

Communications

Satellites orbit the Earth, beaming back all kinds of information. They send TV signals, supply weather information, and help us look into space.

Clothing technology

Advances in sports-clothing technology have impacted everyday clothes. Breathable fabric, stretchy spandex, and thermal underwear were developed from specialized sportswear.

From here to there

Science and technology make it much easier to get around. Trains, planes, and cars make the world a smaller place and allow us to visit exotic destinations. They are also useful for getting to school on time.

Bullet trains in Japan travel up to 185 mph (300 kph).

Turn and learn

Health: **pp. 40-41**

Electricity: **pp. 76-77**

Sputnik 1, launched by the Soviet Union in 1957.

The living world


Spider


Dragonfly

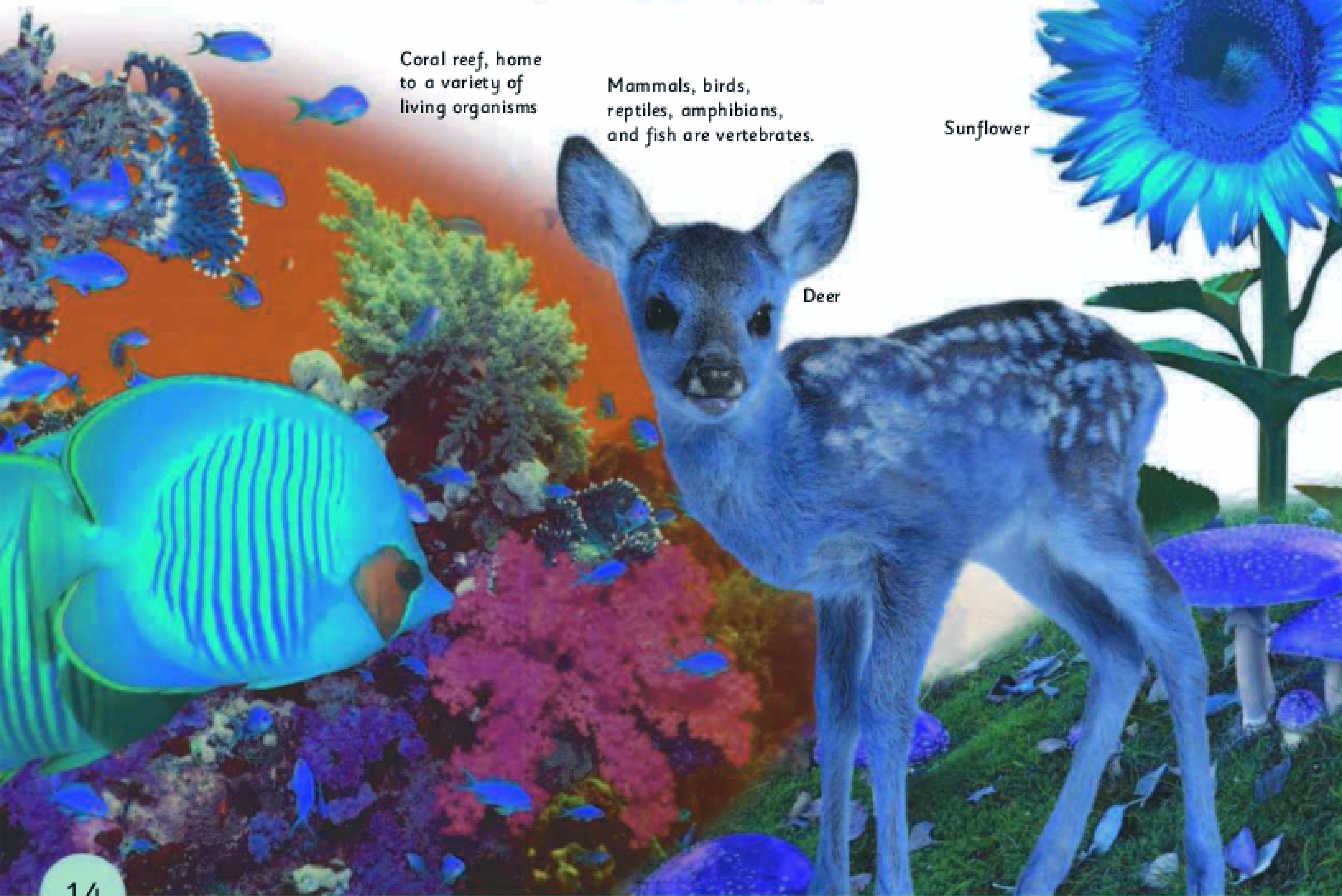
Our amazing world is filled with millions of species, or types, of living thing. They can be as big as elephants or so small that you have to look through a microscope to see them.

Animals

The animal kingdom is made up of vertebrates (animals with a backbone) and invertebrates (animals without a backbone).

Microorganisms

Microorganisms are very tiny—each of them is made up of a single cell. This amoeba has been magnified more than 100 times.


Coral reef, home to a variety of living organisms

Mammals, birds, reptiles, amphibians, and fish are vertebrates.

Sunflower

Deer

Which group of animal has the most members?

Snake

Insects, such as butterflies, are invertebrates.

Plants

Plants cannot move around like animals. To survive and grow, they have to make their own food. Plants provide food for many animals and fungi, too.

Signs of life

Living things share some characteristics. They all need food and water. They also grow, reproduce, and adapt to their environment.

Fungi

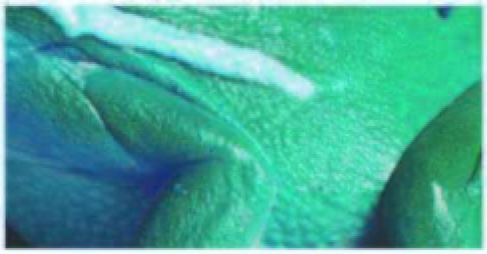
Fungi (like toadstools, mushrooms, and molds) are neither plants nor animals, but they're more like plants than animals.

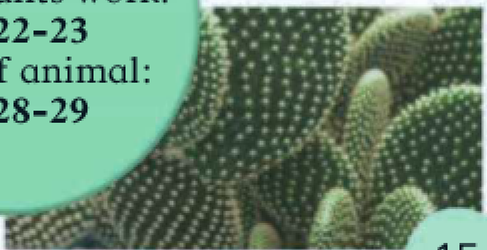
Tree frog

Fungi

Picture detective

Look through the Life Science pages and see if you can identify the pictures below.





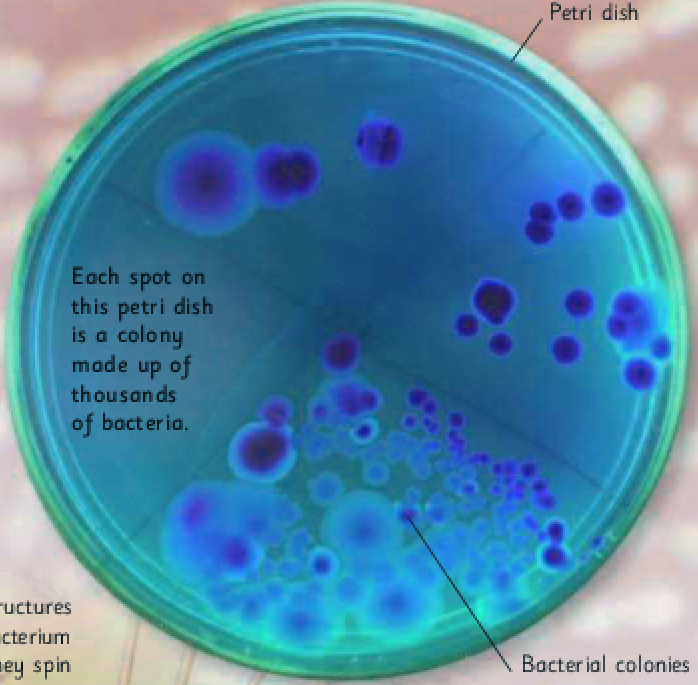
Turn and learn

How plants work: **pp. 22-23**
Types of animal: **pp. 28-29**

Invertebrates—they make up 97 percent of all animal species.

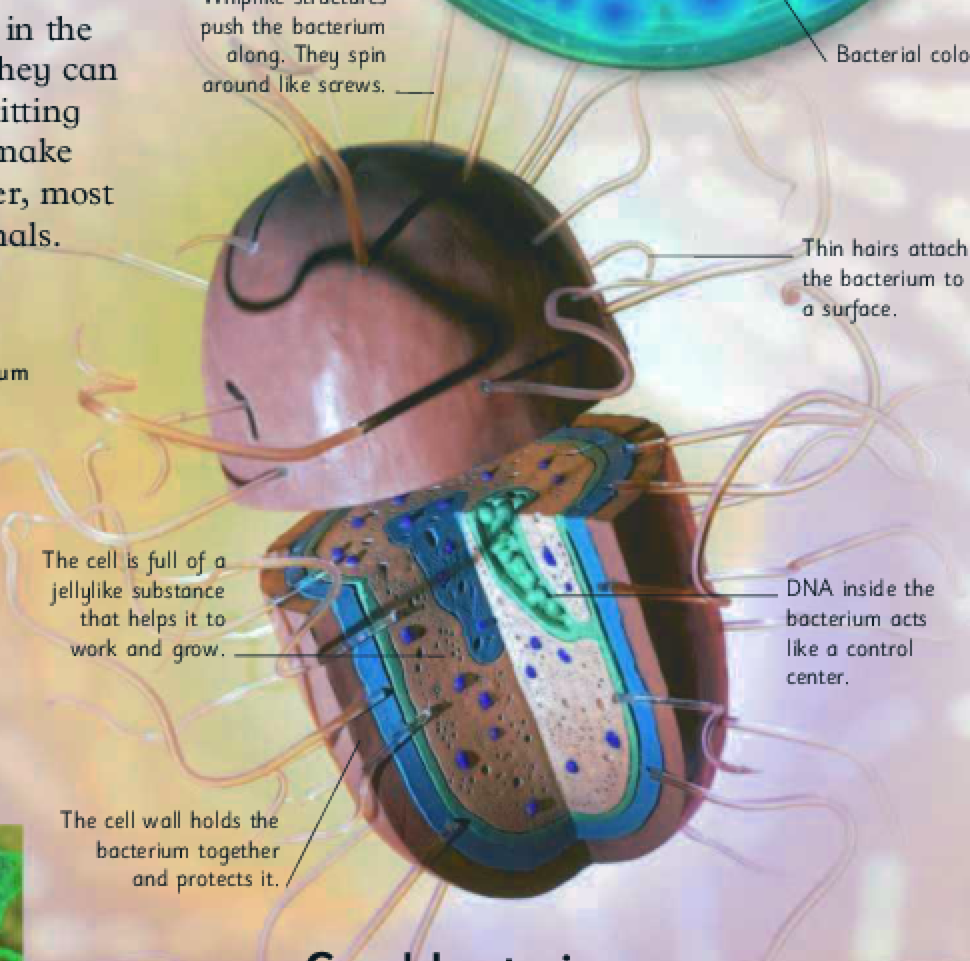
Micro life

Most living things are made up of just one cell, and are too small to see. To study them, we must use powerful microscopes.



Bacteria

Bacteria are single-celled life-forms. They are found in the ocean, in the air, and even in our bodies. They can reproduce very quickly by splitting into two. Some bacteria can make energy from sunlight. However, most feed on dead plants and animals.



Model of a bacterium

Harmful bacteria

Some bacteria can cause serious illnesses such as cholera and tetanus. Good sanitation and antibiotic drugs help fight diseases caused by harmful bacteria.

Bacteria may be shaped like rods, spirals, or spheres.

Good bacteria

Some bacteria are helpful to humans. Bacteria in our guts protect us from illnesses. Other bacteria are used to make foods such as yogurt and cheese.

How many copies can a single bacterium make of itself in 24 hours?

Model of a virus

Viruses

Viruses are much, much smaller than bacteria. They are shaped like spheres or rods. Viruses are not really alive, because they are not made of cells. They only become active when they invade a cell. They copy themselves by taking over the cell and turning it into a virus factory.

Plant viruses

Plant viruses can change the way that plants develop. For example, one virus affects the pigment in tulips' petals. It stops the pigment from working in some places. This makes the petals look striped.

The streaked patterns on this tulip are caused by a virus.

A virus has made light patches appear on these leaves.

Vaccinations

Vaccinations can help to protect people from harmful diseases. A person is injected with a weakened form of a virus or bacterium. This prepares the immune system for the real thing.

Harmful viruses

Viruses can cause different illnesses.

Chickenpox is easy to catch. The main symptom is itchy sores.

Rabies is a fatal virus that is common in animals such as dogs.

Colds are viruses and can bring on a sore throat, runny nose, and cough.

Other tiny cells

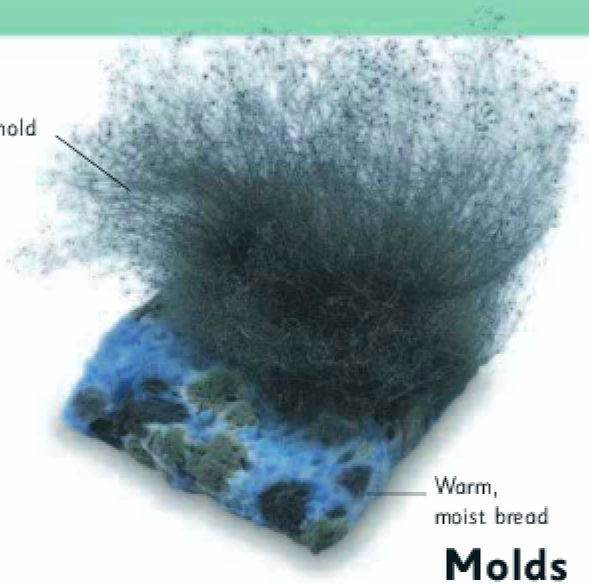
Like bacteria, another group of organisms called archaea are all single-celled. There are also some single-celled organisms, such as amoebas, algae, and yeasts, that are closely related to animals, fungi, and plants.

Microscope photograph of algae

It can make 4,000 million million copies.

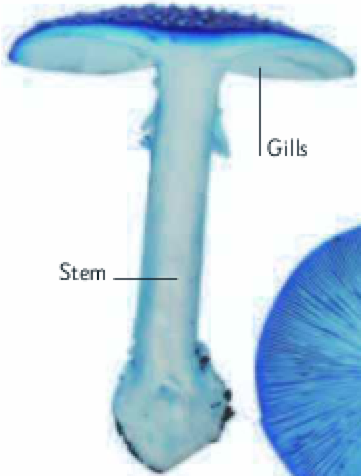
Fungi

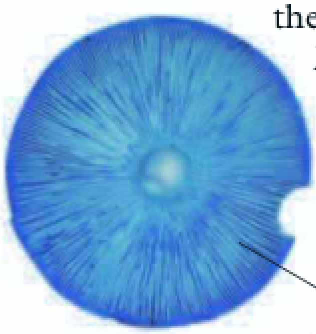
Mushrooms, toadstools, yeasts, and molds are kinds of fungi. Fungi are neither animals nor plants. They feed on living or dead animals or plants and absorb their nutrients.



Molds

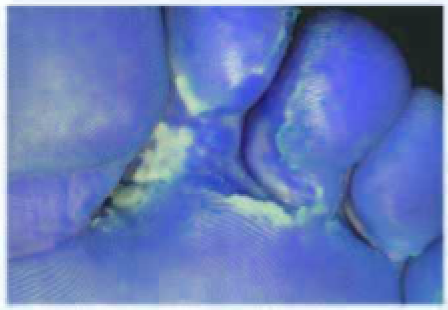
Molds are microscopic fungi that grow in long strands called "hyphae." They feed on dead organic matter—like our food—by making it rot.





Mushrooms

Many fungi are hidden in the soil, or inside food sources like trees. They only become visible when they grow mushrooms. Mushrooms scatter spores, which will grow into new fungi.



Athlete's foot

Athlete's foot is a disease caused by ringworm fungi growing on human feet. It makes the skin between your toes turn red and flaky.

Picking wild mushrooms

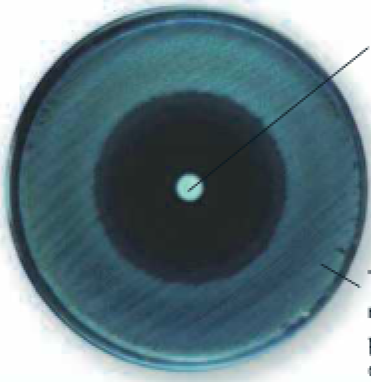
Many wild mushrooms are not only edible, but also delicious. However, some are highly poisonous! Harmful mushrooms are often called toadstools. They sometimes have bright colors that warn animals not to eat them.

How big is the world's largest fungus?

Sir Alexander Fleming (1881–1955)

Penicillin

In 1928, the Scottish scientist Sir Alexander Fleming made an important discovery. He realized that the mold *Penicillium notatum* makes a chemical that kills bacteria. That chemical, called penicillin, is used today as a medicine to treat many illnesses.



Truffles

Truffles are strong-smelling fungi that grow underground. They are a delicacy used in cooking. Truffle hunters use pigs and dogs to sniff them out.

Pig sniffing out mushroom

White truffle

Black perigord truffle

Yeast

Yeast are microscopic, single-celled fungi. When they feed, they turn sugar into the gas carbon dioxide and alcohol. Yeast plays an important part in bread-making. As it releases gas, it makes bread rise.

Uses of fungi

Fungi have many uses in the home and in industry.

Medicinal fungi can be used to cure many diseases that were once fatal.

Wine is made from grape juice when yeast turns the sugar in the juice into alcohol.

Blue cheese is made with a mold called *Penicillium roquefortii.*

Soy sauce is made by adding fungi and yeast to soy beans and roasted wheat.

Pesticidal fungi can be an environmentally friendly way of killing insects or weeds.

Shaggy parasol mushroom

Shaggy cap mushroom

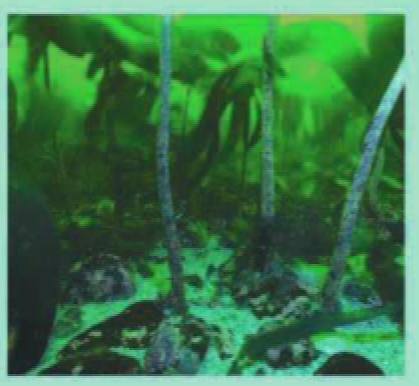
Common chanterelle mushroom

Chicken of the woods mushroom

A mushroom in the Malheur National Forest in Oregon covers 3.4 sq miles (8.9 sq km).

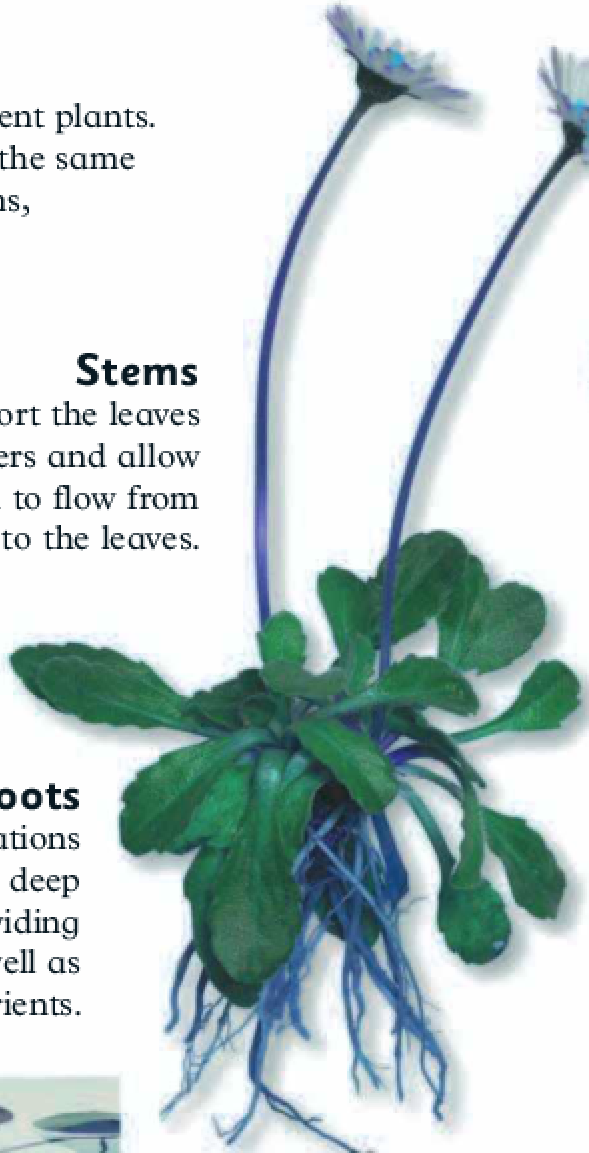
What is a plant?

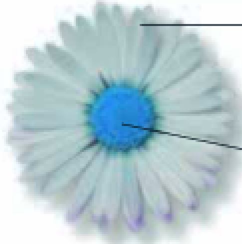
Plants make their own food from the Sun's rays. Most have leaves that reach outward to capture sunlight and roots that dig deep for nutrients and stability.



Seaweed
Seaweed looks like a plant, but is an alga. It doesn't have roots, so it has to stick to rocks or float with the tide.

Plant parts
There are lots of different plants. But most are made of the same vital parts—roots, stems, leaves, and flowers.



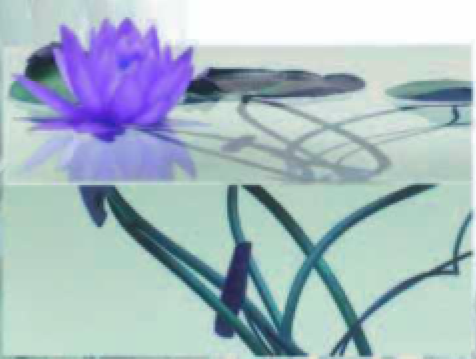


Stems
Stems support the leaves and flowers and allow water and food to flow from the roots to the leaves.

Flowers
Flowers are key to plant reproduction. They make pollen and develop seeds and fruit.

Roots
These are the foundations of the plant. They dig deep into the soil, providing stability, as well as sucking up nutrients.

Leaves
These are the work factories of the plant and capture the Sun's energy.



Water lily
The water lily's flat leaves float on the pond surface, as its roots sink into the pond bed.

weird or what?
The Venus flytrap doesn't just get its energy just from the Sun. It also lures and feeds on unsuspecting insects. Yum!

What plant has the largest leaves?

Types of plant

Take a look around you. Not all plants are the same. But some plants are more similar than others.

Most conifer trees keep their leaves all year round.

Fern leaves unfurl as they grow.

Ferns

Ferns love damp and shady areas. They have pronglike leaves and spread using spores.

There are about 12,000 species of moss.

Moss

Mosses love moisture and grow in clumps. They don't have roots or grow flowers.

Conifers

Conifer trees grow cones that store their seeds. Most conifers have needle-shaped leaves.

The sequoia is the largest tree in the world.

Leaves

You can identify a tree by the shape of its leaves. In most plants, leaves are broad and flat.

Ash leaf

Maple leaf

Scarlet oak leaf

Flowering plants

This is the biggest group of plant. They produce flowers, fruits and seeds, which mainly grow in seasonal cycles.

Rain forest

These warm and wet forests are home to nearly half the world's plant species.

Deciduous

Deciduous plants shed their leaves to survive drier seasons.

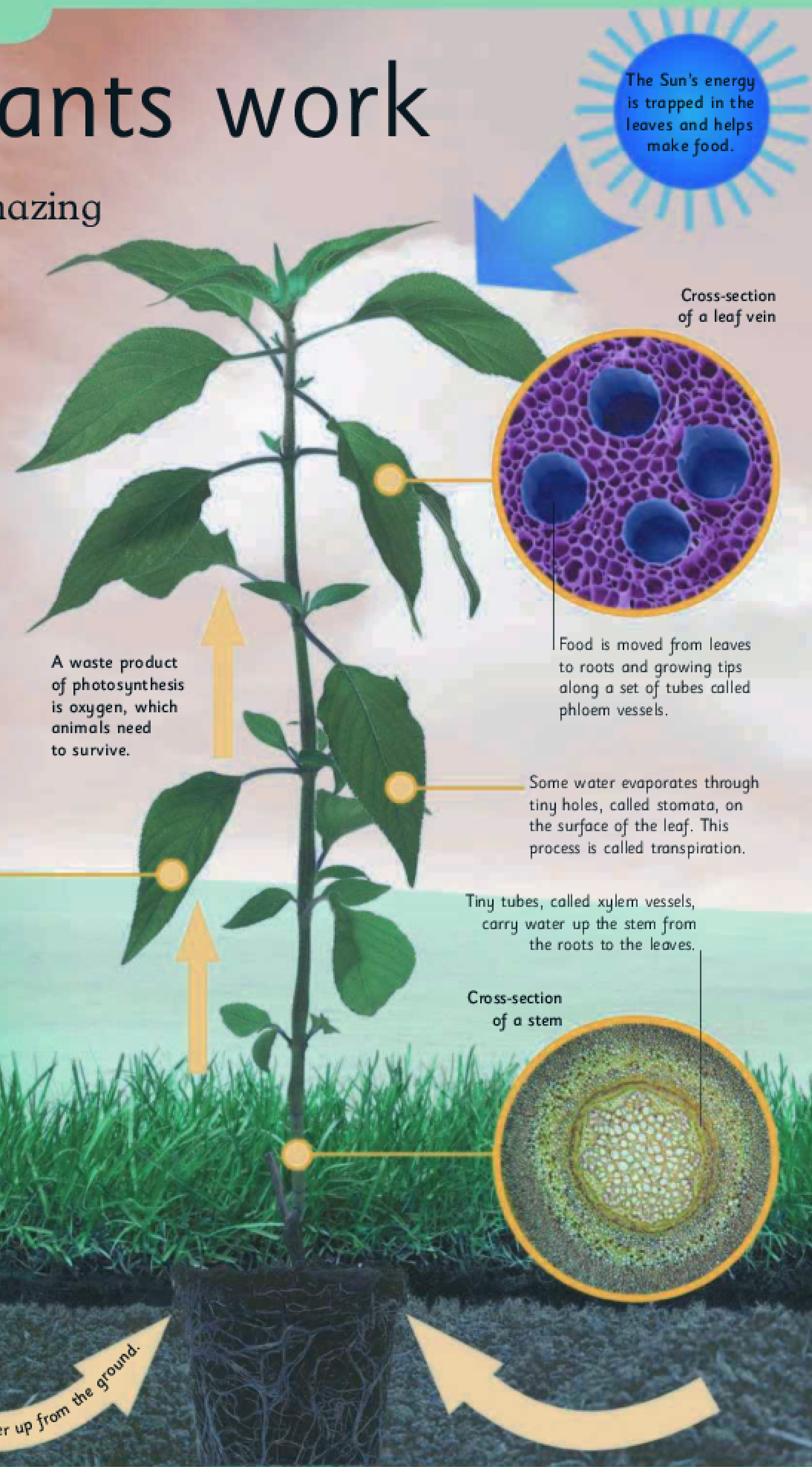
The raffia palm has leaves that grow up to 80 ft (24 m) long.

How plants work

Plants have an amazing system for making and transporting food to all their different parts.

Photosynthesis

Leaves have a green pigment called chlorophyll, which absorbs energy from sunlight. This energy is used to change water and carbon dioxide into sugar.



New growth

Plants use sugar and starch as fuel. The fuel is transported to cells where it is burned to release energy, which is used to grow new cells and repair old ones.

Wilting leaves

On warm, sunny days, plants lose a lot of water from their leaves. If they lose too much, their leaves collapse. This is called wilting. If plants don't get enough water, their leaves will shrivel and die.

Desert plants

Plants that live in dry areas such as deserts have to save their water. Many have leaves that are thick and covered in wax to stop transpiration. Cacti have spines rather than leaves and thick stems in which they can store water.

The fruit acts as a store of sugar and water.

Carrot plants store food in their roots.

Storing food

Spare food is stored for future use. Plants such as hyacinths store food in the base of their leaves. This makes the leaves swell and form a bulb. The bulb survives the winter and in spring it sprouts new leaves.

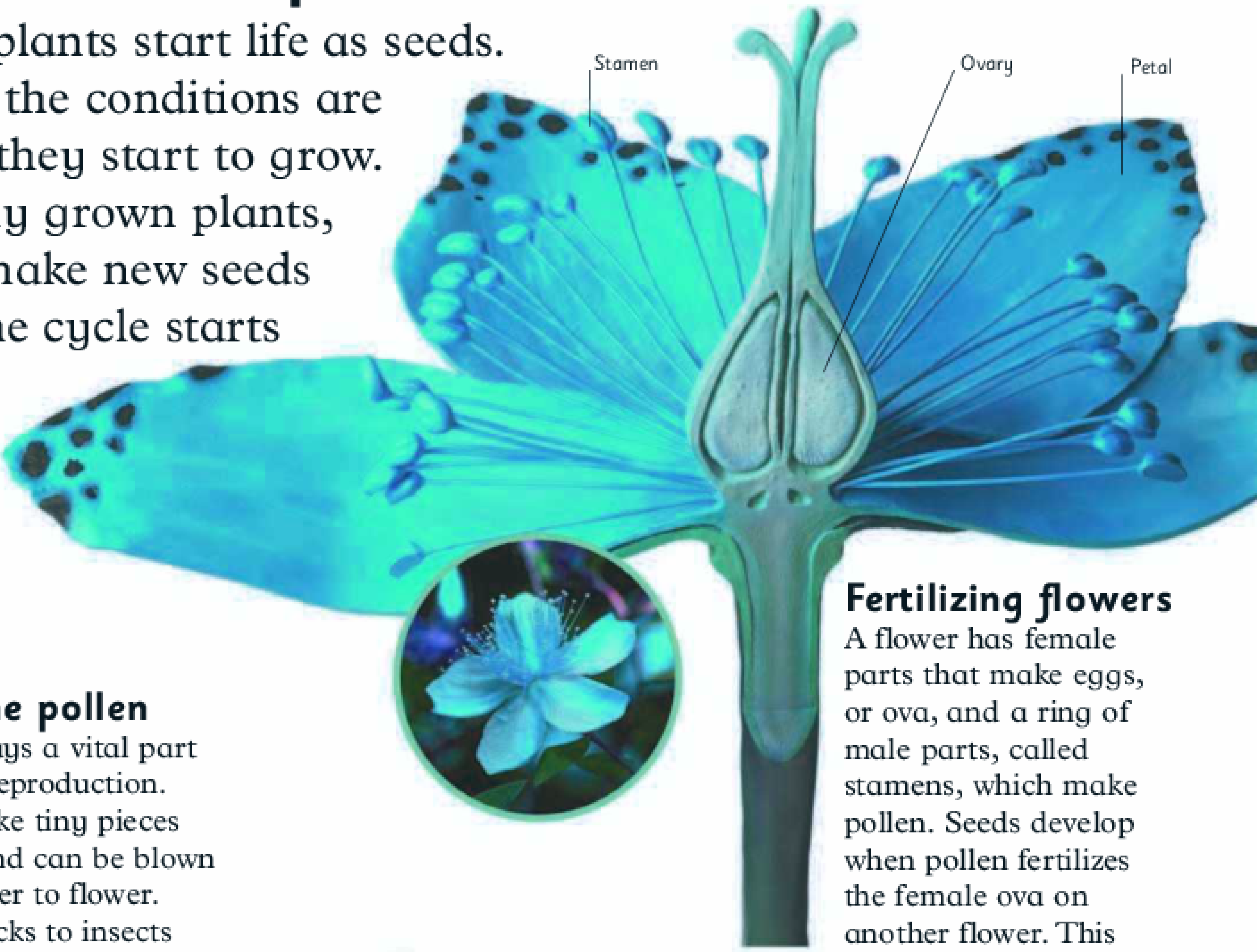
Weird or what?

The sea slug *Elysia chlorotica* uses photosynthesis. The slug eats algae that it doesn't fully digest. The remains in its system continue to photosynthesize the food and provide energy.

No, many bacteria also make food by photosynthesis.

Plant reproduction

Most plants start life as seeds. When the conditions are right, they start to grow. As fully grown plants, they make new seeds and the cycle starts again.



Pass the pollen

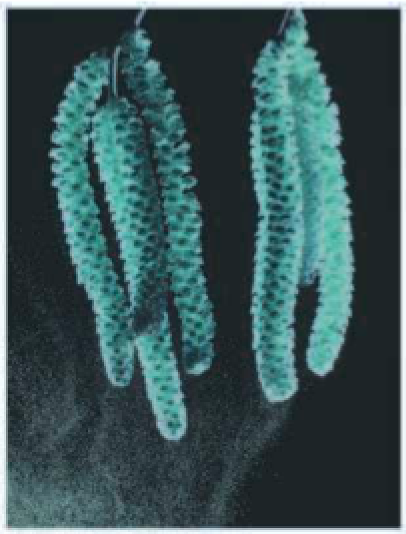
Pollen plays a vital part in plant reproduction. It looks like tiny pieces of dust and can be blown from flower to flower. It also sticks to insects and birds and gets flown to new flowers.

Fertilizing flowers

A flower has female parts that make eggs, or ova, and a ring of male parts, called stamens, which make pollen. Seeds develop when pollen fertilizes the female ova on another flower. This is called pollination.

Waving in the wind

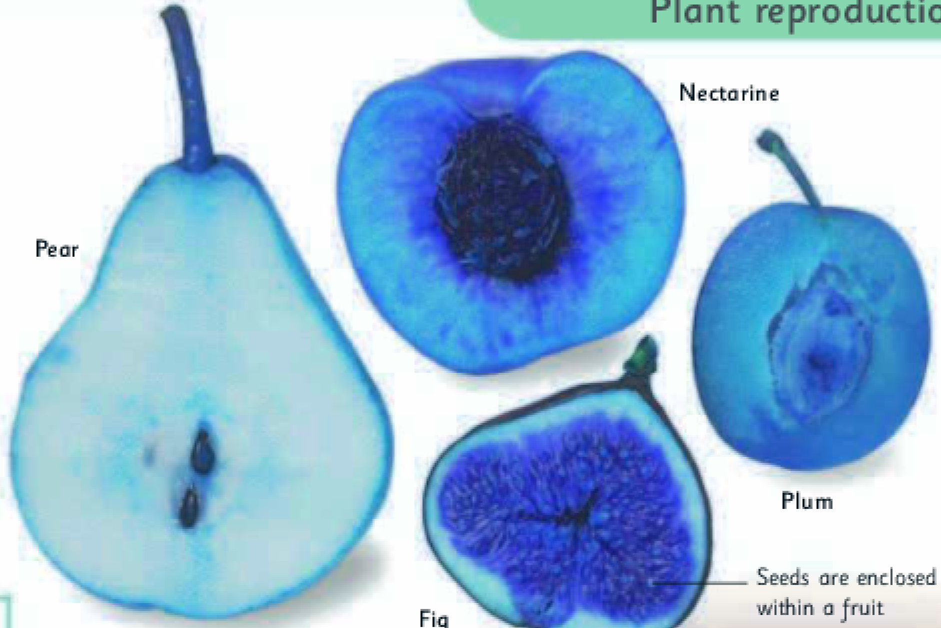
A catkin is the flower of the willow tree. In catkins, the male and female parts are on separate flowers. Catkins move in the wind and release a lot of pollen, which then pollinates the female flowers.



What is a spore?

Fruits and seeds

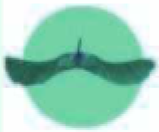
When a plant has been fertilized, the ovary swells up and becomes a fruit. There are many different types of fruit. Some are fleshy and sweet tasting, and others are dry and hard.



Scattering seeds

Plants scatter their seeds in different ways.

Dandelions have seeds with tiny **parachutes** that are carried by the wind.



Maple seeds have a **wing** that allows them to glide to the ground.

Burrs become attached to animal fur and get carried far away.

Animals eat fruits and drop the seeds on the ground.

New life

Seeds contain everything needed to grow a new plant. With enough food, water, and light the seed sprouts a root and baby stem, known as a shoot.

Running away

Not all new plants grow from seeds. The strawberry plant produces long stems, called runners, that grow along the ground. When the runner touches the ground, a new plantlet takes root and becomes a new plant.

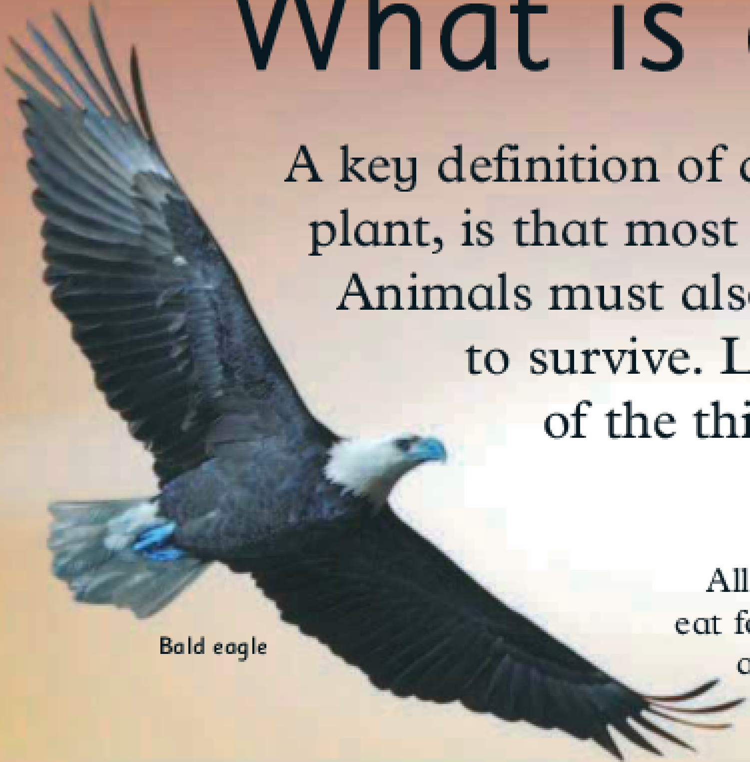
hands on

Make your own small garden inside a jar or can. Fill it with soil, then plant some seeds. Water them and watch them grow!

It is similar to a seed and plays the same role in fungi and algae life cycles.

What is an animal?

A key definition of an animal, as opposed to a plant, is that most animals can move voluntarily. Animals must also eat other living things to survive. Let's take a look at some of the things animals do.



Bald eagle

Food is fuel

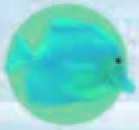
All animals have to find and eat food to survive. Carnivores are animals that eat meat. Herbivores eat mainly plants. Omnivores are creatures that eat both plants and meat.

Squirrels eat seeds, nuts, fruits, and fungi.

Getting around

Many animals have muscles, which allow them to move in a variety of ways.

Birds **fly** by flapping wings or gliding on currents of hot air.

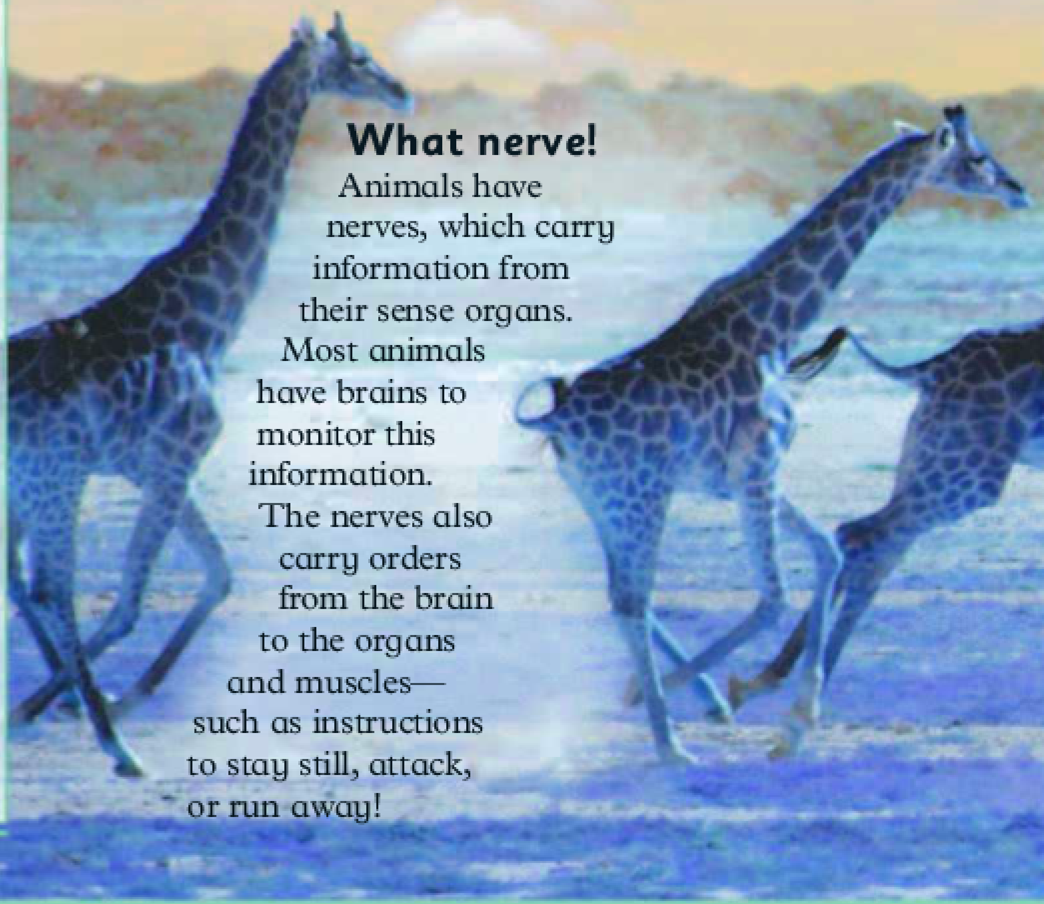


Animals like fish **swim** by moving their bodies and fins.

Some snakes **wriggle**; others raise and flatten their bodies.

Many animals **walk** and **run** using their legs.

Sea anemones **reach out** their tentacles to sting prey.



What nerve!

Animals have nerves, which carry information from their sense organs. Most animals have brains to monitor this information. The nerves also carry orders from the brain to the organs and muscles—such as instructions to stay still, attack, or run away!

Pythons can go without food for months after one big meal!

Making babies

Most animals reproduce when a female egg is fertilized by a male sperm. Some animals give birth to babies, while others lay eggs.

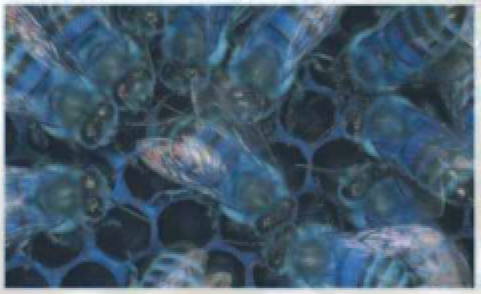
Birds lay hard-shelled eggs that hatch into chicks or ducklings.

Baby birds have to break out of the egg on their own.

Do animals talk?

Many animals are able to communicate with each other using either sounds or signals.

Most beetles will send "messages" to other beetles using special chemicals.



Honey bees constantly communicate. They give directions with a special dance.

Giraffes have seven vertebrae in their necks—the same as most other mammals. They are just much longer.

Monkeys scream at each other to sound an alarm.

No one knows, but there are probably about 8 million.

Types of animal

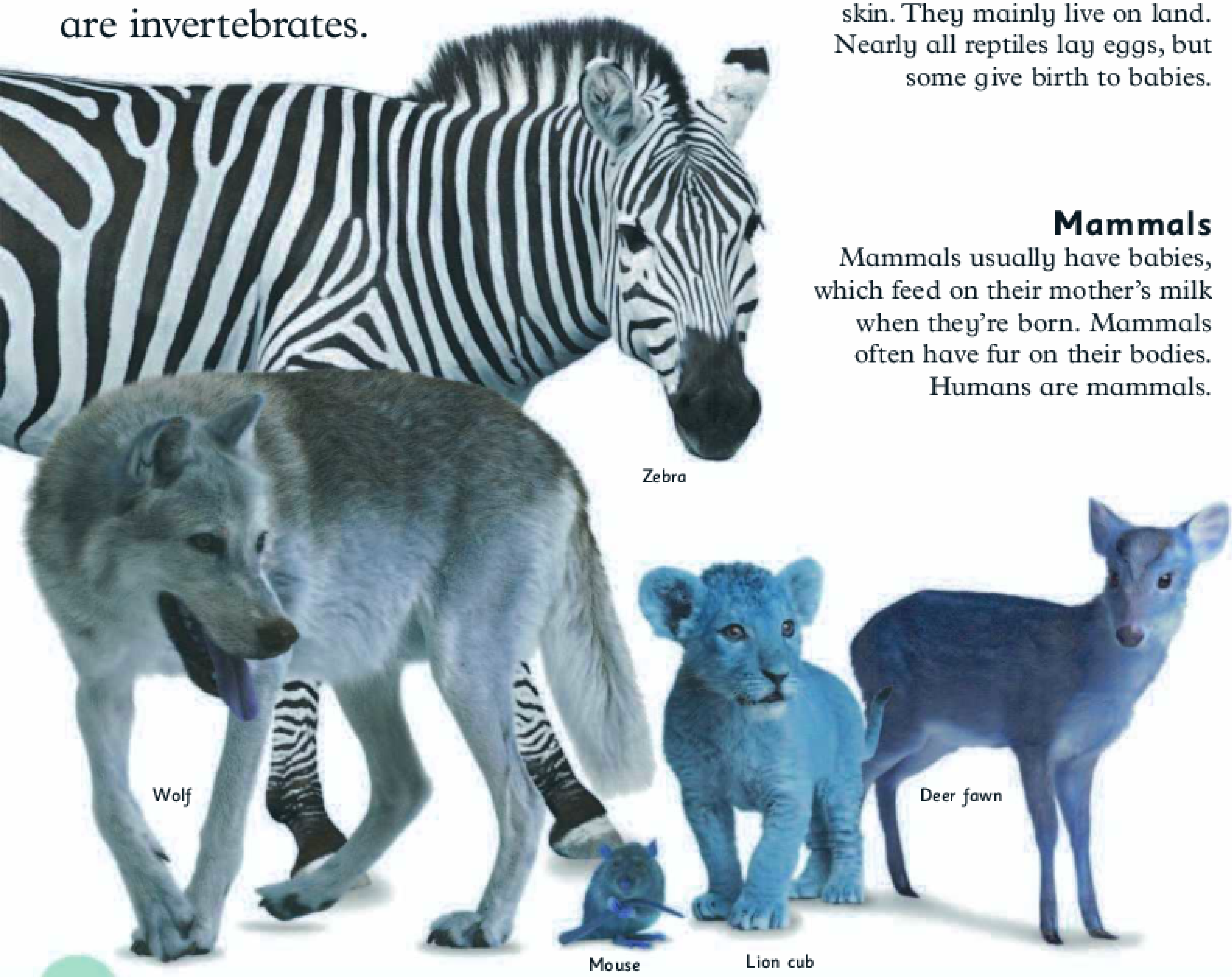
There are many different types, or species, of animal. Scientists put them in groups based on their similar characteristics. Mammals, birds, reptiles, amphibians, and fish are vertebrates. Creepy-crawlies are invertebrates.

Reptiles

Most reptiles have dry, scaly skin. They mainly live on land. Nearly all reptiles lay eggs, but some give birth to babies.

Mammals

Mammals usually have babies, which feed on their mother's milk when they're born. Mammals often have fur on their bodies. Humans are mammals.



Which is the only mammal that can fly?


Parrot

Birds

All birds have wings, and most (but not all) can fly. They have feathers and a beak. Baby birds hatch from eggs.


Ostriches can run fast but can't fly.

Spineless creatures

Animals without backbones are called invertebrates. There are several types of invertebrate.


Insects, spiders, and **crustaceans** are part of the largest animal group.


Snails and **slugs** are part of an invertebrate group called gastropods.


Worms have long, soft bodies and no legs. They like damp areas.


Jellyfish, starfish, and **sponges** are invertebrates that live in water.


Octopus and **squid** live in the ocean. They have eight arms.

Amphibians

Amphibians live both in water and on land. They usually have slimy skin. Baby amphibians hatch from jellylike eggs.


Frog


Salamander

Fish

Fish need to live in water. They breathe through gills and most are covered in scales. Fish use their fins to move through water.


Butterfly


Ladybug

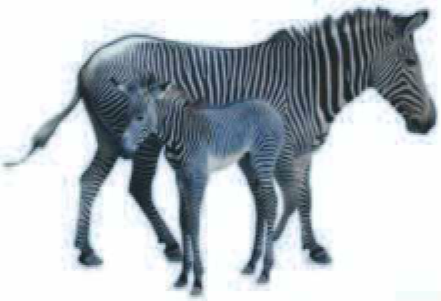
Insects

There are more types of insect on the Earth than any other animal. There are species of insects living almost everywhere. They have six legs and bodies with three sections.

Animal reproduction

Every kind of animal has young—this is called reproduction. Usually, it happens after males and females mate.

A mother macaque holding her baby



Zebra mother and baby

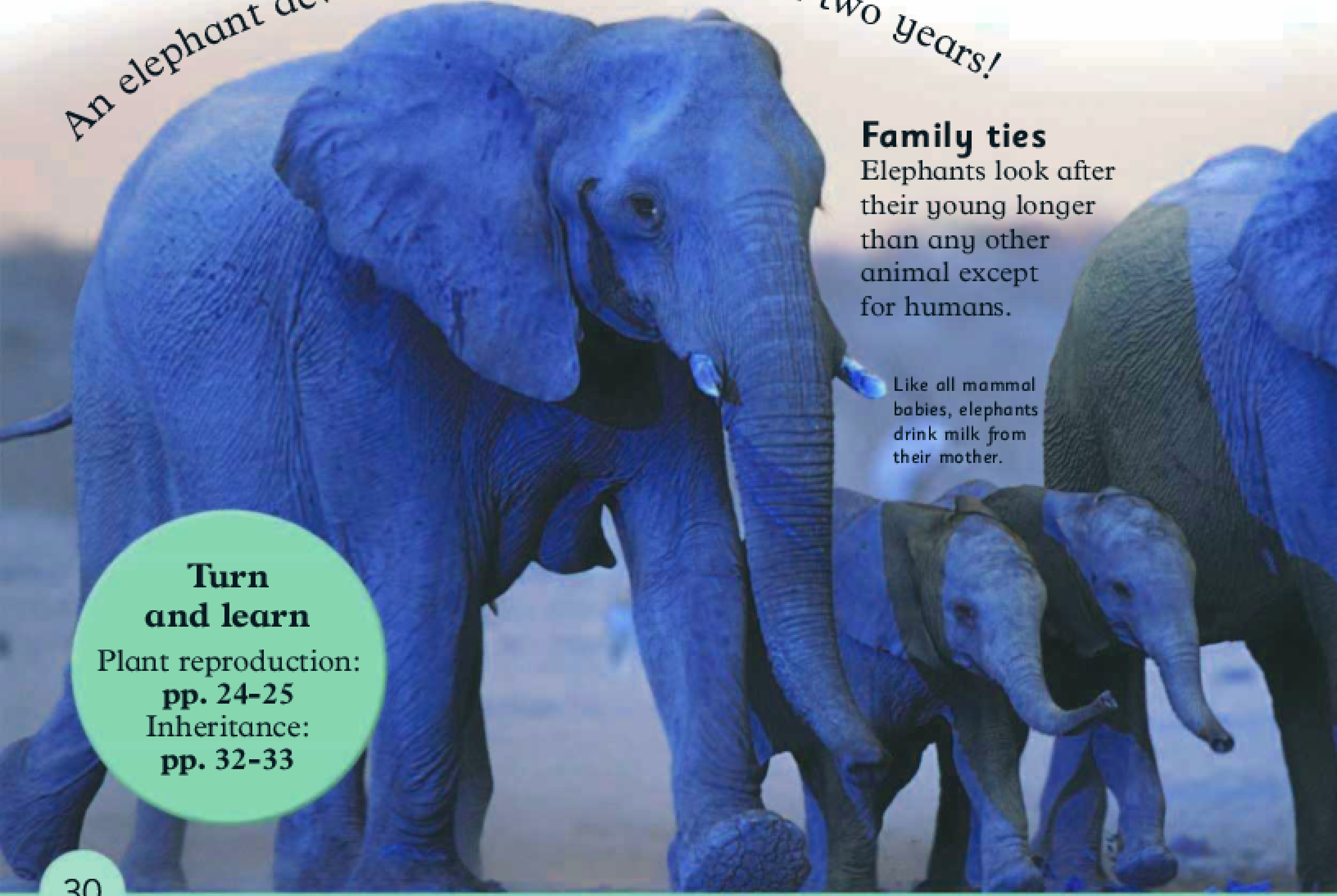
Mammal reproduction

After animals mate, egg cells develop inside the mother. With mammals, the eggs develop fully into babies before the mother gives birth.

Helpless creatures

Monkeys and apes need years of nurturing before they can look after themselves.

An elephant develops inside its mother for two years!



Family ties

Elephants look after their young longer than any other animal except for humans.

Like all mammal babies, elephants drink milk from their mother.

Turn and learn

Plant reproduction: **pp. 24-25**
Inheritance: **pp. 32-33**

Which animal lays the largest egg?

Babies from eggs

Most birds, fish, insects, and reptiles lay eggs. The number of eggs they lay can range from one to millions!

A baby crocodile hatching from its egg

Young and free

Once hatched in the sand, baby turtles have to find their own way into the sea.

Change and grow

Some animals, like butterflies, change enormously during their life cycle.

A butterfly begins its life as an **egg**, which hatches into a tiny caterpillar.

The **caterpillar** attaches itself to a twig and forms a hard outer shell.

Inside the shell, the caterpillar **changes** and grows.

The **shell**, which is often camouflaged, eventually splits open.

A **butterfly** emerges. This process is known as metamorphosis.

Pouch babies

A female kangaroo has a pouch on its belly. After it's born, the tiny baby crawls into the pouch, where it stays for around three more months, feeding and growing.

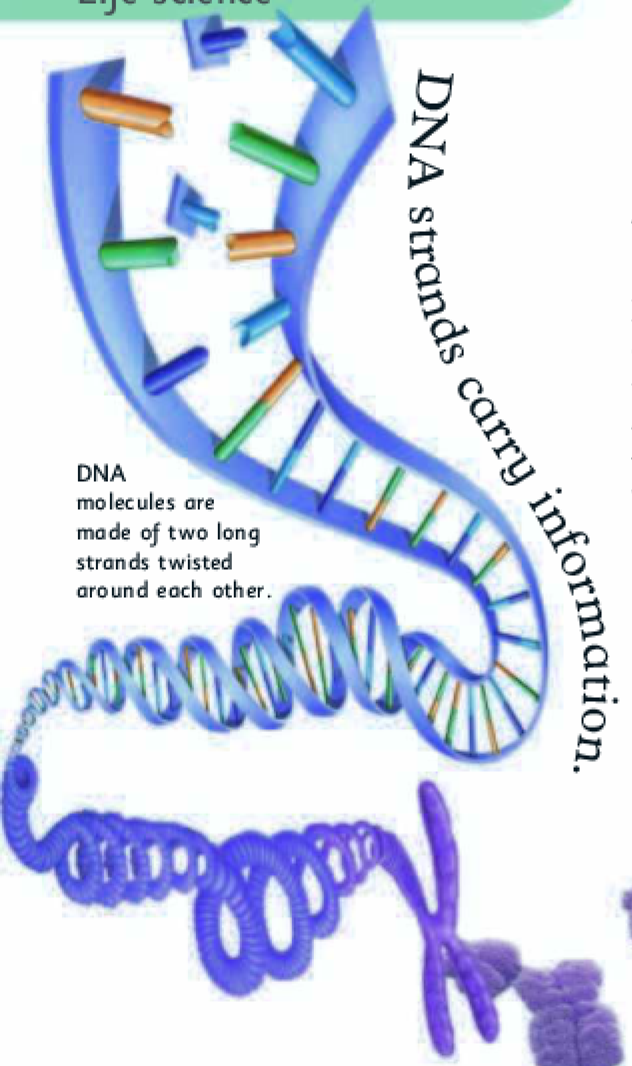
Family ties

Female elephants stay with their family their whole lives. Males leave when they are around 13 years old.

Male emperor penguins look after the young while the females search for food.

Inheritance

Your genes are a set of chemical instructions for building someone just like you. You inherit them from your parents, which is why you are like them in many ways. But unless you are a twin, your genes are unique.

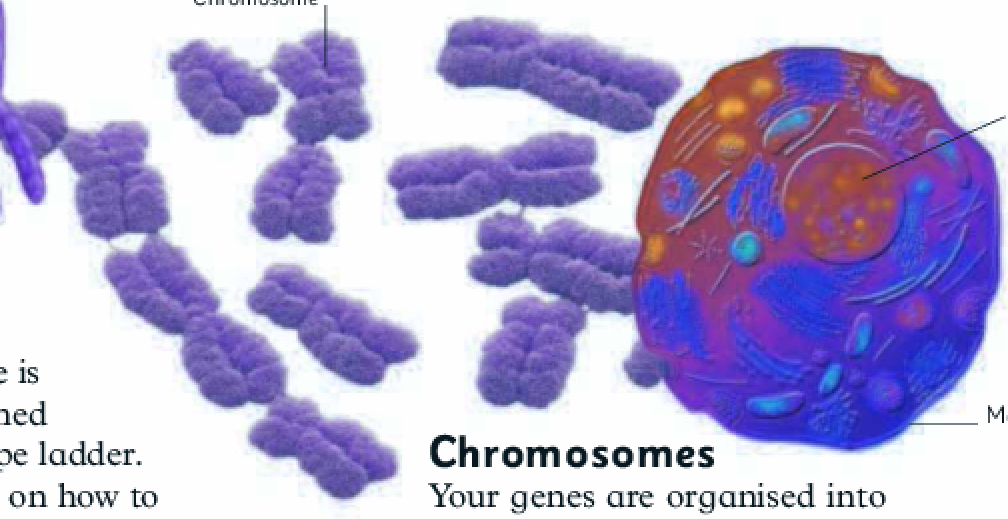


DNA strands carry information.

DNA molecules are made of two long strands twisted around each other.

Tiny cells

Cells are the building blocks that make up all living things. Each cell in your body contains a complete set of genes—the information to make you as you are.



Amazing DNA

DNA is made of long molecules. Each molecule is made up of two parts joined together like a twisted rope ladder. DNA carries instructions on how to make cells work, and how different types of cells develop and join together to build a living thing, such as a plant or animal.

Chromosomes

Your genes are organised into 46 chromosomes, arranged in 23 pairs. Genes and chromosomes are made from the chemical called DNA.

What is a gene?

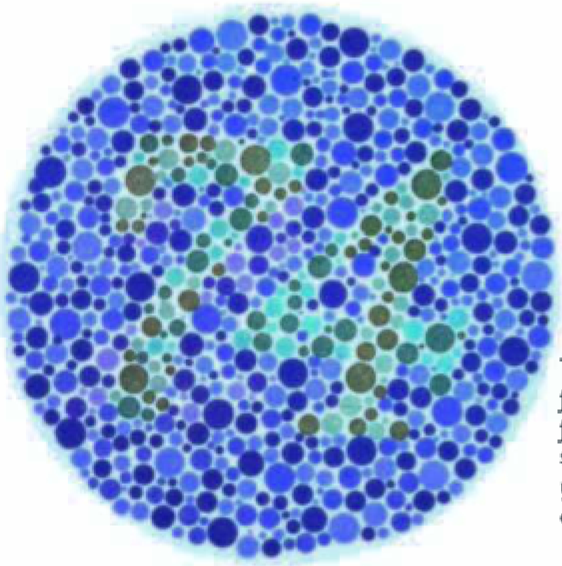
Every cell in your body contains a set of about 20,000 genes. All living things pass on their genes to their offspring. Sexual reproduction combines two sets of genes. You've got two of each gene, one from your mother and one from your father. Sometimes the gene from your mother comes into action, and other times your father's gene wins out.

You can only roll your tongue if the right genes are active.

What does DNA stand for?

Color blindness

Some people have a gene that causes them to be color blind. Look at the circle below. If you can see the number inside then you aren't color blind.



Test your family and friends to see if anyone you know is color blind.

Seeing double

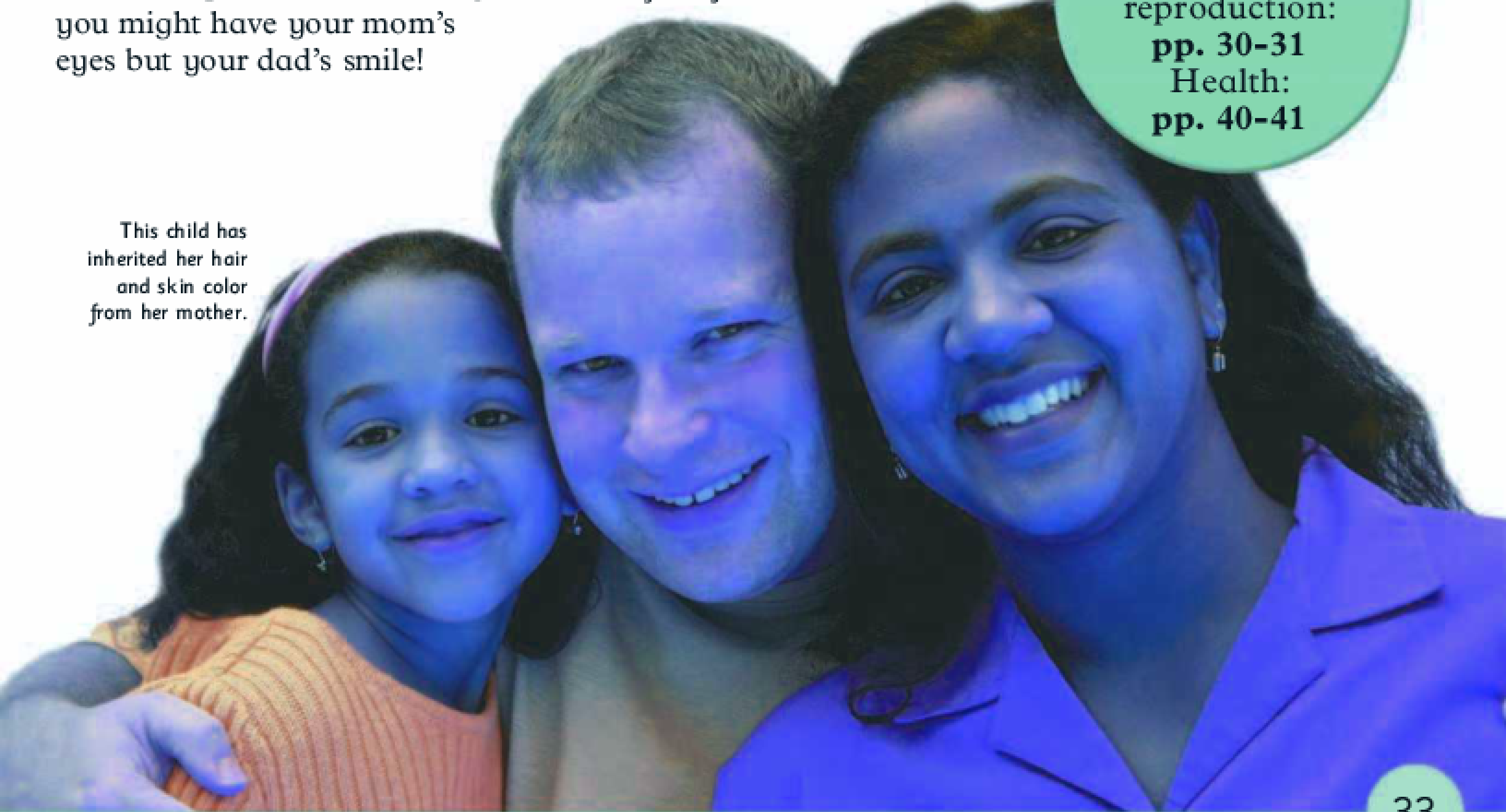
Identical twins share most of their genes. A quarter of these are mirror twins, which means that they are a mirror image of each other. For example, they might have an identical mole, but on the opposite arm to each other.

Turn and learn
Animal reproduction: **pp. 30–31**
Health: **pp. 40–41**

Who do you look like?

Children have a mixture of genes from their parents. This is why you might have your mom's eyes but your dad's smile!

The chromosomes of your father determine whether you are a boy or a girl.

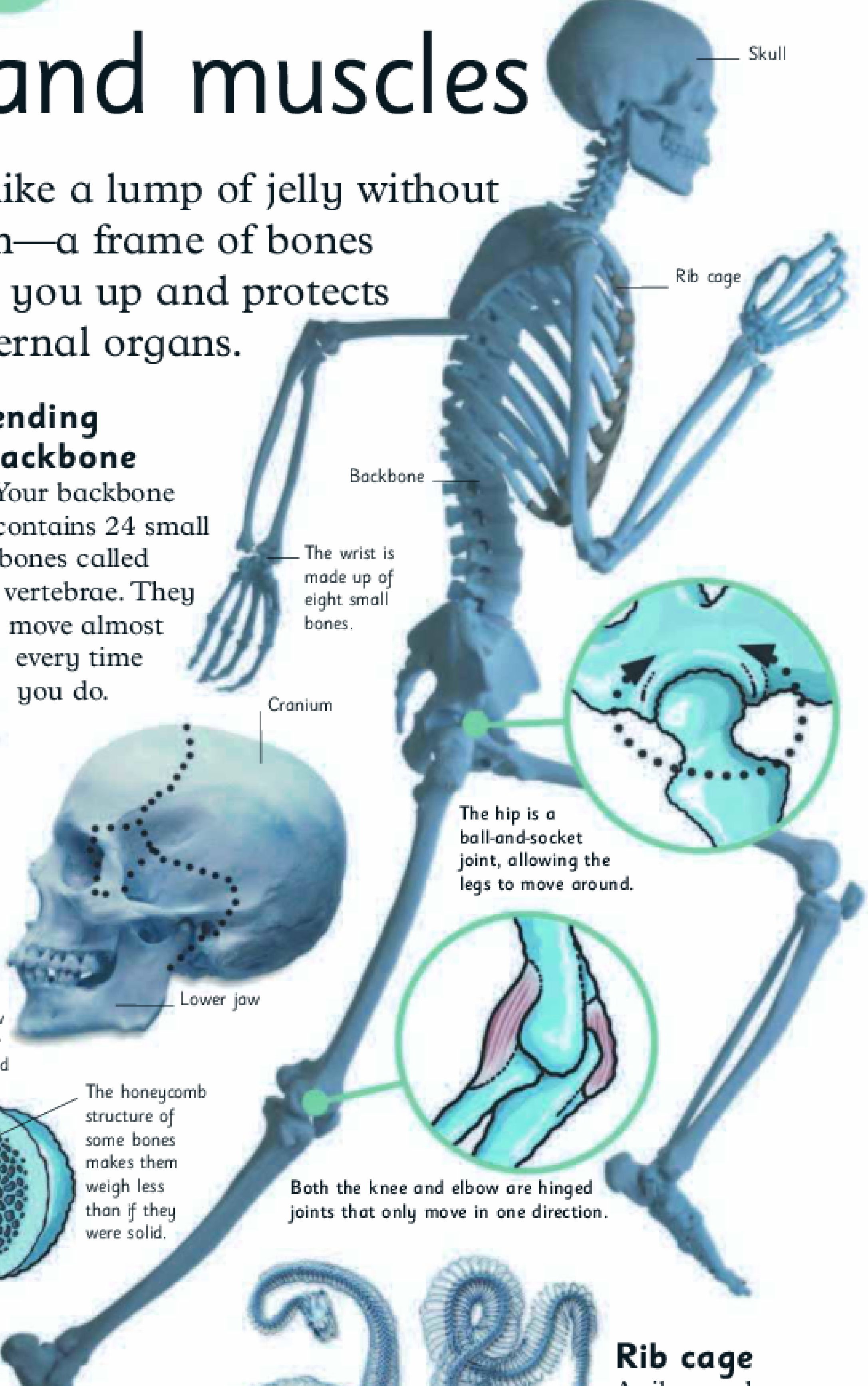


This child has inherited her hair and skin color from her mother.

Deoxyribonucleic acid.

Bones and muscles

You would be like a lump of jelly without your skeleton—a frame of bones that holds you up and protects your internal organs.



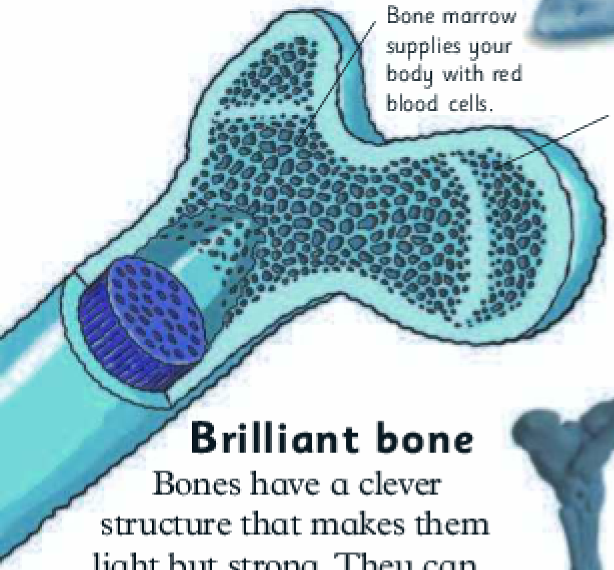
Bending backbone

Your backbone contains 24 small bones called vertebrae. They move almost every time you do.

The vertebrae in your back allow you to twist and bend.

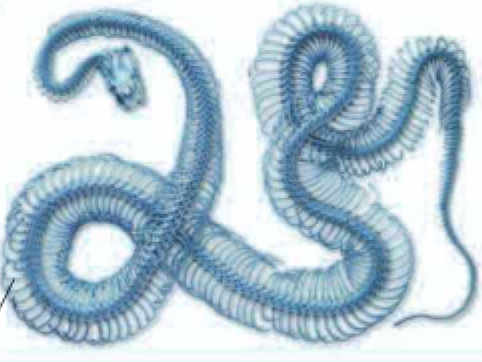
Head case

The bones that make up your skull join after you are born. The skull has two parts—the lower jaw and cranium. Only your jaw can move.



Brilliant bone

Bones have a clever structure that makes them light but strong. They can heal themselves if broken.



Snake rib cages can run almost the entire length of their bodies.

Rib cage

A rib cage has long, curved bones that protect vital organs such as the heart and lungs.

How many bones does an adult human have?

Bending bits

Different kinds of joints all over your body keep you moving.

Fingers and **thumbs** have joints that allow them to move in many ways.

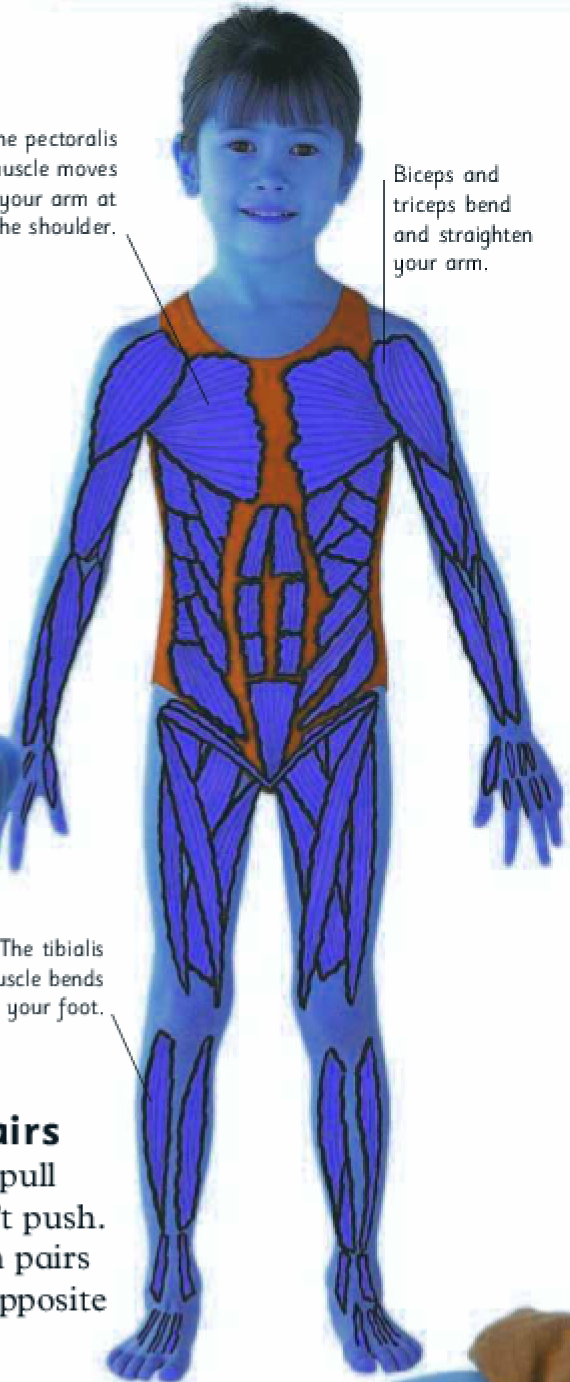
Ankles contain different joints for up-and-down and side-to-side movement.

Wrists have a joint that allows them to turn but not go all the way around.

Neck bones feature a pivot joint that allows your head to turn.

Muscle magic

Muscles are rubbery, stretchy straps. You can control some of your muscles, like the muscles in your arms and legs. Others, such as your heart and bladder, operate without you having to think about it.

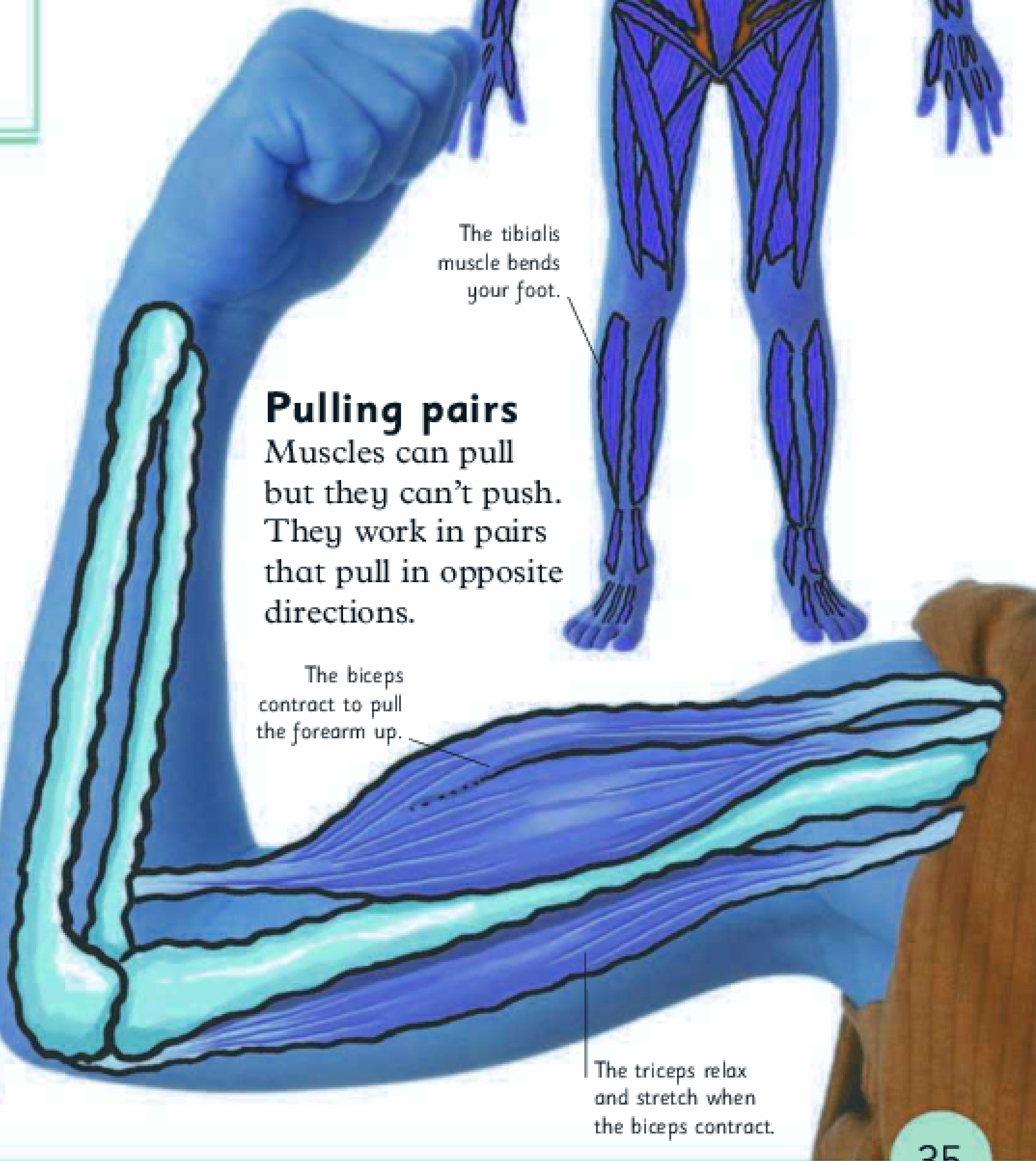


Making faces

Muscles in your face are attached to skin as well as bone. They allow you to make all kinds of expressions to show how you are feeling.

Pulling pairs

Muscles can pull but they can't push. They work in pairs that pull in opposite directions.



There are 206 bones in an adult skeleton.

Blood and breathing

Every few seconds you breathe in air. Inside your lungs, oxygen from the air passes into your blood, which carries the oxygen all around your body.

Liquid of life

Blood is made up of three types of cells floating in plasma.

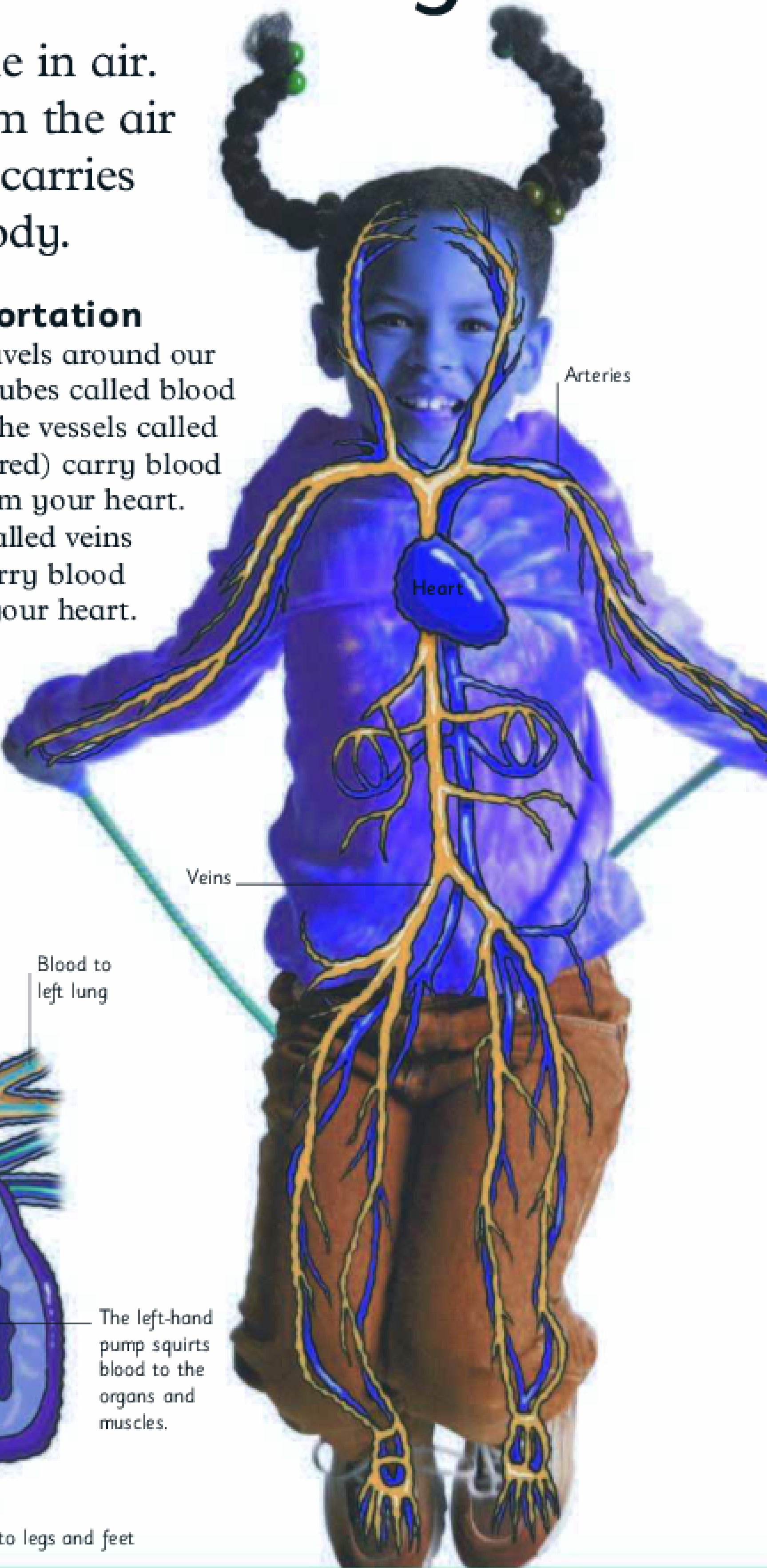
Red blood cells, the most common type of blood cell, carry oxygen.

White blood cells, which are part of the immune system, fight disease.

Platelets help to repair broken skin and blood vessels.

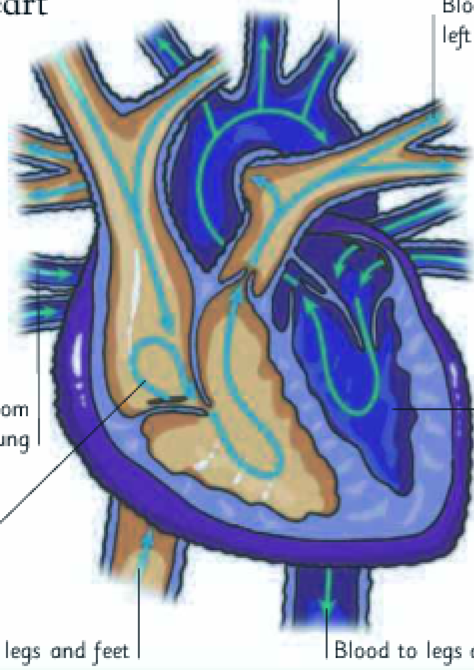
Transportation

Blood travels around our body in tubes called blood vessels. The vessels called arteries (red) carry blood away from your heart. Vessels called veins (blue) carry blood back to your heart.



Your beating heart

Every time your heart beats, it pumps blood around your body. Half of the heart sends blood through your lungs. The other half sends blood around the rest of your body.



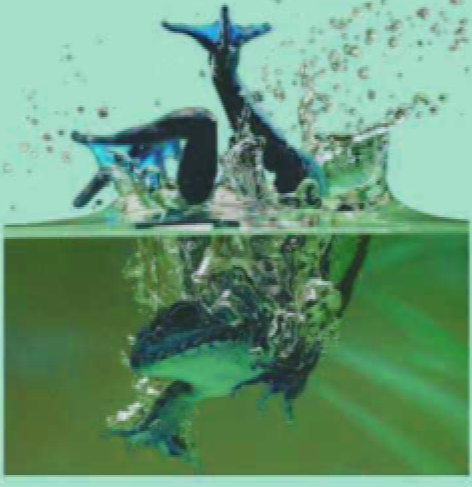
How many times does a child's heart beat every day?

Lungs

Your lungs fill most of the space inside your rib cage. They take in oxygen from the air and send out waste carbon dioxide.

No lungs

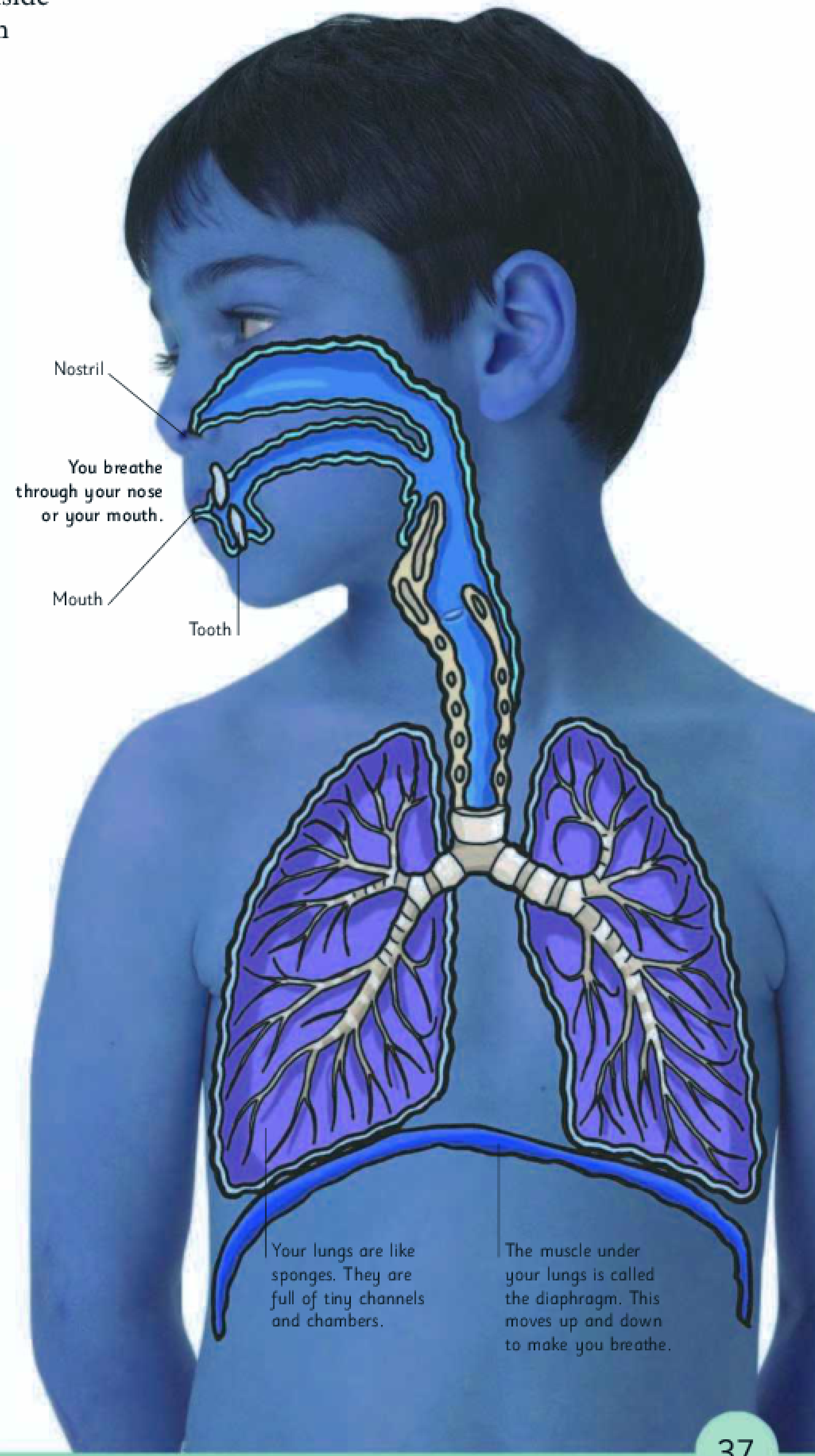
Not every animal has lungs. There are other ways animals breathe.



Frogs can absorb oxygen through their skin—even underwater.

Insects such as caterpillars breathe through body openings called spiracles.

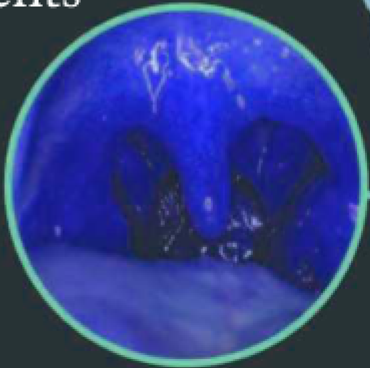
Many sea creatures, such as sharks, breathe through gills.

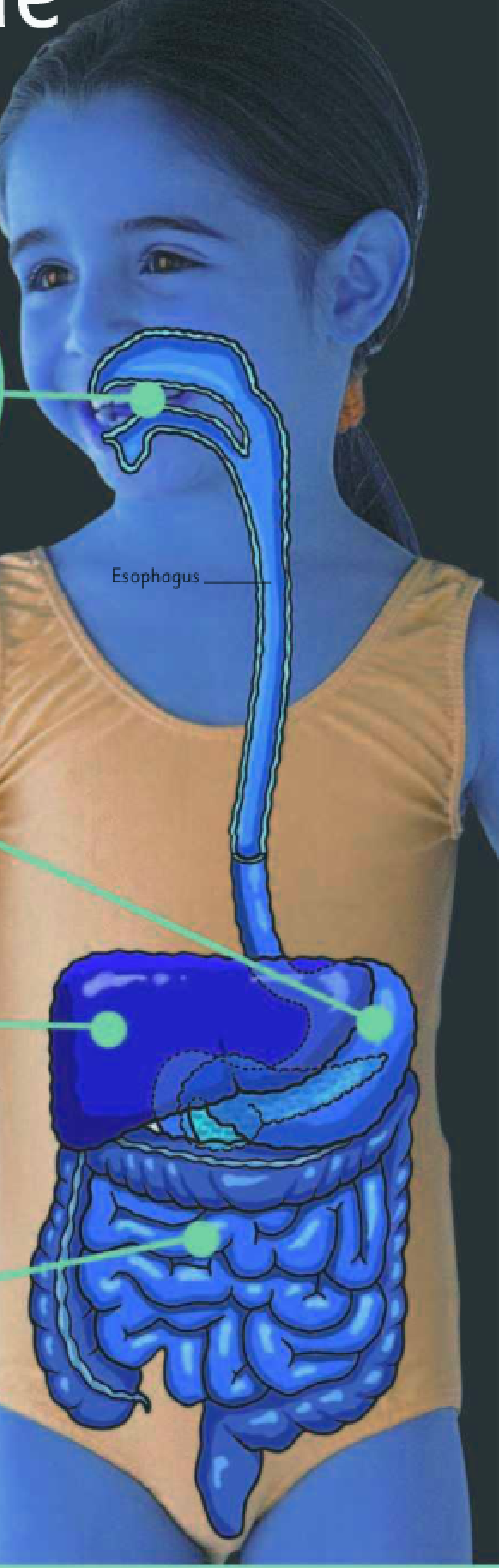


A child's heart beats between 130,000 and 170,000 times a day.

The digestion ride

Take a ride down your digestive system as it breaks down your food to take out the nutrients and get rid of waste.



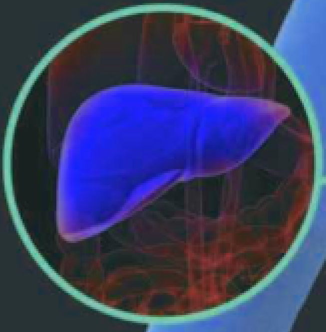


Mouth

First stop is the mouth. Saliva moistens the food to make it easier to chew and swallow. Food then heads down the esophagus to your stomach.

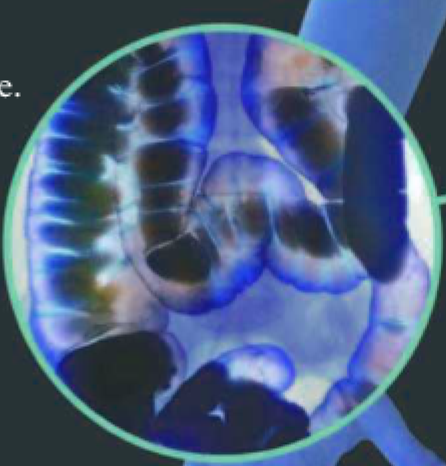
Stomach

In your stomach, muscles churn the food around. Stomach acids help turn it a semi-liquid before it is squirted into the intestines.



Liver

Your liver stores some vitamins and a sugar called glucose, which gives you energy.



Intestines

Your intestines are a long, tangled tube. The small intestine absorbs food into your bloodstream. The large intestine deals with undigested leftovers.

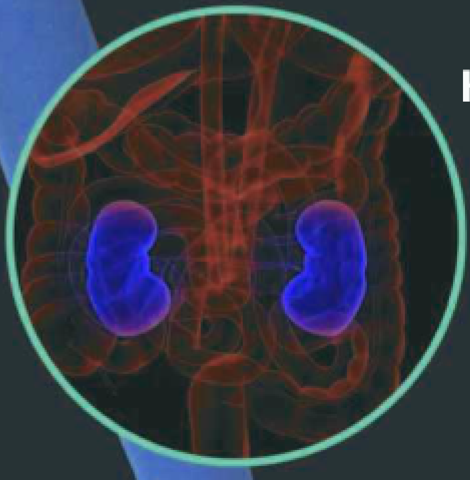
Which is longer: your small intestine or your large intestine?

Super system

Cows have an amazing digestive system. There are four parts to a cow's stomach. Each one performs a different function to make sure food is digested and used in the most efficient way. Cows need this system to help them digest tough grass.

Stone eaters

Some birds eat grit. The tiny stones help digestion by breaking down food in the bird's stomach.



Kidneys

Your kidneys filter and clean your blood, taking out the chemicals that your body doesn't need. Kidneys also control the amount of water in your blood.

Waste disposal

Solid waste from the large intestine is stored in the rectum, and urine is stored in the bladder, until you are ready to go to the toilet.

Food for health

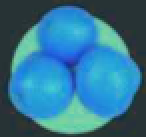
You need to eat a variety of foods to keep your body working efficiently. A good diet includes a balance of food from each of the five food groups.

Carbohydrates, found in food such as bread, cereal, and potatoes.

Fats, which can be found in food such as oils. Fats give you energy.

Proteins, which can be found in eggs, fish, meat, dairy products, and nuts.

Minerals such as iron and calcium. Iron is found in some green vegetables.



Vitamins such as vitamin C are found in fresh fruits and vegetables.

weird or what?

Humans taste with their tongues—but other animals have different methods. Butterflies use their feet!

Your small intestine.

Health

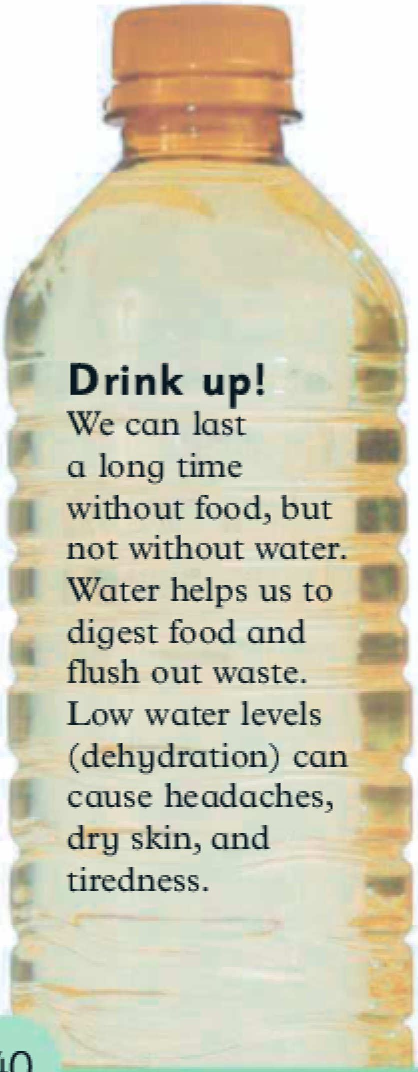
5-a-day

You need to eat at least five portions of fruits and vegetables each day.

Our way of life affects our health. Eating properly, exercising regularly, and getting enough sleep are all important for staying happy and fit.

A balanced diet

It is vital to eat a balance of the right foods. There are five major food groups and they all help your body in different ways.



Drink up!

We can last a long time without food, but not without water. Water helps us to digest food and flush out waste. Low water levels (dehydration) can cause headaches, dry skin, and tiredness.

You need to drink water frequently each day or you will dehydrate.

Which vitamin do we get from sunlight?

Ideally, children should be getting about 60 minutes of exercise a day.

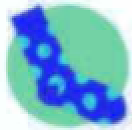
Swimming is a good way of exercising all your muscles.

Keeping clean

Dirt contains harmful bacteria. Keeping clean helps you stay healthy.

Brush your teeth three times a day, after each meal.

Wash off the dirt with regular baths or showers.



Wear clean clothes, especially clean pants and socks, every day.

Exercise

Exercise strengthens the muscles and heart and encourages the production of special chemicals called endorphins. These make us feel good and act to reduce pain.

Carbohydrates

Foods in this group include bread, pasta, and potatoes. Carbohydrates provide your body energy. They should make up just over a third of your diet.

Many children go to sleep more easily with a special, stuffed toy.

Read a book!

Health is not just about your body; it's important to have an active mind. Reading is a good activity because it stimulates your brain.

Sleep

When you sleep, your body rests and your mind refreshes itself. When you are young, you need a lot of sleep, but you need less as you get older.

A child needs between 10 and 12 hours sleep a night.

Turn and learn

Muscles: **pp. 34–35**

Digestion: **pp. 38–39**

Vitamin D, which is important for strong bones.

Food chains

Everything in the living world needs food to survive. And everything must feed on something else. This is called a food chain. Each species is part of several different food chains.

5 Decomposers

At the start and end of every food chain there are decomposers, such as earthworms, fungi, and dung beetles. They help break down dead animals and plants, releasing the nutrients back into the soil.

1 Producers

Plants, such as acacia trees and grasses, get their energy from the Sun. They are known as producers.

2 Herbivores

Herbivores, such as impala or zebra, eat the plants. They do not eat meat.

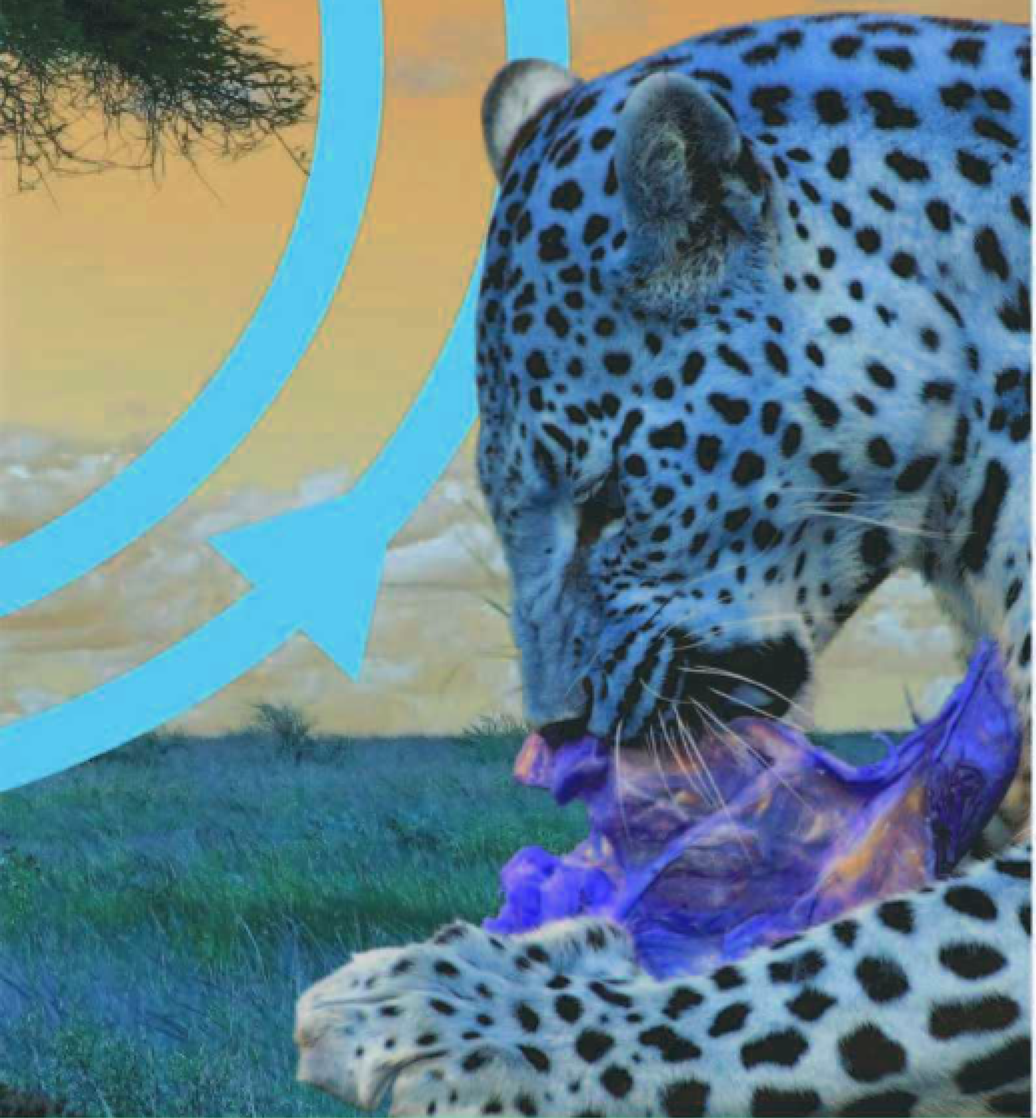
What carnivorous plant catches and eats flies and spiders?

4 Scavengers

Dead meat is known as carrion and is eaten by scavengers such as hyenas, vultures, and bald eagles. These creatures rarely kill for food—they find animals that have died of natural causes and eat other animals' leftovers.

3 Carnivores

Carnivores only eat meat. On the African plains, carnivores include lions, leopards, and cheetahs.



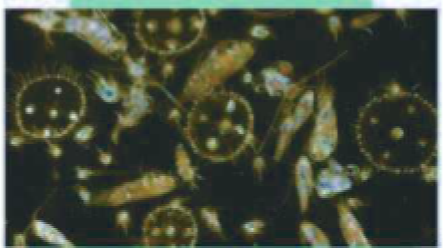
Sea food

The farther you go up the chain, the fewer animals there are. So, in the sea, there are countless plankton, fewer fish, just a few seals, and still fewer polar bears.

Polar bear

Seals

Fish



Zooplankton

Phytoplankton

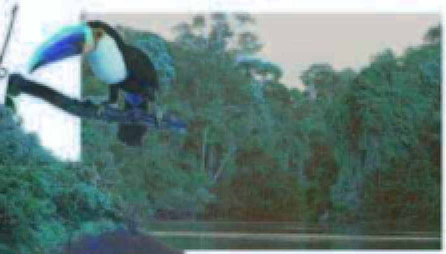
A Venus flytrap.

Ecosystems

All over the world, living things exist in distinct kinds of places called ecosystems. Each has its own climate, soil, and complex community of plants and animals. Oceans and deserts have their own ecosystems.

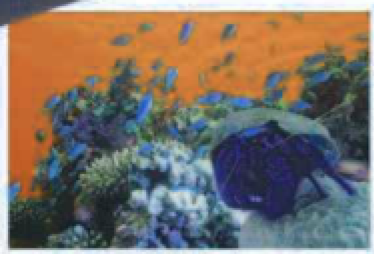
Natural variety

There are different ecosystems all over the world, and the animals and plants in each one are adapted to its conditions.



Forests

Wherever there is enough rain, forests grow, and they provide homes for a huge range of plants and animals.



Oceans

More than 70 percent of the Earth's surface is covered by oceans, which contain many different habitats.

Rivers and lakes

Freshwater ecosystems exist in pools, lakes, rivers, and streams. They are found over most of the world's land surface.

Polar and tundra

The freezing polar lands are at the far north and south of the Earth, in the Arctic and Antarctic. At the edges farthest away from the poles, they merge into warmer tundra areas.

Homes, sweet homes

One ecosystem contains a number of habitats. A habitat is the natural home of a particular plant or animal. A tree, or even a leaf, can be a habitat.

Turn and learn

Animal survival: **pp. 46–47**
The carbon cycle: **pp. 50–51**

What are the different types of forest ecosystem?

Mountains

Climate conditions change as you go up a mountain, so different ecosystems can exist here.

Seashores

Seashore ecosystems are half land and half sea. They change as the tide comes in and out.

Grasslands

Humans evolved in grassland habitats. Today, the largest and fastest land animals live here.

Deserts

They can be hot or cold, but deserts are always dry, with little rain. Only a few animals and plants survive here.

Living together

A group of living things in a habitat is called a community. Each one contains plants, animals, and other organisms that all rely on each other.

Tropical rainforests, deciduous woodlands, and cold, coniferous forests.

Staying alive

All animals and plants need food, water, shelter, and space to survive. Each type of animal or plant has its own particular way of finding them.

Camouflage

On the grasslands of Africa, lions try to creep up on their prey. They can hide in the long grass because they are the same color. This is called camouflage.

Let's stick together

Clown fish and sea anemones live together and help each other (symbiosis). The sea anemone's tentacles can sting most fish, but the clown fish don't get hurt.

Long-eared bat eating a moth

Night hunter

Some animals hunt for food at night. The long-eared bat uses sound to find insects in the dark. It makes a squeaking noise and listens to the echo as the noise bounces back off objects. It can tell exactly where an insect is.

A huge worm is enough food to keep a shrew going for only a few hours.

All-day hunter

Some animals have to hunt for food day and night. Shrews need to eat 80 to 90 percent of their body weight every day to survive. These animals are tiny, but aggressive.

A tapeworm is a kind of parasite. Where does it live?

The tiny Arctic tern makes a long migration. It flies between the North and South poles each year.

A wasp has laid eggs on this caterpillar. The grubs that hatch will feed on the caterpillar as parasites.

Parasites

Some organisms, called parasites, live on or inside the bodies of other organisms, which they feed on. Caterpillars live as parasites on plants.

Great travelers

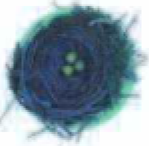
When food and water become scarce in one place or the weather gets too cold, animals may move home (migrate). Some animals migrate once every year.

Pack of wolves

Wolves live and hunt in groups called packs. This is safer than living alone and makes it easier to hunt larger animals.

House builders

Many animals build homes for themselves to provide shelter from predators and bad weather.



Birds make nests out of mud or twigs, often hidden away in trees or bushes.

Rabbits and **badgers** use burrows dug into the soil.

Beavers pile up sticks in rivers to make a nest with an underwater entrance.

Wasps chew up wood to make soggy paper, which they then shape into nests.

An elephant eats for about 16 hours each day.

Big hunger

Elephants have big appetites. A hungry elephant will push over a whole tree and eat every leaf and twig to satisfy its hunger.

The Earth's cycles

Everything in nature is recycled. Living things take in oxygen, nitrogen, carbon, and water and use them to live. When they die and decompose, the substances they are made of are used again.

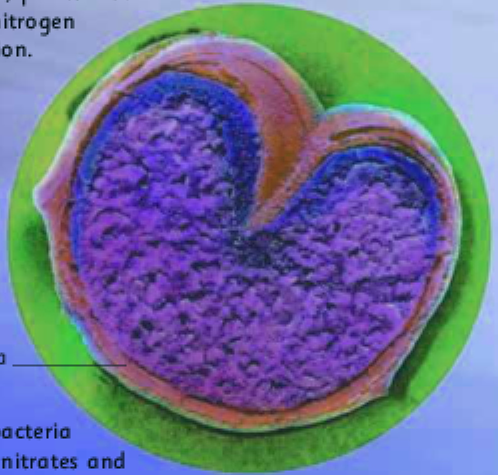
At night, plants take in oxygen and give out carbon dioxide.

Nitrogen cycle

All living things need nitrogen. Plants take in nitrogen from the soil. Animals get nitrogen from eating plants. When animals and plants die, they put nitrogen back into the soil.

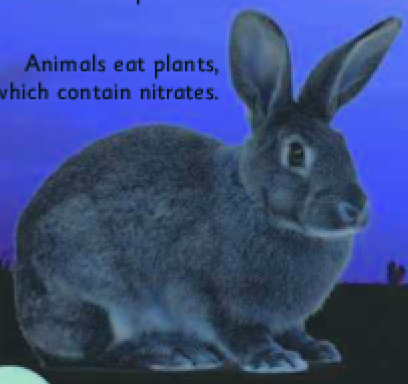
Certain bacteria play an important role in the nitrogen cycle. They change nitrogen into the form plants can use. Without bacteria, plants would die of nitrogen starvation.

Nitrogen is abundant in our atmosphere.



Bacteria

Other bacteria take in nitrates and release nitrogen back into the atmosphere.



Animals eat plants, which contain nitrates.

Decaying animals and plants put nitrogen back into the soil.

Is there more oxygen or nitrogen in our atmosphere?

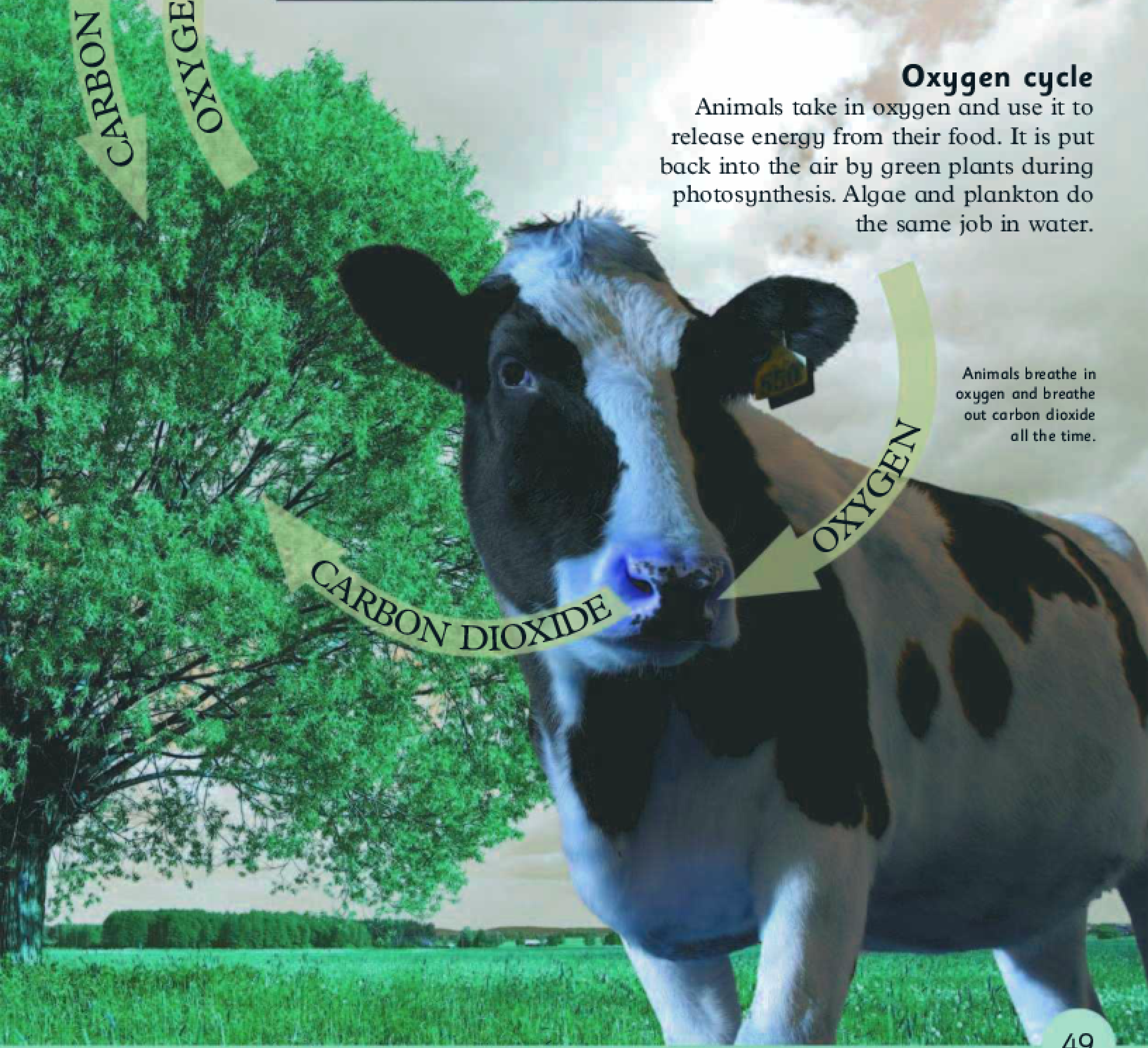
During the day, plants take in carbon dioxide and give out oxygen.

From atmosphere to the Earth

During an electrical storm, some nitrogen is washed out of the atmosphere and falls to the ground. Plants can then draw the nitrogen in through their roots.

Oxygen cycle

Animals take in oxygen and use it to release energy from their food. It is put back into the air by green plants during photosynthesis. Algae and plankton do the same job in water.



Animals breathe in oxygen and breathe out carbon dioxide all the time.

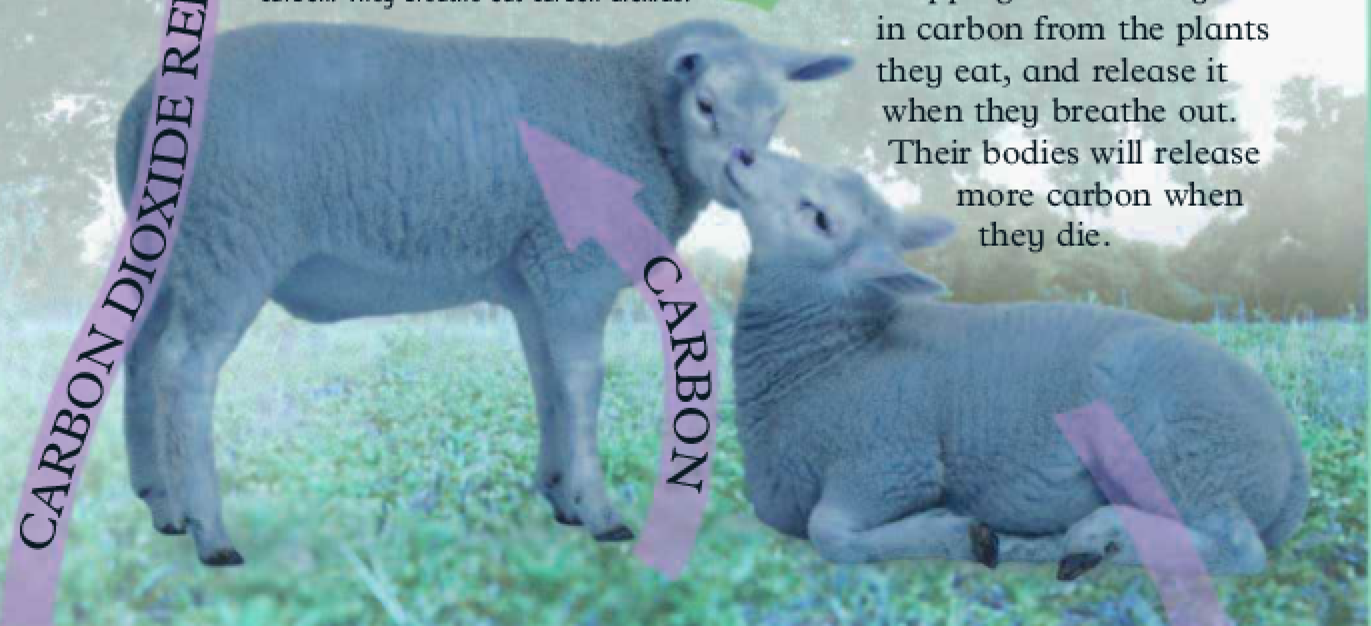
Our atmosphere contains 21 percent oxygen and 78 percent nitrogen.

Carbon cycle

Every living thing contains carbon. Human beings take in carbon through carbohydrates, fats, and proteins in food, and release it as carbon dioxide gas when breathing out. It is also released from dead matter, sometimes quite soon, sometimes millions of years later in fuels such as oil and coal.

Plants take in carbon dioxide from the atmosphere

Animals eat plants and take in some carbon. They breathe out carbon dioxide.



An animal's droppings also contribute to the carbon cycle.

It's in the air

Green plants take in carbon dioxide from the air and use it to make food, converting it into things such as carbohydrates. Animals take in some of the carbon when they eat plants.

Animals

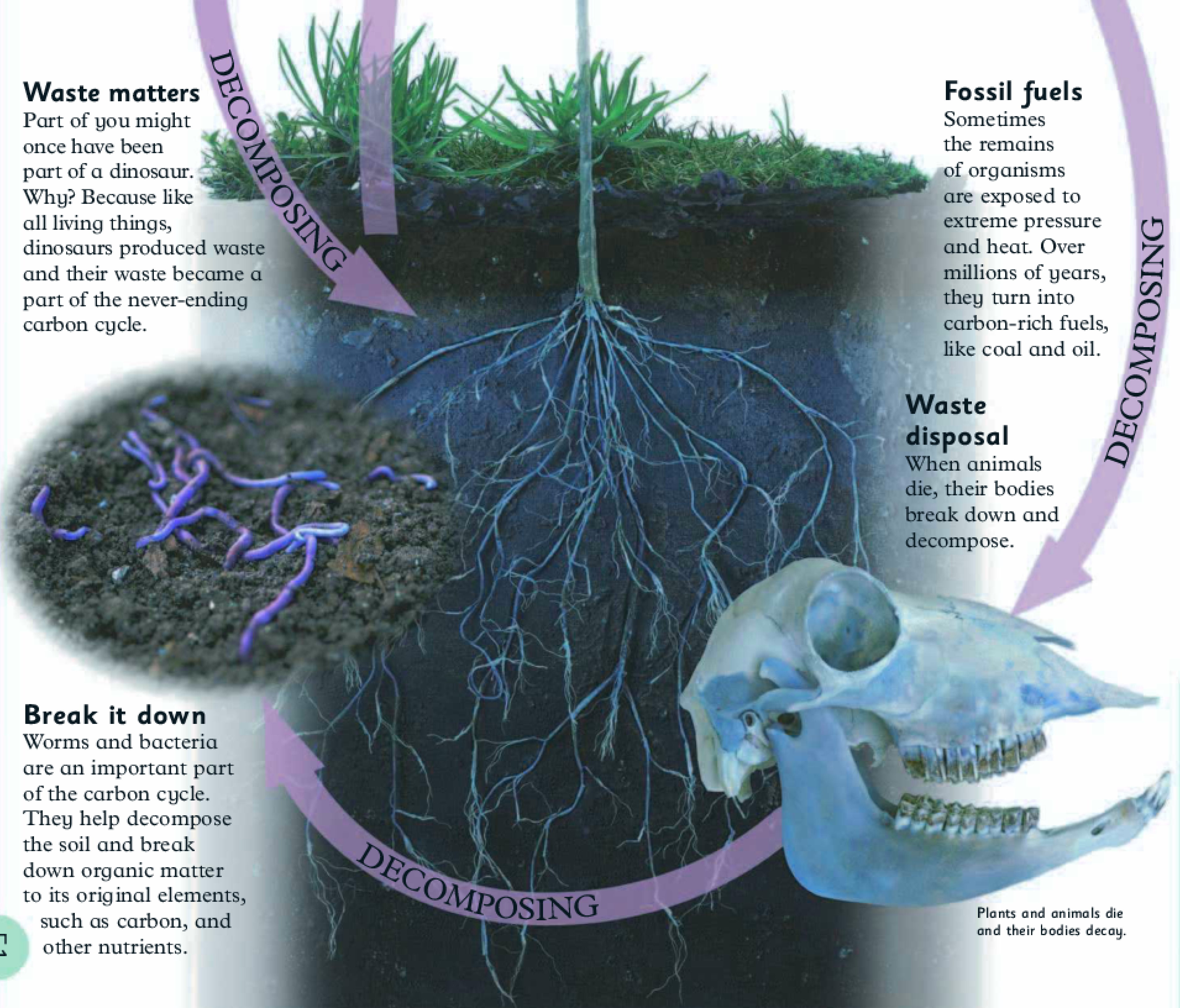
Animals, such as these sheep, contribute to the carbon cycle by eating grass, breathing in air, and dropping waste. They take in carbon from the plants they eat, and release it when they breathe out. Their bodies will release more carbon when they die.

In particular circumstances, carbon forms a hard crystal. What is it called?

Waste matters
Part of you might once have been part of a dinosaur. Why? Because like all living things, dinosaurs produced waste and their waste became a part of the never-ending carbon cycle.

Fossil fuels
Sometimes the remains of organisms are exposed to extreme pressure and heat. Over millions of years, they turn into carbon-rich fuels, like coal and oil.

Waste disposal
When animals die, their bodies break down and decompose.



Plants and animals die and their bodies decay.

Break it down
Worms and bacteria are an important part of the carbon cycle. They help decompose the soil and break down organic matter to its original elements, such as carbon, and other nutrients.

What's the matter?

Everything around you is made of matter, even the things you can't see. But everything looks and acts differently—that's because matter has different forms.

Four states

There are four main states of matter.

Solids have a definite shape. Most of them are hard, such as rocks.

Liquids take on the shape of their container, and have a fixed volume.

Gases have no fixed shape. They fill any space they are in, such as a balloon.

Plasma exists at very high temperatures, like inside the Sun.

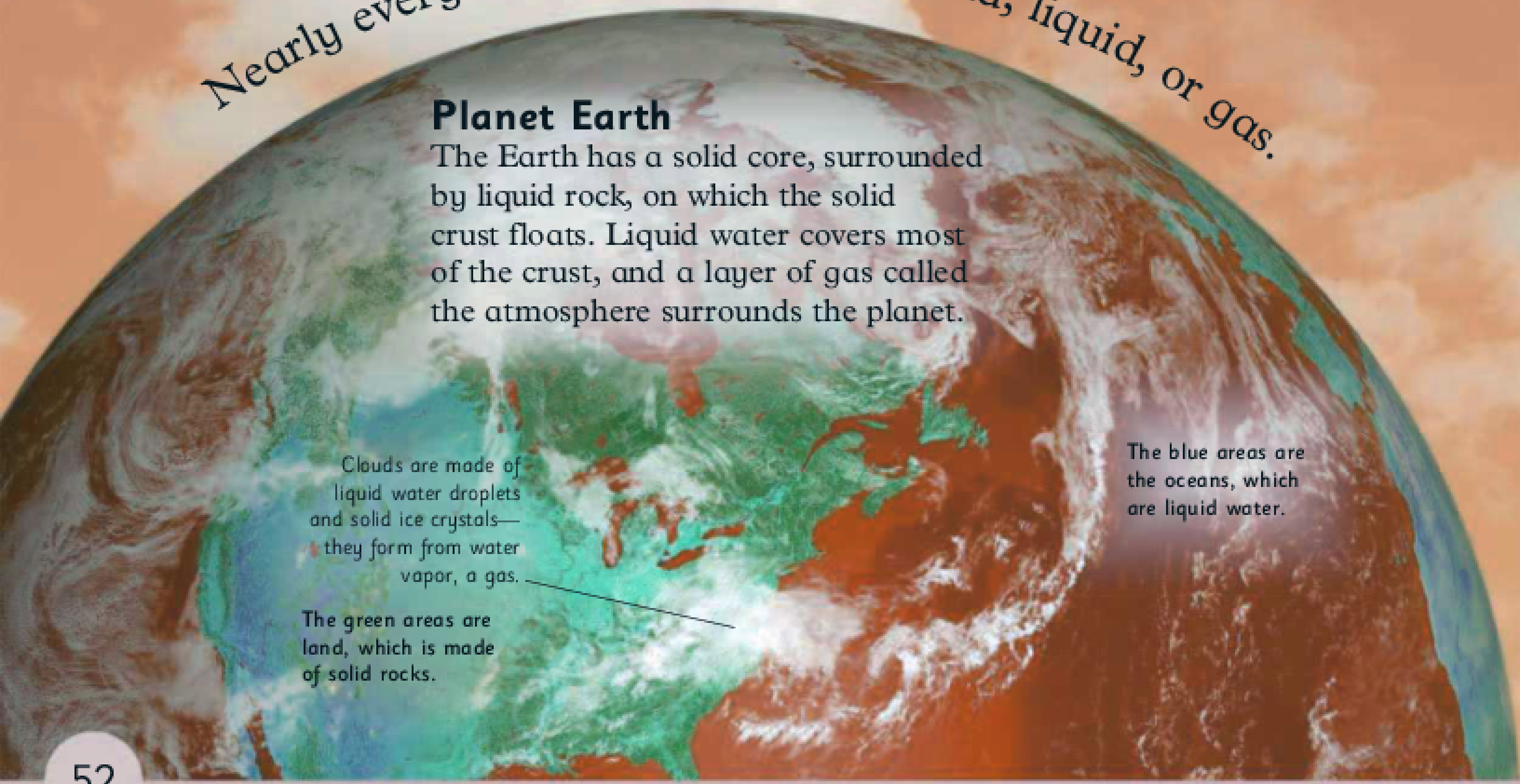
Solid, liquid, or gas

The most common states of matter are solid, liquid, and gas. Each state behaves differently because the particles in their makeup move in different ways.

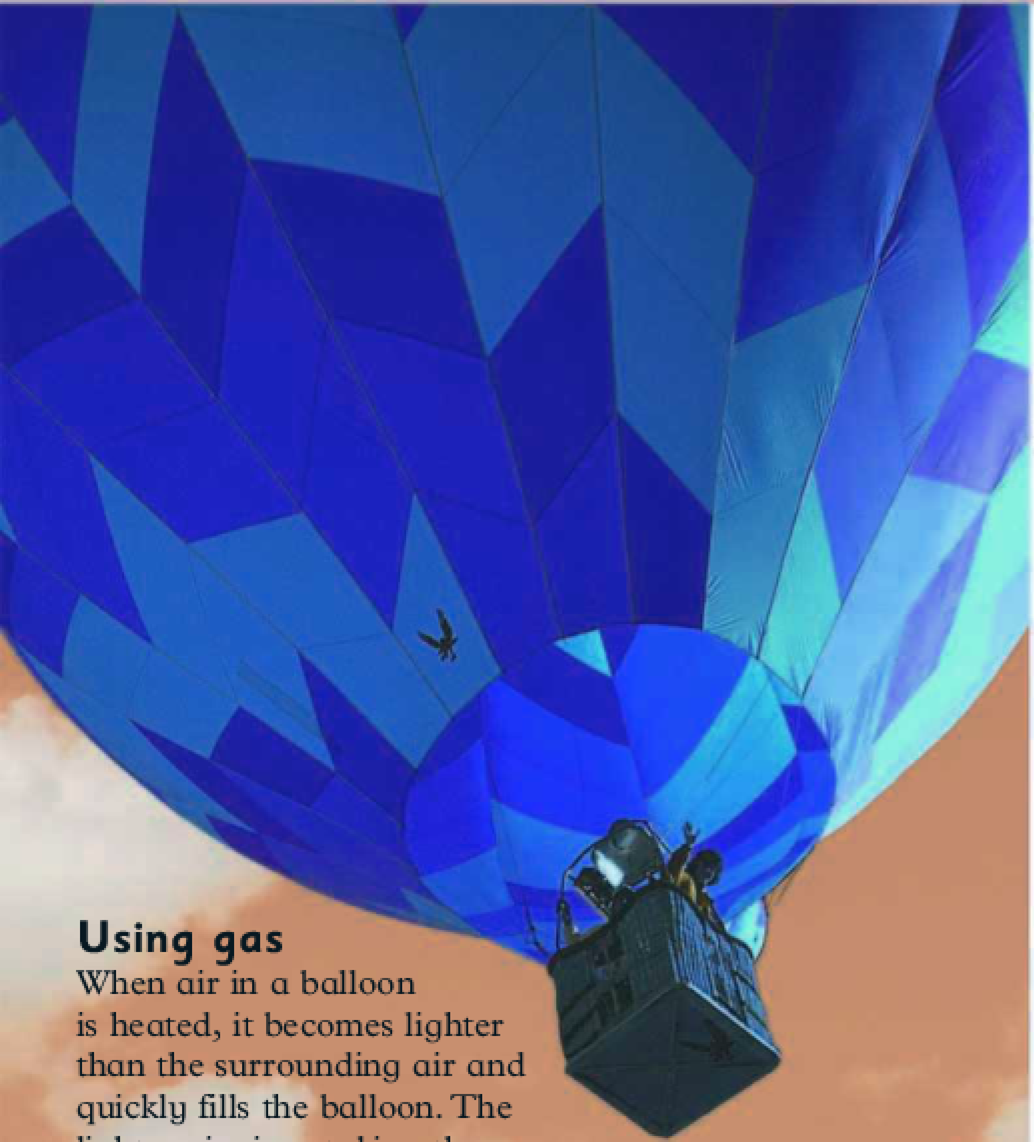
Nearly everything on the Earth is solid, liquid, or gas.

Planet Earth

The Earth has a solid core, surrounded by liquid rock, on which the solid crust floats. Liquid water covers most of the crust, and a layer of gas called the atmosphere surrounds the planet.



Which form of matter are humans?



Using gas

When air in a balloon is heated, it becomes lighter than the surrounding air and quickly fills the balloon. The lighter air rises, taking the balloon and passengers with it.

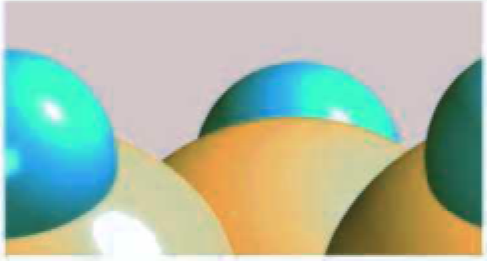
No matter

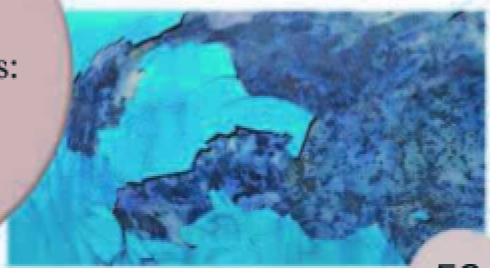
A place with no matter, not even air, is called a vacuum. The closest thing to a vacuum is the space between stars.

Astronauts wear special suits in space because it is very cold and there is no air to breathe.

Picture detective

Look through the Materials Science pages and see if you can identify the picture clues below.





Turn and learn

Amazing atoms: **pp. 58-59**
The universe: **pp. 94-95**

We are three forms, our bones are solid, our blood is liquid, and we breathe in air.

Properties of matter

Main properties

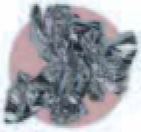
There are many different properties of matter.

Boiling point is the hottest a liquid can get before becoming a gas.

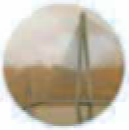
Freezing point is the temperature at which a liquid becomes a solid.

Plasticity is how well a solid can be reshaped.

Conductivity is how well a material lets electricity or heat travel through it.



Malleability is how well a solid can be shaped without breaking.

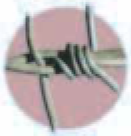


Tensile strength is how much a material can stretch without breaking.

Flammability is how easily and quickly a substance will catch fire.

Reflectivity is how well a material reflects light. Water reflects well.

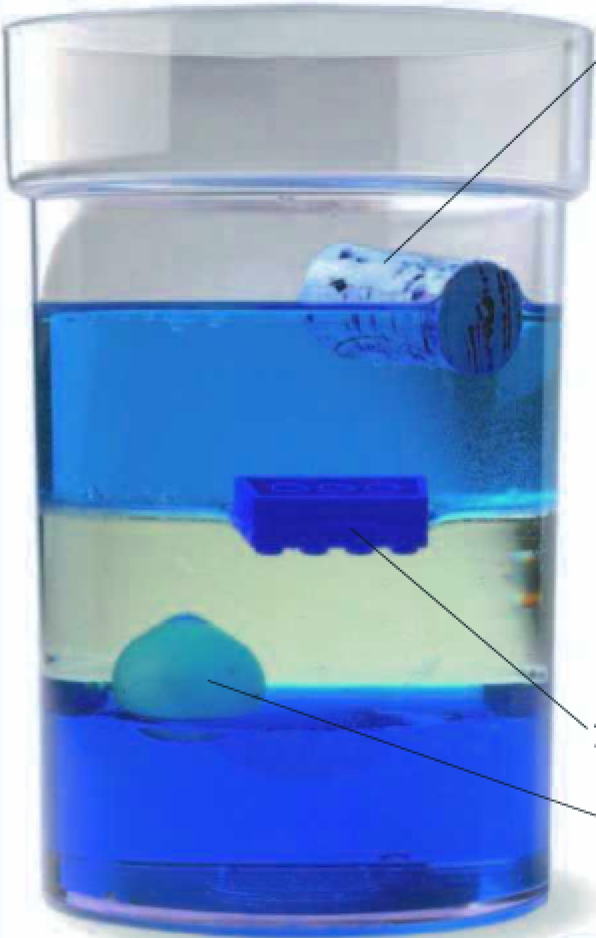
Transparency is how well a material will let light pass through it.



Flexibility is how easily a material can be bent.

Solubility is how well a substance will dissolve, such as salt in water.

Some materials are hard and brittle, while others are flexible. Some materials are colorful, while others are transparent. These kinds of features are called "properties."



A cork floats on oil. Oil floats on water.

A plastic building brick sinks through oil but floats on water.

An onion sinks through oil and water, but floats on syrup. Syrup sinks below water.

Does it float?

It's easy to learn about some properties, such as the ability to float. The amount of matter in a certain volume of an object is called its density. Objects and liquids float on liquids of a higher density and sink through liquids of a lower density.

A good insulator

Heat cannot easily pass through some materials. These are known as insulators. For example, aerogel can completely block the heat of a flame. But don't try this at home!

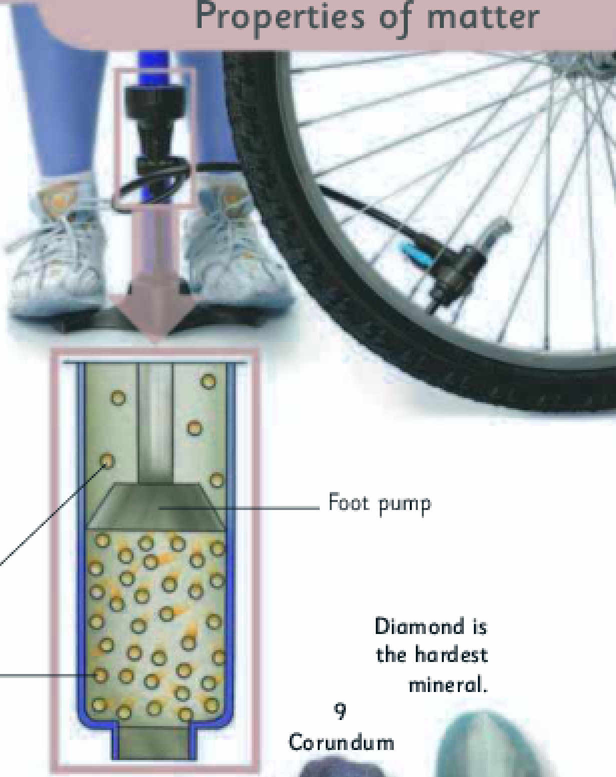
Broken glass

Brittleness

Some materials, such as window glass, are particularly brittle. They will break when pushed out of shape even a small amount.

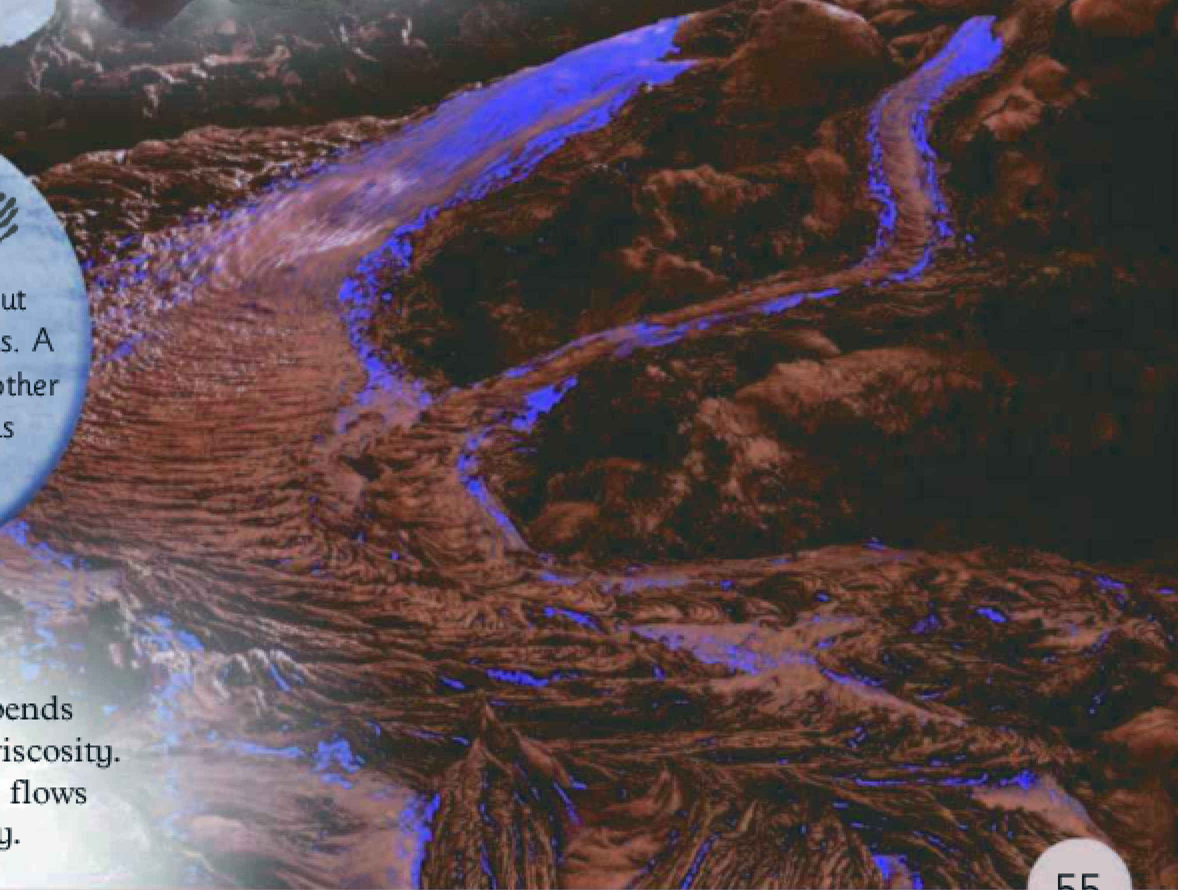
Compressibility

Gases can be squashed, or compressed, by squeezing more into the same space. This is what happens when you pump up a tire.



Hardness

A scientist named Friedrich Mohs created a scale using 10 minerals to compare how hard they are. Many materials are graded on this scale.



hands on

Collect some different pebbles and put them in order of hardness. A pebble is harder than another if it scratches it. This is how Mohs figured out his scale.

A smooth flow

Some liquids flow more easily than others. It depends on their "stickiness," or viscosity. Hot lava from a volcano flows slowly because it is sticky.

Yes, diamond is the hardest mineral of all. It can scratch quartz.

Changing states

Many solids melt, to become liquids, when they become hot enough. When liquids get cold enough, they freeze and become solid. This is called changing states and it happens to all kinds of substances.


Liquid metal

Many substances melt and boil at particular temperatures (its melting and boiling points). Most metals are solid at everyday temperatures because they have a high melting point. But mercury has such a low melting point that it is liquid even at room temperature.

Changing states of water

Water exists as a solid, liquid, or gas. You can find all three forms of water in your home. They are ice, water, and water vapor.

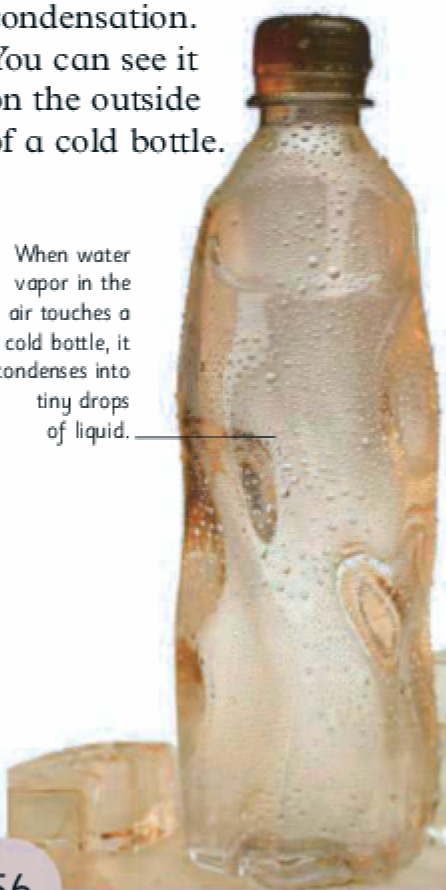
Ice is solid water. It forms when liquid is cooled until it freezes. Each piece of ice has a definite shape.

When ice is warmed, it melts and becomes liquid and takes on the shape of the container holding it.

As water is heated, bubbles of water vapor (gas) form. They escape from the surface and condense to form a mist of liquid droplets called steam.

Condensation

As water vapor in the air is cooled, it changes into liquid water. This is called condensation. You can see it on the outside of a cold bottle.



Rivers of iron

Iron must be heated in a furnace to make it melt. Molten iron is so hot it glows yellow. It is poured into a mold and left to harden to make solid iron objects.

Why does chocolate become soft and gooey in your mouth?

Laundry dries faster on a hot day, when heat turns water into vapor very quickly.

Evaporating

In the open air, water slowly turns into vapor—this is called evaporation. Wet clothes dry on a clothesline because the water they hold evaporates.

Melting chocolate

Mmmm... frozen fruit inside

Freezing

Icicles are spikes of ice that form when dripping water freezes. You often see them on trees in winter. If water keeps dripping down and freezing, the icicle will get longer and longer.

Melting

When you don't eat your ice cream quickly enough, it melts and changes from a solid into a liquid! Chocolate melts, too, and makes your hands sticky. Most solids will melt if the temperature is high enough.

Turn and learn

Actions and reactions: **pp. 68–69**

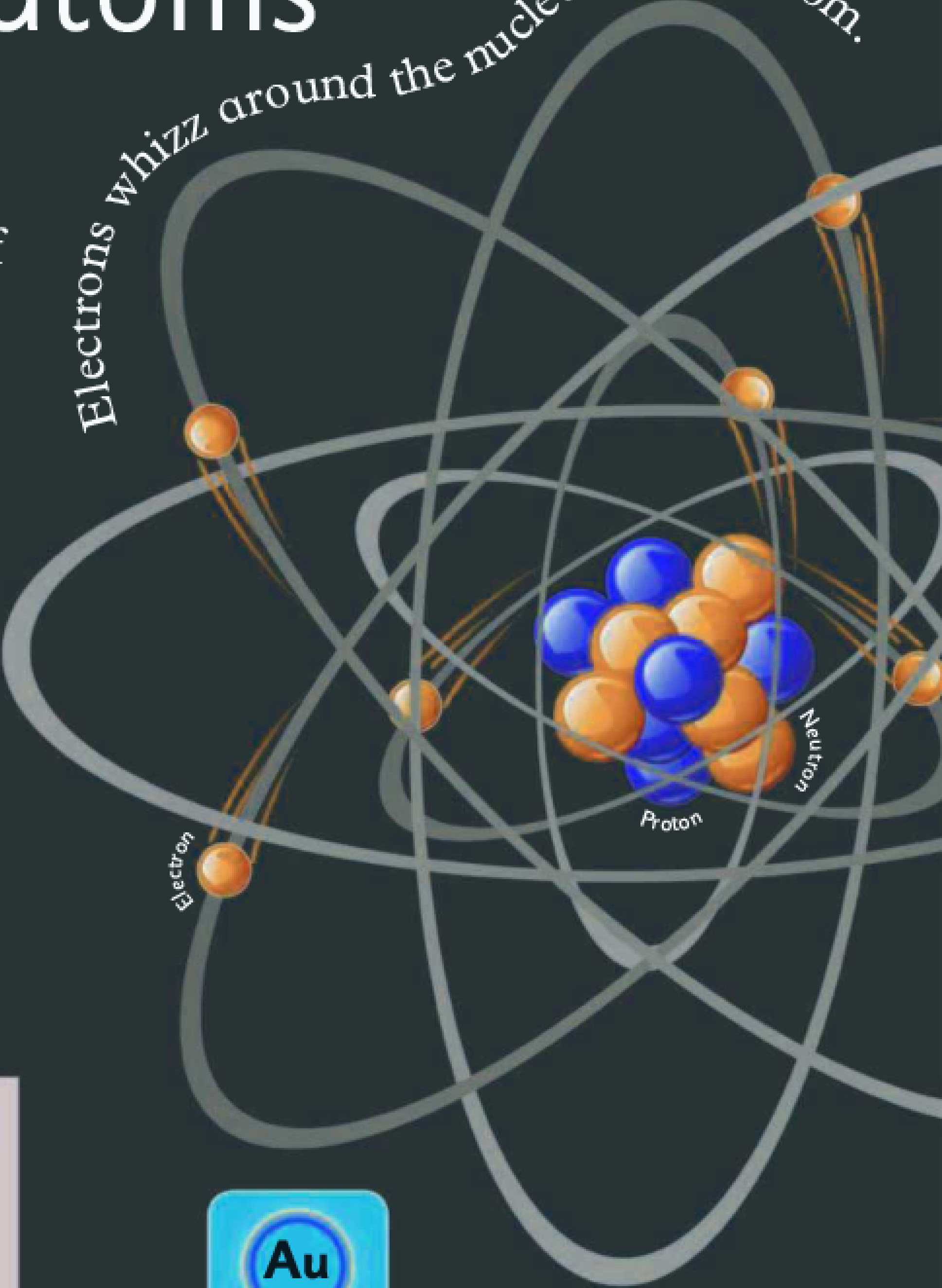
The power of heat: **pp. 86–87**

Because the warmth of your mouth makes it melt.

Amazing atoms

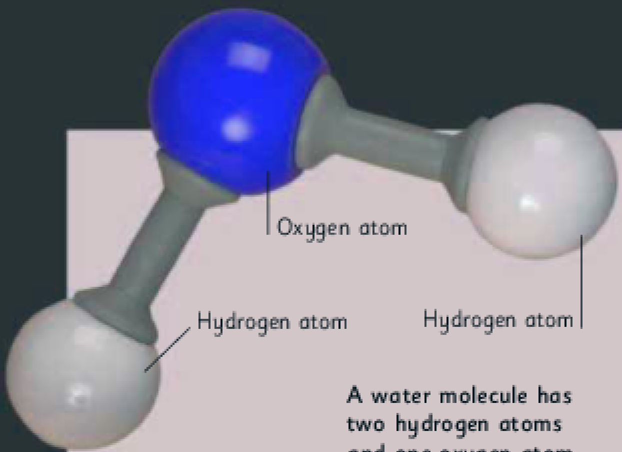
Atoms are tiny particles that make up everything around us. Each atom of a substance contains the chemical properties the substance is made up of.

Electrons whizz around the nucleus of the atom.



Inside an atom

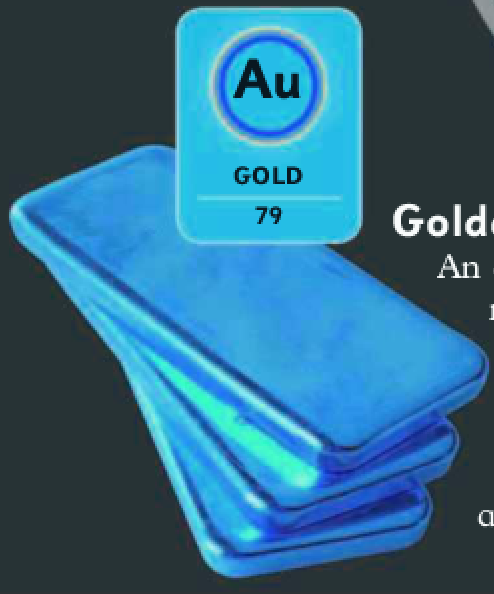
Inside an atom are three tiny types of particle: protons, neutrons, and electrons. Protons and neutrons make up the atom's nucleus (core). The electrons are outside this.



A water molecule has two hydrogen atoms and one oxygen atom.

Molecules

Substances are made from little groups of atoms called molecules. The molecules of water have three atoms.

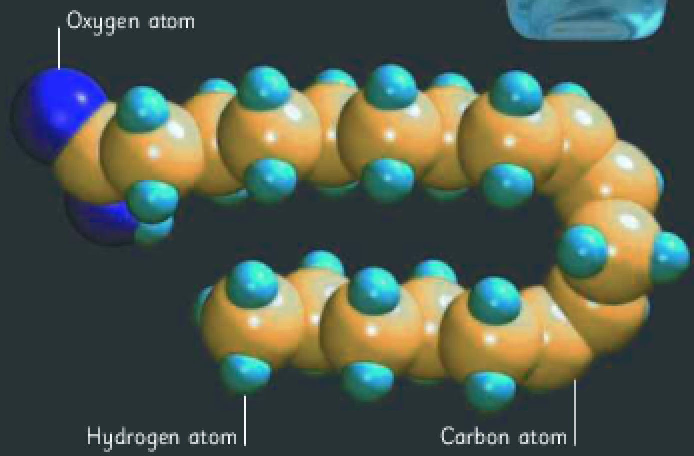


Golden number

An atomic number is the number of protons in an atom. The atomic number of gold is 79. This means that each gold atom has 79 protons.

How many atoms are there in a drop of water?

Sunflower oil comes from the seeds that grow in the middle of a sunflower.



Big molecules

In natural substances like vegetable oil, the atoms are often joined in chains to make very large molecules. The molecules in sunflower oil contain 50 atoms each.

weird or what?

An atom is mostly empty space. If an atom were the size of a sports stadium, the nucleus would be the size of a marble in the middle.

The explosion of a nuclear bomb can create a spectacular "mushroom cloud."

The mighty atom

When the nucleus of an atom is split, it releases a huge amount of energy. Nuclear bombs use this "atomic energy" to create violent explosions. Nuclear power plants use the energy to produce electricity.

About 5 sextillion (5,000,000,000,000,000,000,000,000,000,000,000).

Molecules

In most materials, atoms are joined in tiny groups called molecules. The shapes of molecules and the way they pack together can help explain how different materials behave.

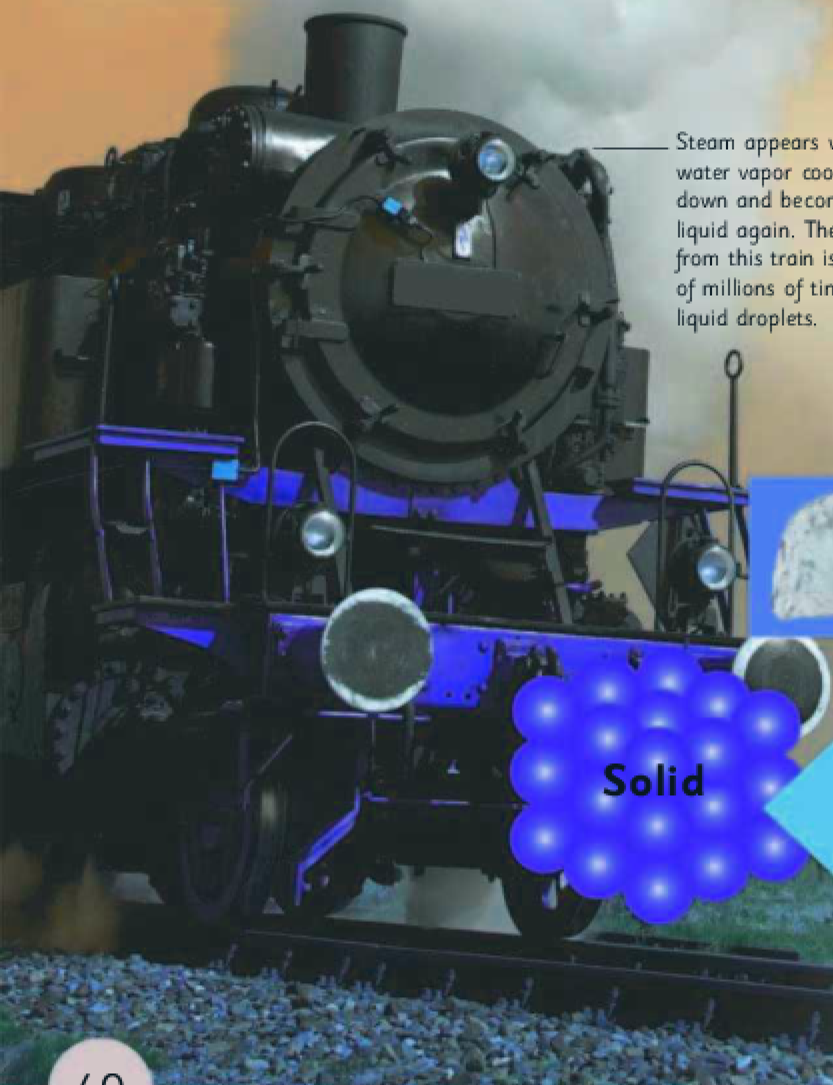
Steaming ahead

Molecules are always jiggling around. When they get hot, they move farther and faster. When water heats up, the molecules may start moving so fast that they escape into the air as water vapor.

Frozen solid

Cold molecules move slowly, allowing them to pack together more easily. When water freezes, the molecules line up in neat rows, forming ice crystals.

Snow may look like white powder, but if you look closely you can see thousands of tiny crystals as clear as glass.

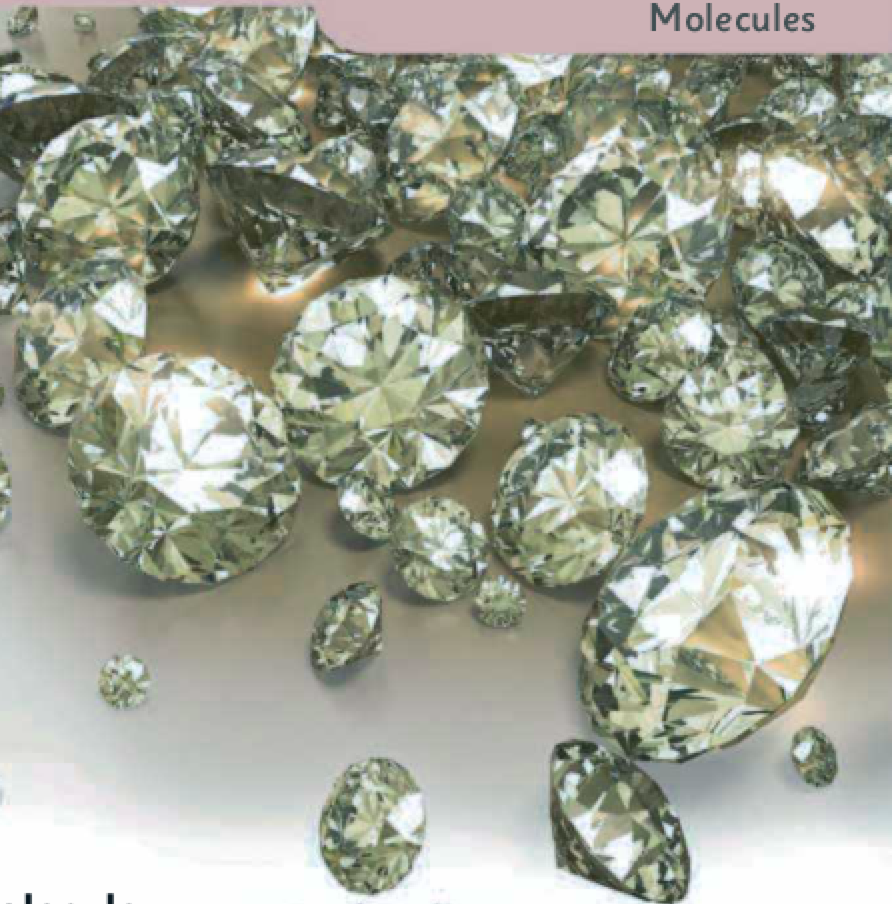


Steam appears when water vapor cools down and becomes liquid again. The steam from this train is made of millions of tiny liquid droplets.

Melt: As a solid heats up, its molecules move faster until they break free from each other and move separately, turning the solid into a liquid.

Solidify: As a liquid cools, its molecules lose energy and move more slowly. Eventually, they start sticking together, turning the liquid into a solid.

If a liquid is poured into a jar or bottle, it takes the shape of its container and stays in place.



Diamond is made into jewels that are almost indestructible.

Diamond molecule

Diamond is the hardest natural substance known. Its hardness comes from the way the carbon atoms in diamond are arranged. Each atom is joined by strong bonds to four neighboring atoms.

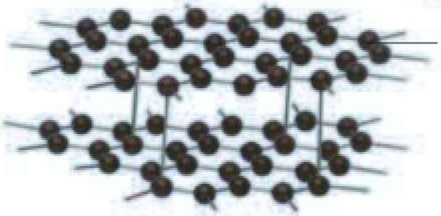
Each group of five atoms in diamond forms a pyramid shape. This shape makes diamond amazingly strong.

Turn and learn

Changing states: **pp. 56–57**
Minerals: **pp. 104–105**

Graphite molecule

Graphite, like diamond, is also made of carbon atoms, but the atoms are arranged in a different way, making graphite very soft.



Each carbon atom in graphite is joined to only three neighbors. The atoms form layers that slip over each other, making graphite soft.

Graphite is used to make the soft lead in pencils.

Evaporate: As a liquid heats up, its molecules speed up until they move fast enough to float away as gas.

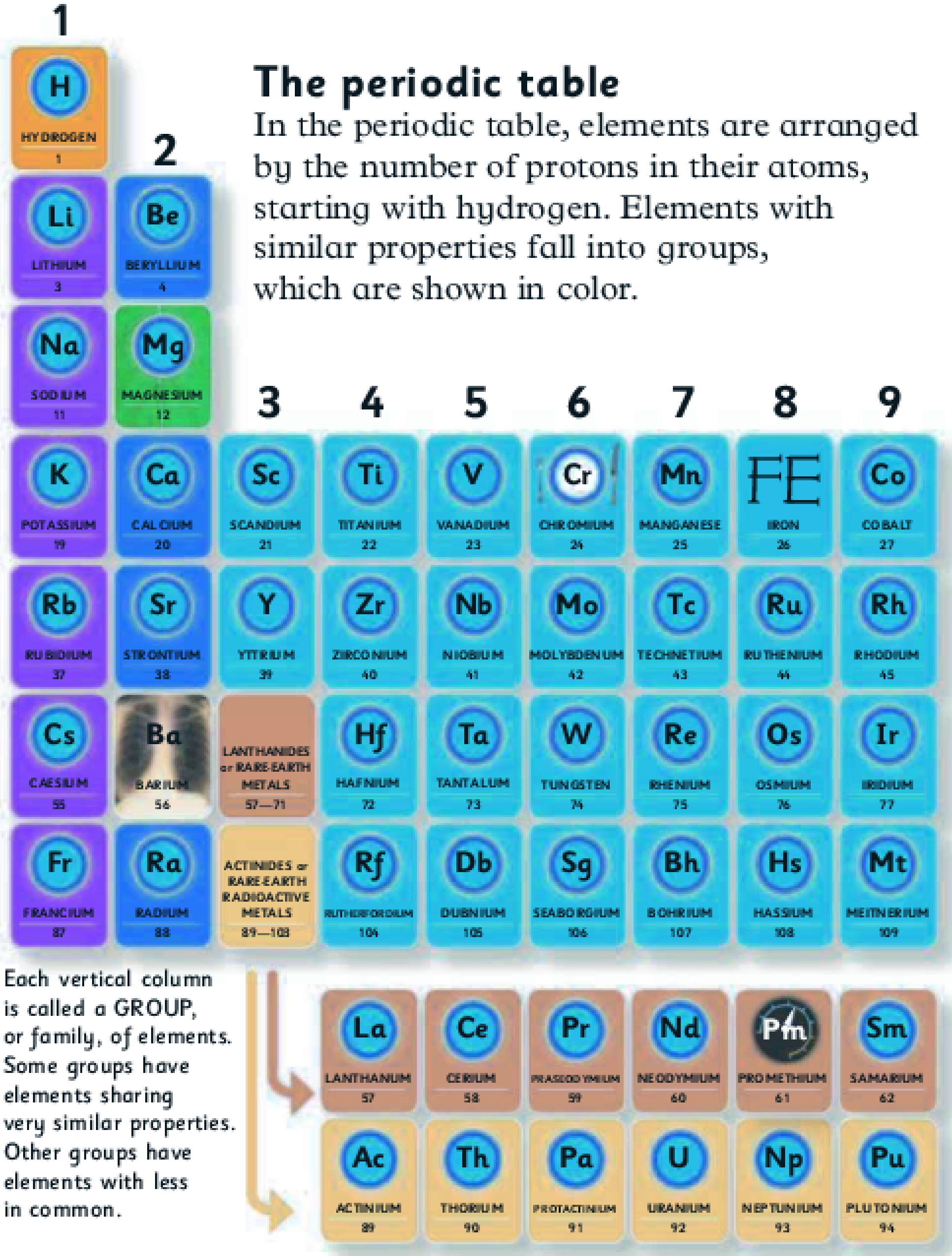
Condense: When gas molecules lose energy and slow down, they stick together and form liquid.

A gas can fill any container it's put in. If there's no lid to seal the container, the gas will escape into the air.

No, you can burn them.

Elements

An element is a substance made up of just one type of atom. Scientists have discovered 117 different elements. The chart on this page, called the periodic table, shows most of them.



The periodic table

In the periodic table, elements are arranged by the number of protons in their atoms, starting with hydrogen. Elements with similar properties fall into groups, which are shown in color.

Each vertical column is called a GROUP, or family, of elements. Some groups have elements sharing very similar properties. Other groups have elements with less in common.

The elements in our bodies mostly come from what we eat.

Milk contains the element calcium, which helps form your teeth and bones.

This bucket is made of the element iron, coated with zinc, which stops iron from rusting.

Metal and non-metals

Most elements are metals, and the others are called non-metals. Metals are normally solid, shiny, and hard. They all conduct electricity and heat. Silver, aluminum, and zinc are metals. Carbon, oxygen, and silicon are non-metals.

Which was the first element to be made artificially?

Every element has a name—a symbol made of usually one or two letters—and an atomic number. The atomic number is the number of protons in one atom of the element.

Kr	Symbol
KRYPTON	Name
36	Atomic number

Oxygen makes up about one-fifth of the air, and it's so important that we have to take it with us when we are underwater.

10	11	12	13	14	15	16	17	18
								He HELIUM 2
			B BORON 5	C CARBON 6	N NITROGEN 7	O OXYGEN 8	F FLUORINE 9	NEON 10
			Al ALUMINUM 13	Si SILICON 14	PHOSPHORUS 15	S SULFUR 16	Cl CHLORINE 17	Ar ARGON 18
Ni NICKEL 28	Cu COPPER 29	Zn ZINC 30	Ga GALLIUM 31	Ge GERMANIUM 32	As ARSENIC 33	Se SELENIUM 34	Br BROMINE 35	Kr KRYPTON 36
Pd PALLADIUM 46	Ag SILVER 47	Cd CADMIUM 48	In INDIUM 49	Sn TIN 50	Sb ANTIMONY 51	Te TELLURIUM 52	I IODINE 53	Xe XENON 54
Pt PLATINUM 78	Au GOLD 79	Hg MERCURY 80	Tl THALLIUM 81	Pb LEAD 82	Bi BISMUTH 83	Po POLONIUM 84	At ASTATINE 85	Rn RADON 86
Ds DARMSTADTIUM 110	Rg ROENTGENIUM 111							

Eu EUROPIUM 63	Gd GADOLINIUM 64	Tb TERBIUM 65	Dy DYSPROSIUM 66	Ho HOLMIUM 67	Er ERBIUM 68	Tm THULIUM 69	Yb YTTERBIUM 70	Lu LUTETIUM 71
Am AMERICIUM 95	Cm CURIUM 96	Bk BERKELIUM 97	Cf CALIFORNIUM 98	Es EINSTEINIUM 99	Fm FERMIUM 100	Md MENDELEVIUM 101	No NOBELIUM 102	Lr LAWRENCIUM 103

KEY:

Alkali metals: These silvery metals are very reactive.

Alkaline-earth metals: These shiny, silvery white metals are reactive.

Transition metals: Many are strong and have high boiling and melting points.

Lanthanides: Many are soft, shiny, and silvery white metals.

Actinides: These are radioactive heavy elements.

Poor metals: These are softer, weaker metals.

Non-metals: Most are gases at room temperature and easily snap as solids.

Halogens: These non-metals are highly reactive and harmful.

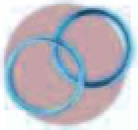
Noble gases: These non-metals are the least reactive of all the elements.

Turn and learn

Elements: **pp. 64–65**
Electricity: **pp. 76–77**

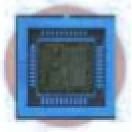
Useful elements

We use elements to make all sorts of useful or decorative objects.

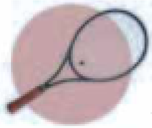


Gold is a precious metal. It is used to make jewelry.

Copper is a metal that conducts electricity well. It is used in electrical wires.



Silicon is a non-metal used to make the chips that power computers.



Carbon fibers are strong but light, so they are used for tennis rackets.

Iron is a strong, silvery metal. It is magnetic and has many uses.

Aluminum is a soft, shiny metal. It is used to make soda cans.

Sulfur is a yellow non-metal used to harden rubber to make tires.

Titanium is a very strong, light metal used in aeroplane bodies and space rockets.

Helium is a gas used in balloons because it is less dense than air.

Chlorine is a yellow-green gas, used in bleach and to make some plastics.

Mercury is a liquid metal used in dental fillings and is the gas inside fluorescent lightbulbs.

Technetium (Tc).

Properties of elements

In the periodic table, elements with similar properties are arranged in groups. Some groups are made up of elements that react easily with other chemicals to form new compounds. Other groups include elements that barely react with anything at all.

Alkali metals

These are soft, lightweight metals that react easily with other chemicals, such as water. When put in water, they fizz and pop violently. Sodium is an alkali metal. It reacts with the gas chlorine to form common salt.

Transition metals

This group includes well-known and useful metals.

Silver is used in medals, ornaments, jewelry, and flatware (knives and forks).

Zinc protects things from rusting. One of its many uses is in the casing of batteries.

Nickel is used in silver-colored coins because it does not lose its shine.

Titanium is lightweight yet incredibly strong. It is used to repair bones and joints.

What are transition metals?

Forty elements make up a group known as the transition metals. These are typical metals, being solid, shiny, and mostly hard. The precious metals gold, silver, and platinum are in this group.

Pure gold is found as grains in rock or, more rarely, as whole rocks (nuggets) that are worth a small fortune.

Precious metals such as gold are long-lasting because they react poorly with other chemicals. Gold is one of the least reactive elements.

Which element is the most valuable precious metal?

Calcium is found in seashells in the compound calcium carbonate.

The dazzling light of fireworks comes from burning magnesium.

Alkaline-earth metals

Five elements, including magnesium and calcium, are called alkaline-earth metals. Like alkali metals, they are soft and light. They don't react as strongly with water, but they join with other chemicals to make many compounds important in nature.

Noble gases

The six noble gases get their name because they hardly react with other chemicals, as though staying aloof. They include neon and argon, which are used to make lasers and colored lights.

Tin cans are actually made of steel with a thin coating of tin.

Poor metals

The elements in this group are soft and weak. They are called poor metals but are very useful. Tin, lead, and aluminum are examples of poor metals.

Halogens

Five elements make up a group called the halogens. These are all highly reactive chemicals. The gas chlorine is one of the best-known halogens. It is added to the water in swimming pools because it kills germs.

Chlorine smells strongly and can sting your eyes.

Mixtures

Mixture of milk and cereal

A mixture is created when two or more things are combined together, without bonding. A mixture can usually be easily separated back into its original parts. When atoms of different elements join, or bond, a compound is formed.

Colorado River, Arizona, USA

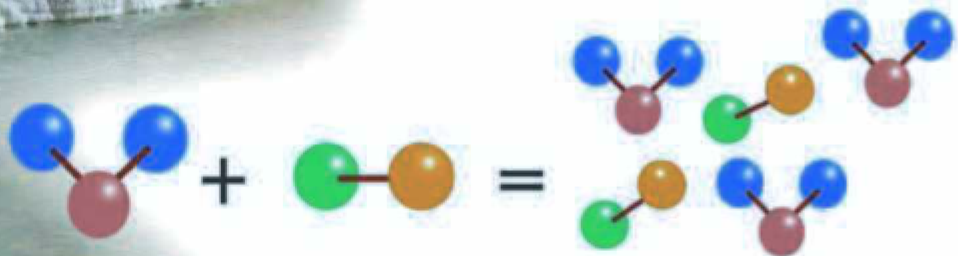
Suspension

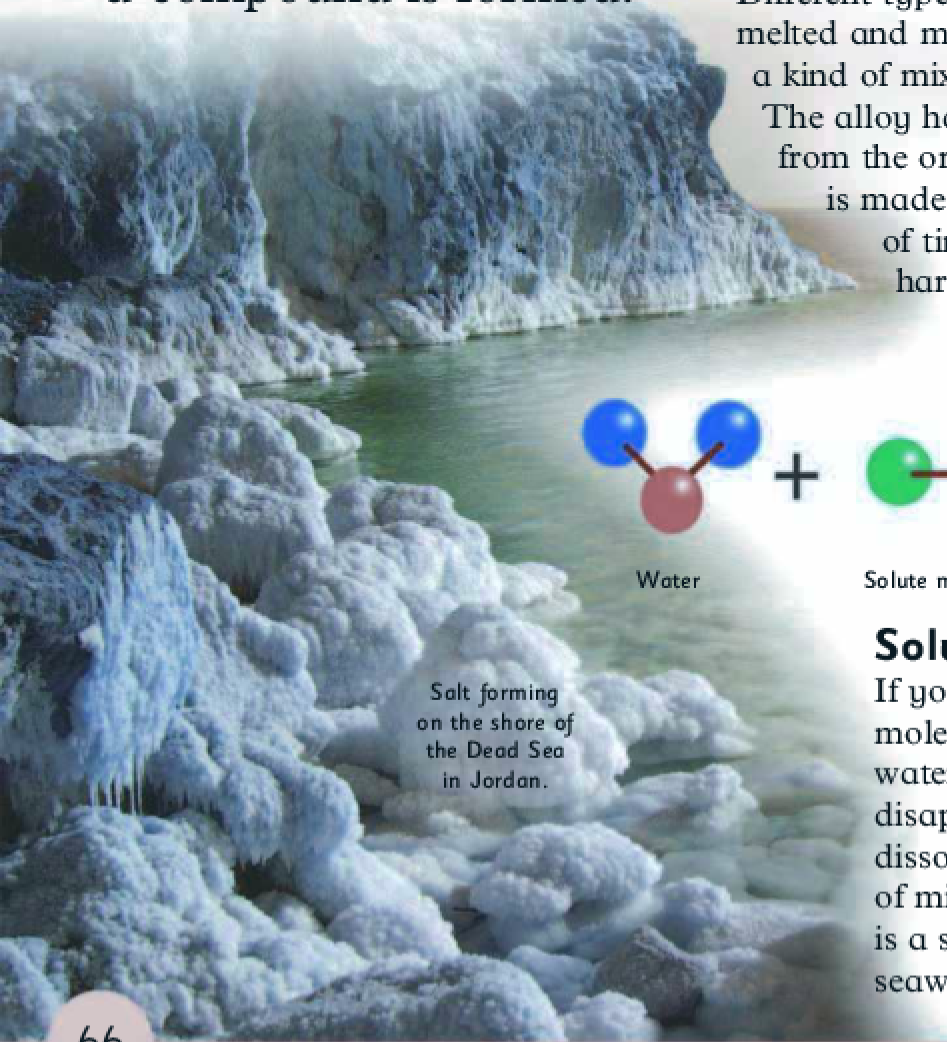
A muddy river is a type of mixture called a suspension. Small particles of soil are "suspended" in the water, making it brown and cloudy.

Alloy

Different types of metal can be melted and mixed together to make a kind of mixture called an alloy. The alloy has different properties from the original metals. This tankard is made of pewter, which is an alloy of tin and lead. Pewter is much harder than tin or lead.

Pewter tankard

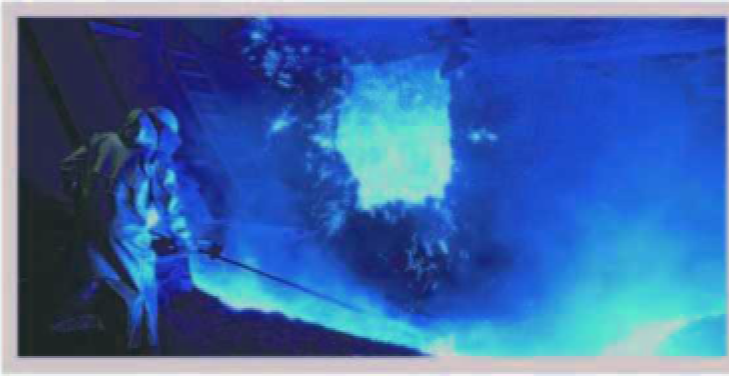




Salt forming on the shore of the Dead Sea in Jordan.

Solution

If you stir sugar into water, the sugar molecules spread out and fit between the water molecules, making the sugar seem to disappear. We say the sugar (a solute) has dissolved in the water (a solvent). This kind of mixture is called a solution. Seawater is a solution of water and salt. If you let seawater dry out, the salt reappears.



Separating compounds

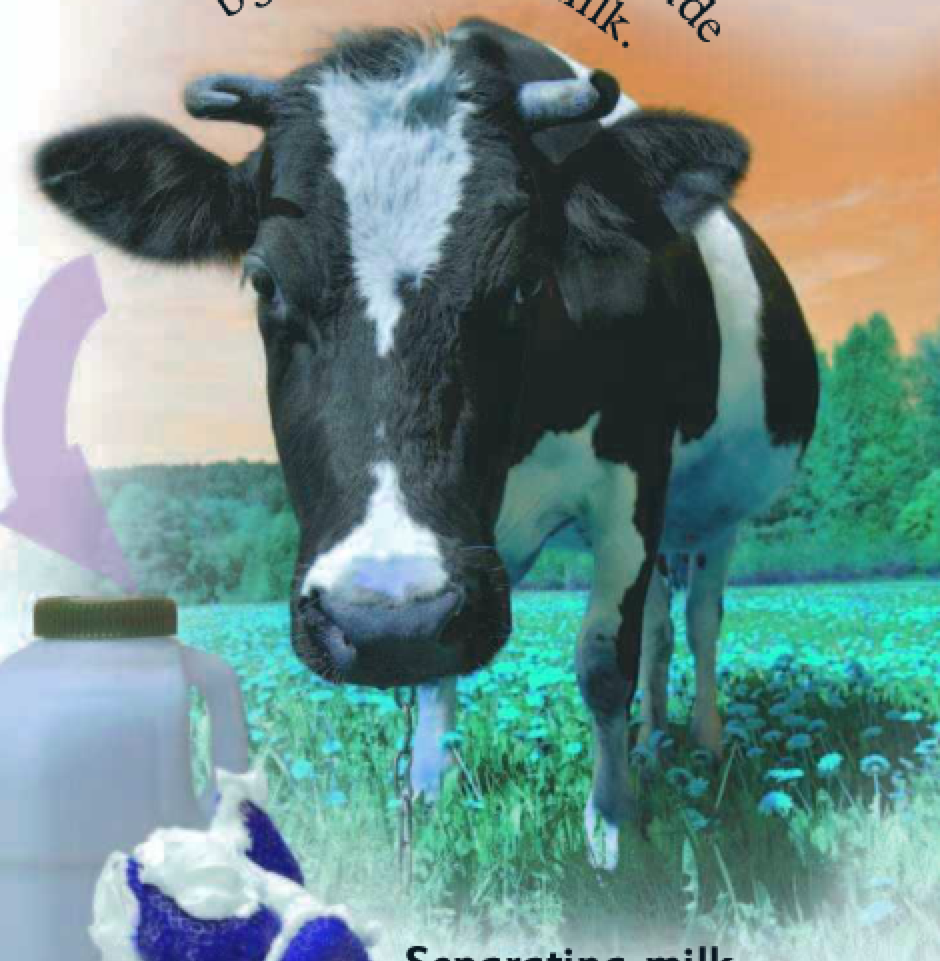
It takes a great deal of effort to separate a compound into pure elements. To make pure iron, you have to separate the compound iron oxide, into iron and oxygen. This is done in a very hot blast furnace.

Iron ore

Pure iron

The mineral iron ore is rich in iron oxide. It is mined to extract iron, which is mostly used to make steel.

Cream and cheese are made by separating milk.

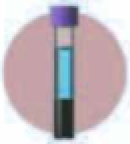


Separating mixtures

A mixture can be easily separated in several ways.

Evaporation removes water from a mixture by turning it into a gas (water vapor).

Filtration separates large particles, such as coffee grinds, from a suspension.



Spinning at high speed separates blood cells from blood, in a device called a centrifuge.

Distillation separates mixtures of liquids by making them evaporate and condense.

Milk

Strawberries and cream

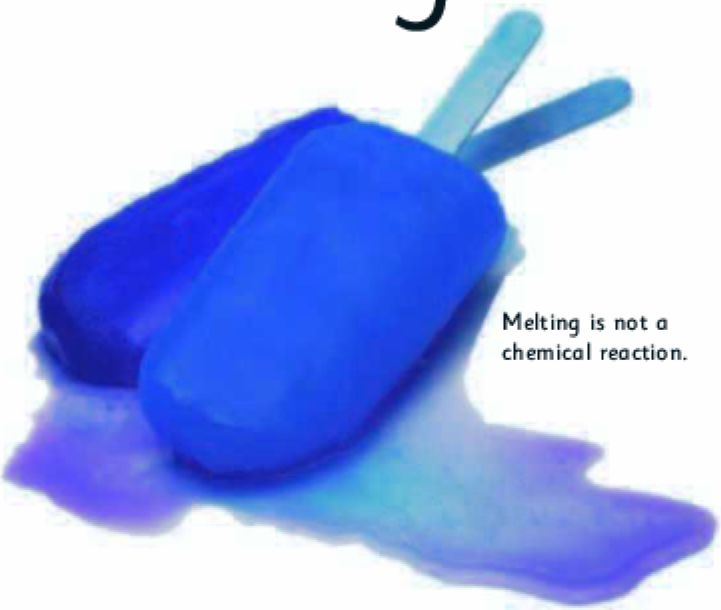
Separating milk

Whole milk can be separated into cream and skim milk by spinning it in a bowl. The heavier skimmed milk spins away from the lighter cream, which stays in the center of the spinning bowl.

It is an alloy containing 75 percent gold and 25 percent other metals, such as silver.

Reactions and changes

Materials change as a result of physical processes or chemical reactions. In a chemical reaction, atoms join with or break away from other atoms, forming different compounds. Chemical reactions often lead to a dramatic change.



Melting is not a chemical reaction.

Chemical change

Burning is a chemical reaction involving oxygen (O). Wood is made of compounds containing carbon (C) and hydrogen (H). When it burns, the carbon and hydrogen react with oxygen to produce carbon dioxide (CO_2) and water (H_2O).

Physical change

Not all dramatic changes are caused by chemical reactions. When ice pops melt, the atoms in the water molecules do not get rearranged into new molecules—they remain water molecules. Melting is simply a physical change.

Burning is a chemical reaction.

Escaping energy

Chemical reactions can release energy as heat and light. A sparkler contains chemicals that release a lot of energy as light to create a dazzling shower of sparks.

What chemical reaction makes silver objects slowly turn gray and dull?

Speeding up reactions

Cooking makes carrots softer because the heat causes a chemical reaction. Chopping carrots into small pieces speeds up the reaction because it increases the area of contact between the carrots and the hot water.

Sliced carrots cook faster than whole carrots.

Glow in the dark

Light sticks glow in the dark thanks to a chemical reaction that releases energy as light. You can slow down this reaction by putting a light stick in the fridge, which makes it last longer.

Soda volcano

If you drop mints into a carbonated drink, the drink turns to foam and explodes out in an instant. This is a physical change rather than a chemical reaction. The rough surface of the mints helps gas, dissolved in the drink, to turn into bubbles much more quickly than it normally would.

hands on

Ask an adult to boil some red cabbage and save the colored water. Let the water cool. Then add acid (vinegar) or alkali (baking soda) and watch for a spectacular change of color!

Tarnishing. It happens when silver atoms react with the oxygen atoms in air.

Irreversible changes

Nylon jacket

Physical changes are reversible—for example, you can freeze water, and heat can turn the ice into liquid water again. However, many chemical reactions are irreversible because they involve atoms joining together in new ways.

Manmade materials

Chemical reactions can be used to create new materials that don't exist in nature. Nylon, for example, is a fabric made using chemicals from oil. Many types of clothes, from socks to coats, are made of nylon.

Cooking

When food is cooked, heat triggers chemical reactions that change it permanently. When a freshly baked cake cools down, it doesn't turn back into gooey cake mixture.

Baking powder

Baking powder makes cakes light and fluffy. It contains chemicals that react when they're wet to produce bubbles of gas.

A fresh pepper looks plump and brightly colored.

An old pepper darkens and shrivels up as it rots.

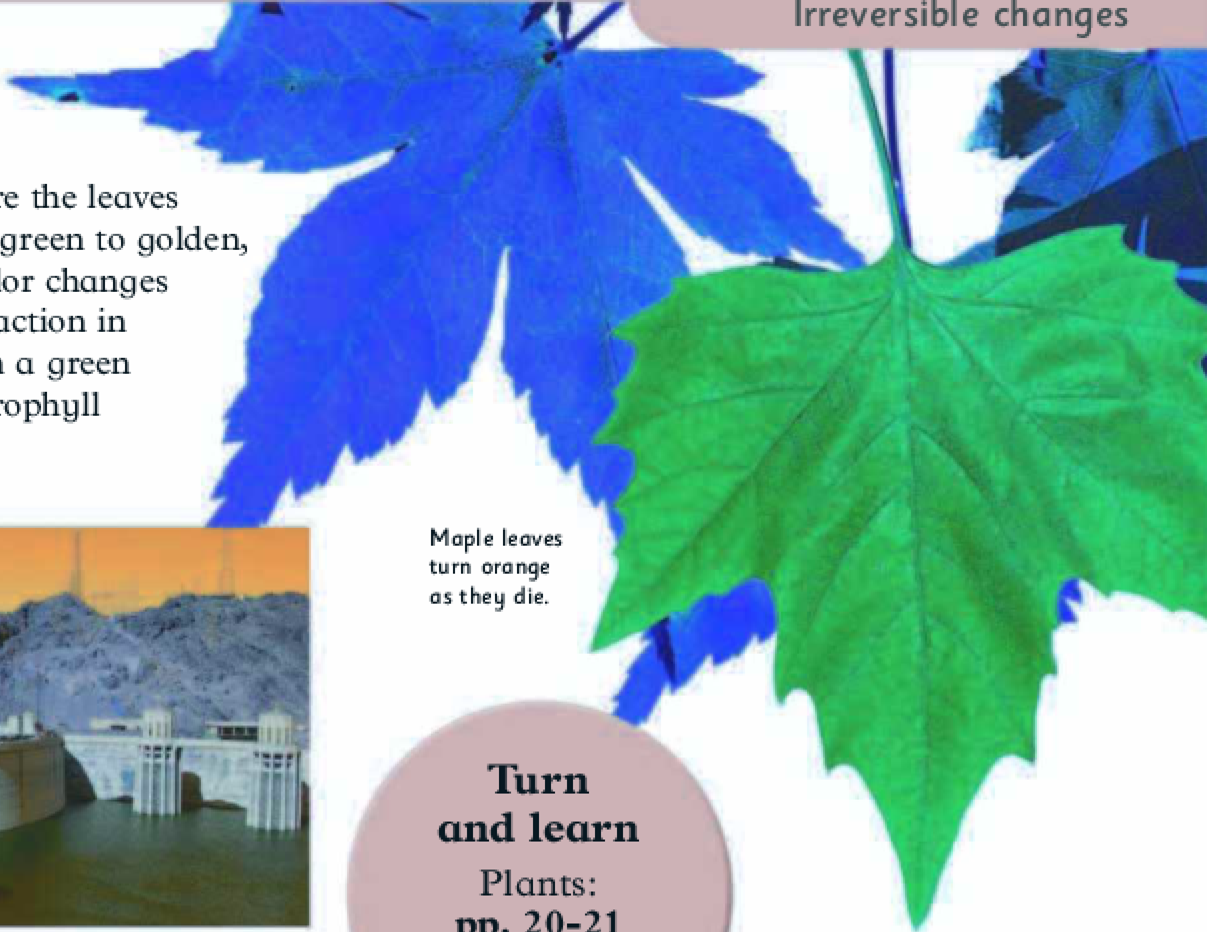
Rotting

Rotting food is full of tiny organisms such as a bacteria and fungi. These organisms trigger chemical reactions that break down food molecules, changing them permanently.

Why are some parts of cars covered with a layer of shiny chrome (chromium)?

Ready to fall

Maple trees shed their leaves in the fall. Before the leaves die, they change from green to golden, orange, or red. The color changes because a chemical reaction in the leaves breaks down a green compound called chlorophyll inside leaf cells.



Maple leaves turn orange as they die.

Turn and learn

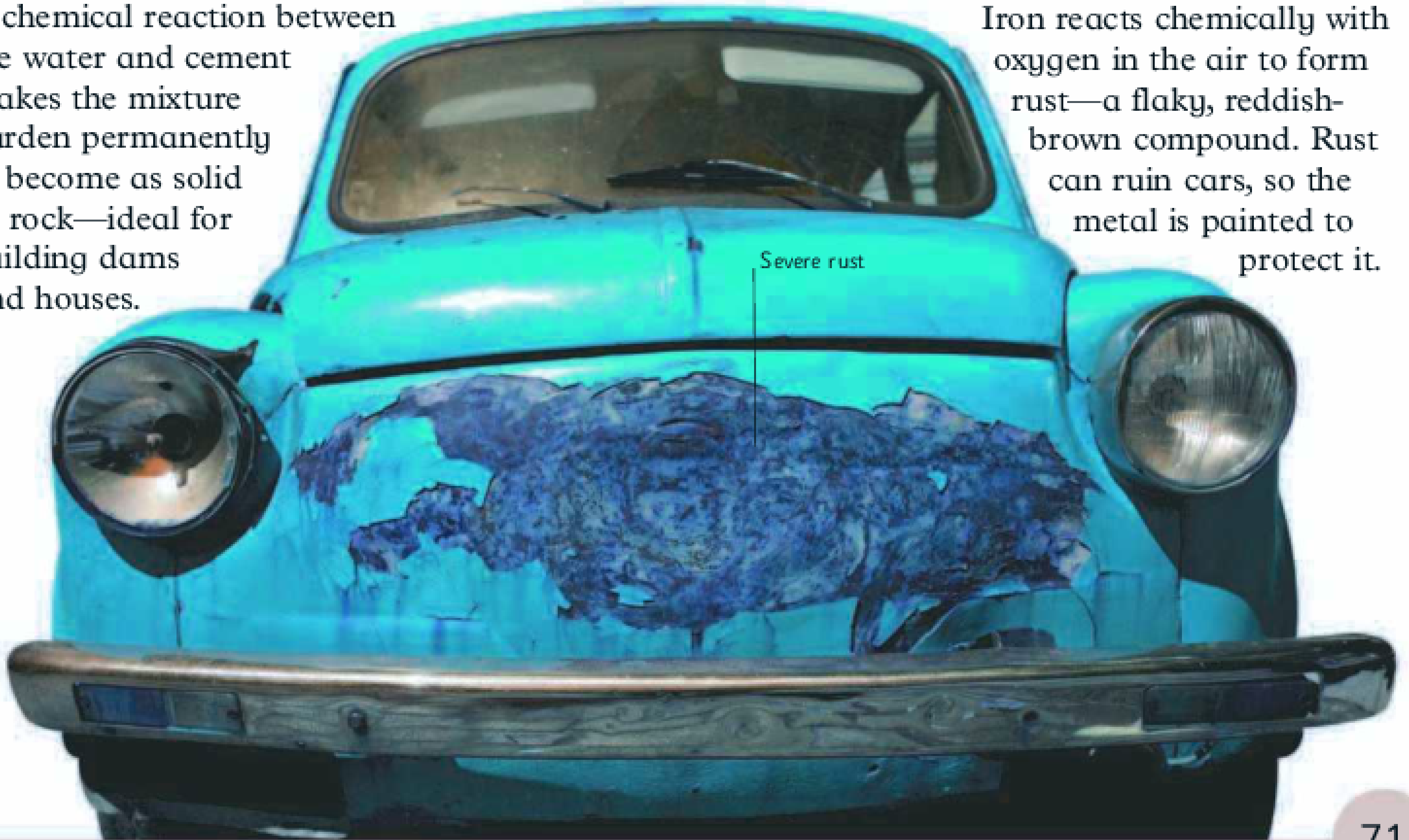
Plants: **pp. 20-21**
Ecosystems: **pp. 44-45**

Solid as a rock

Concrete is made by mixing gravel, sand, cement powder, and water. A chemical reaction between the water and cement makes the mixture harden permanently to become as solid as rock—ideal for building dams and houses.

Rust

Iron reacts chemically with oxygen in the air to form rust—a flaky, reddish-brown compound. Rust can ruin cars, so the metal is painted to protect it.



The chrome protects the iron underneath from rusting.

What is energy?

Energy is what makes everything happen. Your body needs energy so that you can move, grow, and keep warm. We also need energy to power our cars, light our homes, and do thousands of other jobs.

Sunshine

We get nearly all our energy from the Sun. Plants absorb the energy in sunlight and store it as chemical energy. The stored energy enters our body through food and is released inside our body's cells. Sunlight absorbed through our skin is also necessary to produce certain vitamins and minerals in our body. The Sun is the ultimate source of energy for all plants and animals.

Only a tiny fraction of the Sun's energy reaches the Earth.

A bow stores energy by bending. When you let go, the bow springs back into shape and releases the stored energy.

Sources of energy

Energy comes from lots of different sources.

Wind drives wind turbines, which convert movement energy into electricity.

Geothermal energy is heat from deep underground.

Dried plants can be burned to provide energy for cooking, heating, and lighting.

Waves can be used to generate large amounts of electricity.

Dams harness the energy in rivers flowing downhill to make electricity.

The **Sun**'s energy can be captured by solar panels to make electricity.

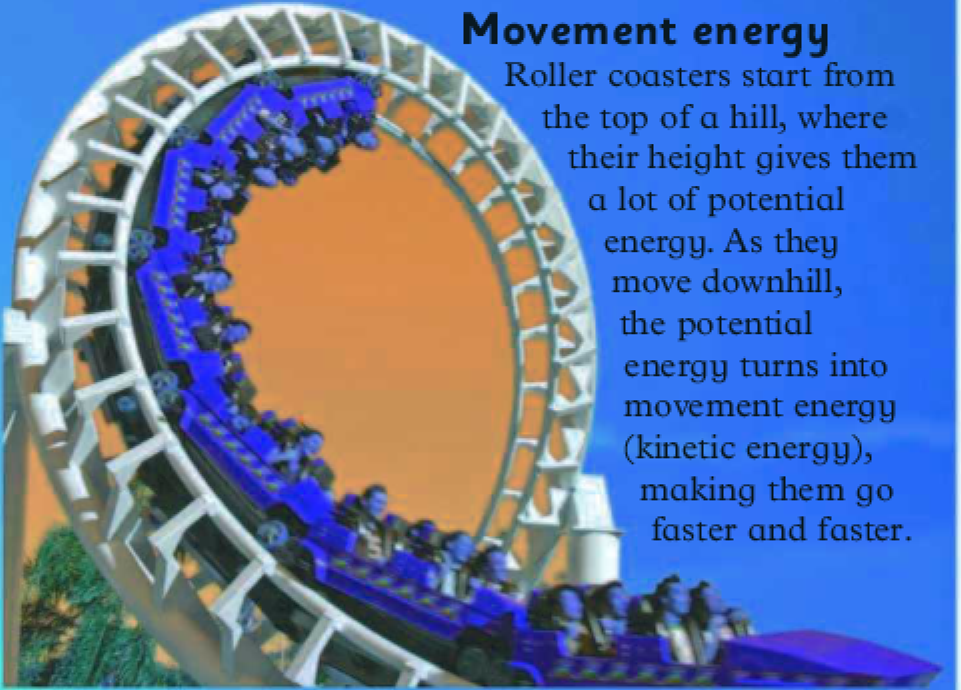
Fossil fuels, such as oil, are used to power cars and to make electricity.

Stored energy

An object can store energy and release it later. When you wind a wind-up toy, energy is stored in a spring. A bow and arrow uses stored energy to shoot the arrow. Stored energy is also called potential energy because it has the potential to make things happen.

Is energy destroyed when we use it?

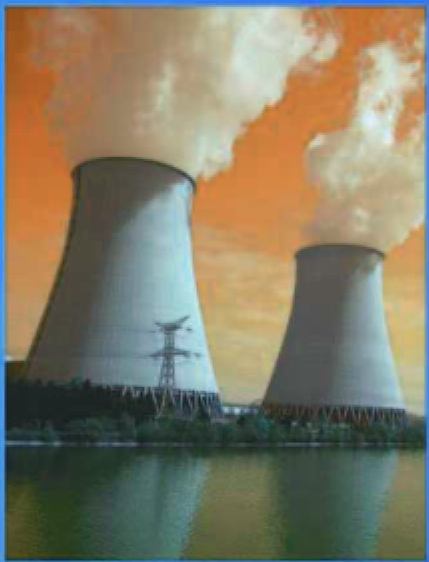
Movement energy



Roller coasters start from the top of a hill, where their height gives them a lot of potential energy. As they move downhill, the potential energy turns into movement energy (kinetic energy), making them go faster and faster.

Nuclear energy

Matter is made up of tiny particles called atoms. The center of an atom, called a nucleus, stores huge amounts of energy. This nuclear energy is used in power plants to make electricity.

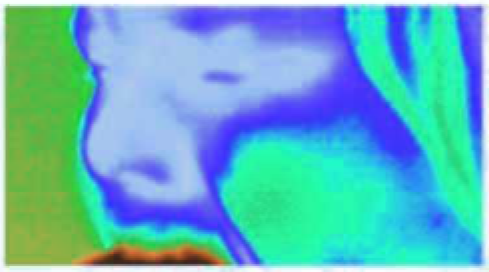


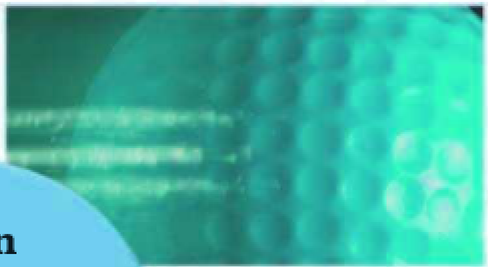
Electrical energy

Lightning is caused by electrical energy in a storm cloud. The electrical energy turns into the heat and light energy of lightning and the sound energy of thunder.

Picture detective

Look through the Physical Science pages to identify each of the picture clues below.





Turn and learn

Light: **pp. 82–83**
Heat: **pp. 86–87**

Energy cannot be destroyed. It turns into another form of energy when it's used.

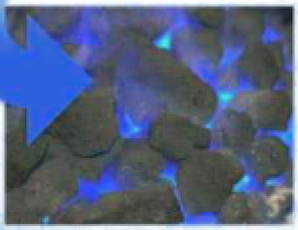
Energy changes

All around you, energy is being converted from one form to another. You can see these changes happen—switching on a light turns electrical energy into light energy.

Energy chain

Changing energy from one type to another is called "energy conversion." The steps can be linked to make an energy chain.

Coal contains chemical energy.



Burning coal produces heat energy, which is used to boil water. Boiling water creates steam.

Moving steam is a form of kinetic (motion) energy, which operates turbines.

The kinetic energy produced by the moving turbines creates electricity.

Electrical energy used by television sets changes into light, sound, and heat energy.

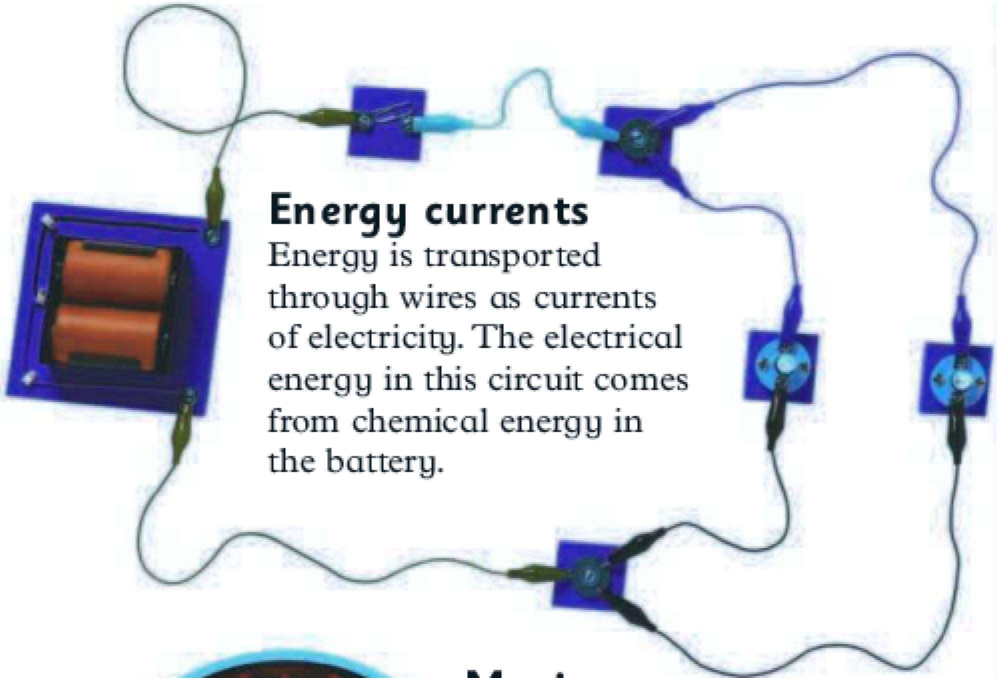
Driving force

Car fuel is full of chemical energy. When the engine starts, the chemical energy is changed to heat energy. This is the first in a series of energy changes that make cars run.

Heat to sound

Some heat energy becomes sound energy. The roar of a race car engine can be deafening!

What are energy sources like coal, oil, and gas called?



Energy currents

Energy is transported through wires as currents of electricity. The electrical energy in this circuit comes from chemical energy in the battery.

Energy savings

Energy is precious, so people are finding extra ways to limit energy use.

Roof insulation stops heat energy from escaping and helps keep houses warm.

Energy-saving lightbulbs last longer and use less energy than standard ones.

Washing clothes at low temperatures saves the energy needed to heat water.

Boiling only as much water as you need in a kettle saves time and energy.

Moving on

Some heat energy is changed to kinetic energy as the pistons move. The movement of the car is also kinetic energy.

Wheels of fire

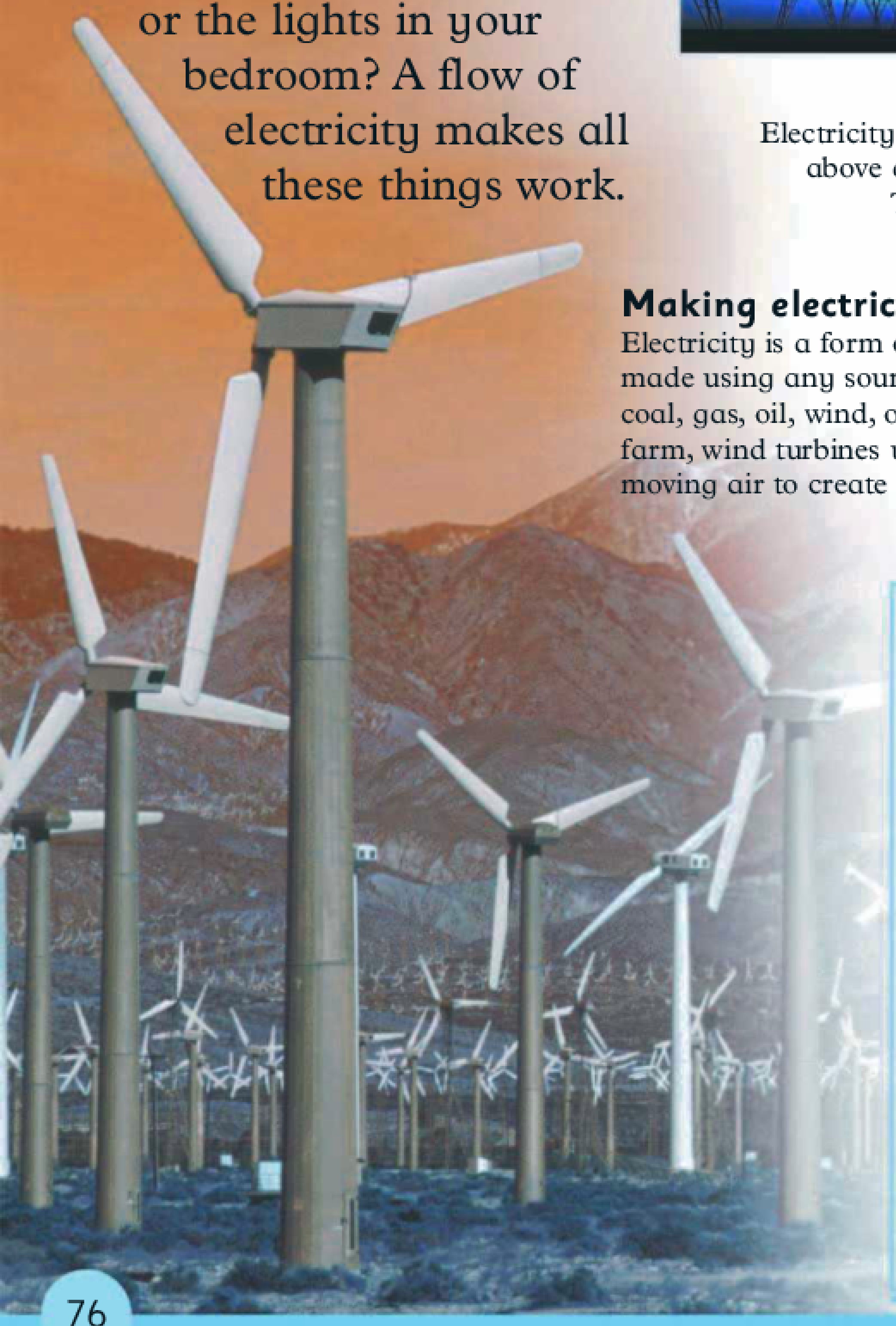
Some of the kinetic energy in the wheels becomes heat energy. The hottest parts are shown white and yellow.

Turn and learn

Types of energy:
pp. 72-73
Resources:
pp. 110-111

Electricity

Have you ever thought about what powers your television, your computer, or the lights in your bedroom? A flow of electricity makes all these things work.



Power supply

Electricity travels to your home along wires above and sometimes below the ground. The wires above the ground hang on metal towers.

Making electricity

Electricity is a form of energy. It can be made using any source of energy, such as coal, gas, oil, wind, or sunlight. On a wind farm, wind turbines use the energy of moving air to create electricity.

Everyday electricity

We use electricity in all sorts of ways in our everyday lives.

Electricity is used to **heat** up household appliances such as irons and stoves.

Electricity is used to **light** up our homes, schools, offices, and streets.

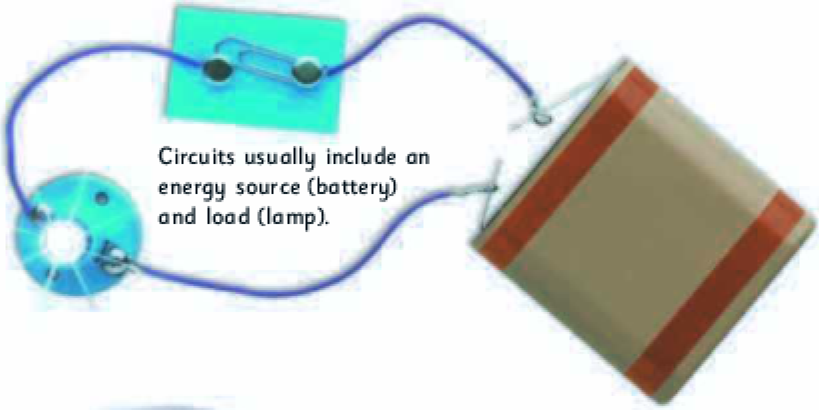
Electricity helps in **communication** by powering telephones and computers.

Electricity helps in **transportation** by powering certain vehicles, such as trains.

What's the name of a small object that can store electricity?

Circuits of power

An electric circuit is a loop that electricity can travel around. An electric current moves through the wires in this circuit and lights up the bulb.



Circuits usually include an energy source (battery) and load (lamp).

Electrical cables

Electrical cables are made of metal and plastic. Electricity flows through the metal (which is called a conductor). The plastic (which is called an insulator) stops electricity from escaping.

hands on

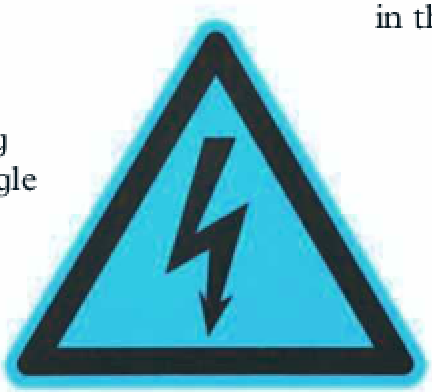
Rub a party balloon up and down on your clothes. The balloon will now stick to the wall. This is because rubbing it gives the balloon an electric charge.

Lightning strikes

Electric charge building up in one place is called "static electricity." Lightning is an electric current caused by static electricity building up in thunderclouds.

High voltage

Electricity can be very dangerous. This triangle is an international warning symbol. It means "Caution: risk of electric shock."



Food battery

Food that contains water and weak acid will conduct electricity. In a food battery, a chemical reaction between the metal and the acid in the food creates an electric current.

A conductor attached to food (containing acid) forms an electric circuit.

Magnetism

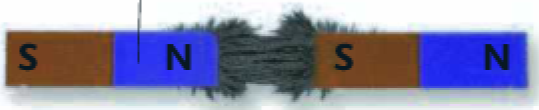
Magnets exert a force called magnetism, which can attract certain objects—especially those containing iron.

This magnet has attracted a clump of steel paper clips because steel has an iron content.

Attract or repel?

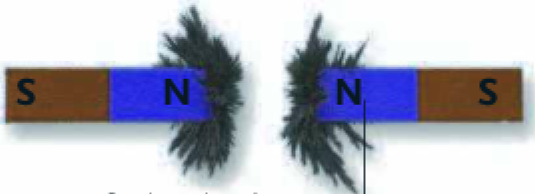
Magnets attract materials containing iron, and they can also attract other magnets. Two magnets can also push apart, or "repel."

Opposite poles of a magnet attract each other.

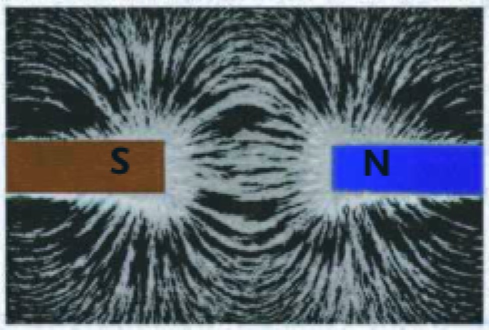


Magnet rules

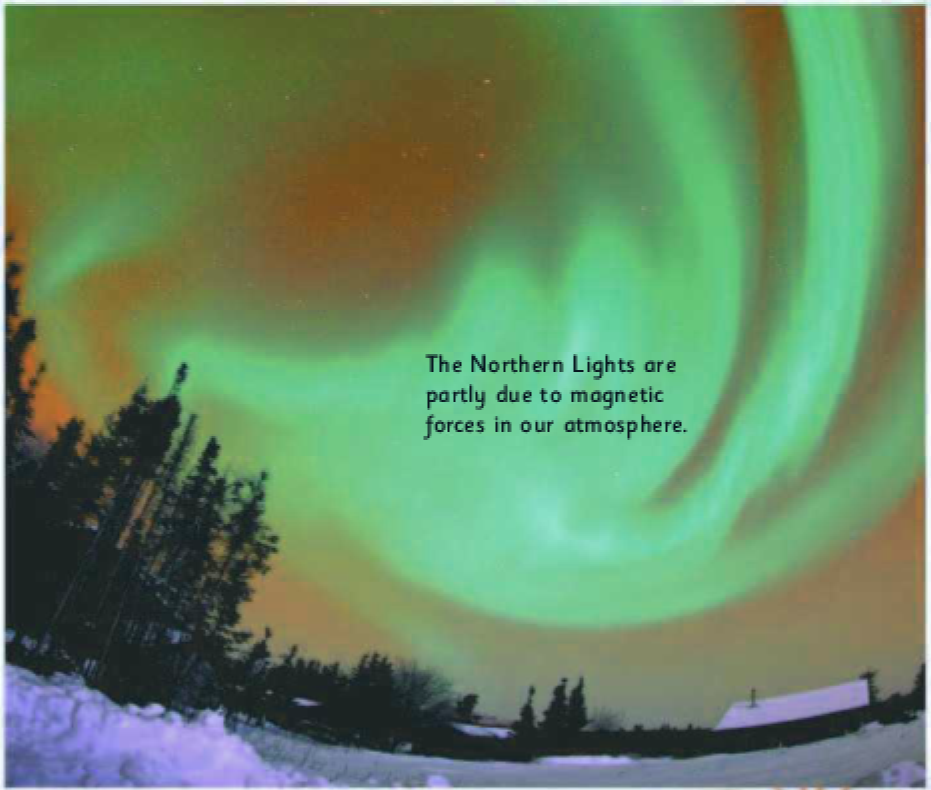
The ends of a magnet are called the north and south poles. Opposite poles attract each other. Similar poles repel each other.



Similar poles of a magnet repel each other.



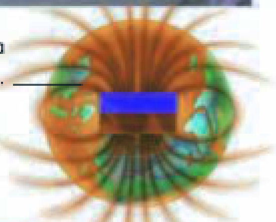
Iron filings show the magnetic field between the two magnets.



The Northern Lights are partly due to magnetic forces in our atmosphere.

Lights in the sky

Amazing lights are caused when particles in the solar wind (streaming from the Sun) travel into the atmosphere along force lines in the Earth's magnetic field.



The Earth has a magnetic field.

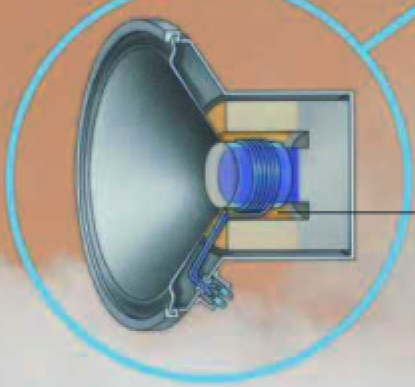
The Earth as a magnet

The Earth behaves as if there is a giant invisible magnet between the North and South poles. That's why we can use a compass to find our way.

What is a magnetometer?

Electromagnets

When an electric current flows through a wire coil, the coil becomes magnetic. This creates an electromagnet. Automatic doors, loudspeakers, and electric motors all use electromagnets.



Electromagnets are used in speakers.

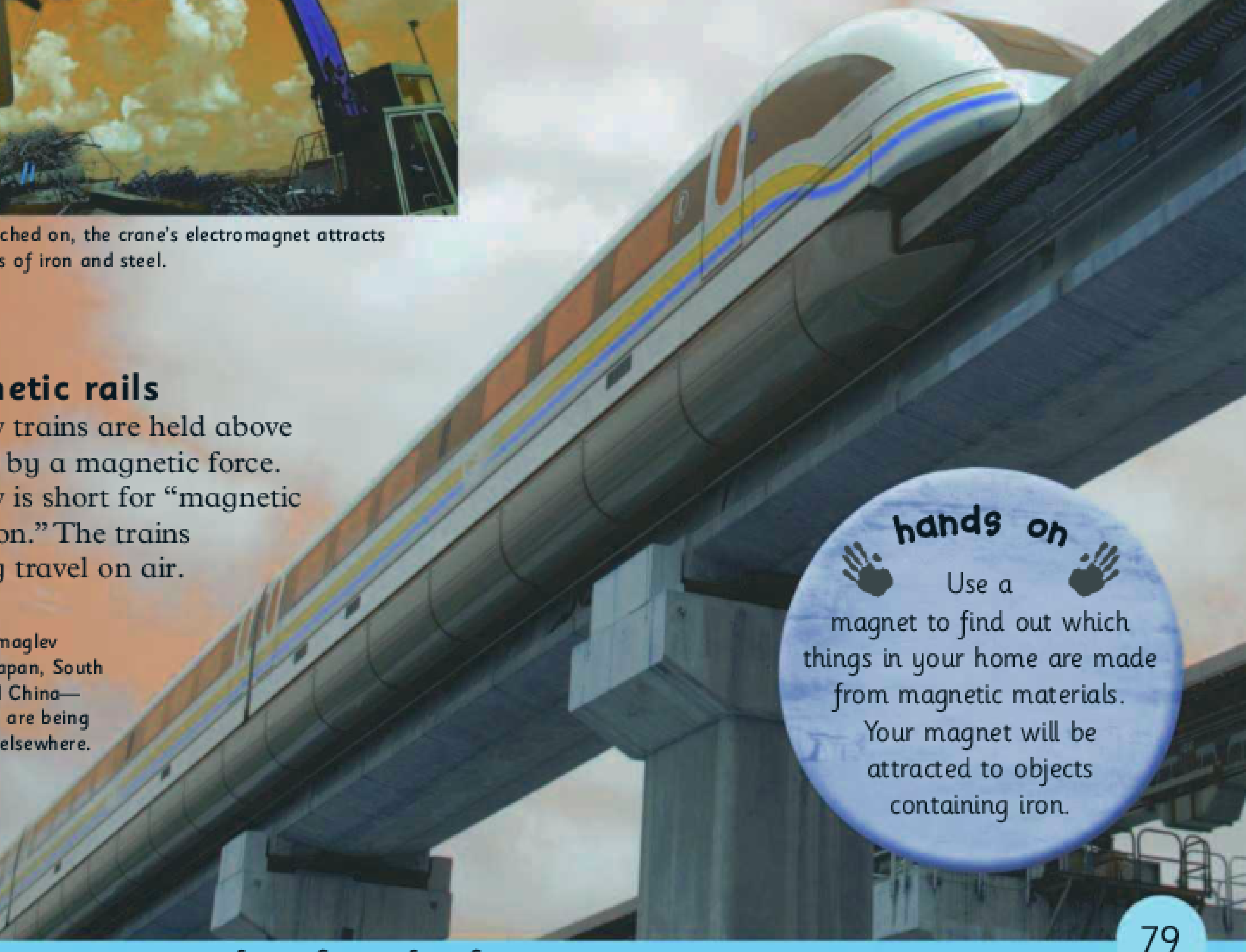
Lifting with magnets

Some cranes use magnetic force, in the form of giant electromagnets, instead of hooks. The electromagnet can be switched on or off.

When switched on, the crane's electromagnet attracts huge pieces of iron and steel.

Magnetic rails

Maglev trains are held above a track by a magnetic force. Maglev is short for "magnetic levitation." The trains literally travel on air.



There are maglev trains in Japan, South Korea, and China—and others are being developed elsewhere.

hands on

Use a magnet to find out which things in your home are made from magnetic materials. Your magnet will be attracted to objects containing iron.

A device that measures the strength of a magnetic field.

Energy waves

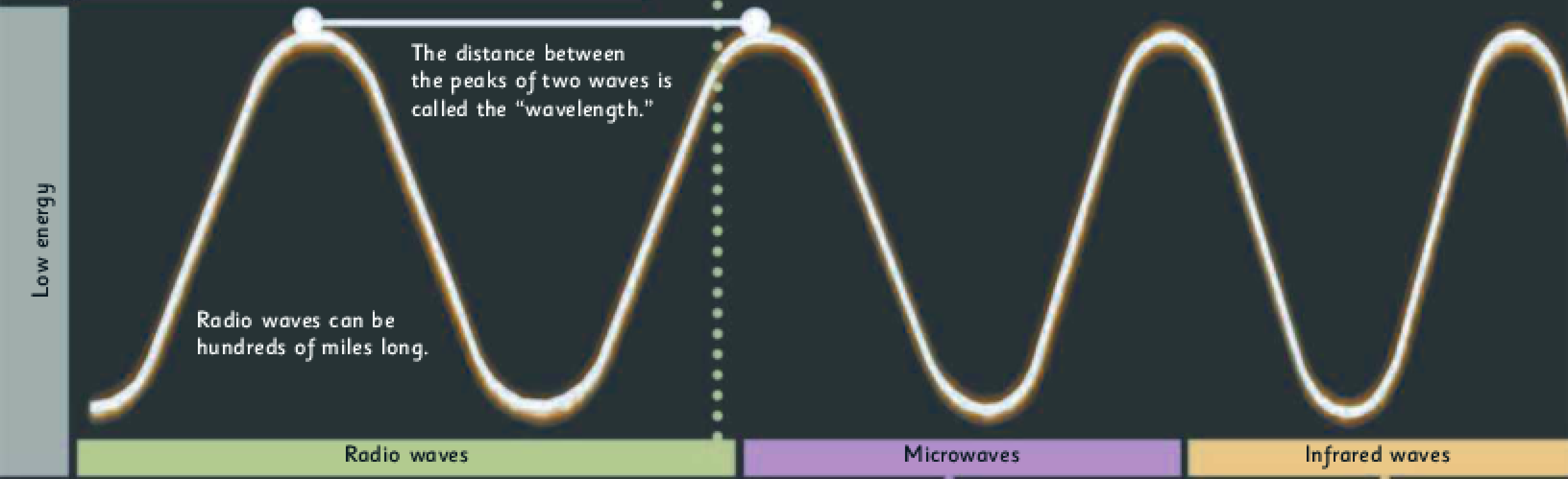
A form of energy called "electromagnetic radiation" travels in waves, like waves on the surface of a pond. Just as waves in a pond can be close together or far apart, different types of electromagnetic radiation have different wavelengths.

The spectrum

Visible light is a type of energy wave that we can see. There are other waves that are not visible to us, such as radio waves. The spectrum is made up of different types of waves, with varying wavelengths.

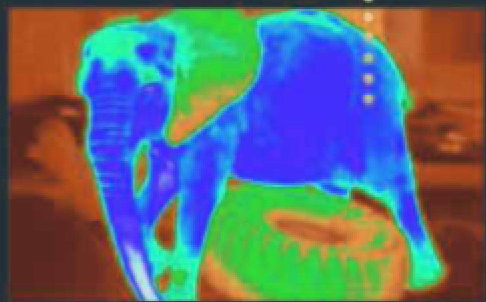
Radio waves

Radio waves have the longest wavelengths and are good at traveling far. Radio and TV programs are broadcast as radio waves.



Microwaves

Microwaves are used to heat food in microwave ovens. They are also used by mobile phones and by satellites in space.



Infrared waves

Hot objects give off invisible rays of heat called infrared waves. An infrared camera can detect these waves to create images.

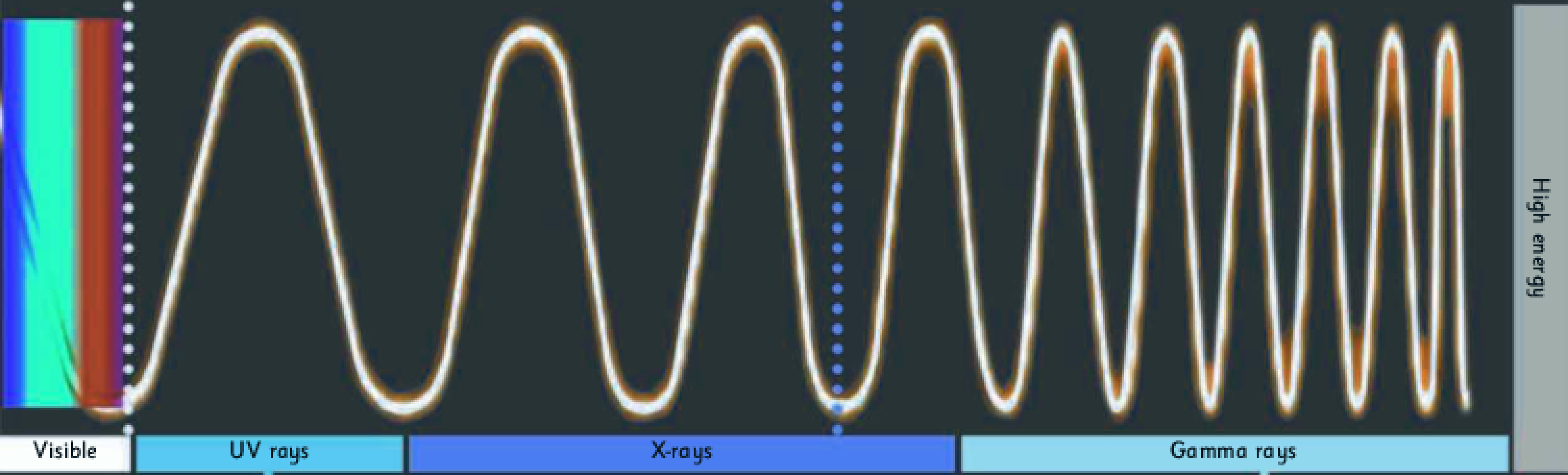
What is invisible to human eyes but visible to the eyes of a bee?

Visible light

Light waves bounce off every object around us, allowing us to see things. Visible light includes all the colors of the rainbow, each of which has a particular wavelength.

X-rays

X-rays are invisible waves that pass through soft parts of the body but not bone. This is why doctors can use X-rays to take images of bones.



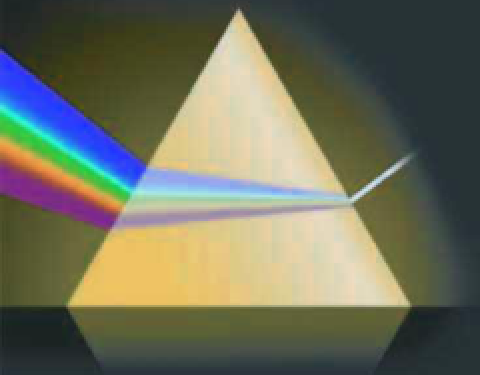
Ultraviolet (UV) light

In addition to producing visible light, the Sun produces invisible rays of ultraviolet light. UV light makes you tan but too much of it can cause skin cancer and eye damage.

Gamma rays

The wavelengths of gamma rays can be as small as the nucleus of an atom. Gamma rays are packed with energy, which makes them powerful. They are used in hospitals to kill cancer cells.

This man is being treated with gamma rays to kill cancer cells inside his body.



Light

Light is a form of energy that our eyes can detect. It comes in all the colors of the rainbow, but when the colors are mixed together, light is white.

Fireflies

Some animals create their own light. Fireflies flash a yellowish-green color from their abdomens at night to attract mates.

Where does light come from?

Light is produced by electrically charged particles in atoms—especially negatively charged electrons.

Candlelight is produced by hot atoms in tiny particles of soot inside the flame.

Casting shadows

Light can only travel in straight lines. If something blocks its path, it casts a shadow—a dark area that the light cannot reach.

Using light

We can use light for many different things.

CDs and **DVDs** store digital information that can be read by laser beam.

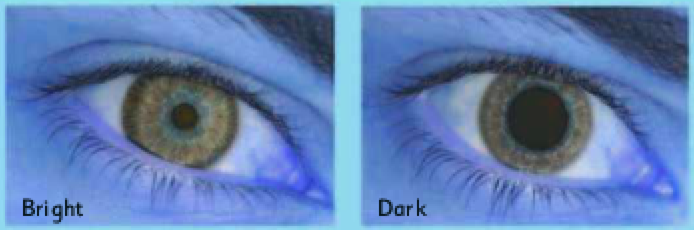
Cameras capture light in a split second to create photographs.

Telescopes collect the light from stars and planets, and produce magnified images of them.

Mirrors reflect light so we can see images of ourselves.

Periscopes bend the path of light so we can see around corners.

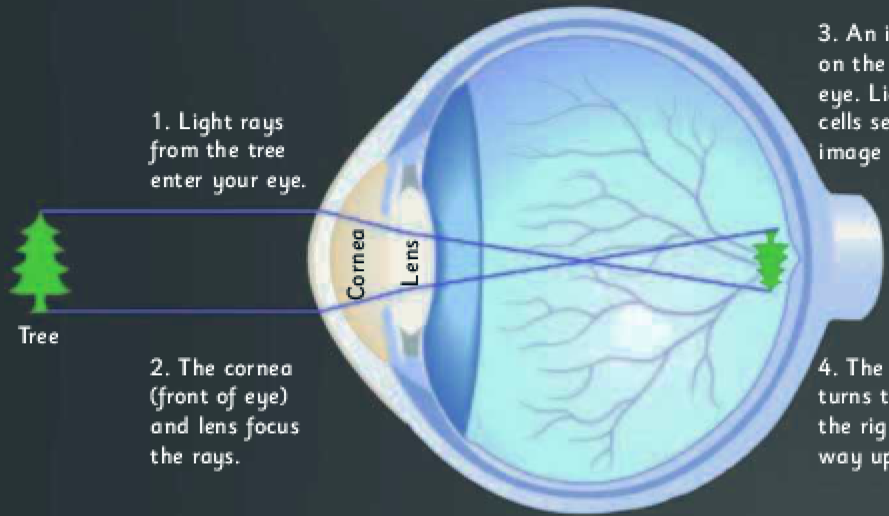
Flashlights shine a beam of light to help us see in the dark.



Light enters your eyes through your pupils (the black circles in the middle). Pupils can change size. When it's dark they get bigger to let more light in, and when it's bright they shrink so you don't get dazzled.

How your eye works

The human eye works like a camera. The front parts of the eye focus light rays just as a camera lens does. The focused rays form an upside-down image in the back of your eyeball.



1. Light rays from the tree enter your eye.

2. The cornea (front of eye) and lens focus the rays.

3. An image forms on the back of the eye. Light-sensing cells send the image to the brain.

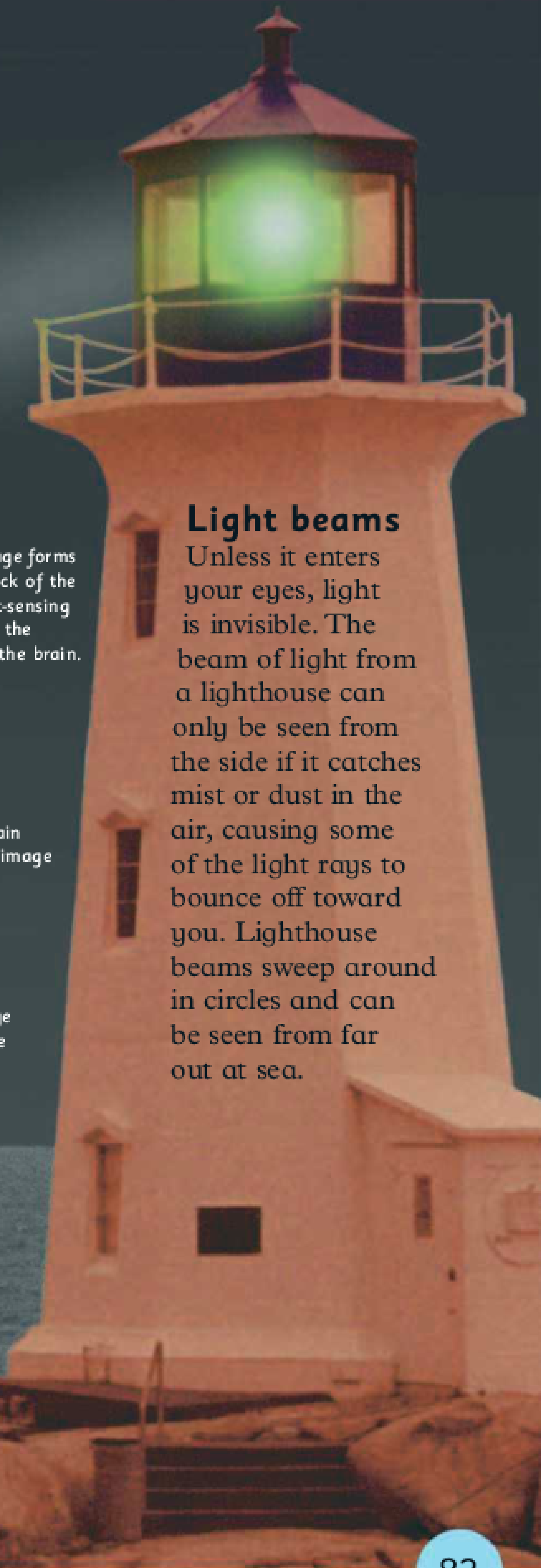
4. The brain turns the image the right way up.

Reflecting light

When light hits a mirror, it bounces right back off. If you look into a mirror, you see this bounced light as a reflection.

Convex mirrors bulge outward. They make things look smaller but let you see a wider area.

Concave mirrors bulge inward. They make things look bigger but show a smaller area.



Light beams

Unless it enters your eyes, light is invisible. The beam of light from a lighthouse can only be seen from the side if it catches mist or dust in the air, causing some of the light rays to bounce off toward you. Lighthouse beams sweep around in circles and can be seen from far out at sea.

Light. It travels at 600,000,000 mph (1 billion kph).

Sound

Every sound starts with a vibration, like the quivering of a guitar string. The vibration squeezes and stretches the air, sending its energy out in waves in all directions. This is a sound wave.

Sound notes

When you blow across a bottle, the air inside vibrates. Small air spaces vibrate more quickly than large spaces, making higher notes. So partly empty bottles produce lower notes than fuller ones.

Silent space

Sound can travel through solids, liquids, and gases, but it can't travel where there is no matter. There is no sound in space because there is no air.

Measuring sound

Loudness is measured in decibels.

Leaves rustling nearby make a sound of only 10 decibels.

Somebody **whispering** close by measures about 20 decibels.

City traffic reaches approximately 85 decibels.

Drums being played nearby makes a sound of around 105 decibels.

Road-drills measure about 110 decibels from a close distance.

A **lion's roar** would measure 114 decibels if you were close enough.

Fireworks can measure 120 decibels or more.

The sound of **jet engines** sometimes hit 140 decibels if heard from nearby.

Sound waves travel through air like a wave along a coiled spring.

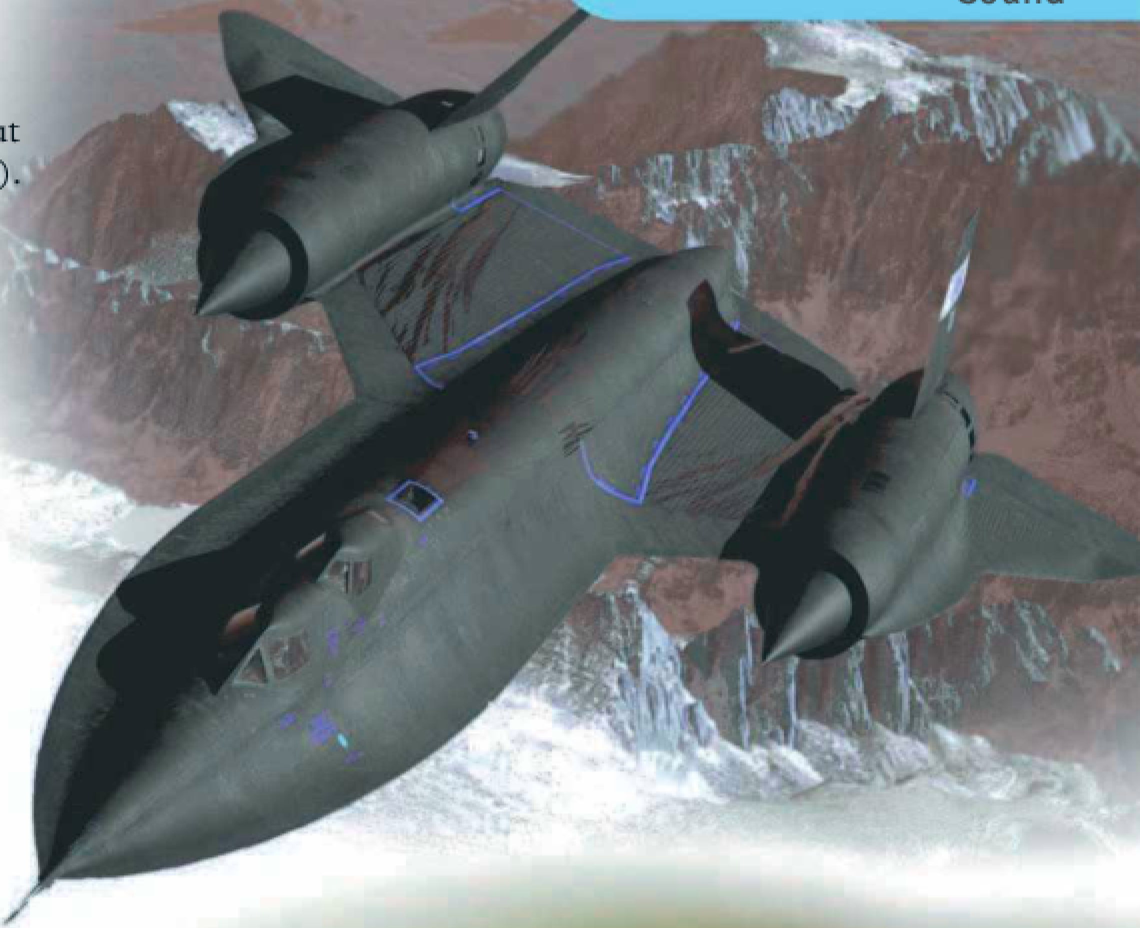
How hearing works

When a sound reaches your ears, it makes your eardrums vibrate. The vibrations are passed to your inner ear through tiny bones. From here, nerves send messages to your brain that allow you to recognize the sound.

Do all animals hear sounds in the same way?

Speeding sound

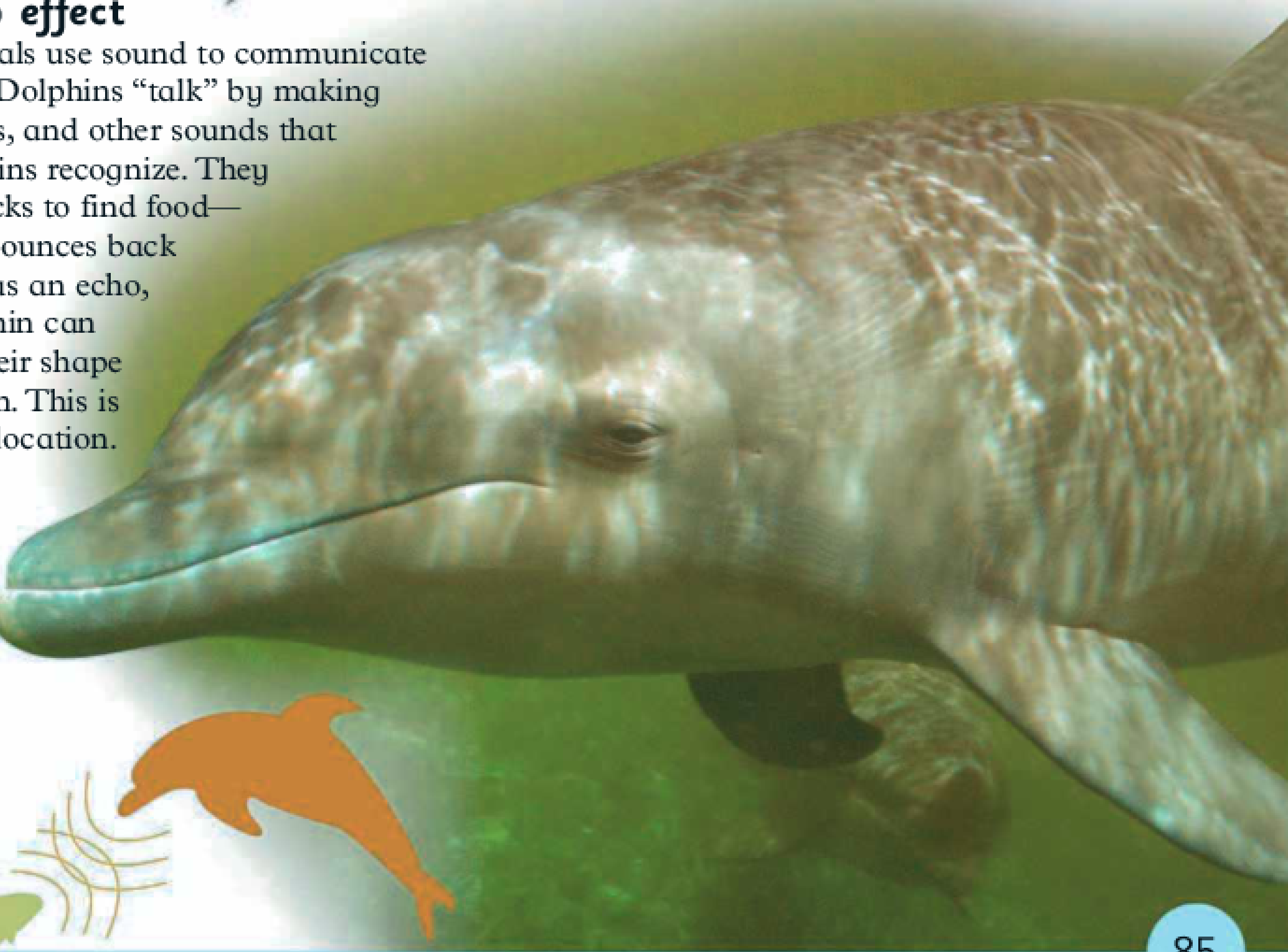
Sounds travel through air at about 750 mph (1,200 kph). It travels faster through solids and liquids than through gases. Supersonic jets fly faster than the speed of sound, so they can pass over you before you hear their sound.



When a supersonic jet breaks the speed of sound, it catches up with the sound waves in front of it and squashes them. As the air is squashed, it produces a sound called a "sonic boom."

The echo effect

Some animals use sound to communicate or to hunt. Dolphins "talk" by making clicks, barks, and other sounds that other dolphins recognize. They also use clicks to find food—the sound bounces back off objects as an echo, so the dolphin can establish their shape and position. This is called echolocation.



When sounds bounce back, the dolphin can tell if the object is a yummy fish or another dolphin!

No—dogs and bats can hear higher notes than people.

Heat

Atoms and molecules are always jiggling around. The faster they move, the more energy an object has. We feel this energy as heat. When something is hot, its atoms are moving quickly. When something is cold, its atoms are moving slowly.

Sources of heat

Heat can be produced in several different ways.

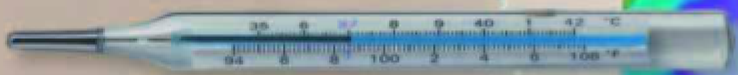
Friction (rubbing) makes heat. If you pull on a rope, your hands will feel warm.

Combustion means burning. When something burns, it produces heat.

Electricity is used to create heat in electric ovens and heaters.

Feel the heat

Heat always tries to spread from hot things to cooler things. When you touch a hot object, heat energy flows into your skin, triggering sense cells that make your skin feel hot. When you touch a cold object, heat flows out of your skin, triggering a different feeling.



Temperature

The temperature of an object tells you how hot it is on a numbered scale. A device called a thermometer is used to measure temperature.

Warm glow

Heat escapes from warm objects as invisible rays that travel like light. We call this infrared radiation. Special cameras use infrared rays rather than light to take photos. Hot areas appear white or red and cold areas, such as this ice pop, appear black.

Keep your cool

Heat travels from the Sun as infrared rays. Just like light, infrared rays are reflected away by white objects but absorbed by black objects. In hot countries, people paint houses white to reflect the heat and keep the indoors cool.

Free ride

When land gets hot, it warms the air above it. The warm air rises. Birds use these areas of rising air (thermals) to lift them high in the sky.

Eagles can fly without flapping when they catch a thermal.

Conduction

Heat spreads through solids by a process called conduction. Hot atoms, which move around a lot, knock into cooler atoms and make them jiggle faster, passing on the heat energy.

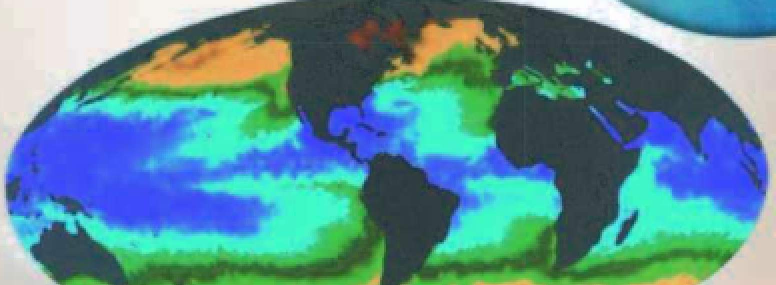
Heat is spreading along this metal bar. Metal is good at conducting heat quickly.

Convection

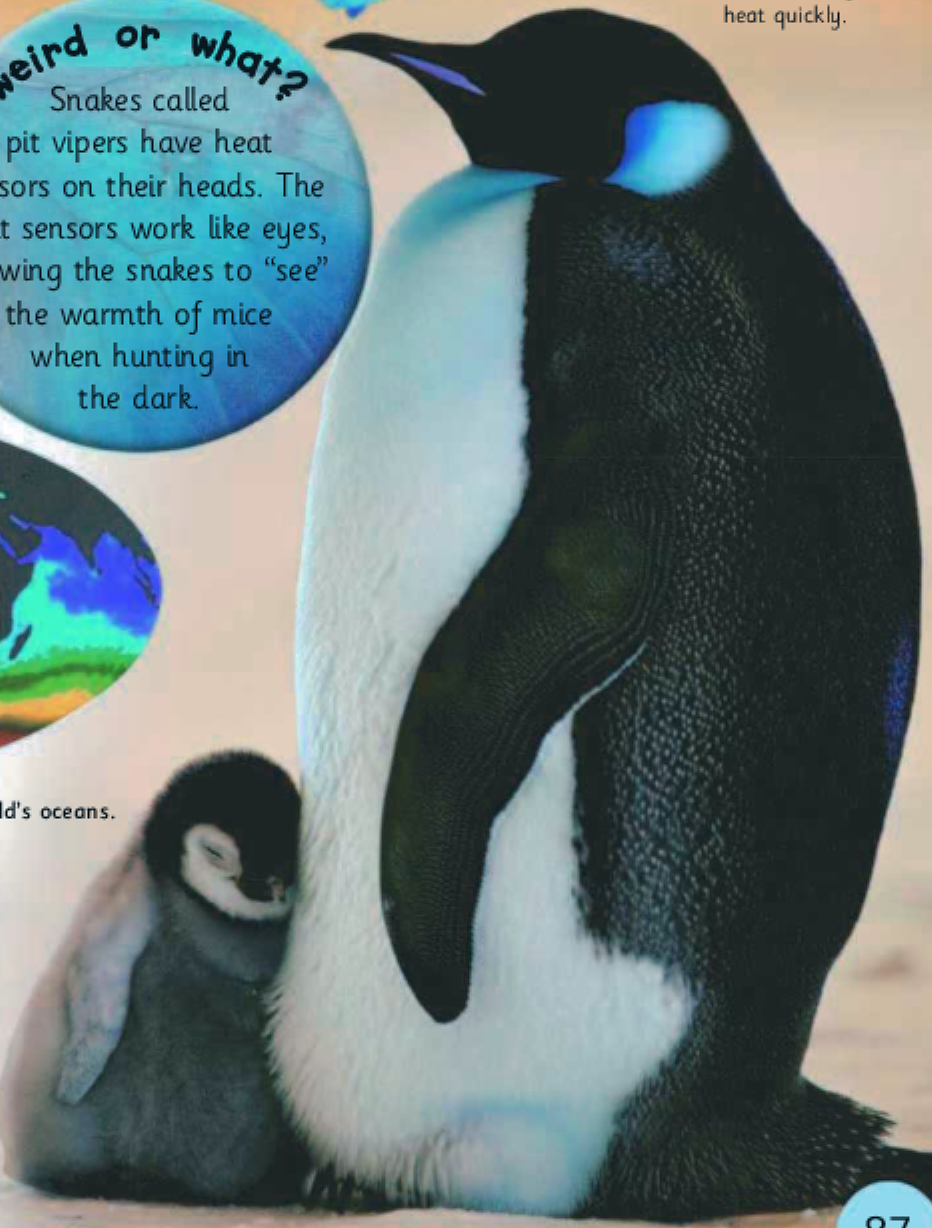
When air or water warms up, it rises, and cool air or water sinks to take its place. This process is called convection. Convection helps keep the ocean currents moving, spreading heat around the world.

Weird or what?

Snakes called pit vipers have heat sensors on their heads. The heat sensors work like eyes, allowing the snakes to "see" the warmth of mice when hunting in the dark.



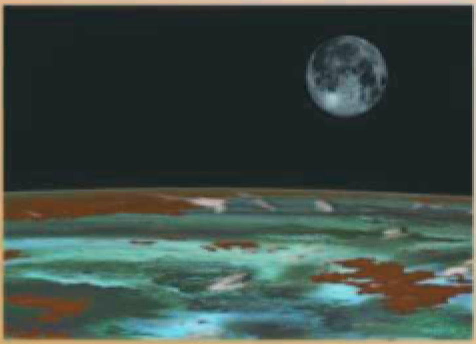
This satellite image shows the temperature of the world's oceans.



Keeping warm

Emperor penguins live in the icy Antarctic. Their feathers trap air, which stops heat from escaping from their bodies by conduction. This trapping layer is called insulation.

Yes, if you use it to build an igloo. Snow is a good insulator.



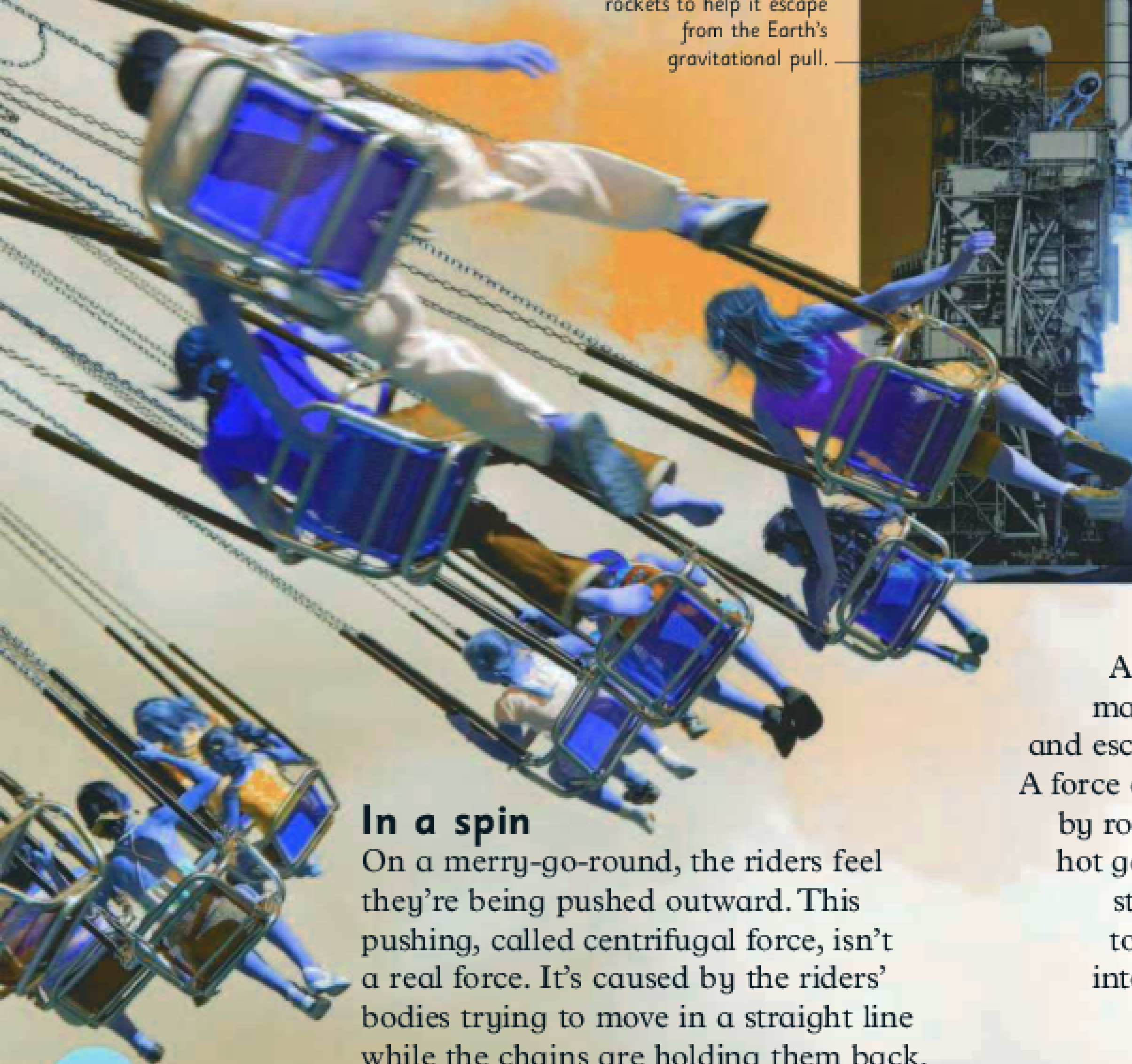
Forces

A force is simply a push or a pull. When you push or pull something to make it move, you are using forces. Some forces work only when objects are touching, but others, such as gravity and magnetism, work at a distance.

Gravity

The force that makes things fall to the ground is gravity. Gravity keeps the Earth in orbit around the Sun and keeps the Moon in orbit around the Earth. It is one of the most important forces in the universe.

This NASA space shuttle, which was in operation until 2011, needed three rockets to help it escape from the Earth's gravitational pull.



Lift-off

A huge force is needed to make a spacecraft take off and escape the Earth's gravity. A force called thrust is provided by rockets. The rockets make hot gases, which expand and stream out at the bottom to push the spacecraft up into the air at great speed.

In a spin

On a merry-go-round, the riders feel they're being pushed outward. This pushing, called centrifugal force, isn't a real force. It's caused by the riders' bodies trying to move in a straight line while the chains are holding them back.

What force makes compass needles point toward the North Pole?

Friction slows down a skier.

Friction

When objects rub or slide against each other, they create a force called friction. Friction slows down moving objects and wastes their energy, turning the energy into heat.

hands on

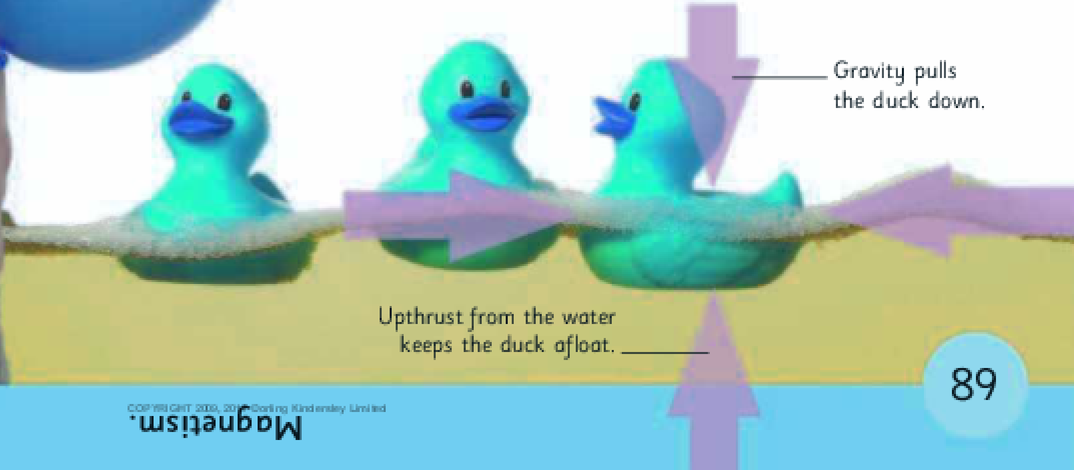
Rub your hands together as hard and fast as you can for 10 seconds and see how hot they get. The heat is caused by the force of friction acting on your skin.

Electric forces

When objects become charged with electricity, they pull on each other with an invisible force that is a bit like magnetism. If you rub a balloon on your hair, the balloon becomes charged and will stick to your shirt.

Buoyancy

What makes objects float? The answer is a force called buoyancy. If an object is lighter than water, the force of buoyancy outweighs gravity and the object floats.



Forces and motion

It can be difficult to make an object move, but once it is moving, it will continue to move until something stops it. Force is needed to start something moving, make it move faster, and make it stop.

The soccer ball would stay still if the player didn't kick it.

Newton's laws of motion

In 1687, Isaac Newton presented three important rules that explain how forces make things move. They have become the foundation of physics and work for just about everything, from soccer balls to frogs.

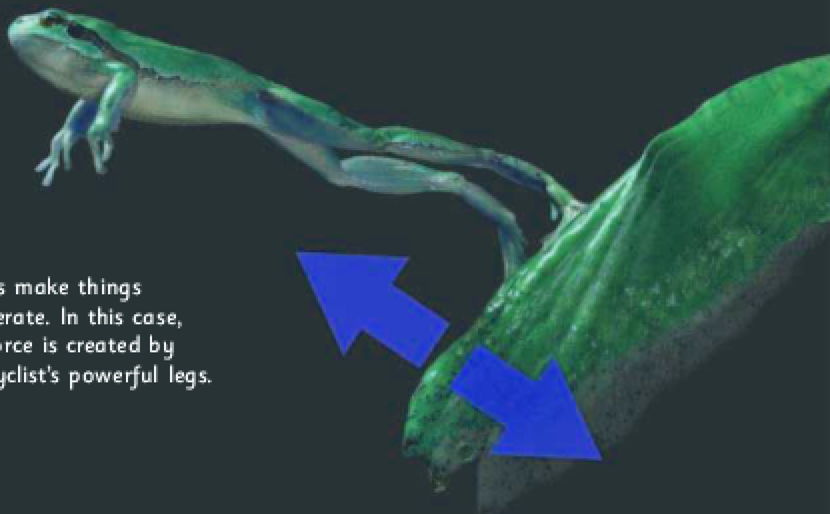
Newton's first law

An object stays still, or keeps moving in a straight line at a constant speed, if it isn't being pushed or pulled by a force.

Forces make things accelerate. In this case, the force is created by the cyclist's powerful legs.

Newton's second law

The bigger the force and the lighter the object, the greater the acceleration. A professional cyclist with a lightweight bike will accelerate faster than a normal person cycling to work.

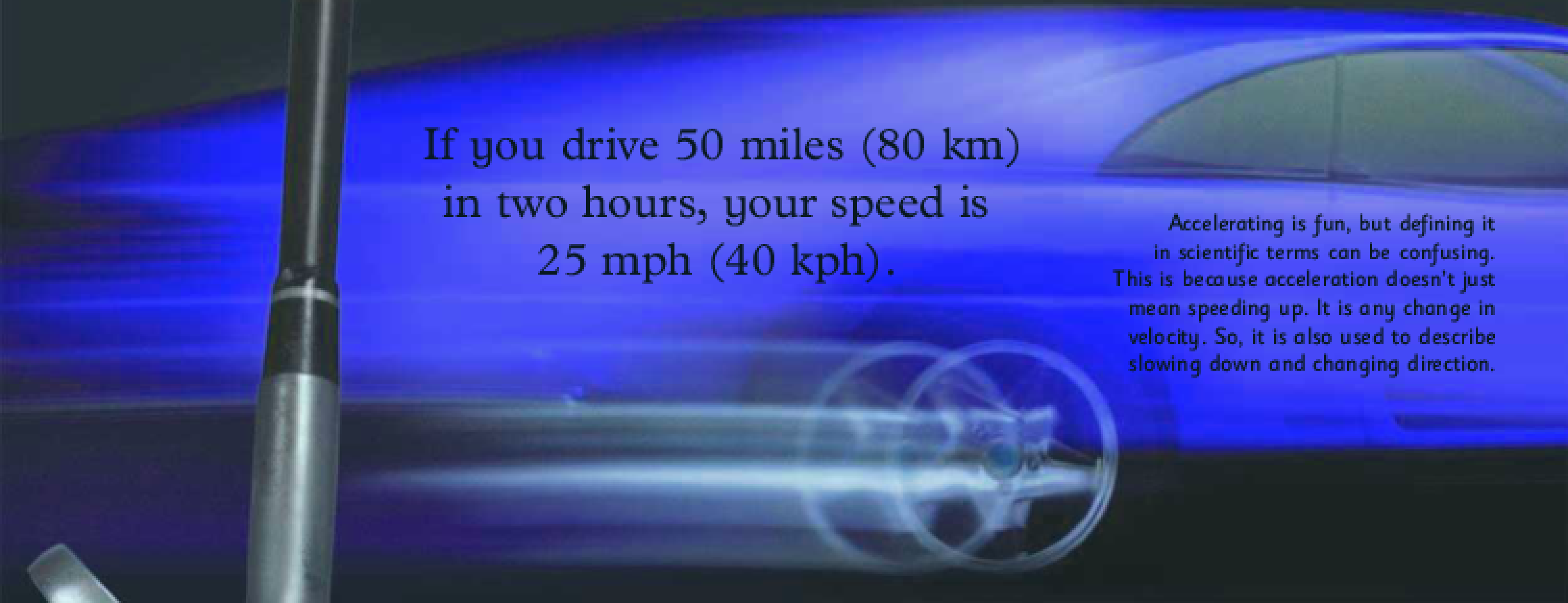


Newton's third law

Every action has an equal and opposite reaction. The leaf moves away as the frog leaps in the opposite direction.

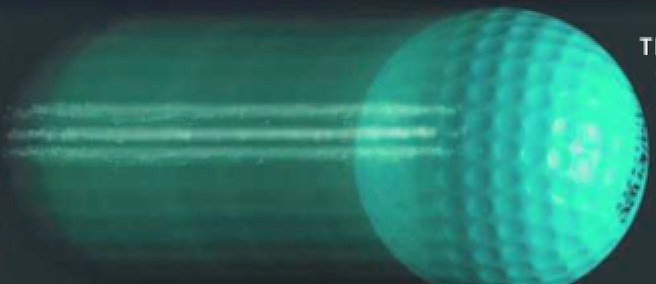
Speed and velocity

Speed is different from velocity. Speed is how fast you are going and is easy to determine—divide how far you travel by the time it takes. Your velocity is how fast you travel in a particular direction. Changing direction without slowing reduces your velocity, but your speed stays the same.



If you drive 50 miles (80 km) in two hours, your speed is 25 mph (40 kph).

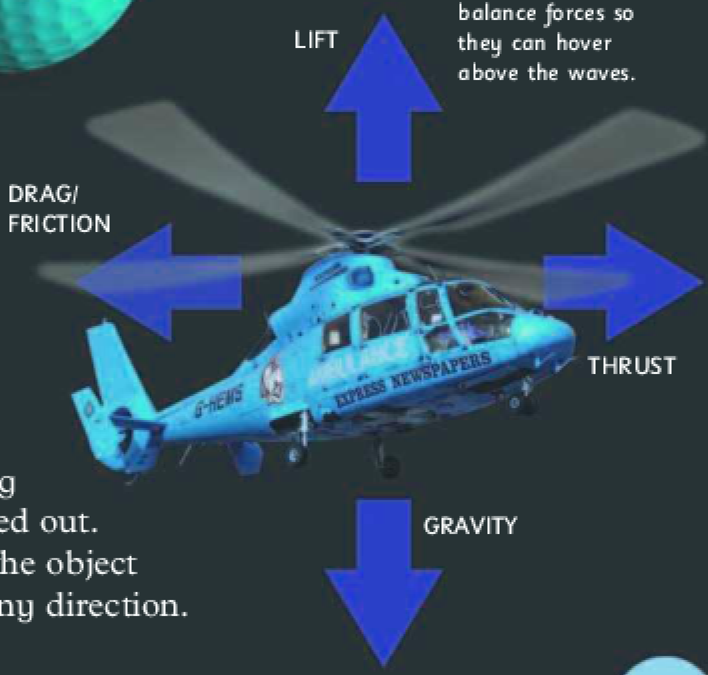
Accelerating is fun, but defining it in scientific terms can be confusing. This is because acceleration doesn't just mean speeding up. It is any change in velocity. So, it is also used to describe slowing down and changing direction.



The golf ball will keep rolling until friction, gravity, and air resistance slow it down.

Inertia

When things are standing still or moving, they continue to remain in the state they are in (unless force is applied to them to change it). This tendency to be as they are is called inertia.



Rescue helicopters balance forces so they can hover above the waves.

Turn and learn

Magnetism: **pp. 78-79**
Gravity: **pp. 88-89**

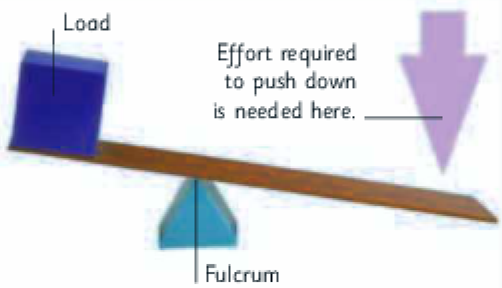
Balanced forces

Forces act on objects all the time. Opposing forces can be balanced out. When this happens, the object won't be pushed in any direction.

The maximum velocity of falling through air is 125 mph (200 kph).

Machines

Machines make tasks easier. They reduce the effort you need to move something or the time that it takes. They work either by spreading the load or by concentrating your efforts. All the machines you see here are called simple machines.



Levers

A lever is a bar that can turn around a fixed point (fulcrum). If you apply a force (effort) to one part of a lever, another part exerts a force (load).

One type of lever works like a seesaw with the fulcrum between the load and the effort.

Another type places the load between the fulcrum and the effort (as on a wheelbarrow).

A **third type** of lever, shown by tongs, places the effort between the fulcrum and the load.

Wheel and axle

An axle goes through the center of a wheel. Together they work as a simple rotating machine that makes it easier to move something from one place to another.

Gears

Gears are wheels with teeth that interlock so that one wheel turns another. They increase speed or force. Gears on a bicycle affect how much you must turn the pedal to spin the wheel.

The pedal turns a wheel, which turns a smaller wheel at a greater speed.

hands on

Try walking straight up a hill and then zigzag your way up. The winding path works like a simple machine. It increases the distance you walk, but decreases the effort you use.

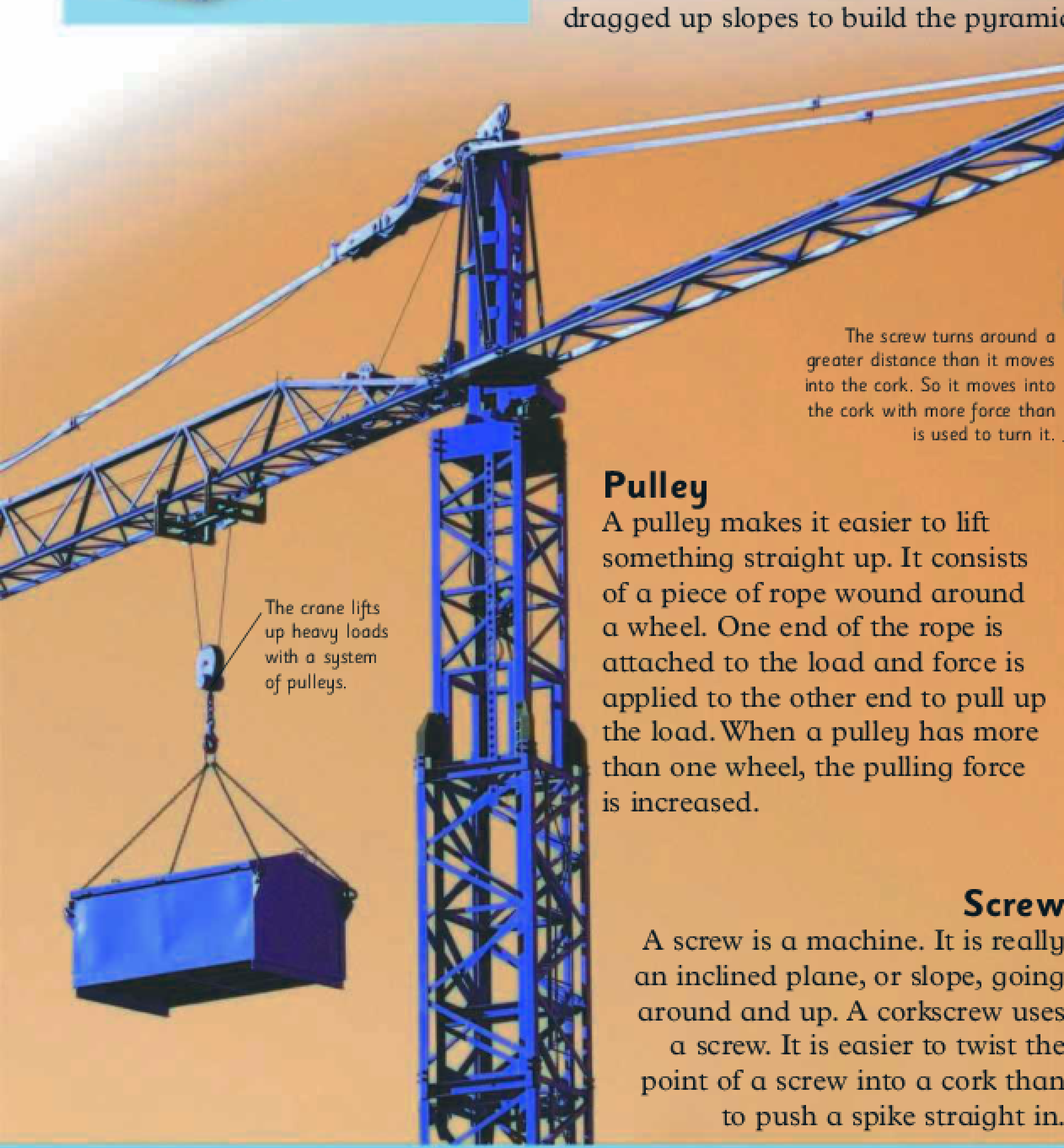
What is another name for gear?

Wedge

An ax blade is an efficient but simple machine that increases force. When it hits the wood, the wedge forces the wood to split apart between its fibers.

Inclined plane

It is easier to push or pull something up a slope than lift it straight up. A slope, or inclined plane, therefore increases force. In ancient Egypt, stones were dragged up slopes to build the pyramids.



Pulley

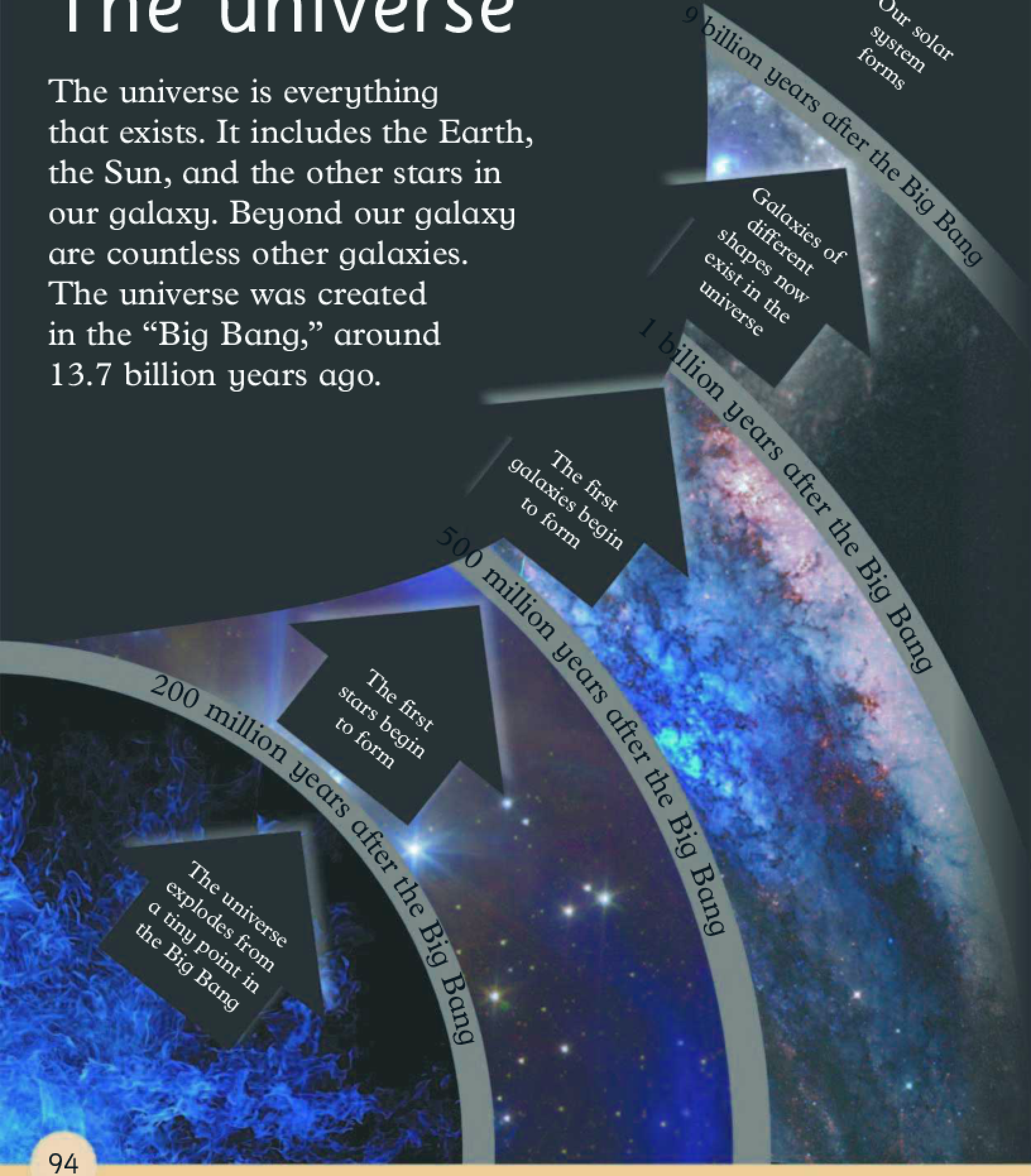
A pulley makes it easier to lift something straight up. It consists of a piece of rope wound around a wheel. One end of the rope is attached to the load and force is applied to the other end to pull up the load. When a pulley has more than one wheel, the pulling force is increased.

Screw

A screw is a machine. It is really an inclined plane, or slope, going around and up. A corkscrew uses a screw. It is easier to twist the point of a screw into a cork than to push a spike straight in.

The universe

The universe is everything that exists. It includes the Earth, the Sun, and the other stars in our galaxy. Beyond our galaxy are countless other galaxies. The universe was created in the "Big Bang," around 13.7 billion years ago.



How many stars are there in the Milky Way?

Galaxies

Galaxies are groups of stars held together by gravity. There are more than 100 billion stars in a typical galaxy. Galaxies are different shapes. Some are spirals and some are oval.

Near neighbor

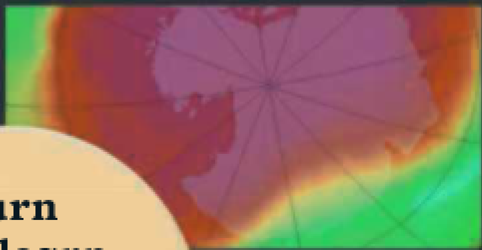
The nearest galaxy to our own is the spiral-shaped Andromeda galaxy. It would take around 2.2 million years to get there—if you were traveling at the speed of light!

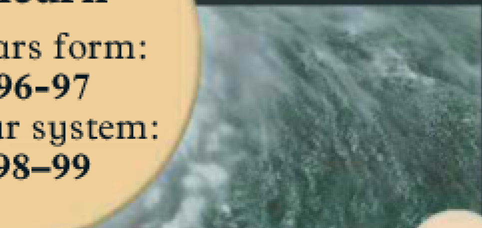
The Milky Way

Our solar system is part of a galaxy called the Milky Way. From the inside (where we are), it looks like a haze of light in the sky.

Picture detective

Look through the Earth and Space Science pages. Can you identify the picture clues below?





Turn and learn

How stars form: **pp. 96–97**
The solar system: **pp. 98–99**

Between 200 billion and 400 billion.

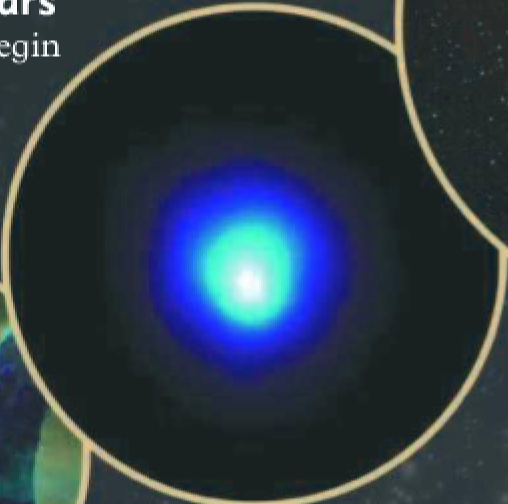
Starry skies

There are many more stars in the universe than there are grains of sand on all the beaches on the Earth. Many are far brighter than our Sun.

The lives of stars

The lives of stars begin inside thick clouds of gas in space, called nebulae.

Nebulae
Gravity pulls together little knots of dust and gas inside the nebulae. Each one could become a star, as gravity squeezes it tighter and it becomes hotter.



Red giants
Stars are fueled by the gas hydrogen. They burn until the hydrogen starts to run out. Then they expand, forming a red giant star.

White dwarfs
The outer layers of the star are eventually thrown off into space. The cooling core is left behind. This is called a white dwarf. White dwarfs are no bigger than the Earth.

Supernovae
The most massive stars end their lives in huge supernovae explosions.

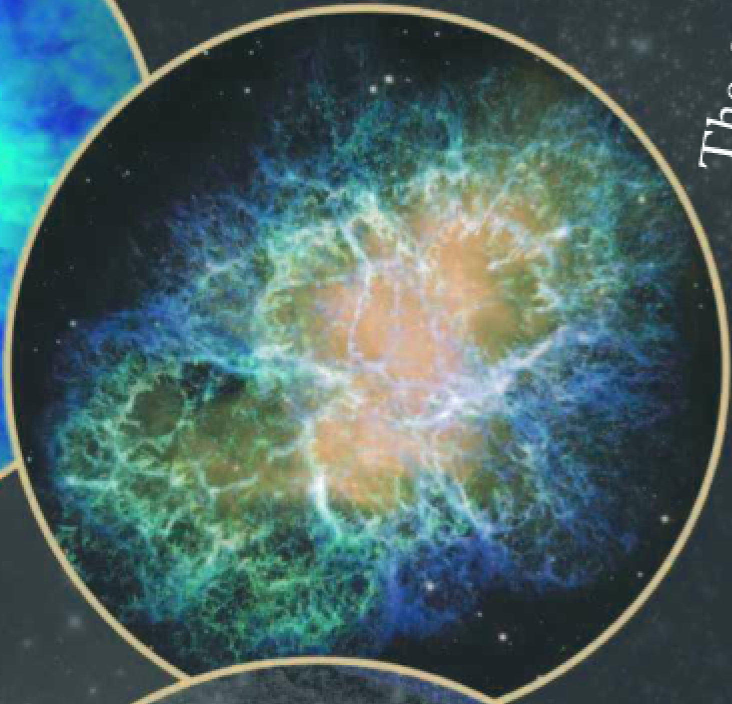
Leave a camera shutter open for a few hours on a clear night and you can see the stars leave trails as the Earth rotates.

Stars in motion

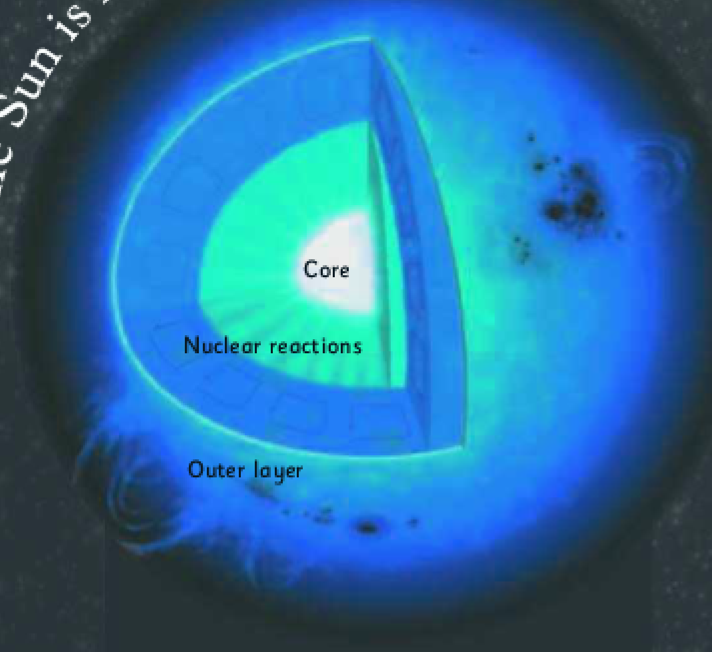
The position of the stars seems to change throughout the night. The stars are not really moving, though. It is the Earth that is turning beneath them.

How many stars can you see on a clear, dark night?

Remnants
The fragments of the star can remain glowing in space for hundreds of years.



The Sun is made mostly of hydrogen.



Starshine

Our Sun is a star that is halfway through its life. In the life cycle, it sits between being formed within a nebula and becoming a red giant.

Black holes
When the biggest stars explode, most material is blown outward. But the core is crushed and collapses to form a black hole.

Shapes in the sky

Hundreds of years ago, people grouped stars that appear close together in the sky into shapes called constellations. They all have names—often related to their shapes. This is the Big Dipper, in Ursa Major.

About 2,000.

The Moon

Our Moon is a cold, dusty world that moves around the Earth in space. There is no air and almost no water on the Moon, so nothing can live there. Scientists think that the Moon is around 4.5 billion years old.

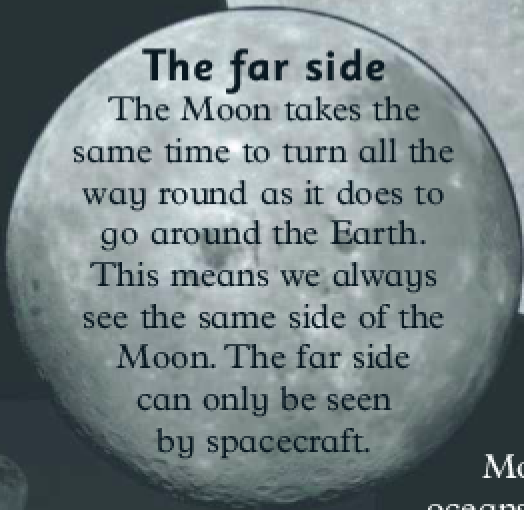
The Moon spins once during each orbit of the Earth.

In addition to craters, there are mountains and valleys on the Moon's surface.

Battered surface

The surface of the Moon is covered in craters. These have been caused by meteors crashing into it over millions of years.

From the Earth, we only see the near side of the Moon.



The far side

The Moon takes the same time to turn all the way round as it does to go around the Earth. This means we always see the same side of the Moon. The far side can only be seen by spacecraft.

Orbiting Moon

The Moon moves around the Earth once every 27 days. As the Moon, Sun, and Earth move, we see different amounts of the Moon lit by the Sun each night. These different views are called "phases."

Ocean bulges

The pull of gravity between the Moon and the Earth tugs on the Earth's oceans, making them bulge on either side of the planet. As the Earth turns, once every 24 hours, different parts of the oceans bulge—the sea's tides rise and fall.

Between the periods the water bulges, the ocean falls and it is low tide.

As each bulge arrives, the ocean rises and it is high tide.

Moon men

The Moon is the only celestial world that humans have visited. In 1969, astronauts walked on the Moon for the first time.

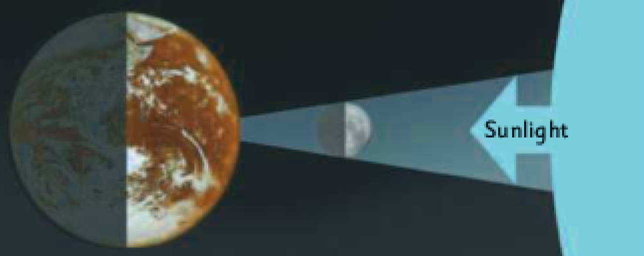
Astronaut Buzz Aldrin walking on the Moon

Lunar eclipse

When the Earth passes exactly between the Moon and the Sun, the Earth's shadow falls on the Moon and blocks out most of its light. This is called a lunar eclipse.

Solar eclipse

When the Moon passes exactly between the Earth and the Sun, it totally or partially blocks the Sun. This is a solar eclipse.

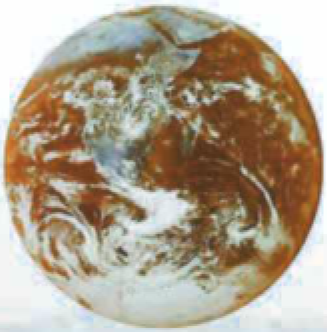


Total eclipse

A total solar eclipse occurs when the Moon blocks the Sun fully. Not all parts of the world can view a total eclipse.

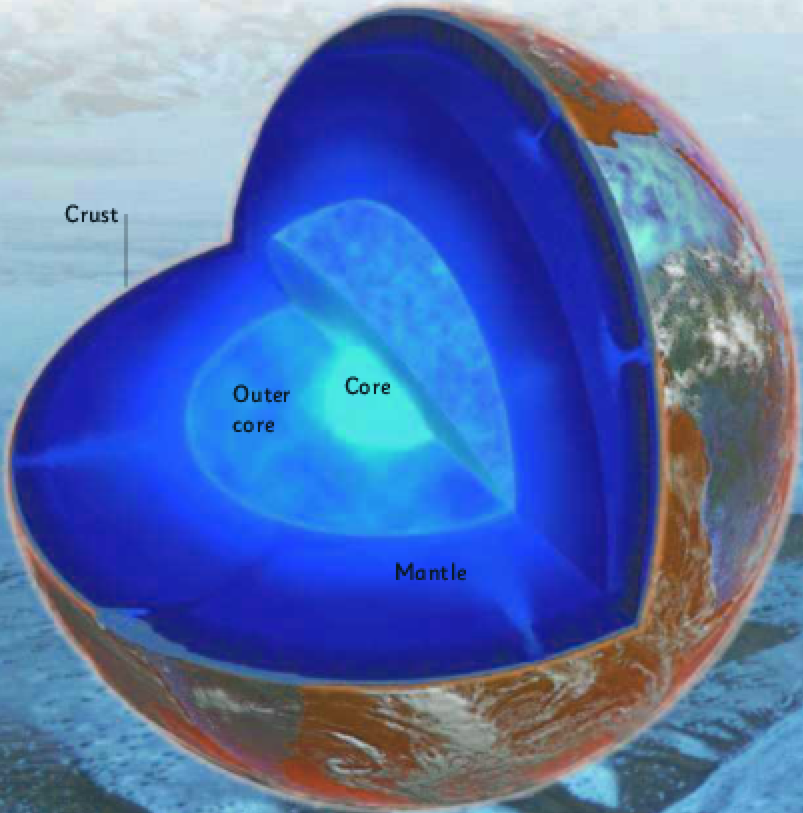
Around 239,000 miles (384,000 km).

The Earth's structure



Seen from space, the Earth is a mass of blue oceans and swirling clouds.

The Earth is the only planet in the solar system that can support life because it's just the right distance from the Sun. Our amazing world is a huge ball of liquid rock with a solid surface.



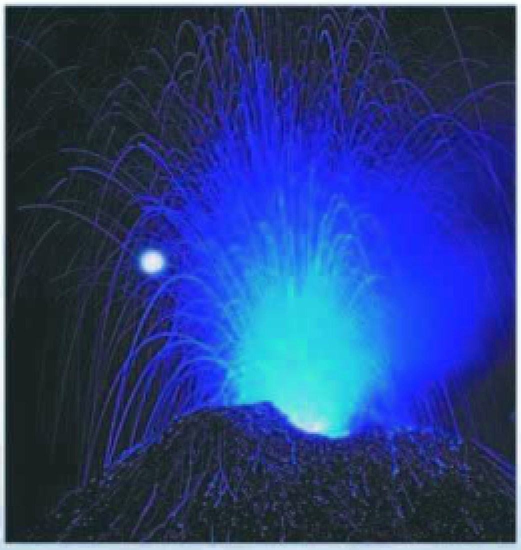
Inside the Earth

If you could cut the Earth open, you'd see it's made up of layers. The thin top layer, where we live, is called the crust. Underneath is a layer of syruplike rock called the mantle, then an outer core of molten (liquid) iron and nickel. At the center is a solid iron-and-nickel core.

Life-support systems

The Earth's atmosphere and its surface water play an important role in supporting life. They help keep our planet at just the right temperature by absorbing the Sun's heat and moving it around the world.

What is the biggest ocean on the Earth?



Volcanoes

Volcanoes are openings in the Earth's crust. Sometimes, magma (melted rock) from just beneath the crust bursts through these openings as a volcanic eruption. Lots of ash and dust shoot out, too.

Making mountains

The Himalayas started to form 50 million years ago, when two moving plates collided. The mountains are still growing! Mount Everest, the tallest peak in the world, is a part of the Himalayan range and is growing ¼in (4 mm) each year.

Fault lines

Earthquakes happen when two plates of the Earth's crust rub against each other. The boundary between the plates is called a fault line.

Earthquakes often occur along the San Andreas Fault.

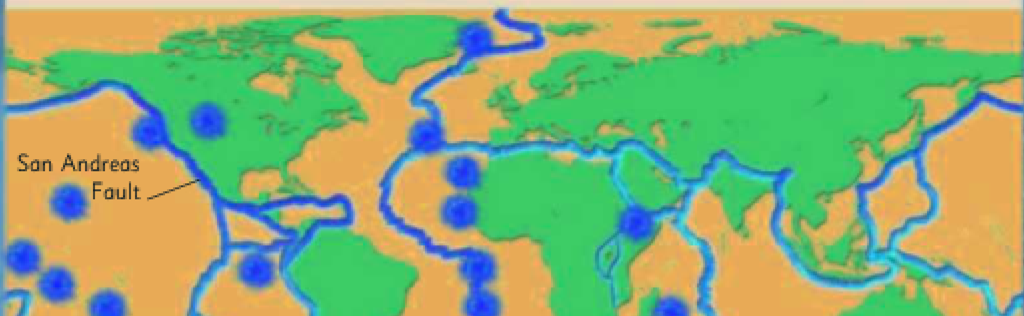
Drifting continents

The world hasn't always looked like it does now. Millions of years ago, all the land was joined together. Slowly, it broke up and the continents drifted apart.

200 million years ago — 135 million years ago — 10 million years ago

Cracked crust

The Earth's top layer is made up of giant pieces called "plates." These fit together like a jigsaw puzzle, but they're constantly moving. Volcanoes and earthquakes often happen in the weak spots where plates move against each other.



Rocks and minerals

Serpentine is a mineral that stone carvers use to create works of art.

Gabbro is a rock that is used to make kitchen surfaces and floors.

White mica is a mineral that you can find in some kinds of toothpaste.

The Earth's crust is made up of different rocks. Some of these are hard but others are soft and crumbly. They are formed in different ways.

What is a rock?

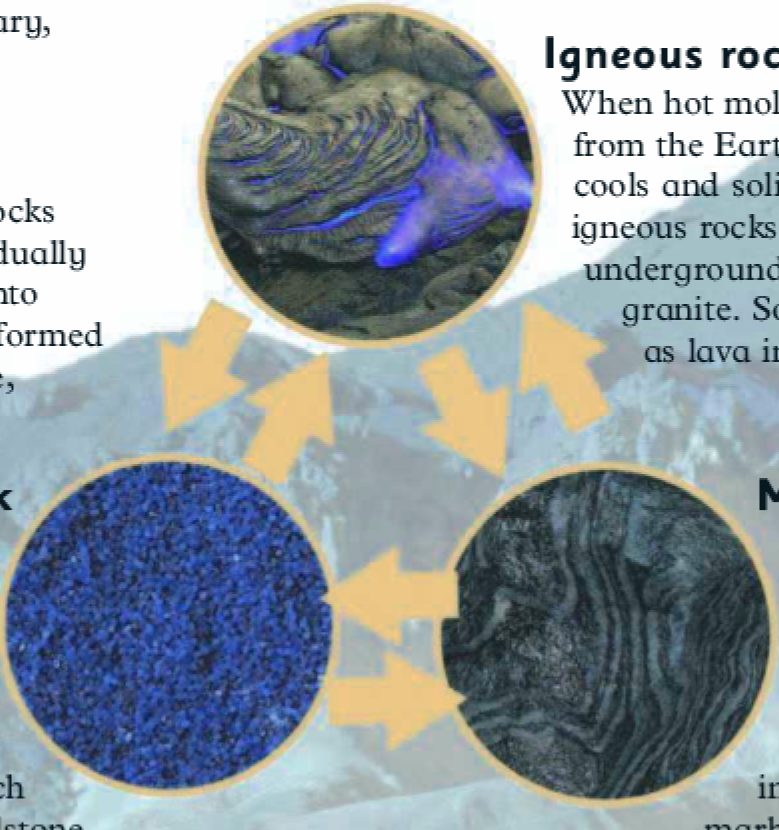
A rock is formed from minerals. Most rocks are made up of different minerals, but some contain just one. There are three main types of rock: igneous, sedimentary, and metamorphic.

Fossils in stones

Fossils are the remains or imprints of plants and animals that died millions of years ago, preserved in stone.

The rock cycle

Over many years, the rocks in the Earth's crust gradually change from one type into another. They are transformed by wind, water, pressure, and heat.



Igneous rock

When hot molten magma from the Earth's interior cools and solidifies, it forms igneous rocks. Some harden underground, such as granite. Some erupt first as lava in a volcano.

Sedimentary rock

Wind and water wear rocks away. Small pieces wash into the sea. These settle into layers, which pack together to form sedimentary rocks, such as limestone and sandstone.

Metamorphic rock

Sometimes rocks are crushed underground, or scorched by hot magma. Then they may be transformed into new rocks, such as marble, slate, and gneiss.

Which type of rock floats on water?

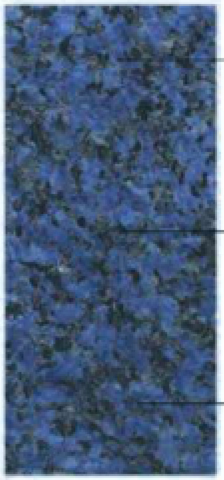
Rock salt is a mineral that is spread on roads in icy weather. It makes the ice melt.

What is a mineral?

A mineral is a solid that occurs naturally. It is made up of chemicals and has a crystal structure. Minerals are everywhere you look. We use minerals to build cars and computers, fertilize soil, and to clean our teeth.

Mineral mixtures

Granite rock is made up of different colored minerals. The black mineral is mica, the pink is feldspar, and the gray mineral is quartz.



Feldspar is used for glazing ceramics.

Mica is ground up and used in paint.

Quartz can also occur as the gemstone amethyst.

Crystals

Minerals usually form crystals. Crystals have a number of flat surfaces. The largest crystals form when minerals in magma or trapped liquids cool very slowly.

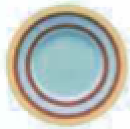
Quartz stalactites form in caves over thousands of years.

Minerals in your home

Minerals make up many common objects.

Halite is the natural form of salt, which we add to our food for flavor.

Quartz from sand is used to make the silicon chips in calculators and computers.



Kaolinite is used to make dishes. It is also used to make paper look glossy.

Illite is a clay mineral and is used in terra-cotta pots and bricks.

Mica is used to make glittery paint and nail polish.

Graphite is the lead in pencils. It is also used in bicycle brakes.

Rhodochrosite is a rose-colored gemstone used in jewelry.

Pumice—it is filled with air bubbles, so some pieces can float.

Shaping the land

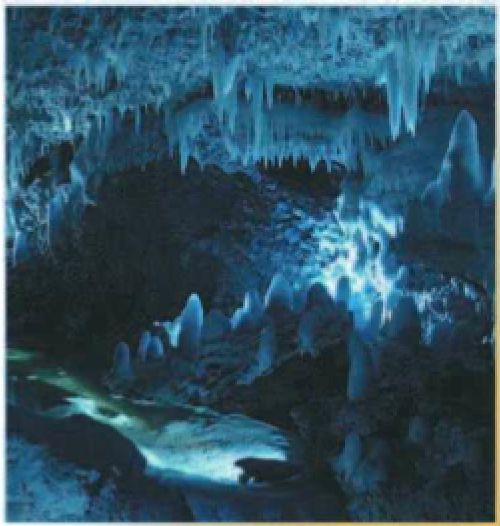
The surface of our planet never stops changing. Over millions of years, land is slowly worn away by wind, rain, and rivers. Floods, volcanoes, and earthquakes can change the shape of the land in just a few hours.

River power

The Grand Canyon formed over millions of years as the Colorado River slowly wore down the rock deeper.

Going underground

Caves form when rain seeps underground and eats away at soft rock such as limestone.



Coastal shapes

Powerful waves shape the coastlines around the world's oceans.

Bays form where waves wear into areas of softer rock along the coast.

Headlands are areas of harder rock that have not been worn away.

Sea arches form when waves open up cracks in headlands.

Sea stacks are pillars of rock left in the sea after an arch collapses.

Glaciers at work

Glaciers are huge rivers of ice that flow slowly off snowcapped mountains. Broken rock sticks to the bottom of the glacier, which then wears away the land like sandpaper, carving out a deep, U-shaped valley.

What is the most active volcano on the Earth?

New islands

Some volcanoes are hidden under the ocean. When they erupt, they can give birth to new islands, like Surtsey in Iceland (left). Surtsey burst out of the sea in 1963.

Before flood

After flood

Floods

Heavy rain makes rivers overflow, causing floods. Floods have enormous power and can wreck buildings and reshape the land.

Hills of sand

In deserts, winds blow sand into hills called dunes. In some deserts, the dunes stretch for hundreds of miles, forming a "sand sea."

Worn by wind

Strong winds can lift sand off the ground and blast it hard against rocks. The rock is worn into strange shapes.

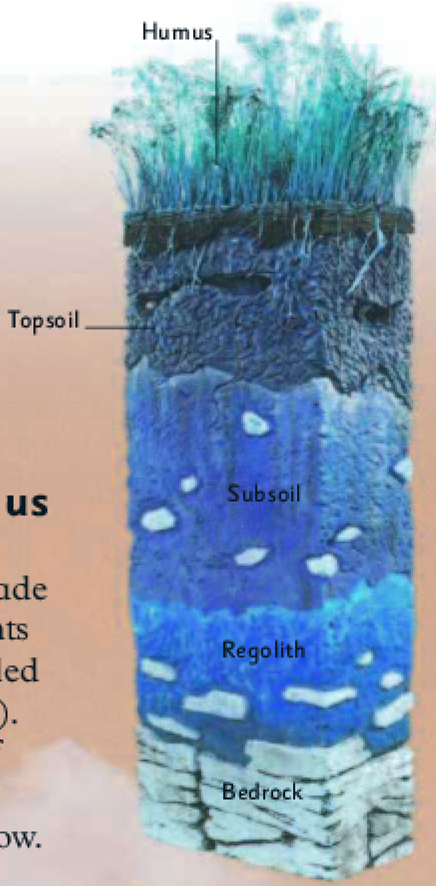
Mount Kilauea in Hawaii.

Soil

Soil is the thin layer of loose material on the land. Soil contains minerals, air, water, and decaying organic matter.

Healthy humus

Humus is a dark, rich substance made up of rotting plants and animals (called "organic matter"). It contains lots of nutrients, which plants need to grow.



Layers in soil

Soil builds up in layers over many years. Plant roots grow in the topsoil, which is generally the richest in plant food. The lower layers are rocky. Plant roots do not reach this far down in the soil.

Life underground

Soil is home to thousands of animals, including slugs, ants, beetles, and spiders. Larger animals that spend time underground, such as moles, mix up humus and minerals as they burrow through the soil.

What is a scientist who studies soil called?

Sizing up soil

Different types of soil have different sized particles.

Sandy soils contain particles about 0.08 in (2 mm) across.

Clay soils have very small particles. Water collects between them.

Loamy soils have a mixture of small and large particles.

Soil erosion

When soil is farmed too much, its nutrients get used up. The topsoil blows or washes away. Not many plants can survive in these areas without the rich topsoil.

Plowing breaks up soil, stopping it from getting hard and solid. This helps keep soil fertile and crops grow more easily.

Important earthworms

Earthworms help to make fertile soil. Their burrows let air into the soil and create pathways for water to move around more easily. Earthworms also help the remains of plants and animals to decompose. This releases important nutrients into the soil. Earthworm waste is good for soil too!

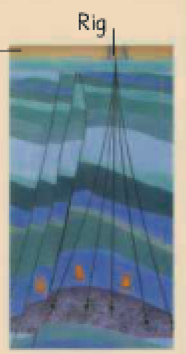
hands on

Fill a jar halway with soil and top it off with water. Put on the lid and shake. Let stand for a day. The soil should separate into layers.

A pedologist.

Resources in the ground

The ground holds many useful things, from fuels like coal and oil, to drinking water and building materials. These valuable items are known as resources, and we have dug, drilled, and searched for them for many years.



People drill holes to extract oil and gas from deep under the seafloor.

Finding fuels

Oil and gas are often found in pockets deep underground. Sometimes, these are even below the seabed. Coal develops closer to the surface in layers called seams.

Deep drilling

Oil rigs far out at sea use huge drills to extract the liquid oil from the ground. Coal is solid, and is dug out in mines or pits.

In hot water

Water in the ground can get very hot near volcanoes. In Iceland, they use this naturally hot water to heat houses or make steam to turn electricity generators.

Which underground resource are plastics made from?

Getting gas

Gas is only found in certain places. To get it to where it is needed, it is fed through very long pipes, or changed into liquid and put in special ships.

Glass bottles are shaped from molten glass.

Making glass

Glass is made by melting together sand, soda ash, and ground limestone. People blow or machine-press the red-hot mineral mixture into different shapes. These set hard and clear as the glass cools.

Extracting metals

Most metals are found underground as minerals in rocks called ores. Giant machines dig up the ore. The metal is extracted, or taken out, from the ore using heat.

Metal variety

Different metal resources have different uses.

Aluminum is a soft metal used to make cans, aircraft, and car bodies.

Gold is rare and looks beautiful, so it is often used to make awards and medals.

Iron is strong. It is used to make steel for ships, buildings, and towers.

Copper prevents barnacles from growing on it, so parts of ships are often coated with it.

Creating concrete

Concrete is an important building material. It is made with water, sand, gravel, and cement. Water, sand, and gravel are found in the ground, while cement is made from limestone, which is also found in the ground.

Fresh- and saltwater

The Earth is often called the blue planet because 75 percent of its surface is covered in water. Most of the Earth's water is saltwater in the oceans. Less than one percent of all the water on the Earth is fresh.

The hydrosphere

The hydrosphere is the name for all the water on the Earth. It includes oceans, rivers, and lakes. It also includes water that is frozen, such as icebergs.

Freshwater sources

People get freshwater from different sources on the Earth's surface, including rivers, streams, lakes, and reservoirs.

Rivers and **streams** flow from mountains down to the oceans.

Lakes are natural dips in the Earth where water collects.

Reservoirs are man-made lakes that are built to store water.

Trapped in ice

Less than 33 percent of freshwater is usable by humans. The rest is frozen in glaciers or icebergs (below) or as huge sheets of ice at the North and South poles.

Water for life

All living things must have water to survive. In mammals, including humans, water is part of the blood and of organs, such as the skin and brain. There is water in every cell in your body. In fact, cells contain about two-thirds of the body's water!

Salty seas

The world's oceans are salty because they contain a lot of dissolved chemicals that scientists call salts. Drinking water also contains salts, but only in small amounts, so you can't taste them.

The Dead Sea, located in Asia, contains so much salt that people can just float on the surface.

hands on

Put an egg in a glass of water. The egg will sink. Start stirring in salt until the egg rises. The egg will eventually float because saltwater is denser than freshwater.

Surviving in saltwater

Countless animals live in water. They don't drink, but take water into their bodies in other ways. Fish often absorb water as it washes in and out of their gills. Saltwater fish absorb only a little of the salt.

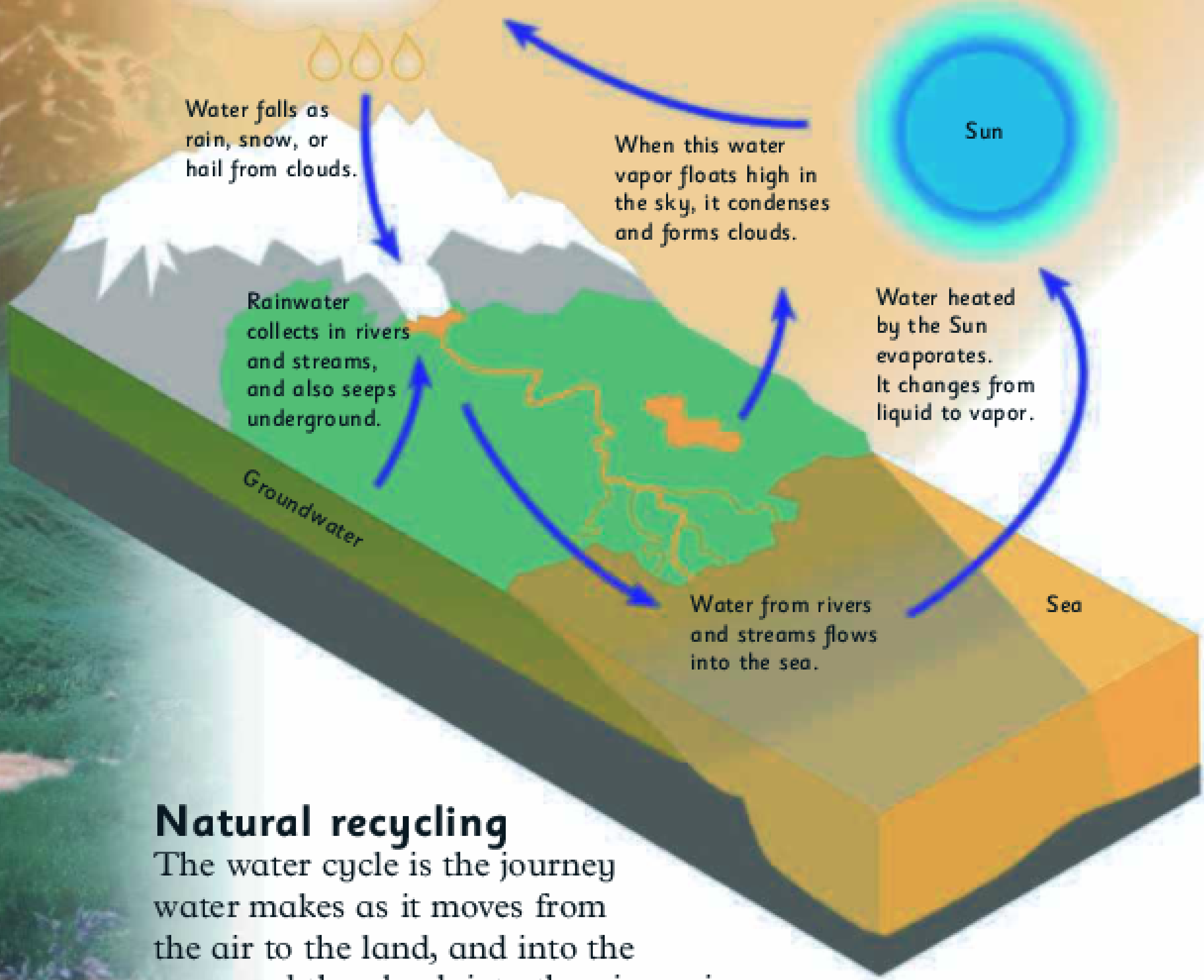
Estuary life

An estuary is the wide part of a river where it nears the sea. When the tide comes in, saltwater flows into the estuary. When the tide goes out, the estuary contains mostly freshwater from the river or stream that flows into it. Mangrove trees, like those shown here, are able to live in the changing estuary water.

Your body is approximately 70 percent water.

The water cycle

Water is constantly on the move, between oceans, land, air, and rivers. This movement is called the water cycle.



Natural recycling

The water cycle is the journey water makes as it moves from the air to the land, and into the seas, and then back into the air again.

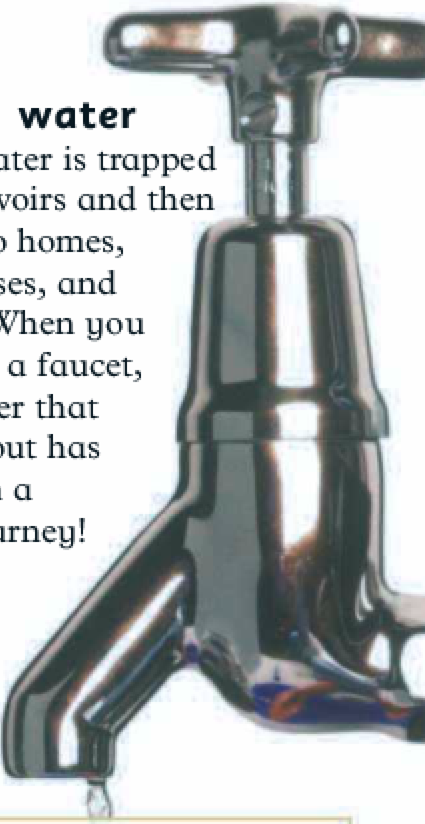
On the dry side

Moisture-laden sea air has to rise when it hits a coastal mountain. Since air cools as it rises, all the moisture condenses and falls as rain. So, on the other side of the mountain, no rain falls. This area is called a rainshadow.

What is electricity generated by running water called?

Groundwater

In the water cycle, some water seeps underground, where it collects in rocks and sometimes forms pools in caves. Some groundwater is pumped up and used for drinking or irrigation.



Using water

Freshwater is trapped in reservoirs and then piped to homes, businesses, and farms. When you turn on a faucet, the water that comes out has been on a long journey!

Damp ground

Wetlands form on land in areas where freshwater does not drain away. They provide a habitat for many plants, birds, animals, and fish.

Drought

When very little rain falls, experts call it a drought. Droughts do not occur only in deserts—any area that gets much less rain than usual is said to be suffering from drought.

Saving water

There is a limited amount of freshwater on the Earth. If we want to make sure there's enough to go around, it's important that everyone uses less.

Turn off faucets while you are brushing your teeth or washing.

Flush the toilet only when necessary. Some toilets have two flush controls.

Don't run the dishwasher when it's half empty—wait until it's full.

Take a shower instead of a bath. Showering uses much less water.

The atmosphere

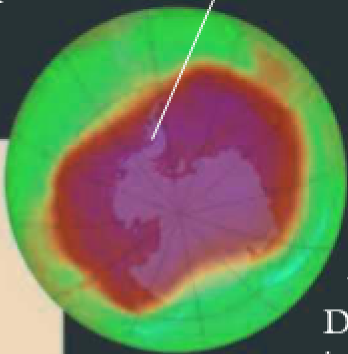
Planet Earth is wrapped in a thin layer of air called the atmosphere. Without this protective blanket of gases, life on the Earth could not exist.

Shimmering particles

The atmosphere is mainly made up of gases, but it also contains tiny particles of dust, pollen, and water droplets. All particles can cause a haze in the air when the Sun shines through them.

Gases in air

Air is a mixture of different gases, including nitrogen, oxygen, and carbon dioxide. Oxygen is vital for plants and animals as it allows them to breathe. Carbon dioxide is also vital for plants. They absorb it from the air and use the carbon atoms to help build new leaves and stems.



The purple area, where the ozone layer is the thinnest, is called the ozone hole.

Protective layer

A gas called ozone in the atmosphere protects the Earth from harmful rays in sunlight. This ozone layer has become thinner because of chemical pollution. During the spring season (August–October) in the Southern Hemisphere, an area of the ozone layer above Antarctica becomes much thinner than anywhere else. This "ozone hole" occurs every year.

The greenhouse effect

If there was no atmosphere, the Sun's warming rays would bounce off the Earth and disappear into space. But the atmosphere traps some of the heat, making the Earth warm enough for us to survive.

How far up from the ground does space officially begin?

Into thin air

Like everything else, air is pulled by gravity. Most air molecules are pulled close to the ground, where the air is thick and easy to breathe. Higher up, air is so thin that climbers need oxygen tanks.

From space, the atmosphere looks like a blue haze over the Earth.

Layers of the atmosphere

The atmosphere is made up of layers, each with a different name. The bottom layer is the troposphere, where clouds form and planes fly. Above this, the air gets thinner and thinner as the atmosphere merges into space.

Light spectacular

Sunlight can create dazzling effects as it strikes the atmosphere and is scattered by air, water, and dust.

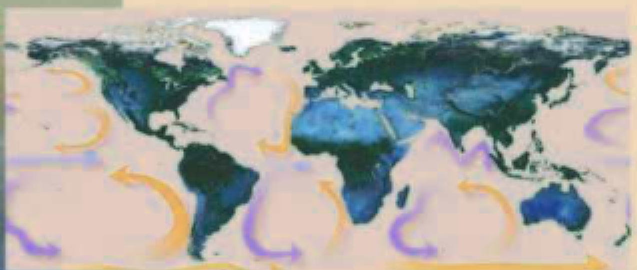
Rainbows form when water droplets reflect sunlight and split it into different colors.

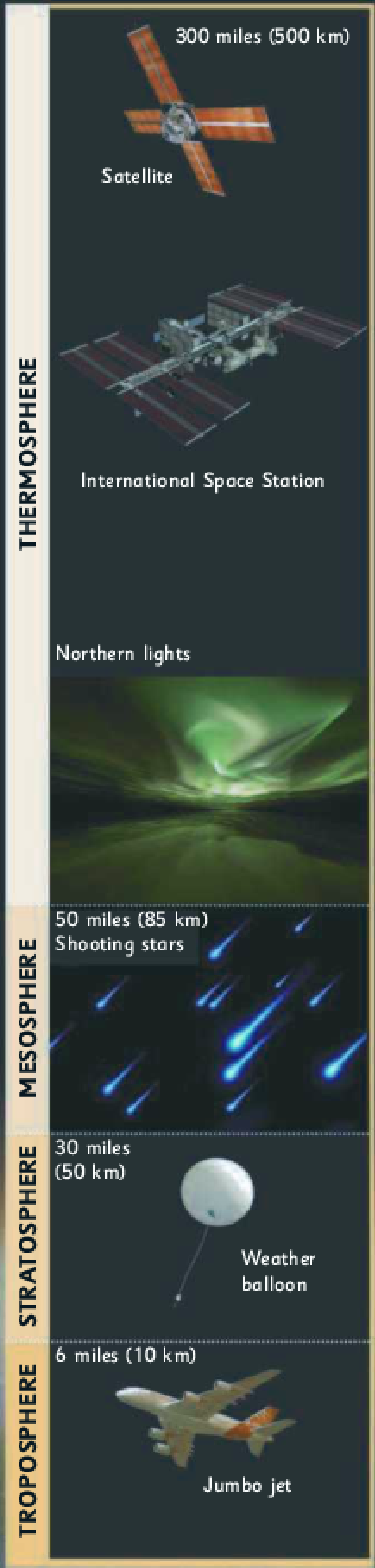
The **sky looks blue** on clear days because air molecules scatter blue light the most.

At **sunset**, only the red and orange light of sunlight make it through the atmosphere.

Moving water

The atmosphere is always swirling around, creating winds. The winds push on the oceans, causing the water to swirl too. These swirling currents carry warmth around the planet.





60 miles (100 km).

Weather

Is it sunny or rainy? Is there snow on the ground or a thunderstorm brewing? People are always interested in the weather because it affects what we do and what we wear.

Kites stay high in the air by catching the wind.

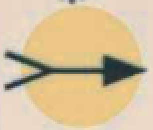
Weather words

Here are some main features of the weather.

Sunshine gives us heat and light. It warms the air and dries the land.

Clouds are made from tiny water droplets. Dark clouds mean rain is coming.

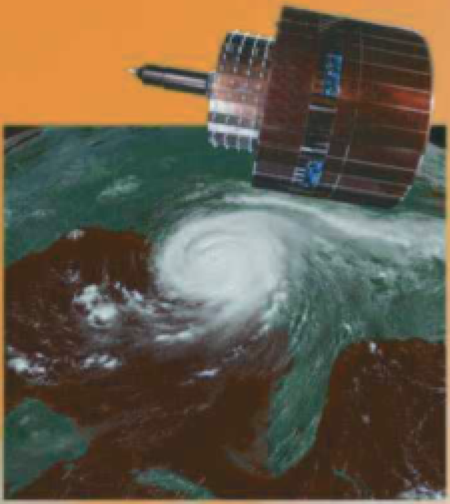
Hailstones are balls of ice that grow inside thunderclouds.



Wind is air moving around. Winds can be a light breeze or a strong gale.

Rain is drops of water that fall from clouds. Rain is very good for plant life.

Snow is made from tiny bits of ice. It falls instead of rain when it is very cold.

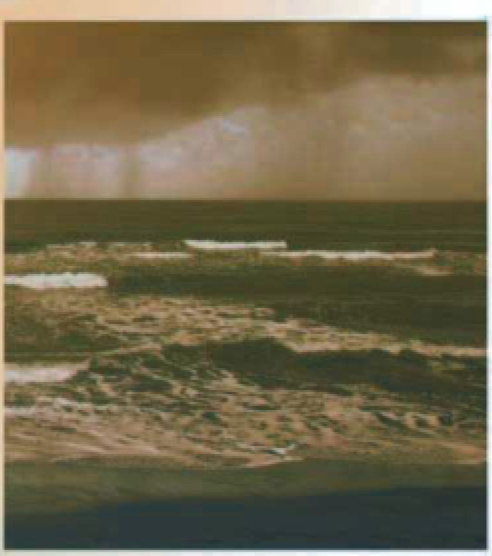


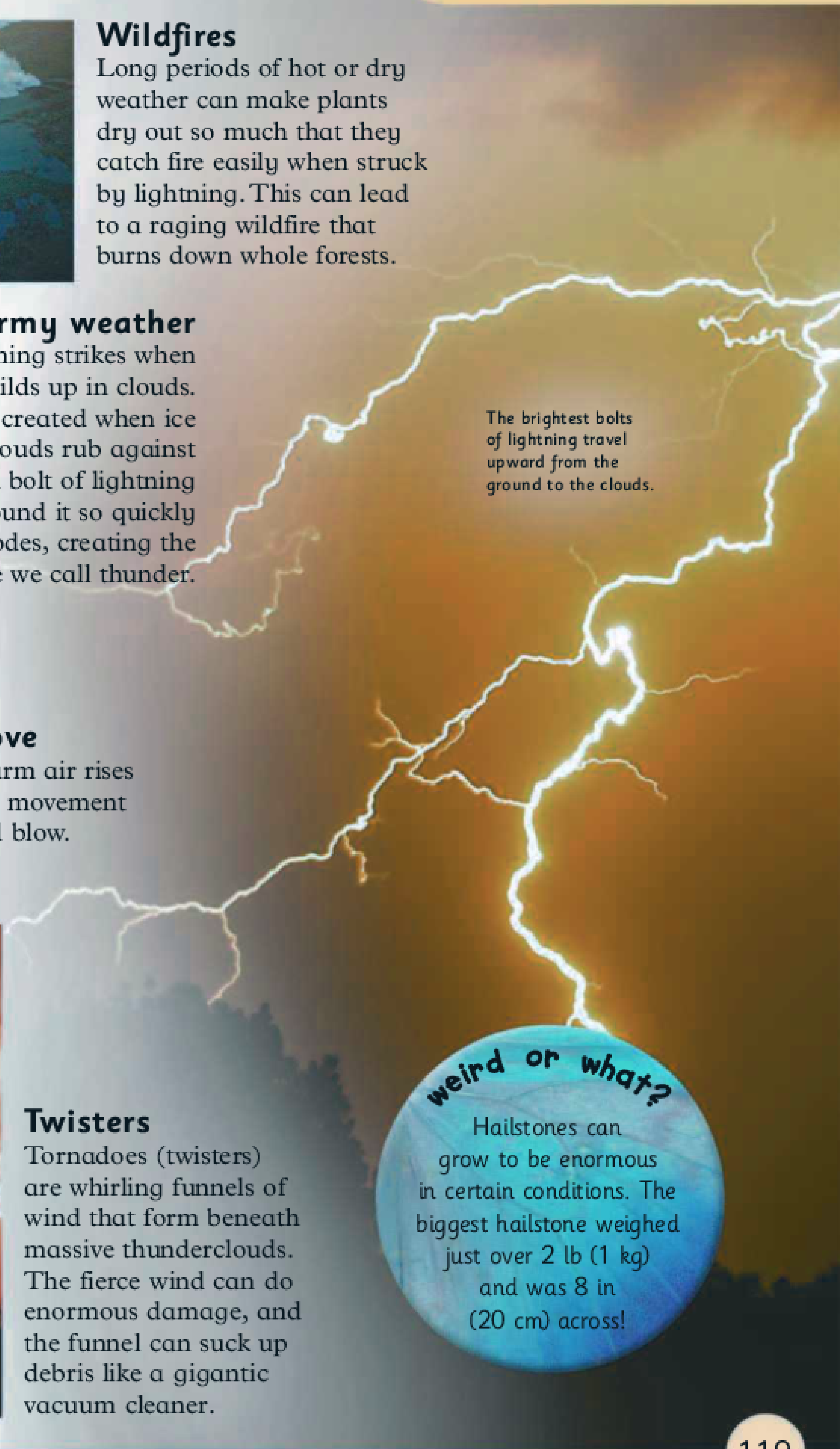
Predicting the weather

Weather forecasters look at pictures beamed back from weather satellites. Computers then help forecasters figure out what the weather is going to be like over the next few days.

Rainy days

Rain clouds form when warm, moist air rises upward and then cools. Droplets of water join together until they become so heavy that they fall. Rain clouds look dark because sunlight cannot shine through the droplets.





Wildfires

Long periods of hot or dry weather can make plants dry out so much that they catch fire easily when struck by lightning. This can lead to a raging wildfire that burns down whole forests.

Stormy weather

Lightning strikes when electricity builds up in clouds. The electricity is created when ice crystals in the clouds rub against each other. A bolt of lightning heats the air around it so quickly that the air explodes, creating the rumbling noise we call thunder.

The brightest bolts of lightning travel upward from the ground to the clouds.

Winds on the move

Wind is moving air. Warm air rises and cool air sinks. This movement is what makes the wind blow.

Twisters

Tornadoes (twisters) are whirling funnels of wind that form beneath massive thunderclouds. The fierce wind can do enormous damage, and the funnel can suck up debris like a gigantic vacuum cleaner.

weird or what?

Hailstones can grow to be enormous in certain conditions. The biggest hailstone weighed just over 2 lb (1 kg) and was 8 in (20 cm) across!

A hurricane is thousands of times bigger than a tornado.

The energy crisis

People around the world use energy for many different purposes—from powering cars to heating homes. Most of this energy comes from burning coal, oil, and natural gas (fossil fuels). But these fuels won't last forever, and their fumes are damaging the atmosphere.

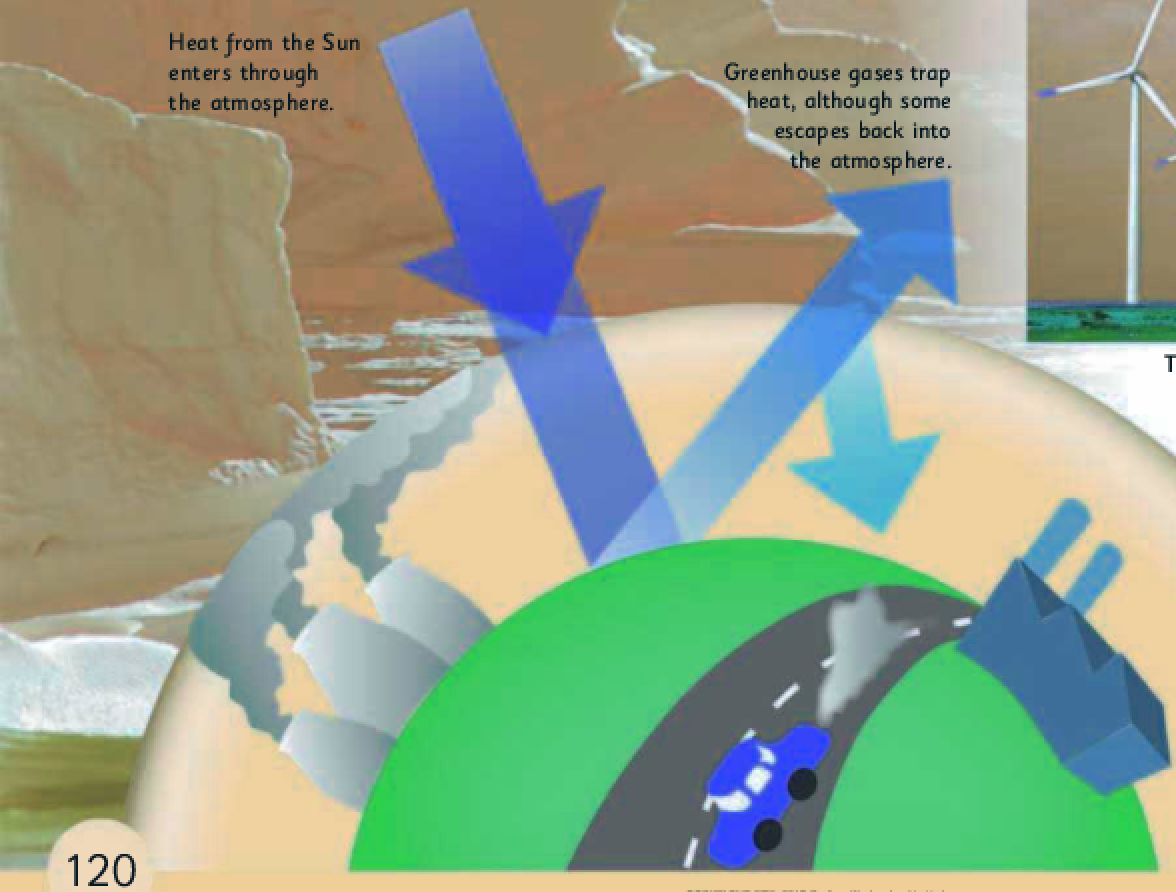
Nuclear power plants generate energy by splitting atoms.

Alternative energy

We need to find sources of energy other than fossil fuels—sources which cause less pollution and will not run out. Nuclear power is one option. Others possibilities include energy from sunlight, wind, and waves.

Global warming

Burning fossil fuels fills the air with greenhouse gases, which trap some of the Sun's heat in the atmosphere. If the Earth becomes too warm, polar ice caps will melt, the sea level will rise, and deserts will spread.



The wind provides a limitless supply of non-polluting energy. However, wind turbines are large and can be costly to set up.

What are fossil fuels made of?

Cleaner cars

Ordinary gas cars use a lot of oil, and produce harmful fumes. Now carmakers are looking for alternatives to gasoline. Electric cars do not give off any kind of fumes. Hydrogen engines burn hydrogen gas, and only give off water.

To recharge an electric car, you just plug it in.

Rising energy needs

As the world's population grows, we are using more and more energy. But to stop global warming, we may have to reduce the amount of energy we all use.

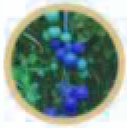
Energy-saving homes

This house saves energy by using solar panels and wind turbines to generate its own non-polluting electricity. The walls are thick, so that less energy is needed to heat the house.

To reduce the energy used in manufacturing, it's a good idea to use recycled building materials.

Making a difference

There are lots of small things we can all do to save energy.



Start growing your own vegetables and fruits, even if they're only in pots.

When planning a vacation, remember that trains, boats, and cars use less energy than airplanes.

Instead of buying new clothes, swap with a friend or buy them secondhand.

Eat local food that hasn't traveled miles, because transporting food costs energy.

Don't throw away glass, plastics, metal, or paper—reuse or recycle them.

Take your own bags when you go shopping. Making plastic bags takes energy.

Don't leave your TV or laptop on standby—this wastes lots of electricity.

Hang your laundry outside to dry. Don't waste electricity running a dryer.

Ask your parents about **insulating the roof** to prevent heat from escaping.

If you get cold, **put on a sweater** instead of turning up the heat.

The remains of plants and animals that lived millions of years ago.

True or false?

Can you figure out which of these facts are real and which are completely made up?

1 The microscope was built by two Dutchmen.

2 Jupiter has more than 60 moons.

3 Mica is used to make the silicon chips in calculators.

4 Nuclear power plants harness energy from the Sun.

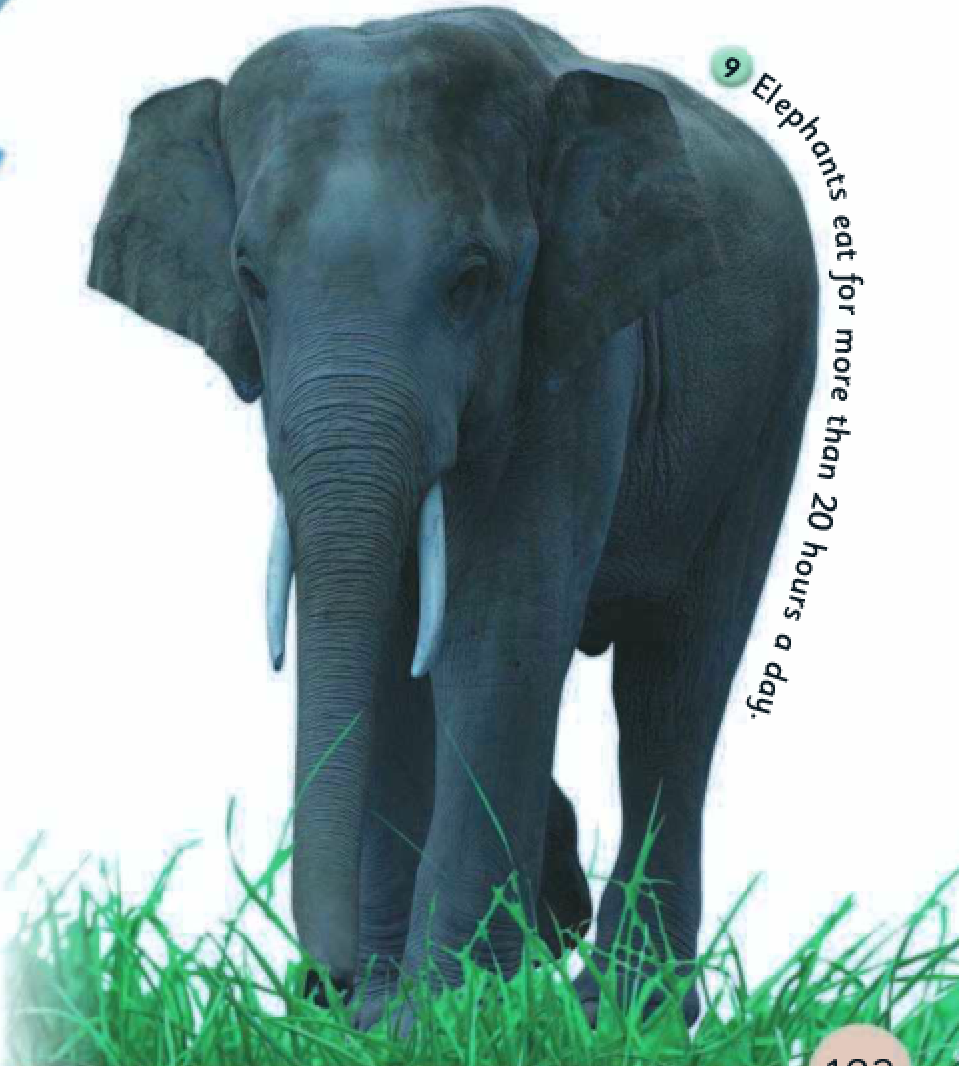
5: False—they are called paleontologists 6: True 7: True 8: True 9. False—they eat for about 16 hours a day.

5 Scientists who study fossils are called ecologists.

6 Cream and cheese are made by separating milk.

7 Frogs can absorb oxygen through their skin.

8 Glass is made with sand, ground limestone, and soda ash.



9 Elephants eat for more than 20 hours a day.

Answers. 1: True 2: True 3: False—quartz is used 4: False—they harness energy by splitting atoms

Quiz

Test your knowledge of science with these quiz questions.

1 What is the name of the chemical reaction that makes silver slowly turn gray and dull?

A: Rusting **B. Tarnishing**
C. Photosynthesis **D. Rotting**

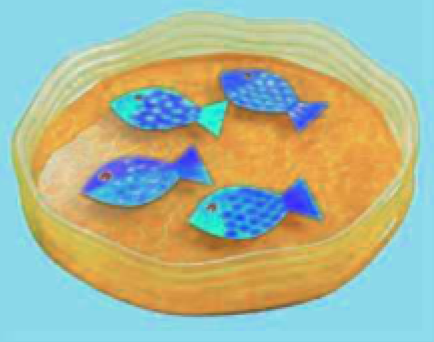
2 Which kind of energy wave is used in hospitals to kill cancer cells?

A: Gamma rays **B: X-rays**
C: Infrared waves **D: Ultraviolet light**

3 Which one of these minerals can be found in nail polish?

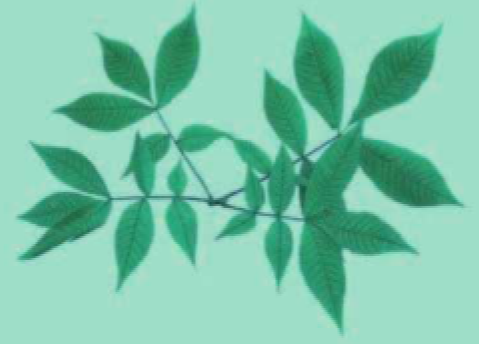
A. Mica **B. Sulfur**
C. Graphite **D. Illite**

4 What makes objects float?



A: Gravity **B: Centrifugal force**
C: Buoyancy **D: Insulation**

5 Leaves have a green pigment called...



A: Pollen **B. Chlorophyll**
C. Hyphae **D. Xylem**

6 When rain seeps underground and eats away at soft rock, it forms...

A: Sea arches **B: Sea stacks**
C: Caves **D: Stalactites**

7 Which year was Teflon invented in?

A. 1941 **B. 1948**
C. 1938 **D. 1950**

8 What is the wide part of a river where it nears the sea called?

A: Wetland **B: Estuary**
C: Reservoir **D: Bay**

9 A pit viper has heat sensors on its...

A. Tongue **B. Skin**
C. Head **D. Tail**

10 Which one of these elements is a halogen?

A. Silicon **B. Mercury**
C. Cobalt **D. Chlorine**

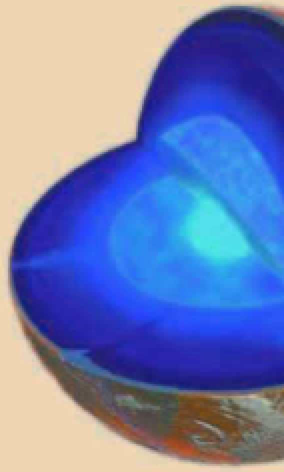
11 How many stars are there in the Milky Way?

A: 200–400 billion **B: 500–600 million**
C: 50–100 billion **D: 900 million**

12 When a pulley has more than one wheel, the pulling force is...

A. Increased **B. Decreased**
C. Divided **D. The same**

13 What is the innermost layer of the Earth called?



A: Mantle **B: Plate**
C: Core **D: Crust**

14 What is the fastest thing in the universe?

A: Sound **B: Heat**
C: Wind **D: Light**

15 Butterflies taste with their...

A. Feet **B. Antennae**
C. Tongue **D. Wings**

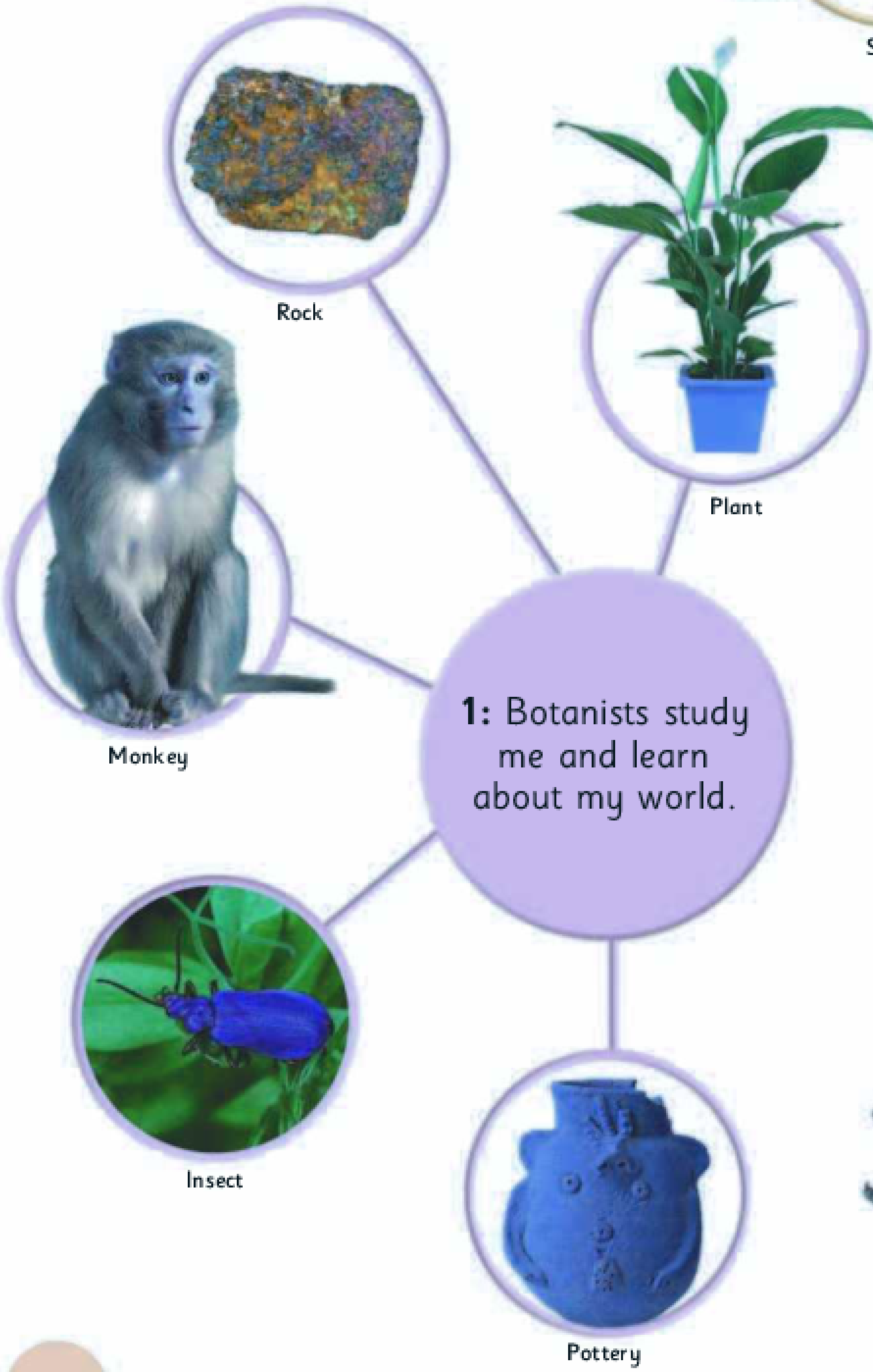
16 What is the process of the atmosphere trapping the Sun's rays called?

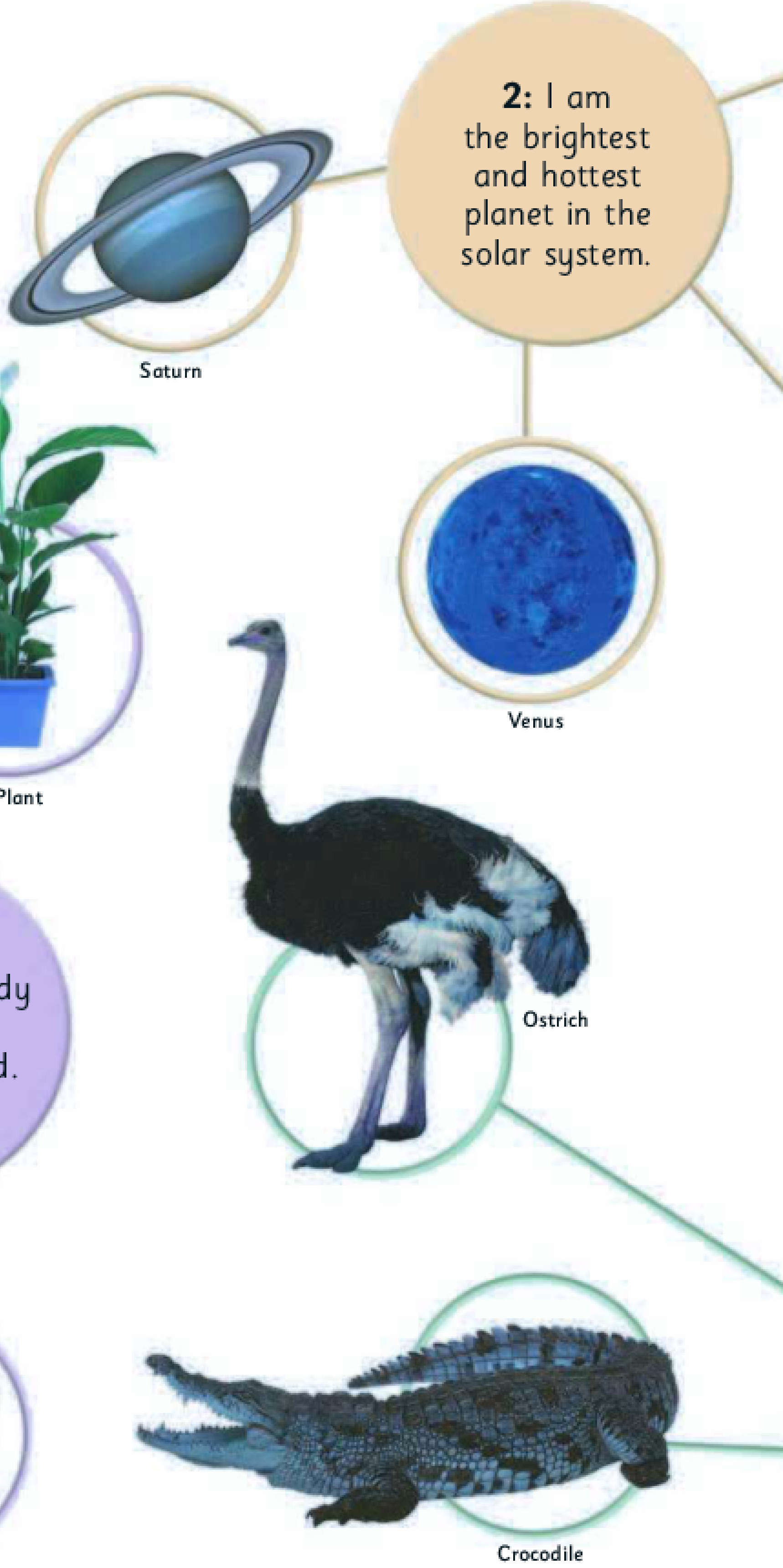
A. Echolocation **B. Greenhouse effect**
C. Radiation **D. Carbon cycle**

Answers. 1:B 2:A 3:A 4:C 5:B 6:C 7:C 8:B 9:C 10:D 11:A 12:A 13:C 14:D 15:A 16:B

Who or what am I?

Can you figure out who or what is being talked about from the clue?





Mars

Jackhammer

Fireworks

Jet engine

3: I can be as loud as 140 decibels.

Drums

Mercury

Diamond

Gold

Quartz

Tortoise

5: I am the hardest of all minerals.

4: I lay the largest egg in the animal kingdom.

Python

Topaz

Answers. 1: Plant 2: Venus 3: Jet engine 4: Ostrich 5: Diamond

1: Located in Hawaii, this is the most active volcano on Earth.

2: The Grand Canyon was formed due to years of erosion caused by this body of water.

3: This NASA orbiter was part of the Space Shuttle program that ended in 2011.

4: This medicine, discovered by the Scottish scientist Alexander Fleming, kills bacteria.

5: This was first tested in 1617 by Faust Vrancic, in Italy.

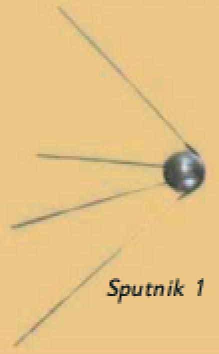
6: This animal lives in the African grasslands and uses its body color as camouflage.

Where in the world?

Match the description of each of these objects or animals with the pictures and discover what part of the world each belongs to.

Blood

Mount Kilauea



Sputnik 1

Parachute

Dead Sea

Emperor penguin

7: Blood 8: Dead Sea 9: Mount Everest 10: *Sputnik 1* 11: Paper 12: Emperor penguin

7: Austrian scientist Karl Landsteiner discovered that this substance can be divided into four groups.

9: Part of the Himalayas, this is the tallest mountain peak in the world.

10: Launched by the Soviet Union in 1957, this was the first satellite in space.

11: This was created in China in 105 BCE, but was kept a secret for many years.

8: This body of water in Asia is so salty that you can easily float in it.

12: This Antarctic animal has a heat-trapping layer on its body.

The *Atlantis*

Lion

Colorado River

Penicillin

Paper

Mount Everest

Answers. 1: Mount Kilauea 2: Colorado River 3: The *Atlantis* 4: Penicillin 5: Parachute 6: Lion

Glossary

atmosphere Mass of air that surrounds the Earth

attraction Force that pulls things together. The opposite ends (poles) of two magnets attract each other

bacteria Tiny one-celled creatures found all around us. Some bacteria are good, but others cause disease

carbohydrate Along with fats and proteins, energy-rich carbohydrates, such as sugar and starch, are one of the three major food groups

carnivore Animal that eats only meat. Lions, wolves, sharks, and crocodiles are carnivores

carrion Remains of dead animals that other animals eat

chlorophyll Pigment in plants that traps the energy of sunlight for photosynthesis and gives them their green color

circuit Loop that an electric current travels around

compound Chemical made when two or more elements are joined by a chemical reaction

continent One of the Earth's huge landmasses, like Asia. There are seven continents

electromagnet Powerful magnet created by a flow of electricity through a coil

endorphins Chemicals released by the brain that make you feel happy and reduce pain

erosion Wearing down of rock by water or the weather

estuary Wide part of a river where it meets the sea

fertilization Process in which the male and female parts of an animal or plant join together to reproduce

force Push or a pull. Gravity is the force that keeps you on the ground

fossil fuels Fuels that come from the earth and are the remains of living things. Coal, oil, and natural gas are all fossil fuels

genes Chemical instructions in your cells, holding the information that makes you who you are

global warming Slow rise in average temperatures around the world, believed to be caused by the greenhouse effect

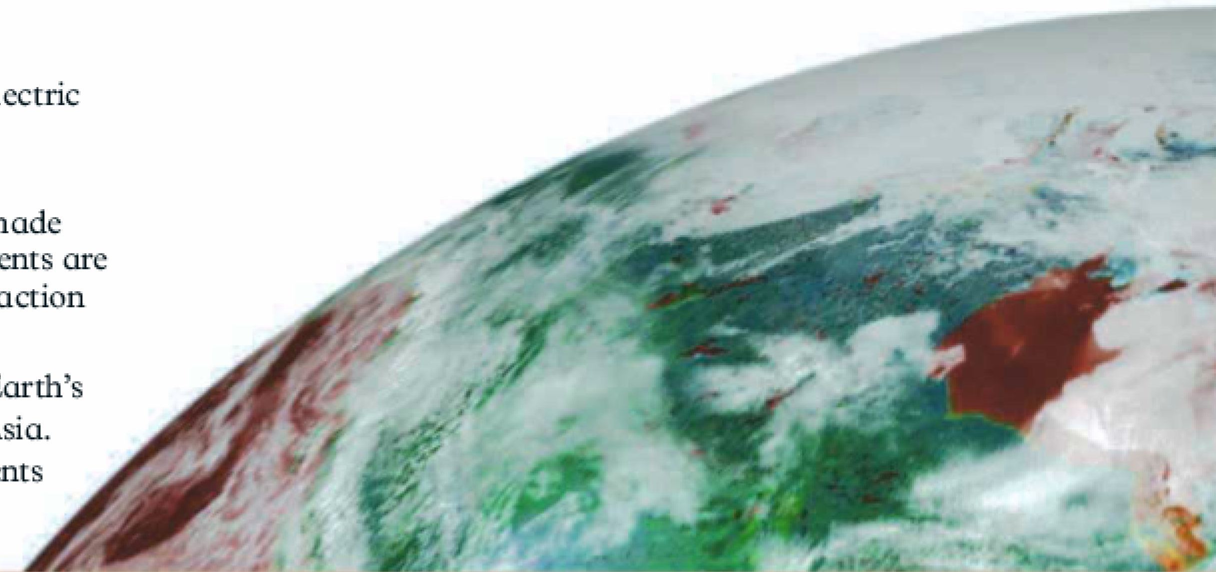
greenhouse effect When the atmosphere traps in heat, the Earth becomes warm enough for life to thrive

habitat Area where a particular species of plant, fungus, or animal lives

herbivore Animal that eats only plants. Cows, koalas, and elephants are herbivores

invertebrates Animals that don't have a backbone

laboratory Place where scientists carry out their experiments



limestone Rock made from the skeletal remains of marine animals, built up in layers over thousands of years

migration Movement of animals, particularly birds, from one place to another to find food or warmth

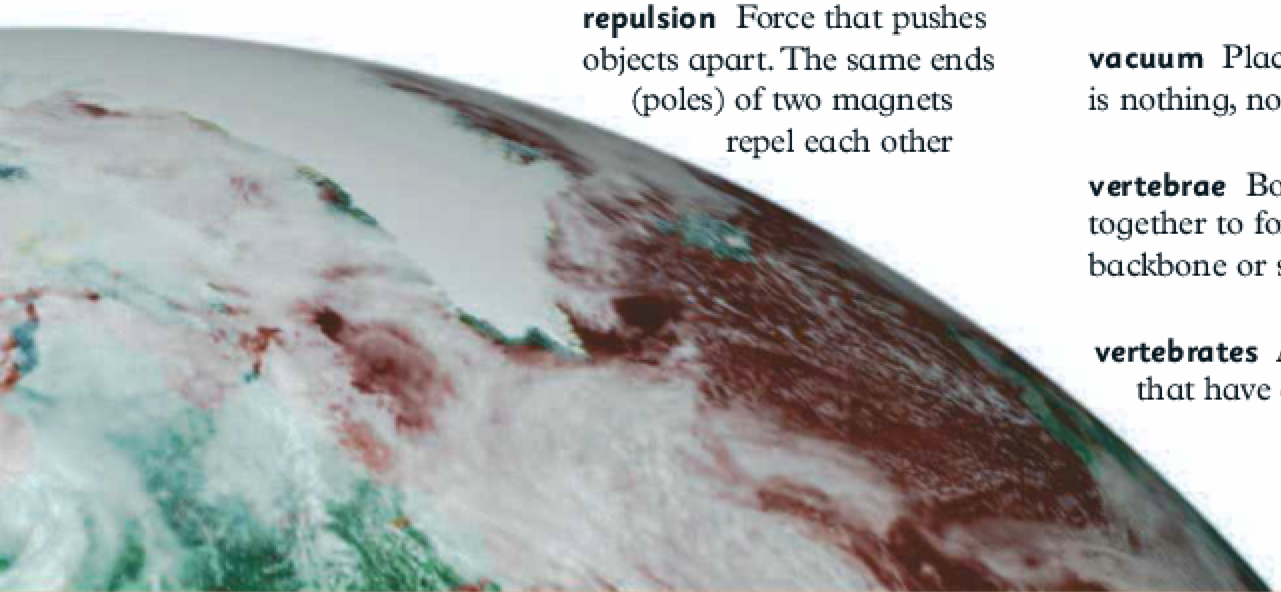
mineral Solid chemical substance usually found as crystals in rock

mixture Two or more substances combined together, but not joined chemically

nerves Threads of tissue that carry high-speed signals around the body

nutrients Foods or chemicals that a plant or animal needs in order to live and grow

omnivore Animal that eats both meat and plants. Pigs, bears, and humans are omnivores



orbit Path taken by an object in space as it moves around another object

ores Minerals that are important sources of metals

organ Group of tissues that form a body part designed for a specific job. The heart is an organ

organic matter Remains of dead plants and animals. Organic matter is an important part of soil because it contains lots of nutrients

organism Living thing that has a number of parts working together as a whole

parasite Organism that lives on or inside another plant or animal, often harming it

particle Very, very small bit of matter, such as an atom or a molecule

repulsion Force that pushes objects apart. The same ends (poles) of two magnets repel each other

reservoir Place where water is collected and stored

satellite Natural or man-made object that moves around another object. The Moon is the Earth's natural satellite. Man-made satellites circle the Earth and send back information on things such as weather

species Type of living thing that can breed with others of the same type

spore Special cell made by organisms such as fungi. Spores can grow into new organisms

temperature Measure of how hot or cold things are

tissue Group of cells that look and act the same. Muscle is a type of tissue

transpiration Evaporation of water from a plant into the atmosphere

vacuum Place where there is nothing, not even air

vertebrae Bones that link together to form an animal's backbone or spine

vertebrates Animals that have a backbone

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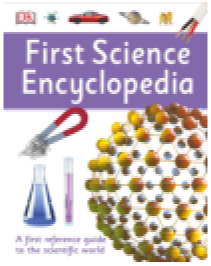

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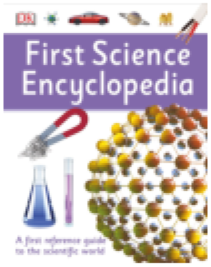

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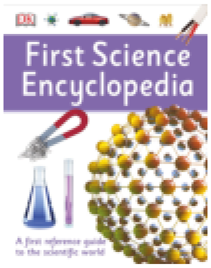

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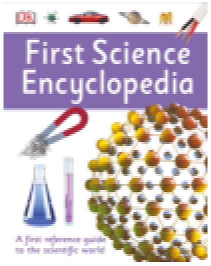

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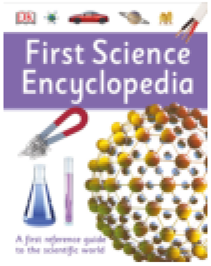

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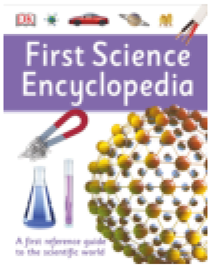

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