

**DK findout!**

# Science



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Fun Facts, Amazing Pictures, Quizzes





**findout!**

# Science



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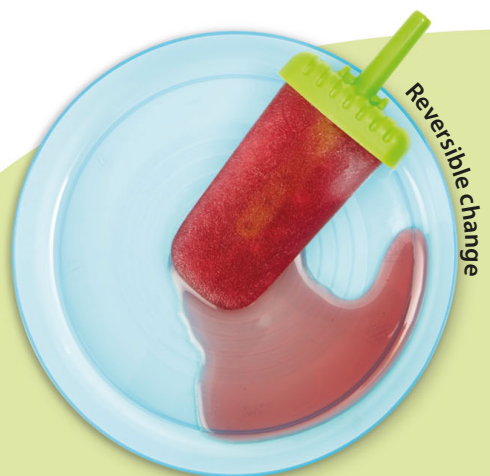
Simple machines



Human body

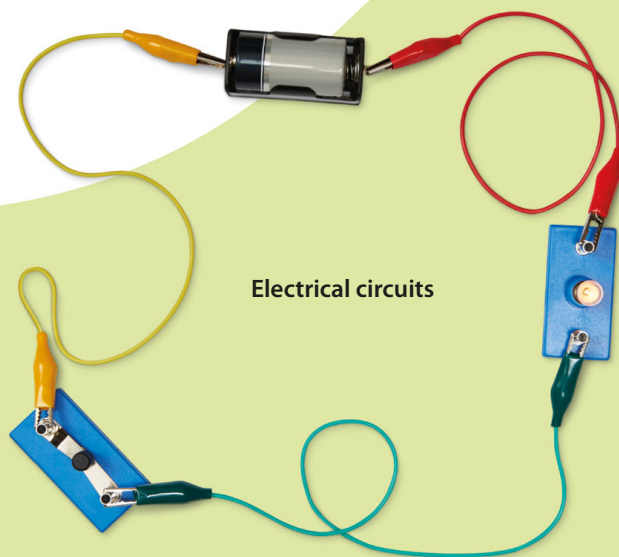
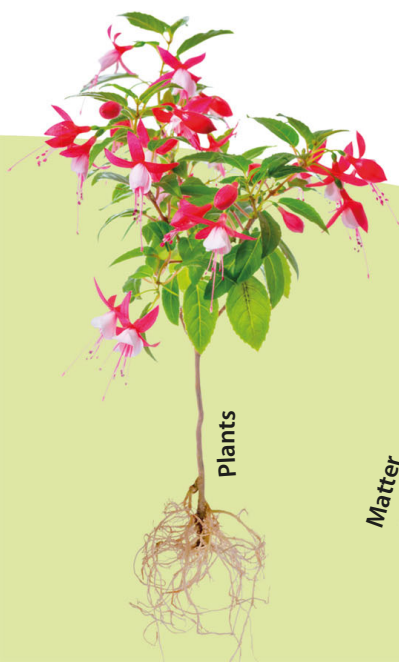
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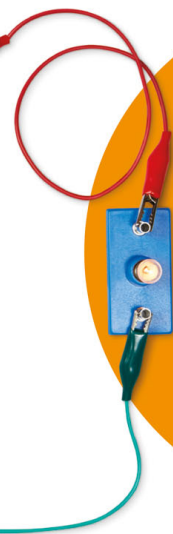


# What is science?

Science isn't just a lot of facts in a book. Science is a way of thinking. Science is about asking questions and finding out the answers. Scientists come up with new ideas and invent new ways to make life easier for everyone. Here are some examples of things that can be explained by science.

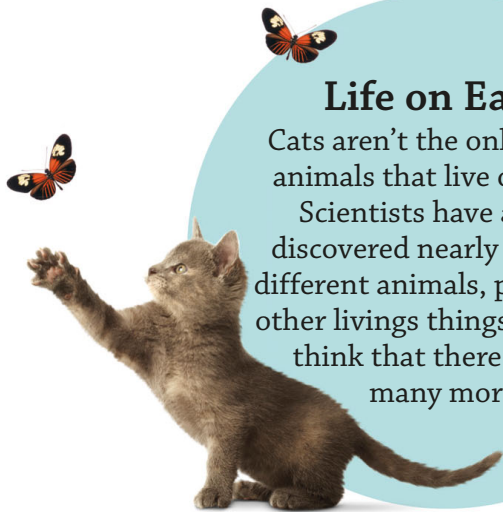
## Bright sparks

Electricity is one of several different types of energy that have been studied by scientists. Electrical energy flows through wires and is used to power things like lights and computers.



## Life on Earth

Cats aren't the only curious animals that live on Earth! Scientists have already discovered nearly 9 million different animals, plants, and other living things, and they think that there may be many more.



Where does electricity come from?

What materials conduct electricity?

Where does lightning come from?

Why do plants need sunshine?

Why do humans have bones?

How do you know if something is alive?

What is gas?

What is the hardest material on Earth?

What is a magnet?

Why do only some things stick to magnets?

Where does light come from?

How are shadows made?

## Material matters

Everything around you is made of matter, and that includes your body! Scientists have explained how matter can take different forms, and why it behaves differently when it is a solid, liquid, or gas.



## Forces of attraction

Magnets produce an invisible pulling and pushing force called magnetism. The ancient Greeks knew this force existed, but it took until 1279 for a scientist to explain how it works!



## Casting shadows

Have you ever wondered why you only sometimes have a shadow, and why its length changes? Well, science has the answer, and once you have read this book, you will know the answer, too!



# What is matter?

Matter is the “stuff” that all things are made of. Everything we see, touch, and breathe is made of matter. Matter has different forms, called states. The three most common states on Earth are solids, liquids, and gases. Matter behaves differently in each of these states.

## LIQUID

Liquids do not hold their shape on their own. They will take on the shape of their container, like water in a glass.

» Liquids flow, like this river, and they can be poured, like milk and juice.

» Liquids flow downward because they are pulled toward Earth by gravity.

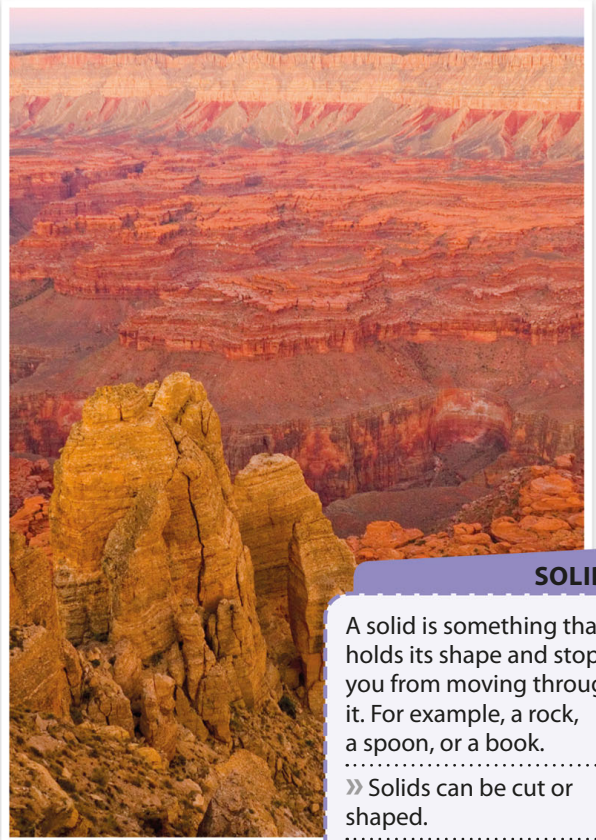


## SOLID

A solid is something that holds its shape and stops you from moving through it. For example, a rock, a spoon, or a book.

» Solids can be cut or shaped.

» Most solids are hard, like metal.





## GAS

Gases have no fixed shape at all. They fill any space that they are in, for example, air in a room.

» Gases are always moving.

» Gases are lighter than solids and liquids.



## Matter matching

Each image below shows an everyday object. Can you figure out whether each one shows a solid, liquid, or gas? Read the descriptions for clues.

1 SOLID    2 LIQUID    3 GAS

### Steam

This steam is rising from the surface of a very hot cup of coffee.



B



### Backpack

This backpack is made of fabric and strong plastic.

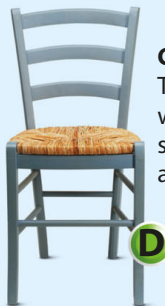
### Balloon

This balloon has been filled with air so that it will float. What is the state of the matter inside it?



### Chair

This chair is made out of wood and has a wicker seat, so it is strong but also comfortable.



### Sesame oil

Sesame oil is used for cooking and can be poured from a bottle.



## Switching states

Most things change from one state to another when their temperature changes. When a solid gets hot, it melts and changes into a liquid. When this liquid is heated, it evaporates, changing into a gas or vapor.



Ice is a solid. It is very cold.



When ice is heated above 32°F (0°C), it melts and becomes a liquid called water.



When water is heated to 212°F (100°C), it boils and changes into a vapor called steam.

# What is a material?

Some materials are found naturally on Earth; others are made by humans. One material may be hard and brittle, while another may be soft and flexible. These types of features are called “properties.” We choose a material for a specific job based on its properties. For example, you wouldn’t build a castle out of chocolate!

## 1 Metal

Metals are usually strong, but not brittle, which means they do not break easily. Iron, for example, may be used to make strong chains. Metals are also good at allowing heat and electricity to pass through them.

## Types of metal

Different metals have different properties and so are used to make different things.



**Gold** is a shiny metal from which crowns and jewelry are made.



**Iron** is heavy. Heated flatirons were once used to press clothes.



**Aluminum** is a light metal. It is used to make cans and aircraft.



**Copper** is easy to bend. It is often used for water pipes or wires.



**! WOW!**

**The strongest known material is the tooth of a shellfish called a limpet.**

## 2 Brick

Bricks are rectangular blocks of clay mixed with sand. They are heated to a high temperature to make them very hard. Because we can make as many bricks as we want that are exactly the same size, they are an ideal building material.

## 3 Glass

Glass is made by melting sand. It is transparent, which means we can see through it, so it is often used to make windows. It can also be made in different colors. Glass is hard, but brittle and therefore breaks easily.

## 4 Wood

Wood comes from the trunks of trees. It is strong and light. Wood is easy to cut into different shapes, so it is used to make bridges, buildings, and furniture. Wood is also easy to set on fire. Burning wood is useful because it produces heat.

## 5 Cloth

Cloth can be made by knitting or weaving cotton, wool, or silk. It is a soft, light material, and people have made clothes from it for thousands of years. It can also be used to make colored flags.

## 6 Rock

Rock is a natural material. For example, mountains are made of rock. Some rocks are hard, but others are soft and crumbly, such as chalk. Humans have often used hard rocks to build tall, strong walls.

### Lichtenstein Castle

This castle on top of a cliff near Honau, Germany, is made from lots of different materials.



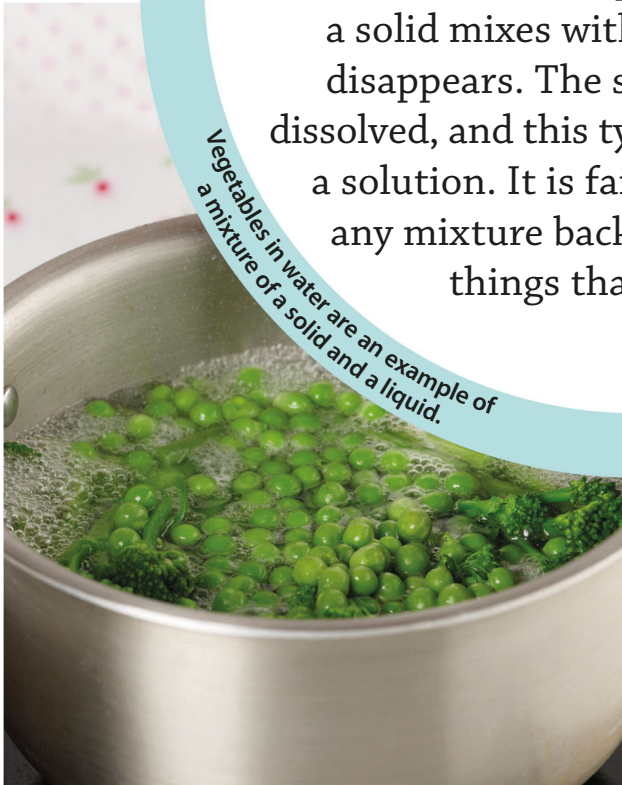
Different types of solids can be mixed together, such as this mixture of shells and sand.



Sugar dissolves in hot drinks, forming a solution in which the sugar can no longer be seen.

# Mixtures

Solids, liquids, and gases can sometimes be mixed together. For example, you can have a mixture of two or more solids, or you can mix a solid with a liquid. Sometimes, when a solid mixes with a liquid, the solid disappears. The solid is said to have dissolved, and this type of mixture is called a solution. It is fairly easy to separate any mixture back into the different things that formed it.



Vegetables in water are an example of a mixture of a solid and a liquid.



Tiny grains of solid sand form a cloudy mixture with seawater.

## Separating mixtures

Mixtures can be separated back into their different parts. Choosing the correct method depends on what type of things the mixture is made up of.

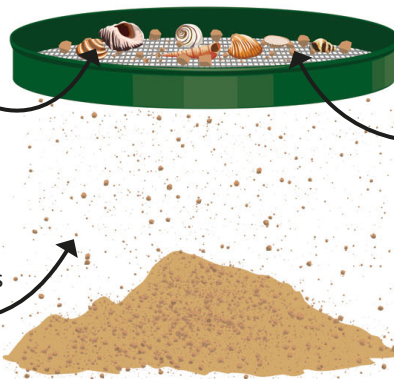
### Sieving

Sieving can be used to separate a mixture of solids, but the solids must be different sizes. Liquids containing large solids can also be separated by sieving.

A mixture of solids is passed through a sieve.

The small pieces of solid pass through the holes in the sieve.

The sieve stops the big pieces of solid from getting through.



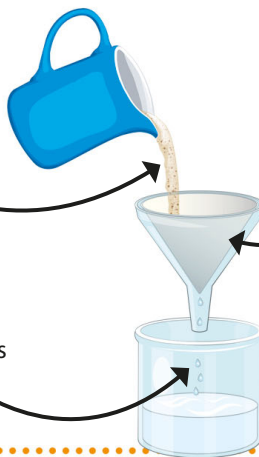
### Filtering

Mixtures of solids and liquids can be separated by a process called filtration. The mixture is passed through a fine mesh, such as filter paper, which holds back the solid pieces, but allows the liquid through.

A mixture of a solid and a liquid is passed through filter paper.

The liquid passes through the tiny holes in the filter paper.

The filter paper stops the solid pieces from getting through—even very small pieces of solid, such as grains of sand.



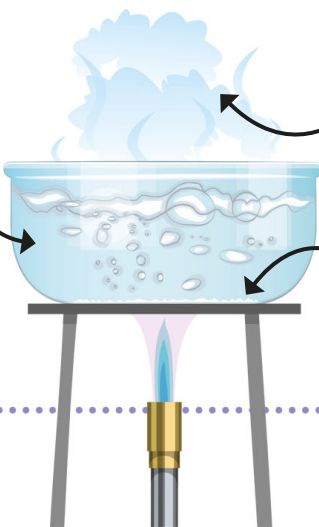
### Evaporating

When a solid has dissolved in a liquid to form a solution, it cannot be separated by filtration. The solution must be heated until the liquid evaporates, leaving the solid behind.

A solution of sugary water is heated in a pan.

The hot water evaporates.

Eventually, all the water evaporates and solid sugar is left behind in the pan.



# Changes

Changes are taking place in the world around us all the time. Sometimes, after a change, things can be put back to the way they were before. Other types of change leave things altered forever.

## Reversible change

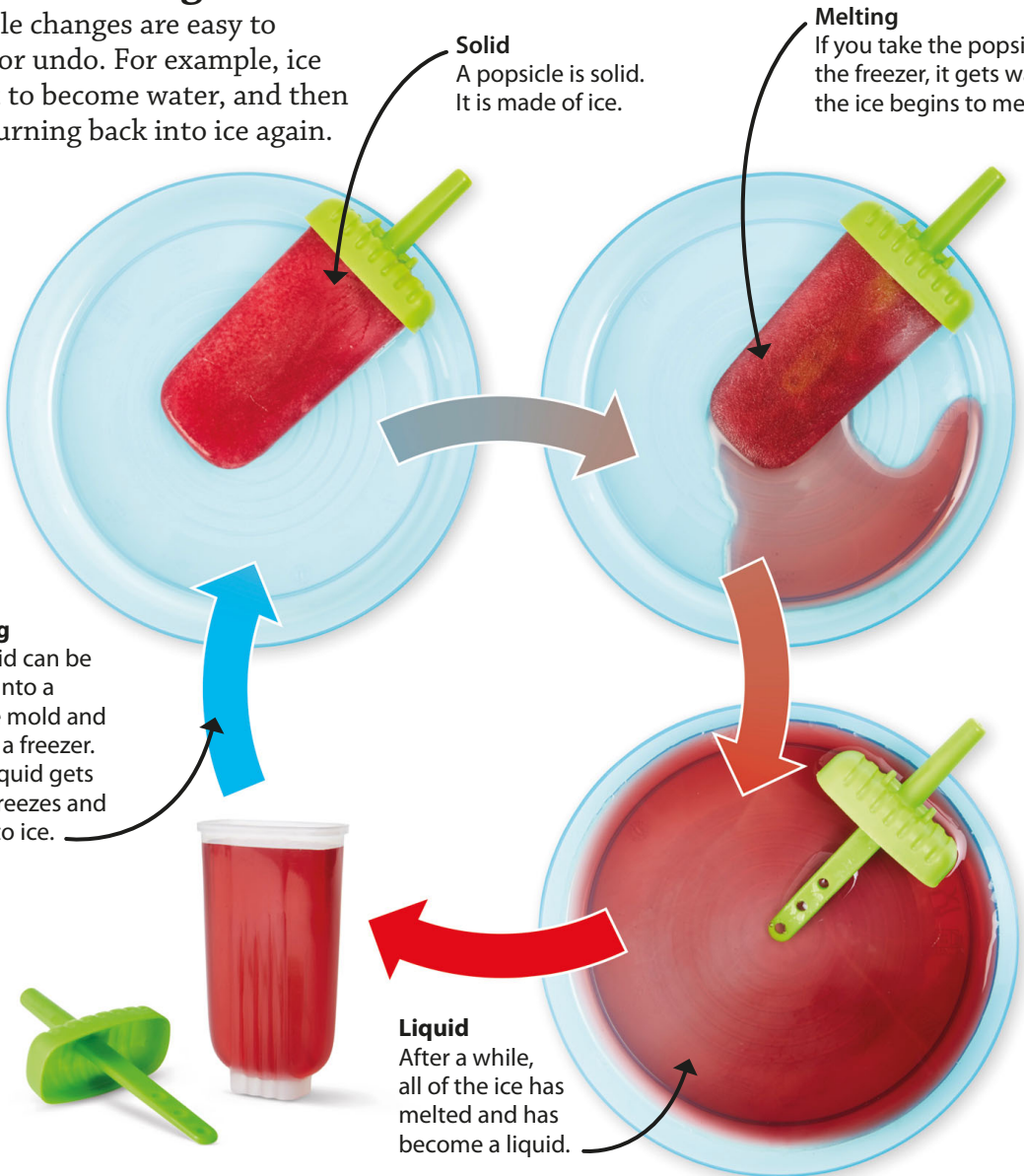
Reversible changes are easy to reverse, or undo. For example, ice can melt to become water, and then freeze, turning back into ice again.

**Solid**  
A popsicle is solid.  
It is made of ice.

**Melting**  
If you take the popsicle out of the freezer, it gets warm and the ice begins to melt.

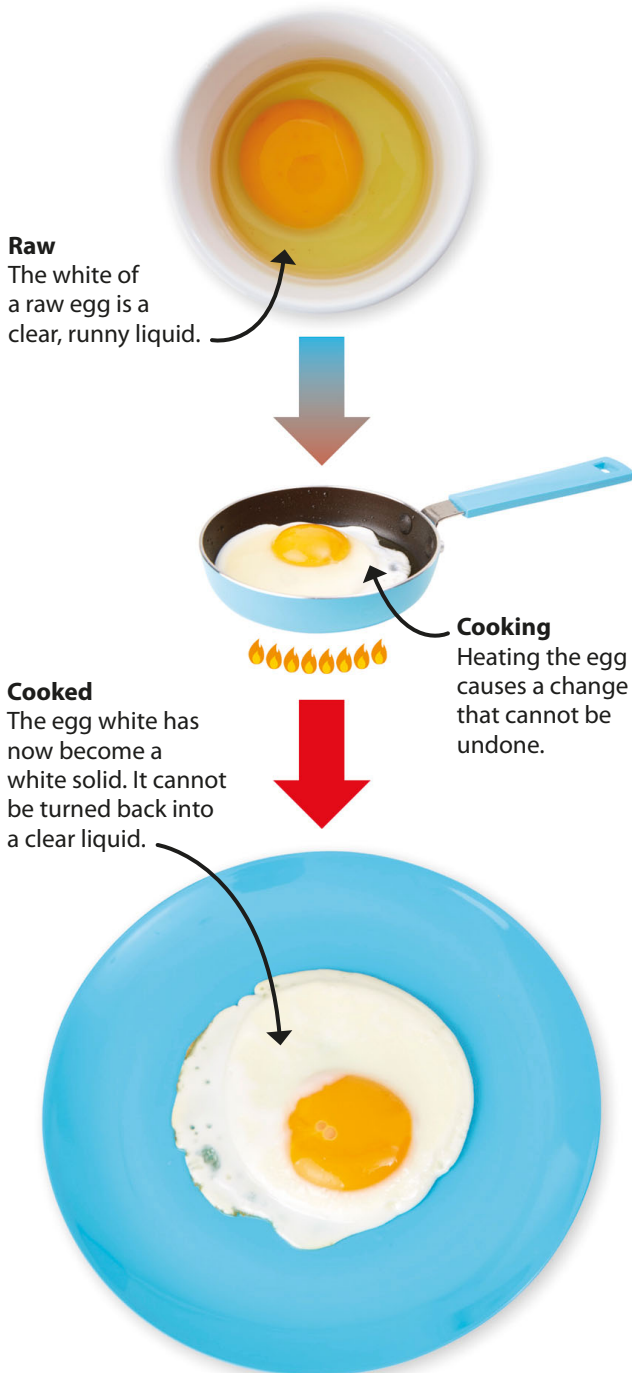
**Freezing**  
The liquid can be poured into a popsicle mold and put into a freezer. As the liquid gets cold, it freezes and turns into ice.

**Liquid**  
After a while, all of the ice has melted and has become a liquid.



## Irreversible change

Irreversible changes cannot be undone. They are permanent. For example, once you have cooked an egg, it cannot be turned back into a raw one!



## Everyday changes

Here are some examples of common reversible and irreversible changes that you may see from time to time.

### Steamed window

When invisible water vapor in the air hits a cold window, it condenses, turning into tiny water droplets. When the window gets warm, the droplets turn back into water vapor.

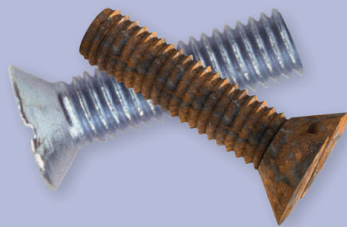


### Fall leaves

Most trees lose their leaves in the fall. Before the leaves fall off the tree, they change from green to red to brown. This change cannot be undone, which means it is permanent.

### Rusting

Rust forms slowly when iron comes into contact with air and water. Iron objects left in the rain become flaky and reddish-brown forever.

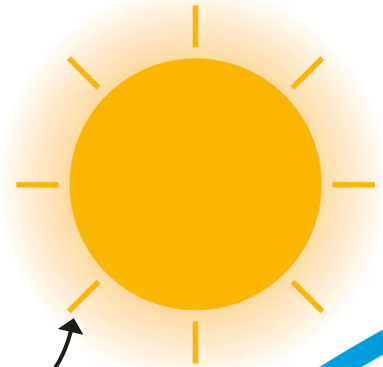


### Rotting food

When food gets old, it can be attacked by tiny living things called mold and bacteria. As the food rots it turns brown, smells nasty, and shrivels up. It cannot be changed back into its fresh form again.

# The water cycle

Almost three-quarters of the Earth's surface is water. Water is found in rivers, lakes, and oceans, and it can also be seen as tiny water droplets in clouds, or falling to Earth as rain or snow. Water is constantly moving from one place to another around the planet. This movement is called the water cycle.



The Sun's rays warm the land and the oceans.

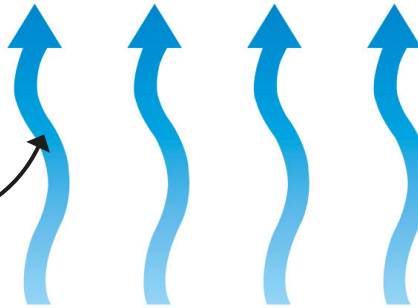
## Water on the move

The constant cycle of evaporation and condensation of water is almost entirely caused by heat from the Sun.



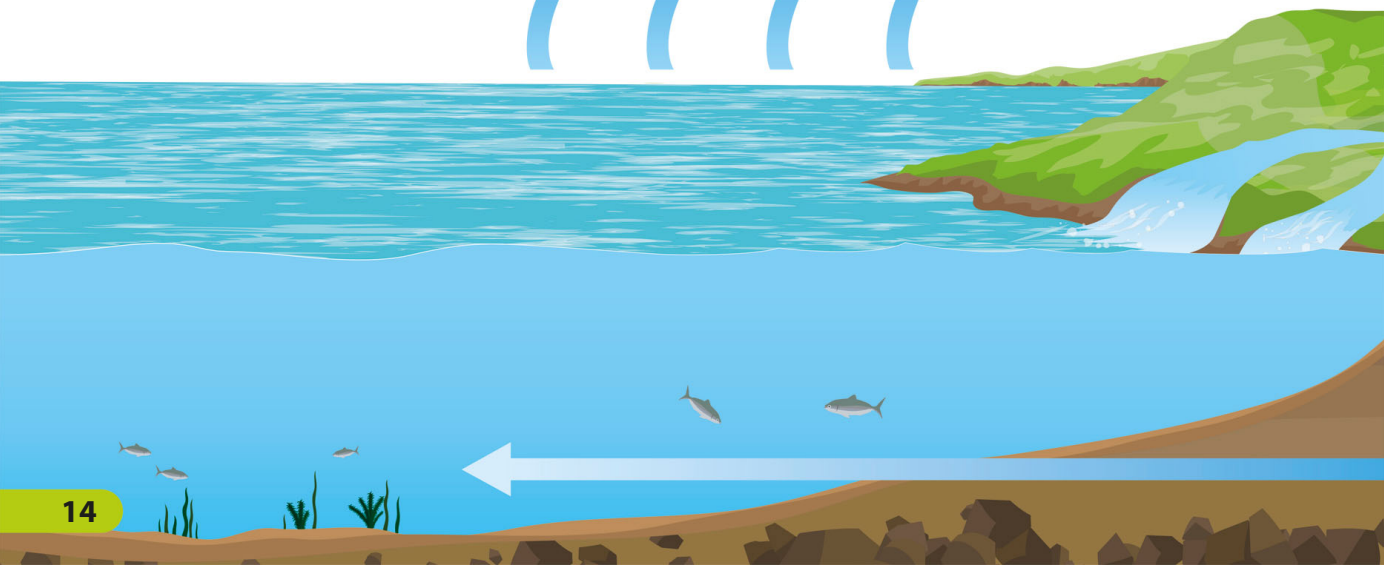
### Evaporation

Heat from the Sun causes water in the ocean to evaporate, turning into invisible water vapor. Water also evaporates from rivers and lakes.



### Condensation

As water vapor rises it cools and condenses into tiny water droplets, forming white clouds.





## Extreme conditions

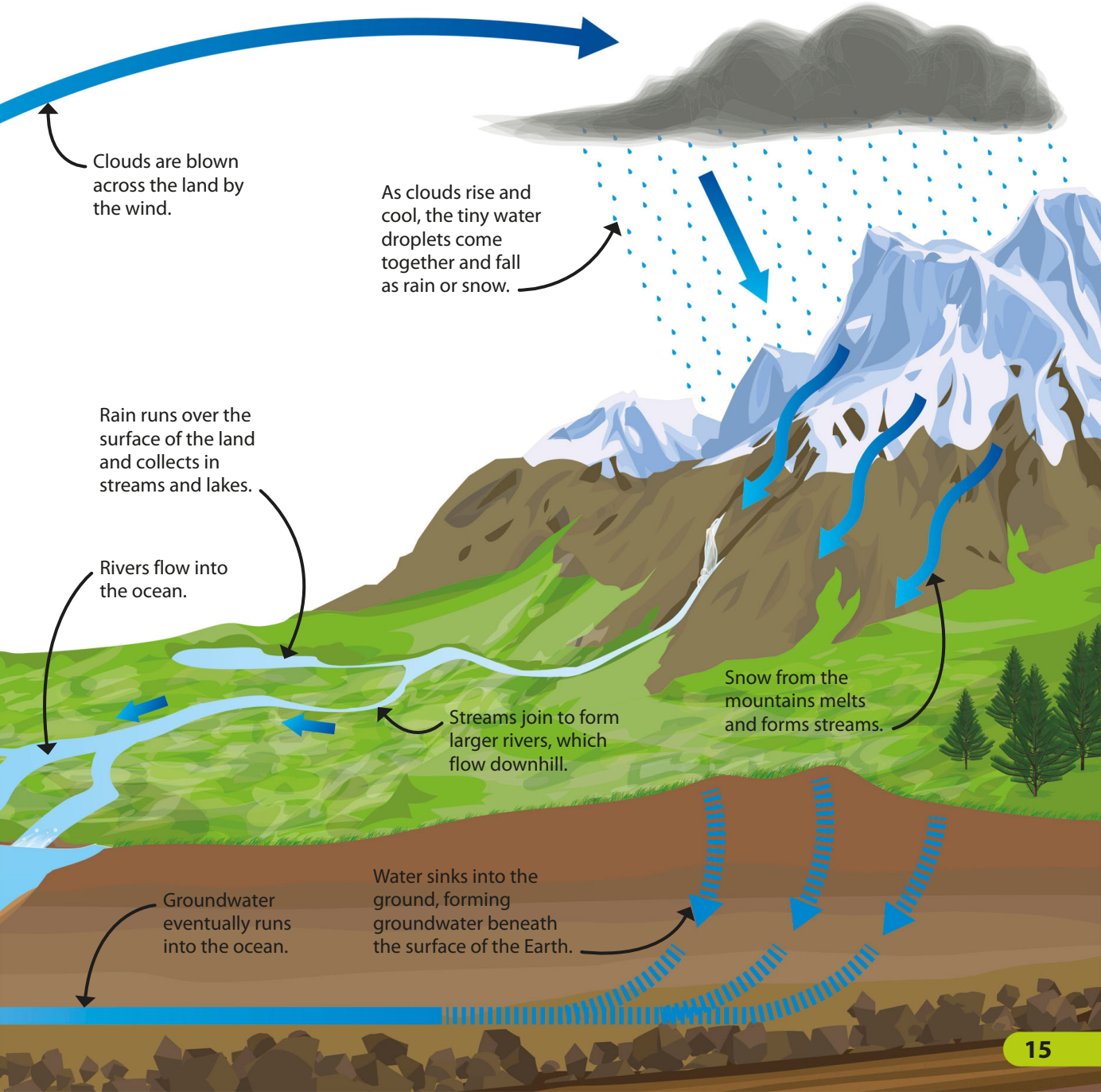
Deserts are places where very little rain falls. The Atacama Desert in Chile is the driest place in the world, with only 0.6 in (15 mm) of rain every year. The wettest place on Earth is Mawsynram in India, which has 467 in (11,872 mm) of rain every year.



Atacama Desert, Chile



Mawsynram, India



# Forces

A force is a push or a pull. Forces are needed to make things move. They can also make things speed up, slow down, or stop moving. Forces can also cause things to change direction or change shape. Most forces only act when things touch each other. Other forces, such as gravity and magnetism, act at a distance.

## Pushing forces

A sail boat uses the pushing force of the wind to start moving and to keep moving in the water. If the wind dies down, the boat will slow down and eventually stop, because the air and water are pushing back against it.

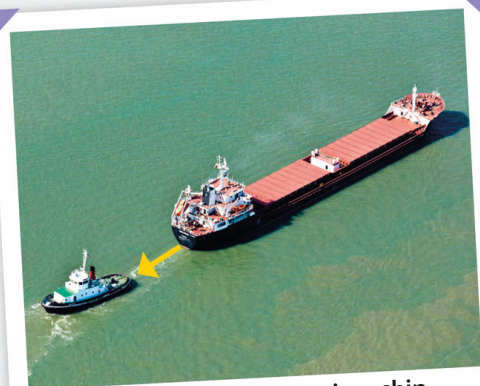
### Wind

The wind pushes against the sail, moving the boat forward through the water.



## Pulling forces

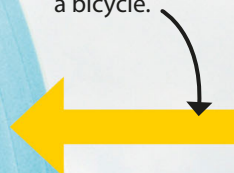
A small tugboat is able to pull a much larger ship through water because it has a very powerful engine. The engine produces a strong pulling force, which acts through the towline connecting the two boats.



Tugboat pulling a container ship.

### Air resistance

As the boat moves forward, the air pushes back against it. This is called air resistance. You can feel the force of air resistance on your face when you pedal hard on a bicycle.



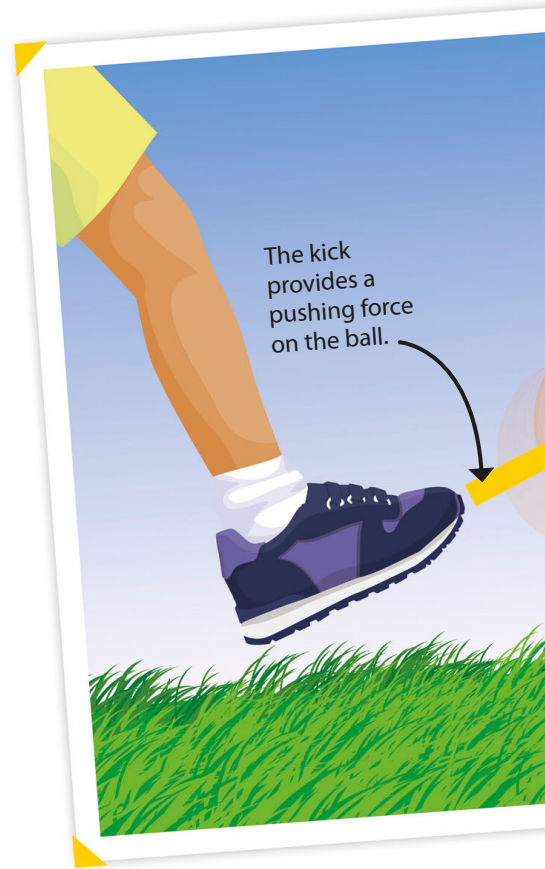
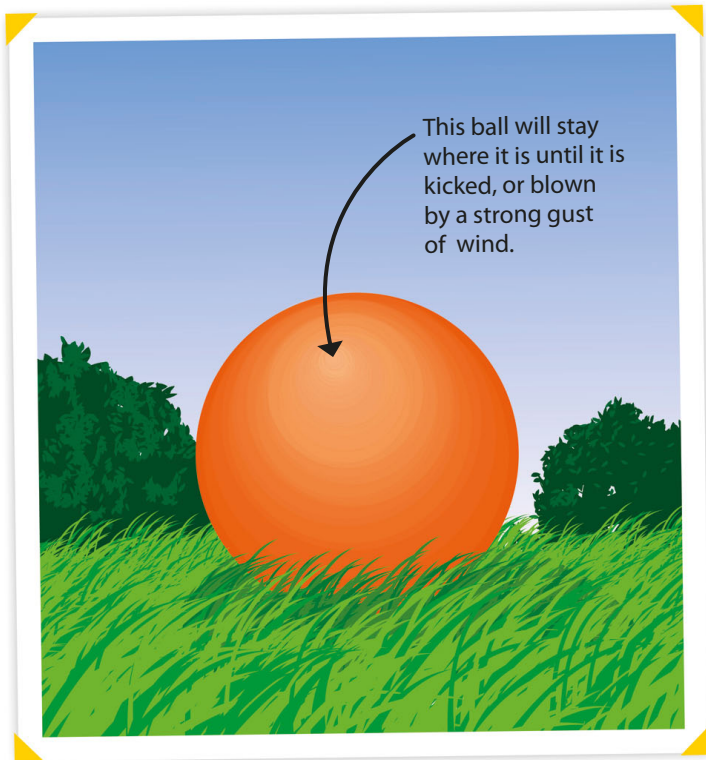
### Water resistance

As the boat moves forward, the water pushes back against it. You can feel the force of water resistance when you try to run through water.



# Laws of Motion

Nothing can move without a force to start it on its way. Forces are also needed to make things move faster, to change their direction, and to make them stop. In 1687, the English scientist Isaac Newton came up with three simple ideas that show how forces affect the way things move. These ideas are called the Laws of Motion.

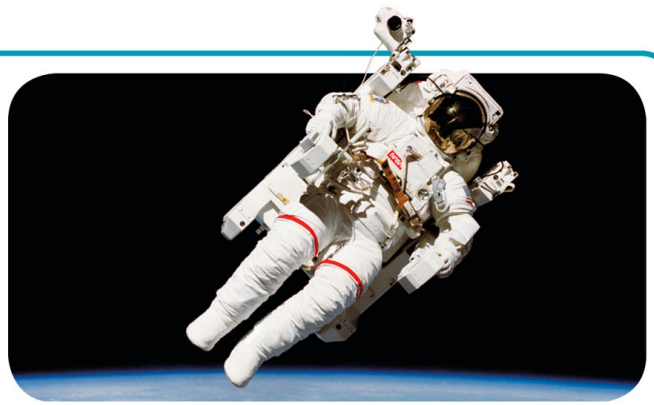


## Newton's First Law

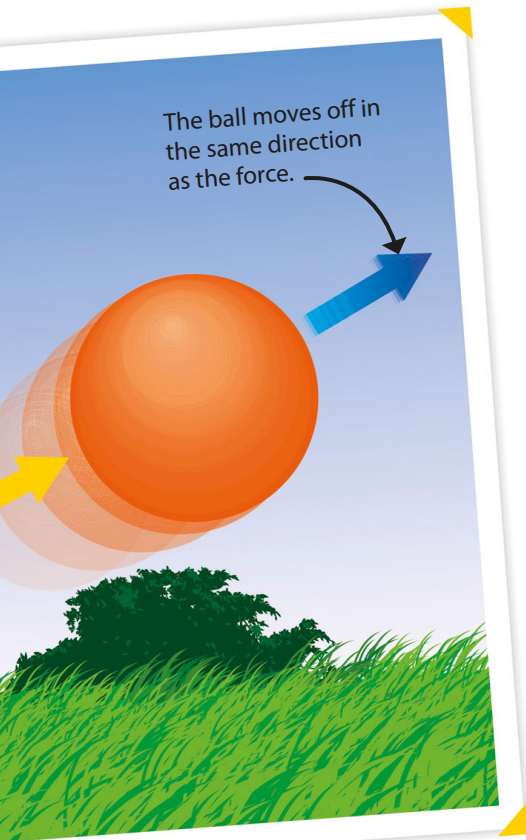
If an object is not moving, it will stay completely still unless an outside force acts on it. If an object is already moving, it will keep on moving at the same speed, and in a straight line, unless an outside force, such as gravity, causes it to change its motion.

## Moving forever

Every object that is moving through air will eventually come to a stop because the air pushes back against the moving object, slowing it down. This force is called air resistance. However, in space there is no air, which means that once something starts to move, it will keep moving forever! This is an example of Newton's First Law.



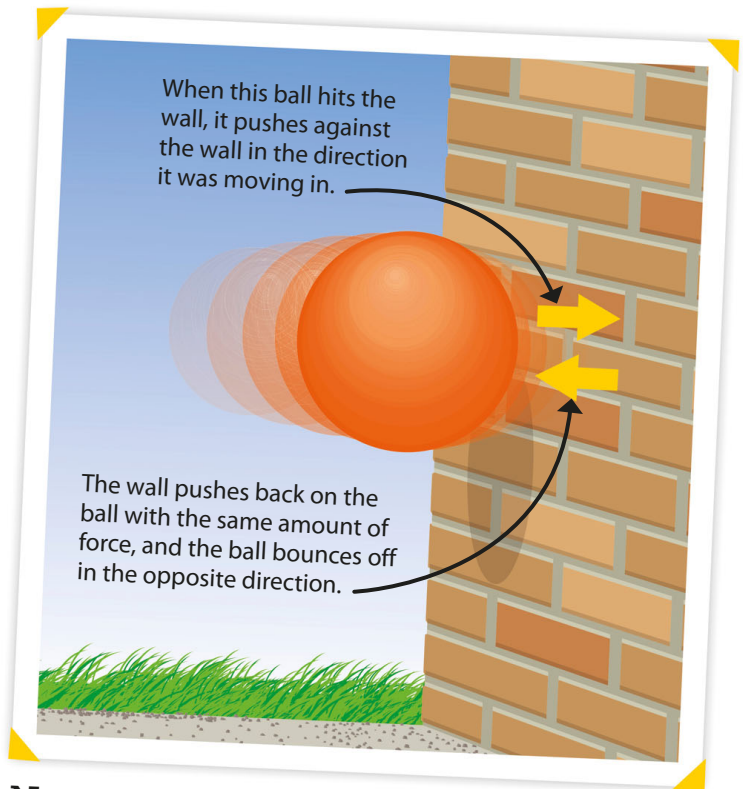
An astronaut floating through space.



The ball moves off in the same direction as the force.

## Newton's Second Law

If an outside force pushes or pulls on an object that is not moving, it will start to move in the same direction as the force. If an object is already moving, an outside force will cause it to move faster, slow down, or change direction.



When this ball hits the wall, it pushes against the wall in the direction it was moving in.

The wall pushes back on the ball with the same amount of force, and the ball bounces off in the opposite direction.

## Newton's Third Law

This law says that "Every action has an equal and opposite reaction." This means that when a force acts in one direction, it creates another equal force in the opposite direction. An example of this is a ball bouncing off a wall.

# Friction

Friction is a force that slows things down. It occurs when two surfaces rub against each other. Different types of surface produce different amounts of friction. Smooth surfaces, such as ice, do not create much friction, so things slide over them easily. Rough surfaces, such as roads, produce a lot of friction. This helps car wheels to grip the road and allows cars to stop easily.

## Sliding race

Four metal bobsleds are held at the top of a slope. Each slope has a different surface. The bobsleds are let go of at the same time.

Which one will move the fastest?



## Super friction

If the pages of two books are interleaved, it is almost impossible to pull them apart. This is because there are hundreds of pages, and therefore hundreds of surfaces, that are trying to slide against each other at the same time. This produces an enormous amount of friction, which stops the pages from being pulled apart.

### Linked books

The pages of these two books have been alternately stacked.



Two cars would struggle to pull these books apart!



## Slippery surface

A smooth surface, such as this slope covered in oil, creates hardly any friction. Objects slide very easily and quickly along them. Ice skaters and skiers make use of slippery surfaces.



## Wooden floorboards

Floorboards are fairly smooth, producing only a little friction, which allows objects to slide over them very easily. This is why you can sometimes slide on floorboards in your socks.



## Scratchy sandpaper

Sandpaper is rough and so creates a lot of friction. This means that an object sliding over sandpaper will slow down and stop more quickly than an object sliding over a smoother surface.



## Green grass

A very rough surface like grass produces lots of friction, causing an object sliding over it to slow down a lot. The longer the grass, the more quickly the object will slow down.

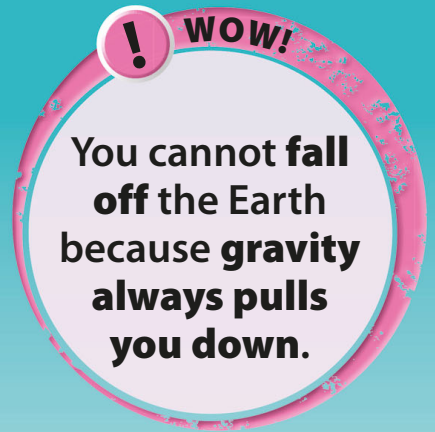


**REALLY?**

**When you rub your hands together, it is friction that causes them to get warm.**

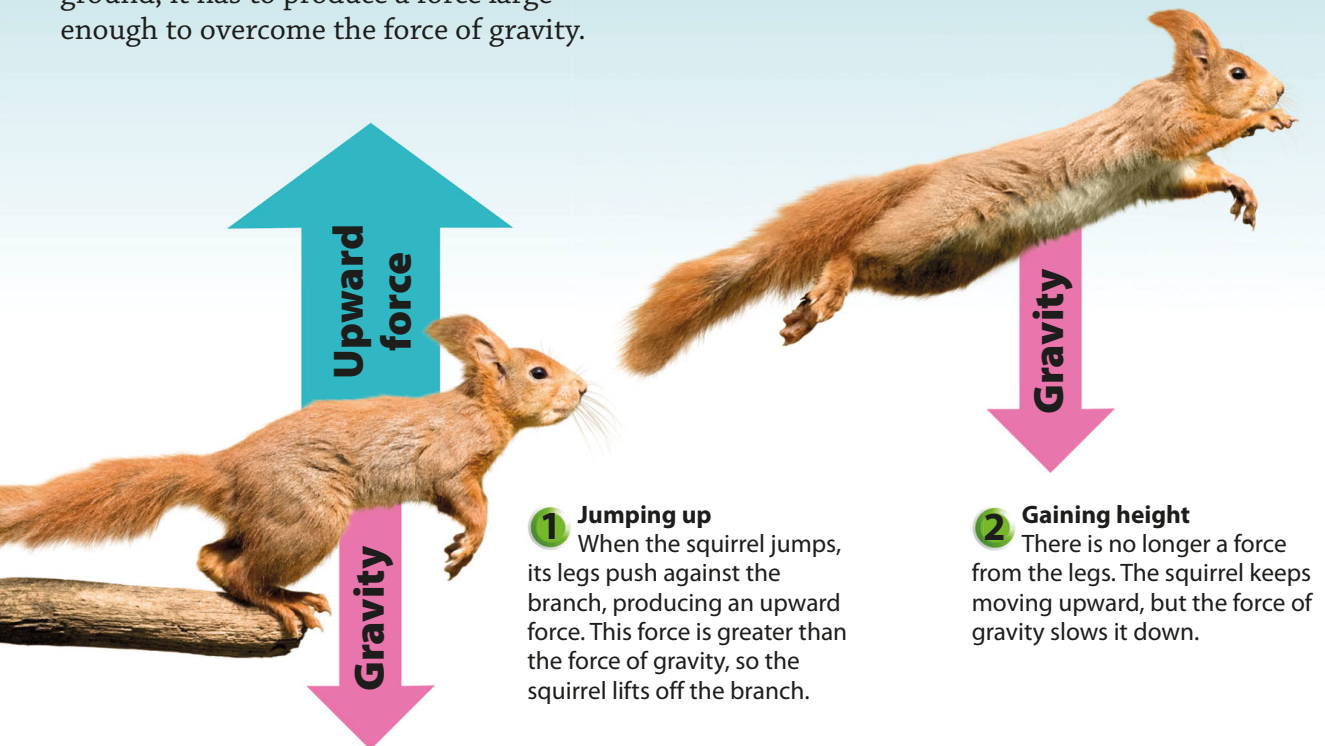
# Gravity

Gravity is an invisible force that pulls things toward the center of the Earth. It pulls everything toward the Earth, whether the object is in the air, in water, or already on the ground. Even the Moon is kept moving around the Earth by the pull of Earth's gravity.



## Leaping squirrel

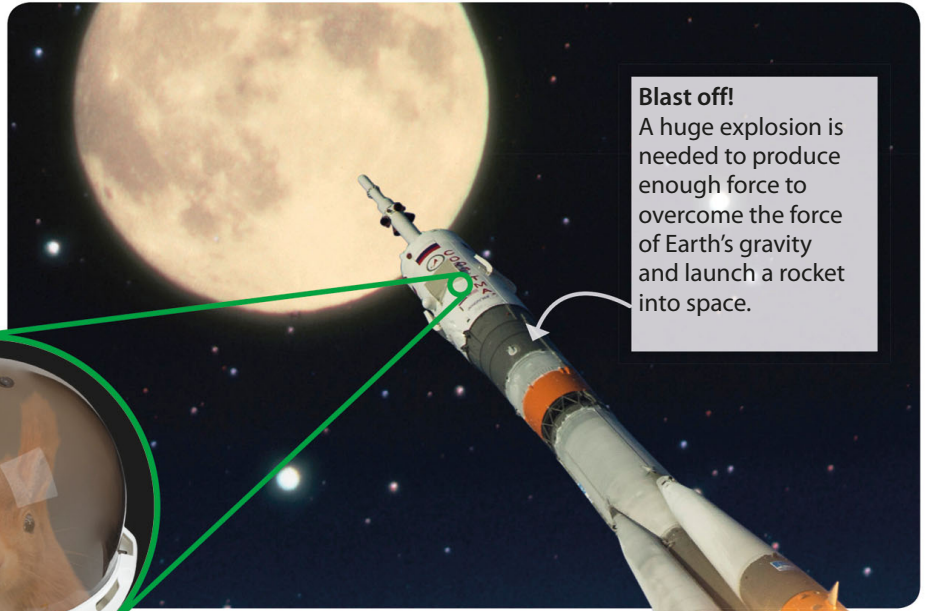
Gravity keeps things held to the Earth. For something to be able to lift off the ground, it has to produce a force large enough to overcome the force of gravity.





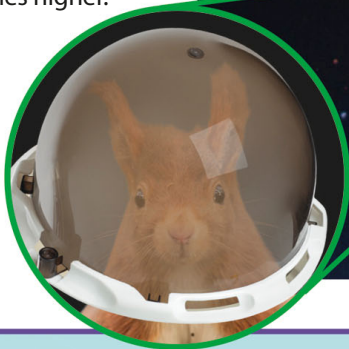
## The Moon

The Moon has its own gravity, but because it is smaller than the Earth, its force of gravity is not so strong. The squirrel would feel lighter on the Moon, and it would be able to jump almost seven times higher.



### Blast off!

A huge explosion is needed to produce enough force to overcome the force of Earth's gravity and launch a rocket into space.



The squirrel takes a rocket to the Moon.



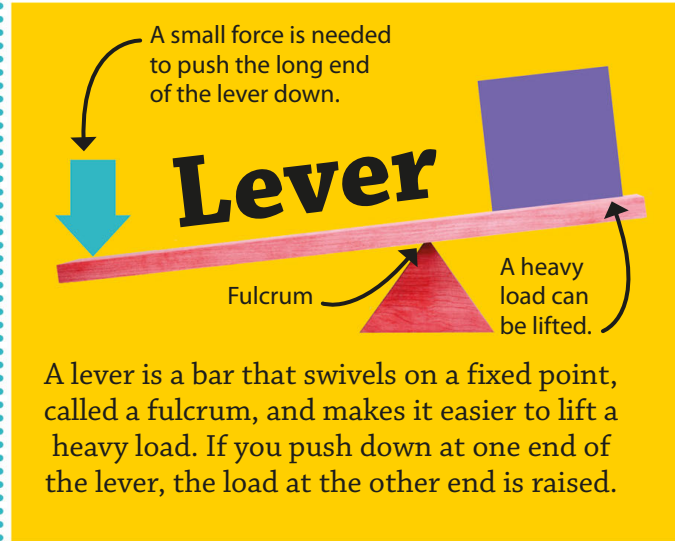
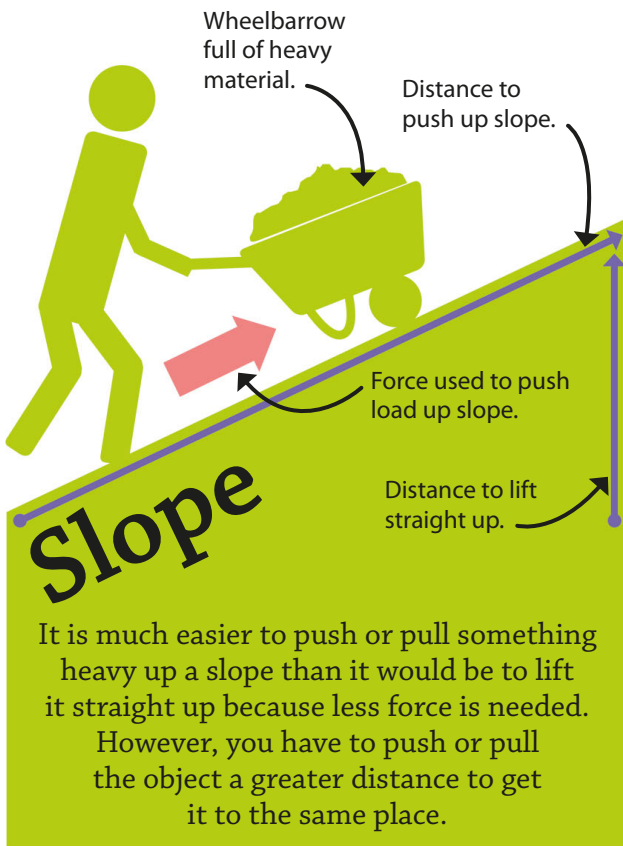
- 3 Falling down**  
The squirrel slows down so much that for a tiny moment it stays totally still in the air. Then gravity causes the squirrel to begin to fall toward the ground.

- 4 Landed**  
Once the squirrel has landed on another branch, the force of gravity holds it there until it decides to jump again.



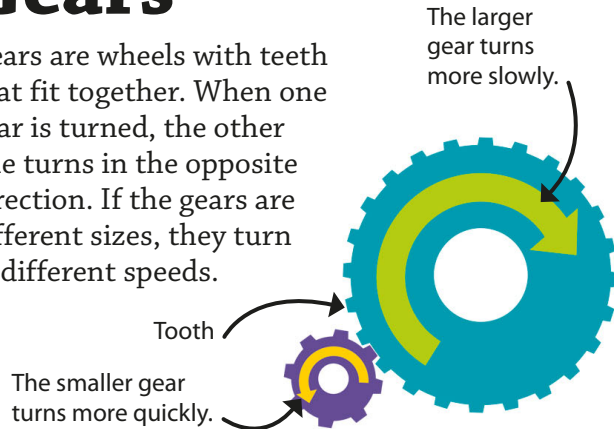
# Simple machines

Machines are used to make a task easier. They reduce the amount of effort that we need to put in (the force) to lift or move a heavy object (the load). Machines can also change the direction of a force, so we can move things in a more helpful way.



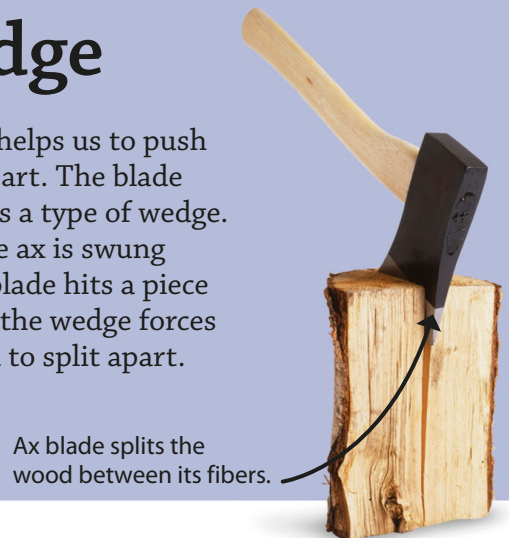
## Gears

Gears are wheels with teeth that fit together. When one gear is turned, the other one turns in the opposite direction. If the gears are different sizes, they turn at different speeds.



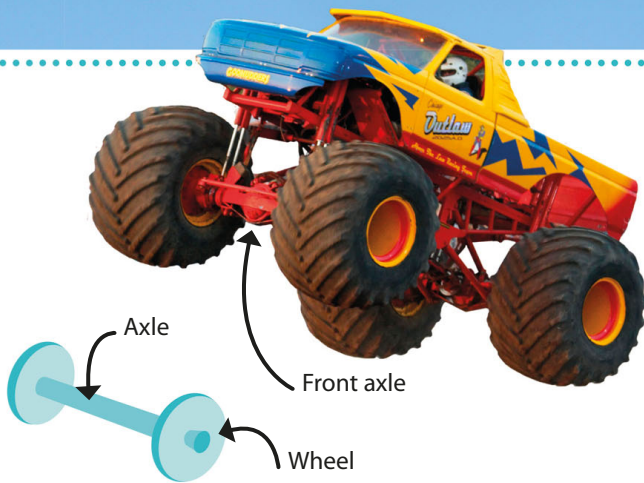
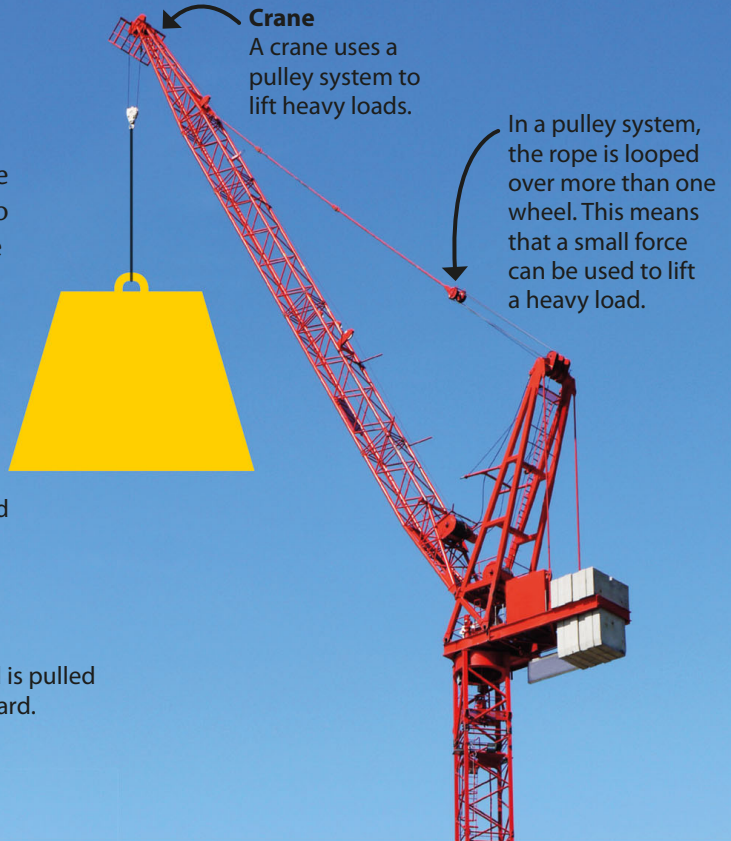
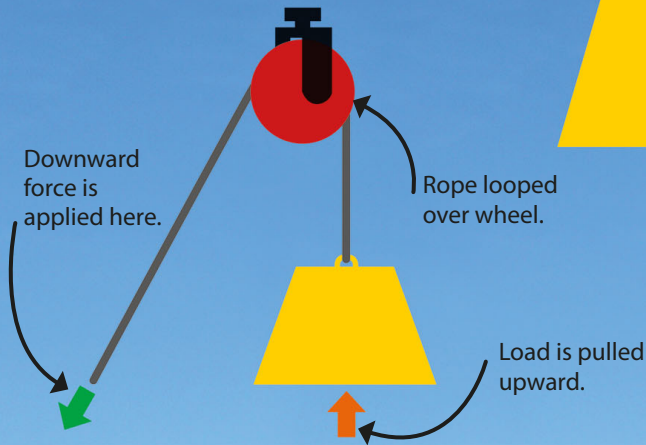
## Wedge

A wedge helps us to push things apart. The blade of an ax is a type of wedge. When the ax is swung and the blade hits a piece of wood, the wedge forces the wood to split apart.



# Pulley

A pulley makes it easier to lift a heavy object (load) straight up. A rope is looped over a wheel and one end of the rope is attached to the load. It is easier to lift the load by pulling down on the rope than by picking it up.

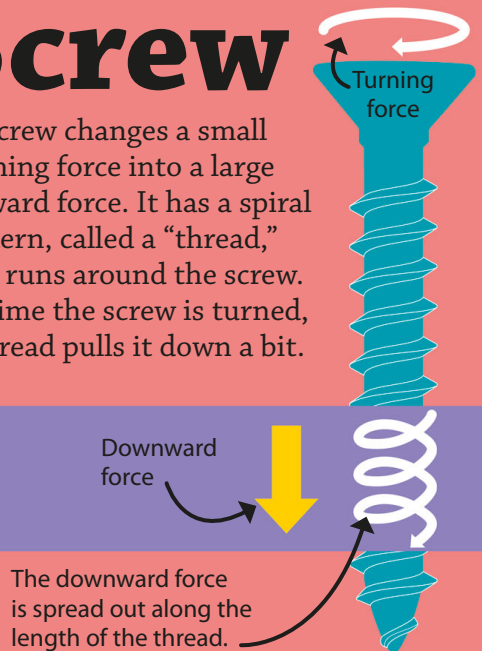


# Wheel and axle

A wheel and axle work as a turning machine that makes it easier to move something from one place to another. When the axle is turned, the rim of the wheel turns more quickly.

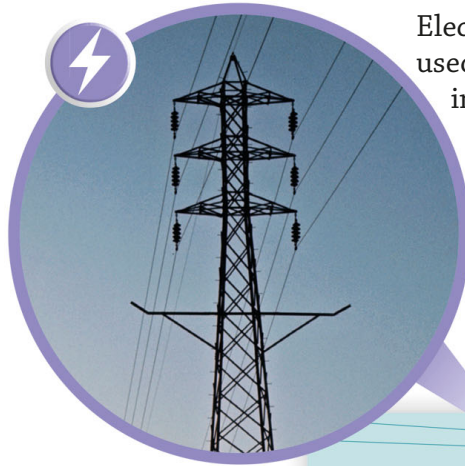
# Screw

A screw changes a small turning force into a large downward force. It has a spiral pattern, called a "thread," which runs around the screw. Each time the screw is turned, the thread pulls it down a bit.



# Energy

Energy is needed to make things happen. Every movement or change, no matter how small, requires energy. Energy has many different forms. For example, some types of energy are needed to move cars or light up homes. Your body needs energy to move, grow, and keep warm.



## Electrical

Electrical energy is used to power things in our homes, such as a television. Electricity flows easily through wires. Lightning is also caused by electrical energy.



## Movement

All moving things have energy, from dogs to waterfalls. The faster something moves, the more energy it has.



**! WOW!**

**Without energy our world would be freezing cold, dark, silent, and lifeless.**

## Chemical

There is energy stored inside the chemicals in food. When animals eat, their bodies break down the food, releasing the energy.



## Light

Glowing objects give out light energy, which we see with our eyes. Nearly all the energy on Earth comes originally from the Sun.



## Stored energy

Sometimes energy is trapped inside things. This is called stored, or potential, energy. When this stored energy is released, it can make things happen. A stretched catapult stores elastic energy. When you release it, it gives energy to the ball, making the ball fly out.

The more the catapult elastic is stretched, the more stored energy it has.



## Sound

Sound is a form of energy that is produced when objects vibrate, or shake. For example, when a bell is hit, it makes a sound. We receive sound energy through our ears. This is called hearing.



## Heat

Hot things contain lots of heat energy. They pass on this energy to cooler things around them, so hot things like a fire can be used to keep us warm. We get most of our heat energy from the Sun, and from burning things, such as wood.



# Heat

Heat is a type of energy that we can feel. The hotter something is, the more heat energy it gives out. Heat energy always tries to spread from a hotter to a colder thing. So, when you touch a hot object, heat energy flows out of the object into you, warming you up.

## Convection

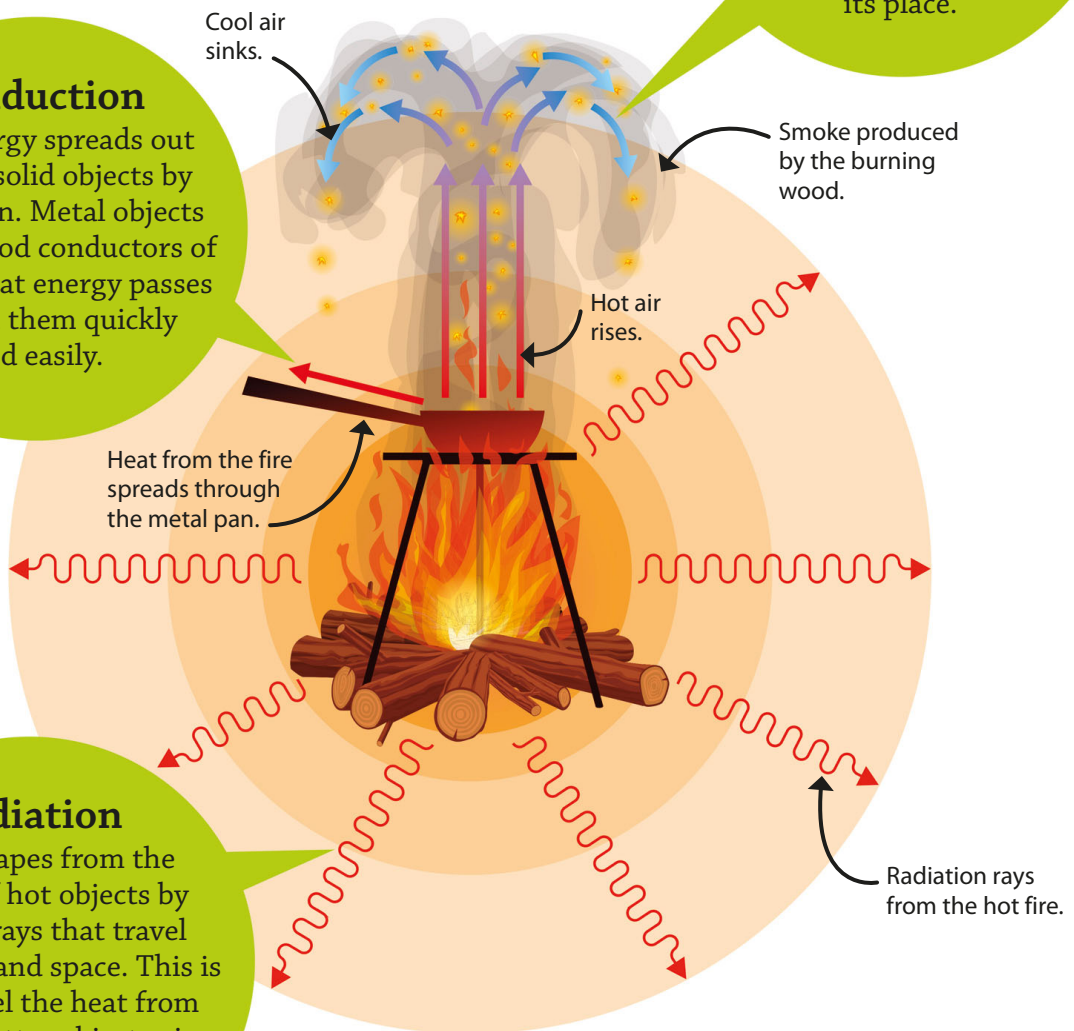
When gases and liquids get hot, heat energy spreads out through them by convection. Hot air or water rises, and cold air or water sinks to take its place.

## Conduction

Heat energy spreads out through solid objects by conduction. Metal objects are very good conductors of heat, so heat energy passes through them quickly and easily.

## Radiation

Heat escapes from the surface of hot objects by invisible rays that travel through air and space. This is how we feel the heat from the Sun. Hotter objects give out more radiation than cooler ones.



# Temperature

Temperature is the measure of how hot or cold things are. It is recorded in degrees Fahrenheit (°F) or degrees Celsius (°C).



**27 million°F**  
(15 million°C)

The temperature at the center of the Sun.

**3,200°F**  
(1,760°C)

The temperature at which sand melts and turns into glass.



**212°F**  
(100°C)

The boiling point of water.

**450°F**  
(232°C)

The temperature at which dry wood catches fire.

**134°F**  
(56.7°C)

The hottest temperature recorded on Earth, at Death Valley, California, on July 10, 1913.

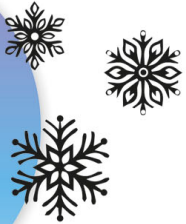
**98.6°F**  
(37°C)

The average temperature of the human body.



**35.6°F**  
(2°C)

The temperature of the air when rain turns to snow.



**32°F**  
(0°C)

The freezing point of water.

**-128.5°F**  
(-89.2°C)

The coldest temperature recorded on Earth at Vostock Station, Antarctica, in 1983.

**-458°F**  
(-272°C)

The temperature of the Boomerang Nebula, a cloud of dust and gas that is the coldest place in the universe.



# Sound

Sound is produced when things vibrate, or shake. A vibrating object makes the air next to it vibrate as well. These vibrations travel through the air as a sound wave, which we hear with our ears. Sound waves can also travel through liquids and solids, such as water, rock, or wood.

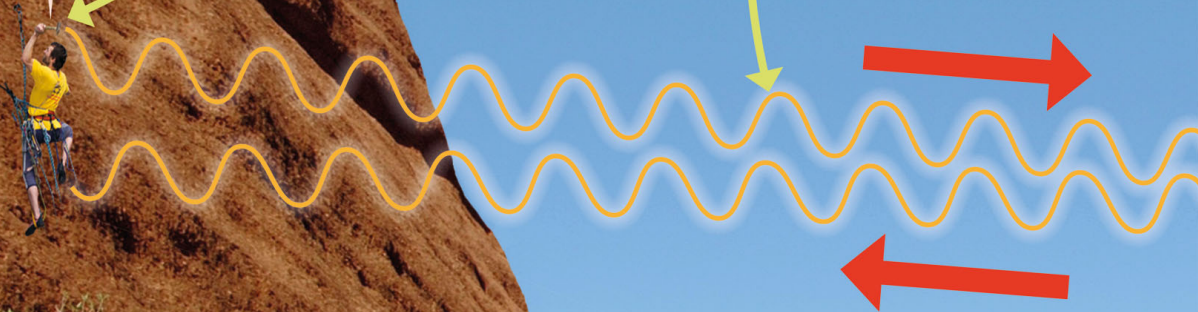


## Making sound

When the climber hits the metal spike with his hammer, it vibrates. This vibration causes the surrounding air to vibrate, too, producing a sound wave.

## Sound wave

The sound wave spreads out through the air. It travels away from the rock and hammer until it reaches a solid surface.



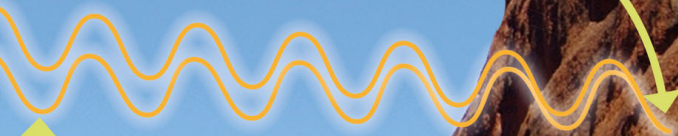


**! WOW!**

**Sound waves need air to travel, so there are no sounds in space.**

## Reflection

When the sound wave hits a solid surface, such as the side of a cliff, some of the energy bounces back toward the climber. The rest of the sound energy travels through the rock.



## Echo

The climber will hear the reflected sound wave as an echo, a few moments after he first produced the sound.

# Loudness

Vibrations with lots of energy produce big waves and make loud sounds. So, banging a drum harder will produce a louder sound. Sound waves lose energy as they travel, which means that the farther you are from a sound, the quieter it will be.



### Rustling leaves

When leaves brush against one other, they produce tiny vibrations in the air. These vibrations only have a small amount of energy, so the rustling sound is very quiet.

Small shallow wave



### Roaring lion

A lion's roar causes the surrounding air to vibrate with lots of energy. It produces a loud sound, which can be heard up to 5 miles (8 km) away.

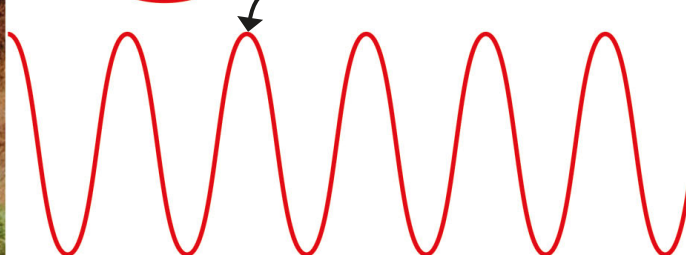
Bigger wave



### Rocket launch

When a rocket launches, the exploding gases produce huge amounts of sound energy. The noise is louder than 10 million rock bands performing at once!

Large deep wave

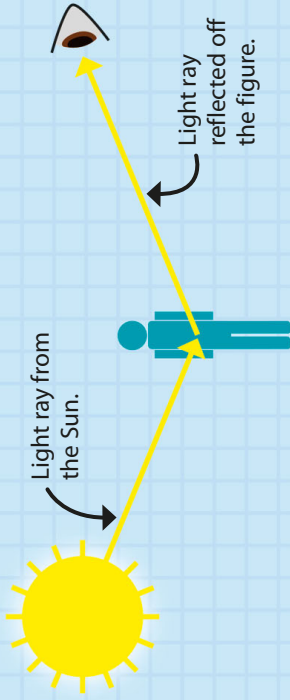


# Light

Light is a type of energy that allows us to see things. Light travels as rays, in straight lines. Light rays are given off by things that glow, such as the Sun, a candle, or a lightbulb. These things are called light sources. Other objects around us look bright because they bounce light from light sources back to our eyes. When there is no light source everything looks dark, for example, at night.

## Seeing things

Most things do not give out their own light. We can see these objects when we look at them because they reflect the light that falls on them. Light from a light source, such as the Sun, bounces off the object and into our eyes.



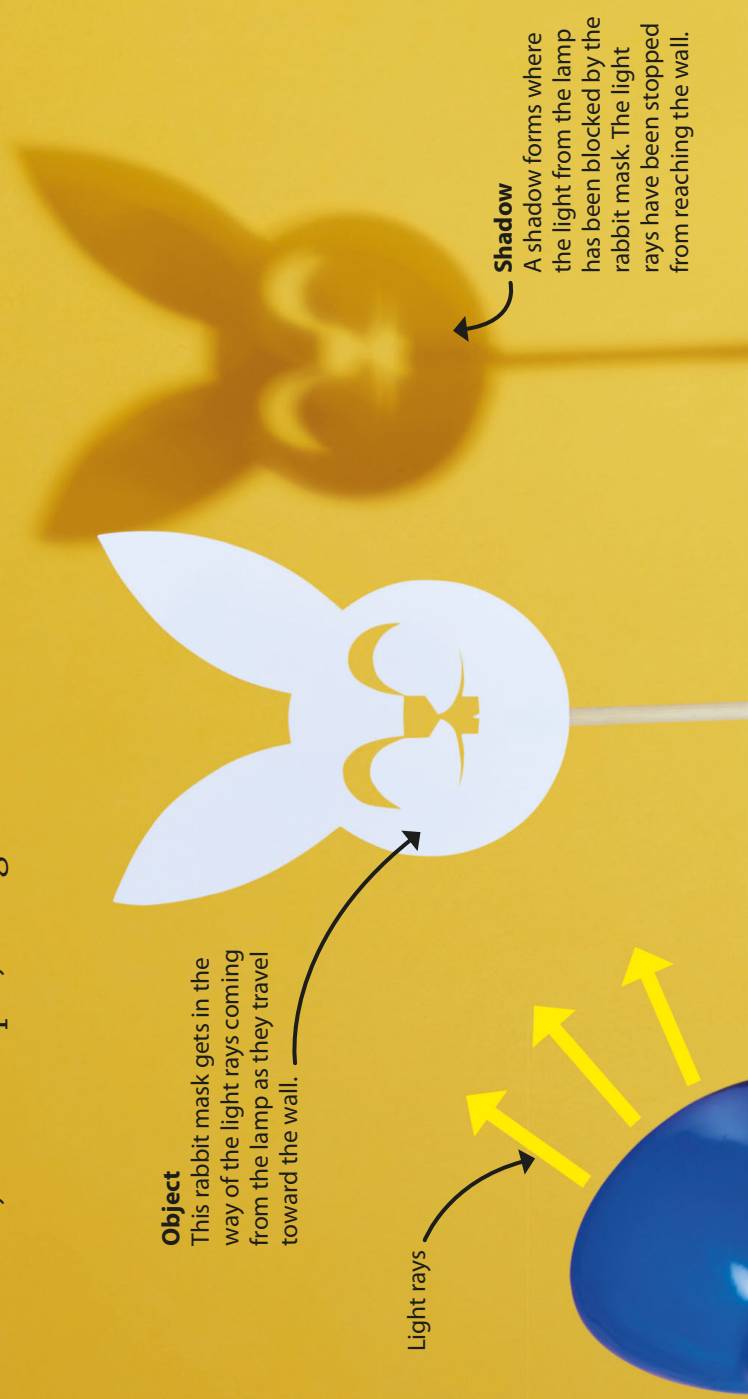
## Object

This rabbit mask gets in the way of the light rays coming from the lamp as they travel toward the wall.

Light rays

## Shadow

A shadow forms where the light from the lamp has been blocked by the rabbit mask. The light rays have been stopped from reaching the wall.





**Light source**  
This lamp is a light source. It gives out light rays that travel toward the wall in straight lines.

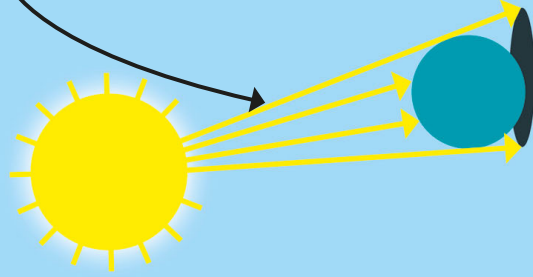
## Creating shadows

If something solid gets in the way of light coming from a source, the light rays are blocked. This creates a shadow behind the object, which is the same shape as the object.

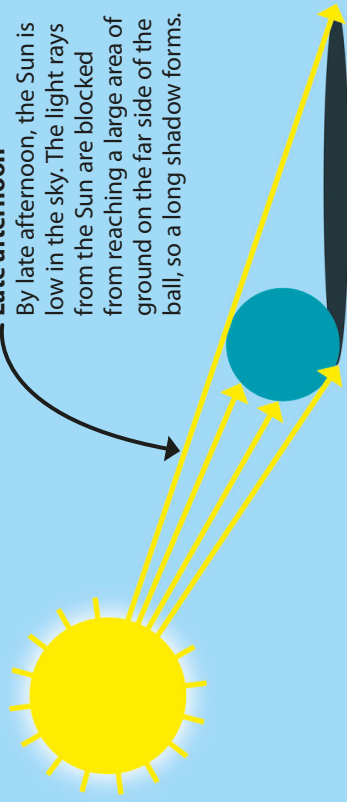
## Shadow length

The length of the shadow of an object can change, depending on where the light source is. The more directly above an object a light source is, the shorter the object's shadow will be.

**Noon**  
At noon, the Sun is almost directly overhead. The light rays from the Sun can reach most of the ground on the far side of the ball, forming a short shadow.



**Late afternoon**  
By late afternoon, the Sun is low in the sky. The light rays from the Sun are blocked from reaching a large area of ground on the far side of the ball, so a long shadow forms.



# Rainbows

We usually see light as white, but it is actually a mixture of different colors. We know this because we can see the colors in a rainbow. When the Sun is shining low in the sky behind you and rain is falling in front of you, you may see a rainbow.

## Seeing a rainbow

As sunlight passes through a shower of raindrops, it bends and splits into different colors.

### Double rainbow

If the sunlight is reflected twice inside each raindrop, you can see a second rainbow outside the main one, with its colors in the opposite order.

## Inside a raindrop

1 Rays of sunlight shine toward the falling raindrops.

2 When a ray enters a raindrop, it bends and the white light spreads into different colors.

3 The light reflects off the back of the raindrop.

4 When the light leaves the raindrop it bends again, so the colors spread out even more and shine down toward your eyes.



**WOW!**

Rainbows appear only in the **morning** or **late afternoon**.

### The colors of a rainbow

The colors always spread out in the same order. We call the pattern they make a spectrum. The seven main bands of color blend into each other, creating millions of different colors.



**Red**

**Orange**

**Yellow**

**Green**

**Blue**

**Indigo**

**Violet**



#### Color arc

Rainbows are curved because the colors leave the raindrops at different angles.

#### Bright colors

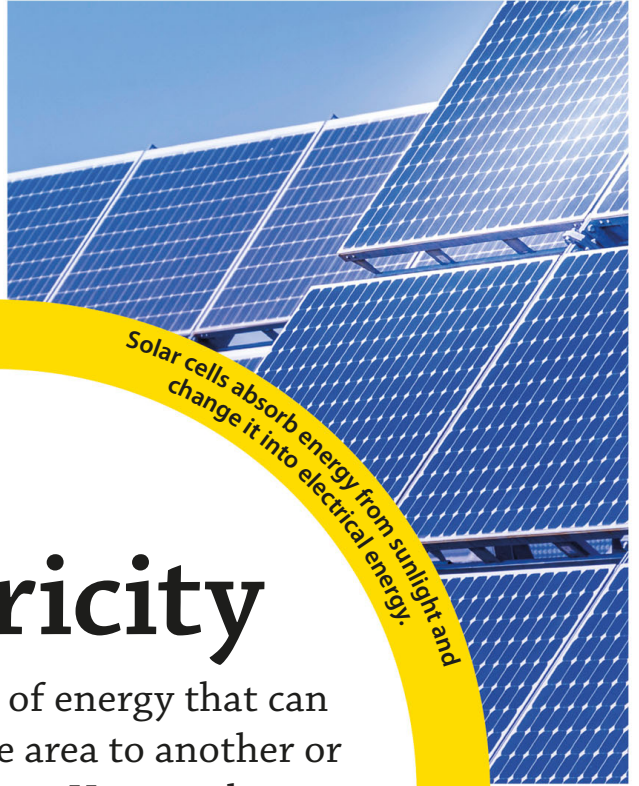
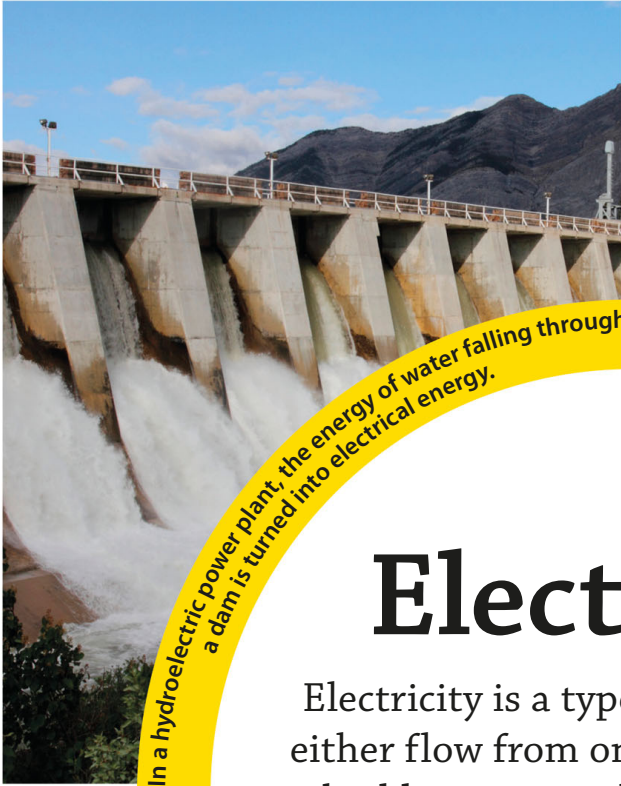
Large raindrops form bright, clear rainbows, while small raindrops make faint, fading ones.



#### Is it the end?

If the ground weren't in the way, you would see the rainbow as a circle.





In a hydroelectric power plant, the energy of water falling through a dam is turned into electrical energy.

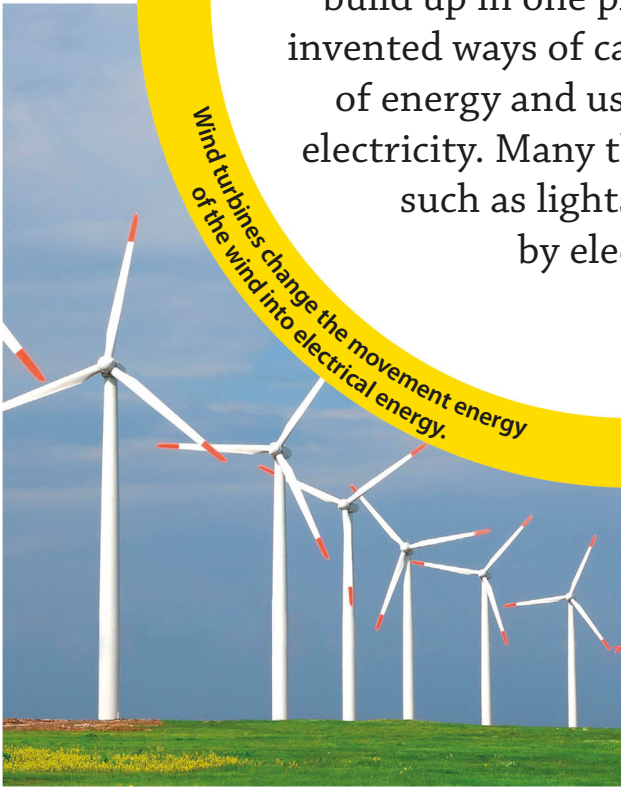
Solar cells absorb energy from sunlight and change it into electrical energy.

# Electricity

Electricity is a type of energy that can either flow from one area to another or build up in one place. Humans have invented ways of capturing other forms of energy and using them to make electricity. Many things in our homes, such as lights, are powered by electricity.

Wind turbines change the movement energy of the wind into electrical energy.

The heat energy released from burning fuels such as coal, oil, or gas can be used to make electrical energy.





A series of cables and towers is used to transport electricity from place to place.

## Into our homes

After electricity has been made by a power plant, it travels to towns and homes along a series of underground or overground cables, called the electrical grid. The electrical cables send electricity into the sockets found in most buildings.

**! WOW!**

**Electricity travels through wires 100 times slower than the speed of light.**

## Static electricity

Sometimes electrical energy builds up in one place. This is called static electricity. The buildup can happen when things are rubbed together, like a balloon and a sweater, which can cause them to stick together. When a buildup of electrical energy is released, a spark of electricity can sometimes be seen or felt.



### Lightning

A lightning bolt is a giant spark of electricity. When rain clouds rub against the air around them, static electricity builds up. If the buildup gets big enough, the electrical energy leaps to Earth as a bolt of lightning.



# Electrical circuits

## Battery

A battery stores electrical energy and releases it when connected to a circuit. The battery will eventually run down and will have to be replaced.

## Switch

A switch allows the bulb to be turned on or off without removing the battery. When the switch is closed, the circuit is complete and the bulb lights up.

An electrical circuit is a loop around which electrical energy can move. Electricity travels from a power source, such as a battery, through wires, and back to the power source. In a simple circuit, other useful items that make use of the electricity, such as a bulb or a buzzer, are added. Electricity can only flow when there is a complete circuit.



Open switch

When the switch is open, there is a gap in the circuit and the bulb cannot light up.

Closed switch



## Wires

Electricity flows around the circuit through a series of wires. Wires are usually made of copper because copper is a good conductor of electricity.

## Conductors and insulators

Conductors allow electricity to flow easily through them. Metals, such as copper, are good conductors of electricity. Insulators do not let electricity pass through them. Plastic, rubber, and wood are good electrical insulators.



### Conductor

Electrical wires are made of metal so electricity can flow easily through them.

### Insulator

Wires are coated in plastic to prevent you from getting an electric shock if you touch them.

## Bulb

As electricity flows through the bulb, the electrical energy is converted to light energy, and the bulb glows brightly.

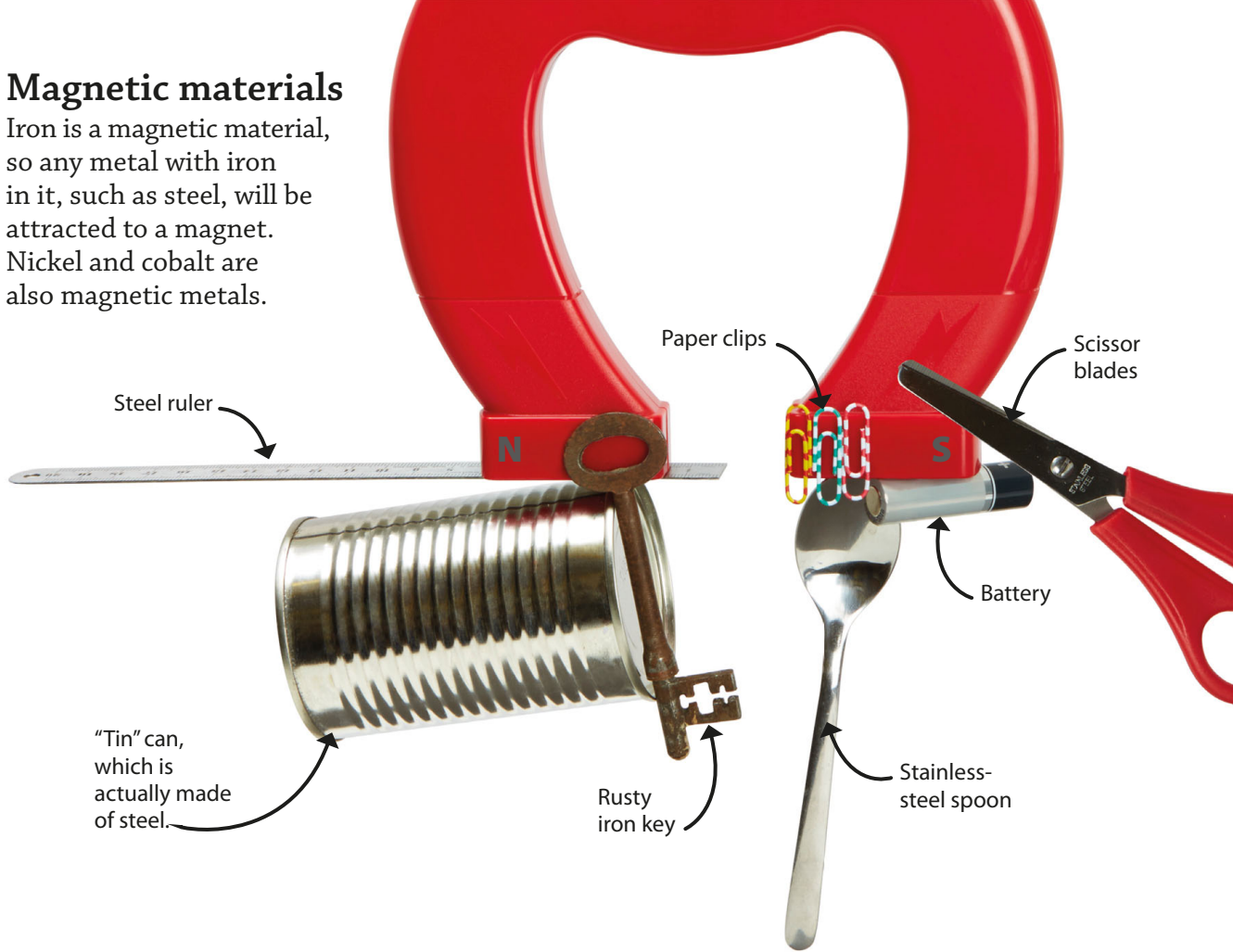
## Switching on!

Many electrical items do not need batteries because they can be plugged into outlets using a long wire. Once they have been plugged in, these items are usually turned on by pressing a switch, which completes the electrical circuit.



## Magnetic materials

Iron is a magnetic material, so any metal with iron in it, such as steel, will be attracted to a magnet. Nickel and cobalt are also magnetic metals.



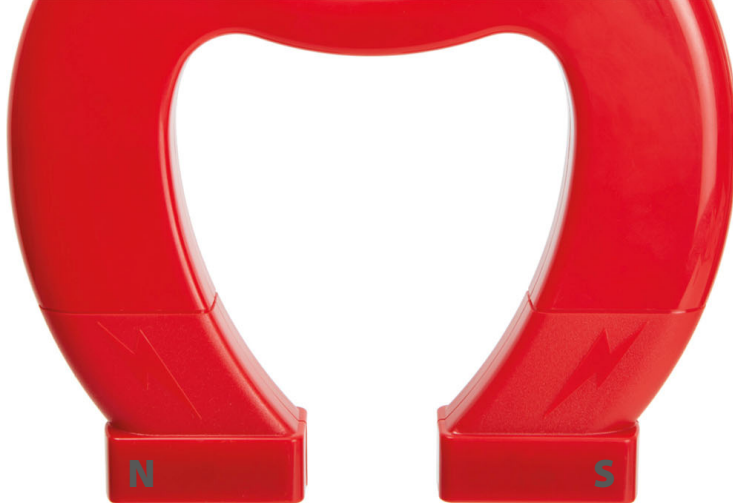
# Magnets

Magnets are objects that produce an invisible force called magnetism. When two magnets are close to each other they produce pushing or pulling forces on one another. Magnets can also pull on, or attract, other objects that are made of magnetic materials, such as iron. Magnets are often U-shaped, like a horseshoe.

**! WOW!**  
If you cut a magnet in half, you get two smaller magnets, each with its own north and south pole.

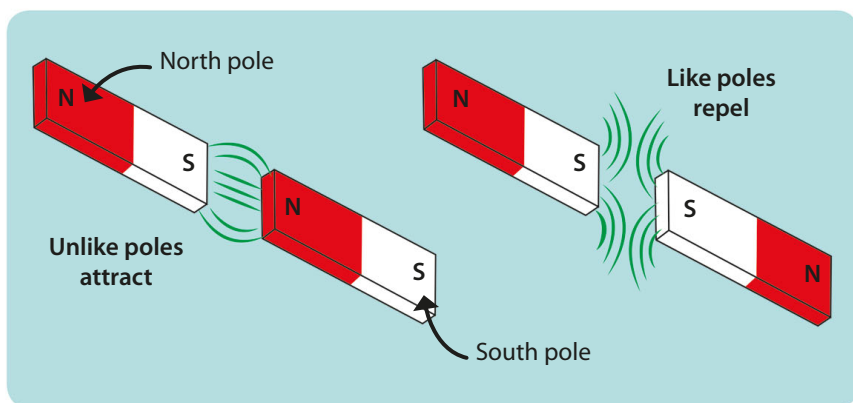
## Non-magnetic materials

Magnets have no effect on non-magnetic materials. Non-magnetic materials include all non-metals, such as glass, plastic, or wood. Most metals are also non-magnetic, including gold, aluminum, and copper.



## Magnetic poles

Magnets have two ends, or poles, called a north pole and a south pole. Unlike poles pull on each other, or attract, so a north pole pulls a south pole. Like poles push on each other, or repel, so a north pole pushes another north pole away.



# Meet the expert

Dr. Suze Kundu is a materials scientist at Imperial College London in the UK. She works on materials that capture energy from the Sun. Dr. Kundu also gives talks at schools and science festivals and is a science writer and television host.



**Q:** We know it has something to do with science, but what do you do?

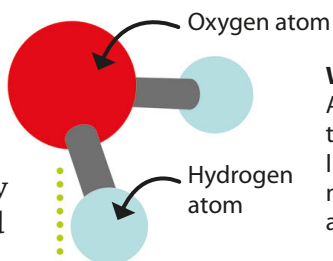
**A:** I work in a laboratory, finding out what new materials are like and how they act under different conditions. I then find ways in which a new material can be used, and make changes to it, so it works in the best way possible for a specific task.

**Q:** What made you decide to become a materials scientist?

**A:** I didn't really decide to become a materials scientist! I followed my heart and studied a subject at university that I really loved, which was chemistry. That was when I discovered nanotechnology, which is working with individual molecules and atoms, and creating new materials. It was the idea of inventing new materials and finding ways to use them that excited me.

**Q:** What is a usual workday for you?

**A:** When I am in the laboratory, I work on a material that can capture energy from sunlight and use it to split water. Water is made of hydrogen and oxygen, and so by splitting it we can make



## Water molecule

A molecule is a group of tiny things called atoms that are linked together. One water molecule has one oxygen atom and two hydrogen atoms.

hydrogen gas, which can be collected and used as a cheap and clean fuel. When hydrogen is burned, lots of energy is released, and water is produced. This means that, for example, hydrogen can be used to power a car, and it will produce water vapor instead of pollution-causing exhaust gases.

**Q:** What kind of equipment do you use?

**A:** I use the usual things that you see in laboratories, like glass beakers and flasks. I make solutions that are put on materials in very thin layers, called films. This can be done by spraying or dipping, so I have

## Hydrogen cell car

The Toyota Mirai is one of the new types of car that are powered by hydrogen.



equipment that can do that. The films must then be baked, but an oven wouldn't get hot enough, so I use furnaces that can get as hot as 1,800°F (1,000°C)! After that, I use special equipment that tells me what the films look like, and how they act. Finally, I test the films to see how well they split water into hydrogen under white light.

**Q: What are your days like when you are not in the laboratory?**

**A:** My days outside the laboratory are very varied. I spend a lot of time teaching students. I also write science articles and talks, prepare for shows at schools, do news and radio interviews, and film television programs. I love the variety in my job, and I wouldn't have it any other way!

**Q: What is the most difficult thing about your job?**

**A:** One day an experiment could work really well, and I think I have stumbled across something pretty amazing. Yet, if I try the experiment the next day and don't get the same result, I wonder why. It could be due to the tiniest change. That can be very frustrating, but if I can get the same result again and again, then I know I have a winner!



The equipment that Dr. Kundu uses includes glass flasks.



### **Aerogel**

Aerogel was invented by the US scientist Samuel Kistler around 1930. It is one of the lightest known solid materials.

**Q: Do you have a favorite material?**

**A:** My favorite material ever invented is aerogel. It is like a solid dry jelly and can be made of materials similar to glass. It is very light and has lots of pockets of air inside it, which means heat passes through it very slowly. NASA has used it on space missions to study comets, which are balls of ice and dust that circle the Sun. The aerogel collects bits of dust thrown off the back of the comet when it gets hot.

**Q: What do you love most about being a materials scientist?**

**A:** Materials science is the science of all the stuff around us, from the clothes we wear to the food we eat, and the cell phones we take selfies with. By studying it, I feel that I understand how much science is in all of the things in our lives.

**“I love the fact that my work builds on the history of science discoveries, and that I am helping to make new ones!”**

# Living things

All living things have certain characteristics in common. To count as being alive, a living thing has to be able to perform seven different processes, which are listed below.

## Life checklist

### Movement

All living things can move on their own. Even plants have leaves that turn to face the Sun.



### Reproduction

Living things can produce new versions of themselves.



### Sensitivity

Living things can detect and respond to changes in the world around them. For example, the ability to react to changes in light, or to hear sounds.



### Growth

Living things get bigger as they get older until they reach their full size.



### Respiration

All living things turn food into energy, using oxygen from the air.



### Excretion

All living things must get rid of any waste that they produce.



### Nutrition

All living things need food. Unlike animals, plants make their own food.



## Animal

Animals can move from place to place. They cannot make their own food, so they rely on eating other living things to survive.



## Plant

Plants are fixed in the ground, but their roots, leaves, and flowers can move. They make their own food by using the Sun's rays.

## Fungus

Funguses may not look alive, but they are. Most funguses feed on the remains of dead plants or animals. Mushrooms, toadstools, and molds are all funguses.



## Is it alive?

A car can move, and it uses fuel as its food. It turns this fuel into energy, and it gives out its waste as exhaust fumes. However, a car cannot grow or produce baby cars, so it is not alive!

## Tree trunk

When a tree dies it usually falls to the ground. Funguses can grow on the dead tree trunk and soak up its nutrients.

**! WOW!**

There are about **8.7 million** different types of living thing on Earth.

# Plants

Plants make their own food using sunlight. Most plants are held in the ground by their roots and have green leaves. There are thousands of types of plant, ranging from huge oak trees to small ones like this fuchsia.

Bees are attracted to sweet-smelling, colorful flowers. While inside a flower, they pick up pollen then pass it to other flowers they visit.



## Berries

Fruits, such as berries, are the parts of a flowering plant that contain seeds. Once in the ground, the seeds will grow into new plants.

## Flowers

Most plants have flowers for reproduction. They have male pollen and female eggs, which join together to make seeds.



## Leaves

Plants use their green leaves to capture energy from the Sun's rays. The leaves use this energy, together with carbon dioxide from the air, and water, to make food for the whole plant.

## Stem

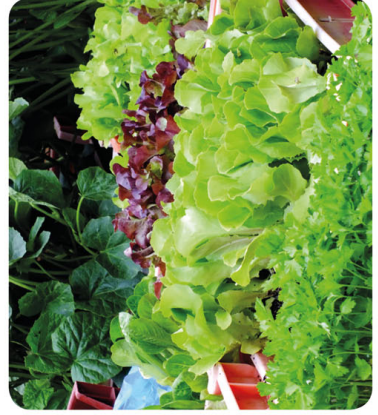
The stem supports the leaves and flowers, holding them up toward the light. The stem also carries water and nutrients in the form of mineral salts from the roots to the rest of the plant.

## Roots

Plants usually grow in the earth or soil. The roots dig deep into the ground, keeping the plant in place. They also soak up mineral salts and water from the soil.

## Why we need plants

Nearly every animal relies on plants in some way or other. Some animals, called herbivores, eat only plants. Humans grow lots of types of plant for food, and also some plants just for their flowers. Some types of tree are grown for their wood.



**! WOW!**

The world's biggest plant is the **General Sherman**. This giant sequoia tree is **275 ft (84 m) tall**.

# Spreading seeds

Seeds contain everything needed to form a new plant. To do that, they need to be scattered away from the parent plant to a new place on the soil where they can grow. Different types of plant have different ways of spreading seeds. Some need animals to move seeds, while others use wind or even fire to scatter them.

**! WOW!**

The **heaviest seed in the world** is the **double coconut**. It weighs up to **65 lb (30 kg)**.



**Blown in the wind**

Some plants have very light seeds and so can use the wind to spread them. This dandelion has seeds with tiny parachutes that allow them to be carried away when the wind blows.



**Yum!**

## Tasty treats

Many plants have seeds that are hidden inside tasty fruits, such as berries. When an animal eats the fruit, the seeds pass through its body unharmed and are released in its droppings.



## Sticky seeds

Animals can carry seeds away from plants without even realizing it. Sticky seeds will attach to different parts of their body, while some seeds, called burs, have little hooks that stick to the animal's fur.

## Earth, wind, and fire

Some plants have more dramatic or unusual ways of spreading their seeds. Fire may kill the parent plants, but it leaves behind fertile ash for their seeds to grow in.



### Heat treatment

Jack pine cones are glued shut with resin. When a fire sweeps through the trees, the resin melts and the seeds are released.



### Desert rover

Tumbleweed is the dried-up top part of some plants. It rolls around the desert whenever the wind blows, scattering its seed as it goes.

## Exploding pods

The Himalayan balsam plant keeps its seeds in pods. These pods explode when they are ripe, shooting the seeds out of them. The explosion can scatter the seeds up to 22 ft (7 m) away, often startling unsuspecting passers-by.

Pop!



Moth



## Insects

All insects have six legs and a pair of feelers on their heads, like this moth. Most of them have wings and can fly.

Tortoise



## Reptiles

Reptiles are covered in hard, dry scales, or a shell, like this tortoise. They have either four legs or no legs at all.

Giraffe



## Mammals

Mammals have fur or hair on their bodies, and feed their babies milk. Humans are a type of mammal.

# Animals

There are millions of different types of animal on Earth, so scientists have divided them into groups, based on features that they share. For example, is their body covered in fur, feathers, or scales? The amazing imaginary animal shown here combines key parts of animals from six well-known groups.



Parakeet



## Birds

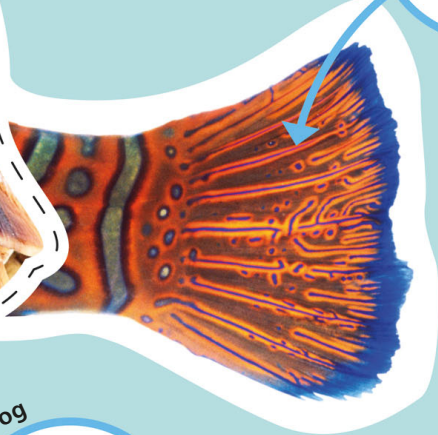
Birds have wings, and they are the only animals that have feathers, which keep them warm and help them to fly.



## Fish

All fish live in water and use their tails to help them swim. Their bodies are covered in scales, and they have gills for breathing underwater.

Mandarin fish



Frog

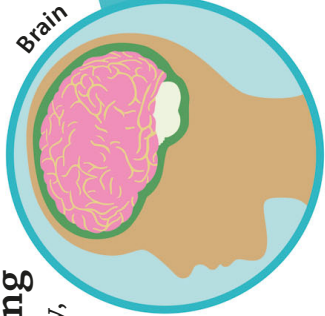


## Amphibians

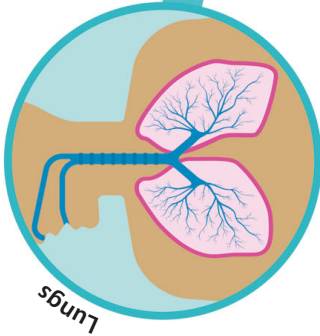
Amphibians live both on land and in water. Most of them have four legs, which they use for walking and swimming.

## Thinking

The brain controls the body, sorting out information from the world around you and sending out instructions. It also stores memories.



Brain



Lungs

## Breathing

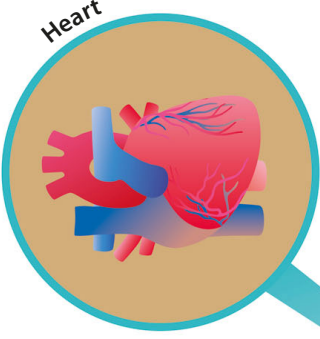
Lungs bring air into the body through breathing. This air contains oxygen, which is needed to keep the body alive.

The jaw and teeth are used to bite and chew food.

**Pumping**  
With each beat, the heart pumps blood around the body, delivering nutrients and oxygen to every part.

The ribs form a cage that protects the heart and lungs.

Hands can grip and hold objects such as tools and pens.



Heart

Digestive system



## Eating

The body needs food to survive.

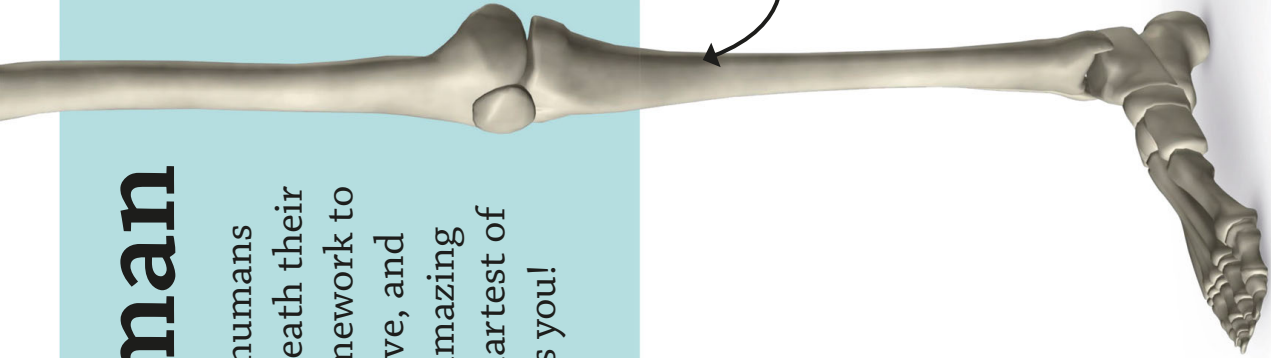
The digestive system breaks food down, keeping the nutrients and getting rid of the waste.

# Being human

Like all vertebrate animals, humans have bony skeletons underneath their skin and muscles. It is a framework to hold up the body, help it move, and protect what is inside. The amazing brain makes humans the smartest of all the animals. That includes you!

## 4 Body facts

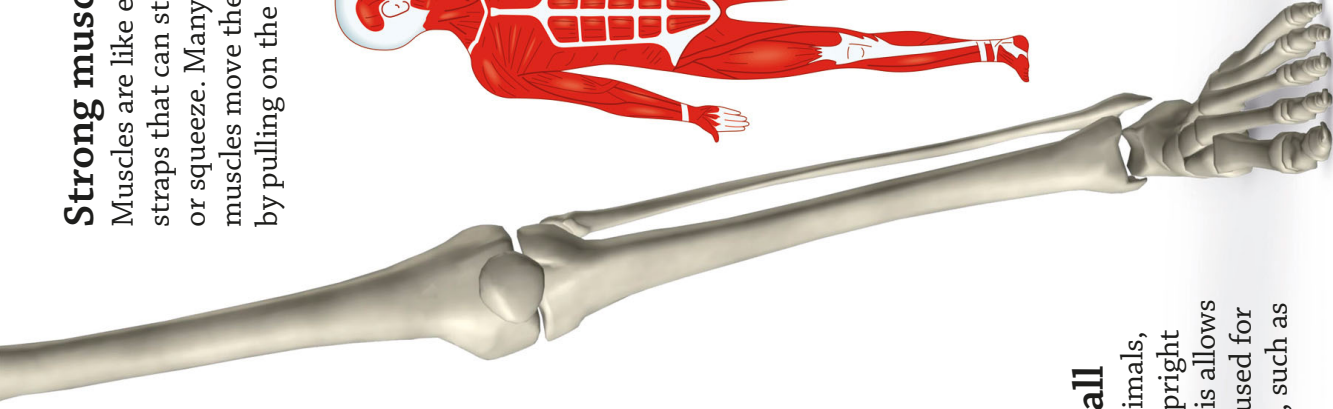
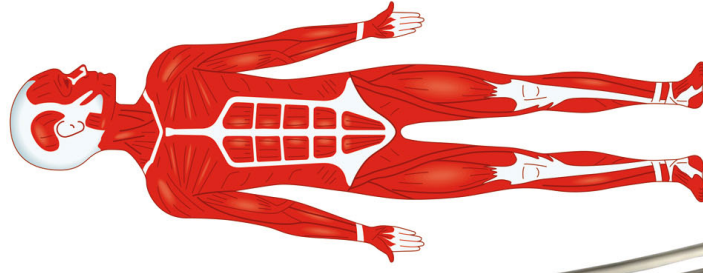
- 1 Human skeletons contain more than 200 bones. The smallest bone is inside the ear and is only  $\frac{1}{8}$  in (3 mm) long.
- 2 The thighbone is the strongest bone in the body. It is about four times stronger than concrete.
- 3 A human heart beats more than 100,000 times in a day. That is over 35 million times in a year.
- 4 In one day, blood travels about 12,000 miles (19,000 km) around the body.



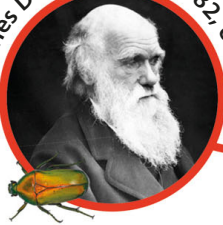
Strong legs help humans to run, climb, and swim.

**Standing tall**  
Unlike most animals, humans walk upright on two legs. This allows the arms to be used for other activities, such as making things.

**Strong muscles**  
Muscles are like elastic straps that can stretch or squeeze. Many muscles move the body by pulling on the bones.



Charles Darwin, 1809–1882, UK



Beetle



Moth

## Evolution

Charles Darwin figured out how animals, such as moths and beetles, can change over many generations to become new species. This process is called evolution.

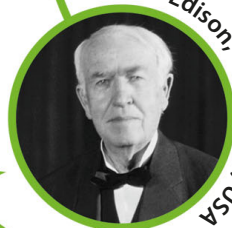
# Great scientists

Life is full of problems, and scientists are always trying to find new ways to solve them. There are hundreds of great scientists who have changed our lives for the better, through their discoveries and their inventions. Here are seven of them.

Lightbulb

## Lightbulb

Thomas Edison is best known for inventing the first lightbulb that could be made in large numbers. He also invented a sound recorder and a moving-image projector, which helped to start the age of movies.



Thomas Edison, 1847–1931, USA

“To invent, you need a good imagination and a pile of junk.”

## Computers

Ada Lovelace wrote the first published computer program. She also predicted that a computer would be able to make music and images, not just do math problems.

Ada Lovelace, 1815–1852, UK



```
01101010100010100010
110000101010111100101
0010100010010010100010
11110010101 0110101010001
100010111000010101011110010
0001010001001001010001011100001
101 011010101000101000100100101000101
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10101011110010101 0110101010001010001
111000010101011110010101 011010101000
0100010111000010101011110010101 01101
1001001010001011100001010101111001010
010100010010010100010111000010101011
010 011010101000101000100100101000101
```

Modern computer



Isaac Newton, 1642–1727, UK



## Gravity

Isaac Newton is said to have discovered how gravity works when he saw an apple fall from a tree. He realized that there must be a similar force that keeps the Earth moving around the Sun.



## Radioactivity

Marie Curie discovered two substances, called radium and polonium, that give off invisible rays that can pass through materials. She called these rays radioactivity.



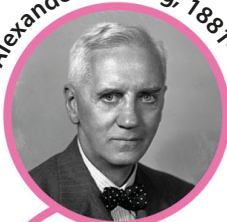
Marie Curie's work also helped with the development of X-rays for use in operations in hospitals.

Marie Curie, 1867–1934, Poland



“Nothing in life is to be feared. It is only to be understood.”

Alexander Fleming, 1881–1955, UK



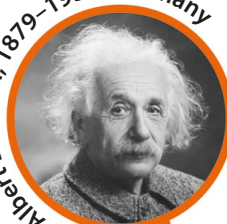
## Antibiotics

Alexander Fleming discovered penicillin, which led to the creation of a group of medicines called antibiotics. They kill the bacteria that cause many infections in humans and other animals, and so have saved millions of lives.



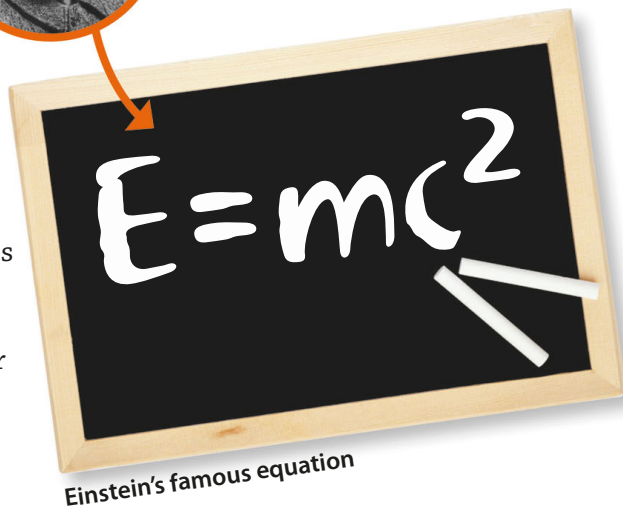
Antibiotics

Albert Einstein, 1879–1955, Germany



## Relativity

Albert Einstein's theories of relativity, along with his groundbreaking  $E=mc^2$  equation, helped scientists to understand the universe, and how energy, mass, space, and time are all related.



Einstein's famous equation

0100101000101  
01 0110101010  
1110000101010  
0100010010010  
0101 011010101  
0101011110010  
1100001010101  
1000101110000  
0010010100010  
1010001001001  
0101000101000  
01 01101010100  
1100101001111  
1100001010101

# Science in action

Science is all around us. From the moment we wake up to the moment we go to bed, almost everything that we do or that happens to us can be explained by science. Here are a few examples of the ways that science helps us to understand what goes on in our daily lives.

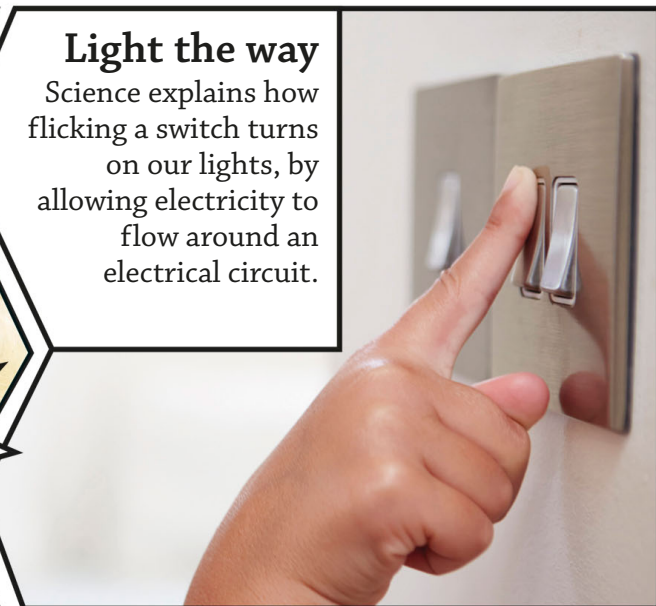
## Rise and shine!

Science explains how a rooster could wake us up in the morning. Sound waves travel through the air from the rooster's mouth to our ears.



## Light the way

Science explains how flicking a switch turns on our lights, by allowing electricity to flow around an electrical circuit.



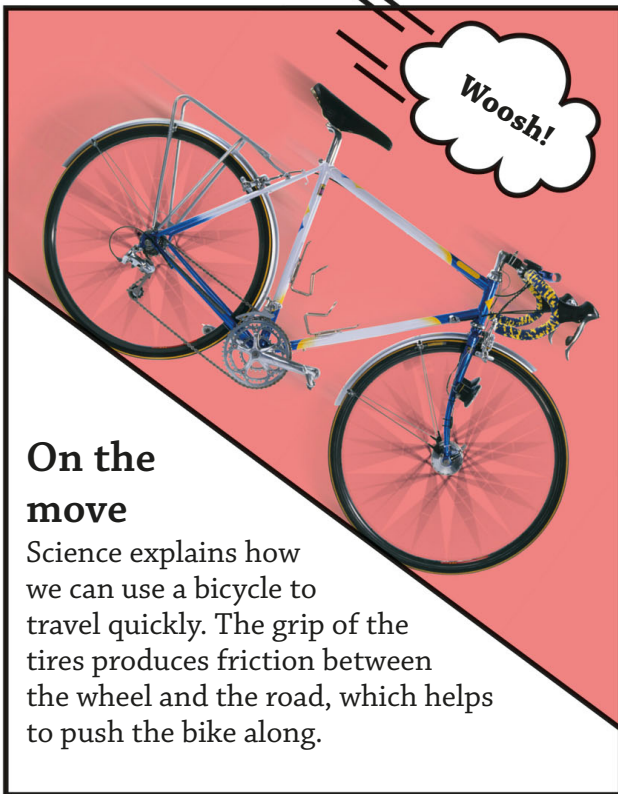
## Keeping warm

Science explains how our clothes keep us warm. Wool and cotton are poor conductors of heat energy, so they stop our body heat from escaping.



## Eat up!

Science explains why we need to eat food every day. Food contains stored energy that we need in order to move, grow, and keep warm.



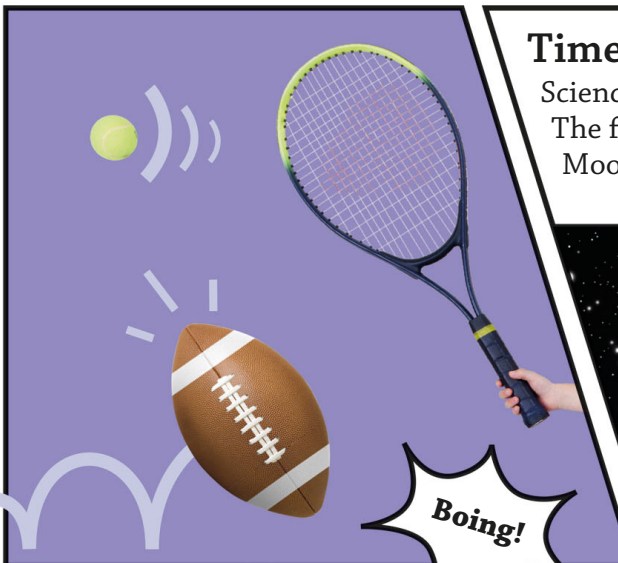
## On the move

Science explains how we can use a bicycle to travel quickly. The grip of the tires produces friction between the wheel and the road, which helps to push the bike along.



## Sun power

Science explains why a plant grows when we put it on a windowsill. Plants use energy from sunlight to produce food, which gives the plant energy to grow.



## Ball games

Science explains why a ball moves when we kick, throw, or hit it. Our arms and legs produce a force that propels the ball forward.

## Time for bed

Science explains why the Moon stays in the sky. The force of gravity from the Earth pulls on the Moon, keeping it in orbit around our planet.



# Science facts and figures

The world of science is full of amazing things. Here are some weird and wonderful facts and figures that you may not know.

**42 quarts**  
(40 liters) is the **total amount of water** in the body of an adult man of average weight.



This is enough cement to make 5,000 of Egypt's Great Pyramid of Giza.



**4½ billion**

**tons** (4 billion metric tons) of **cement are made** in the world every year.

5,000 of Egypt's Great Pyramid of Giza.



A **humpback whale's song** can **travel** more than **1,600 miles** (2,600 km) through water.



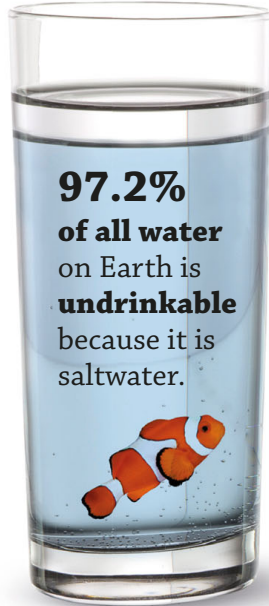
**23** 

English scientist Isaac Newton was only 23 years old when he first described the force of gravity.

**186,283**

miles per second (299,792 kilometers per second) is the speed at which light travels. If you could move this fast, you could go around the Earth 7.5 times in one second.

The Eiffel Tower in Paris, France, "grows" by 6 in (15 cm) in summer when the iron it is made of expands.



97.2%  
of all water  
on Earth is  
undrinkable  
because it is  
saltwater.



The number of times lightning hits the ground in the US every year:  
**25 million**

**600 volts**  
is the **shocking amount of electricity** an electric eel can produce. That is enough to kill any other fish nearby.



**352,000**

different species of flowering plant are alive in the world today, and there may be many more that are yet to be discovered.

**1/2**

in (10 mm) is the distance a maglev (magnetic levitation) train is lifted above the track using magnets.





# Glossary

Here are the meanings of some words that are useful for you to know when learning about science.

**attract** When two things pull toward each other

**bacteria** Tiny creatures that live everywhere on Earth, such as inside food, soil, or even in the human body

**boil** When a liquid is heated to a temperature at which it bubbles and turns into a gas or vapor called steam

**brittle** Easily snapped

**carnivore** Animal that eats only meat

**characteristics** Certain qualities or features that things, animals, plants, or objects have

**circuit** Loop that an electric current travels around

**condensation** When a gas cools and becomes a liquid. Often seen as droplets of water that form on cold surfaces, such as windows

**conductor** Substance that allows heat or electricity to pass through it easily

**echo** Sound that has bounced off a surface and been sent back in the direction it started from

**electricity** Type of energy that can be used to power household items

**evaporation** When a liquid is heated and changes into a gas or vapor

**evolution** Process where living things change, over many generations, to become new species

**force** Push or pull that causes things to start moving, move faster, change direction, slow down, or stop moving

**friction** Force created when two surfaces rub or slide against each other

**gas** State of matter with no fixed shape, such as air, that fills any space it is in

**gravity** Invisible force that pulls objects toward each other

**groundwater** Water found beneath the Earth's surface

**herbivore** Animal that eats only plants

**invertebrate** Animal that does not have a backbone

**insulator** Substance that does not allow heat or electricity to pass easily through it

The force of the tennis racket hitting the ball causes the ball to change direction.



**irreversible** Change that cannot be undone

**laboratory** Place where scientists conduct experiments

**light** Type of energy that allows humans and other animals to see

**liquid** State of matter that flows and takes the shape of any container it is in

**magnetism** Invisible force that is created by magnets, which then pull certain metals toward them

**mass** Amount of matter that is in an object

**material** Substance that can be used to make things. It can be natural or made by humans

**matter** Stuff that all things are made of

**melt** When a solid is heated and becomes a liquid

**mixture** Combination of more than one type of thing

**nutrients** Food or substance that gives a living thing the energy or chemicals that it needs to live, grow, and move

**omnivore** Animal that eats both plants and meat

**organ** Body part that has a certain job, for example, the heart

**organism** Living thing

**reflect** When light or sound is bounced off a surface

**repel** When two objects push away from each other

**reproduce** To have young

**reversible** Change that can be undone

**rust** Reddish-brown crystals that form on iron and steel when they come into contact with water and oxygen

**shadow** Formed when light rays are blocked by a solid object

**solid** State of matter that holds its shape

**solution** Mixture that is created when a solid dissolves in a liquid and disappears

**sound** Form of energy that is produced when objects vibrate, or shake

Steel paper clips that have been attracted to a horseshoe magnet.



**spectrum** Range of something—for example, the range of colors in a rainbow

**temperature** Measure of how hot or cold things are

**vertebrate** Animal that has a backbone

**weight** Amount of the force of gravity that acts on an object, making it feel heavy. The more mass something has, the larger the force of gravity on the object, and the heavier it feels



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