

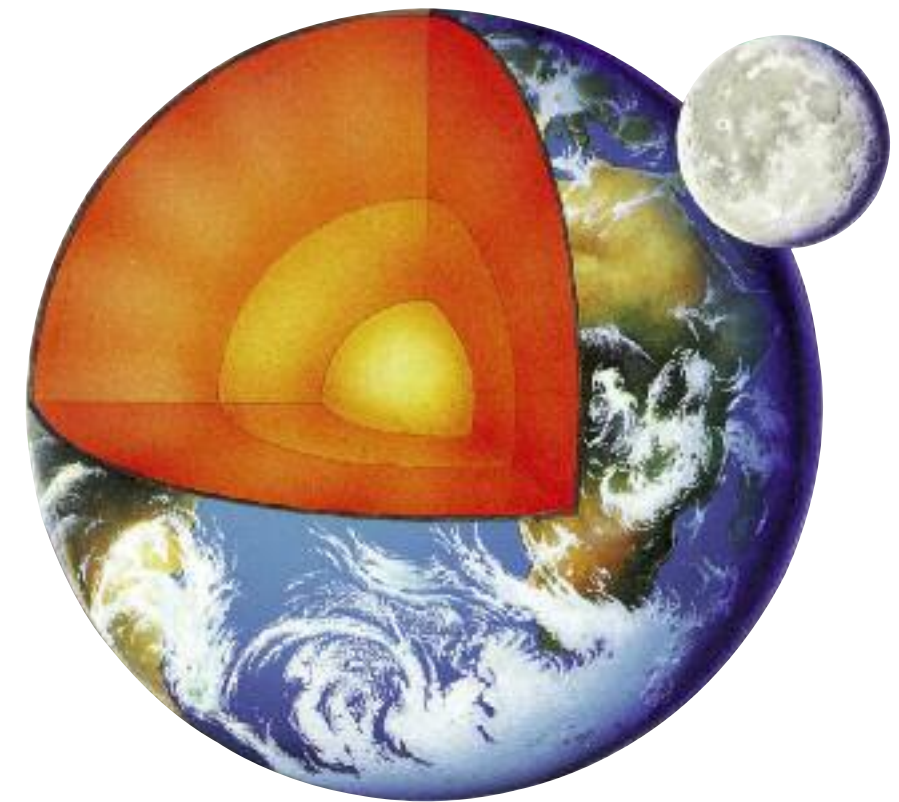
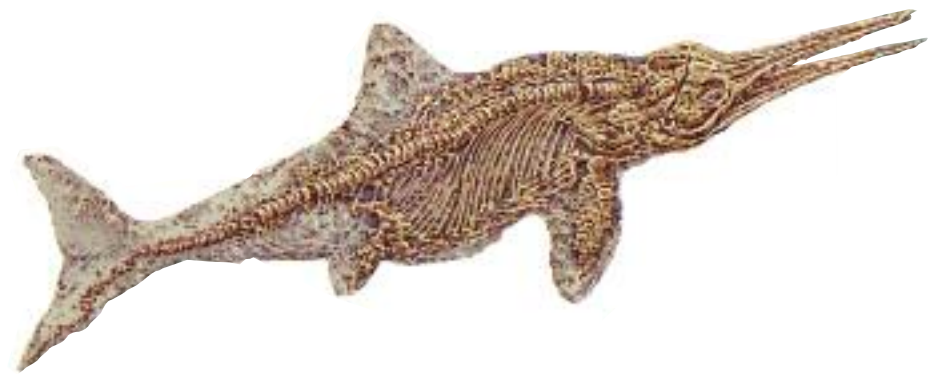
CHILDREN'S  
**SCIENCE**  
ENCYCLOPEDIA

Space • Earth • Forces • Energy

CHILDREN'S  
**SCIENCE**  
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CHILDREN'S  
**SCIENCE**  
ENCYCLOPEDIA





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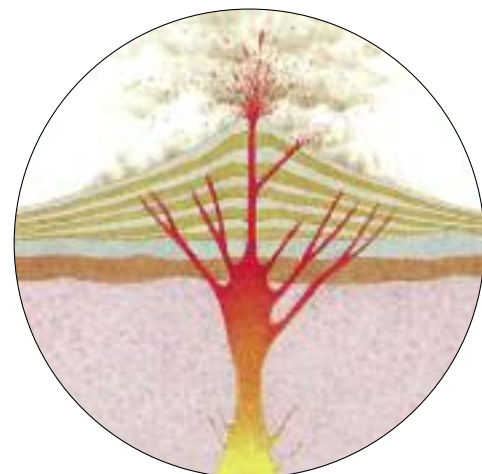
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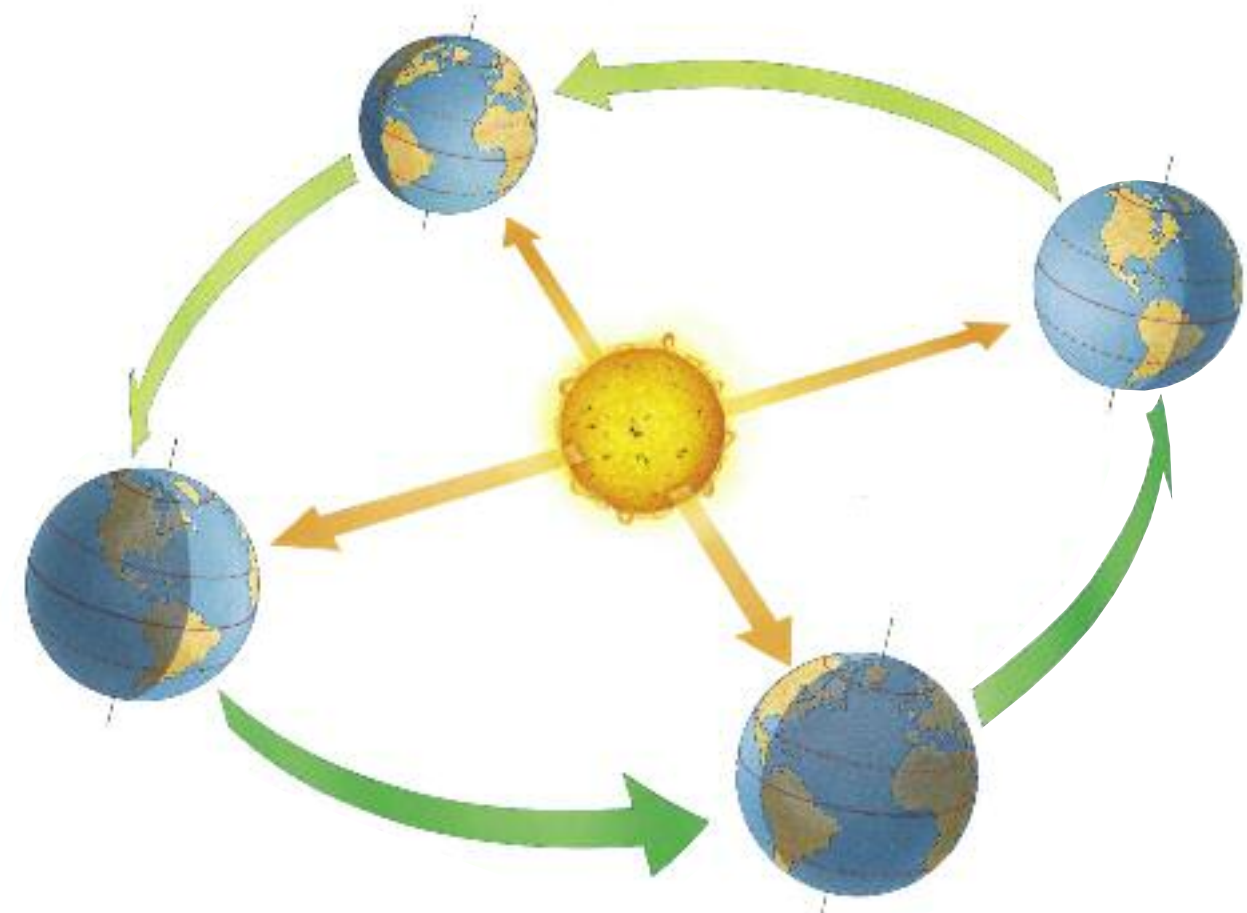
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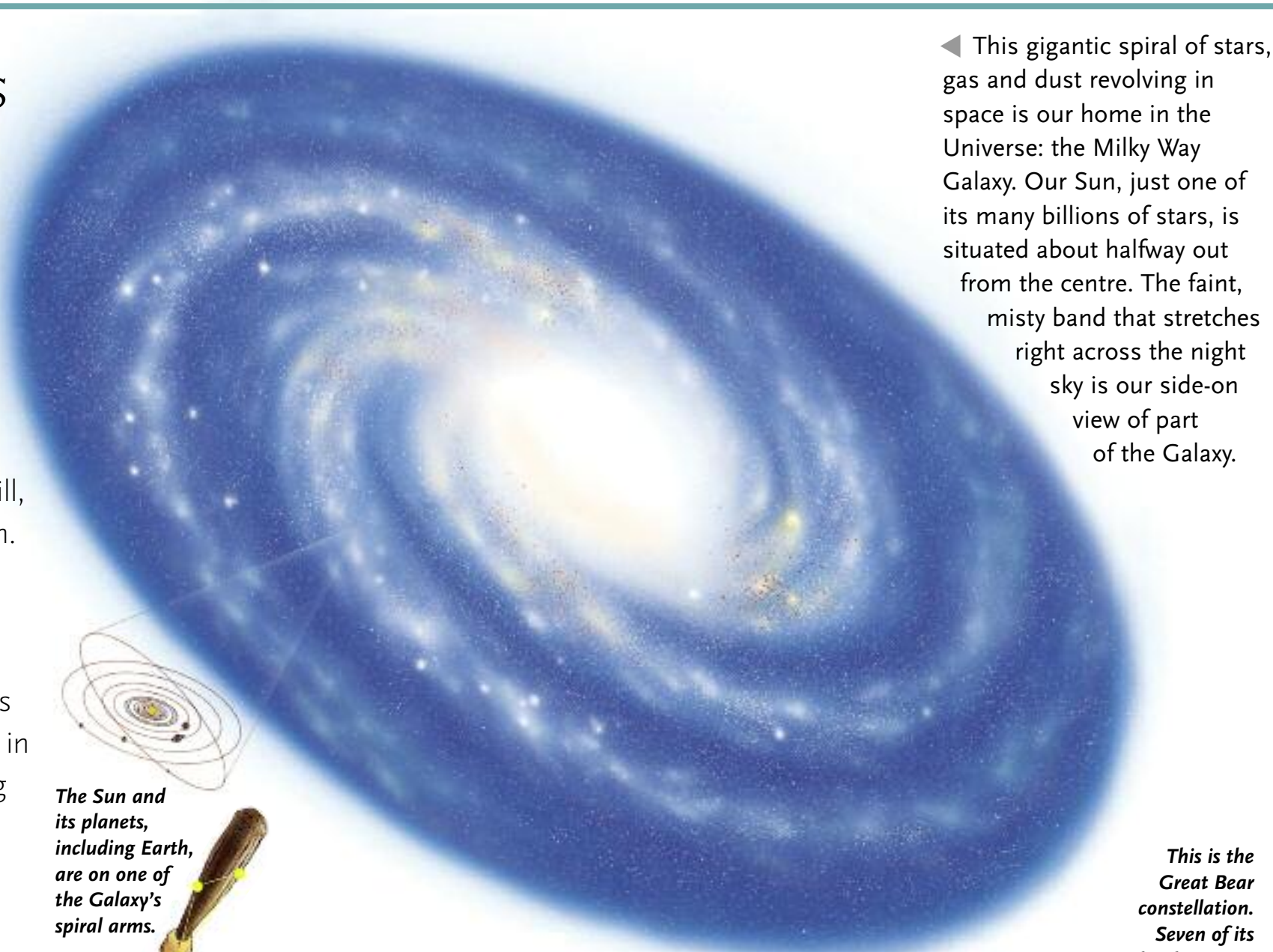
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# STARS AND GALAXIES

**S**TARS are giant, spinning balls of hot, glowing gas. They are like enormous power stations, producing vast amounts of energy as they shine for billions of years. Our local star, the Sun, is “only” 150 million kilometres from Earth. Other stars are incredibly far away. Even the next nearest is so distant it takes four years for its light to reach us. Almost certainly, many other stars will, like the Sun, have planets circling around them. On some of those there may be life.

Nearly everything we see in the night sky is part of the Milky Way Galaxy, an enormous spiral-shaped cluster of stars. There are billions of stars in the Galaxy—and billions of galaxies in the Universe. The Universe includes everything there is: space, galaxies, stars, Earth, your home and you, yourself!



◀ This gigantic spiral of stars, gas and dust revolving in space is our home in the Universe: the Milky Way Galaxy. Our Sun, just one of its many billions of stars, is situated about halfway out from the centre. The faint, misty band that stretches right across the night sky is our side-on view of part of the Galaxy.



*The Sun and its planets, including Earth, are on one of the Galaxy's spiral arms.*

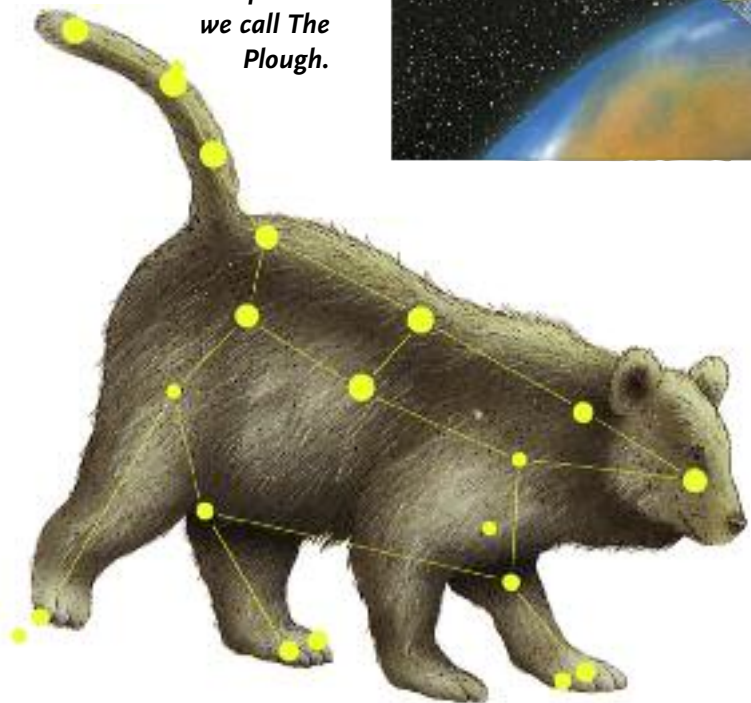


*The constellation of Orion. The three stars of his belt point downwards towards Sirius, the brightest star in the sky.*

◀ Some stars have been shining for millions of years. Others have only just begun to do so. New stars are born in gigantic clouds of dust and gas called nebulae. This nebula has a shape just like a horse's head. (The Horsehead Nebula is in the constellation of Orion. It can be seen only by using a telescope.) The dust and gas eventually come together to form incredibly hot, young stars.



◀▶ Looking up at the night sky, it is easy to spot certain patterns in the stars. Throughout the year, different ones appear and disappear from view. Years ago, astronomers thought that these patterns looked like people and animals from popular legends—a dog, a bull, a centaur, a scorpion and so on. The familiar shapes of these constellations, as they are called, help stargazers to find and name other stars.



*This is the Great Bear constellation. Seven of its brighter stars make up what we call The Plough.*

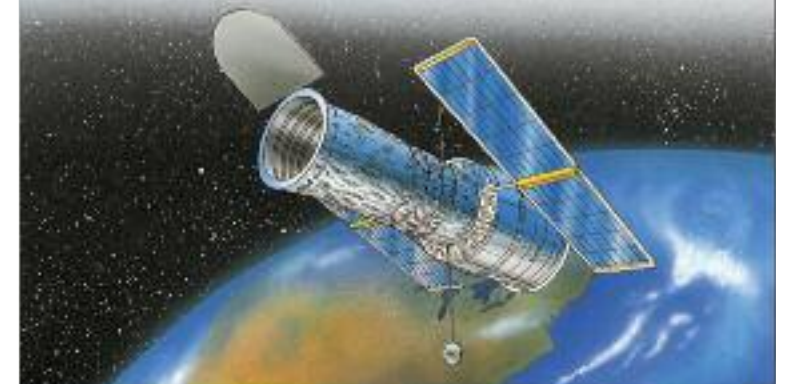
*A line running through two of the end stars of The Plough points to the Pole Star, almost exactly due north.*



## STUDYING STARS



**P**EOPLE have been studying the night skies since earliest times. The ancient Greeks thought that the Sun and planets all moved around the Earth. In 1543 the Polish astronomer Copernicus suggested that, as we now know, the Earth and planets move around the Sun. In 1609 the Italian Galileo became the first astronomer to use a telescope (*above*). He saw craters on the Moon and discovered Jupiter's moons. Modern telescopes allow us to see enormous distances. There is even a telescope out in space itself, the Hubble Space Telescope (*below*). Scientists can receive clear pictures of distant stars from it.



# SOLAR SYSTEM

**O**UR SUN is a star. It appears much bigger and brighter than other stars only because it is nearer to us.

Circling around, or orbiting, the Sun is its family of planets. In order of distance from the Sun, they are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and the dwarf planet, Pluto. The Earth takes one year to complete an orbit, but some of the outer planets take many years to do so.

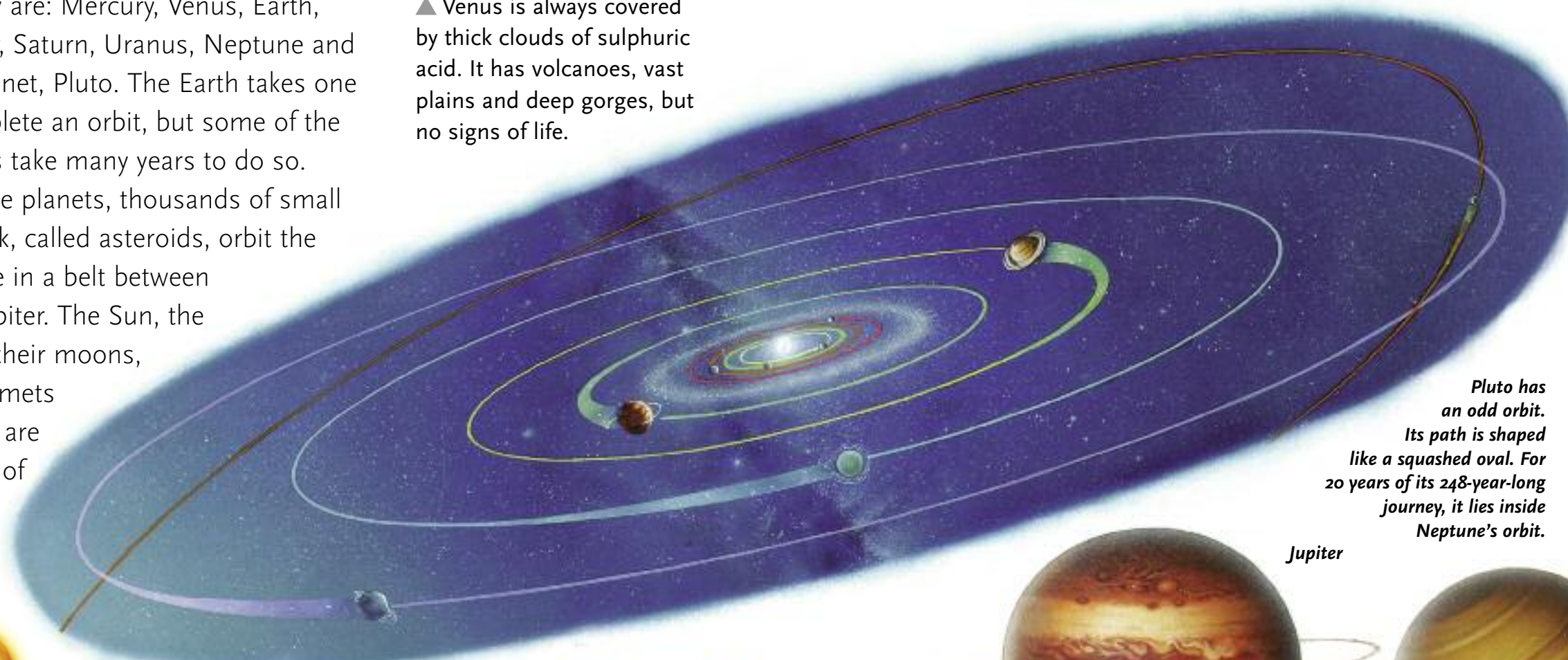
Besides the planets, thousands of small pieces of rock, called asteroids, orbit the Sun. Most lie in a belt between Mars and Jupiter. The Sun, the planets and their moons, asteroids, comets and meteors are all members of the Solar System.

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▲ Venus is always covered by thick clouds of sulphuric acid. It has volcanoes, vast plains and deep gorges, but no signs of life.

► Most planets have moons. One of Saturn's moons, Mimas, has a giant crater. Jupiter's Io is covered with volcanoes. Miranda, a moon of Uranus, is scarred by grooves. Neptune's Triton is the coldest world of all.



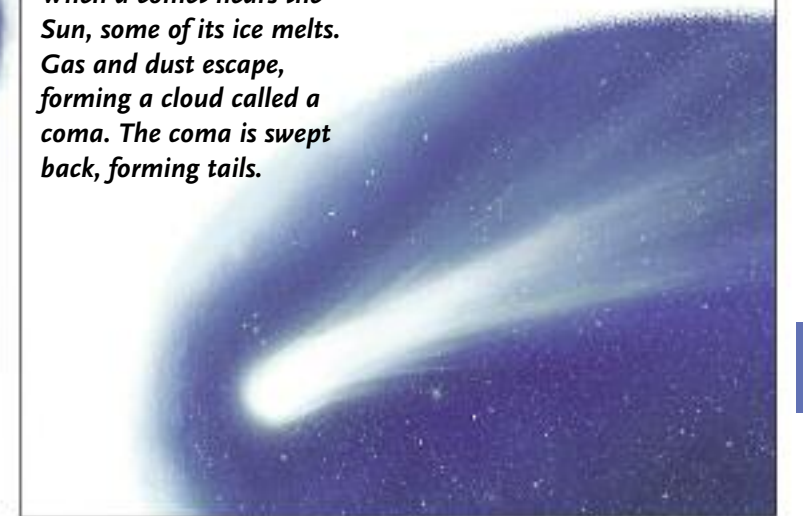
Pluto has an odd orbit. Its path is shaped like a squashed oval. For 20 years of its 248-year-long journey, it lies inside Neptune's orbit.

# COMETS AND METEORS

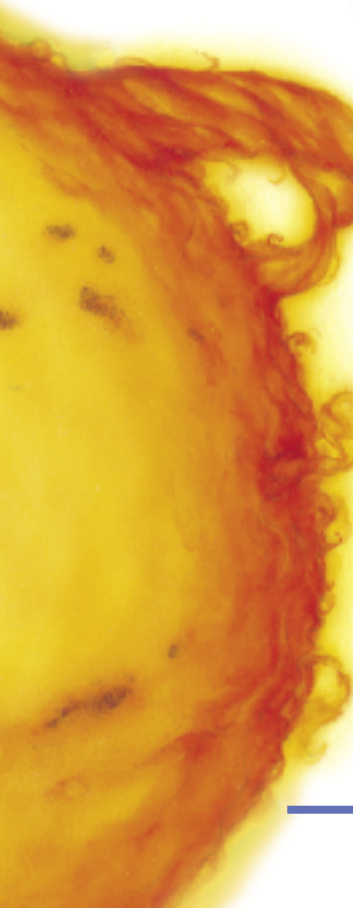
**C**OMETs are lumps of dust and ice that hurtle across the Solar System. Comets come from the edge of the Solar System and pass very close to the Sun. As they approach the Sun, two long tails trail behind them. If you are lucky, you may see a comet "hanging" in the night sky.

Dusty pieces sometimes break off comets. We see them as split-second streaks of light. They are called meteors, or shooting stars. Meteorites are fragments of rock that fall through our skies and crash to the ground.

When a comet nears the Sun, some of its ice melts. Gas and dust escape, forming a cloud called a coma. The coma is swept back, forming tails.



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◀ The Sun is a huge, incredibly hot spinning ball of gas. Without heat and light from the Sun, no life could exist on Earth. It is so big that approximately 1,400,000 globes the size of Earth could fit inside it. Its surface bubbles and spits like water in a boiling kettle. Dotted around it are dark patches, called sunspots, that come and go.

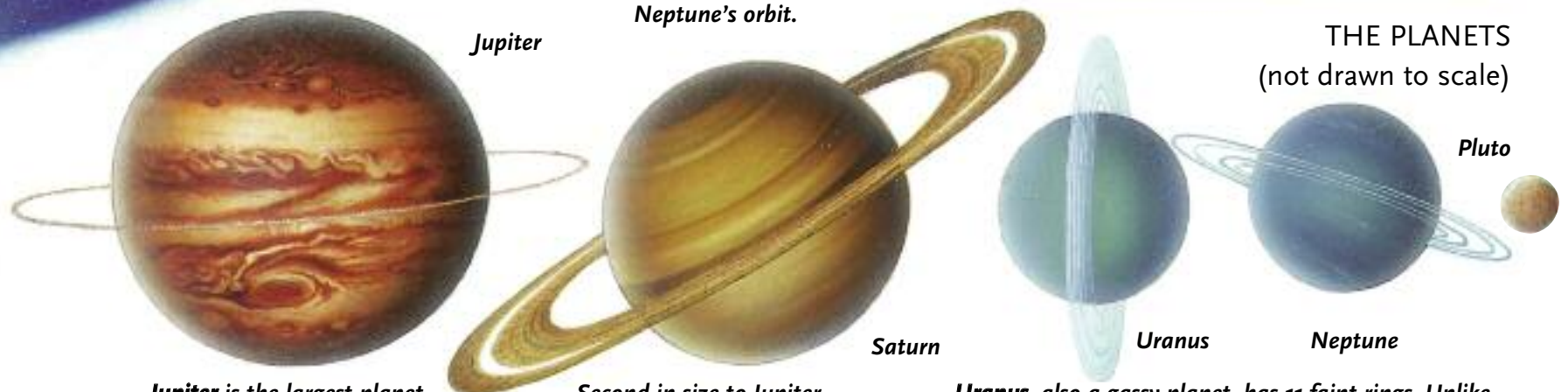


**Mercury** is very hot where it faces the Sun, but very cold where it faces away.  
**Diameter:** 4880 km **Day:** 58.6 days **Year:** 88 days **Average distance from Sun:** 58 million km

The temperature on **Venus** is hotter than molten lead.  
**Diameter:** 12,109 km **Day:** 243 days **Year:** 225 days **Average distance from Sun:** 108 million km

**Earth** is our home planet.  
**Diameter:** 12,761 km **Day:** 24 hours **Year:** 365.26 days **Average distance from Sun:** 149.7 million km **Moons:** 1

Dry riverbeds show that water once flowed on **Mars**.  
**Diameter:** 6797 km **Day:** 24.6 hours **Year:** 687 days **Average distance from Sun:** 228 million km **Moons:** 2



**Jupiter** is the largest planet. Its surface (including the Great Red Spot) is not solid, but consists of swirling gases. Only its core, twice the size of Earth itself, is made of solid rock. Jupiter's largest moons are bigger than Mercury and Pluto.  
**Diameter:** 142,960 km **Day:** 9.8 hours **Year:** 11.8 years **Average distance from the Sun:** 779 million km **Moons:** 16

Second in size to Jupiter, **Saturn** is also a "gas giant". It is the outermost planet visible with the naked eye. It spins very quickly and bulges in its middle. Saturn's amazing rings are made up from countless blocks of ice and rock.  
**Diameter:** 120,514 km **Day:** 10.2 hours **Year:** 29.5 years **Average distance from Sun:** 1427 million km **Moons:** 18

**Uranus**, also a gassy planet, has 11 faint rings. Unlike the other planets, it spins on its side.  
**Diameter:** 51,166 km **Day:** 17.2 hours **Year:** 84 years **Average distance from Sun:** 2869 million km **Moons:** 15

**Neptune** is streaked with wispy clouds.  
**Diameter:** 49,557 km **Day:** 16.1 hours **Year:** 164.8 years **Average distance from Sun:** 4496 million km **Moons:** 8

**Pluto** has recently been re-classified as a dwarf planet.  
**Diameter:** 2300 km **Day:** 6.4 days **Year:** 248 years **Average distance from Sun:** 5,900 million km **Moons:** 3

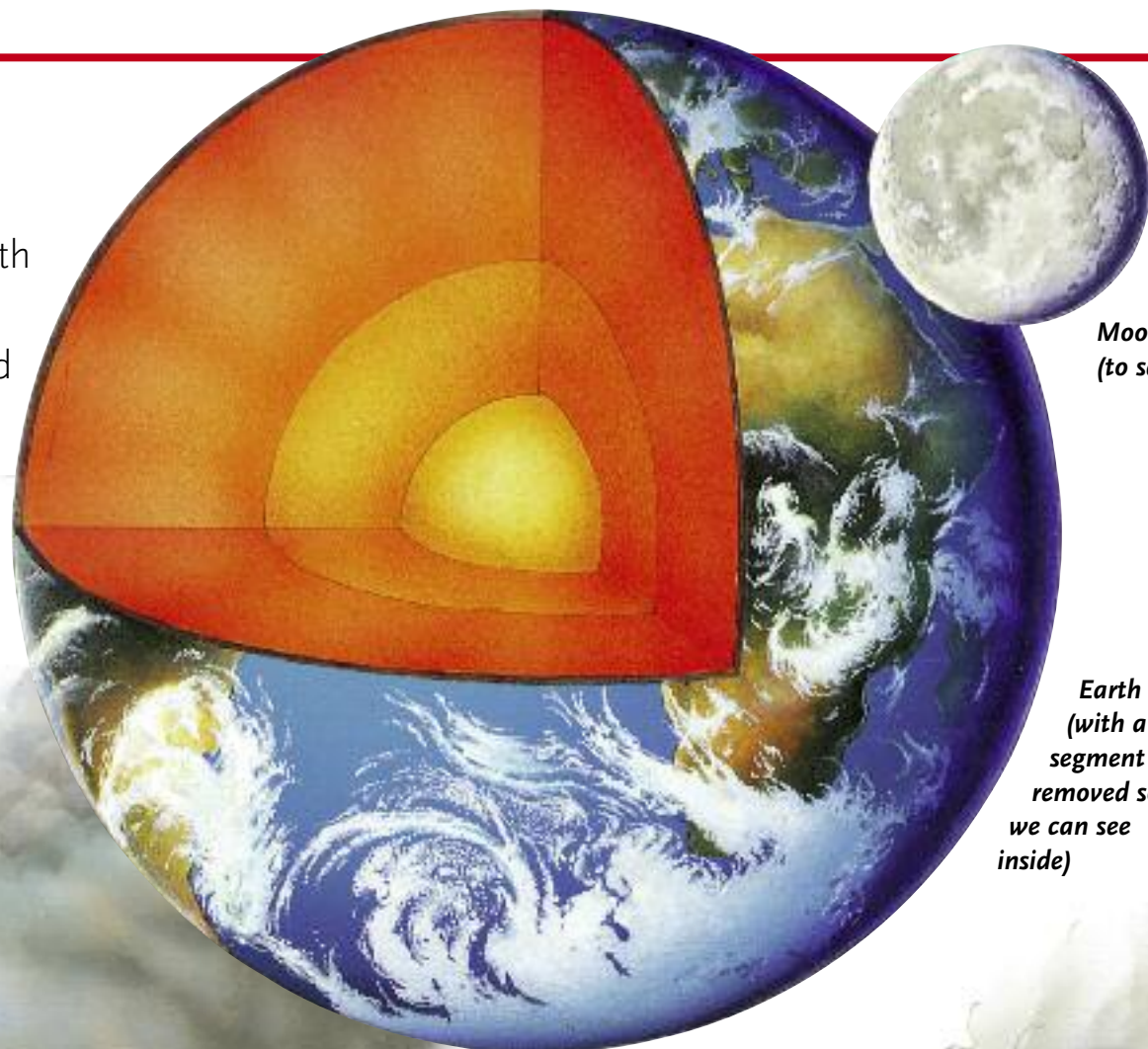
THE PLANETS (not drawn to scale)

Pluto

# EARTH AND MOON

**A**BOUT 4600 million years ago, our Earth was born. At first, it was a ball of very hot, liquid rock. Then volcanoes started to erupt everywhere. The gases they blasted out surrounded Earth with air and clouds. Rains fell and filled the oceans with water.

Earth has the perfect conditions for life to exist. It is neither too hot nor too cold, and there is also liquid water, which is essential for life. The blanket of air around the Earth, the atmosphere, protects us from the harmful rays of the Sun, but it also lets in warmth.



*Moon (to scale)*

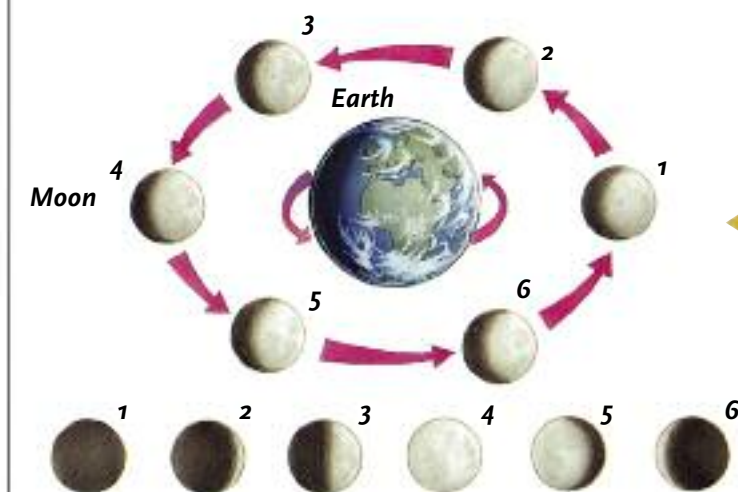
*Earth (with a segment removed so we can see inside)*

◀ The Earth has several layers inside it. The rocks that make up the continents and the ocean floors form a thin outer layer called the crust. The crust lies above a thick layer of very hot, partly melted rocks, called the mantle. The lava that erupts through volcanoes comes from here. Below the mantle is the liquid metal outer core. The solid inner core, mostly made of iron, is nearly as hot as the surface of the Sun.



## A BARREN WORLD

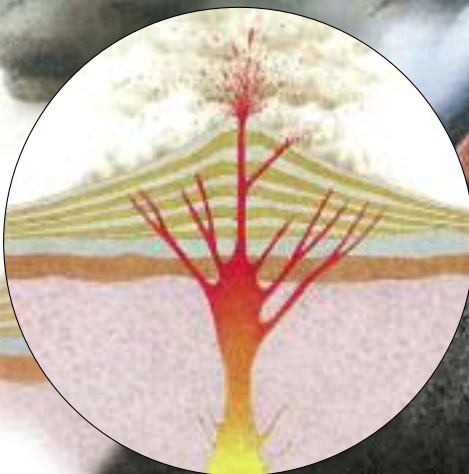
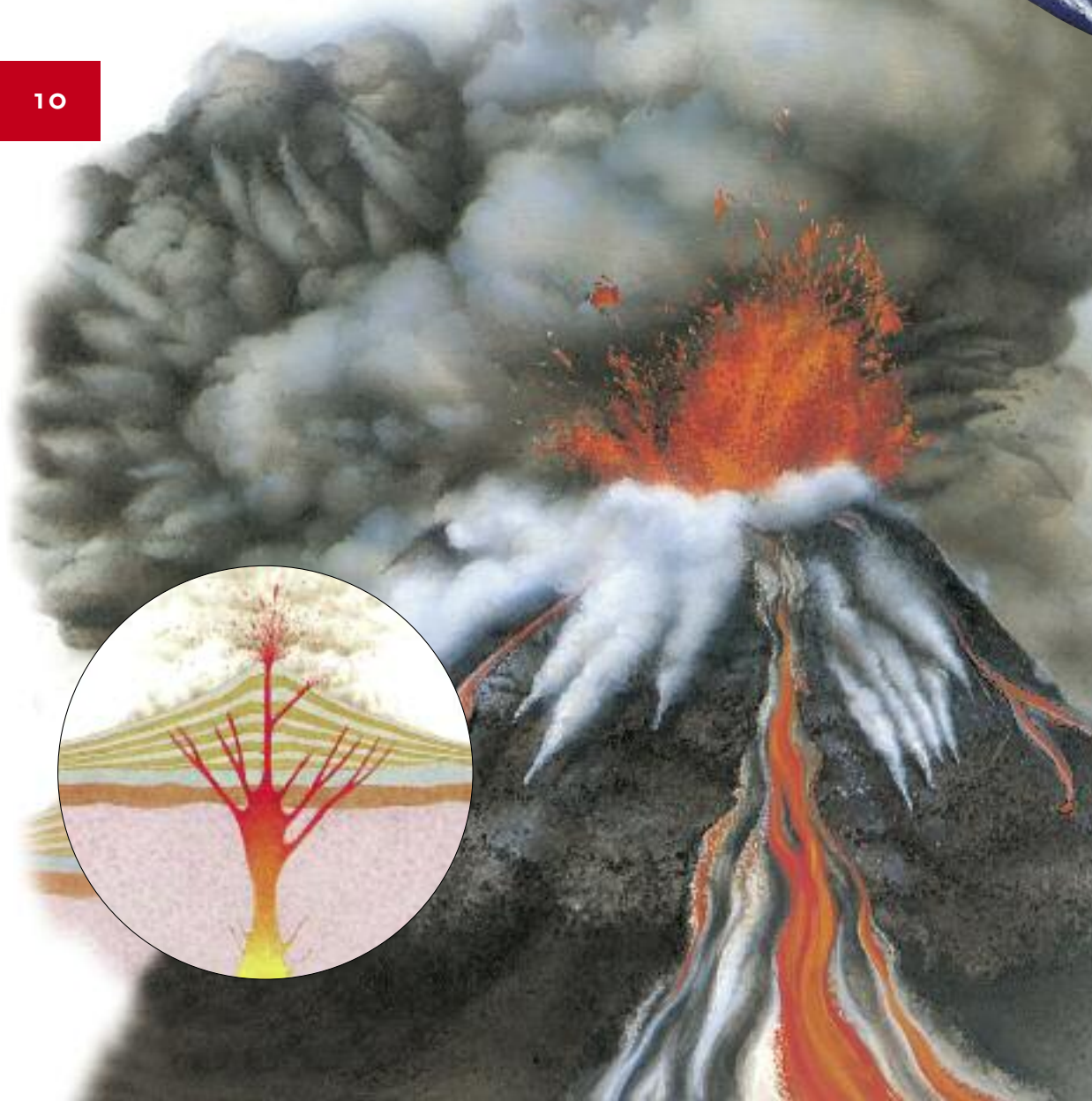
**T**HE MOON is a ball of rock that travels around our planet Earth. It is much smaller than our planet and, unlike ours, a barren world. No life can exist there because there is no air or water. The surface of the Moon is covered with craters. These are made by pieces of rock, called meteorites, crashing down from space. On a clear night, you can quite easily see the “splash” marks surrounding one of the Moon’s craters without the need of a telescope.



*This is how we see the Moon as it goes round the Earth.*

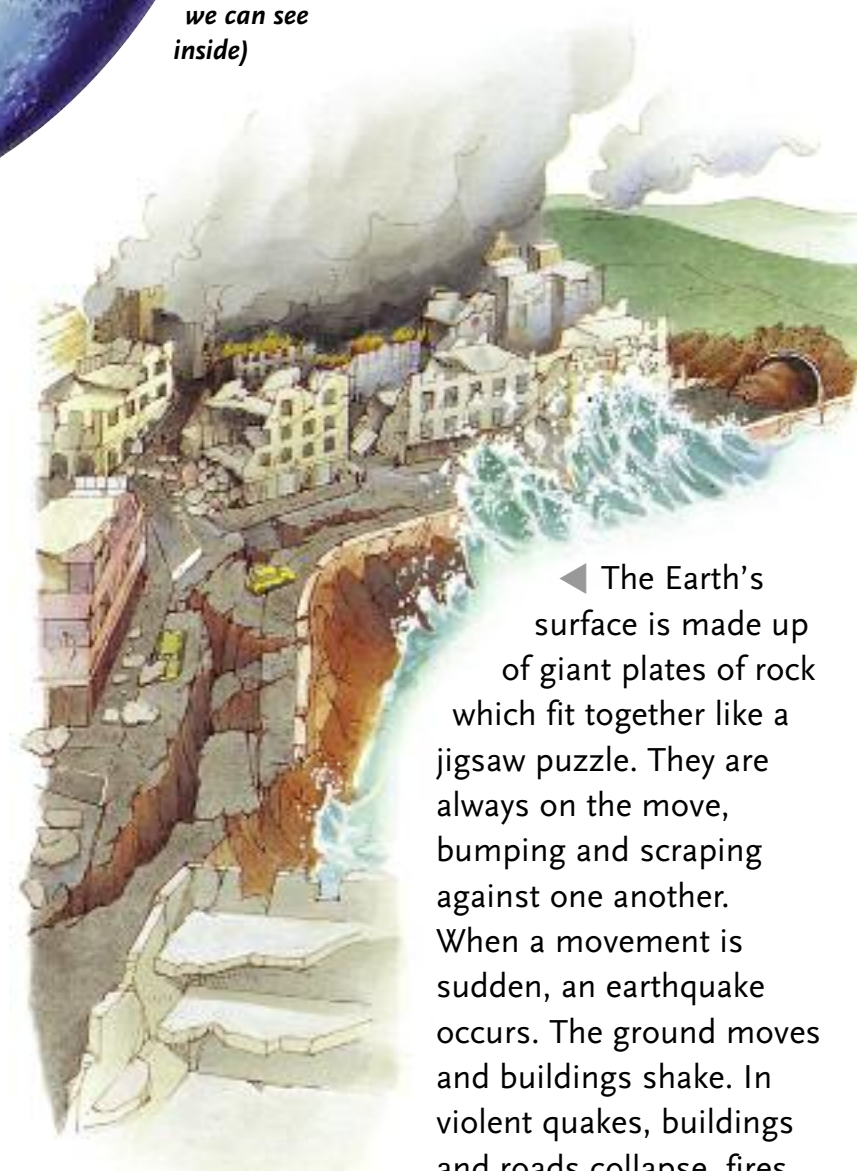
## CHANGING SHAPE

**T**HE MOON seems to change shape from one night to the next. This happens because, as it travels around the Earth (taking about 27 days to complete the circle), the same side of it faces us all the time. It is our view of the sunlight on it that changes. When the side facing us is completely turned away from the Sun, we cannot see the Moon at all (1). When it is turned fully towards the Sun, we can see a Full Moon (4).



◀ Many volcanoes are mountains shaped like cones. They have circular openings, called craters, at their summits. If you were to peer over the edge of a crater, you might see a bubbling lake of red-hot melted rock, called lava. When a volcano erupts, lava, rocks, and huge clouds of ash and dust are exploded high into the air. Rivers of lava flow down the volcano’s slopes.

*(far left) Inside a volcano, melted rock rises up through a cone made of layers of ash and lava.*



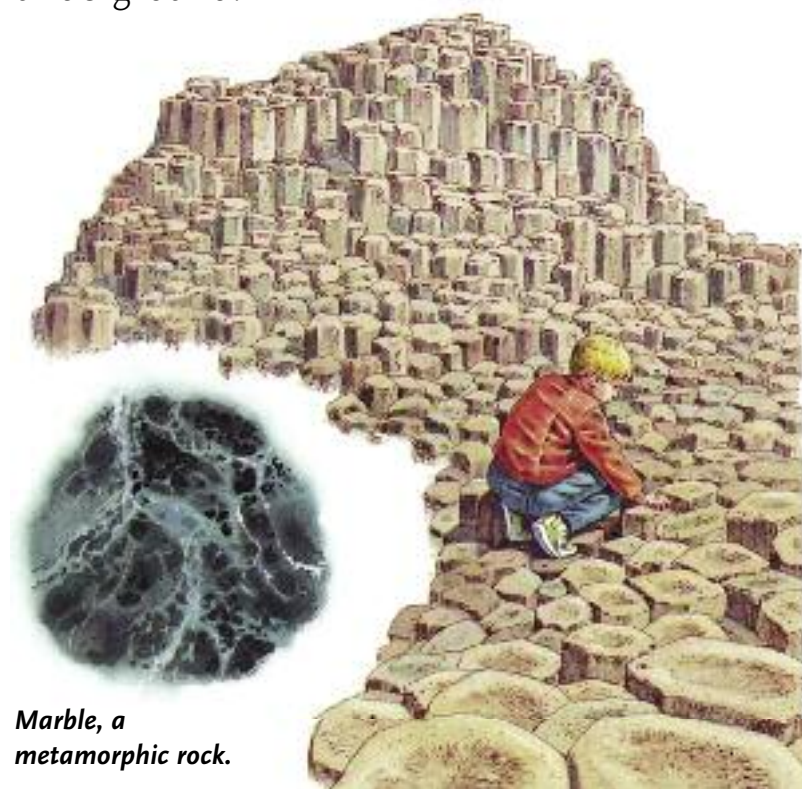
◀ The Earth’s surface is made up of giant plates of rock which fit together like a jigsaw puzzle. They are always on the move, bumping and scraping against one another. When a movement is sudden, an earthquake occurs. The ground moves and buildings shake. In violent quakes, buildings and roads collapse, fires break out and many people are killed.



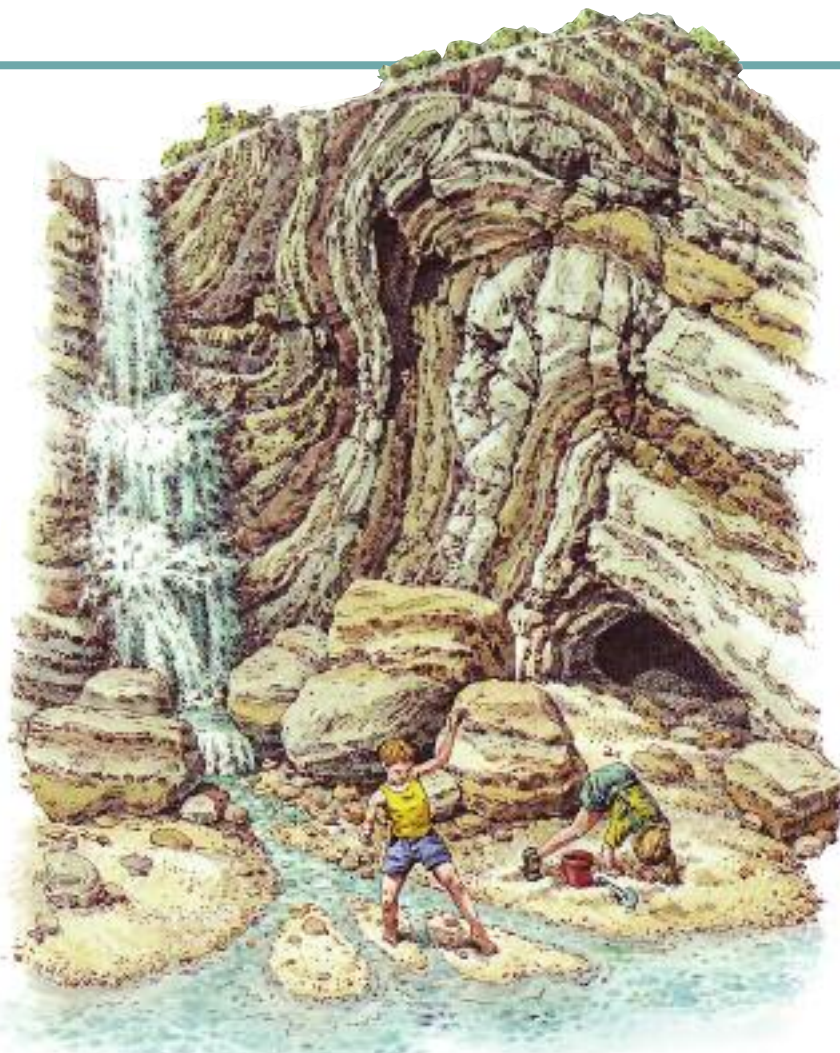
# ROCKS AND FOSSILS

**D**IG DOWN beneath the soil and in the end you will reach solid rock. Rocks are made of chemical substances called minerals. Minerals are, themselves, made up from combinations of elements (see page 18) such as silicon, oxygen, sodium or magnesium, found naturally in the Earth.

There are many different kinds of rock and they can be divided into three groups. Igneous rocks, the first group, result from the cooling of very hot, melted rock that comes from the mantle, deep inside the Earth. Sedimentary rocks, the second group, are made up from fragments of sand, mud or the remains of living creatures compacted together. The third group, the metamorphic rocks, are formed when rocks are changed in some way by great heat or pressure underground.



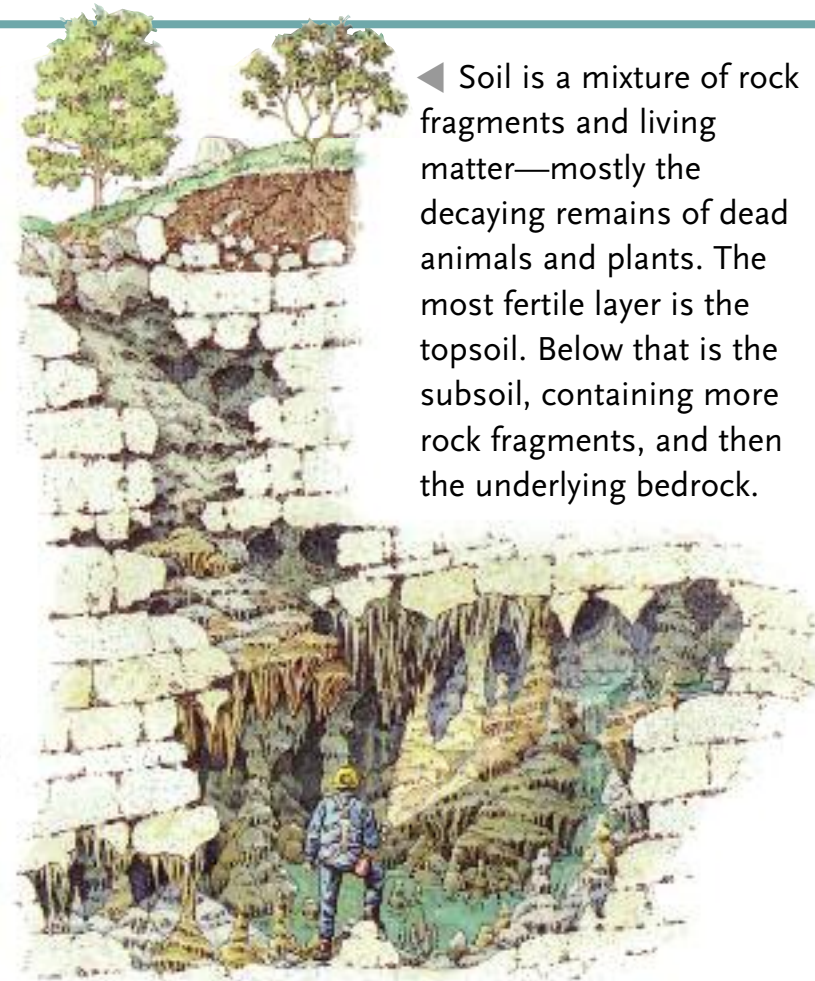
Marble, a metamorphic rock.



▲ One of the best places to look at rocks is at the seashore. This cliff shows layers of rock all following the same curved shape, known as folds. It takes millions of years for rocks to fold. It happens when the giant plates of rock that make up the Earth's crust (see page 11) push against one another. The layers of rock buckle and fold like creases in a blanket on a bed.

◀ Igneous rocks sometimes take on amazing shapes. Here, the melted rock that formed these basalt rocks cooled very slowly and cracked into regular shapes known as crystals.

Millions of years ago, swampy forests covered the tropics. As the trees decayed, they formed a thick black soil called peat that later hardened to coal.



◀ Soil is a mixture of rock fragments and living matter—mostly the decaying remains of dead animals and plants. The most fertile layer is the topsoil. Below that is the subsoil, containing more rock fragments, and then the underlying bedrock.

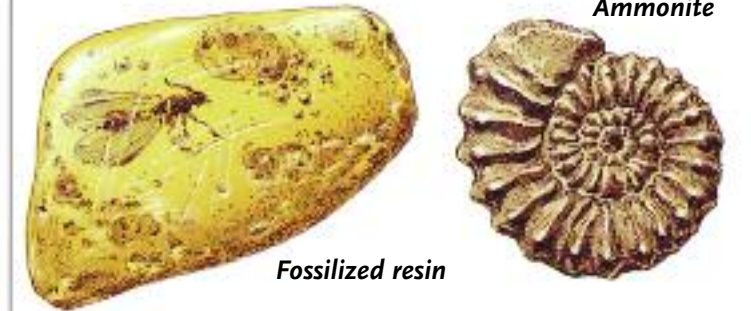
Today, shafts (vertical tunnels) are made so people can go down to the coal layer and mine it for fuel.



▲ Limestone is a sedimentary rock, made up of the remains of tiny sea creatures that lived millions of years ago. Water that seeps into the cracks in the limestone gradually dissolves it away, hollowing out underground caves. Dripping water containing minerals produces hanging "icicles" of rock called stalactites. Stalagmites, growing up from the cave floor, are formed by splashes from above.

A fossil leaf in coal.

## LIFE TURNED TO STONE



Fossilized resin

Ammonite

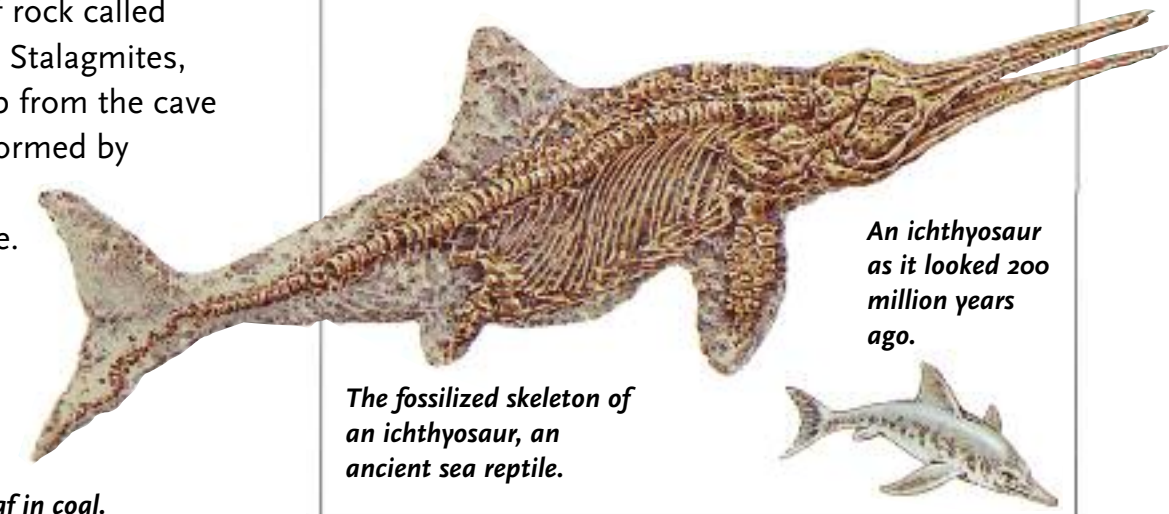
**F**OSSILS are the remains of animals or plants that have been preserved in rocks. Sometimes, as in this example of an insect trapped in fossilized resin (a sticky substance found in tree trunks), the whole creature is preserved, soft parts and all. But most fossils, like this ammonite, a prehistoric sea creature with a coiled shell, are of the hard parts such as shell or bone.

After the soft parts have rotted away, the remains of a creature are buried in sand or mud, usually under water. The original shell or bone is dissolved away and replaced by minerals in the water. The sand or mud turns to rock, which holds a fossil of the creature. Another kind of fossil is made when a living thing leaves a mark on its surroundings, such as a footprint, that is preserved in rock.

Fossils can tell us about the story of life millions of years ago because they formed at the same time as the rocks around them.



A fossil of a dinosaur's footprint.



The fossilized skeleton of an ichthyosaur, an ancient sea reptile.

An ichthyosaur as it looked 200 million years ago.



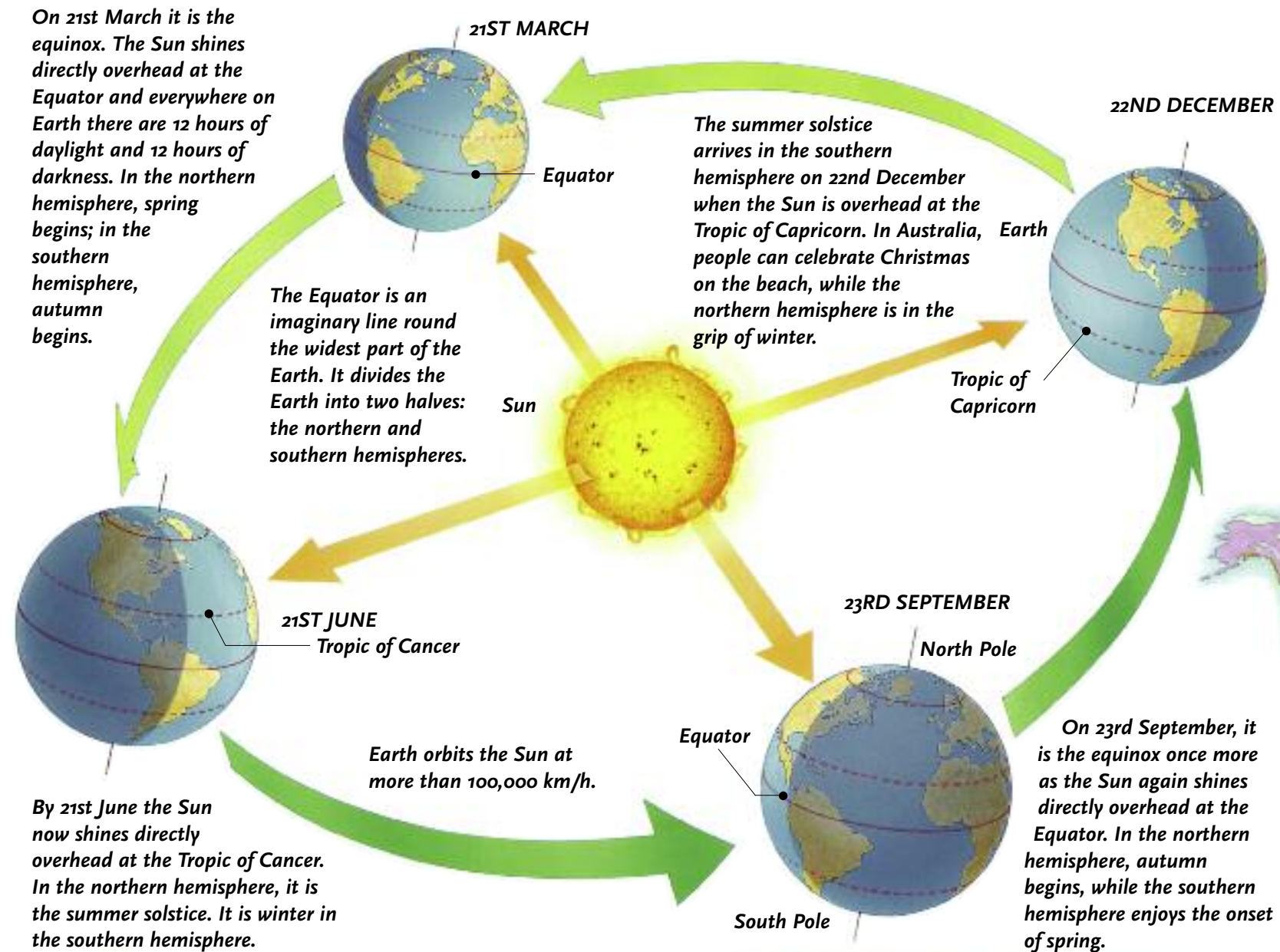
# SEASONS AND CLIMATES

**T**HE EARTH takes just over 365 days to complete a full circuit, or orbit, around the Sun. It also spins on its own axis (an imaginary line running through it from the North to the South Pole) once every 24 hours. As the Earth spins, it is not perfectly upright, but slightly tilted. This tilt, always in the same direction, gives us the seasons of the year.

When the northern half of the Earth (the northern hemisphere) leans nearer the Sun, it is warmer and the days are longer there: summer has arrived. At the same time, in the southern hemisphere, which is tilted away from the Sun, it is winter. When the northern hemisphere leans away from the Sun, it is winter, while it is summer in the southern hemisphere.



These illustrations show how the changing seasons affect the countryside in countries with a temperate climate (see opposite). Winter brings snow and ice. Deciduous trees have lost their leaves. To survive the cold, some animals sleep through the winter. This is called hibernation.



When spring comes, plants and flowers start to grow again. Leaves on deciduous trees burst into bud. The weather is warmer, and many animals and birds make nests, give birth to their young and search for food for them. Crops sown in the fields are now growing.



Summer days are long, sunny and warm. Tree leaves are fully open and their fruits ripen. Farmers work hard to bring in the harvest of crops. Birds that migrated to warmer lands for winter have returned. They feed on the rich variety of insects and fruits.

## WORLD CLIMATES

**D**IFFERENT regions of the world have different patterns of weather: for example, dry summers, mild winters, and so on. These patterns are called climates. Regions with tropical climates lie close to the Equator. They have hot, wet weather all year round. Deserts have hardly any rain. Temperate regions have warm summers and cold (but not too severe) winters. Polar lands and some high mountainous areas are always extremely cold.

Tropical	Cool temperate
Desert	Polar
Temperate	Mountain



In the autumn, the leaves on the trees turn brown, yellow or red and fall to the ground. Migrating birds fly off to warmer countries for the winter. Some animals store food and find a warm, dry place to sleep. Farmers plough their fields to prepare the soil for next year's crops.

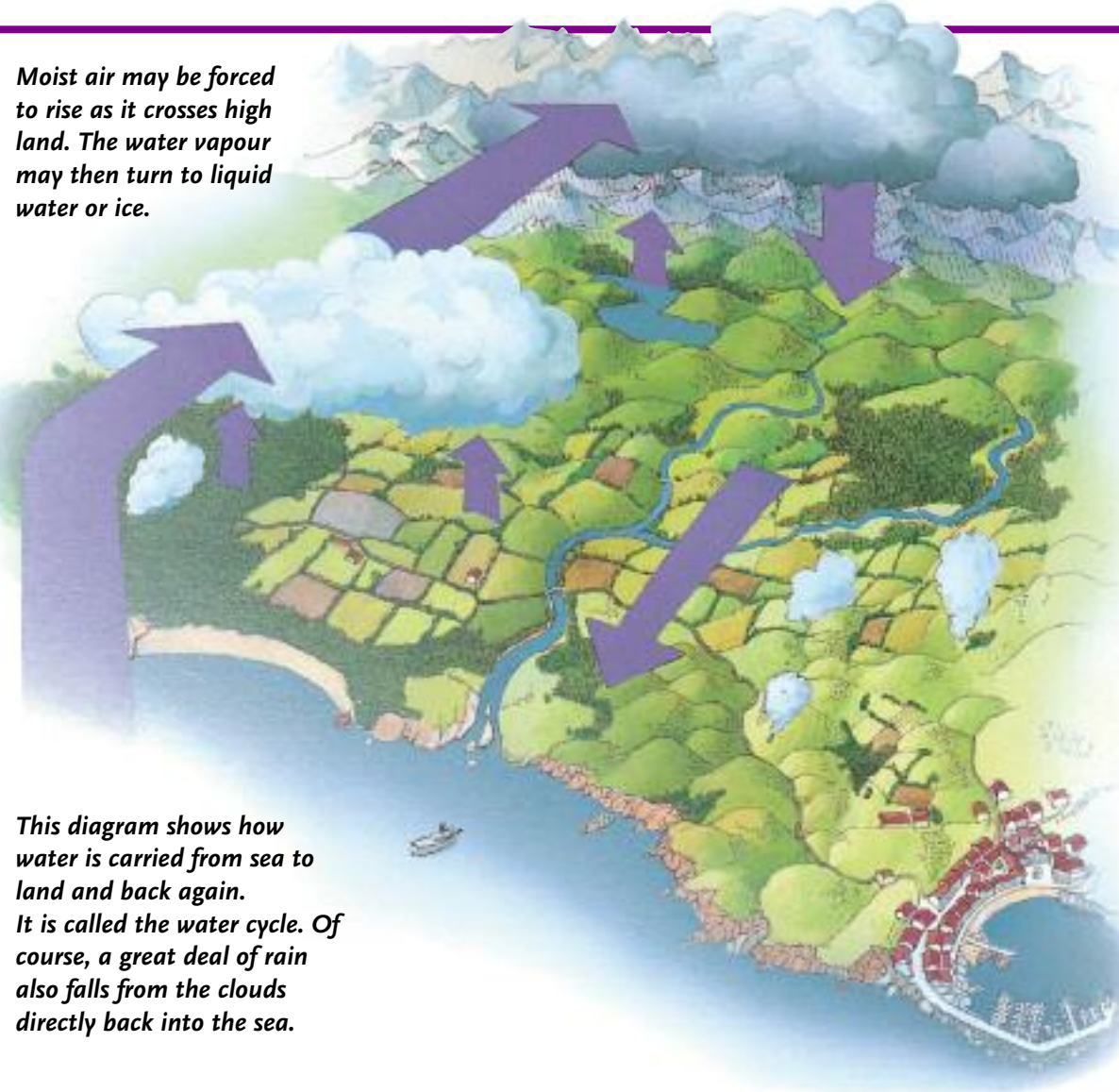
# WEATHER

**W**eather is the word we use to describe the conditions of the air in a certain place at a certain time: for example, whether it is raining or snowing, windy or still, hot or cold. The air around the Earth is always on the move. It also contains water vapour, which, when the air is cooled, turns to ice or liquid water and falls to the ground as rain, snow or hail (frozen raindrops).

Weather plays an important part in our lives. For example, without rain, our crops would die, but too much rain can cause floods. It is very useful to be able to predict what the weather has in store for us. To do this, weather forecasters gather together information from satellites in space and weather stations.

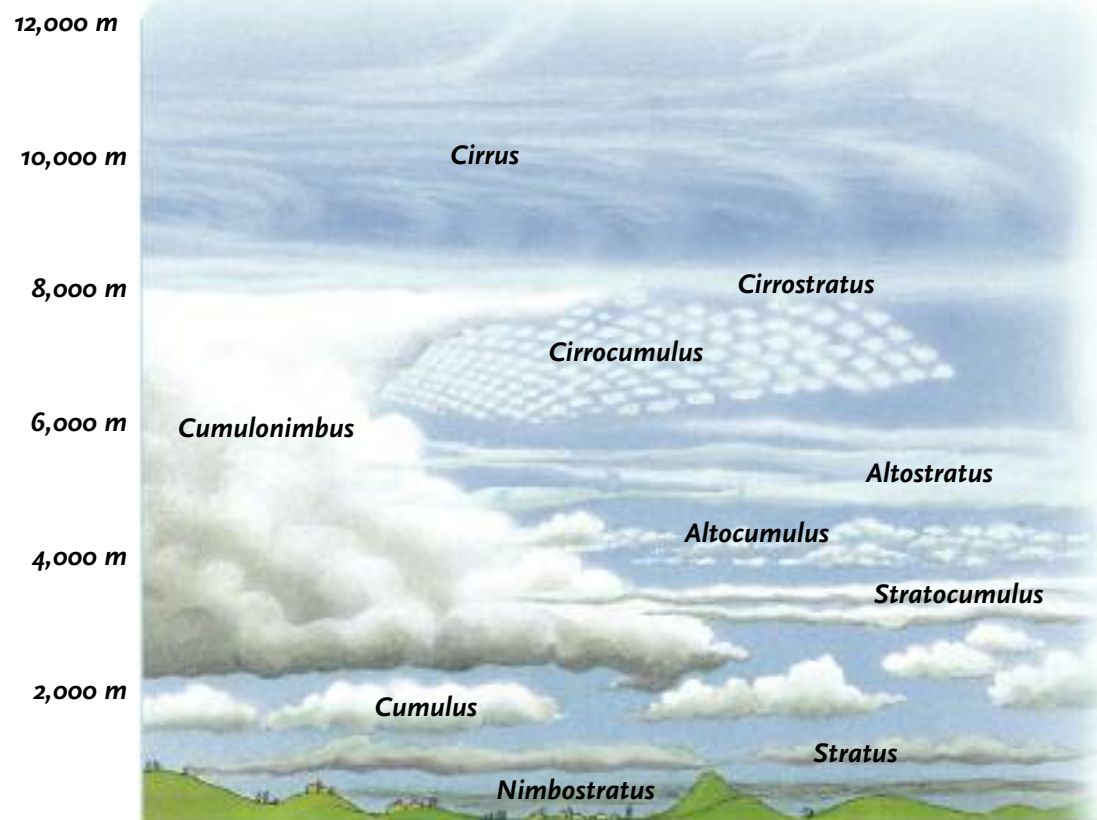
*Moist air may be forced to rise as it crosses high land. The water vapour may then turn to liquid water or ice.*

*This diagram shows how water is carried from sea to land and back again. It is called the water cycle. Of course, a great deal of rain also falls from the clouds directly back into the sea.*



◀ The Sun's heat causes water from the sea, lakes, rivers or the ground itself to evaporate (turn into vapour). Winds carry the moist air to other regions. As the air rises it cools. The water vapour in the air begins to condense (turn back into liquid) around tiny particles in the air, such as sea salt or dust. Millions of these tiny water droplets gather together to form clouds (or fog when close to the ground). In the highest clouds, the water freezes into ice. When the ice or water droplets become too heavy to stay up, they fall as rain, or snow if the air is below freezing. Rivers carry the water that has collected on land back to the sea and the cycle begins again.

◀ Very high clouds, such as cirrus and cirrostratus, are thin and wispy and contain ice particles. Cirrocumulus clouds form a "mackerel sky", so called because they look like fish scales. Altostratus and altocumulus may signal rain is on the way. Cumulus are the fluffy white clouds we see on a summer's day. Huge, anvil-shaped cumulonimbus clouds threaten storms. Stratus are low clouds that can cover the whole sky, while dark nimbostratus clouds bring rain or snow.



*At night, the ground cools down faster than the air. Water vapour in the air condenses and soaks everything, even spider's webs, with dew.*

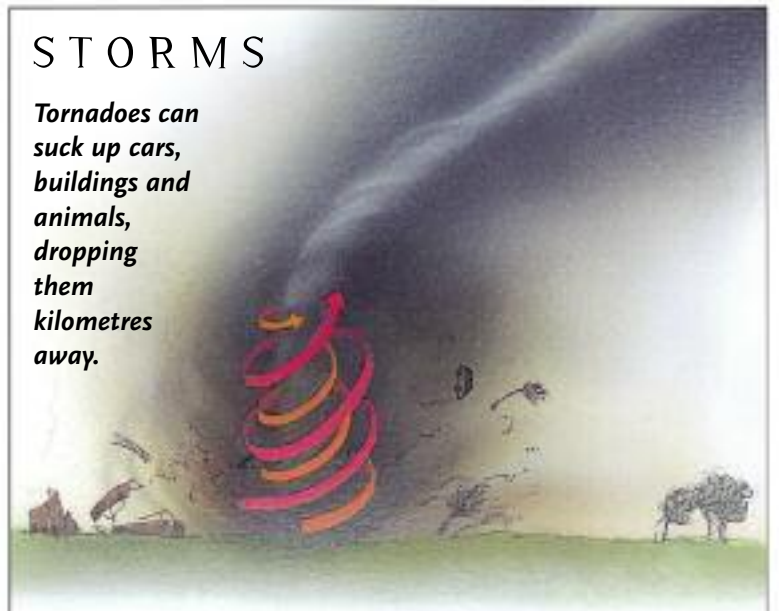


*If the air is below freezing, the condensed water vapour forms ice crystals. These cover everything in a layer of frost.*



# STORMS

*Tornadoes can suck up cars, buildings and animals, dropping them kilometres away.*



**T**ORNADOES are twisting columns of air stretching up from the ground. Winds of up to 500 km/h destroy everything in their path. Hurricanes begin when warm, moist air from the oceans is stirred up into a huge, spinning mass. Strong winds and rain swirl around a calm centre, the "eye" of the storm. Hurricanes can cause serious damage, often ripping up trees and overturning cars.



◀ When warm, moist air rises into the sky and cools very quickly, thunderclouds form. Electricity can be produced inside the cloud as ice and water droplets bump together. This electricity is released as flashes of lightning. The lightning is so hot that it makes the air around it expand quickly, making a sound we call thunder.



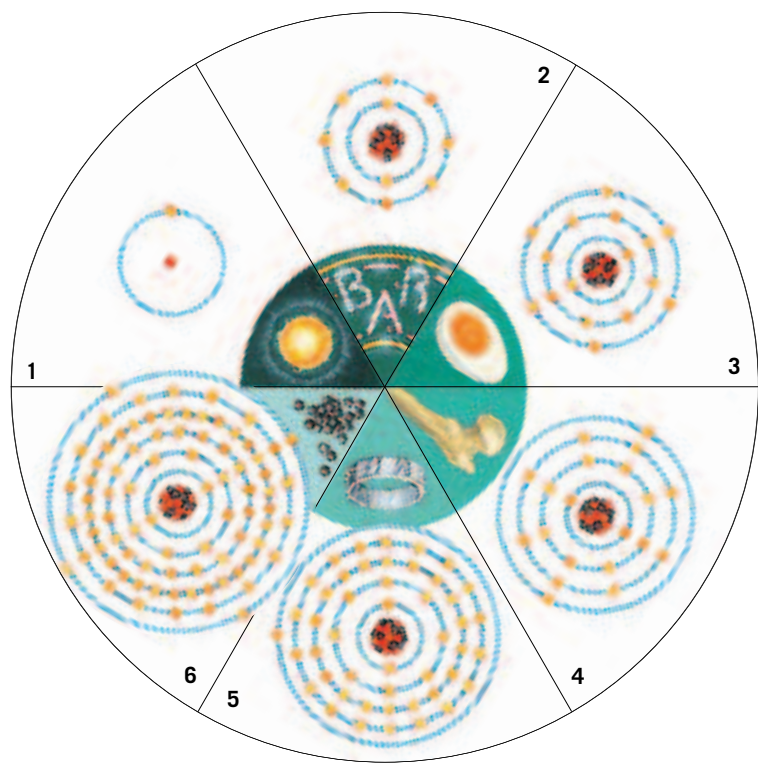
*Seen under a microscope, no two snowflakes are exactly alike, although they all have six equal sides.*

# ATOMS AND MOLECULES

**A**LL MATTER—that is, everything around you, such as wood, plastic, glass or other people—is made up from tiny building blocks called atoms. They are minute: the tiniest speck of dust contains a million million atoms.

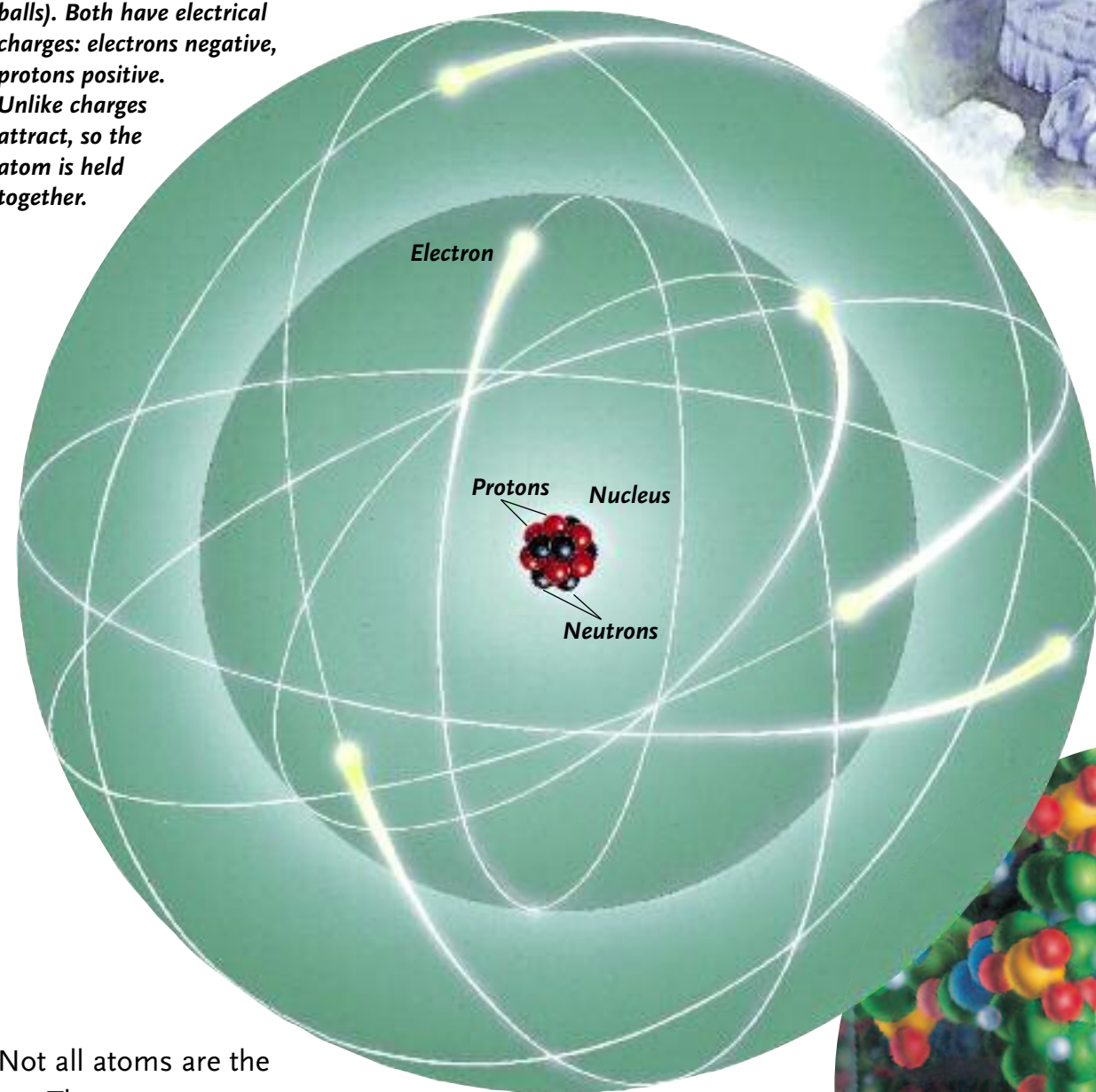
Each atom is almost entirely made up of empty space. At the very centre, the nucleus, is a minuscule cluster of particles called protons and neutrons. Little bundles of energy, called electrons, whizz around the nucleus at the speed of light.

Atoms often link together to make different substances. When linked, hydrogen and oxygen atoms form a very familiar substance: water. Atoms that are linked are called molecules.

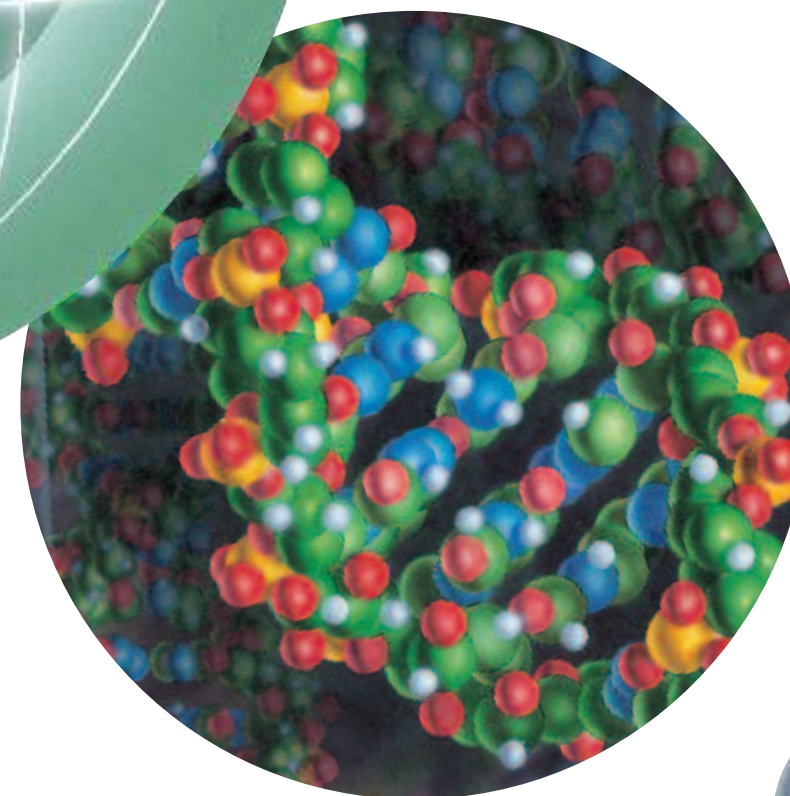


◀ Not all atoms are the same. There are 92 different kinds of atom. A substance made from just one kind of atom is called an element. Each element has a different number of protons and neutrons in its nucleus and a different number of electrons. It is this unique structure that gives each element its individual properties. Six elements are shown here: hydrogen (1), neon (2), sulphur (3), calcium (4), silver (5) and lead (6).

*Inside an atom, there are the same number of electrons as there are protons (red balls). Both have electrical charges: electrons negative, protons positive. Unlike charges attract, so the atom is held together.*



*Oxygen is one of the commonest elements on Earth. Substances burn by joining with oxygen. This is called combustion. Here, fuel is mixed with oxygen to produce a flame hot enough to melt and cut metal.*

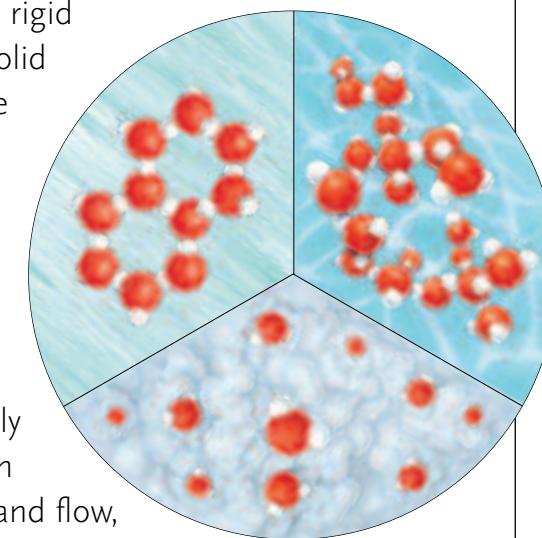


▲ Atoms are usually found linked together in molecules. Molecules made up of different kinds of atoms are called compounds. The links between atoms are called bonds. Carbon atoms bond particularly well with other atoms. They form the molecule DNA, found in all living things.

## MATTER

**S**UBSTANCES come in three different forms: solid, like rocks, liquid, like water, or gas, like air. These are called the states of matter. In a solid, the molecules are packed closely together and joined in a rigid pattern. So a solid object stays the same volume and does not change shape. In a liquid, the molecules are still close but can move slowly about. They can change shape and flow, but, like a solid, still take up the same volume. In a gas, the molecules can move freely, so it can get bigger or smaller, to fill the container it is in. Water appears in nature as liquid, as a solid (ice) and as a gas (water vapour, which turns to tiny droplets to form clouds).

Matter changes state from solid to liquid, or liquid to gas, by being heated. It can also change state the other way, by cooling. A common example is the water cycle (see page 18).



◀ Stir in a teaspoonful of table salt into a glass of water and the salt

disappears. It has dissolved. The salt molecules have been broken down into their individual atoms: sodium and chlorine. The result is called a solution. The sea is a salt solution. If there is so much salt that no more can dissolve, it is saturated. Lumps of solid salt start to appear on the surface (above).

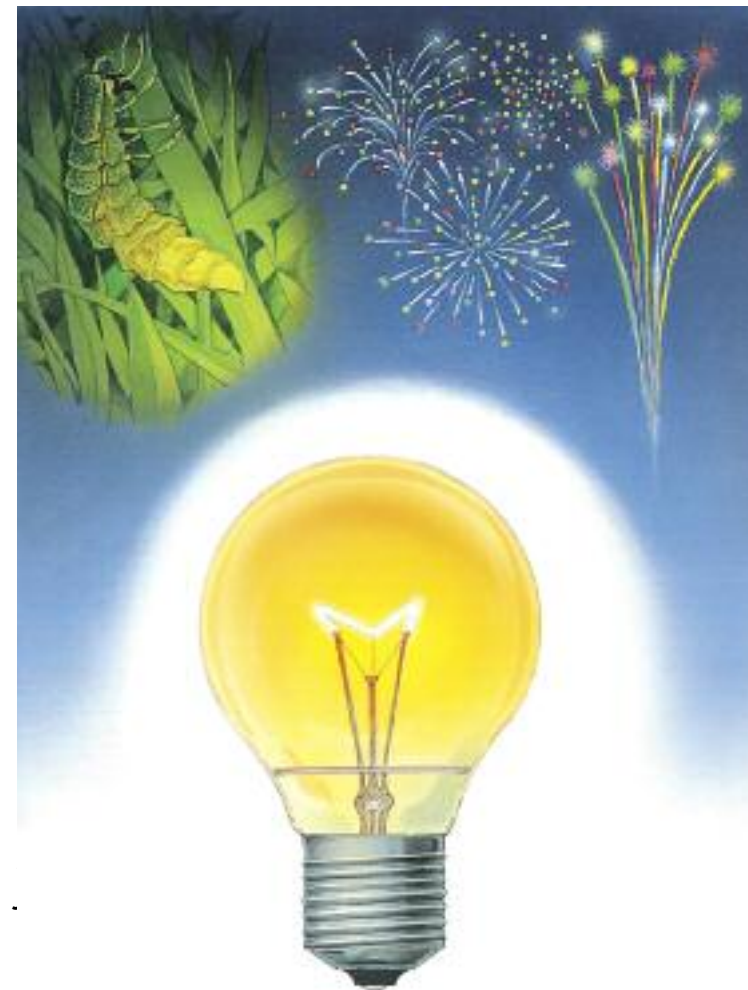


◀ A hot-air balloon contains matter in a gaseous state: air. Heat from the burner causes the air molecules to move apart. When there are fewer air molecules inside the balloon than outside it, the balloon is less dense, and so rises.

# LIGHT AND SOUND

Light is a kind of energy (see page 23). It allows us to see things. It travels in straight lines, so there are shadows behind things that stand in its way. Light also travels very fast: about 300,000 kilometres (seven-and-a-half times round the world) per second.

Sunlight is made up of coloured lights. We see these when a rainbow forms. In fact, only three, red, green and blue (called primary colours), are needed for our eyes to see every colour there is. Many different colours can be made by mixing together primary colours in different amounts.



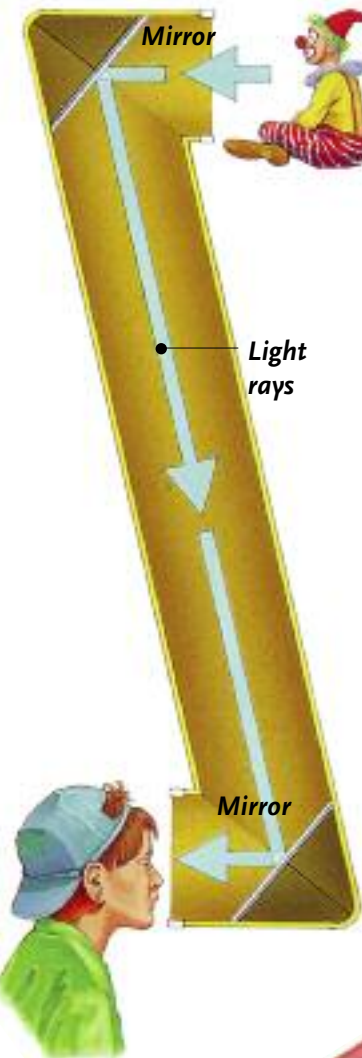
▶ Light from the Sun seems to have no colour at all. In fact, as the scientist Isaac Newton (see page 22) once showed, sunlight, or white light, is made up of several colours. He took a prism, a piece of glass with triangular sides, and allowed a tiny chink of sunlight to shine on it. The prism split the white light into red, orange, yellow, green, blue and violet colours. These are called the colours of the spectrum. We see them whenever there is a rainbow in the sky. Raindrops act like tiny, tear-shaped prisms.

▶ You can prove that white light is made up of coloured lights by making a wheel like this. When it is spun, the colours merge and look white.



When light rays pass through raindrops, they are split into the colours of the rainbow.

▶ Light rays can bounce off objects. This is called reflection. In fact, for us to see any object at all, some light must be reflected from it otherwise it would appear black. A smooth, white surface reflects more light than a rough, dark one, but a flat, shiny surface reflects light best of all. Mirrors, sheets of glass with a thin layer of metal on the back, are perfect reflectors. By placing two mirrors carefully in a tube you can make a periscope, a device to see round corners. Light coming in at one end is reflected through to the viewer at the other end.



▲ A lens, a shaped piece of glass or plastic in a magnifying glass, brings light rays together to a point called a focus. It makes something we see through it appear larger. Our eyes have natural lenses in them.

## SOUND



SOUND is made by vibrations: very quick movements backwards and forwards. When something vibrates, it sets the air around it vibrating, too. The effect is like ripples in a pond. When a pebble is thrown in, tiny waves spread out from that point. Sound also travels in waves. The stronger the vibrations, the greater the waves and the louder the sound.

Music is simply a series of controlled and—usually!—pleasant sounds. A trumpeter (above) blows into a metal tube and sets the air inside vibrating to produce musical sounds.



A high-pitched sound has faster vibrations than a lower-pitched one. A rocket taking off makes a very loud, low-pitched sound, a female opera singer can produce loud, high-pitched sounds, while falling leaves make very soft, medium-pitched sounds.

Sound travels through solids and liquids as well as air. Sound waves can also bounce off another surface and be reflected back. This is called an echo.



We can use very high-pitched sounds, called ultrasound, to echo back through the human body and find out about an unborn baby inside. The echoes can be turned into pictures on a computer screen.

# FORCES AND ENERGY

ANYTHING that pushes or pulls an object is called a force. A breath of wind, a car engine, a magnet and an elastic band are all examples of things that can produce a force. Gravity is a very important force. You can see it at work if you let a pen drop. The pen is being pulled towards a very large object—the Earth itself.

Hammer a nail into wood, and the force of the hammer makes it push down into the wood. This is a force causing motion. The wood pushes back with its own resisting force. As the nail goes deeper, the resisting force of the wood increases. It may eventually equal the force of the hammer hitting the nail. The amount of force for a certain area is called pressure. A nail goes into wood easily because the force hammering it is concentrated into the tiny area of the nail's sharp point, giving very high pressure.



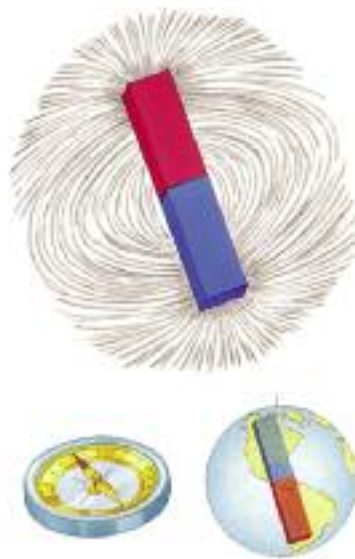
◀ There is a very powerful force always pulling on you. It is called gravity, the force that attracts all objects to each other. Everything has gravity, but only really huge objects like the stars and planets have a strong pull. The Earth pulls everything on its surface towards its centre. It is said that the great English scientist Isaac Newton first realized this when he saw an apple fall from a tree.



◀ When we sit on a fairground ride like this, we can feel a force pushing us quite strongly outwards. We have to hold tight to stay on! This force is called the centrifugal force. At the same time there is another force at work, keeping us moving in a circle around the roundabout. This force is called the centripetal force. It is these two balancing forces that keep the Earth and other planets travelling in orbit around the Sun (see page 8).

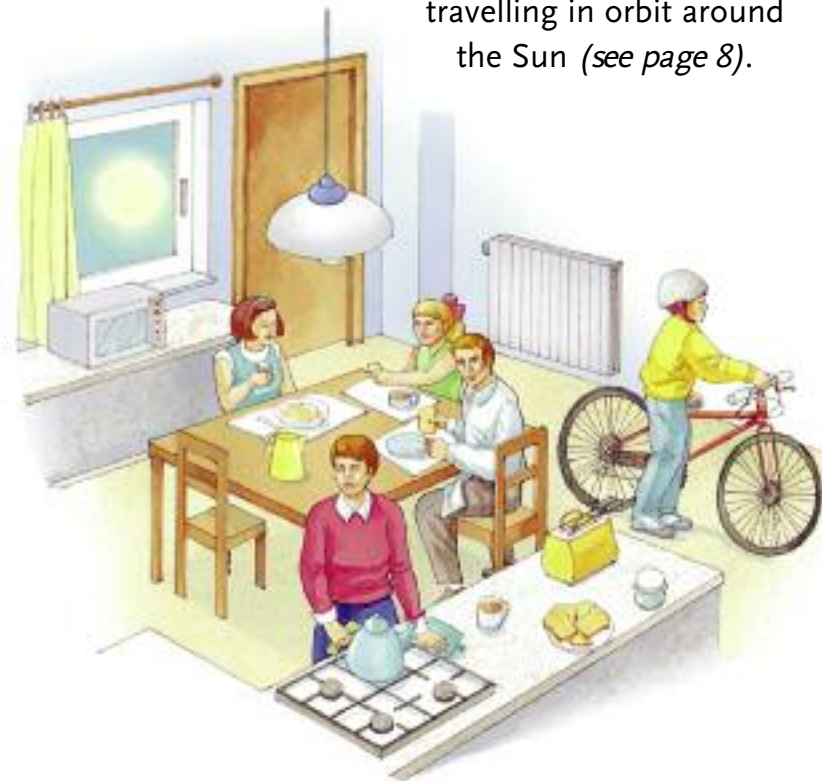


◀ An object tends to stay at rest, or keep on moving at the same speed, unless it is acted upon by a force. This tendency is called inertia. If a bus stops suddenly, everyone on it falls forward because there is nothing to stop them moving. (Seat belts would hold them in place.)



*The Earth itself has a magnetic field, as if it had a magnet inside it. A compass has a small magnet balanced inside it. The north pointer is attracted to the northern end of the "Earth-magnet".*

◀ Another important force is magnetism. A magnet is a piece of iron or steel that attracts other objects made of iron or steel, but has no effect on wood, plastic or most other kinds of metal. All magnets have two ends called north and south poles. North poles attract south poles but similar ("like") poles always push each other away. The area around a magnet is called a magnetic field. A sprinkling of tiny pieces of iron around a magnet shows its pattern.



▲ Energy means the ability to do something: for example, walk and run, power a car, light up a room or cook a meal. There are several different kinds of energy. This illustration shows them at work. We receive light and heat energy from the Sun. Light bulbs, microwave ovens and toasters can also supply this energy, of course: they work by using electrical energy (see page 24). For our bodies to work, they need the chemical energy that is stored inside food. Mechanical energy is used for activity and movement, such as lifting a box or riding a bicycle.

## FRICTION

WHEN TWO OBJECTS which are touching try to move past each other, they rub against each other. This produces a force, called friction, which tries to stop the movement. If the surfaces of the objects are rough like sandpaper then friction is greater. If they are smooth and slippery, especially if lubricated with oil or grease, then friction is less. Friction slows things down, causes wear and tear and changes energy into waste heat. But friction can also be helpful. A vehicle's tyres grip the road because of friction. A bulldozer's tracks dig into the earth with so much friction that they cannot slip (above).



A skier slides easily over snow and ice because the skis press down and rub hard on them (below). The friction makes them heat and melt into water, which is very slippery with low friction.



► Why does a heavy ship float? Some objects are denser than others: their atoms are more tightly packed together. Anything that is less dense than water (like wood) will float, while a denser object (such as a pebble) will sink. A ship contains lots of air, so its overall density is less than water.



# ELECTRICITY

**E**LECTRICITY is a kind of energy. It is invisible and stored inside atoms, the minute building blocks of which all things are made (see page 23). Atoms themselves are made up of even tinier pieces, called particles. They include electrons, which have a negative electric charge, and protons, which have a positive electric charge. In normal atoms, there are the same number of electrons and protons, and so the charges cancel each other out. To make electricity, we must make the atoms lose or gain electrons.

Things that run on electricity are connected to the source of electrical power by metal wires. When the current is switched on, or a battery is connected, the electrons in the wire all move in the same direction. This is called current electricity. We can use electricity in all sorts of ways: to light our homes, switch on a television, power a train, and so on.

Rod (positive terminal)



Battery case (negative terminal)

Inside a battery, there is a rod surrounded by chemicals that produce electricity. The positively charged rod attracts electrons from the negatively charged battery case.

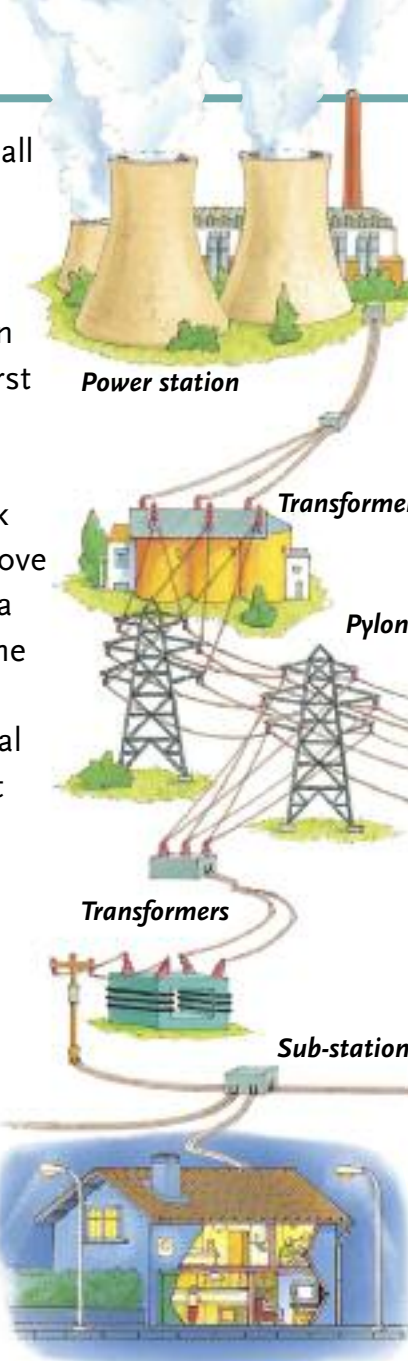


Electrons flow along the wire between the rod and battery case.



▶▶ In static electricity, the electrons do not move. You can make static electricity by running a comb through your hair. The comb leaves a few of its electrons behind in the hair, so the comb now has a small positive charge. It can pick up small pieces of paper because it attracts the electrons in the paper's atoms. If you comb your hair in a dark room then hold the comb close to your thumb, you will see a tiny spark. The electric charge heats the air atoms between comb and thumb, producing a flash of light. This is exactly what happens—but on a much grander scale—when lightning strikes during a thunderstorm (see page 00). Thunder is the noise of the air expanding rapidly in the intense heat.

▶ We need electricity for all kinds of things in our homes. Most homes are connected to mains electricity. A power station makes electricity in the first place. Boosted by transformers, electricity travels along cables (thick wires) supported high above the ground by pylons, to a sub-station. From here, the wires run to our homes. When we plug an electrical appliance into a socket, it connects up to mains electricity.



When lightning passes from clouds to the ground, the amount of electric energy produced can be very great, enough to destroy a building or kill a person. With a lightning conductor, a metal rod running from the top of a tall building to the ground, the massive electric charge is led safely down the rod and away from the building.

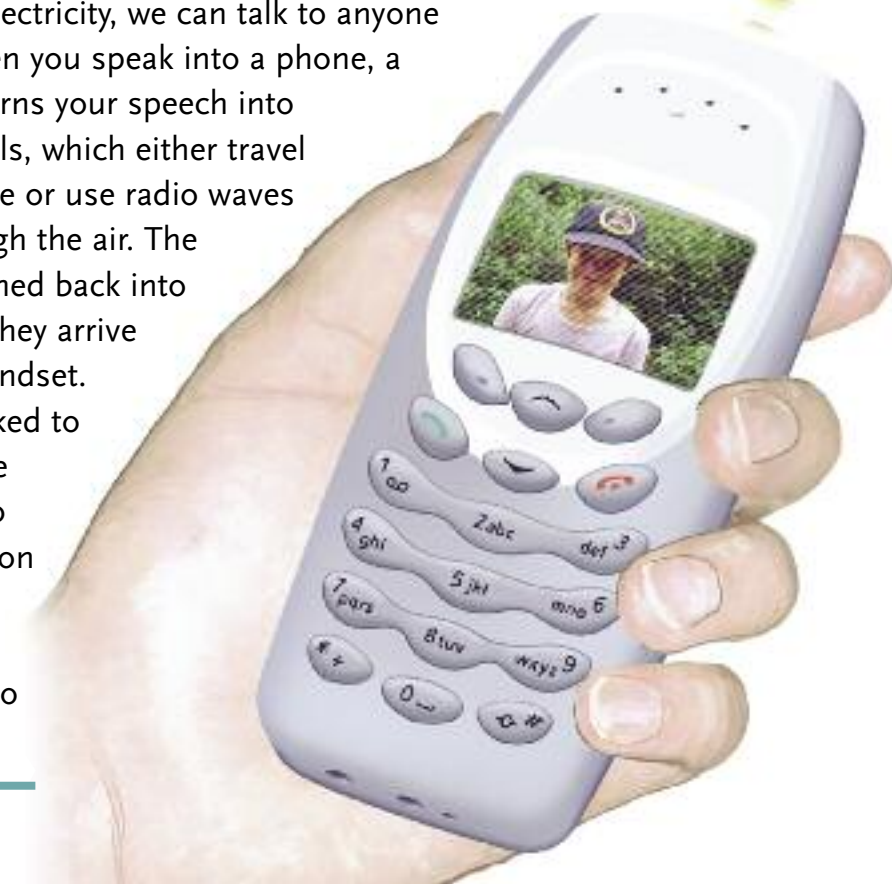


# ELECTRONICS



**B**ESIDES metal wires, electricity can also flow through empty space and other materials such as silicon. Devices that make use of this are called electronic components. These are essential parts of machines that enable us to hear sounds from a radio or a hi-fi stereo system, and use a calculator or computer. Modern electronic components can all be fitted on to a miniature integrated circuit, or silicon chip. A computer uses them to store information and make calculations. Like a person, a computer has a memory and a “brain” or central processing unit.

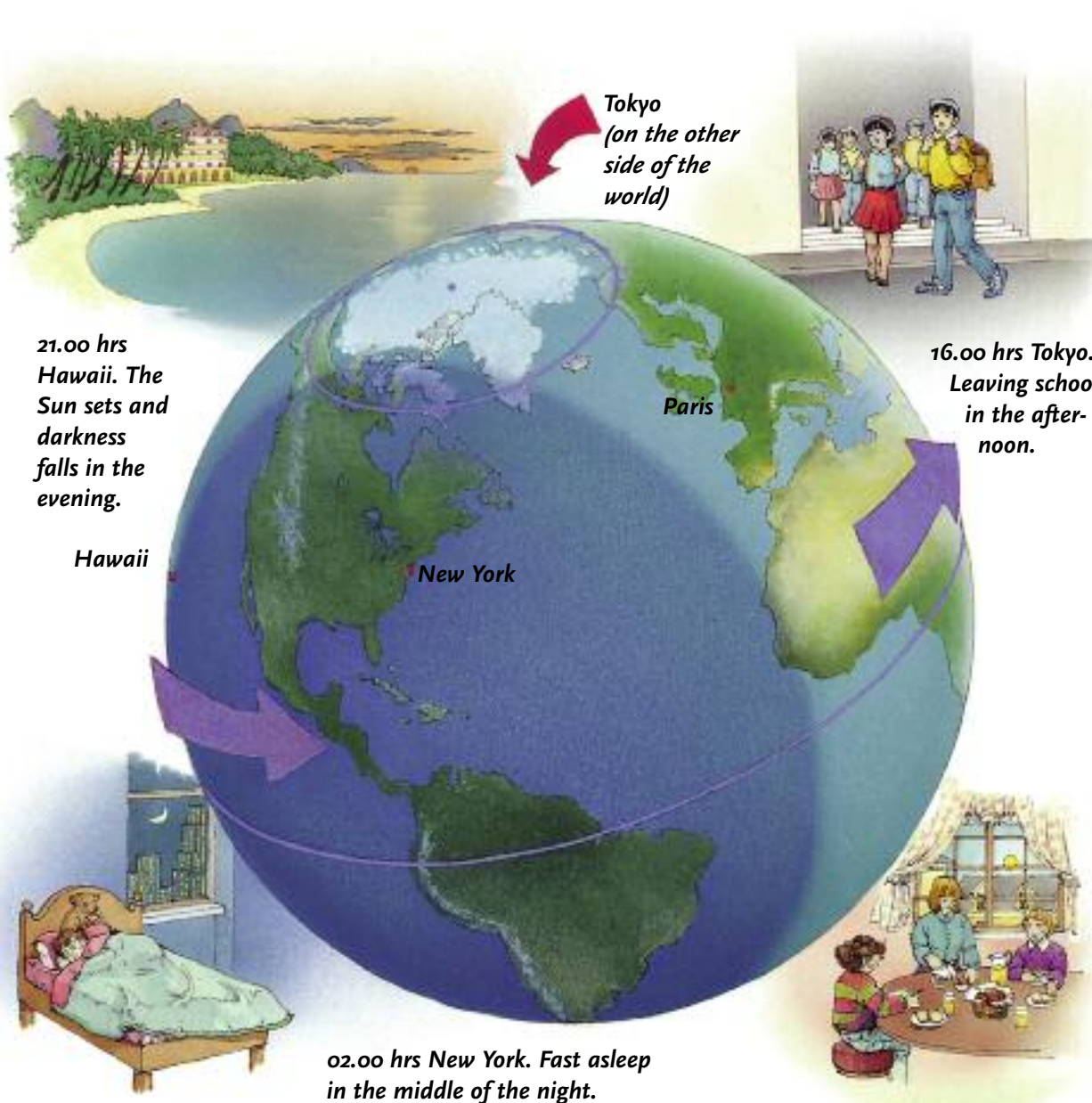
▶ Thanks to electricity, we can talk to anyone by phone. When you speak into a phone, a microphone turns your speech into electrical signals, which either travel along a landline or use radio waves to travel through the air. The signals are turned back into sounds when they arrive at the other handset. Computers linked to the internet the world over also send information to each other along phone lines or by radio waves..



# TIME

**W**HAT is the time? You probably want the answer to this question many times each day. In the modern world it is very important to know what the time is: a great number of everyday events depend on it. Television, trains, air flights, schools and sporting contests must all run on time.

People who lived in Egypt and the Middle East in ancient times also wanted to record time accurately but had no clocks with which to do so. Nevertheless, 5000 years ago, astronomers from the ancient city of Babylon divided a day (the period from sunrise to sunrise) into 24 hours, each hour into 60 minutes and each minute into 60 seconds. Today, although we have clocks that can measure time to within the tiniest fraction of a second, the ancient Babylonian units of time still survive.

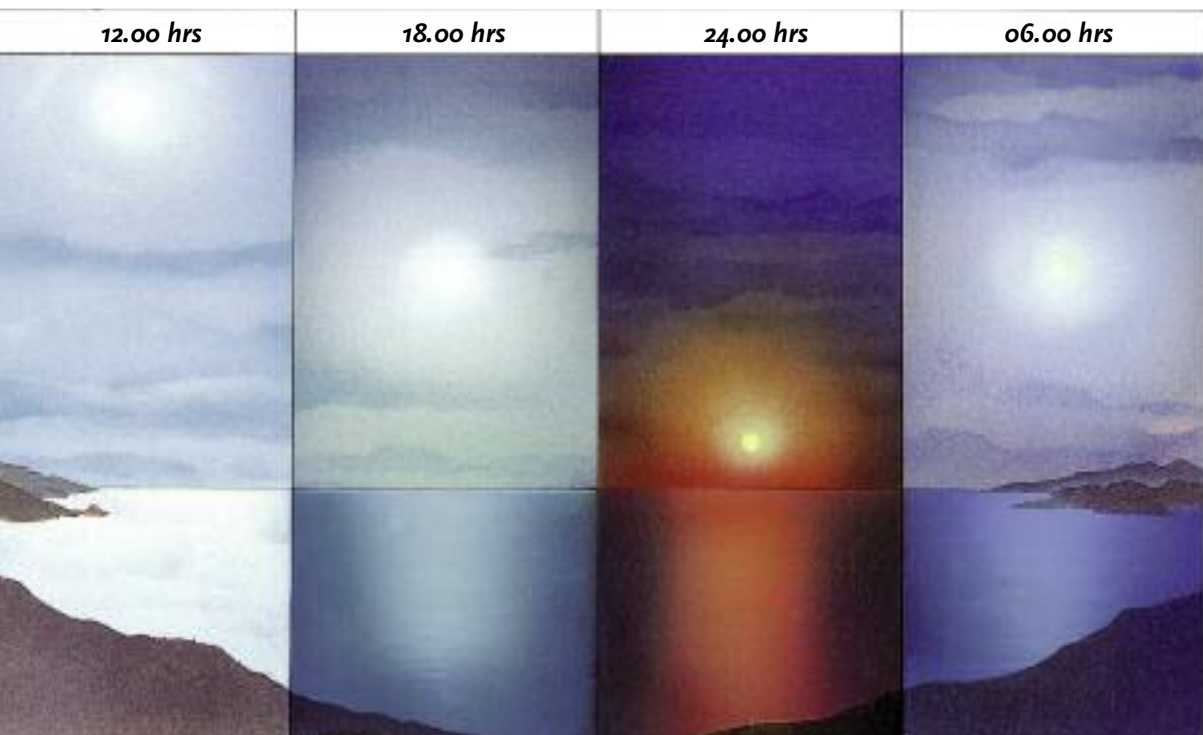


◀ The Earth takes 24 hours, or one day, to complete one spin. While one half of the Earth is lit up by the Sun, where it is daytime, the other half remains in night-time darkness. Clocks in any part of the world are set to a time according to the Sun's position. This is different from one part of the world to the next. So, at any one moment, clocks around the world tell completely different times. When it is mid-afternoon in Tokyo, Japan, it is evening on the previous day in Hawaii!

▼ Built in England more than 4000 years ago, Stonehenge may have helped people to record the days of the year, like a giant calendar. The Sun always appeared above a particular stone at a certain time of the year.



◀ We have day when our part of the world faces the Sun and night when it is turned away. Because the Earth is slightly tilted, lands near the Poles face towards the Sun for most of the summer and away from it for much of the winter. Summer days are very long, winter days very short. In northern Scandinavia, the "Land of the Midnight Sun", there is one day, shown here, when the Sun never sets.

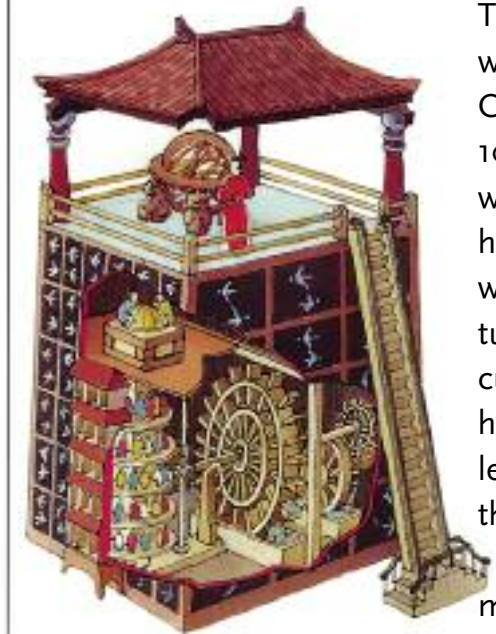


## MEASURING TIME

As the Earth turns, the shadow cast by the central pointer of this sundial moves slowly across a dial marked in hours.

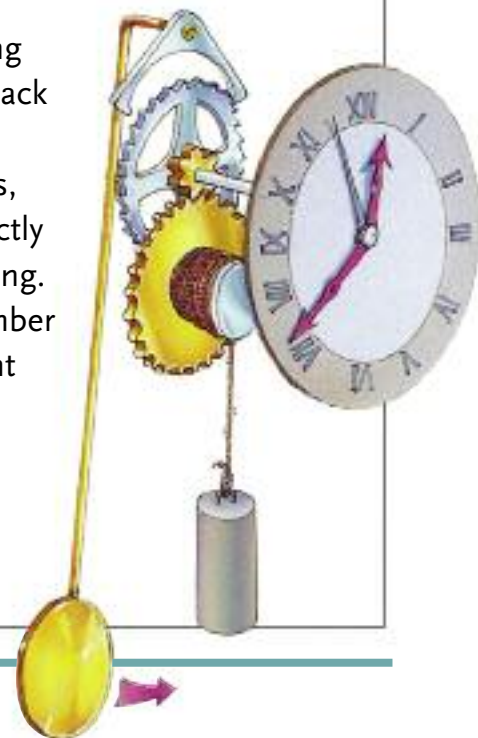


**T**HOUSANDS of years ago, in order to tell the time, people simply followed the passing of days and nights and the changing seasons. The simplest clocks, to indicate the passing of hours, were sundials. They were first used in ancient Egypt.



This clock (left) was invented in China more than 1000 years ago. A waterwheel inside had cups filled with water. It turned when the cups became too heavy, setting off levers and rods that moved the clock mechanism.

Pendulum clocks were the first accurate clocks. A pendulum, a weight hung on a long arm, swings back and forth at regular intervals. In some clocks, the pendulum takes exactly one second for each swing. It is connected by a number of cogs to a heavy weight on a string: this falls gradually, second by second. The force of the gradually falling weight drives the clock.



# GLOSSARY

**Atmosphere** The blanket of gases surrounding the Earth that enables life to exist.

**Asteroid** A rocky body that orbits the Sun. Asteroids range in size from tiny specks to about 1000 kilometres in diameter. They are sometimes known as minor planets.

**Atom** A basic building block of matter. It consists of a nucleus, made up of protons and neutrons, surrounded by a number of electrons.

**Condensation** The process by which a gas becomes liquid.

**Constellation** A group of stars forming a pattern in the sky.

**Core** The innermost portion of the Earth.

**Crater** A saucer-shaped feature found on the surface of many moons and asteroids, and some planets. It is formed by the impact of meteorites.

**Crust** The thin, rocky outer layer of the Earth. There are two main types of crust: continental and oceanic.

**Density** A measure of how compact something is. An object is denser than another if its atoms are larger or more tightly packed together.

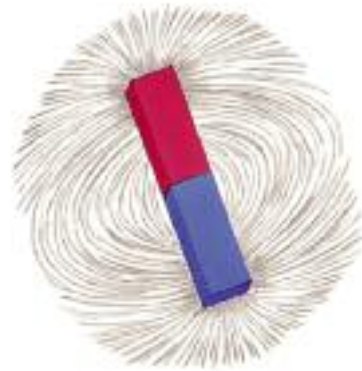


**Electron** A subatomic particle that orbits the nucleus of an atom. The electron carries a negative electrical charge, while the protons in the nucleus are positively charged. Positive and negative charges attract each other, so the atom is held together.

**Element** A substance composed of atoms of the same type that cannot be broken down by chemical means into simpler substances. Lead, hydrogen and carbon are all elements. All matter in the Universe is made up of 92 natural elements.

**Energy** The ability of something to do work, make an event happen, exert a force or cause change in some way.

**Fold** A bend or buckle in rock caused by intense pressure. Folds usually occur in elastic rocks, which tend to bend rather than break.



**Force** Something that changes the movement or shape of an object.

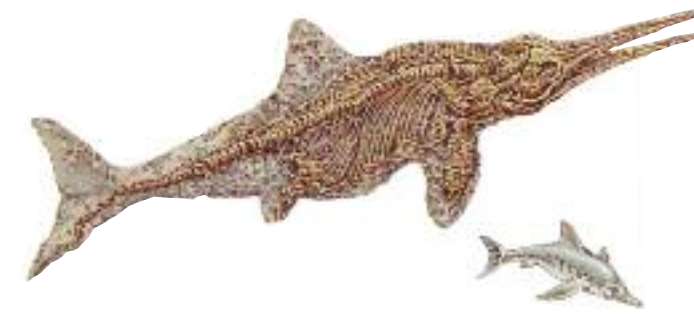
**Fossil** The ancient remains or traces of a once-living thing, usually found preserved in rock.

**Friction** A force that resists (acts against) the movement of one surface against another.

**Galaxy** An enormous collection of stars, gas, dust and planets. Galaxies are gathered together in clusters.

**Gravity** The force that attracts all objects to each other. The larger an object's mass (the amount of matter it contains), the greater its gravitational pull. The greater the distance between objects, the smaller the force of gravity between them.

**Igneous rock** A type of rock formed from magma that has cooled and hardened.



**Lava** Magma that has reached the Earth's surface through volcanoes or fissures.

**Magnetic field** The region surrounding a magnet, an object which has two poles, and a force of attraction between them.

**Magnetism** The invisible force of attraction or repulsion between materials, especially those made of iron.

**Mantle** The layer of the Earth that lies between the crust and outer core.

**Metamorphic rock** A rock that has changed due to intense pressure or heat. Metamorphic rocks can form from igneous rocks, sedimentary rocks, or even other metamorphic rocks.

**Meteor** A mass of rock or metal that has entered the Earth's atmosphere, often forming a streak of light as it burns.

**Meteorite** A meteor that reaches the surface of the Earth.

**Mineral** A natural chemical substance that is neither plant nor animal. Rocks are made up of minerals. Minerals are the most common solid material found on the Earth.

**Moon** A smaller object that orbits a planet, also known as a natural satellite.

**Nebula** A cloud of gas or dust in space.

**Orbit** The circular or elliptical (oval-shaped) path followed by one object round another. For example, the Moon orbits Earth, while Earth orbits the Sun.

**Planet** A smaller object that orbits a star. Planets do not radiate their own light, but reflect the light from the star.



**Sedimentary rock** A type of rock that is formed by the pressing together of rock fragments or the remains of living things.

**Sediments** Eroded rock fragments that are transported by wind, water or ice and laid down elsewhere.

**Star** A globe of gas that produces heat from nuclear reactions inside its core and radiates energy from its hot surface.

**Universe** Everything that exists: all matter and space.

**Volcano** An opening in the Earth's crust through which magma erupts. The name is usually used to describe a cone-shaped mountain with a central vent and a crater at the summit.

**Water cycle** The process by which water circulates from the land or oceans to the atmosphere and back again.



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