TEACHER'S GUIDE

Simply Science 3

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CONTENTS

INTRODUCTION

Aims and content of the course

Simply Science is based on the Pakistan National Curriculum for Primary Science and the exemplar scheme of work prepared jointly by the Qualifications and Curriculum Authority (QCA) and the Standards and Effectiveness Unit of the Department for Education and Employment in Britain. The course aims to meet the needs of teachers and pupils by building on the core scientific themes in carefully graded stages, thereby providing a comprehensive introduction to science for pupils aged 3 to 11 years.

The course is designed to do three main things:
1) To give students a solid body of knowledge in the natural, physical and earth sciences.
2) To introduce them to the nature of scientific enquiry.
3) To enable them to explore values and attitudes through science.

These three elements are developed side by side through the books which make up the complete course. At the same time, the course aims to provide all the help and guidance necessary to allow the busy non-specialist teacher to cope with the demands of primary school science. To this end, it is hoped that the course will save the teacher time, resources and preparation.

The course

The course consists of units to be taught in years Prep to 5. These units are planned to cover the programme of study in three two-year cycles, thus ensuring that key areas are revisited, consolidated and extended. However, care has been taken to ensure that, though the course builds on students' earlier experiences, it does not repeat activities and investigations. This approach will also support those teachers planning for mixed ability and mixed age classes. The units in any one year are interchangeable and do not have to be delivered in the order given within any one student's book. This will help to meet the demands imposed by the availability of materials and the local seasonal and climatic conditions that may affect when certain environmental aspects of science can be taught. Each unit starts from real-life situations, and much of the information is presented in both picture and text. The context for activities within the units can be either cross-curricular or specifically scientific, depending upon the preferred teaching style. *Simply Science* is aimed at the average student but is flexible enough to allow use by students of all abilities. It also promotes the development of independent learning by students.

Using this Teacher„s Guide

The demands which the *Simply Science* course make upon the teacher depend entirely on how far he or she wishes to progress with a particular class or group of children. The student's books are intended to provide core material on the three broad themes of:

- Life and living processes
- Materials and their properties
- Physical processes

The themes chosen are based firmly on the students' own experience and cover areas affecting their everyday lives. The units in the student's books contain a high proportion of direct teaching, so that they can be used as they stand or as part of a more extensive science programme, with the help of the appropriate Teacher's Guides.

The themes within any one student's book can be taught in almost any order. If there are two or more teachers with classes of students of the same age, they could each choose different themes. The teachers could acquire the materials for their particular theme and then, after the work is completed, they could exchange materials and ideas, and discuss any problems that arise.

For practical activities, it may be necessary to divide the class into groups of a size you consider appropriate for each particular activity. The groups should be as small as possible but should have enough students to adequately handle the materials and to keep a record of the results. For most activities, two or three students is probably the optimum number for a group. Many of the activities can be done individually. Certainly the groups should never be so large that some students are merely spectators. In the case of activities which require a great deal of the teacher's attention, it is suggested that the class is divided into two, and while part of the class is engaged in the practical activity, the other part is kept busy with the 'desk-bound' written or other activities in the student's books or in the ***Going Further*** sections of this Teacher's Guide.

Most of the sections in this Teacher's Guide are self-explanatory. There is an introductory section, directed specially at the non-specialist teacher, which aims to explain what science is and how it works.

Background information is aimed at giving the non-scientist teacher confidence. It contains all of the scientific knowledge necessary to teach a particular unit.

Answers provides, where possible, the expected results of any activity and answers to any questions posed under the headings of *Rapid Ïre* and *Try it out*.

Going further contains activities, experiments, demonstrations and suggestions for discussion which can be used to add depth to each lesson, or to reinforce it.

Worksheets The worksheets are designed to be photocopied and used within the purchasing institution. They are designed to allow the students to record their findings on the actual worksheets, but you should also encourage the students to use IT and other methods of recording, as appropriate.

Although it is in the *doing* of science that students learn best, this involves more than just practical work. As well as needing to observe, record, predict, measure, look for patterns, classify, ask questions and so on, students need time to discuss their work. In this connection, the worksheets should be discussed both before and after the completion of the activity. This is particularly important with those students who are not fluent readers. Such discussion also helps to clarify the main ideas and will help you to monitor progress and discover what interests the students, with a view to developing their interests in future sessions. Discussion will also reveal any misunderstandings which can then be corrected as soon as possible.

Notes on individual worksheets explains the key idea behind each worksheet. It also describes briefly expected results or answers and makes suggestions for further activities and investigations. This section also warns of any safety considerations involved in the topic. The question of safety is dealt with more fully in the section below.

Glossary The glossary at the end of the book is intended for use by the teacher and it gives brief definitions of some of the most important scientific words in this Teacher's Guide.

Equipment and materials

Essential materials and equipment are listed under 'What you need' on each worksheet. Nearly all the items are readily available. It may be necessary from time to time to call upon the school kitchen for access to a refrigerator or deep freeze. The students themselves may be able to collect some of the materials if they are given sufficient notice.

Safety!

The activities described in this Teacher's Guide and in the student's books mainly use everyday items of equipment, and materials which are perfectly safe if used sensibly. All the activities have been checked for safety as part of the reviewing process. In particular, every attempt has been made to ensure that all recognized hazards have been identified, suitable safety precautions are suggested, and, wherever possible, the procedures are in accordance with commonly used risk assessments.

However, it is important to be aware that mistakes can be made. Therefore, before beginning any practical activity, you should carry out your own risk assessment in relation to local circumstances. In particular, any local guidelines issued by your employer **must** be observed, whatever is recommended here. As a general principle if, on safety grounds, you are not completely sure about the ability of your class to carry out an experiment, then demonstrate it to them rather than risk an accident.

General safety precautions

There are a number of general safety rules which you should observe:

- If the students taste or handle food, ensure they wash their hands before doing so and that tables and utensils are clean and foods are fresh and uncontaminated. Do not use nuts, as some children are allergic to them, particularly peanuts. Be sensitive to different dietary requirements.
- Young children have little say or control over what they are given to eat at home. When discussing the components of a balanced diet, take care to ensure that children do not feel that you disapprove of their dietary habits. Similarly, when comparisons are made between students, it is important to emphasize that we are all different. Children are built differently, grow at different rates, and have different backgrounds and likes and dislikes.
- Visits beyond the school grounds must be carried out in accordance with the guidelines of your school or employing authority.
- Warn students never to look directly at the Sun. It could damage their eyesight or cause blindness.
- Some children are allergic to certain plants, e.g. some flower bulbs, and pollen (from flowers), and remember that some plants are poisonous. Many children are allergic to certain animals.
- Many seeds bought from garden centres will have been treated with pesticides and are not safe for students to handle. Seeds bought from health food shops are usually safe, although it is best to avoid red kidney beans.
- Whenever possible, use transparent plastic containers, rather than glass containers, particularly for holding water or collecting living things outside.
- Night lights and short, stubby candles are difficult to knock over. When using a naked flame always work in a metal tray, such as a baking tray, filled with sand.
- Use soils free from glass, nails and other sharp objects, and collect soil samples from places that are unlikely to be contaminated with dog or cat faeces. Wash hands after handling soils.
- Wash hands after handling animals.
- Be alert to the potential risks of suffocation associated with polythene bags.
- Students should not touch ice immediately after it has been taken out of a freezer.
- Take great care with hot water or steam.
- Mercury thermometers (recognizable by the silver colour of the liquid inside them) are not suitable for use in primary schools because of the dangers from the toxic metal mercury if they are broken.
- Warn students of the dangers of mains electricity. However, assure them that the batteries they use in class are safe.
- Use plastic mirrors wherever possible. If you have to use glass mirrors, ensure that they do not have sharp edges; bind edges with masking tape or insulating tape.

What is science?

Before taking a class for science, it may be helpful for the non-specialist teacher to consider what this 'mysterious' subject is all about. The word 'science' comes from the Latin word *scire*, to know. Science is concerned with our knowledge of the universe and all that is in it. Science is an organized body of subject matter, and in this it is no different from geography, history or any of the other subjects in the school curriculum. Where science differs from these other subjects is that it involves a method of discovery based on experimentation. Experiments entail finding an answer to a question by observing the effects of making systematic changes.

The first stage in the development of any science is based largely on observation. Science begins when we notice something interesting and ask questions about it. 'I can crush this drink can by standing on it.' 'Will all metal cans crush as easily as this?' 'This block of wood floats. Will all types of wood float?' 'How many seeds are there in a dandelion 'clock'? Will they all grow?' It is important to remember that careful observation is a practical skill which can be encouraged and enhanced by regular practice.

It comes naturally for young children to try things out to see how they work, to manipulate, to feel, to be curious, to ask questions, and to seek answers. That is science. They should ask Who? Where? When? Why? How many? How much? How far? and so on. They should be encouraged to find their own answers, as far as possible by devising simple experiments.

The testing out of an idea, properly called a hypothesis, is the usual way in which scientists carry out an experiment, but children often carry out an experiment with no particular hypothesis in mind, simply to see what happens.

A useful test in science is the controlled experiment, in which two situations are compared that are identical except for the one factor (called a variable) being tested. Having observed mung bean seeds growing on moist cotton wool, and dying when the cotton wool was allowed to dry out, we might decide that water is an important factor in initiating the germination of mung bean seeds (our hypothesis). We might then take two saucers filled with cotton wool, on which equal numbers of mung bean seeds are sprinkled. The saucers are placed next to each other on a sunny window sill. They are identical except that the cotton wool in one is kept moist while the other is left dry. The saucer with the dry cotton wool in it is the 'control' experiment.

The notion of a 'fair test' or control experiment is an important one, but devising suitable controls for experiments is difficult for many primary school students, and indeed many secondary school students and some university students. However, young children do have a well-developed sense of fairness, and this is a necessary stage in the development of an understanding of the need for controlled experiments. If, for example, we try to see which of two snails can move fastest over a sheet of paper, we may soon be rebuked by the student who points out quite rightly. 'That's not fair, this snail is bigger than that one!' We should, whenever possible, encourage students to see that their experiments are 'fair' and that they can identify the variables involved.

All experiments 'work', although not always in the way we expect them to. When experiments fail to produce expected results, it is sometimes because the hypothesis being tested needs to be thought out again, or because the experiment itself may be badly designed. Deciding which is the case is a matter of experience, but also provides a golden opportunity for more scientific thought and experimentation.

Another possible cause of difficulty is that sooner or later a student will ask a question to which the teacher does not know the answer. Teachers who are unsure about areas of science are then placed in a situation where their areas of greatest insecurity may well be called upon by the students without warning.

What the teacher and students together can do is to set about finding the answer, by experiment if possible, with the aid of reference books or the Internet or, if all else fails, by asking someone more knowledgeable. If the teacher can approach the finding out by experiment without any preconceived ideas, then the experience will be very valuable for both teacher and taught. This is definitely one situation where the clear-thinking, 'non-scientist' teacher has a distinct advantage.

Sometimes it will be necessary for a primary school student to be told, tactfully, that the answer to a question is quite simply too difficult for him or her to understand at present.

Active learning

Students learn most effectively through 'doing' and being actively involved. This is what this Teacher's Guide, and the student's books that make up *Simply Science*, hope to encourage.

It should be emphasized that, all the way through, it is important that the students have understood the activity or problem that has been set before they begin any practical work. It is also important to remember that students learn not only by doing but also by thinking and talking about what they have done. Students learn by fitting their latest activity or discovery into their existing pattern of experience, and thus continue to develop and refine the ideas they are already forming about the world in which they live. Quality learning, with time to think out theories, develop ideas and talk them through, is very difficult to achieve in a busy classroom, with all the pressures on the teacher's time and attention.

Lesson objectives

- To show how the skeleton is related to movement, support and protection in humans
- To demonstrate what happens to the skeleton and muscles as a human being moves
- To compare human bones and skeletons with those of other vertebrate and invertebrate animals
- To show the effects of exercise on muscles

Background information

Human beings have an internal skeleton made up of more than 200 bones. The skeleton supports and protects the body and allows free movement. At the same time it allows the body to grow normally. Mammals, birds, reptiles, amphibians, and fish all have internal skeletons.

The bones in the skeleton have a number of other functions. They protect delicate organs of the body and provide an attachment for muscles. Some bones store minerals and manufacture red blood cells. The bones also give shape to the body and hold it upright.

Joints

Different parts of the body need to move in different ways and this is brought about with the help of joints. A joint is a place where two or more bones meet. Some joints, such as the knee or elbow joints, allow movement in one direction only. This is called a hinge joint. A ball and socket joint, as in the joint between the thigh bone and the hip, can move in all directions. There are some places in the body where bones meet but there is no movement at all, as in the bones of the skull and pelvis. These are called immovable joints.

Because the bones in joints are involved in movement, there is a danger that the ends of the bones will rub against each other. To protect the ends of the bones, so that they do not wear away, they are covered with a thin layer of very tough material called cartilage. Cartilage, or gristle, also makes up the ears and the flexible tip of the nose. A joint also contains a lubricating fluid. Individual bones are held together by strong cords called ligaments.
The top of the skull has immovable joints. It consists of bones with toothed edges locked together. In young babies the edges of the bones of the skull are not joined, so that the brain can grow inside the skull. The bones only become immovable when this growth is complete.

Muscles and movement

Movement of the joints of the skeleton is brought about by muscles. There are roughly 650 different muscles in the human body. The ends of the muscles are attached to bones by tough cords called tendons. The tendons are very prominent behind the knees, and on the backs of the hands and tops of the feet. There is also one very large tendon in the back of each ankle, known as the Achilles tendon. When tendons are pulled by muscles, the movement of bones takes place at the joints.

The muscles of the upper arm give a good illustration of how muscles work. There are two main muscles in the upper arm, the biceps and triceps. If you clench your fist and bend your elbow to raise the forearm, you will see (and feel) the biceps muscle changing shape; it becomes shorter and fatter, or contracts. At the same time, the triceps muscle, on the back of the upper arm, becomes longer and thinner, or relaxes.

Since muscles are flexible structures (the ‘lean’ of a joint of meat is muscle), the only way for the raised arm to be lowered again is for the triceps muscle to shorten or contract. Thus the raising and lowering of the arm depends upon two muscles. Muscles can only shorten, or contract, to pull bones. Muscles cannot push.

The arrangement of muscles throughout the body follows this basic rule. Wherever there is a muscle, there is another muscle that works against it. Muscles always work in pairs. When someone smiles, one set of muscles pulls the mouth into the smile and another set pulls the mouth back into its relaxed shape again. All muscle contraction needs energy and so uses up food and oxygen. Muscles are well provided with blood vessels to provide this food and oxygen and to take away the waste products muscle action produces.

Safety

It almost goes without saying that great care and sensitivity is needed in any work where children compare themselves, their bodies and their physical capabilities.

Answers

Skeletons: **Rapid Ïre, p 3**

1) A skeleton supports our body, protects certain delicate parts of it, and provides attachment for muscles, allowing movement by way of joints. In addition, the marrow in the larger bones forms new red blood cells.
2) Tubes, usually made of aluminium or steel are used for television aerials, scaffolding poles and bicycle frames. The handles of some garden tools also consist of metal tubes.
3) a) 2 b) jaw bone c) thigh bone d) knee cap e) X-rays f) marrow—helps to make blood

Skeletons: **Try it out, p 3**

1) Taller children do not always have longer legs or arms.
3) The holes and cavities in bones show where blood vessels and nerves pass into the bone and where tendons and muscles are attached. The cavities at the ends of bones are part of the joints between the bones.

More skeletons: **Rapid Ïre, p 5**

1) The skeletons are those of a dog, a pigeon and a rat. They mainly differ from our own skeleton by being smaller and, in the case of the dog and rat, the backbone is extended into a tail. Both of these animals walk on four legs, while the fore-limbs of the pigeon are used as wings. The shape of the teeth and skull in the dog and rat differ from ours, while the pigeon has a beak.
2) The body of a whale is so large that it needs the support of the water to stop its internal organs from being crushed by the sheer weight of its body.
3) An elephant has a backbone made up of very large and strong vertebrae. Its leg bones are also very large and strong to support its great weight.

More skeletons: **Try it out, p 5**

3) The five groups of vertebrates all have an internal skeleton with a backbone and skull.

Animals without backbones: **Rapid Ïre, p 7**

1) Animals with a hard shell on the outside of their bodies include snails, clams, oysters, mussels and other shellfish, crabs, lobsters, crayfish, sea urchins and scorpions. A tortoise is not an invertebrate because, although it has an external shell, it also has an internal skeleton with a backbone.
2) The shell is that of a sea animal called Nautilus. Its body is arranged in a spiral to fit inside the shell.

3) Vertebrates: human, dog, snake, turtle, eel, frog, eagle, salmon and shark.
   Invertebrates: snail, worm, wasp, slug, caterpillar, maggot, beetle, jellyfish and octopus.

Animals without backbones: **Try it out, p 7**

1) There are many more invertebrates in the world than vertebrates.
2) An earthworm moves through the soil by extending its body and gripping the soil at the front end with the tiny bristles on each of its segments. It then draws up the rear half of its body, anchors itself with its bristles and then extends its body forwards again.
3) A snail makes its own movement easier by secreting a ribbon of slime underneath its body, over which it moves.

Muscles: **Rapid Ïre, p 9**

1) a) Muscles work by contracting (becoming shorter) and pulling on bones or some other part of the body.
   b) The wings of a bird or insect are moved by muscles.
   c) An earthworm has two sets of muscles, one set running along the length of the body, and the other set running around each of the segments that make up the worm's body.
   d) A human has roughly 650 muscles.
   e) The largest muscle in the human body is in the buttocks.
   f) Muscles you do not have to think about are called involuntary muscles.
   g) The strongest muscle in the human body is one of the jaw muscles that is used for biting the food.
   h) The heart is made of involuntary muscle.

Muscles: **Try it out, p 9**

2) The muscle of meat is red because it is well supplied with blood vessels and blood.
3) The muscles which raise the ribs are located between the pairs of ribs on either side of the chest.

Muscles, joints and movement: **Rapid Ïre, p 11**

1) A string puppet works in a similar way to our bones and muscles because the strings pull on the 'bones', moving them at joints. Because the strings are soft and flexible, like muscles, one string is needed to move a part of the body and a second string to pull it back to its original position. However, the strings do not contract on their own, but have to be pulled by a human operator.
2) Muscles are soft and flexible, and so they cannot push but can only pull. As a result, one muscle is needed to move a part of the body and another is needed to return the part of the body to its original position.
3) The muscles we cannot control (involuntary muscles) include those of the heart and those which push the food through the intestines.

Muscles, joints and movement: **Try it out, p 11**

1) There are a large number of joints in the body, besides the obvious ones. The joints in the pelvis and skull are fused together so that they do not move, apart from the hinged jaw joint. There are 19 moveable joints in each hand, not counting the ones in the wrist.
2) The 'muscle' at the front of the upper arm shortens to pull up the lower arm. The 'muscle' at the back of the upper arm shortens to straighten the lower arm again.
   The 'muscle' at the front of the neck shortens to pull the head down, while the 'muscle' at the back of the neck shortens to pull the head up again.

3) a) It is the muscles in your upper back which contract to hold your arm up straight above your head.
   b) The muscle at the front of your upper arm contracts to lift a ball while bending the arm at the elbow.
   c) The thigh muscles contract when we stand on tiptoe while keeping the lower leg straight.

Muscle power: **Rapid Ïre, p 13**

1) You feel hot when you have been exercising because your muscles have been contracting and relaxing and producing heat as they use oxygen to burn up dissolved food to produce energy. You feel out of breath because, to burn up the food, the muscles need extra oxygen carried to them from the lungs by the blood.
2) Exercise strengthens the muscles, particularly those of the heart and respiratory system. It increases stamina, fitness, suppleness and flexibility. It also burns up surplus food that might otherwise turn to fat.
   You need to rest in order to prepare your body for more activity, your muscles can then relax and recover, your heartbeat and breathing can slow down. You also need time to think and plan. When you are asleep, a special kind of rest, your body can relax, grow and repair itself.
3) Activities which use a lot of energy include cycling, running, playing ball games, swimming and doing gymnastics.
   Activities which use little energy include reading, watching TV, playing computer and board games, and listening to music.

Muscle power: **Try it out, p 13**

2) One way to compare the strength of the arm muscles is to see who can push hardest on bathroom scales.
3) The muscle which contracts to bend the leg at the knee is the muscle at the back of the thigh. The muscle at the front of the thigh contracts to pull the leg straight again.

Going further

Discuss with the students the various ways in which we move. Emphasize that some of our movements are very small, such as when we breathe in and out. Other movements are large when, for example, we run or jump. Point out that we mostly move around on two legs, unlike many other animals, some of which have many legs.

Ask the students to describe the ways in which animals move. Make a list of words which describe animal movements, such as ‘crawl’, ‘hop’, ‘run’, ‘fly’, ‘gallop’, ‘trot’, ‘slide’, ‘swim’, ‘dive’, and so on. Discuss why animals need to move from place to place including to find food, to escape enemies and to find a mate.

Play ‘Simon says’ (run, jump, hop, skip, walk and so on). The students should obey the instruction only if ‘Simon says’ they are to do so. Extend this activity to involve the parts of the skeleton, e.g. Simon says touch your patella (kneecap). It may be useful for the teacher to consistently get the parts of the skeleton wrong, to discourage the students from copying his or her movements.

Ask students to bend over and gently feel the bones of their spine with their fingertips. Can they follow these bones, called vertebrae, from the neck down to the waist?

Discuss whether stronger people have more muscles. (They do not, they just have more highly developed muscles. Exercising a muscle makes it stronger, while not using it allows it to become weaker. We all have muscles than can make our ears ‘waggle’, but because most of us do not exercise these muscles, they are weak and ineffective.)

Ask the students to place one hand, palm up, under their desk and to push up fairly hard. They will feel how the muscle at the front of the arm (the biceps) is hard and contracted, while the muscle at the back of the arm (the triceps) is softer and relaxed. Now ask them to place one hand on top of the desk and push down. The biceps will now be soft and relaxed, while the triceps is hard and contracted.

How many times can students squeeze a clothes peg in half a minute? Without resting, try the test two or three times again. Do they find that the muscles get tired? Can they improve their skills at this game with practice?

Ask the students to press their fingers gently against their head, just above and in front of the ear, and then to move their lower jaw. They will be able to feel their jaw muscles contracting and relaxing. These muscles are attached high up on the skull to allow maximum movement of the jaw.

Ask students to cut out a shape of the human body and remove the head and limbs. Reattach them with paper fasteners to make an articulated human figure that demonstrates the importance of joints.

Ask the students to work their way around their bodies, moving one joint at a time. Can they decide how each joint moves? Does it move in one plane, like the joints in the knee and elbow—a hinge joint? Or is their movement in many directions, as at the shoulder and hips—a ball-and-socket joint?

Students should ask a friend to tape their thumb and first finger together gently. Now see how difficult it is to open an exercise book, pick up a pen and write.

1. Moving about

What you need:

- pencil

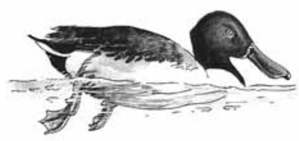
What you do:

Look at the animals in these pictures.
In the space below the pictures draw up a chart that shows the animals' names and how each of them is moving.
Then think of some more animals to add to your chart.







2. The skeleton

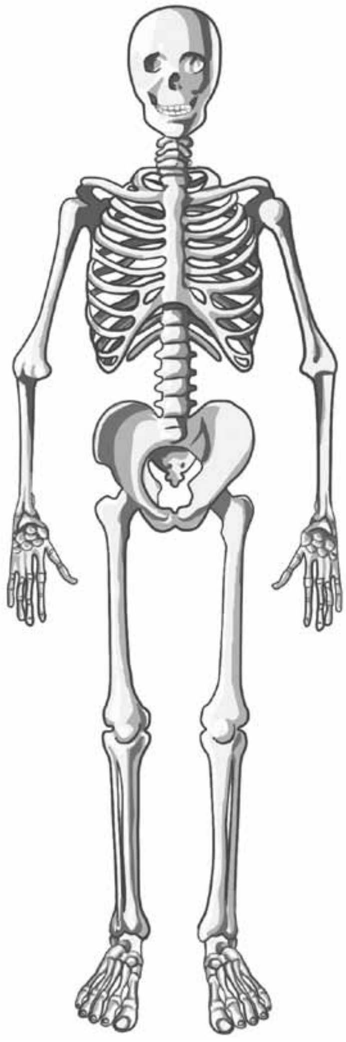
What you need:

- pencil
- tape measure or ruler and piece of string

Work with a friend

What you do:

Look at this drawing of a human skeleton.
Draw a line from the name of each part to its position on the skeleton.



Work with a friend. Measure the length of some of the bones on your skeleton. Make a table of your results. Compare your measurements with those of your friend.

Which THREE important functions does the skeleton have in the human body?
Tick THREE boxes.

protection	☐	health	☐	comfort	☐
support	☐	movement	☐	speed	☐

3. Walking and standing

When we walk or stand, which parts of our feet touch the ground?

What you need:

- pencil
- sheet of black paper
- sheet of white paper
- talcum powder

What you do:

Lightly sprinkle some talcum powder over the sheet of white paper.
Take off your shoe and sock and press the bottom of your foot on to the talcum powder.
Now press that foot on to the sheet of black paper.

Look at the footprint.
Which parts of your foot press down on the ground?

____

Are all footprints the same?

____

What do the footprints tell us about shoes? Why do you think the bottoms of shoes are not completely flat?

____

____

____

4. Which joints do you use?

What you need:

- pencil

What you do:

Make each of these movements. Think carefully about which joints you move for each one. Put a tick in the correct column of the table.

Which joint?	write	talk	walk	run	jump	crawl	kneel	nod	wave
jaw									
neck									
shoulder									
elbow									
wrist									
finger									
hip									
knee									
ankle									
toe									

Which joint do you use most? ____

____

Which joints do you use least? ____

____

5. Muscle movements

There are hundreds of muscles in your body. They make parts of your body move. Some of your muscles only move when you want them to. They are called *voluntary muscles.* Other muscles move without you having to think about them. They are called *involuntary muscles.*

What you need:

- pencil

What you do:

Think about the muscles in the boxes below.

Sort them into two groups: voluntary and involuntary muscles.

Make a table of your two groups.

muscles which move your fingers	muscles which move your hands
muscles which make your heart beat	muscles which move your legs
muscles which move your arms	muscles which blink your eyes
muscles which mix up the food in your stomach	muscles which squeeze food through your intestines
muscles which move your eyeballs	muscles which move your jaws
muscles which let you kick a ball	muscles which move your tongue

Which of these sets of muscles is the odd one out? ______________________________

____

Say why ____

____

____

____

6. How hard can you push?

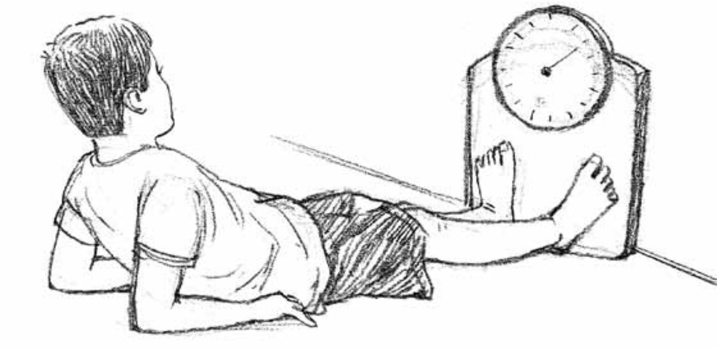
What you need:

- pencil
- bathroom scales

Work with a friend.

What you do:

Stand the bathroom scales against a wall.
Lie down on the floor and put one foot against the scales. Push as hard as you can.
Ask your friend to read the scales while you are pushing them.
How hard can you push?
Repeat the experiment with the other foot. With which foot did you press the hardest?
Now do it with both feet.



Let your friend have a turn. Who pushed hardest with the left foot, right foot and with both feet?
Now see who can push hardest with the left hand, right hand and both hands.

Do these activities again but see which muscles are being used in pushing. These muscles will feel hard.

Notes on individual worksheets

1. Moving about

Key idea — *To show the variety of methods of moving used by members of the animal kingdom.*

Outcome — *The most likely sub-divisions of the methods of moving of the animals in the pictures are:*
Swim: Ïsh, dolphin and duck.
Walk: man and possibly spider.
Crawl: baby and possibly spider and snake.
Climb: squirrel.
Fly: dragonÌy and bat.
The children may decide that the snake is slithering or sliding, rather than crawling.

Extension — *Repeat this exercise using only invertebrate animals (animals without internal skeletons and backbones).*

2. The skeleton

Key idea — *To be able to name the main bones of the human skeleton.*

Outcome — *Three important functions of the skeleton are protection, movement and support.*

Extension — *Discuss why an internal skeleton is better than an external skeleton (mainly because it allows growth to occur gradually, without the need to shed the external skeleton periodically, and because it is relatively light and allows greater Ìexibility of movement).*

3. Walking and standing

Key idea — *Only part of each foot touches the ground when we stand or walk.*

Outcome — *Unless a child is severely Ìat-footed, only a part of the foot usually touches the ground, usually the tips of the toes, the ball of the foot and the heel. Shoes are not completely Ìat so that they can support the heels and arches of the feet.*

Extension — *Make plaster casts of animal footprints.*

Safety — *In view of the dangers of spreading athlete„s foot, ensure that each child has a clean sheet of white and black paper. Powdered chalk can be used instead of talcum powder.*

4. Which joints do you use?

Key idea — *To investigate some of the joints we use in carrying out familiar movements.*

Outcome — *There will be some variation in the results of this activity. For example, some people nod their head while they are talking. Nevertheless the likely answers are: writingflwrist and Ïnger; talking fljaw; walkingflhip, knee, ankle and toe; runningflhip, knee, ankle, toe, shoulder and elbow; jumpingflhip, knee, ankle, toe, shoulder, elbow and possibly wrist; crawlflshoulder, elbow, wrist, hand, hip and knee; kneelflknee; nodflneck; waveflshoulder, elbow and wrist.*

Extension — *Try to perform some of these movements without bending the joints listed in the table.*

5. Muscle movements

Key idea — *To distinguish between voluntary and involuntary muscles.*

Outcome — *The voluntary muscles are the muscles which move your Ïngers, hands, legs, arms, eyeballs, jaws, and tongue and let you kick a ball.*
The involuntary muscles are the muscles which make your heart beat, mix up the food in your stomach, and squeeze food through your intestines.

The muscles which are the odd ones out are the muscles which blink your eyes. You can deliberately blink your eye or, if someone waves something towards your face, you can carry out the reÌex (or involuntary) action of blinking.

Extension *Use a small plastic funnel and a piece of rubber or plastic tubing to make a model stethoscope with which to listen to the heart beating.*

6. How hard can you push?

Key ideas *We push with the help of our muscles and people differ in their degree of physical strength.*

Extension *Can you Ïnd a way of discovering who has the strongest grip?*

Lesson objectives

- To introduce some of the differences between solids and liquids, and to show that the same substance can exist as both solid and liquid; to show how liquids are measured
- To demonstrate the relationship between melting and freezing and to show that melting and dissolving are different
- To show the changes that occur when solids and liquids are mixed and how to reverse these changes

Background information

Solids, liquids and gases

Materials may be solids, liquids or gases. Water is a liquid, but if it is cooled to below 0^0C it freezes and forms ice, a solid. And if water is heated to 100^0C, it boils and changes to water vapour or steam, a gas. We say that, in both instances, the water has changed its state.

Water can evaporate and turn into water vapour at any temperature above freezing point, as we can see when a puddle begins to dry up on a fairly cold day. The rate of evaporation is temperature dependent.

As with water, any material's state depends on its temperature. Solids may turn to liquids and gases and then back to solids again, as the temperature rises and falls. The change in state can be explained by how closely the tiny particles, atoms or molecules, which make up the material are packed together and by the extent of their movement. Both of these properties are a result of the amount of heat energy the material contains. In the case of water, ice is a solid because the molecules are held tightly together and can only vibrate about a fixed point. When the molecules are close together they attract one another, and considerable energy is needed to push them apart. Ice, a solid, has a fixed shape. When you heat a solid, the heat gives the particles energy. They start vibrating a lot and move away from each other. If ice is warmed it melts and turns to water. The water molecules can move, and are no longer arranged in a regular pattern. The shape of the water depends on the shape of the container. If water is heated still further it changes to water vapour. The molecules now move fast and freely in all directions, spreading further apart until they fill the room or whatever is confining them. The more heat energy the water vapour contains, the more frequent and powerful are the collisions the molecules make with the walls of the container. That is why heating a gas increases its pressure.

We usually see metals such as gold in their solid state, but if gold is heated in a strong flame it becomes softer and if it is heated to a high enough temperature, it suddenly melts and becomes a liquid. The liquid gold can then be shaped by pouring it into a mould. Once the molten gold cools, it changes back to a solid. If liquid gold is heated strongly enough it will form a gas.

Solutions

A teaspoon of salt seems to disappear in a glass of water, although a sip of the liquid tells us that the salt is still there.

What has happened, in simple terms, is that when the salt dissolves in the water, the small water molecules get between the slightly larger particles of which salt is composed, forcing them apart. The salt particles and water molecules mix to form a solution, and we say the salt has dissolved. The liquid which does the dissolving, in this case water, is called the solvent while the substance dissolved, the salt, is called the solute.

Many solutes dissolve in water and thus water is a good solvent, although there are many other solvents. Gloss paint, for example, dissolves in white spirit.

The amount of solute that will dissolve in a solvent depends on a number of things, not least the amount of solvent. The greater the volume of solvent the more solute it will dissolve. Temperature is also important.

The higher the temperature of the solvent, the more solute it will usually be able to dissolve. Solutes are not always solids. Fizzy drinks, for example, consist of carbon dioxide gas dissolved in flavoured water.

Separating substances

There are many mixtures of chemicals in the world. The air is a mixture of gases and dust; sea water is a mixture of chemicals—mainly salt—in water and is thus a gigantic salt solution. Sometimes we need to separate these chemicals from each other.

One way of separating substances is to use a filter. A face mask is really a type of filter. It is made of a material which is full of tiny holes. The microscopically small molecules of gases in the air can pass through these holes, but the larger particles of, say, dust and paint are too big and are trapped on the outside of the mask.

An insoluble solid, such as finely powdered chalk, in a liquid such as water forms what is called a suspension. It should separate after being left to stand for a long time, when the water above the chalk can be carefully decanted off. Alternatively, the insoluble material can be separated from the liquid by filtration. This is done by pouring the mixture through a filter paper held in a funnel. The chalk powder or other insoluble substance remains in the filter paper while the clear liquid (known as the filtrate) passes through it. On an industrial scale, a filter press or a rotary filter is used.

A filter would not help to separate a dissolved substance, such as salt, from a solution. The salt molecules and the water molecules which form a salt solution are small enough to pass through the holes of any filter. But if the solution is warmed, the water evaporates quickly and eventually only salt is left behind. Two liquids can be separated by distillation. This involves heating the solution. The liquid with the lowest boiling point evaporates first. This vapour is condensed and thereby separated from the mixture. The components of crude oil, including petrol, diesel oil and jet fuel, are separated by a process called fractional distillation, in which the different liquids vaporize at different temperatures. The vapours are then separated and cooled, producing the desired liquids.

Chromatography

Very similar substances, which are difficult to separate chemically, such as plant pigments, can sometimes be separated by using a technique known as chromatography. In a laboratory, a solution of the mixed substance is passed through a column of absorbent material. More usually in the primary school, a piece of absorbent material, such as blotting paper, filter paper, paper towelling, or even blackboard chalk, has the material dripped on to it or is dipped into the solution. The substances move through the material at different speeds, and so form a series of coloured bands.

Safety

Students should not touch ice immediately after it has been taken out of a freezer.
Take great care with hot water or steam.
The students should be warned not to invent their own experiments unless a responsible adult is present to supervise.

Answers

Grouping materials: **Rapid Ïre, p 15**

1) Plant: rubber tyre (although much rubber is now made from oil (rocks/minerals), chocolate bar, pencil (the ‘lead’ is made from rocks/minerals).

   Animal: leather belt (the metal buckle is made from rocks/minerals).

   Rocks/minerals: screw, pottery vase, glass marble.

2) A scientist would probably examine a new material to see whether it was a solid, liquid or gas, whether it was strong or weak, hard or soft, transparent, translucent or opaque, whether or not it was waterproof, and whether or not it conducted electricity or heat.
3) Strong materials include iron, steel and most metals, carbon fibre and some plastics, and most rocks. Soft materials include wool, cotton, cotton wool, duck down, and many man-made fabrics. Some kinds of materials such as nylon are both strong and soft.

Grouping materials: **Try it out, p 15**
2) The easiest way to compare the strength of samples of threads of different kinds would be to suspend identical lengths of each from hooks. Weights could be hung, one at a time, from the bottom of them to see what weight is needed to break each of them.

Solids and liquids: **Rapid Ïre, p 17**
1) Everyday solids include bread, butter, margarine, sugar, salt, sand, soil, rocks, metals, wood, plastics, glass, and objects made from these materials.
   Everyday liquids include water, milk, petrol, oil, cooking oil and vinegar.
2) Solids have strength and a fixed shape. They can be cut and shaped. Liquids flow, they can be poured, and they have no fixed shape but take up the shape of the container into which they are poured.
3) a) solid b) solid c) liquid d) liquid e) solid f) solid g) liquid

Solids and liquids: **Try it out, p 17**
1) One method would be to cut a plastic bottle in half lengthwise and rest one end of each half on a book. Equal amounts of the two liquids could be poured at the same time, one into the top of each half of the bottle. It would then be possible to see which liquid reached the bottom of the slope first.
2) Bigger solids do not always weigh more—think of a sponge or expanded polystyrene!

Measuring liquids: **Rapid Ïre, p 19**
1) The volume of a solid, such as a brick, can be measured by multiplying the length, width and height. The volume of a liquid is measured by pouring it into a measuring cylinder of the appropriate size.
2) It would be very difficult to measure the volume of a gas because it has no fixed shape and can easily spread out to fill a large container or be compressed to fill a smaller container.
3) The three main liquids used in a car are water (for cooling), oil (for lubrication), and petrol (as a fuel). The water comes ultimately from rain, whereas the oil and petrol are refined from crude oil which comes from the Earth's crust. It is particularly important that we measure the volumes of oil and petrol carefully because they are expensive, non-renewable, and obtaining them damages the Earth. When oil and petrol are used they can also pollute the Earth and its atmosphere.

Measuring liquids: **Try it out, p 19**
2) The meniscus is always flat but curves up slightly where it touches the edges of the container.
3) Solutions, such as sugar or salt in water, also form a meniscus.

Melting and freezing: **Try it out, p 21**
1) The easiest way to make a jelly set more quickly would be to cool the solution, ideally in a refrigerator or freezer.
2) Tap water normally freezes before salty water.
3) Metals are soldered by using a molten metal (solder) to form joints. Soldering is used mainly to join wires in electrical circuits. It is carried out at quite low temperatures so the joints are not strong. In welding, the

edges of the metal parts to be joined are softened by heating them to very high temperatures. Molten metal is then added to the joint. This bonds with the softened metal and produces a strong joint when it cools. Welding can be used to join large pieces of metal, such as components of a ship's hull or a pipeline for oil or gas.

Mixing materials: **Rapid Ïre, p 23**

1) a) True: a), c), f) and g). False: b), d), and e).
2) Solids that dissolve in water include sugar, salt, instant coffee, washing soda, bicarbonate of soda and soap. Solids that are insoluble in water include sand, chalk, soil, cork, metals, plastics and glass.
3) Although water may look clean it could contain harmful bacteria (or germs) that are too small to see without a microscope.

Mixing materials: **Try it out, p 23**

1) To make sugar cubes dissolve faster in water one could crush the sugar cubes, stir the mixture, or raise the temperature of the water.
2) Coffee granules do dissolve better in hot water than cold water. This could be proved by having two cups, one containing hot water and the other an identical volume of cold water. Measured amounts of coffee granules could be added slowly to each until no more dissolves.
3) When oil and water are mixed, the oil floats on the surface of the water because it is less dense (lighter) than water.

Separating mixtures: **Rapid Ïre, p 25**

1) Insoluble tea leaves and water, or sand and water, could be separated using a filter. Salt and sugar cannot be separated from water by filtration because they are soluble and their molecules ('particles') are small enough to pass through a filter.
2) The liquid coming through the filter paper was brown because some of the constituents of the tea leaves had dissolved in the hot water.
3) The white chalky substance in a kettle has come from the tap water and has precipitated out when the water was boiled.

Separating mixtures: **Try it out, p 25**

1) Shake up the mixture of salt and sand with water. Pour the mixture through a filter paper in a funnel where the insoluble sand will be left in the filter paper. Leave the clear liquid (the filtrate) to evaporate in a saucer near a sunny window sill where the salt will be left.
3) The cork will float on the water and can be spooned off the surface of the water. If the water is carefully poured away (decanted), the sand will be left at the bottom of the jar.

Going further

Ask students to examine the clothes they wear. Try to find out which of the materials came from plants and which came from animals. Which clothes are made of artificial or man-made materials? Make lists or a table of all three kinds of clothing.

Ask sudents to draw a bottle of milk or fizzy drink. Label the drawing. Use the words 'solid', 'liquid' and 'gas' in the labels.

Ask students to make a list of all the solids and liquids they use in one day. Can any of the solids be changed into liquids easily? (ice, butter, margarine, lard and chocolate or ice cream melt easily.)

Can the students think of any other way of separating an insoluble substance from a liquid, apart from filtering? (The two main methods would be to use a sieve if the particles of the substance were large enough, or to let the insoluble substance settle out at the bottom of the liquid and then decant off the liquid, leaving the solid behind.)

Is there anything dissolved in rainwater? Let rain fall onto a sheet of clean glass or Perspex. Let it dry. Observe the smear that is left on the glass or Perspex. This is made from substances (mainly pollutants) that dissolved in the rainwater as it fell through the air.

In some countries there is a shortage of fresh drinking water, but there is often plenty of sea water. It is not possible to get the salt out of sea water by filtering. How could fresh water be obtained from sea water? Why is this not done very often? (Fresh water can be obtained from sea water by distillation, but the process is expensive and can be used only in those countries which have a ready supply of cheap oil to use as a fuel.)

Many students confuse dissolving with melting. Let a wax candle melt and drip into a bowl or dish of cold water. What happens? Does the wax dissolve? (In fact, the molten wax does not dissolve, it simply solidifies as it touches the cold water.)

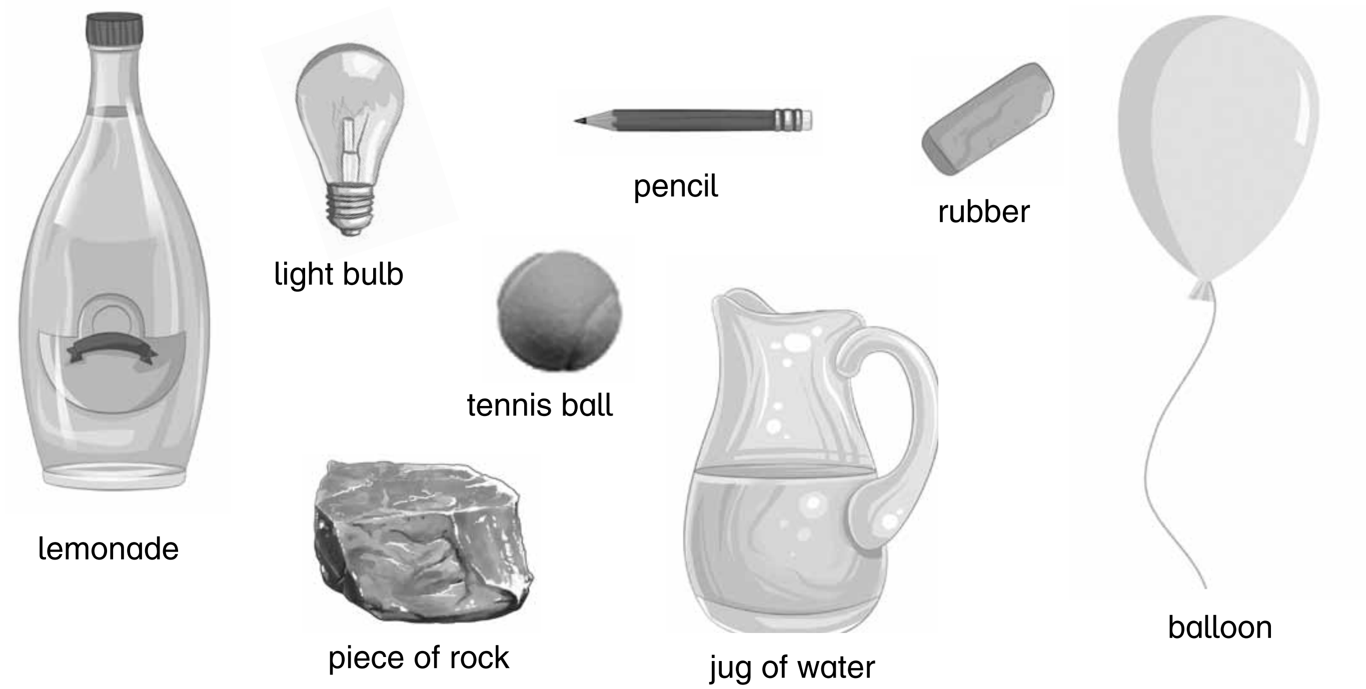
1. What state is this?

What you need:

- pencil

What to do:

Look at the pictures.



a) Which of the pictures show objects which are solid all through?

____

b) Which pictures show containers of gases?

____

c) Which pictures show containers of liquids?

____

Read the sentences below. After each sentence, write down whether you think it is about SOLIDS, LIQUIDS or GASES.

1. They flow to take the same shape as the bottom of their container. ____________
2. They can melt when heated. ____________
3. They stay the same shape and do not pour. ____________
4. These substances spread out until they fill their container. ____________
5. They are often invisible. ____________
6. Oxygen, carbon dioxide, nitrogen and helium are examples of these. ____________
7. Milk and vinegar belong to this group. ____________
8. Iron, clay and wood are examples of these. ____________

2. Melting and dissolving

Melting and dissolving are two important processes in science. Do you know the difference between them?

What you need:

- pencil

What you do:

Write the word MELTING or DISSOLVING at the end of each of the following sentences.

1. Ice cream becoming soft and runny. ____________________
2. Salt being mixed with water. ____________________
3. A snowman disappearing. ____________________
4. Solid wax changing to a liquid. ____________________
5. Gold being heated and poured into a mould. ____________________
6. Jelly being mixed with hot water. ____________________
7. Instant coffee powder being mixed with hot water.____________________
8. Ice changing to water. ____________
9. Sugar being mixed with water. ____________
10. Margarine put into a hot pan. ____________
11. A chocolate bar becoming soft on a hot day. ____________
12. Sugar being put into hot tea. ____________

Some of these changes are reversible, which means the materials can be returned to how they were originally. Which of the changes below are reversible? Write a letter ‘R’ against the changes that are reversible.

a) Burning a match ____________
b) Water changing to water vapour ____________
c) Boiling an egg ____________
d) Candle wax burning ____________
e) Candle wax melting ____________
f) Bread being made into toast ____________

3. Dissolving things

Which substances will dissolve in water?

What you need:

- pencil
- instant coffee, sugar, salt, cocoa, mustard, starch, flour, jelly cubes, sand, tea, toothpaste, soap flakes
- a clean, transparent plastic jar
- plastic teaspoon
- water

Ask a grown-up to help.

What you do:

Half fill the jar with water and add a little coffee.

Stir it with the spoon. Does any dissolve? Leave the jar to stand for a while. What happens?

____

Now try each of the other substances in turn, using clean water and a clean spoon.

Which substances dissolve a little? ______________________

Which substances dissolve a lot? ______________________

Which substances do not dissolve at all? ______________________

Do the experiment again using hot water. Do you get the same results?

____

Do you think the experiment is fair? What could you do to make it fairer?

____

4. Filtering

What you need:

- pencil
- funnel
- three see-through plastic jars
- coffee filter papers
- water
- sand, salt, gravel, sugar, flour, powdered chalk, sawdust

What you do:

Mix some sand and water in a jar. Let it stand until the sand and water separate.

In another jar, mix more sand and water. Slowly and carefully pour the mixture into a filter like the one in the picture.

The sand will stay in the filter paper, while the water passes through.

Now mix the other substances with water, one at a time.

Which of them can be separated using a filter?

Complete this table:

Mixture	Can the mixture be separated with a filter?
water and sand	
water and salt	
water and gravel	
water and sugar	
water and flour	
water and chalk	
water and sawdust	

Which kind of substances can be separated with a filter?

____

5. What will be left?

What you need:

- pencil
- salt, sugar, flour, coloured ink, soil, lemon juice, water
- small plastic jars
- clean saucers
- plastic spoon

What you do:

Make up the solutions as given in the table.
Leave them in saucers on a warm window sill or shelf.
Label each saucer saying what it contains.
Fill in the table. Say what you think will be left in each saucer after all the water has evaporated.
Wait to see if you were right.

Solution	What I think will be left	What was left after evaporation
Salt and water		
Sugar and water		
Soil and water		
Flour and water		
Coloured ink and water		
Lemon juice and water		

6. Changing states

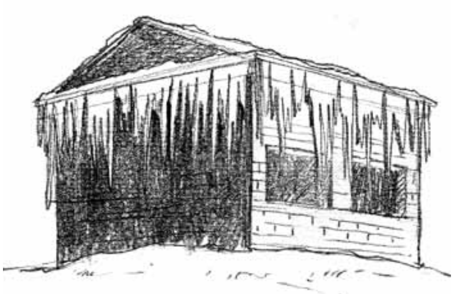
What you need:

- pencil

What you do:

Choose the correct word from the ones listed below to show the changes taking place in each of the pictures. You may have to use some words more than once.

Freezing **Evaporating** **Melting** **Condensing**



7. A separation machine

Pretend you are looking after your uncle's shop when you accidentally mix up the pasta and rice. You need to separate the two solids quickly before the first customers arrive. You have only the equipment listed below from which to make a machine to separate the two foods.

What you need:

- pencil
- 50g pasta
- 50g rice
- piece of card
- 30 cm of string
- paper clip
- sticky tape

What you do:

Draw your machine here:

Explain how your machine works:

Notes on individual worksheets

1. What state is this?

Key idea *To examine the differences between the three states of matter: solid, liquid and gas.*

Outcome *a) pencil; rubber; piece of rock*
b) light bulb; balloon; tennis ball
c) kettle of water; bottle of lemonade
1 and 7 are liquids; 2, 3 and 8 are solids; 4, 5, 6 are gases.

Extension *Look around your home. How many solids and liquids can you Ïnd? Make lists of them. (Adult consent and supervision required.)*

2. Melting and dissolving

Key idea *To show the differences between melting and dissolving and between reversible and irreversible reactions.*

Outcome *Meltingfl1, 3, 4, 5, 8, 10 and 11. Dissolvingfl2, 6, 7, 9, 12.*
The only reversible changes are b) water changing to water vapour and e) candle wax melting.

Extension *Write a sentence or two to explain to an interested younger brother or sister the difference between melting and dissolving.*

3. Dissolving things

Key idea *Some substances dissolve completely in water, others partially, while some are insoluble.*

Outcome *Sugar, salt, instant coffee, soap Ìakes and toothpaste dissolve fairly readily in cold water. Cocoa, mustard, starch, Ìour, jelly cube and tea dissolve to a small extent. All of these substances dissolve more readily in hot water. Sand is insoluble.*

Extension *Discuss why it is we can pour sand, sugar or salt even though they are not liquids.*

Safety *The children should be warned against experimenting with dissolving unless a responsible adult is present.*

4. Filtering

Key idea *We can use a Ïlter to separate some substances from a mixture with a liquid such as water.*

Outcome *The insoluble substances (e.g. sand, gravel, Ìour, chalk and sawdust) can be separated from water by Ïltering. The soluble substances (e.g. sugar and salt) will pass through a Ïlter paper.*

Extension *Make your own Ïlters using a number of different materials. How good are they at cleaning dirty water?*

5. What will be left?

Key idea *A practical investigation of the residues left after various solutions have been evaporated to dryness.*

Outcome What was left after evaporation: salt and water leaves salt; sugar and water leaves sugar; soil and water leaves soil (most of the constituents of soil are insoluble); flour and water leaves flour; coloured ink and water leaves dye crystals the colour of the original ink; lemon juice and water leaves traces of yellow lemon powder.

Extension Devise a way to separate powdered cork from either sugar or salt.

6. Changing states

Key idea *An assessment activity to test the students„ knowledge and understanding of melting, freezing, evaporating and condensing.*

Outcome *a) condensing; b) melting; c) evaporating and condensing; d) freezing; e) evaporating; f) melting.*

Extension *Ask the students to make a ‚Change Word Book„ and write deÏnitions of evaporating, condensing, melting, freezing and other ‚change words„ as they meet them.*

7. A separation machine

Key idea *A practical assessment activity to assess how the students can apply their knowledge of the properties of two food substances to separate a mixture of them.*

Outcome *The simplest method would be to use the card to make a funnel with a hole at the bottom small enough to allow the grains of rice to pour through but not the larger pieces of pasta.*

Extension *Practice using sieves of different sizes to separate the components of soil or mixtures of solids such as sand and gravel.*

Lesson objectives

- To introduce the notion of temperature as a measure of how hot or cold objects are
- To demonstrate the use of thermometers and the measurement of temperature
- To measure body temperature in sickness and in health
- To show the effect of temperature on weather
- To show the use of thermal conductors in the home and classroom
- To show that thermal insulators can help to keep things warm or cool

Background information

Measuring temperature

Temperature is a measure of exactly how hot or cold something is. The first known thermometer was made by the Italian scientist Galileo. It consisted of a bottle of water with a narrow neck. People suspected of having fevers put their hands around the bottle. The warming effect of their hands caused the water to expand and rise above a certain level in the neck of the bottle if their body temperature was higher than normal. Many other kinds of thermometer have been made since that time, but most operate on the same principle as Galileo's: most matter expands when it is heated and contracts when it is cooled. This applies to solids, liquids and gases, and there are thermometers that use each of these three states of matter.

Body temperature

Your body has mechanisms to keep itself at a constant temperature. Whether the outside temperature is hot or cold, the temperature inside our bodies stays at a constant 37°C, unless we are ill. Skin helps us to maintain this constant temperature, partly with the help of the three million or so sweat glands in our skin. When we are hot, the blood vessels under the skin dilate to increase the blood flow to the surface, making the skin look redder. Then the sweat glands release droplets of sweat which make the surface of the skin wet. The sweat evaporates, turning into water vapour which escapes into the air. To evaporate, the sweat uses energy and heat is taken from our skin, so cooling it down. When we are cold, the tiny blood vessels threaded through the skin shut down to prevent the warm blood being cooled. We shiver when it is cold, thus generating heat as our muscles contract and relax.

Temperature and heat

Temperature and heat are not the same, though they are indicators relating to each other. Temperature is a measure of hotness or coldness; heat is a measure of energy. Whilst something that is hot may have a great deal of heat energy this is not always so. The converse is also true. A spark from a sparkler has a high temperature but contains little heat energy. A hot water bottle is not very hot but contains a considerable amount of heat energy. A red-hot iron bar has a high temperature and contains a great deal of heat energy.

Conductors and insulators of heat

Heat generally passes from hotter to cooler places. It travels much more quickly through conductors, such as steel, copper, and other metals, than it does through insulators which contain pockets of air, such as plastic foam, fibreglass, woollen sweaters, and string vests. Smaller objects heat up and cool down faster than larger objects made of the same substance. For this reason, a human baby or other baby animals are much more susceptible to low temperatures than adults of the same species. (This is because they have a larger surface-to-volume ratio i.e. they have a larger surface area to lose heat from, compared with their size.)

Safety

Students should not touch ice immediately after it has been taken out of a freezer. It can stick painfully to their fingers.

Take great care with hot water or steam.

Mercury thermometers (recognizable by the silver colour of the liquid inside them) are not suitable for use in primary schools because of the dangers from the toxic metal mercury if they are broken.

Answers

Measuring temperature: **Rapid Ïre, p 27**

1) The coldest object is the freezer, the hottest is the firework. The order, in terms of increasing temperature, is probably: freezer, glass of iced lemonade, goldfish bowl, boy, hot bath, bowl of hot soup, electric iron, firework.
2) A thermometer consists of a narrow closed tube with a bulb at one end. Inside the bulb is a liquid (usually alcohol or mercury) which expands and rises up the tube when it is heated, and contracts and moves down the tube when it is cooled. The level of the liquid (the temperature) can be read off against a scale.
3) If a thermometer is put in a cold place, the liquid in it will contract and move down the scale. In a warm place the liquid will expand and move further up the scale.

Measuring temperature: **Try it out, p 27**

1) To show how the temperature outside on the playground changes from day to day you would need to take the temperature at the same time each day, in exactly the same place (ideally in the shade) and use the same thermometer.
3) Temperatures in the shade are more accurate, and often lower, than those taken in the open. This is because the thermometers are not being affected directly by the heating powers of the Sun's rays.

Temperature and the weather: **Rapid Ïre, p 31**

1) Some words that describe temperature include: hot, warm, tepid, lukewarm, boiling, baking, blistering, burning, fiery, roasting, sizzling, sweltering, cool, cold, freezing, frozen, icy, chill, chilly, feverish, frosty, bleak, biting, bitter.

   Some words that describe the weather include: blustery, bright, brilliant, clear, close, cloudless, cloudy, cold, drizzly, dull, fair, fine, foggy, foul, freezing, frosty, grey, hazy, hot, icy, misty, overcast, rainy, rough, showery, snowy, stormy, sultry, sunless, sunny, sweltering, teeming, thundery, torrential, wet, windy, wintry.
2) a) In general, clouds block out the Sun's rays and so lower temperatures.
   b) It is usually warmer in the daytime than at night.
   c) Bare soil is usually warmer than ice or snow because the dark coloured soil absorbs the Sun's heat rays, whereas ice and snow reflect the Sun's rays back into the air.
   d) The lands around the Equator are warmer than the polar regions because the Sun is directly overhead at the Equator, whereas the Sun's rays have further to travel to reach the polar regions. When the Sun's rays reach the polar regions they are spread over a wide area, because of the curvature of the Earth's surface, and so do not warm the surface very much.
   e) The Sun does not warm the air directly, as most people think. Instead the Sun warms the Earth, which then warms the air above it. As you climb a mountain it becomes colder because you are moving further away from the source of the heat. In addition, high up on a mountain the wind blows strongly, quickly cooling anyone and anything in an exposed position.

3) Farmers and gardeners usually plant crops in the spring because the soil is beginning to warm up after the winter and the long, hot days are ahead, during which the plants can mature and be harvested.

Conductors of heat: **Rapid Ïre, p 33**

1) Heat travels quickly up the handle of a metal spoon from a cup of hot tea by a process called conduction. As the heat reaches the tip of the spoon, the spoon becomes too hot to hold.
2) a) conduction;
   b) heat travels from a hot object to a cold one;
   c) a brass jug feels cold if you touch it because brass is a good conductor of heat and conducts the heat away from your fingers quickly when you touch it;
   d) a woollen jumper feels warm if you touch it because wool is a poor conductor of heat (a thermal insulator) and does not conduct the heat away from your fingers.
3) An electrical conductor is usually a metal (or the non-metal graphite). It conducts or carries electricity. Cables, wires, and the metal parts of plugs and sockets are just a few of the places where electrical conductors can be seen in use.

Conductors of heat: **Try it out, p 33**

1) The good conductors of heat will be made of metal. The poor conductors of heat will be made of non-metals such as wood, plastic, paper, wool, cotton and nylon.
2) The simplest way to show that a metal knitting needle or a large nail is a good conductor of heat would be to place one end in hot water and to see how quickly the heat travels along the object to the fingers. Alternatively, one end of the nail or knitting needle could have a blob of wax fitted onto it. The other end of the nail or knitting needle could then be heated with a candle flame until the wax melted and fell off. There are obvious safety implications with this second method.
3) Metals all feel cold to the touch (they are good conductors of heat). Metals are hard solids (apart from mercury), they are generally strong, conduct electricity and can be polished until they are shiny.

Thermal insulators: **Rapid Ïre, p 35**

1) Both paper and polystyrene are good thermal insulators. Paper is a particularly good thermal insulator when it is in the form of several layers, which trap air, also a good thermal insulator, between them. Thus several layers of paper, or polystyrene, will keep a hot food hot by keeping the heat in, or keep an ice lolly cold by keeping the warm air out.
2) a) Oven gloves are made of a thermal insulating material and they prevent the heat from a hot frying pan reaching the hands.
   b) When you touch chocolate with warm fingers, heat is transferred from your fingers to the chocolate and the latter, having a low melting point, begins to melt.
   c) A thermal insulator will keep heat in or out. See 1) above.
3) Good thermal insulators can be found in a kitchen in the form of oven gloves, the handles of saucepans, pans, irons and kettles and in table mats. Ovens, refrigerators and freezers also have a lining which is a good thermal insulator.

Thermal insulators: **Try it out, p 35**

1) The simplest way to show the difference in thermal conductivity between a plastic spoon and a metal spoon, would be to place both in the same cup of hot liquid and hold the tip of each with the fingers. The handle of the metal spoon will quickly become hot, while the handle of the plastic spoon will remain cool.

2) The outside of the thin plastic beaker will feel much warmer than the outside of the polystyrene beaker. The water in the polystyrene beaker will also stay warmer for longer. This is because polystyrene is a much better thermal insulator than thin plastic.

Air as an insulator: **Rapid Ïre, p 37**

1) The wood, cork and carpet on a floor would be warmer than concrete, clay tiles or plastic tiles. Carpet is the warmest, while the concrete and clay tiles probably feel equally cold to the touch. However, the carpet might not be the best material for a bathroom floor if water is likely to be spilled. Wood or cork, varnished to make it waterproof, would probably be the best material for a bathroom floor.
2) When you get cold, the blood is drawn away from the small blood vessels in the skin, and particularly from the extremities such as the ears, nose, fingers and toes. This is done to conserve the body's heat. It is these extremities which get cold first. Your body's natural reaction to cold is to start to shiver, when the rapid contraction and relaxation of the muscles produces heat. You could also put on extra clothes to warm yourself up or take a hot drink.
3) Several thin layers of clothes are better than one thick layer in cold weather because air, which is a good thermal insulator, is trapped between the layers of thin clothing, producing an even more effective insulator.

Air as an insulator: **Try it out, p 37**

2) One way to compare the thermal insulating powers of two pairs of gloves would be to carefully place an identical container of hot water at the same temperature in one glove of each pair. The rate at which the two containers of water lost heat, perhaps measured with a thermometer, could then be compared.
3) In order to compare the effectiveness of insulating materials in keeping a drink hot, it will be necessary to use exactly the same type of container for each test, and the container must have exactly the same amount of drink in it at the same temperature. Suitable insulating materials to test could include woollen cloth, cotton cloth, cotton wool and newspaper. Ideally the same thickness of each material should be put around the test container. The rate at which the containers lose heat could then be tested by feeling (Careful!) or, more accurately, with a thermometer.

Insulation in house and home: **Rapid Ïre, p 39**

1) a) The walls of the house lose most heat.
   b) The least heat is lost through the floor.
   c) Walls, roof, draughts, floor.
   d) The roof and walls of the house could be lined with an insulating material, such as glass fibre. Draughts could be reduced by applying a thin strip of rubber foam to the insides of the door frame and also to the insides of the frames of those windows which open. A thick carpet or rugs would reduce heat loss through the floor.
2) It is important that we reduce the amounts of fuel and electricity we use to prevent air and water pollution, to reduce the effects of global warming, to conserve the stocks of coal, oil and gas which are non-renewable and the extraction of which causes damage to the environment. Last, but not least, reducing the consumption of fuels and electricity saves us money.

Insulation in house and home: **Try it out, p 39**

2) Houses in very hot places have thick walls which are often white in colour so that they reflect the Sun's heat and stay cool inside. If the rainfall is low, these houses may have flat roofs and they may be made of baked clay. Houses in very cold places also have thick walls to retain the heat inside. They often have double-glazed windows, and steeply sloping roofs so that rainwater and snow are carried clear of the walls. The walls are often made of brick, stone or overlapping planks of wood, while the roofs are made of overlapping clay tiles or slates to keep them weatherproof.

Staying cool: **Rapid Ïre, p 41**

1) When we are hot we feel uncomfortable and sweaty. Our skin may turn red as the blood vessels close to the skin try to get rid of the surplus heat. Reducing the amount of clothing, taking a cold drink, and sitting quietly in the shade may help to cool us, as may a cold shower or a dip in a swimming pool or the sea.
2) An ice lolly wrapped in several layers of a thermal insulator will stay frozen for quite a long time because the insulating material, and the air trapped between its layers, slow down the rate at which warm air can reach, and heat up, the ice lolly. An ice lolly not wrapped in a thermal insulator will quickly gain heat from the surrounding air and melt.
3) A thermometer under white paper will show a lower temperature in sunshine than a thermometer placed next to it under the same sized sheet of black paper. This is because white paper reflects the Sun's rays while black paper absorbs them, warming up quickly. The difference between these two colours can be appreciated if you touch the roof of a white car and a black (or dark-coloured) car in hot, sunny weather.

Staying cool: **Try it out, p 41**

2) The ice cubes used in the experiment would need to be exactly the same size and at the same temperature. The insulating materials would all need to be applied at the same time, or for the same length of time. At the end of the experiment it would be necessary to either measure, or estimate, the size of the remaining ice cube or the volume of the meltwater. The best insulating material would contain the largest remaining ice cube, or the least amount of water.

Going further

Ask students to collect copies of the weather forecasts from newspapers every day for a week. Compare the weather forecast with what really happened. Which newspaper has the most accurate weather forecasts?

It is important when you do a scientific experiment to make sure the test is fair. If you wanted to record the temperature outside on the playground every day for a week, how could you make sure that the test was fair? (Use the same thermometer at the same time in the same place (ideally in the shade)).

Ask students to practise taking temperatures in as many different places as possible: in full Sun and in the shade, in short grass, long grass, down holes, under rocks and stones, at different depths in a pond (or under snow). How do temperatures change between mornings and afternoons and between consecutive days?

Ask students (with permission) to feel the roofs of cars parked in direct sunlight. What difference is there between the temperatures of light and dark coloured cars? (Dark coloured cars become much hotter than light coloured cars, because dark colours absorb the Sun's heat rays, while light colours reflect them.) How hot does it become inside a closed car? (Take the temperature in a shaded part of the inside of the car.) Why would it be dangerous to leave a baby inside a car in hot sunshine? How does the temperature of the car change when a window is opened?

Ask students to plan a fair test to find out whether thin or thick fabric is best for keeping you warm. Do two or three layers of very thin fabric keep them warmer than one layer of thick fabric? (Normally they do.)

Ask students to plan an experiment to see which of two picnic bags keeps food cool the longest. They should describe what they would do and what measurements they would take. How would they make the experiments fair? (One way would be to put the two cool bags side by side in exactly the same conditions and place, say, an ice lolly in each. At intervals quickly check to see which ice lolly has melted first.)

Ask students to collect pictures of the clothes worn in hot and cold weather. Compare the two sets of pictures. How are the clothes alike? How are they different? Think in particular about the colours and thicknesses of the clothes and the materials from which they are made.

1. Can you tell hot from cold?

Our skin tells us if something is hot or cold. But how good is our sense of temperature?

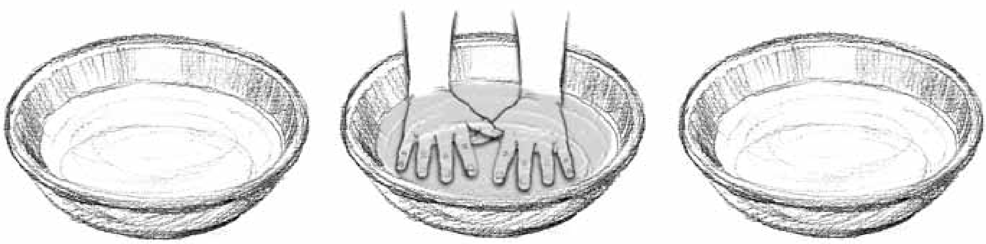
What you need:

- pencil
- towel
- three similar bowls
- cold water and very warm water

What you do:

Put the three bowls in a row.
Into one bowl put very warm water.
Into the second (middle) bowl put a mixture of very warm and cold water. We call water like this lukewarm.
Into the third bowl put cold water.
Put your right hand in the very warm water.
Put your left hand in the cold water.

Count to 100.
Then put both hands in the lukewarm water. What do you feel?
Dry your hands.



How did your right hand feel in the lukewarm water?

____

How did your left hand feel in the lukewarm water?

____

Can you always believe what your skin tells you?

____

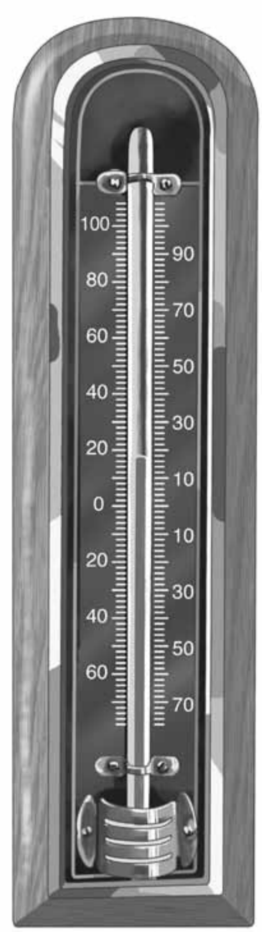
2. Thermometers and temperature

What you need:

- pencil
- wall thermometer

What to do:

The picture shows a thermometer.
A thermometer tells us how hot or cold something is.
It measures temperature in degrees Celsius. We write it as °C.
This thermometer measures the temperature of the air.



What temperature does this thermometer show?

____

Use your thermometer.

Handle it carefully or it will break.

What is the temperature in your classroom?

____

What is the temperature in the school hall?

____

What is the temperature outside in the playground?

____

What is the temperature outside in the shade?

____

Why is it usually warmer inside than outside?

____

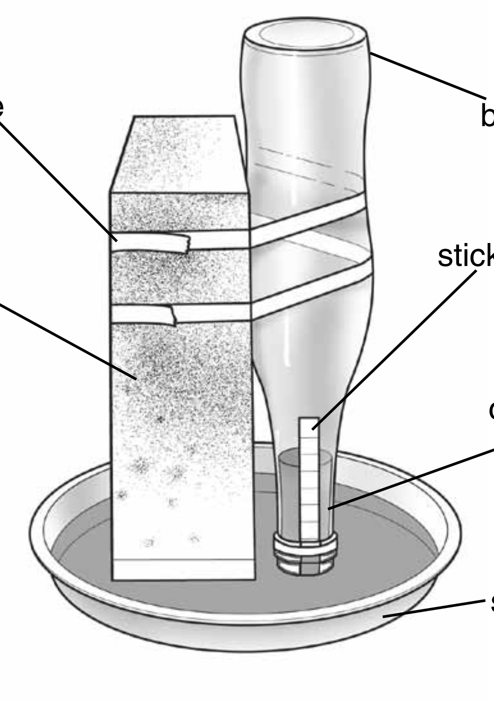
3. Make a model thermometer

What you need:

- pencil
- sticky labels
- food colouring
- house brick or long, narrow block of wood
- tall, narrow, see-through plastic bottle
- sticky tape
- shallow dish, half-filled with water

What you do:

Put a sticky label along the neck of the bottle.
Warm the bottle, either by holding your hands around it, or by standing it in a bowl of hot water for a few minutes.
When the bottle is warm, turn it upside down with its mouth in a dish of water.
Colour the water with two or three drops of food colouring.
Carefully tape the bottle to the brick or block of wood.



As the air in the bottle cools, what happens to the level of the water inside the bottle?

____

Mark the water level on the sticky label.
What happens to the water level in the neck of the bottle on a cold day?

____

What happens to the water level on a hot day?

____

Why do these changes occur?

____

4. Which materials are good conductors of heat?

Good conductors of heat let heat through quickly.

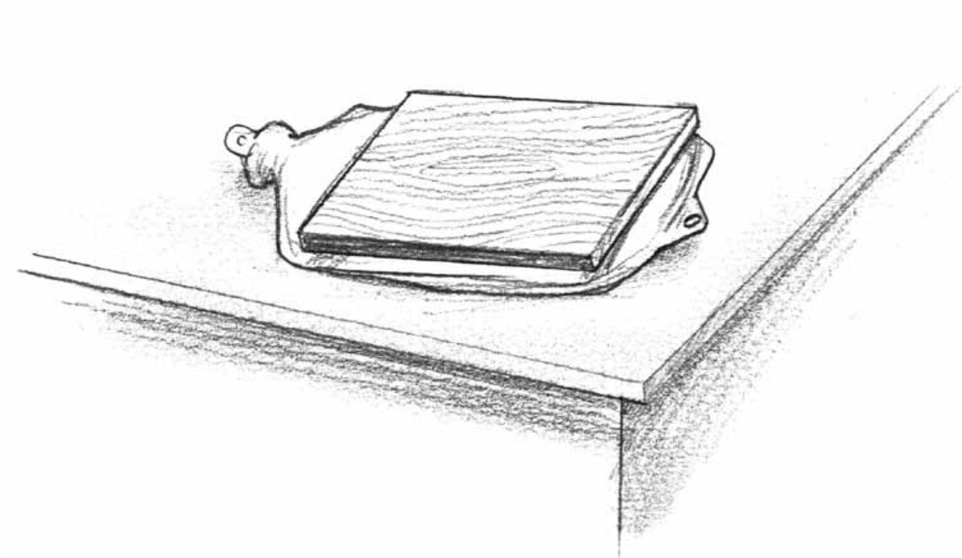
What you need:

- pencil
- clock or watch
- rubber hot-water bottle
- piece of wood, plastic plate, metal baking tray or tin lid, sheet of paper, cotton cloth

What you do:

Ask an adult to fill the hot-water bottle with hot water.

Carefully lay the hot-water bottle on the table. Quickly touch the outside of the bottle? Does it feel hot?



Lay the piece of wood on top of the bottle. Leave it there for three minutes. Does the wood feel hot, warm or cool now?

___

Now lay the baking tray or tin lid on the hot-water bottle. Leave it there for 3 minutes. Is it hotter or colder than the wood was?

___

Test the other materials.

Which of the materials let heat through quickly? These are the good conductors of heat.

___

Which of the materials let heat through slowly? These are good insulators of heat.

___

Is this experiment fair? Say why.

___

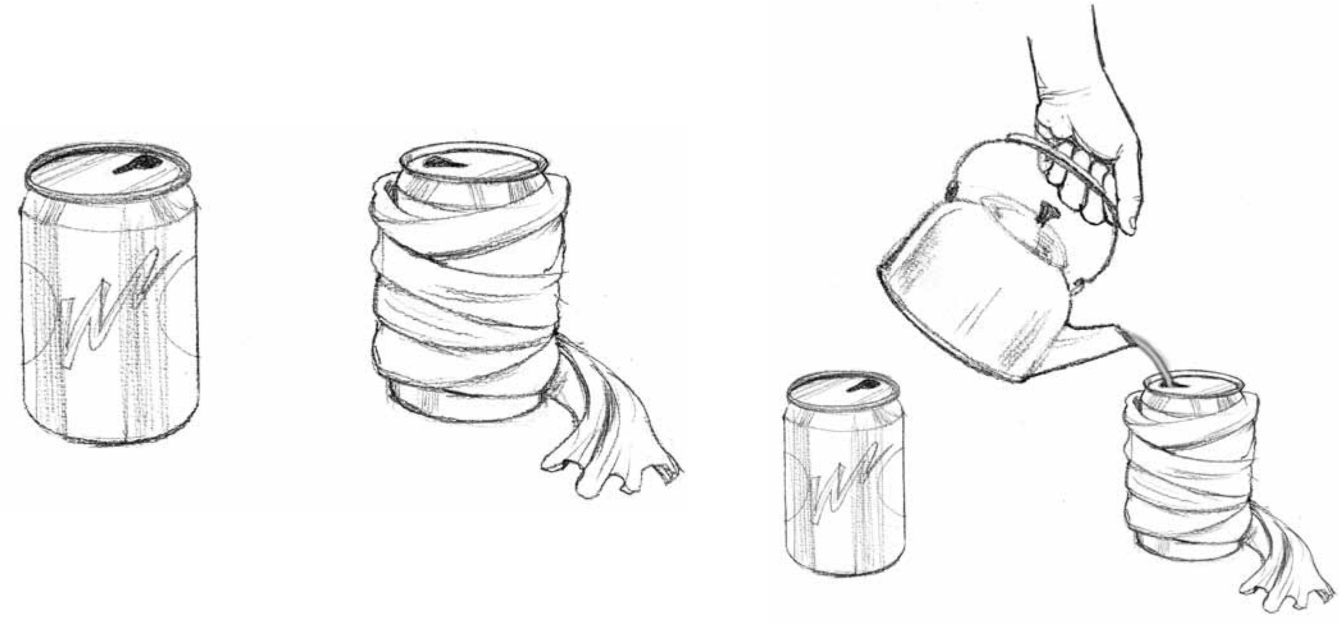
5. Keeping warm

What you need:

- pencil
- two tin cans with lids (both the same size)
- hot water
- scarf or strip of woollen cloth
- clock or watch

What you do:

Stand the two cans side by side.
Carefully wrap the scarf or woollen cloth around one of the cans.
Fill both cans with hot (NOT boiling) water. Carefully put on the lids.



Leave the cans for an hour. Which can feels warmer?

Is your experiment fair? If not, what could you do to make it completely fair?

Try this experiment with cotton wool, cotton fabric and newspaper in place of the scarf. Which would keep the cans warmer?

Try the experiment with other materials and also compare two different materials. What measurements would you need to make?

6. Melting chocolate

A good thermal insulator stops heat from passing through it. A good thermal conductor allows heat to pass through it easily. Test some materials to see whether they are good thermal conductors or insulators.

What you need:

- pencil
- chocolate buttons
- thermometer
- cotton cloth, cotton wool, newspaper, aluminium foil, plastic bag and other materials
- watch or clock with a second hand

What to do:

Hold a chocolate button in your hand. How long does it take for the button to melt?

____

Now wrap a chocolate button in one layer of cotton cloth. Hold the wrapped up button in your hand for the same length of time. Then see if the chocolate button has melted, partly melted or stayed solid.

Repeat this with one layer of each of the other materials around a chocolate button.

Which buttons melt most?

____

Which buttons stay solid?

____

Which material is the best thermal insulator?

____

Which material is the best thermal conductor?

____

What would happen if the temperature of your hand was higher?

____

What would happen if the temperature of your hand was lower?

____

Try other materials.

Notes on individual worksheets

1. Can you tell hot from cold?

Key idea Our sense of temperature is not completely reliable.

Outcome In the lukewarm water, the hand from the cold water will feel hot, while the hand from the very warm water will feel cold.

Extension Discuss why we need to use a thermometer when measuring temperatures. Discuss the clothes we wear in hot and cold weather.

Safety The water in the ‚very warm„ bowl should be hand hot.

2. Thermometers and temperature

Key ideas Temperature is a measure of how hot or cold something is. A thermometer gives us a reliable way of measuring temperature.

Outcome The thermometer in the picture shows 18^{o}C.

Extension Record the temperature taken at the same spot outside the classroom at the same time each day for a week or longer. Make block graphs to show the changes that occur.

Safety A wall thermometer is easier for children to handle. Use only spirit-Ïlled or digital thermometers.

3. Make a model thermometer

Key idea Thermometers work because liquids expand when they are heated, and the higher the temperature, the more the liquid expands.

Outcome When the model thermometer is warmed, the coloured water in it expands and the water level in the neck of the bottle rises slightly. When the model thermometer is cooled, the water contracts and its level falls slightly.

Extension Use a real thermometer to help draw a temperature scale on the model thermometer. Demonstrate how and why a clinical thermometer (ideally a digital one) is used.

4. Which materials are good conductors of heat?

Key idea Some materials are good conductors of heat; others are poor conductors (or good thermal insulators).

Outcome Metal objects allow heat to pass through them quickly; they feel hot to the touch. Wood, plastics, china, paper, cardboard and fabrics are generally poor conductors of heat.
Strictly speaking this experiment is not fair because not all of the materials are the same size and thickness and all through the experiment the water in the hot-water bottle is cooling.

Extension Test other materials. Discuss why saucepans are usually made of metal, while their handles are made of wood or plastic.

Safety The water in the hot-water bottle should be hot, but not boiling.

5. Keeping warm

Key idea Some clothes are good heat insulators and can help to keep us warm.

Outcome The water in the can with the scarf wrapped around it will feel warmer at the end of the experiment. To be fair, the two cans need to be Ïlled to exactly the same level with water at the same temperature at exactly the same time.

Extension Repeat the experiment, measuring the temperature of the water at 10-minute intervals for the duration of the experiment. Plot a graph of the results.

Safety The teacher or an adult helper should Ïll the cans with hot water for the children.

6. Melting chocolate

Key idea Good thermal insulators can be used for keeping heat out as well as in.

Outcome The unwrapped chocolate button will melt fastest. The chocolate buttons in cotton wool and woollen cloth should last longest.

Extension Which types of clothing would you choose to stop heat escaping from your body? Find out how polar bears, seals and penguins keep themselves warm in cold climates.

Lesson objectives

- To extend the students' knowledge and understanding of circuits and electrical conductors and insulators
- To show the need for a complete circuit in order for an electrical device to work
- To provide an understanding of switches and their importance in controlling the flow of electricity
- To introduce ways of varying the current in an electrical circuit

Background information

Electricity

The technical definition of electricity is a 'flow of charged particles or electrons'. Electrons move or flow through certain kinds of materials. Materials through which electrons (i.e. electricity) can flow easily are called conductors. With one exception, all conductors are metals, such as copper, zinc, steel, tin, gold, silver, and even platinum. The exception is the non-metal graphite, the so-called pencil lead, which is a form of carbon that is a good conductor of electricity.

Materials that do not conduct electricity are called insulators. Insulators are usually made of non-metallic materials such as rubber, wood (when it is dry), plastic, and porcelain. Insulators are used for confining electricity within conductors. Wires and other parts of appliances carrying an electric current always have an insulating cover to prevent the current from taking a wrong pathway and to protect the user from electric shocks or burns.

Electricity generation

Mains electricity is made at the power station by machines called generators, which work on the same principle as cycle dynamos. Inside steel cages are huge coils of wire in the middle of which are electromagnets. Fuel is used to heat water and turn it into steam. This then turns turbines connected to the generators. When the latter are turned they produce an electric current. Because large quantities of electricity are difficult to store, most electricity must be made as it is needed.

Batteries or cells

Another way of producing an electric current is by means of chemical action in a cell or battery. There is no difference between the electricity that comes from a generator at the power station or that comes from a cell or battery; it is simply the method of production that is different. Although the terms are often used synonymously, strictly speaking a battery is two or more cells connected together. Electricity is not stored in a battery; the chemicals within it react and cause a flow of electrons when wires are connected to it. A car battery, and other rechargeable batteries, produce electricity in the same way as an ordinary battery. The chemical reaction can, however, be reversed by passing an electric current through the battery in the opposite direction to the current obtained when the battery is being used.

AC and DC

The electricity produced from a battery is called direct current (DC). The current flows in one direction all the time, from the negative terminal to the positive. By contrast, alternating current (AC) behaves as if the connections are being swapped over and over again. The direction of the current constantly changes. Household electricity is AC and its direction of flow changes 50 times each second, too fast to make the lights flicker noticeably. Household electricity is said to have a frequency of 50 Hertz (50Hz). This frequency is set at the power station.

Electrical circuits

It should be remembered when working with electric currents that electrons (electricity) must have a complete conducting path from their source, through a device that will use some of the current, and back to the source. This flow is known as an electric circuit. If there are any gaps in the circuit, the electric current cannot flow. A torch bulb will use the electricity produced by a cell if they are both parts of a circuit. Copper wires, or metal strips, are needed to conduct the electricity from the cell, to the torch bulb, and back to the cell again.

In a simple electrical circuit we can judge the size of the current by the brightness of the bulb. A large current will make the bulb glow brightly while a small current will make the bulb glow only dimly, if at all. For more accurate measurements of current, an instrument called an ammeter is used. This measures the rate at which the current flows through the circuit, or the amount of electricity flowing through it in a given time, in units called amperes (amps for short).

It sometimes helps to think of a cell as a kind of pump, forcing an electric current around the circuit. The harder the pump works, the more electricity will flow. In other words, the amount of current flowing depends on the pressure behind it. Electrical pressure is termed voltage, and is measured in volts. It is sometimes called electromotive force (EMF), a reference to the fact that it is the pressure or force that pushes the current around the circuit. The voltage of most domestic supplies is between 200 and 250 volts, while a battery of the kind used in a torch gives only 1.5 volts.

Resistance

As we have seen, like heat, electricity travels better through some materials than others. When an electric current flows through a wire, for example, the atoms or molecules of the wire offer a resistance to the flow of electrons. Some substances, such as silver and copper, offer very little resistance and are good conductors. Others, such as glass, rubber, china, and plastics, offer a great deal of resistance and are bad conductors but excellent insulators.

Electrical resistance is like a form of friction that causes the moving charges in an electric current to lose energy irreversibly. When a wire is thinner there are fewer paths for the electric current to flow through, so the resistance is higher. When a wire is longer there are more obstacles to the flow of the electric current, so again the resistance is higher.

Safety

Warn students of the dangers of mains electricity. However, assure them that the batteries they use in class are safe.

Answers

Electrical circuits: **Rapid Ïre, p 43**

1) Things which use electricity from batteries include torches, radios, calculators, Walkmen, i-Pods, MP3 players, some computers, cameras, some toys.

   Things which use mains electricity include televisions, computers, washing machines. dishwashers, vacuum cleaners, electric lights, electric fires, refrigerators, freezers, electric trains and trams.
2) To compare the two torch bulbs it would be necessary to place them in identical torches containing the same types of batteries, or the same torch using new batteries of the same kind for each test. It would then be necessary to compare how long the bulbs lasted.
3) A switch acts like a moveable bridge or gate across a gap in a circuit. When the switch is ‘on’, the gap

in the circuit is closed and electricity can flow. When the switch is ‘off’, there is a gap in the circuit and electricity cannot flow.

Switches: **Rapid Ïre, p 45**

1) A switch is needed in a circuit to control the flow of electricity at will. It is easier, and safer with mains electricity, to use a switch than to join two wires together or break them apart.
2) A bulb might not light in a circuit because the bulb is ‘dead’, the battery is used up, the switch is in the ‘off’ (open) position, or the connections between the wires and the switch and bulb holder are loose. It is also possible that the bulb is not screwed into the holder properly, so failing to make an electrical contact.
3) a) circuit; b) complete, continuous; c) stop; d) flow.
4) A British railway company installed the first electric telegraph in 1837, but it was the Morse code, invented by an American artist, Samuel Morse (1791-1872), that made it a success. With Joseph Henry (1797-1878) and Alfred Vail (1807-1859), Morse devised a switch that sent short pulses of current (dots) and long ones (dashes) along a wire. A receiver at the other end marked the dots and dashes on a strip of paper so that they could be read off as messages. The telegraph caused a sensation when the first 65-kilometre long line opened in 1844.

Conductors and insulators of electricity: **Rapid Ïre, p 47**

1) Electricity is carried by underground cables in towns for safety reasons, so that people and machines cannot accidentally touch or damage the cables easily. Electricity is carried across country on tall pylons because there is less risk of damage to the cables by people and machines, it is cheaper, and it is also easier to find and repair a break in a cable.
2) The electrical conductors are: iron nail, coin, cooking foil, and gold ring, all of which are made of metals. The electrical insulators are: matchstick, plastic spoon, drinking straw, cork, cardboard, pencil and rubber band, all of which are made of non-metals. However, although the wooden body of the pencil is an insulator, the graphite (lead) core is a conductor, even though it is a non-metal.
3) True: d), e) and f). False: a), b) and c).

Conductors and insulators of electricity: **Try it out, p 47**

1) Good conductors of heat (metals) are also good conductors of electricity.
2) The metal ‘pins’ of the plug are conductors, while the plastic casing of the plug is an insulator.

Varying the current: **Rapid Ïre, p 49**

1) All of the circuits are series circuits. The brightest bulb would be the one in the circuit on its own. The least bright bulbs would be the four that are sharing a battery. These are also the bulbs which, assuming all the bulbs used are the same age, would burn the longest since they are not working to full capacity.
2) In a series circuit, all the bulbs or other devices, share the electric current. If one component fails, they all stop working since the circuit has been broken. In a parallel circuit, each bulb or other device has a separate circuit back to the battery or electricity supply. These bulbs are brighter than those in a series circuit. If one bulb in a parallel circuit fails, the other stay alight.

Varying the current: **Try it out, p 49**

1) One way to measure the brightness of a torch bulb would be to count how many layers of, say, tissue paper it can be seen through clearly. Alternatively, one could measure the distance over which the light from the bulb can be seen.
2) Any metal object, or the non-metal graphite (pencil lead), could be used in a circuit instead of wire.

3) The doll's house would need to be fitted with parallel circuits if the rooms are to be lit separately. Alternatively there would have to be a separate circuit and battery for each room.

Using electricity safely: **Rapid Ïre, p 51**

1) The covering on an electrical cable, switch or plug is made of an electrical insulator. It is there to prevent electricity reaching the body of anyone who touches these objects.
2) It is dangerous to play near pylons, overhead cables and transformer stations because these carry very high voltages of electricity. If a toy or a fishing rod or the string of a kite touched them, electricity could pass into your body and kill you.
3) Water and damp air are conductors of electricity. If you took a television set into the bathroom, the water or damp air could conduct electricity to your body and kill you or burn you badly.

Using electricity safely: **Try it out, p 51**

2) What Mrs Asiya did was very dangerous because if the metal fork touched one of the heating elements of the toaster which carry electricity, the electricity could be passed into her body and kill or injure her.

Going further

Make a collection of switches of different kinds. Discuss with the students how each switch works and where it might be used.

Some houses have special switches in them called time switches. Find out what these switches do. Where are time switches used in town and village streets? (Mainly to operate the streetlights and some street signs, so that they are switched on when darkness falls and are turned off at daybreak.)

Plan an investigation to find out whether a solution of salt in water will conduct electricity. Now test other solutions. (This can be done by placing two bare wires, that are part of a circuit containing a battery and bulb, close together in a strong salt solution. If the two wires are close enough together the bulb will light, proving that salt solution does conduct electricity.)

Design and make a circuit which will switch on a torch bulb when a toy car passes by.

Can the students design, and possibly make, a set of switches for a long flight of stairs where the light can be turned on and off at the top of the stairs as well as at the bottom?

Ask the students to draw pictures of electrical devices which use switches. Display these on a wall together with the students' own drawings of circuits they have made that include switches.

Challenge the students to join up as many conductors as they can and still make a bulb light up. This will demonstrate to them the importance of having good connections in a circuit and give them experience in finding faults in a circuit.

Against a white background, examine torch bulbs with a hand lens or magnifying glass. Draw a big sectional picture of a bulb. Are all torch bulbs alike? (No, they vary in the type of fitting—screw or bayonet—and in the way the filament is constructed.)

1. A simple circuit

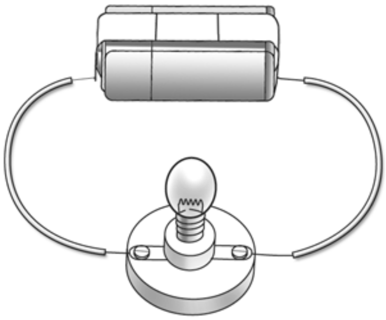
Make a torch bulb light up.

What you need:

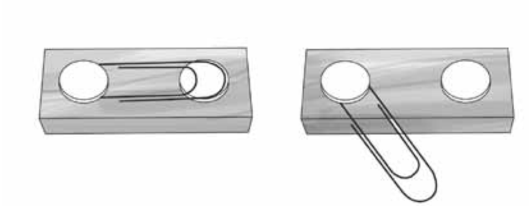
- pencil
- 1.5V battery
- small screwdriver
- sticky tape
- two drawing pins
- wire paper clips
- torch bulb in a holder
- three pieces of wire with their ends bared
- small block of wood or cork

What you do:

Connect the battery, wires and bulb so that the bulb lights up.



If the bulb lights up you have made a simple circuit. Now use the small block of wood or cork, two drawing pins and a paper clip to make a simple switch like this:



Add your switch to the circuit you have made.
Test your switch. Does it work?
Draw your circuit here.

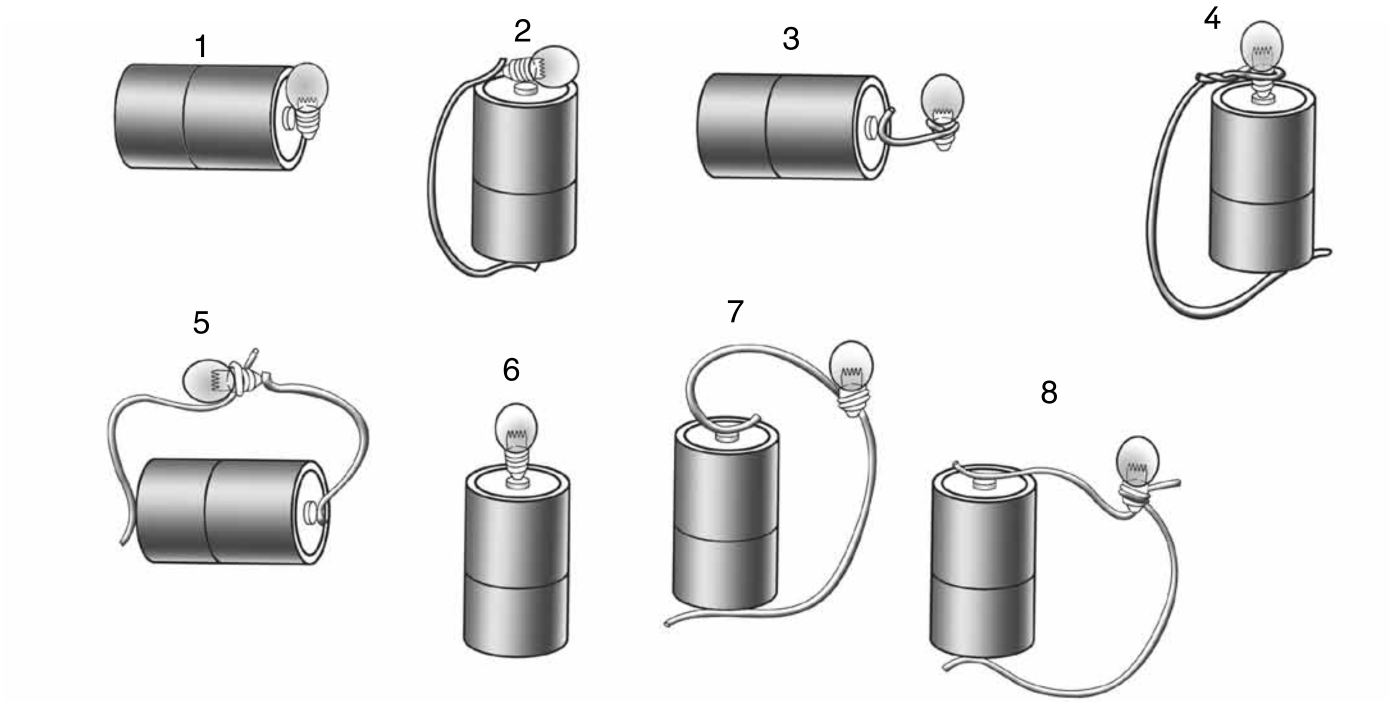
2. Bulbs and batteries

What you need:

- pencil
- battery (cell)
- torch bulb
- piece of wire with the ends bared

What you do:

Here are eight different ways to join a bulb and a battery.



Only four of the bulbs will light. Can you say which four? Write their numbers here.

What would you have to do to make the other four bulbs light?

____

____

Now make each of these circuits to see if you were right.

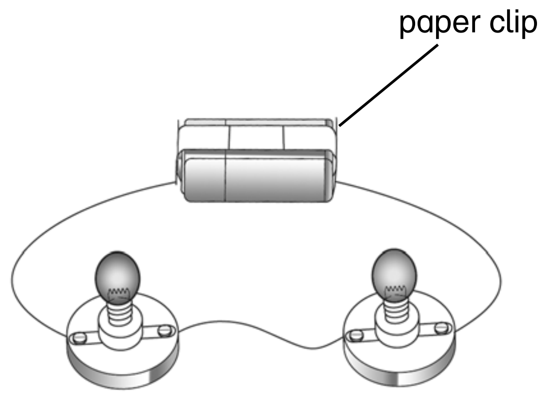
3. Series and parallel circuits

What you need:

- pencil and paper
- 1.5V battery
- six pieces of wire with their ends bared
- three torch bulbs each in a bulb holder
- sticky tape
- small screwdriver

Adult help is needed

What you do:



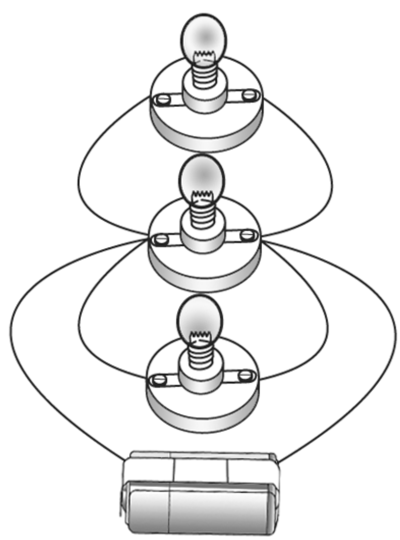
Make a circuit like the one in the picture.
This is called a series circuit because the bulbs are in a series or row.

Now add an extra bulb to the circuit.
Are the bulbs brighter or dimmer than before?

Ask your teacher to unscrew one of the bulbs. What happens to the other bulbs?

Now wire up three bulbs like this:

This is called a parallel circuit.



Are the bulbs brighter or dimmer than before?

Ask your teacher to unscrew one of the bulbs. What happens to the other bulbs?

Draw all your circuits on a separate sheet of paper.
What have you learned about series and parallel circuits?

---

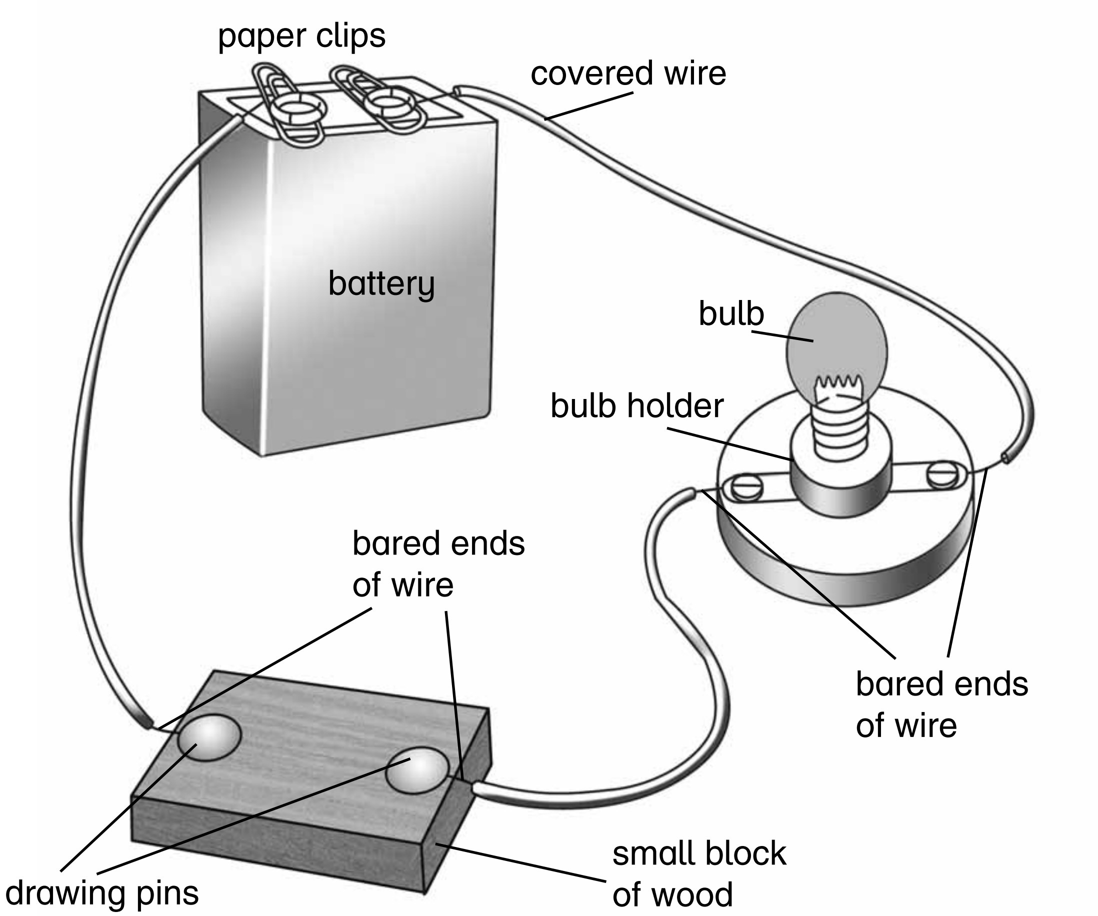
4. Electrical conductors

What you need:

- pencil
- battery
- paper clips
- torch bulb in a holder
- three short pieces of covered wire with their ends bared
- small block of wood or cork
- two drawing pins
- small screwdriver
- collection of small objects

What you do:

Push the two drawing pins into the block of wood or cork about 4 cm apart.
Join up the battery, bulb and drawing pins with wire. See that all the joints are tight.



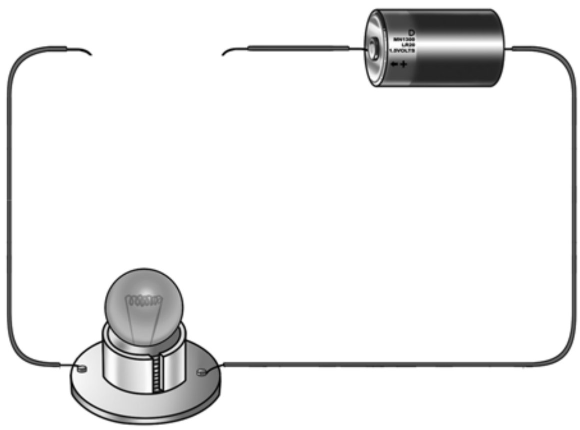
Lay the metal blade of a screwdriver across the drawing pins. What happens?
Now try the plastic handle of the screwdriver. What happens?
Try this with other objects and materials. Record your results on a table.

5. Conductors and insulators of electricity

What you need:

- pencil

What you do:



Tick the objects that would make the bulb light up if they were placed across the gap in the circuit?

a)	iron nail	b)	bar of soap	c)	steel paper clip
d)	piece of paper	e)	plastic pot	f)	gold ring

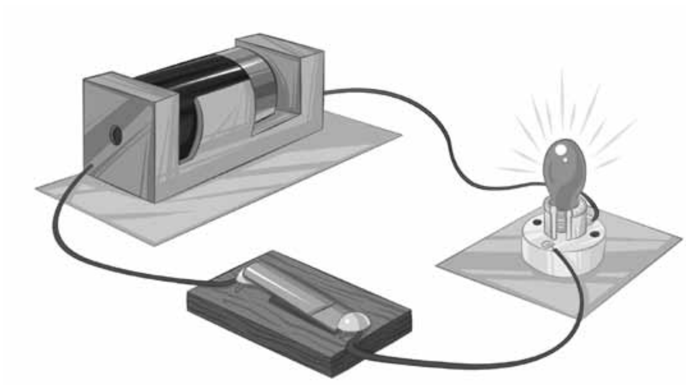
6. What will happen?

What you need:

- pencil
- torch bulbs in holders
- batteries
- wires
- buzzer

What you do:

Look at this simple circuit.



Can you predict what might happen if you make each of the following changes to this circuit? Complete the table below.

Change	My prediction	What happened
Take away a battery		
Add some extra wires		
Add a second bulb		
Add a buzzer		
Add an extra battery		

7. Make a cat detector

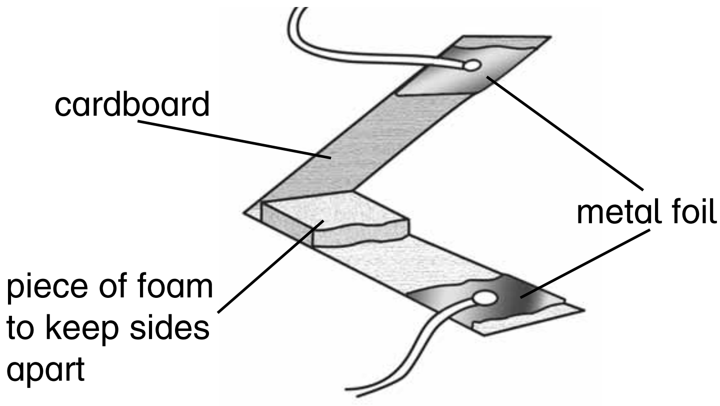
Pretend you have a cat that stays out at night. You want to know when the cat comes home so that you can feed it. Can you design an alarm to sound or light up when the cat comes home?

What you need:

- pencil
- battery
- bulb in a bulb holder or a buzzer
- glue
- wires
- piece of card
- metal foil

What you do:

This is one way to make a pressure pad switch, but perhaps you can design your own.



Draw your circuit with your cat detector here:

Notes on individual worksheets

1. A simple circuit

Key idea — *To make a bulb light up it is necessary to have a complete circuit. A switch acts like a movable bridge or gate in a circuit.*

Outcome — *If the bulb does not light up, check to see that it is screwed into the holder tightly and that the connections to the battery and switch are secure*

Extension — *Make a torch bulb light up without the bulb holder. Which materials or objects other than wire paper clips can be used to make a switch?*

Safety — *It is safe for the students to experiment with torch batteries but not mains electricity.*

2. Bulbs and batteries

Key idea — *To examine some of the different ways in which a circuit can be completed so that a torch bulb will light.*

Outcome — *Only the bulbs in 2, 4, 5 and 8 will light. For the bulb to light, the base of it must be connected to both the terminal at the top of the battery and its base.*

Extension — *Make a twisted wire obstacle course and make up a ‚steady hand„ game, in which you must move a small ring of bare wire around the twisted course without making a light bulb or buzzer work.*

Safety — *It is safe for the students to experiment with torch batteries but not mains electricity.*

3. Series and parallel circuits

Key idea — *There are two ways of wiring an electrical circuit: in series and in parallel.*

Outcome — *In a series circuit, an extra bulb makes all the bulbs go dimmer since they are sharing the available electric current. If one bulb is removed, the other bulbs go out. In a parallel circuit, all the bulbs are equally bright; if one is removed, the others stay alight.*

Extension — *Discuss why, if one light fails at home or school, all the others do not go out.*

4. Electrical conductors

Key idea — *Metals are good conductors of electricity, whereas most other materials are poor conductors (or electrical insulators).*

Outcome — *The materials which do not make the bulb light (insulators) are non-metals such as wood, plastic and glass. The one common exception to this is the non-metal graphite, the so-called pencil lead, which is a good conductor. Metals and metal objects are good conductors of electricity.*

Extension — *Discuss why electric cables with torn or frayed covers can be dangerous.*

Safety — *The students should be warned never to experiment with mains electricity.*

5. Conductors and insulators of electricity

Key idea — *An assessment exercise to test the knowledge of circuits, conductors and insulators.*

Outcome — *The objects which are conductors of electricity and which would complete the circuit and make the bulb light up are; a) iron nail; c) steel paper clip; f) gold ring.*

Extension — *Devise an experiment to see whether tap water will conduct electricity.*

6. What will happen?

Key idea	*A practical exercise to test the students„ understanding of the effects of changes to a circuit.*
Outcome	*Taking away the battery will cause the bulb to go out.*
	If the extra wires added to the circuit are very long and very thin, they will make the light from the bulb dimmer.
	Adding a second bulb to a series circuit like this will mean that they share the electricity and will not be as bright as one bulb alone.
	Again, adding a buzzer will mean the two components share the electricity and will not work as effectively as if they were on their own in the circuit.
	Adding an extra battery will make the light from the bulb much brighter. The bulb will burn out quite quickly.
Extension	*Invent your own bulb and battery holders.*

7. Make a cat detector

Key idea	*The application of a simple circuit and pressure pad switch to make a working model.*
Extension	*Can the children devise a circuit containing a switch that will warn them when it is raining outside or when a bath is full of water?*

Lesson objectives

- To introduce friction as a force that opposes motion
- To examine simple, everyday examples of the harmful and beneficial effects of friction
- To examine friction and lubricants; to introduce the forces of air resistance and water resistance and how they are used and reduced

Background information

If you look at a highly polished piece of metal or wood under a microscope, you will see that it is anything but flat. It looks as if it is made up of hills and valleys. If you put two such surfaces together, they touch at only a few places. When one of the surfaces is rubbed over the other, the 'hills and valleys' lock with each other, and so resist movement. The harder the two surfaces are pressed together, the more firmly the two sets of hills and valleys grip, and the greater the resistance to movement. This resisting force is called friction. It is friction that brings a bicycle to a stop when the brake pads rub against the rims of the wheels. It is friction that stops a car when the brake pads press against the drums, and makes a car move when the clutch plates engage.

Friction and heat

All surfaces that come into contact with each other, even a bullet hurtling through the air, or a ship cutting through the water, experience friction. They are not only slowed down, but some of the energy of movement is converted to heat energy. The heat generated by friction when a meteorite enters the atmosphere is almost always enough to burn it up before it reaches the ground. Designers of cars, ships, and aircraft try to cut down friction losses from air and water resistance by streamlining. Birds and fish have natural streamlined shapes.

Lubrication

Friction in machines is destructive and wasteful: it causes the moving parts to wear and it produces heat where it is not wanted. Engineers reduce friction by using very highly polished materials and by lubricating their surfaces with oil or grease. They also use ball bearings and roller bearings because rolling objects cause less friction than sliding ones.

A world without friction

Although friction can be an expensive nuisance, it would be a very strange world without it. With no friction, walking would be impossible because our feet would not grip the ground, and if we started moving we would be unable to stop. The wheels of bicycles and cars would not grip the road surface, but would spin out of control. Nails and screws would never hold, ladders would slide to the ground, and scaffolding would collapse.

There are other uses of friction. We use the heat produced by friction to start a tiny explosion when we strike a match. Primitive people rubbed two sticks together until the friction made the sticks hot. Even today, in very cold weather, we may rub our hands together vigorously until the friction makes them warm, although some of this heat comes from the flow of blood to the hands.

Using air resistance

All forces work in pairs. Whenever there is a force on one thing in one direction, another force is operating in the opposite direction. When a gun is fired, at the instant the bullet shoots out of the barrel, the gun kicks back into the shoulder of the user.

Air resistance, or drag, is a form of friction. It, too, is one of a pair of forces. Gravity makes all falling objects accelerate towards the centre of the Earth, but air resistance is a force opposing this motion. In space there is no air, so there is no friction. A space shuttle, for example, experiences no friction as it moves through space, until it re-enters the Earth's atmosphere. Then the friction between the shuttle and the air makes it glow red-hot.

Air resistance depends on the size and shape of an object and its speed. As the object accelerates while it is falling, the air resistance gets much larger. We can obtain an understanding of this if we think of a skydiver jumping from an aircraft at a great height. As a skydiver leaves an aircraft the force of gravity causes him or her to accelerate. Initially the skydiver's velocity will be small and so too will be the air resistance (air friction). As the skydiver's velocity increases, the force of air resistance increases. There comes a point where the accelerating force due to gravity balances the air resistance force. The skydiver then continues to fall at a constant velocity (known as terminal velocity) because there are no unbalanced forces acting. When the parachute opens there is an immediate increase in the air resistance force. The imbalance over the force of gravity causes the skydiver to slow down (decelerate) to a new but slower terminal velocity.

Water resistance and streamlining

Water is much denser than air, so more friction acts on objects moving through water and reduces their speed. Most people have experienced how difficult it is to walk in a swimming pool or the edge of the sea because of the necessity to push the water away with the legs. In both the air and in water, reducing friction helps to gain speed and saves energy.

One way to reduce friction caused by the air or water is by streamlining. A streamlined shape is narrow and dart-like. A pointed nose or, in the case of a boat or ship, a pointed bow, makes it easier to cut through the air or water. A smooth surface allows the air or water to rub as little as possible. Streamlining is important for aircraft, cars and boats and ships, and for animals such as fish, whales, dolphins and birds. In the case of aircraft, cars, boats and ships, streamlining helps to gain speed and reduces fuel consumption. In the case of birds and other animals, streamlining gains speed and reduces the consumption of food energy.

Safety

Stretching elastic bands can result in eye and facial injuries.
Careful supervision of activities where students drop parachutes and spinners from a height will be necessary to avoid accidents to onlookers. Ensure that model parachutes and spinners are not thrown into the air anywhere near overhead power cables.

Answers

The force of friction: **Rapid Ïre, p 53**

1) The force of friction was greatest on Ikram's car because it did not travel as far as Saima's car. The cars stopped rolling because the friction of the cars' wheels on their axles and the friction of the wheels on the surface they were travelling over eventually became greater than the force created when they rolled down the slope.
2) The worst material for the cars to run on would be the carpet, because there would be a great deal of friction between the tiny wheels of the toy car and the fluffy surface of the carpet. It is not possible to say for certain which would be the best surface out of sandpaper and polished wood. A certain amount of friction is necessary for wheels to grip, and it is quite possible that the polished wood would be so slippery that the toy car's wheels would not be able to grip, but would simply skid.

The force of friction: **Try it out, p 53**

2) The toy car will roll further if the slope is made steeper.
3) One way to test which shoe grips best would be to allow them to slide down a steep slope consisting of a plank of wood propped up at one end on several books. The shoe that slid the shortest distance would be the one with the best grip. The experiment would not be completely fair because, even if the shoes were the same size, they might have different weights. In addition, because a shoe grips well on a smooth surface, it might not grip as well on a loose or rutted surface.

Friction is a nuisance: **Rapid Ïre, p 55**

1) Unscrewing the lid of a jar is simply a case of applying friction to it. If your hands are clean and dry, the tiny ridges and grooves on the surface of your skin can grip the jar lid quite easily. If, however, your hands are wet and soapy, the water and soap act as lubricants and your hands cannot produce the same amount of friction on the jar lid.
2) Trainers need to have rough soles to increase the friction between the wearer's feet and the ground. Rough soles are particularly important when the ground is smooth, wet or icy.
3 The main groups of things which wear out because of friction are shoes, clothes, pencils, and engines and other machines with movable parts. Knives, saws, drills and scissors become blunt because of friction. It is also interesting that the outer layer of your skin is constantly being worn away and replaced from underneath by new skin cells. Every four years you shed your own body weight in dead skin.

Friction is a nuisance: **Try it out, p 55**

1) Of the usual surfaces on which the marble or small ball is likely to be tested, grass or a carpet are likely to produce most friction. A smooth, polished floor would have least friction.
2) It is dangerous to drive, or be a passenger in, a vehicle with worn tyres because the tyres would not be able to grip the road, particularly if the road was wet or icy or if the vehicle had to brake suddenly.
3) Skiers put wax on their skis to reduce the friction between the skis and the ice or snow. That way the skier can travel further or faster with less effort.

Making use of friction: **Rapid Ïre, p 57**

1) When you walk forwards, your foot does not slide backwards because of the friction between your foot or shoe and the ground. Sandpaper and concrete, particularly if the concrete has a rough surface, will give plenty of friction to walk on. Wet soap and a banana skin are so slimy that they act as lubricants between your foot and the ground and could well cause you to slip and fall.
2) Water on a tiled floor can act as a lubricant between your feet and the floor, reducing the amount of friction and making it easy for you to slip and fall. No such problems arise with a dry tiled floor.
3) When you write with a pencil, you are using pushes and pulls to move the pencil backwards and forwards, but it is friction which makes the pencil lead make a mark on the paper. You need to sharpen the pencil from time to time because friction wears way the pencil lead.

Making use of friction: **Try it out, p 57**

2) The cotton reel tank will work best on a slightly rough surface on which it can grip. The tank will be able to grip better if you cut tiny notches in the two outer rims of the cotton reel.
3) The brake blocks grip the wheel of a bicycle to stop it. The tyres with their grooved treads use friction to grip the road, while the hand grips on the handlebars allow the cyclist to hold onto the handlebars easily to make the cycle change direction.

Moving through air: **Rapid Ïre, p 59**

1) Strictly speaking, everything on the surface of the Earth that moves, does so through air. In terms of those things which fly or glide, then amongst living things most birds can fly, and many insects can fly. Of the mammals bats can fly, while animals such as flying squirrels, flying lizards, flying geckos, flying fish and flying frogs glide, mostly from a height.

   Of the non-living things that move through the air: helicopters, aeroplanes and microlites fly with the aid of engines; hovercraft move on a cushion of air created by fans driven by engines; gliders, kites and hang gliders glide, while hot-air balloons drift with the wind. These machines can also be divided into those which have wings (aeroplanes, gliders, hang gliders and microlites) and those which do not (helicopters, hot-air balloons and hovercraft).
2) When a spacecraft re-enters the Earth's atmosphere it is travelling very fast. Air resistance slows the spacecraft down, but at the same time makes it heat up because of the friction of the air rubbing the sides. To keep out the heat and protect the astronauts inside, the spacecraft is covered with special insulating tiles.
3) Although the two sheets of paper weighed the same, the sheet of paper which was not screwed up would take longer to reach the ground because of the greater air resistance on it as it fell.

Moving through air: **Try it out, p 59**

2) The trees and other plants which use air resistance to help disperse their seeds include pine, sycamore, willow, alder and maple trees and dandelions and thistles.
3) It is not possible to give a precise answer to this question. In theory, the larger the paper dart the better it will fly because the air resistance will be greater. In practice, if the dart is too large, or the paper too flimsy, the air resistance will cause the wings of the dart to crumple so that it does not fly well. Stiff cartridge paper will make the best large paper darts.

Moving through water: **Rapid Ïre, p 61**

1) A streamlined shape is narrow and dart-like in order to reduce friction, gain speed and save fuel. A pointed nose or bow makes it easier to cut through the air or water, while a smooth surface or skin minimises the rubbing effect of the air or water.
2) Swimmers streamline their bodies by wearing tight-fitting hats and swimming costumes, by keeping their bodies as straight as possible and their limbs close together and, often, by removing the hair from their bodies which might otherwise increase friction.
3) The sailing boat in the picture is using air resistance by holding a large area of sail up to the wind, so that the wind can push it along. Water resistance is being reduced by the sleek and streamlined hull, which has a pointed bow and a smooth surface.

Moving through water: **Try it out, p 61**

1) Streamlined boats, ships and animals (mainly fish, seals, dolphins and whales) all have a sleek, dart-like shape and pointed front end. They all have a smooth surface. The main difference is that the animals have limbs or fins which project into the water to propel the animal and steer it, while boats and ships generally have only a moveable rudder for steering. If the boat or ship is powered by an engine, then the propellers are at the rear, where they cause least water resistance.
2) A marble or top will spin longer in air than in a bowl of water. This is because the air resistance is much less than the water resistance. The latter quickly makes the marble or top slow down and stop.
3) The piece of Plasticine which will fall fastest is that with the least water resistance—either a bullet shape which is dropped point down or a sphere. The piece of Plasticine which takes longest to fall will have the largest surface area, i.e. a flat, very thin sheet.

Going further

Friction with the ground is important when we walk, run and ride a bicycle or drive a car. Discuss the dangers of oily patches, ice, banana skins and mats on slippery floors. What effect could ice or oil on the road have if you were cycling or driving a car?

Students can see how ball bearings reduce friction with the help of some marbles and a large book. First push the book across a table and notice how quickly friction brings the book to a halt. Now put marbles, all the same size, under the book and push it again. The marbles roll between the book and the table, reducing friction so that the book travels further with less effort.

Test an old roller skate. How far does it roll across the floor after going down a ramp or slope? Do three tests and find the average of the three results. How far does the roller skate go after it has been oiled? Again carry out three tests and find the average of the three results.

Discuss the sports in which friction is useful or a hindrance. Consider, for example, ice hockey, athletics, skiing, archery, football, and sailing. Make a chart showing the sports and the advantages and disadvantages of friction.

Compare pulling a trolley on wheels with pulling it upside down. It weighs the same on both occasions. How could you measure the effects of friction in each case? (One way would be to pull the trolley with a spring balance or force meter and compare and record the reading on both occasions.)

Parents are always complaining that their children's clothes and shoes wear out quickly. Ask students to write a short letter explaining why this happens.

Try to put a screw into wood using a screwdriver with its handle smeared with butter or margarine. (The screwdriver keeps twisting in the hand because of the lubricating effect of the butter or margarine.)

Ask students to blow across a dish of water. Discuss how friction might help to make waves on the sea. (The waves on the sea are caused by the wind blowing over the surface. The friction between the moving air and the water pushes up the water into waves. The stronger the wind, the bigger the waves produced. You could experiment with this by blowing air across the surface of water in a shallow dish.)

Forcing something to overcome friction produces heat. Ask students to carefully feel the blade of a saw after sawing a piece of wood. (Safety!)

Fix up a slope consisting of a tilting board with one end resting on a book. Test this slope with two cotton reels, one allowed to slide down the slope and the other to roll. They weigh the same. What can be learned from this activity? (Rolling produces less friction than sliding.)

1. Friction slows things down

Friction slows things down. Which objects and materials have most friction?

What you need:

- pencil
- long piece of wood or cardboard
- marble, rubber, paper clip, wooden brick, small brush, small stone, ball
- thick books

What you do:

Make a slope by resting one end of the piece of wood or cardboard on a book. Place the marble on top of the slope and let it roll down.

Now try each of the other objects in turn.
Which objects move most easily down the slope?
Which objects have most friction?
Which objects have least friction?

Make your slope steeper by putting two or more books under the wood. Repeat your tests and compare your results with the first test.

Complete this table:

Object	**Does it move easily down the slope?**	
	one book	two books
marble		
rubber		
wooden brick		
brick		
small stone		
paper clip		
ball		

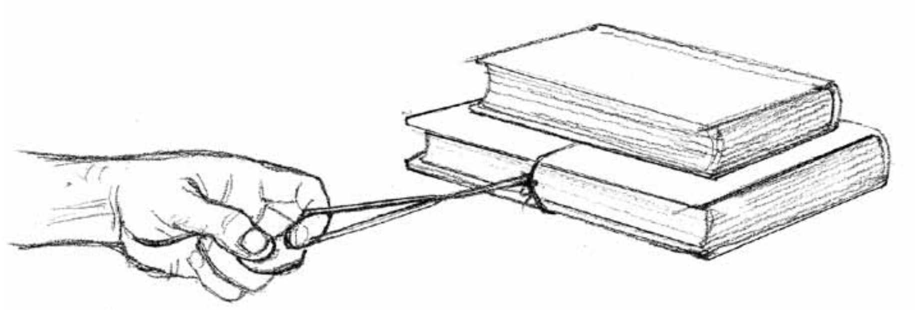
2. Do rollers help to move things?

What you need:

- pencil
- piece of string about 60 cm long
- two large books
- large elastic band
- ten round pencils
- ruler

What you do:

Stack the books in the middle of the table.
Tie the string around the bottom book.
Tie the other end of the string to the elastic band like this:

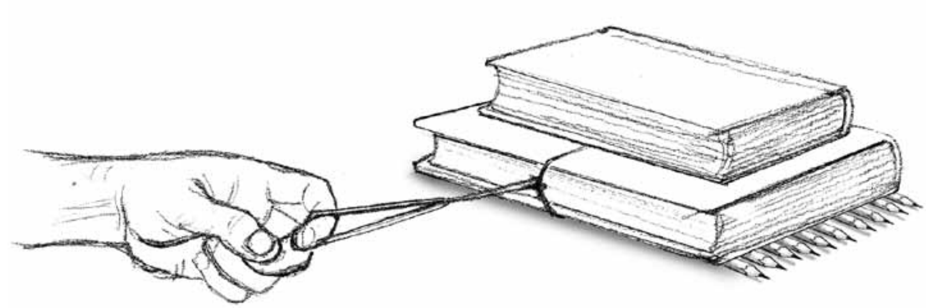


Move the books by pulling on the elastic band.

Measure how far the elastic band stretches. ______________________________

____

Now lay the pencils in a row. Put the books on top of them like this:



Pull the elastic band. Measure how far the elastic band stretches.

____

Do the pencils increase or decrease the force you need to move the books?

____

3. Wear and tear

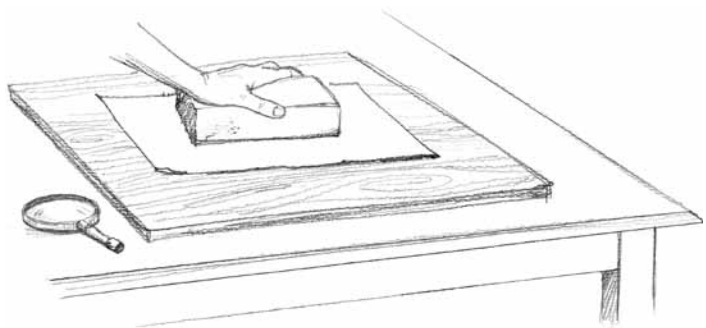
Friction wears out machines, clothes and other materials.

What you need:

- pencil
- a piece of house brick or a pebble
- hand lens or magnifying glass
- large board
- different kinds of paper, cloth and plastic sheeting

What you do:

Put the board on the table to protect it.



Take one of the pieces of paper.
Rub it three times with the brick or pebble.
Look at the paper with a hand lens. What do you see where you rubbed the paper?

Keep rubbing the paper.

How many times do you rub it before the paper is worn right through?
Now try other kinds of paper. Which is the hardest-wearing?

Now try different kinds of cloth and plastic sheeting. Which is the hardest wearing?

Record your results.

4. Do some objects fall faster than others?

What you need:

- pencil
- several small objects, such as a marble, eraser, pebble, pen top and tennis ball
- large metal tray
- chair or bench to stand on

Work with a friend

What you do:

Pick up each of the objects in turn.
Which do you think will fall fastest if you drop it?

Place the metal tray on the floor.
Carefully stand on the chair and hold two of the objects high above the tray.
Let go of both objects at the same time.
Ask your friend which one hits the tray first.

Repeat the experiment with other pairs of objects.

Record your results in a table like this:

Pairs of objects	Which hit the tray first?

Do large objects fall faster than small ones?

5. Air resistance and us

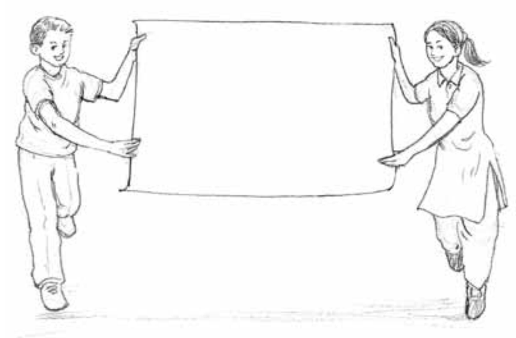
What you need:

- pencil
- large sheet of card, (or plywood or hardboard)

Work with a friend

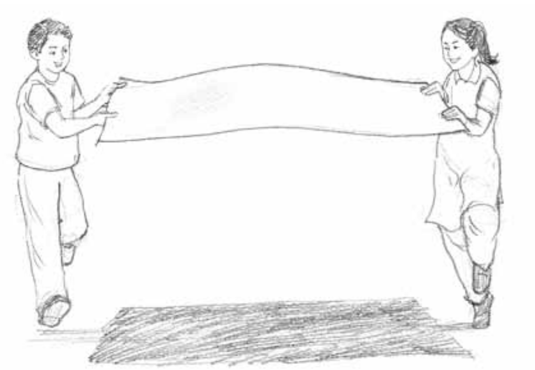
What you do:

Work outside right away from other people.
Hold the sheet of card between you, as shown in the picture.



Run with it across the playground.
What do you notice? ____

Now hold the sheet of card like this:



Run with it across the playground.
What do you notice? ____

When was it easier to run? ____

Why? ____

Why are aircraft, racing cars and fast trains curved or tapered at the front?

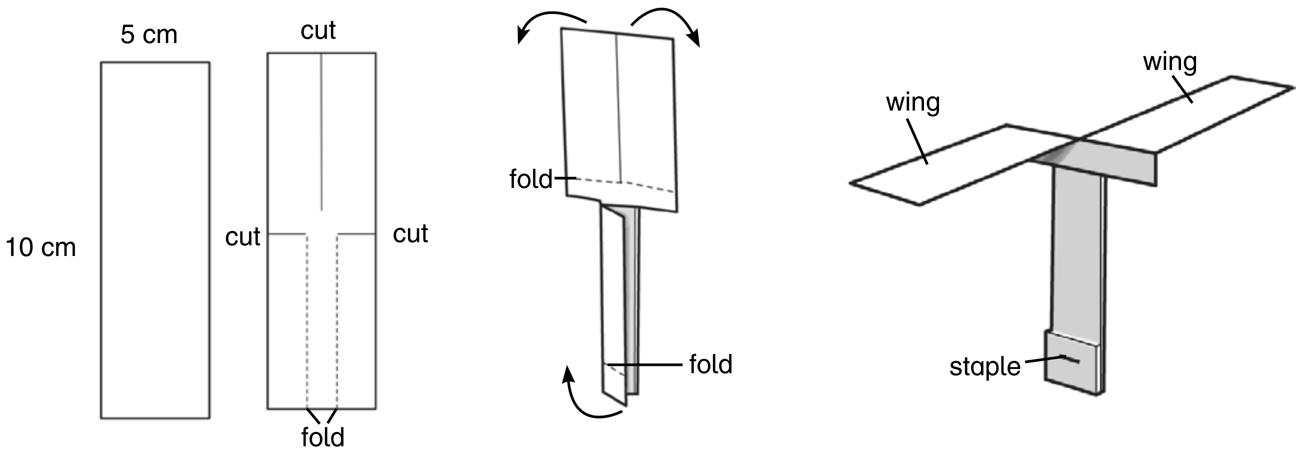
6. Testing paper spinners

What you need:

- pencil
- sheets of writing paper
- stapler
- scissors

What you do:

Cut pieces of paper like this:
Make cuts of different lengths.



Fold back the wings and staple them.

Do this for all the different wing sizes.

Stand on a chair. Take the spinner with the longest wings. Hold it at the staple between your thumb and first finger. Hold it as high as you can and let it fall.
How does it go? ______________________________

____

Now take the spinner with the longest wings and the one with the shortest wings. If you drop them in the same way from the same height, which do you think will reach the ground first? Try it. Were you right?

____

Drop all the spinners, two at a time. What do you discover?

____

Are the spinners all the same weight? ______________________________

____

How do you know? ______________________________

____

7. Friction in liquids

Friction in water is called water resistance. Do all liquids produce the same amount of friction?

What you need:

- pencil
- two clean, clear-plastic bottles, exactly the same size
- washing-up liquid
- water
- drawing pins

What you do:

Fill one bottle with water.

Fill the other bottle to exactly the same level with washing-up liquid.

Take a drawing pin in each hand. At the same moment, drop one into each bottle. Which drawing pin reaches the bottom of the bottle first?

Repeat the experiment nine more times. Record your results.

____

____

In which bottle do the drawing pins usually reach the bottom first?

____

____

In which liquid, water or washing-up liquid, is there most friction?

____

Why was the experiment repeated ten times?

____

What results do you think you would find if you put treacle, syrup or olive oil in one of the bottles?

____

____

What would be the best way to get the drawing pins back out of the bottles?

____

____

Notes on individual worksheets

1. Friction slows things down

Key idea — *Friction affects the movement of objects by slowing them down.*

Outcome — *The marble, toy car and ball are likely to move easily down the slope. These objects have least friction. The eraser, pebble, paper clip and wooden toy brick are likely to have more friction and slide less easily.*

Extension — *What effect does rubbing the slope with oil or soap have?*

Use a large and steeper ramp to investigate how easily different types of shoe will slide down it.

2. Do rollers help to move things?

Key idea — *Rollers make it easier to move objects because they reduce friction.*

Outcome — *The elastic band will stretch less when the books are resting on the pencil rollers because the rollers touch less of the table than the books and therefore have less friction.*

Extension — *You could use a newton meter for this activity instead of an elastic band. Measure the force needed to move a toy truck, with and without wheels.*

Safety — *Stretching elastic bands can result in eye and facial injuries.*

3. Wear and tear

Key ideas — *Friction produces wear and different materials differ in their wearing properties.*

Outcome — *If a sample of tissue paper is included, this will probably be the least hard wearing.*

Extension — *Compare the wearing qualities of different types of fabric used for clothing.*

4. Do some objects fall faster than others?

Key ideas — *Gravity pulls objects of different weights down at the same speed.*

Outcome — *The objects will hit the metal tray at the same time, even though their weights are different.*

Extension — *Compare how high different-sized balls bounce if they are dropped from the same height.*

Safety — *Careful supervision of this activity will be necessary to avoid accidents to onlookers or over-enthusiastic clambering on chairs by the participants.*

5. Air resistance and us

Key idea — *Air resistance slows movement, even along the ground.*

Outcome — *It is difÏcult to run with the card held vertically because of the substantial air resistance. It is much easier to run with the card held horizontally when the air resistance is much less.*

Extension — *Discuss (and possibly investigate) the effect of air resistance when riding a bicycle sitting upright and when bent over the handlebars, as on a racing cycle.*

Safety — *Careful supervision of this activity will be necessary to avoid accidents to onlookers.*

6. Testing paper spinners

Key idea — *Air resistance allows paper spinners to fall through the air slowly.*

Outcome — *In general, the larger the wings of the spinner the slower it will fall. The spinner with the smallest wings will fall fastest. The spinners all weigh the same because they were all cut to the same size from the same sheet of paper. The only unintentional variable could be if the staple pins are not all exactly the same.*

Extension *Now repeat the experiment with spinners cut from different sized rectangles of the same kind of paper.*

Safety *Careful supervision of this activity will be necessary to avoid accidents to onlookers or over enthusiastic clambering on chairs by the participants.*

7. Friction in liquids

Key idea *To show that liquids vary in the amount of friction they exert on an object.*

Outcome *On average, the drawing pins will fall to the bottom of the bottle of water much quicker than they do in the bottle of washing-up liquid. The friction between the drawing pins and the water is less than the friction between the drawing pins and the washing-up liquid because washing-up liquid is a thicker (denser) liquid than water. Treacle, syrup or olive oil would produce even greater friction, and so slow up the movement of the drawing pins even more.*

The experiment is repeated ten times to rule out any variations due to difference in size of the drawing pins or slight variations in the time at which they are dropped into the liquids.

Most drawing pins are made of brass and cannot, therefore, be picked up with a magnet. They are, however, easily retrieved with the help of a sieve or tea strainer.

This experiment is even more effective if it can be carried out in two long transparent plastic tubes.

Extension *Experiment with the water resistance on model boats (cut out from balsa wood) of different shapes and sizes.*

Lesson objectives

- To introduce the concept of habitat and to show how a habitat provides organisms with the conditions for life.
- To introduce simple examples of the ways in which living organisms are adapted to their habitats and to show, by means of food chains, how animals and plants are interdependent.

Background information

The plants and animals that live together in a certain place, or habitat, are dependent upon each other and their environment. Whatever habitat they live in, most living things have the same basic needs: food, water, oxygen, shelter and protection. Plants and animals are adapted to meet these needs, but each species' adaptations allow it to compete successfully with other species. In that way, many species can live together in a habitat, and all can be successful. The mark of success of a species is that it produces enough offspring to keep its species going.

Life under logs and decaying leaves

The animals living under rotting logs or heaps of decaying leaves, for example, feed either on the decaying material around them or on other animals which themselves feed on these materials. Most of them are dependent on the dark, damp conditions for shelter and their water requirements. Nearly all breathe air, although woodlice have gills like their relatives the crabs, and can only survive where the air is moist. To ensure that they do not dry up, woodlice emerge only at night. Many other animals living in dark places are also nocturnal and only emerge when there are few large predators about.

Pond life

The plants and animals living in a pond are similarly adapted to their aquatic environment. The plants growing in and around a pond, for instance, are not indiscriminately placed, but are arranged in distinct zones. This zoning reflects the plants' degree of adaptation to an aquatic life. The first plants to colonize a new stretch of water are the totally submerged water plants. As the pond silts up, then plants which have floating leaves, such as water lilies can grow. Eventually more silting makes way for tall emergent plants such as reeds, bulrushes, and yellow flag iris. After many years of silting and plant growth, a swamp is left where there was once open water. In time this could become scrub or woodland, as the site of the former pond dries out. The animal life is similarly adapted to living in the different zones of a pond. It varies from the fish, tadpoles, water fleas, water snails, and some other animals that remain totally immersed in water, through animals such as frogs, toads, newts, and water voles that spend only some of the time in water. Then there are a few animals, including pond skaters, that live on the water surface. The animals also specialize in a variety of foods, from plant-eaters or herbivores, such as water voles, water fleas, tadpoles (early stages), and lesser water boatmen, to predators or carnivores such as dragonfly larvae, water spiders, sticklebacks, frogs, toads, and newts. In addition, a large number of animals, including some water snails, feed on decaying plants and animal remains.

Life on the seashore

The lives of seashore plants and animals are dominated by the tides that creep up and down the shore. As the tide flows in, the shore is not only covered by water, it is covered by floating food. But as the tide flows out again, the plants and animals are exposed to drying winds, strong sunshine, extreme temperatures and the freshwater in rainfall. Many of the animals burrow in sand or mud or shelter under rocks or seaweed or in rock pools. Some, such as shellfish and barnacles, have tough shells which help to stop them drying out and protect them from the pounding waves. The seaweeds have a slimy coating of mucilage, which helps to prevent them drying out.

Even those plants and animals that survive in rock pools at low tide have had to adapt to extreme conditions. At low tide a rock pool may quickly heat up or cool down. The water may become very salty, because of evaporation, or less salty if there is heavy rain. The plants and animals in the pool have to cope with these rapid changes, or die.

Life in grassy habitats

The plants of grassland and lawns are also well adapted to their habitats and to the levels of human disturbance. The grasses that grow, or are sown, on lawns and pastures generally have short or creeping stems, which are left undamaged by cutting or chewing. This is because, unlike all other plants, grasses have their growing buds at the base of their leaves, rather than at the tip of the leading shoot. When the leaves are mown, or bitten off by a grazing animal, grasses can regrow from the base of the plant. The plants which grow as weeds in lawns and grassland, including dandelions, daisies, and yarrow, show their own adaptations. When the grass is mown, bitten off, or heavily trampled, these plants grow and flower close to the ground; where the grass is allowed to grow long, these plants also grow tall.

Food chains

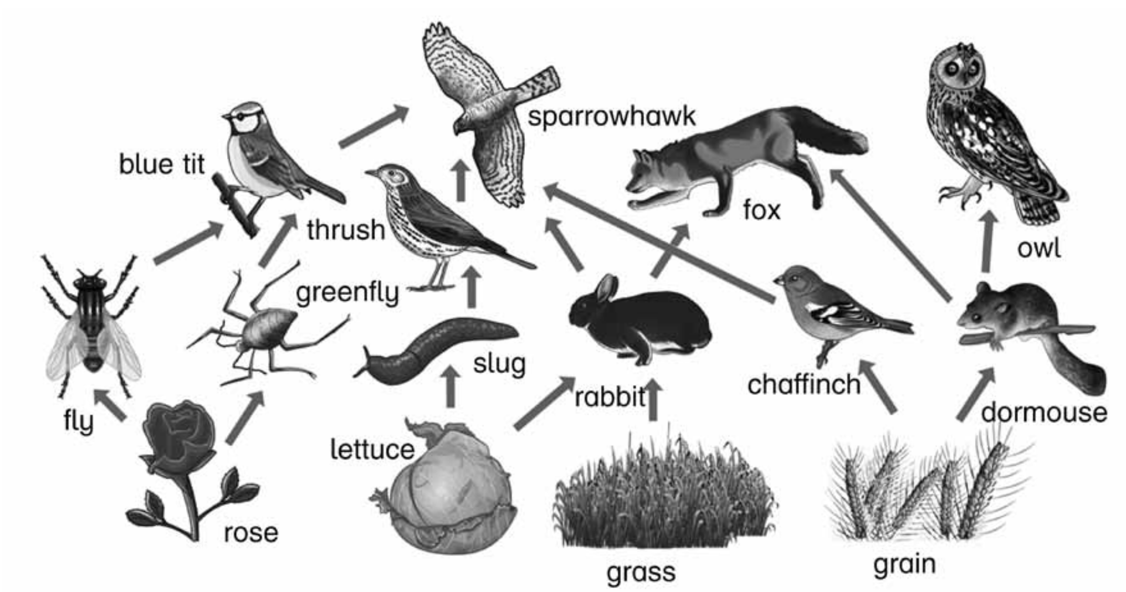
Since the only living things that are able to make their own food are green plants, all other living things, including all animals, are dependent on green plants for food and oxygen. All the different plants and animals in a natural habitat are in a state of balance. This balance is achieved by the plants and animals interacting with each other and with their non-living surroundings (the soil and air).
Some animals, known as herbivores, eat only plants. Some other animals feed on herbivores, while these carnivores or predators may, in turn, be eaten by even larger carnivores. A number of animals eat both plants and other animals, and are called omnivores, while some scavenging animals, or detritivores, eat dead and decaying plants and animals. All living things can thus be joined together in ‘food chains’, all of which begin with green plants (or their dead and decaying remains). One simple example of a food chain can be represented thus:

oak leaf (plant) → caterpillar (herbivore) → sparrow (carnivore 1) → hawk (carnivore 2)

The arrows represent the direction in which energy flows from one organism to the next. All food chains start with plants, and then subsequent links in the food chain are represented by the herbivores that eat plants and the carnivores that feed on herbivores or on other, smaller, carnivores.

With each link of the chain, the amount of energy available gets smaller, and the animal has to search further and wider for enough food. The reason for this is that some energy is lost as it passes from one link to another during a food chain. The leaf uses some energy captured from the Sun to carry out its own life processes. It also wastes some, mainly as heat. There is, therefore, less energy for the caterpillar. The caterpillar, in turn, uses some of this energy it received from the leaf and it also wastes some. There is even less energy to pass on to the sparrow and less still for the hawk. For that reason, most food chains have only five links or less, and the animal at the end of the food chain, the ‘top carnivore’, has to search far and wide over a large territory in order to obtain enough food energy. In general, the organisms at the beginning of a food chain are smaller and more numerous than those at the end of the food chain (the top carnivores).

Food chains are a simple summary of feeding relationships. In reality, in the food chain example given above, many different animals feed on oak leaves, and many different carnivores feed on caterpillars besides sparrows. For this reason, scientists often link food chains together into food webs.



Death and decay

When animals and plants die their bodies decay and eventually disappear into the soil. The main agents of decomposition are bacteria and fungi, although scavengers such as crows and magpies or sexton beetles may feed on the dead animals' remains, and so-called detritivores such as earthworms, woodlice, millipedes, and slugs may feed on the plant remains. Both the scavengers and the detritivores help to break the dead material into smaller pieces. Eventually the dead material becomes food for bacteria and fungi. During the process of decomposition, the once-living tissues are converted to decaying organic matter (or humus) in the soil, and this eventually breaks down to simple mineral salts. These can then be used as food by plants which form the foundation of yet more food chains.

All this recycling of mineral salts occurs as long as the plants and animals die and decay where they have been living. If crops are completely removed from the soil, then the mineral salts and other nutrients are lost from that piece of land. The mineral salts will have to be replaced, by natural or artificial manures or fertilizers, if the soil fertility is not to deteriorate.

Safety

Some children are allergic to certain plants, e.g. some flower bulbs, and pollen (from flowers), and remember that some plants are poisonous. Many children are allergic to certain animals.

Whenever possible, use transparent plastic containers, rather than glass containers, particularly for collecting living things outside.

Use soils free from glass, nails and other sharp objects, and collect soil samples from places that are unlikely to be contaminated with dog or cat faeces. Wash hands after handling soils.

Return any animals to where they were collected after they have been studied. Wash hands after handling animals.

Answers

Habitats and homes: **Rapid Ïre, p 63**

1) A habitat is the place where an animal or plant usually lives.
2) a) woodlouse—hard case, some can curl up into a ball.
   b) ladybird—bright colours and nasty taste.
   c) snail—shell.
   d) bee—sting.
   e) caterpillar—matches the leaves it feeds on.
3) a) shark / sea—streamlined shape, breathes oxygen dissolved in water with gills, moves with fins and tail.
   b) polar bear / Arctic—camouflaged against snow, thick fur and thick layer of fat underneath the skin, its big paws with strong claws act as non-skid soles to grip slippery ice and snow, it is a strong swimmer, and has long, sharp teeth for catching seals.
   c) woodpecker / tree—powerful beak fitted with 'shock-absorbers' for pecking holes in trees and catching burrowing insects, powerful claws for climbing trees, can use tail like a shooting stick to support its body while it climbs a tree trunk.
   d) earthworm / soil—camouflage coloration, elongated shape ideal for burrowing, no legs or hair to impede movement through the soil, two sets of muscles to alter its body shape, bristles on almost every segment to grip the sides of the burrow, can breathe through its skin, obtains its food (decaying plant and animal matter) by eating soil, no eyes or ears as these are unnecessary underground.

Adaptations: **Rapid Ïre, p 65**

1) 'Adaptation' is a special feature or features that make something suited for a particular purpose. The fat stored in the hump of a camel, its ability to go many days without water, and its wide furry feet which act like snowshoes, are among a camel's adaptations to a life in the desert. A fish's adaptations to a life in water include a streamlined body, the ability to breathe dissolved oxygen by means of gills, and fins and a muscular tail for steering and propulsion through water.
2) A snail is adapted to its habitat and food by having a muscular 'foot' on which it slides to reach plant materials. To make its movements over rough surfaces easier it secretes a trail of slime. The snail is able to seal itself inside its shell if the conditions become very dry or very cold, and inside its mouth is a set of teeth rather like a file, which enable it to scrape up and eat plant materials.
3) In general, animals that live in places where there is ice and snow on the ground all the year round are white in colour to match their surroundings. They have either thick fur or very thick, warm feathers, and a layer of insulating fat under the skin. Some hibernate or migrate to warmer climates during the worst of the winter weather; others are able to eat a wide variety of foods so that there is less chance that they will go hungry.

Adaptations: **Try it out, p 65**

1) The snail is able to move over rough and smooth surfaces by secreting a trail of slime, over which its muscular 'foot' can slide more easily.
2) The main kinds of camouflage colouring are white (against snow and ice), green or twig-like (against leaves and trees), sandy- or soil-coloured (against sand and soil) and stripes or blotches (particularly for forest animals such as tigers and jaguars). Many fish have a dark back and lighter underside so that, from above, they match the deep water. A few animals, such as the chameleon, cuttlefish and some toads can change colour to match their surroundings.
3) The adaptations of an earthworm include—camouflage coloration to match the soil, an elongated body shape ideal for burrowing, with no legs or hair to impede movement through the soil, two sets of muscles to alter its body shape, bristles on almost every segment to grip the sides of the burrow. It can

breathe through its thin moist skin, and obtains its food (decaying plant and animal matter) by eating soil. An earthworm has no eyes or ears as these are unnecessary underground, but it is sensitive to light and vibrations.

Finding food: **Rapid Ïre, p 67**

1) Some herbivores that eat mainly grass include cattle, sheep, horses, asses, donkeys, zebras, bison, buffaloes, rabbits, hares, some deer and antelope, and some rhinoceroses. Herbivores that eat plants other than grass include goats, elephants, giraffes, some deer, squirrels, some rhinoceroses, hippopotamuses, and tapirs.
2) Many herbivores look rounded or barrel-shaped because plant material is very difficult to digest and these animals have a very long digestive system to break down the cellulose in plant foods. This long digestive system, packed inside their bodies, accounts for the shape of many herbivores.
3) Herbivores are mainly adapted to eating plants by having sharp incisor teeth to bite off the plants, flattened and ridged molar and premolar teeth to grind their food, and a long and complicated digestive system for breaking down plant cells to obtain the nourishment from them. Most herbivores have their eyes on the sides of their heads so that they can see the approach of enemies while they are bending down to feed. To survive, herbivores have to spend much of every day searching for food and eating. To give themselves greater protection from predators, many live in flocks or herds where there are more eyes and ears to be alert for enemies.

Finding food: **Try it out, p 67**

1) One way to find out how much food a snail or slug eats would be to cut a small square of, say, lettuce or cabbage leaf and measure its area. This piece of leaf is placed in the container with the slug or snail, with no other food available. After 24 hours the area of the leaf eaten can be measured. This technique would allow you to make comparisons between the amount eaten by different individuals or different species of slug or snail.
3) The bees in a bee hive depend upon their human owner for their home, shelter and protection, and sometimes in winter for their food. The bees depend upon each other for finding food, protecting the hive from insect and other intruders, and for caring for the eggs, grubs and queen bee. Certain worker bees also clean the hive.

Carnivores and food chains: **Rapid Ïre, p 69**

1) Herbivores have sharp incisor teeth for biting off plant materials and large, flat-topped molar and premolar teeth for grinding the plant material. By contrast carnivores have long, pointed canine teeth for seizing their prey, while the pointed molar and premolar teeth are used for slicing meat into smaller pieces. Herbivores have a long digestive system, for digesting plant materials, which often makes their bodies appear rounded or barrel-shaped. Carnivores have a shorter digestive system and their bodies are often sleek and streamlined. The eyes of herbivores tend to be at the sides of their heads, while those of carnivores are at the front of the head. Carnivores are usually more intelligent than herbivores.
2) Three food chains of which humans are part are:
   corn ⟶ chicken ⟶ human
   grass ⟶ sheep ⟶ human
   grass ⟶ cow ⟶ human
3) If all the herbivores in a habitat were killed, then the plants would grow and multiply out of control. If all the carnivores were killed, then the herbivores would increase in numbers until, eventually they would have eaten all the plants. At that stage, the herbivores would begin to die of starvation and diseases brought about by shortage of food.

Carnivores and food chains: **Try it out, p 69**

1) A few food chains beginning with grass are:
   grass ⟶ grasshopper ⟶ crow ⟶ hawk
   grass ⟶ antelope ⟶ lion
   grass ⟶ sheep ⟶ human
   grass ⟶ slug ⟶ frog ⟶ otter
   In general, as you move along a food chain the animals become larger and fewer in number.
4) Different bird species eat a wide variety of foods including seeds, plant materials, insects and other invertebrates, and the flesh of vertebrates including fish. Some birds are scavengers. Birds do not have teeth but use their horny beak to tear up or crush their food. The shape of the beak gives a good idea of what a bird eats: flesh-eating birds have hooked beaks to tear at the flesh of their prey, eaters of hard nuts or seeds have stout, powerful beaks to crack them open. Although birds do not have teeth, many species that eat leaves and other plant materials swallow grit. In the birds' muscular gizzard these small stones are used to crush the food. Fish species also eat a variety of foods, plant and animal, invertebrate and vertebrate, living and dead. Some species, including piranhas and sharks do have a large number of pointed teeth.

Wildlife around the school: **Rapid Ïre, p 71**

1) The reason woodlice, earthworms and slugs are often found living under large stones, bricks and pieces of wood, could be because they prefer the dark, prefer high humidity or prefer to live in cool places. It could also be that the food of these animals, decaying plant and animal matter, occurs in these places.
2) a) leaf; b) three; c) slug; d) frog; e) frog; f) heron; g) heron.
3) Four food chains that might occur in an oak tree are:
   leaf ⟶ caterpillar ⟶ sparrow ⟶ hawk
   acorn ⟶ pigeon ⟶ hawk
   leaf ⟶ ant ⟶ spider ⟶ sparrow ⟶ hawk
   acorn ⟶ squirrel ⟶ red fox
   If there were few oak leaves and acorns one year, then the animals which fed on these (the herbivores) would either starve to death or have to find another source of food. If the herbivores died out then the carnivores that preyed on them would either have to find another source of food, or die.

Wildlife around the school: **Try it out, p 71**

1) There will probably be different plants and animals living on the two sides of a wall because one side may be shaded more than the other and, therefore, have more mosses, lichens, ferns and other plants growing on it. The greater abundance of plants will provide more hiding places for those invertebrate animals which eat plants or which prefer dark, damp conditions.
2) The bird species recorded around the school at different times of the year are likely to vary because some species will migrate to the area for the summer to breed and leave in the autumn, while other species will move in to the area for the winter from areas with a colder climate.

Pond life: **Rapid Ïre, p 73**

1) a) Fish, water snails, water beetles, leeches, water spiders, water fleas and freshwater shrimps are just a few of the animals that spend all their lives in water.
   b) Dragonflies, mayflies, damselflies, mosquitoes, frogs, toads and newts are a few of the animals which spend only part of their lives in the water.
   c) Some of the animals that might visit a pond to drink include horses, sheep, cattle, goats, foxes, and hedgehogs.

2) All of the plants need light and water.
3) A frog has strong back legs and large feet to enable it to swim. It can breathe partly through its skin, partly through the inside of its mouth and partly with lungs. Its eyes are near the top of its head to enable it to see while remaining partly submerged.

   A dragonfly has a long tip to its body, from which it can lay eggs onto pond plants. Its larvae are camouflaged and they have powerful jaws that enable them to catch small water animals. Dragonfly larvae can breathe underwater.

   A water flea can feed by filtering tiny plants and animals out of the water. It can breathe underwater and swim with the aid of its tiny feelers and legs.

   A pond snail has camouflage coloration, a shell to hide in and escape from underwater predators, it can breathe underwater and has a tongue covered in tiny teeth for scraping away plant material. Its eggs are laid underwater on plants.

   A water boatman swims on its back while using its slightly flattened legs as oars. It has camouflage coloration and is sensitive to vibrations caused by its prey—small animals moving across the water. It lays its eggs underwater inside plant stems.

Pond life: **Try it out, p 73**
2) It is sometimes possible to make food chains with four or five links if you begin with tiny single-celled algae or dead and decaying vegetation.
3) In general, air loses heat faster than water.

Life by the sea: **Rapid Ïre, p 75**
1) Only the seaweeds in the list are plants. All the other organisms are animals, including sea anemones and sponges.
2) a) The biggest hazard faced by seaweeds is the risk of drying out when the tide goes out and leaves them uncovered. This risk of desiccation is reduced by the production of a slimy liquid that prevents drying out.
   b) Some seashores lack seaweeds because the substrate—sand or gravel—is too mobile for them to be able to attach themselves, or the waves and currents are too strong for them to be able to attach themselves and grow.
   c) There are too many plants which live near the sea to be able to list them. They all have to be able to withstand the strong, salt-laden winds that blow near the coast. In the case of plants which grow on sand dunes, they also have to be able to withstand frequent burial under sand.

Life by the sea: **Try it out, p 75**
2) Oil pollution poisons the seaweeds, shellfish and fish. The feathers of seabirds become coated with the oil so that they either poison themselves trying to clean the oil from their feathers or drown because their feathers are no longer waterproof. The other threats to sea life include pollution by sewage and from chemicals dumped in rivers that flow into the sea. Litter, particularly plastic litter, is often ingested by seals, dolphins, the larger fish and other sea animals.

Going further

Ask students to tie a plastic bag over a low branch of a tree. Shake the branch, but take care not to break it. Look in the bag to see how many small animals have been caught. How, if at all, are these animals camouflaged?

Ask to students to choose an animal that lives in the country and, ideally, near to the school. Find out which habitat it likes to live in and what it eats.

Ask to students to collect 100 ripe seeds from a weed such as a thistle or dandelion plant. Plant the seeds in pots just under the surface of the soil. Keep them warm and moist. How many of the seeds germinate?

Can students find a way to measure the height of a tall tree without climbing it or using a ladder? Test out the method to see whether it works. (One method would be to stand a stick one metre high near the base of the tree. From a distance you then estimate how many times the height of the stick goes into the total height of the tree.)

Do students think animals with more legs move faster than animals with fewer legs? Ask them to plan a test to find out. How will they make the test fair? Try out the ideas and record the results.

Ask students to plan and make a home that offers woodlice a choice of environments, such as light and dark, warm and cold, or moist and dry. Try out the home. Does it work? Record the results.

Ask students to devise an experiment to find out which of three or four kinds of food a common bird prefers. Try out the experiment. Does it work? What did the students discover?

Ask students to collect pictures of different bird species. Find out what are the main foods of each species. How is the shape of a bird's beak adapted to the kinds of foods it eats?

Mosses are some of the most abundant plants. Make a moss garden by planting two or three small tussocks of moss in a few centimetres of soil or potting compost contained in a clear-plastic jar or bottle which is fitted with a lid or stopper. Spray the moss plants and the soil or compost with water from time to time to keep them moist.

Collect pictures of pond or river plants and animals, including fish. Arrange them in order on a card or wallchart so that they form food chains which might occur in freshwater.

Set up an aquarium in the classroom containing either tropical or freshwater fish. Is there a museum or public aquarium in the neighbourhood where the variety of colours and forms of living or preserved fish can be examined and compared?

Discuss the various foods, including fish, shellfish and to a lesser extent seaweeds, we obtain from the sea. Let the students research how these foods are obtained.

Collect pictures of the various structures used by animals for defence, including spines, shells, armour plating, stings, poisons, etc.

1. Plant and animal habitats

What you need:

- pencil

What you do:

Some habitats are better than others for some plants. Match a plant to the habitat in which it would probably be found.

For example, alpine plants are usually found growing on a mountain:

Plant	Habitat
alpine plant	forest
pine tree	marsh
cactus	mountain
moss	sea
pondweed	rock
bulrush	desert
seaweed	lake

In the same way, some habitats are better than others for animals. Match the animal to the habitat where it would probably be found.

Animal	Habitat
squirrel	seashore
deer	river
camel	sea
eagle	woodland
crab	Arctic tundra
reindeer	mountain
whale	forest
trout	desert

2. Habitat conditions

What you need:

- pencil

What you do:

Some plants and animals usually live in places where it is light, others usually live in dark places.

Where do these plants and animals usually live?

Complete the table by putting a tick in the correct box for each plant and animal. You do not need to tick all the boxes for each plant or animal.

Plant or animal	Light?	Dark?	Dry?	Damp?	Hot?	Cold?
earthworm						
woodlouse						
snail						
polar bear						
moss						
cactus						
sunflower						

Can you think of some more examples? Add them to the table.

3. Investigating habitats

What you need:

- pencil
- hand lens
- collecting pots

What you do:

Visit four different habitats in the school grounds.

Habitats you might visit include walls, trees, the soil, lawns, concrete or tarmac, flower beds, and under wood or stones.

Record all the plants and animals you can find in the table below.

Habitat	Animals found	Plants found	Other observations

4. Trees as habitats

Carry out an investigation to find out which animals live in and under trees.

What you need:

- pencil
- plastic spoon
- hand lens
- large sheet of plastic
- collecting trays or pots
- trowel
- plastic bag

What you do:

Lay the large sheet of plastic under the tree.
Shake the branches of the tree using a stick.
Use the spoon to carefully put the animals in pots.
In the classroom, put the animals on a tray and look at them with a hand lens.
Try to identify the animals.

Use a trowel to dig down into the leaf litter underneath the tree.
Take the leaf litter back to the classroom in a plastic bag.
Put some of the leaf litter on a tray and look for animals in it.
Look at the animals with a hand lens.
Try to identify the animals.

Record your findings below.

Tree	**Leaf litter**

Safety: When you have finished looking at the animals, return them to where you found them.

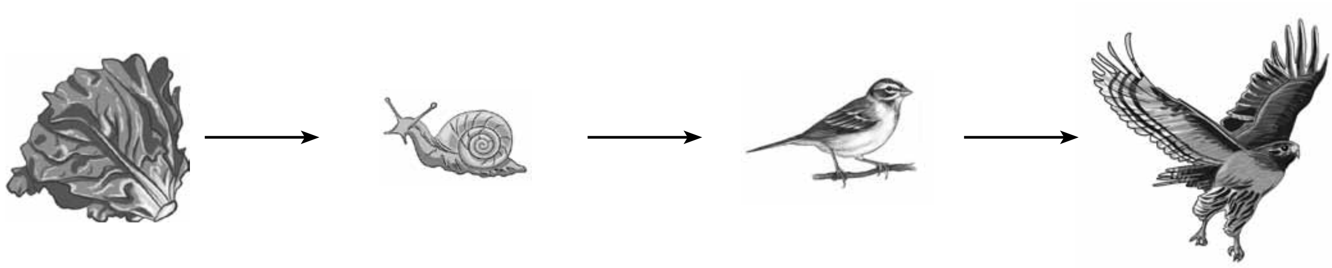
5. Food chains

What you need:

- pencil

What you do:

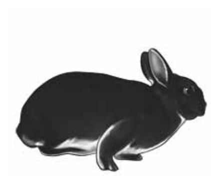
We can make up food chains showing who eats who.
All food chains begin with plants. Here is a simple one:



Here are some pictures of plants and animals you may have seen.
How many food chains can you make using the pictures on this page?
Either write the names of the plants and animals, draw them, or cut out the pictures and stick them on a sheet of paper.










6. Food webs

What you need:

- pencil

What you do:

Most animals eat several kinds of food, so that one animal can be part of many food chains. These overlapping food chains become a food web.

The picture below shows a food web. Which are the producers?

___

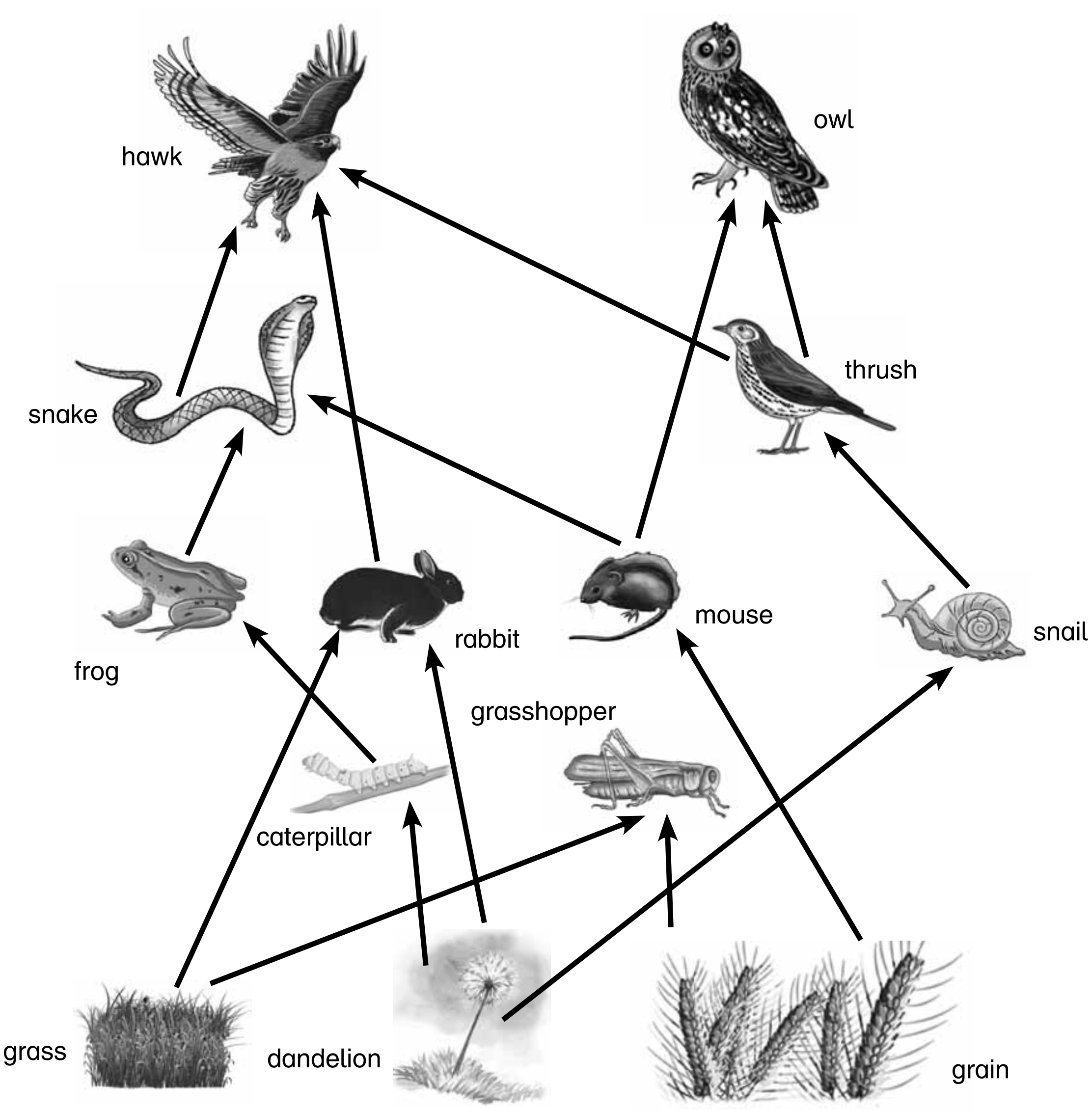
___

Which are the consumers?

___

___

How many different food chains can you see in this food web? Write them out.



Notes on individual worksheets

1. Plant and animal habitats

Key idea *Some habitats are better for certain plants and animals than others.*
Outcome *Alpine plantflmountain; pine treeflforest; cactusfldesert; mossflrock; pondweedfllake; bulrushflmarsh; seaweedflsea.*
Squirrelflwoodland; deerflforest; camelfldesert; eagleflmountain; crabflseashore; reindeerflArctic tundra; whaleflsea; troutflriver.
Extension *Collect pictures of the animals and plants that live in extreme habitats, such as desert and polar regions, and make wallcharts with them.*

2. Habitat conditions

Key idea *To show that animals and plants differ in their requirements from a habitat.*
Outcome *Some of the questions in the table can be left unanswered since the choice does not always make a difference to the plant or animal. These are the likely answers:*
Light: moss, cactus, sunÌower, polar bear.
Dark: earthworm, woodlouse, snail. Dry: cactus.
Damp: earthworm, woodlouse, snail, polar bear, moss, cactus, sunÌower.
Hot: cactus (usually). Cold: polar bear.
Extension *Show the students a picture of a typical house. Discuss what the people who live in the house really need to survive (food, water, shelter, warmth and space). Stress that there are many things we can do without e.g. a TV is not a basic need. Ask the students to draw a house that meets their basic needs.*

3. Investigating habitats

Key idea *To show that different animal and plant species occupy different habitats.*
Extension *Set up a bird feeding area in the school grounds. Observe the birds that visit for food. How are the bird species different according to their size, colour, beaks, feet and feeding habits?*
Safety *Wash hands thoroughly after handling plants, animals and soil.*

4. Trees as habitats

Key idea *To examine trees, and their leaf litter, as possible habitats for animals.*
Outcome *This activity is best carried out using a mature tree which has a previously undisturbed layer of leaf litter beneath it.*
Extension *Put a rotting log or a large stone in a shady part of the school grounds. Look underneath it after several days to see if there are any animal colonists.*
Safety: *Stress the importance of returning the animals to their original habitat after they have been examined. The children should wash their hands thoroughly after handling the leaf litter or the animals.*

5. Food chains

Key idea *Plants and animals in habitats can be linked together as food chains, with each food chain beginning with a green plant.*
Outcome *There are many possible food chains that can be constructed from these plants and animals, but it is important to remember that they should all begin with a green plant. Food chains on land rarely have more than four or Ïve links.*
Extension *Collect pictures of living things that live in a pond or the sea and make food chains with these.*

6. Food webs

Key idea *A food web consists of a series of interlinked food chains.*
Outcome *The producers are the plant species; the consumers are the various animal species.*
Extension: *Discuss what would happen if one or more of the species in the food web was wiped out by a pesticide or some form of pollution.*

GLOSSARY

This glossary gives brief deÏnitions of some of the most important scientiÏc words in the text.

Acid One of a class of sour-tasting substances that contain hydrogen, neutralize alkalis and turn blue litmus red.

Adaptation The process by which organisms change to increase their chances of survival.

Air resistance The force that the air exerts on a moving object.

Algae Simple plants, without proper roots, stems or leaves, that live in damp places, fresh water or the sea.

Animal A living organism that is not a plant and which moves about in search of food.

Atmosphere The layer of air that surrounds the Earth.

Battery A series of two or more electric cells which produce electricity when the chemicals within the battery react together.

Bone One of the hard parts of an animal's body which makes up the skeleton.

Cable Insulated electrical wires bundled together.

Carbohydrates Sugary and starchy foods which are the main source of energy for humans and most animals. Carbohydrates are made by green plants.

Carnivore An animal that feeds mostly on other animals.

Cell (1) The basic unit of living matter. It contains a jelly-like material, called protoplasm, surrounded by a thin cell membrane. Plant cells also have a stiff cell wall on their outside made of cellulose. (2) A container with materials for producing electricity.

Chemical change A change in a material that produces another material.

Chromosome One of a number of paired, microscopic threadlike structures found in the nucleus of a cell. Chromosomes contain the hereditary material, or genes.

Circuit The complete path of an electric current around a series of wires and connections. If there is a break in the circuit, the current will not flow.

ClassiÏcation The grouping together of plants, animals or objects that have similar characteristics.

Competition The struggle among living organisms for a limited supply of such things as food, water, oxygen, mates or a space in which to live.

Conductor A material that allows heat or electricity to pass through it easily.

Consumer A living thing (usually an animal) that consumes food it has not produced.

Contract To become shorter or smaller in size.

Control A standard of comparison for checking the validity of the results of an experiment. (Often an additional experiment where any possible variables are not allowed to vary, and which is run alongside the experiment under investigation.) It is used to eliminate possible sources of error.

Current A flow of electricity (electrons) through a conductor, e.g. in a wire.

Digestion The process by which food is made soluble by the action of digestive juices containing enzymes.

Decant To let a solid settle to the bottom of a liquid and then to pour off the liquid very carefully.

Digest To break down food into tiny pieces that the body can absorb and use.

Digestive system The stomach, intestines and other parts of the body where food is digested.

Dissolve To make a solid substance or a gas break up and disappear into a liquid. Together they make a solution.

Drug A chemical, other than a food, taken into the body which has an effect on the body.

Electricity A supply of energy provided by a flow of electrons.

Energy The power and ability something has to do work.

Environment The surroundings in which animals and plants live.

Evaporate To change a liquid into a vapour by using heat or moving air.

Experiment A test carried out in order to discover something unknown or to demonstrate something that is already known.

Explanation A statement or circumstance that explains something.

Fair test A test or experiment in which only one thing (called a variable) at a time is allowed to change or be tested.

Fibre (1) A thin strand or thread of a material. (2) Plant fibre or cellulose which forms a very important part of our diet and helps to keep the digestive system healthy and functioning properly.

Flower The reproductive part of a seed-bearing plant.

Food chain A series of living things that depend on each other for food energy. The chain starts with a green plant that is eaten by an animal.

Force A push or pull that starts or stops the movement of an object, changes its direction when it is already moving, or changes the shape of an object.

Freeze To change a liquid into a solid by cooling it.

Friction The force that slows down movement and produces heat when two surfaces rub together.

Fuel A material that is used to produce heat or power by burning or nuclear fusion. Most fuels (with the exception of nuclear fuels) are carbon compounds.

Gas One of the three states of matter. A substance that has no shape and can spread everywhere. Air is made up of a mixture of different gases.

Generator A machine for changing mechanical energy into electrical energy.

Growth An increase in size or development of a plant or animal.

Habitat The local environment occupied by a plant or animal.

Heat A form of energy (contrast it with temperature). Heat energy can only be transferred from a hotter body to a colder body.

Herbivore An animal that feeds mainly on parts of plants, such as roots, fruits, leaves or seeds.

Hypothesis A principle put forward to serve as the starting point for an argument or an experimental procedure; an idea that can be tested.

Insulate To cover something to keep it hot or cold for longer; to stop electricity flowing from a wire or other material.

Insulator A material that does not allow heat or electricity to pass through it easily.

Invertebrate An animal that does not have an internal skeleton or backbone.

Involuntary muscle A muscle that works automatically and which we cannot control by thinking about it.

Joint A place in the body where two bones are joined, usually so that they can move freely.

Liquid One of the three states of matter. A substance that can be poured and which spreads out to take the shape of the container.

Mammal A vertebrate animal that is warm-blooded and usually covered with hair or fur. The female produces the young inside her body and feeds them on milk.

Marrow The soft substance found inside bones which produces red blood cells.

Material Any matter from which other things can be made.

Medicine Any substance taken into the body that is used to treat illness or pain.

Melt To change a solid into a liquid by heating.

Melting point The temperature at which a substance begins to change from a solid to a liquid.

Meniscus The curved surface of a liquid in a narrow, open-ended tube or container.

Metal A shiny solid substance (with the exception of mercury which is a liquid at room temperature) that conducts heat and electricity.

Micro-organism A living organism, such as a bacterium, which can only be seen through a microscope.

Mineral salt A soluble mineral substance needed by living organisms to stay alive.

Muscle A special tissue in animals which, when stimulated by a nerve impulse, can contract i.e. becomes shorter and fatter.

Parallel circuit An electrical circuit that splits into branches so that current flows to all branches of the circuit. Each part of the circuit receives the same amount of electricity.

Photosynthesis The process by which green plants make their food from simple raw materials, using the energy from sunlight.

Physical change A change in shape, form or state that does not result in a new material being formed.

Plant A living organism; a member of the plant kingdom. All plants make their own food by photosynthesis. Like animals plants respire, grow, reproduce, excrete, and respond to stimuli; unlike animals, they cannot move from place to place.

Plastic Any synthetic material that can be moulded into a shape when heated, and then sets hard when cooled.

Pollution A substance or action that spoils and poisons any part of the environment.

Population The total number of organisms of a species living in a particular area at any one time.

Predator An animal that eats other animals (also called a carnivore).

Prediction Fortelling or prophesying; suggesting an outcome.

Prey One of the animals killed and eaten by a predator.

Producer A green plant which uses energy from the Sun to make its food so that it can grow and reproduce.

Protein One of the main bodybuilding materials in foods.

Reproduction The process by which living organisms produce offspring.

Respiration A sequence of chemical reactions, in which oxygen usually takes part, that release energy in living cells.

Rust The reddish-brown coat, a form of iron oxide, which forms on iron when it is exposed to moist air.

Science The ever-growing body of knowledge about the physical or natural world.

Series circuit A type of electrical circuit in which all the parts are joined, one after the other, so that the electric current is shared by them.

Skeleton The hard frame that gives the body its shape and protects its soft organs.

Soil The small loose particles, formed from weathered rock and humus, in the top layer of the Earth's crust.

Solid One of the three states of matter. Solids keep their shape unless a force is applied to them.

Solute Any substance that dissolves in water or any other liquid.

Solution A liquid in which one or more solutes are dissolved.

Solvent The liquid in which a solute will dissolve to form a solution.

Species A group of organisms that can breed with each other to produce fertile offspring.

State One of the states of matter, either solid, liquid or gas.

Switch A device used to start or stop the flow of electricity in a circuit.

Telegraph A way of sending messages over a distance by using an electric current and a special switch.

Temperature A measure of the relative hotness or coldness of something. If heat energy is added to a system its temperature will rise. If heat energy is removed, the temperature will fall.

Tendon A strong cord of tissue that fixes a muscle to a bone.

Terminal The parts of a battery to which the wires must be connected in a circuit.

Theory A general view based on a number of hypotheses or suppositions (often with widespread support).

Thermal insulator A material which does not allow heat to pass through it easily.

Thermometer An instrument used to measure temperature.

Universe Everything that exists, including the Sun, Earth, planets, galaxies and other bodies in space.

Variable Any classifiable feature of the subject to be investigated: light intensity, temperature, height, weight, etc.

Variation The differences between the individuals of a race, subspecies, or species.

Vertebrate An animal that has an internal skeleton of bone or cartilage with a backbone, a skull and a well-developed brain.

Vitamin A nutrient, needed in minute quantities, which speeds up some chemical reactions in the body and helps to keep us healthy.

Voltage The electrical 'pressure' that drives an electric current around a circuit—an indicator of the energy carried by the current.

Voluntary muscle A muscle we can control by thinking about it.

Water resistance The force that water exerts on a moving object.

Water vapour The gaseous form of water.

Wave A raised ridge of water along the surface of an ocean, sea or large lake caused by the wind blowing on the water.