TEACHER'S GUIDE

Simply Science 5

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* The staff of the educational institution has the right to photocopy the worksheets in this book only, provided that the number of copies does not exceed the number reasonably required by the institution to satisfy its teaching purposes.

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 especially 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 fire* 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 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 extend the students' knowledge of the way in which plants and animals in different habitats depend upon each other and are adapted to their particular environments
- To relate feeding methods, food chains and food webs to a knowledge of plant and animal nutrition
- To examine the formation, structure and importance of soil
- To introduce simple ideas on animal and plant classification and the use of keys to identify living organisms

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.

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).

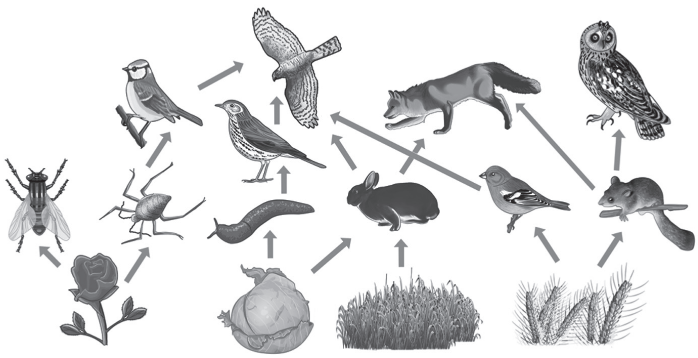
Some animals, known as herbivores, eat only plants. Some other animals feed on herbivores, while these carnivores or predators may, in turn, be eaten by even larger carnivores. A number of animals eat both plants and other animals, and are called omnivores, while some scavenging animals, or detritivores, 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 becomes smaller, and the animal has to search further and wider for enough food. The reason for this is that a lot of energy is lost as it passes from one link to another in 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 available for the caterpillar. The caterpillar, in turn, uses some of the 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 fewer, 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 before, 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 burying 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.

Classification of living things

To make it easier to study the vast array of living things on Earth, scientists arrange them in order, grouping together those resembling each other in important details.

There are many ways in which animals and plants can be classified. They can, for instance, be grouped according to colour, size, or shape. Plants can be grouped by whether or not they are woody. Such groupings are not always satisfactory since, even within one species, these factors may be variable. Although the number or type of limbs and number of body segments are very important in classifying animals, in general, appearance is a poor guide to classification. A whale, for example, looks like a fish but is really a mammal that has taken to the water. Similarly, a bat is not necessarily related to birds because it has wings and can fly.

It is far more reliable when classifying animals or plants to compare their internal structure, how they reproduce, and other such important facts. With younger students, of course, such classification is not possible. It is sufficient for them to know that the animal kingdom can be split into two broad groups. On the one hand we have animals with a backbone inside their bodies, consisting of a number of separate pieces linked like the carriages of a train. These animals are known as vertebrates, and they include mammals, birds, reptiles, amphibians and fish. Then there is the vast array of animals without such a backbone, the invertebrates. Some of these have no skeleton at all, while others have a shell or tough outer casing. The invertebrates include slugs, snails, octopuses, crabs, moths, butterflies, spiders, and many other minute creatures visible only with a microscope.

Vertebrate groups

For students in the upper part of the primary school, some knowledge of the general features of the five groups of vertebrate animals (fish, amphibians, reptiles, birds, and mammals) is important.

Fish

Fish have features that make them perfectly adapted for a life spent permanently in water. They have a streamlined shape and their bodies are covered with overlapping scales. They breathe through gills and swim using fins. Some sea fish, such as sharks, skates, and rays, have a skeleton of a gristly material called cartilage, but the majority of fish have a skeleton of bone. Such bony fish, including cod, haddock, goldfish, trout, and salmon, are buoyed up by an air-filled space in their bodies called a swim bladder, and unless they keep swimming they tend to sink. Almost all bony fish produce vast numbers of eggs; for instance a female cod may lay between one and five million eggs. These are poured out into the water and fertilized by sperm from the male fish. Cartilaginous fish produce only a few eggs which are fertilized inside the mother's body. In many species the egg develops inside a horny container often called a 'mermaid's purse'.

Amphibians

These animals include frogs, toads, newts, and salamanders. They have four limbs and a thin, moist skin without scales. Amphibians can live in fresh water, breathing with gills, but on land they breathe with lungs. They lay their eggs in water, and these hatch into larvae called tadpoles, which breathe with gills and swim with a tail.

Reptiles

Reptiles have a dry, scaly skin. They all have four limbs, with the exception of snakes and a few lizards. All reptiles breathe with lungs, even those species such as terrapins, turtles, crocodiles and alligators, that live in water. Reptile eggs do not have to be laid in water because they have tough, leathery coverings that stop them drying out. The eggs do not hatch into larvae, but into small versions of the parents.

Birds

In those birds that can fly (the vast majority, with the exception of a few species like the ostrich, emu, kiwi, and penguins), almost every part of the body is adapted to help them to fly efficiently. The two fore-limbs have evolved into wings while the legs are scaly, like those of a reptile. Birds have a streamlined shape, with even the ears covered with feathers, and their bones are hollow, honeycombed, or moulded into thin sheets for lightness. Feathers, which are unique to birds, are of three main types. Flight feathers on the wings and tail are responsible for flight; contour feathers cover the body giving it its streamlined shape; and fluffy down feathers keep the bird's body warm. All birds are warm-blooded, which means their body keeps a constant temperature, regardless of the external conditions.

Birds feed using a beak (they have no teeth). Their lungs extend into air sacs, which lighten the body as well as assisting in breathing. A bird's heart is large and it beats rapidly during flight, circulating blood quickly to the flight muscles. These muscles are also large and powerful. They are attached to a huge breast bone which sticks out from the chest like the keel of a boat.

All birds lay shelled eggs, often in a nest. The eggs are incubated by one or both parents until they hatch, when the young are cared for by the parents until they can fly.

Mammals

Mammals, like birds, are warm-blooded. Some of this warmth is kept in by their insulating covering of hair or fur. Female mammals suckle their young on milk from mammary glands (breasts).

There are three groups of mammals. Monotremes are the egg-laying mammals, such as the spiny anteater and duck-billed platypus. After hatching, the young are fed on milk from teatless breasts. Marsupials are the pouched animals, such as kangaroos, wallabies, opossums, koalas, and bandicoots. Young marsupials are born before they are completely developed. After birth they crawl into the mother's pouch, where they obtain milk from a teat and complete their development. The largest group of mammals is the placental mammals, which includes humans. Young placental mammals develop to an advanced stage before they are born. Development takes place inside the mother's body, where the young are attached to the wall of the womb by an organ called the placenta. The placenta supplies the developing baby with food and oxygen taken from the mother's blood.

Other features of mammals include an external part to the ear (pinna), different types of teeth to tear, chew, grind, or chop food, a well-developed brain, and a muscular sheet (diaphragm) which separates the chest from the abdomen and functions in breathing.

Mammals have four limbs. Most of them live on land, but some mammals, such as whales, porpoises and dolphins live in water, while bats have a thin membrane stretching between the fore- and hind-limbs and can fly.

Classification of plants

With plants, simple classification based, perhaps, on trees and shrubs, non-woody flowering plants (flowers), mosses, ferns, seaweeds, and mushrooms and toadstools (or fungi) is more than sufficient in the early part of the primary school. Later it is necessary to go a little further with classification.

It is helpful to think of plants as falling into two broad groups: those that reproduce with seeds and those that reproduce by means of spores.

Seed plants

Of the seed plants, we again have two broad groups. There are plants which produce their seeds inside cones. Technically these are called Gymnosperms, but it is sufficient at this stage simply to call them conifers. Nearly all the conifers are trees. They have clusters of needle-like leaves, and male and female cones (flowers) on the same tree. Male cones are small and yellowish and they occur in groups. In spring and early summer the male cones release clouds of yellow pollen into the air. Female cones are much larger, borne singly, and made up of scales. When pollen has blown on to the open scales of the female cone, the whole cone closes. After fertilization the seeds start to grow inside the female cone, which becomes big and woody. The seeds take over a year to ripen, and eventually the scales of the cone open and the seeds blow away. The conifers include pine, larch, spruce, yew, cedar, redwood, and juniper. The vast majority of conifers are evergreens and their wood makes valuable timber called softwood.

The other group of the seed plants is the flowering plants, or Angiosperms. These bear true flowers which contain reproductive organs that produce seeds. Male organs, called stamens, produce pollen grains. These fertilize ovules (egg cells) in female organs called carpels. A fertilized ovule develops into a seed contained in a fruit. The flowering plants include herbaceous plants, grasses, sedges and rushes, and all shrubs and trees apart from the conifers.

Spore-bearing plants

The spore-bearing plants include ferns, mosses, liverworts and algae. The latter include seaweeds and many simple pondweeds. There is no room, or necessity to look at these in detail here, but a brief examination of the ferns, mosses and liverworts will give an idea of how these primitive plants live and reproduce.

Ferns are the largest of the plants which reproduce by means of spores. Many have big feathery leaves (fronds) that unroll from the tip as they grow. Spores for reproduction are produced on the underside of certain leaves. Bracken is a common example of a fern that grows widely in dry places, although most ferns grow in more moist habitats. The male or shield fern, for example, is commonly planted in moist shady gardens or found growing in woodlands.

Many ferns vary from the typical ones. Hart's tongue fern, for example, has long, undivided leaves, and some small ferns, such as spleenwort, grow in the damp crevices in walls and cliffs. In late summer, a fern produces rows or groups of brown dots or stripes on the underside of some of its leaves. Each of these brown dots or stripes contains minute spores which are carried away in air currents. The spores only grow in moist places and at first they produce a small leafy plant, which looks rather like a liverwort. These tiny plants produce sperms and egg cells and, after fertilization an egg cell starts to grow into a new fern plant.

Mosses and liverworts are closely related simple plants. Liverworts usually grow in the form of a flat plate of green cells against the ground. Mosses and liverworts do not have proper roots, stems or leaves, although they often have structures which look like them. Mosses and liverworts both require water for reproduction, because the male sex organs produce sperms which must swim to the female organ to fertilize it. The fertilized egg cell grows to form a stalk with a capsule on it. The capsule contains many spores which are spread by the wind.

Most mosses grow in woodland or on trees, and walls, or between paving slabs. Sphagnum moss is found in marshes and bogs, where its partially decayed remains solidify to form peat.

Safety

Visits beyond the school grounds must be carried out in accordance with the guidelines of your school or employing authority.
Whenever possible, use transparent plastic containers, rather than glass containers, particularly for holding water or collecting living things outside.
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.
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 and plants, and after investigating ponds, rivers, streams and ditches.

Answers

Living things depend upon each other: **Rapid fire, p 3**

1) a) cow, sheep, goat, horse
   b) grass or human
   c) adult duck (or drake) or human
   d) other worker bees, human, flowers
   e) deer, antelope or some other prey animal
   f) fish, plankton (or even seaweed)
2) a) Secondary predators need good eyesight and a keen sense of smell to detect their prey.
   b) If all the secondary consumers or predators in an area were killed, the number of herbivores would increase until they had consumed or trampled all the plants on which they feed. The population of herbivores would then slump as starvation or disease overtakes them.
3) If the plants at the beginning of a food chain were sprayed with a poisonous chemical, it would probably kill the plants. If it did not, then the herbivores which fed on the plants would consume large quantities of the poison, which, if it did not kill them, would pass on, in increased amounts, to the carnivores in the food chain. These would then either die or be unable to breed.

Living things depend upon each other: **Try it out, p 3**

1) Producers: grass, cabbage, lettuce, oak tree, seaweed.
   First consumers (herbivores): sheep, mouse, caterpillar, limpet, slug.
   Secondary consumers (carnivores): fox, lion, eagle, turtle, otter, tawny owl, thrush, jungle cat, blue whale, shark.

A few food chains using these organisms are:
grass → sheep → lion
grass → slug → thrush → eagle
seaweed → limpet → turtle → shark
cabbage → caterpillar → thrush → tawny owl

Food webs: **Rapid fire, p 5**

1) A few food chains that include humans are:
wheat → chicken → human
grass → cow → human
plankton → shellfish → fish → human
grass → sheep → human
dead leaf → earthworm → chicken → human
2) a) cabbage → caterpillar → thrush
b) tiny plants → tiny animals → fish
c) grass → sheep → human
d) dead leaf → earthworm → frog
3) A few seashore food chains are:
seaweed → limpet → dog whelk → crab
seaweed → winkle → crab → fish → sea bird
seaweed → topshell → crab → sea bird
dead matter → shrimp → sea anemone → sea slug → sea bird

River habitats: **Rapid fire, p 7**

1) Fish have a streamlined body, scales that overlap like the tiles on a roof, fins and a tail, and they breathe with gills so that they do not have to keep coming to the surface to obtain air.
2) Open answers.
3) a) Rivers help people by providing water for drinking, irrigation, industrial processes and cooling, and also hydroelectricity. They provide a means of moving people and goods from place to place.
b) Rivers can hinder people by providing a barrier to transport and by causing death and destruction when they flood.

River habitats: **Try it out, p 7**

3) Rivers are often straightened and made deeper (canalized) to prevent flooding. The water then travels out to sea more quickly than it would if the river was left in its original state. Straightening the river destroys habitats for animals such as otters and water birds on the river banks, and because the water flows more rapidly it is often unsuitable for animals and plants that normally live in slow-moving rivers.

Life in a forest: **Rapid fire, p 9**

2) If forests on hillsides are cut down, the rivers in the valleys below often flood because the trees are no longer present to intercept and absorb the heavy rainfall, and then release it slowly. In addition, without the trees on the hillsides, soil erosion often occurs, and the soil clogs the river below, making it more prone to flooding.
3) deer: camouflage colouring, feed on tree leaves
squirrel: camouflage colouring, strong claws and large tail which acts as a balance when it climbs trees or jumps from tree to tree, feeds largely on tree fruits and seeds

woodpecker: long and strong beak for drilling into wood and extracting insects and their larvae, long, sticky tongue for extracting insects and larvae, tail can be used as a 'shooting stick', strong claws for clinging to tree trunks

woodlouse: camouflage colouring, feeds on decaying wood and leaves, breathes with gills so that it can live in damp, dark places

owl: powerful claws and hooked beak for catching and killing prey, eyes face forward to give binocular vision, can see in dim light

fox: camouflage colouring, eyes at front to give binocular vision, acute sense of smell, strong canine teeth for catching prey

If the forest was cleared, the animals would either have to move to a new habitat, or die.

How soil is formed: **Rapid fire, p 11**

1) Soil consists of ground-up rock, together with decaying plant and animal remains (humus). The rock has been broken down by the action of the weather—wind, rain, ice and the heat of the Sun. The decaying plant and animal matter comes from living things that have grown in or on the rock fragments.
2) Some of the places where rocks are exposed include, cliffs, scree slopes on mountains, river valleys, quarries, and the sides of road and railway cuttings.
3) The soil on the lower slopes of hills is much deeper than that on the tops because the soil either washes down or slips down under the influence of gravity. The soil accumulates on the lower slopes where the gradient is less steep.

How soil is formed: **Try it out, p 11**

3) The easiest way to make a garden on the side of a hill would be to cut steps or terraces in the side of the hill. Ideally the vertical sides of the steps or terraces should be made of brick or stone to prevent the soil within being washed away.

Different types of soil: **Rapid fire, p 13**

1) The difference between the weight of wheat seeds sown and the weight of wheat and straw harvested is due to the fact that wheat plants, like all green plants, make their own food by photosynthesis. Water and mineral salts are taken up from the soil, while carbon dioxide gas is taken from the air. These materials are combined to make food and new growth for the plants.
2) Because of the large gaps between the particles, a gravel soil would be well aerated and also well drained. It would contain few, if any, mineral salts and few plants would be able to grow on it.
3) Few plants grow in desert areas mainly because of the dry conditions. And because few plants grow, there is little humus in a desert soil to hold water and mineral salts. If a desert soil is irrigated it can produce good crops.

Different types of soil: **Try it out, p 13**

1) The soil near the surface of the ground (topsoil) is more fertile than the soil about 30 centimetres down (subsoil). This is because the humus and soil animals such as earthworms are mainly found in the surface layers. One way to compare the fertility of topsoil and subsoil would be to put an equal quantity of each in separate pots and to sprinkle quick-growing seeds, such as grass, mung bean, cress or mustard seeds, in equal quantities on the surface of the soils. The two pots would have to be given identical quantities of water. It would then be possible to see which seeds grew best. A more convincing method would be to use seeds which require large quantities of nutrients, such as those of the radish plant.
2) Briefly, earthworms breathe through their skin, which has to be kept moist. They are hermaphrodite, which means they have both male and female organs, although two worms have to mate before eggs

can be produced. Earthworms feed on decaying plant and animal matter which they extract from the soil. The waste soil is ejected as worm casts, and these are fertile and seeds grow well in them. Earthworms drag leaves into their burrows and these decay and form humus, while the burrows themselves aerate and drain the soil.

Animal groups: **Rapid fire, p 17**

1) Plants: grass, seaweed, oak tree, daisy, pine tree, moss, lettuce, fern and dandelion.
   Animals: earthworm, jellyfish, goldfish, horse, housefly, dragonfly, snake, mouse, eagle and woodlouse.
   The plants could be divided up into those which bear flowers and those which do not, and those which are woody and those which are not. The animals could be divided up into vertebrates and invertebrates, those with and without wings, and those with no legs, two legs or more than two legs.
2) The insects could be divided into those which are solitary and those which live in groups (such as ants, bees, wasps and termites), those with wings and those without wings, and those which are aquatic and those which live on land.
3) a) birds; b) worms; c) mammals; d) insects; e) fish

Animal groups: **Try it out, p 17**

2) Cats and dogs are similar in that they are both mammals. Their young are born blind and helpless and are fed on milk from their mother. They are also carnivores, with the typical carnivore teeth. They have eyes towards the front of their heads, which allows them to judge distances accurately when hunting. They have sensory whiskers on their faces. The principal difference is in size, with domestic cats being smaller than most dogs, and also cats tend to be more nocturnal than dogs. Domestic cats often eat mainly fish, while dogs eat mainly meat.
3) Some of the ways the animals could be divided up include vertebrates and invertebrates; those with an internal skeleton, an external skeleton or no skeleton; mammals, reptiles, birds, fishes, amphibians, and insects and other invertebrates; those with and without wings, and those with no legs, two legs or more than two legs; those which are aquatic and those which live on land; carnivores, herbivores, scavengers and detritivores; and also on the basis of colour, size or shape.

Plant groups: **Rapid fire, p 19**

1) The main difference between a plant and an animal is that plants can make their own food, by the process of photosynthesis, whereas animals eat either plants or other animals. Animals can move from place to place, whereas plants move only slowly as they grow. Animals usually stop growing when they become adult, while plants generally continue to grow for as long as they live. A difference the students may not know is that plant cells are surrounded by a cell wall made of cellulose, whereas animal cells are surrounded only by a thin cell membrane.
2) Open answers.
3) We depend upon plants for food, and to produce the oxygen gas we and all other living things need to breathe. We depend upon plants for wood to use as a fuel and all things made from timber and paper, for clothing materials made from flax (linen) and cotton, and for many medicines. One woody plant, the bamboo, is used to make hats, baskets, mats, house walls and roofs, and for scaffolding poles. The animals which give us meat, milk, eggs, wool and leather also feed on plants. Plants growing on hillsides, mountains and the sides of road and railway cuttings prevent soil erosion, landslides and flooding. Plants are also the major contributors to the humus in soil, on which other plants and animals ultimately depend.

Introducing keys: **Rapid fire, p 21**

1) A key is used to sort plants and animals into groups by examining and comparing their characteristics. A key can also be used to identify unknown plants and animals.

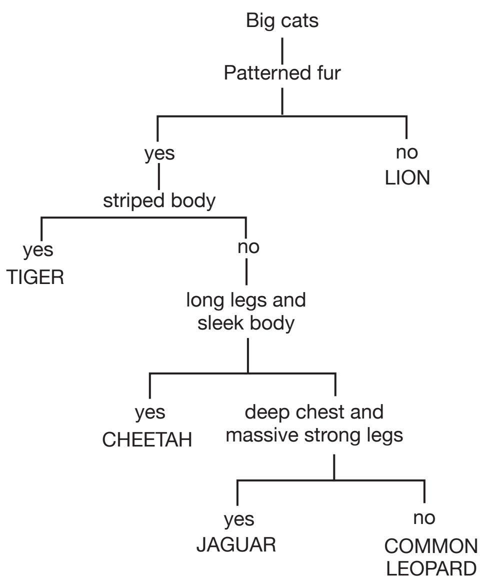
2) a) Mohsin
   b) In order to distinguish between Ejaz and Mohsin, since they both have brown hair
   c) Adil
   d) Nida and Sara
   e) Yasmin

3) A key concentrates on the important differences between plants and animals which are not always visible in a picture.

Introducing keys: **Try it out, p 21**

1)

BRANCHING KEY



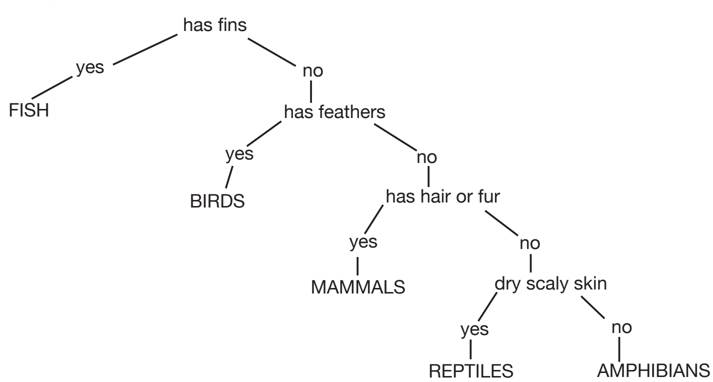
NUMBERED KEY

1	Has patterned fur Does not have patterned fur	2 LION
2	Has striped body Does not have stripes	TIGER 3
3	Has long legs and long, sleek body Has stouter body and shorter legs	CHEETAH 4
4	Deep chest, massive strong limbs Long body and relatively short legs	JAGUAR COMMON LEOPARD

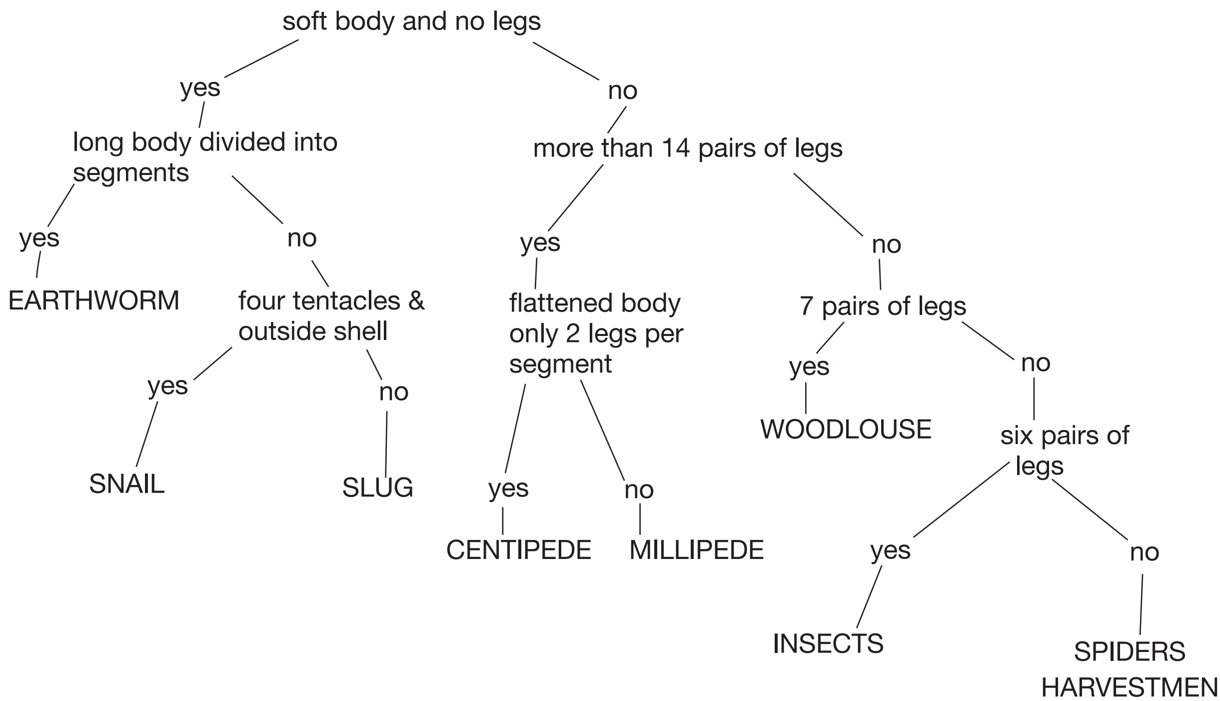
Using keys: **Rapid fire, p 23**

1) When making a key to separate animals it is better to avoid characteristics such as colour, habitat or food since these can vary, even within the same species. It is better to use features such as type of skeleton, if any, type of teeth, number and type of limbs, type of body covering (fur, feathers, scales), method of reproduction (eggs or living babies), etc. These are features, which rarely change during the life of the animal.

2) **VERTEBRATES**



INVERTEBRATES



3)

1	Does it have legs? No legs	4 2
2	Long, thin body with dry scales. Moist, slimy skin	SNAKE 3
3	Long, thin body Body shorter and wider, gold colour	EEL GOLDFISH
4	Two legs and feathers on body Four legs	SPARROW 5
5	Moist body, no tail Has a tail	TOAD 6
6	Small, with dry scaly skin Body with hair or fur	LIZARD 7
7	Has horns No horns	COW HORSE

Please note: There is not a ‘correct’ answer to questions 2 and 3 above. Any key which distinguishes clearly between the animals or animal groups is perfectly satisfactory.

Assessment: **p 24-25**

1) i) c) cabbage
   ii) b) cow
   iii) b) chicken   wheat   cow
   iv) a) deer   c) rabbit   e) sheep
   v) c) lion   d) otter   e) leopard
2) a) The garden soil.
   b) It holds water better than the sand but also contains plenty of air.
   c) Choose from the following: The pots must be exactly the same size; the holes in the bottom of each pot must be exactly the same size; the same amount of soil must be placed in each pot; the same amount of water must be poured in the same way into each pot.
   d) The plant nutrients (mineral salts) are dissolved in the soil water and the plant root hairs absorb the mineral salts when they take water from the soil.
   e) One way would be to cover an identical known volume of each sample of soil with an identical disc of cardboard. Then place an identical heavy weight on each disc and measure by how much the volume of each soil is reduced. This reduction in volume is the amount of air in the samples of soil.
3) a) woodlouse   b) wasp   c) dragonfly
4) a) leopard
   b) octopus
   c) frog and eagle
   d) An amphibian lives part of its life on land and part in water; it has a thin, damp skin; it lays eggs and the young (called tadpoles) breathe with gills, while the adults have lungs.
   e) A human would belong in groups A, D and F
5) a) plankton (in particular the plants in the plankton)
   b) sardine
   c) mackerel
   d) If large numbers of groupers were removed from the food chain, the numbers of mackerel would increase. There would then be a reduction in the numbers of sardines.
   e) If the number of plankton organisms increased dramatically, there would be more food for the sardines and their numbers would increase.
   f) If humans killed more groupers, the numbers of mackerel would increase. There would then be a reduction in the numbers of sardines, which would allow more plankton to be produced so that the numbers of whales would then increase.

Going further

If possible, visit a local zoo, natural history museum or bird sanctuary to allow the students to have practical experience in investigating animal groupings.

Collect pictures of plants and animals from books or, if you can, draw and colour your own pictures of plants and animals. Use your pictures to illustrate a food chain that you might find in:

a) a garden or park   b) a pond, lake or river   c) the seashore   d) a forest

Make a large mural of an aquatic and a land habitat. Add drawings of the plants and animals which are found in each area. Attach labels showing the features of the plants and animals which make them suited to their habitat.

Write the names of five animals across the top of a sheet of paper. Here is an example, but you could choose animals of your own:

lion	eagle	shark	spider	otter
Antelope Grass				

Underneath the name of the animal, write the name of its main food. If that is also an animal, write underneath what it feeds on. Keep on until you finish with a plant or part of a plant. Then write out your lists as food chains. What is the longest food chain you can find? What is the shortest?

Find out what kinds of woods and forests have the most wildlife in them: natural woods and forests of broad-leaved trees or man-made forests of conifers? Why is this?

Working with a group of friends, students make a collage of a forest to show its structure and the different animals which live in it. Collect pictures of the different animals and stick them in the correct places in the forest. For each of the animals, discuss how it is especially suited to its habitat.

Carefully examine some pieces of decaying or rotting wood. Describe their smell and what they feel like. Are there any animals living in the rotting wood? If so, what kinds are they?

Put some pondweed (or a piece of mint plant) under a funnel in a glass or clear-plastic bowl of water. Fill a small transparent bottle with water and invert it over the funnel. Stand the bowl on a sunny window sill. As the plant makes it food, by photosynthesis, it will give off a gas (oxygen) which will collect in the top of the small bottle.

Try putting a small square of carpet on the school field or a lawn. Leave it for a week and then lift it slowly and look underneath. Ask the students what has happened to the plants. Are they still green? How have they grown? What animals have come to the carpet square? What animals choose the dark and damp? What do they do when the carpet square is lifted?

Find out why we dig gardens. Dig a hole in the garden and put all the soil from the hole on to sheets of plastic or thick paper. Now carefully put all the soil back in the hole without treading on it. Can you get all the soil back into the hole? If you cannot, what has made the soil take up more room? (air) Why is this important?

Cut out 30 or 40 pictures of different animals from magazines. Stick each picture on to a separate piece of card. Give the cards to a group of students. In how many ways can the animals be sorted? (Possible groupings may include: colour, size, body covering, how they move, number of legs, with or without wings, where they live, what they eat, and so on.)

Make a collection of house plants, as varied as possible. Challenge the students to sort them into groups in the same way they did the picture cards of animals.

Collect pictures of five different plants. Draw up a key to separate them. When you make your key, think about such things as flowers, leaves, seeds, habitat, whether or not they are woody.

Put labels naming a plant or animal on the backs of three or four students in the class. These students are allowed to ask questions, in turn, either to the rest of the class or to a group of classmates. The questions must be answered with either a ‘yes’ or a ‘no’. For example, ‘Do I eat grass?’, or ‘Do I live in trees?’. As they get close to the identity of their particular plant or animal, they can ask ‘Am I a…..?’ This game will allow the students to identify the unique qualities of each plant and animal.

Collect pictures of five different animals. Draw up a key to separate them. When you make your key, think about such things as feathers, hair, fur, scales, beak, legs, fins, wings, and teeth.

Make a key to separate and identify these five birds: ostrich, penguin, gull, eagle and crane.

1. Habitats and food chains

What you need:

- pencil

What you do:

Jamal went to a small river near his home. During the time he was there he saw some water plants, water snails, fish, a frog, an otter and a heron.

One food chain in the river is:

water plants ⟶ snails ⟶ fish ⟶ heron

a) What is the producer in this food chain?

____

b) Why is it called a producer?

____

c) If some poisonous chemical got into the river and killed the snails, what might happen to the food chain?

____

When Jamal was ready to leave, he looked under the log he had been sitting on. He found some woodlice.

Jamal decided to carry out a fair test to find out why the woodlice might prefer to live under a log. He prepared a box which gave woodlice a choice between light and dark on dry soil and light and dark on moist soil.

He placed 20 woodlice in the centre of the box. The woodlice could move around freely. After 20 minutes he counted how many woodlice were in each part of the box.

Then he did the test twice more.

d) Why did Jamal carry out the test three times?

____

____

Jamal recorded his results in a table.

Number of woodlice in each part of the box

	dry soil light	dry soil dark	moist soil light	moist soil dark
Experiment 1	1	2	4	13
Experiment 2	2	1	3	14
Experiment 3	0	2	4	14

Look at the table carefully.

e) Which conditions do woodlice like best?

____

f) Toads sometimes eat woodlice. Woodlice eat rotting leaves and rotting wood. Write a food chain that includes woodlice.

____

2. Land and water plants

What you need:

- pencil
- hand lens
- land plant, such as a garden weed
- water plant
- ruler

What you do:

Look carefully at both of your plants.
Fill in the table below.

	water plant	**land plant**
What shape are the leaves?		
Where are the roots anchored?		
What is the stem like?		
What keeps the plant upright?		
How tall is the plant?		
What are the flowers like?		

Draw your water plant here

Draw your land plant here

What things make your water plant suited to its habitat?

What things make your land plant suited to its habitat?

3. Your local river or stream

Investigate your local river or stream. **ONLY** carry out this activity when an adult is present.

What you need:

- pencil
- clear-plastic jars, with lids
- white trays
- nets
- corks or small sticks
- stopwatch or watch with a second hand

What you do:

Fill in the details below.

Name of river or stream ____________________

Place ____________________

Choose a part of the river or stream where the water is flowing fairly quickly. Does the water look clean or dirty? ____________________

Carefully collect some of the water in a clear-plastic jar and fasten the lid. Shake the jar thoroughly. Watch the water for 5 minutes. Describe what you have seen.

____

____

____

Repeat the above activity where the water is flowing more slowly. Compare your results. What is it that makes the water look dirty? Where has it come from?

____

____

How fast is your river or stream flowing? Mark a section of the bank 10 metres long. Find out how long it takes a small stick, an old cork or a small orange to float along this section of the river. Take several timings and find the average of them.

____

____

Repeat this activity in different parts of the river or stream. Whereabouts does it flow fastest? ____________________

Are there different kinds of animals and plants in different parts of the river or stream?

____

Why do you think this is?

____

____

4. What is in the soil?

What you need:

- pencil

What you do:

On the left of the page is a list of the things that soil contains. On the right of the page is a list of reasons why these parts of the soil are important. Join each part of the soil with the correct reason.

What is in the soil	Why it is important
air	provides good drainage
sand	without it plants and animals will shrivel and die
water	allows plant roots and animals to breathe
clay	holds water and releases mineral salts as it rots
humus	aerate the soil, mix it and help rot down dead plant materials
bacteria and fungi	holds water well and can hold onto mineral salts
earthworms	help rot down dead plant and animal material

5. Soil drainage

What you need:

- pencil
- two identical clear-plastic jars
- two clean yogurt pots
- fine, dry sand
- garden soil
- water with a little food colouring added
- stopwatch or watch with a second hand

What you do:

Fill one jar with garden soil.
Fill the other jar to exactly the same level with sand.
Fill a yogurt pot with the coloured water.
Sprinkle it on top of the soil.
Time how long it takes for the coloured water to reach the bottom of the jar.

____

Now do the same thing with the jar of sand.

How long did the water take to reach the bottom of the jar of sand?

____

____

What other differences between the two jars did you notice?

____

____

____

____

6. What does a plant need?

What you need:

- pencil

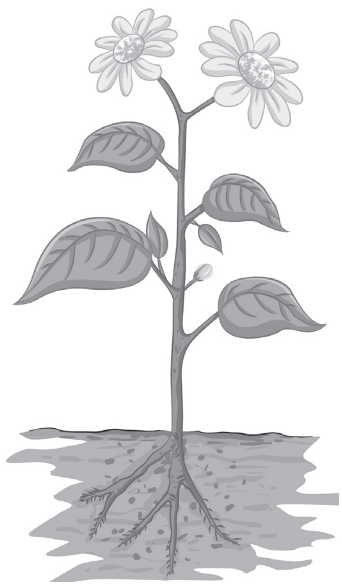
What you do:

Think about the six things shown below.
Why is each of these things important to a plant?

SUNLIGHT

CARBON DIOXIDE

OXYGEN



SOIL WATER

SOIL MINERAL SALTS

SOIL ANCHORAGE

What will happen if the plant does not receive one of these things?

What else might a plant need to grow?

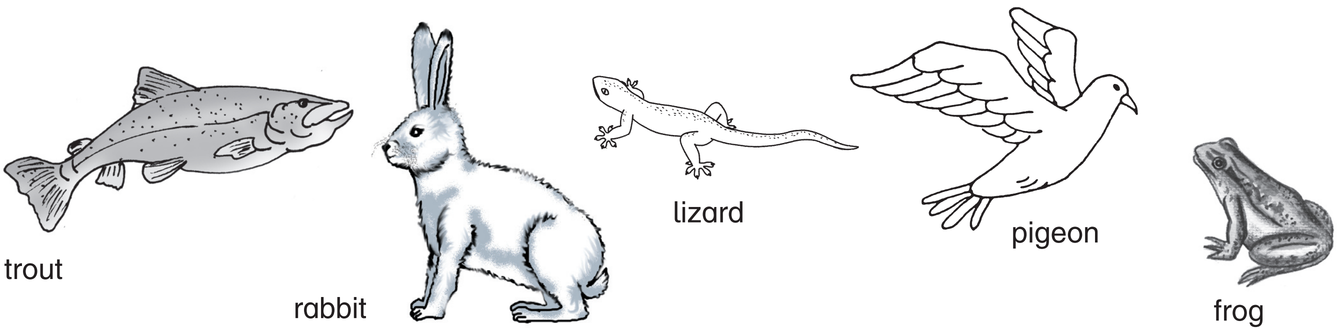
7. Using a key

What you need:

- pencil

What you do:

All of these animals are vertebrates—they have an internal skeleton and a backbone.



Use the key below to answer these questions.

a) Which animal is warm-blooded but does not have feathers? ______________

b) Which animal has a scaly skin but does not breathe with gills? ______________

c) Which animal has a scaly skin and breathes with gills? ______________

d) Which animal is cold-blooded and does not have a scaly skin? ______________

A key to vertebrate animals:

Is the animal warm-blooded?

- **Yes** Does it have feathers?
  - **Yes** BIRDS (pigeon)
  - **No** MAMMALS (rabbit)
- **No** Does it have a scaly skin?
  - **Yes** Does it breathe with gills
    - **Yes** FISH (trout)
    - **No** REPTILES (lizard)
  - **No** AMPHIBIANS (frog)

Notes on individual worksheets

1. Habitats and food chains

Key idea An exercise to introduce river food chains and some reasons for habitat preferences.

Outcome
a) water plants
b) water plants (and plants in general) can make their own food using the process called photosynthesis.
c) the water plants will increase in number, while the fish and heron will either have to find alternative foods, or starve.
d) Jamal wanted to ensure that his results were consistent (or reliable, or roughly the same).
e) moist soil and dark
f) rotting leaves/rotting wood ⟶ woodlice ⟶ toad

Extension If possible, repeat Jamal's experiment with snails or slugs.

2. Land and water plants

Key idea To investigate how a land plant and a water plant are adapted to their habitat.

Extension Collect pictures of a variety of land and water plants and compare them.

Safety Care will be necessary when collecting the water plant if it comes from a pond, lake or river. The students will need to wash their hands thoroughly after handling the plants. If it is suspected that any of the students are allergic to certain plants, then they should wear gloves for this activity.

3. Your local river or stream

Key idea To enable students to carry out fieldwork on a local river or stream and to investigate the plants and animals to be found there.

Extension Draw a sketch map of the river or stream, marking in its source and mouth or confluence. Mark the speed of flow of the water at different places.

Safety The students should to be warned of the dangers of water and of the need for strict hygiene precautions.

4. What is in the soil?

Key idea To examine the living and non-living components of soil and their importance.

Outcome
air—allows plant roots and animals to breathe.
sand—provides good drainage.
water—without it plants and animals will shrivel and die.
clay—holds water well and can hold onto mineral salts.
humus—holds water and releases mineral salts as it rots.
bacteria and fungi—help rot down dead plant and animal materials.
earthworms—aerate the soil, mix it and help rot down dead plant and animal materials.

Extension Collect pictures of larger animals that live in the soil and make a wallchart of them. How are they adapted to their habitat?

5. Soil drainage

Key idea Soils differ in the rate at which they allow water to pass. The larger the particles of the soil, the quicker the water passes through.

Outcome Normally the water will drain through the sand much faster than through garden soil, although soils vary greatly, even over a short distance. What is certain is that the larger the particles of the soil, the quicker the water passes through it. It is important to point out that soils contain air gaps through which rainwater passes, and this air is vital for animals and plant roots to breathe.

Extension Compare the rates of drainage of sand and clay and also of fine shingle.

Safety Ensure that the garden soil is taken from an area not contaminated by animal faeces and see that the students wash their hands thoroughly after handling the soil.

6. What does a plant need?

Key idea To help students understand the relationship between plants and their external environment.

Outcome Plants need sunlight energy to help make their food by the process called photosynthesis.

One of the raw materials plants use to make their food is carbon dioxide gas from the air.

Like all living things, plants breathe (respire) all the time, by night and by day, and in doing so they need oxygen to help them obtain energy from their food.

Plants need soil water to help make their food and to help keep their cells rigid.

Mineral salts from the soil help the plant to grow healthily.

Unless they are free floating in water, plants use their roots to help anchor them in the soil.

If the plant is deprived of any of these factors it will become unhealthy and quickly die.

The other factor plants need for growth is a suitable temperature.

Extension Use reference books and the Internet to find out how plants try to protect themselves from grazing animals.

7. Using a key

Key idea A practice exercise at using a branching key.

Outcome a) rabbit; b) lizard; c) trout; d) frog

Extension Modify this key to identify other vertebrate animals.

Lesson objectives

- To revise the concepts introduced in Books 1 and 3 on simple circuits and the uses of electricity
- To compare and contrast the various methods used to generate mains electricity
- To examine various methods of changing the brightness of a torch bulb or the speed of an electric motor in a circuit
- To introduce simple circuit diagrams and the use of conventional symbols to represent electrical components
- To review the impact of electricity generation on the environment and to explore ways of using electricity safely

Background information

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-metalic 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 in 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. As we shall see later, many methods of generating electricity have harmful effects on the environment.

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 battery, to the torch bulb, and back to the battery 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 battery 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 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.

Resistors

It is often useful to be able to change the size of an electric current, for example, in a theatre or in a household dimmer switch. This can be done by using a variable resistor. This device consists basically of a tight coil of high resistance wire with a sliding contact. As the contact is moved, the length of resistance wire connected to the circuit changes, and the value of the current changes.

Heat and light from electricity

Whenever an electric current flows through a wire, heat energy is produced. The heating depends on the current flowing and the resistance of the wire. In an electric fire, the connecting cable has a very low resistance, but the wire of the heating element has a very high resistance so that virtually all the heat is produced at the element. Electric stoves have a similar kind of electric element.

If the temperature rise is great enough when electricity flows through a high resistance wire, light is produced. This effect is used in electric lamps. Modern electric lamps have coiled filaments made of extremely thin tungsten wire, which become white hot.

Short circuits, fuses and circuit breakers

A short circuit is an accidental action that by-passes a circuit or causes the electric current to take a short cut of lower resistance than that intended. The sudden surge of electricity produced can easily start a fire or seriously damage the appliance being used. To prevent such damage, fuses are incorporated in circuits.

If a wire becomes too hot when an electric current is passed through it, it will burn up and break the circuit, switching off the current. Use of this is made in a fuse, which contains a thin wire made from an alloy of tin and lead with a low melting point. If the current gets too high, the fuse wire melts and breaks the circuit before the appliance is damaged. Fuses are used to protect all electrical appliances in the home. The main fuse box contains fuses, each consisting of a thin strand of wire which, when melted, can be replaced by fastening a new piece between the contacts. When the wire inside the cartridge fuses in each electrical plug melts, the whole cartridge has to be replaced. Fuses are also an essential fire-prevention device: wires with faulty insulation could cause sparks if they were allowed to short circuit. It is very dangerous to use anything other than the correct fuse or fuse wire.

Replacing a fuse or a piece of fuse wire is not always easy, particularly in a darkened house. Some homes now have their electrical circuits protected by small electromagnetic switches called miniature circuit breakers. Normally the switch of the miniature circuit breaker is pushed in to complete the circuit. If the current gets too high, the switch springs out, breaking the circuit. Once the reason for the circuit overload has been found, the switch of the circuit breaker can be pushed back into place. Similar circuit breakers are often fitted to electrical garden machinery and electrical drills and other portable devices, to protect their users from injury or electrocution.

Electricity production and the environment

Many of the harmful changes to our environment, including global warming and acid rain, are the result of our reliance on fossil fuels to produce electricity and our wasteful use of energy. Unless we can limit the output of greenhouse gases and acid rain pollutants, our world will be much less hospitable in the future. Continued climate change could result in millions of people having to be resettled because of floods or droughts and famines. As a matter of urgency, therefore, we have to find other ways of producing electricity which do not rely on the burning of fossil fuels.

Nuclear power

Nuclear power stations have the big advantage that they do not burn fossil fuels, and so they do not produce carbon dioxide to add to global warming. Their disadvantages, though, are the dangers of radiation leaks and the problem of the safe disposal of nuclear waste.

Solar power

Solar panels trap light energy from the Sun and use it to heat water or to generate electricity, so preventing much pollution. The solar panels are expensive to make, but once they are installed they need little attention and will last for years. Their biggest drawback is that the supply of hot water or electricity is much reduced when the Sun is behind the clouds, while it is non-existent at night. Solar power can, however, be used to recharge batteries to produce electricity during the hours of darkness.

Wind power

Wind power, like water and solar power, is a sustainable form of energy that does not produce greenhouse gases or other forms of air pollution. The modern wind turbines are expensive to build and they can be damaged by storms. They can be noisy and a danger to birds and other wildlife, and some people believe that they are unsightly blots on the landscape. They are only reliable when they are sited in places where there is a constant supply of wind energy.

Water power

About 17 per cent of all the electricity used today is generated by flowing water. The water is held back by a dam and is piped downhill to drive turbines. These turn the generators that produce electricity. Such hydroelectric power is clean, but dams are expensive to build and they cause problems for water life. Salmon, for example, have difficulty migrating up rivers to breed if there are dams obstructing their route.

The reservoir, the artificial lake held back by the dam, can provide water for domestic use, for irrigating crops and for fisheries and leisure activities. But as the reservoir fills, it floods valuable farmland and people's homes. Mud and silt collect in the reservoir, eventually rendering it useless.

Tidal and wave power

Another, as yet underused, source of non-polluting power is that of the oceans and seas. There are only two major tidal power stations in the world at present: across the River Rance in northern France and a newer one at Annapolis Royal in Nova Scotia, Canada. The tidal power station, or barrage, is similar in many ways to a hydroelectric dam, except that it is built across an estuary. As the tide flows into the river the turbines are turned in one direction, generating electricity. When the tide falls, and the water rushes out of the estuary, the turbines turn in the other direction, but still generate electricity. Tidal power stations are expensive to build and they affect the flow of water along rivers and the shore nearby. They can also have a damaging effect on wildlife and fisheries.

The waves that break on the shore on a windy day contain massive amounts of energy, but so far this energy has only been harnessed in small-scale trials. Part of the problem is that storm-driven waves are very destructive, so wave-powered electrical generators would have to be very strong, and expensive. The other difficulty is that in calm weather the generators would be idle.

Geothermal energy

In places the heat generated inside the Earth flows nearer to the surface. There it produces hot springs, geysers and boiling mud pots. Any groundwater coming into contact with the hot rocks underground is heated, but because it is under pressure, the boiling point of the water is raised above normal and it becomes superheated. Many hot springs in Japan, New Zealand, Iceland, the United States, Mexico and other countries are harnessed to drive the generators that produce electricity or to provide hot water for domestic use or to heat buildings or greenhouses. However, because hot springs and geysers normally occur in volcano and earthquake zones, there is always the danger that the pipes carrying the hot water or steam may break during an eruption or earthquake.

Biomass as fuel

In developing countries, burning what is called biomass—plant and animal matter—generates a small but significant amount of electricity. In the developed world the use of biomass is negligible. There are signs that this may be changing, however. In eastern England, for example, there are power stations that burn mainly chicken manure or straw. In Brazil, sugar cane is fermented to make alcohol, which is used as a fuel for motor vehicles. In Britain there is a small but increasing use of liquid motor fuels made from plant materials such as cereals, oilseeds, sugar beet and fodder beet. Recycled vegetable oils and fats can also be used as an alternative to diesel. All of these so-called biofuels cut emissions of carbon dioxide by 50 to 60 per cent compared to fossil fuels.

Safety

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

Answers

Producing electricity: **Rapid fire, p 27**

1) Cables are the thick wires along which electricity travels.
2) Pylons are very tall so that farm machinery, lorries and other large vehicles can pass under them safely. The cables are also well out of reach of people.

3) A large shop would use electricity for lighting and air conditioning, to operate freezers and refrigerators, computers and printers, tills and telephones, and to operate the cleaning equipment and lifts. An office would use electricity for lighting, cooling and to operate computers, printers, telephones and fax machines.
4) Electricity is used to cool people and objects in freezers, refrigerators, air conditioning units, fans, and cold drinks machines and ice makers.
5) Some electrical insulators include rubber, plastics, glass, porcelain, dry wood and non-metals other than graphite.

Other ways of generating electricity: **Rapid fire, p 29**
1) The advantages of using cells and batteries to obtain electricity are that they are small and portable. The disadvantages are that they are relatively expensive, provide only small voltages and fairly quickly run down, and have either to be replaced or recharged. Mains electricity has the advantage that the supply is continuous and at high voltages. It is relatively less expensive than cells or batteries but has the disadvantage that mains devices cannot be really portable.
2) The main advantages and disadvantages of alternative methods of producing electricity are:

Energy source	Where available	Advantages	Disadvantages
wind	high or windy places	safe, no polluting gases; produce electricity cheaply	only work when wind blowing; noisy; can spoil scenery and kill migrating birds
Sun	sunny areas	safe and no polluting gases	only work when Sun is shining; expensive to build
hydroelectric	fast-flowing rivers	safe and no polluting gases; can produce cheap electricity all the time	expensive to build; take up a lot of land; affect fish and other water life
tidal	only near the mouths of fast-flowing rivers	safe and no polluting gases; can produce cheap electricity all the time	expensive to build; affect fish, wading birds and other water life; hinder movements of shipping

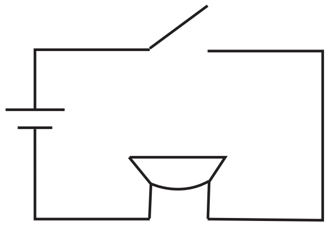
3) Electricity is carried by underground cables in towns and cities to avoid danger to people and damage from motor vehicles.

Cells, batteries and electrical circuits: **Rapid fire, p 31**
1) An electric circuit.
2) 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.
3) The reason a bulb in a simple circuit does not light up could be because the switch is in the off position, the battery has been used up, the bulb has burned out or is not screwed into the bulb holder sufficiently tightly, or one of the wires or other connections is loose.

Circuit diagrams: **Rapid fire, p 33**

1) A terminal is one of the metal contact points on a bulb, battery or some other electrical appliance to which the wires must be connected to complete the circuit.

2)



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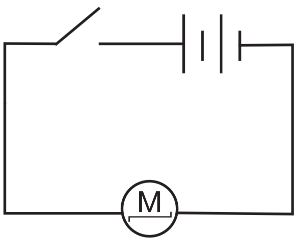

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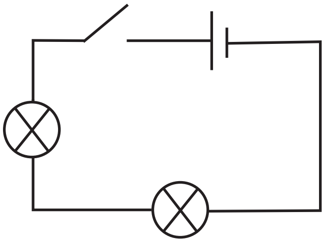


Brighter and dimmer: **Rapid fire, p 35**

1) You could make an electric motor in a circuit run more slowly either by increasing the length of the wires in the circuit or by using a cell or battery of lower voltage. You could also use thinner wires made of a metal which has a higher resistance to electricity, such as iron.
2) The pins of an electrical plug are made of metal so that they conduct electricity. The outer case is made of plastic, an electrical insulator, to prevent electricity passing into the body of anyone who handles the plug.
3) Electrical resistance is the property of some materials that reduces the flow of electricity.

Using electricity: **Rapid fire, p 37**

1) A fuse is a safety device that contains a short piece of thin wire of low resistance to electricity. This wire melts if too much electricity passes through it, so breaking the circuit.
2) Electricity powers many trams, trolley buses and trains, and a few buses and cars. It works the starter motor, lights and other components of motor vehicles. It also operates the ticket machines or computers on public transport systems.
3) A wire with a torn insulating cover is dangerous because the conducting wire underneath is then exposed. If someone touches this, they could receive an electric shock, be burned, or even be electrocuted.

Electricity and the environment: **Rapid fire, p 39**

1) Electric vehicles are quiet and they do not pollute the air. The disadvantages are that at the present time they rely on batteries which are very heavy, the vehicles have a relatively short range before the batteries need to be recharged, and the top speed is quite low. The development of solar-powered vehicles may reduce some of these problems.
2) Recycling or reusing objects and materials is good for the environment because less raw materials are used, and less energy (usually in the form of electricity or fossil fuels is needed). This means there is less air pollution and fewer holes in the ground from where the raw materials have been extracted. There is also less material to be dumped into landfill sites.

Using electricity safely: **Rapid fire, p 41**

1) Water can conduct electricity and the water could easily complete the circuit between someone's wet hands and the metal terminals of an electric plug or socket.
2) Do not touch the cable but inform the police or electricity company right way. Keep spectators away.
3) The television set might topple into the bath, with fatal consequences, or the steam could short circuit the television set, again with fatal consequences.
4) Most bathroom switches work by pulling a cord, to avoid someone with wet hands making contact with the electricity supply. The cord is made of an insulating material.

Assessment: **p 42-43**

1) a) energy b) power station c) hydroelectric d) generator e) nuclear f) wires
   g) pylons h) conductors i) fuse j) filament k) chemical l) cables
   m) insulators
2) a) A—bulb; B—batteries; C—switch; D glass; E—reflector; F—spring.
   b) The reflector is made of shiny metal so that it reflects the light from the bulb forwards in a beam.
   c) The switch closes a gap between two strips of metal which join the bulb with the base of the lowest battery, thus completing the circuit.
   d) The batteries were used up or put in the torch the wrong way round; the bulb was not screwed in tight; the bulb had burned out.
3) The materials which would complete the circuit and make the bulb light are:
   i) iron nail; iii) steel paper clip; vi) gold ring; vii) copper coin
4) a) bulb; b) two cells (or batteries); c) buzzer; d) and e) see page 32 of the student's book
5) a) Only the bulb in circuit d) will light up. It is the only one with a complete circuit from the base of the cell or battery to the base of the bulb and from the metal side of the bulb back to the terminal on the top of the cell or battery.
   b) Whenever electricity flows, it heats up the material it flows through. The greater the resistance the material offers to electricity, the more it heats up. The filament in a bulb consists of a very thin wire made of the metal tungsten. When electricity passes through the filament, the thin wire gets so hot that it glows and gives out light. The bulb is filled with a special gas, called argon, which stops the filament from burning out more quickly.
   c) Torch bulbs are made to be used with a certain voltage of electricity. If extra batteries are added to a circuit, the voltage may then be higher than the bulb was designed for. The bulb will glow brighter than normal but its filament will burn out very quickly.

Going further

Where is the power station nearest to your home or school? Is it near a river, lake or the sea? What kind of fuel does it use or how else does it obtain its energy?

Collect pictures of the things we use in our homes that are powered by electricity. Try to find out how much electricity each one uses. The rate at which things use electricity is measured in watts or kilowatts (a kilowatt is 1000 watts).

Make a list of all the things we can do in our homes and schools to save electricity.

Ask the students to construct circuits which contain two or more working components, such as a bulb and a buzzer or a bulb, a switch and a motor. Does it matter where each component is placed in the circuit?

Design a model room with two working lights so that if one bulb is removed the other stays alight. Draw a circuit diagram of your model room. Make your model and see if it works.

Write down what you think are the advantages and disadvantages of hydroelectric power stations.

Describe how people travelled, cooked their food and lit their homes long ago. Did they cause more or less damage to the environment than people today? Say why.

Look around your home. How many things there use electricity? Find out what people used to do before electricity was discovered. Write down what you have discovered.

Compile a list of electrical appliances and their power in watts. How much does it cost to run each appliance for a given time ? Make comparisons and discover which are the most expensive and which are the least expensive.

Design a poster to encourage people not to waste electricity.

1. Mains and battery electricity

What you need:

- pencil

What you do:

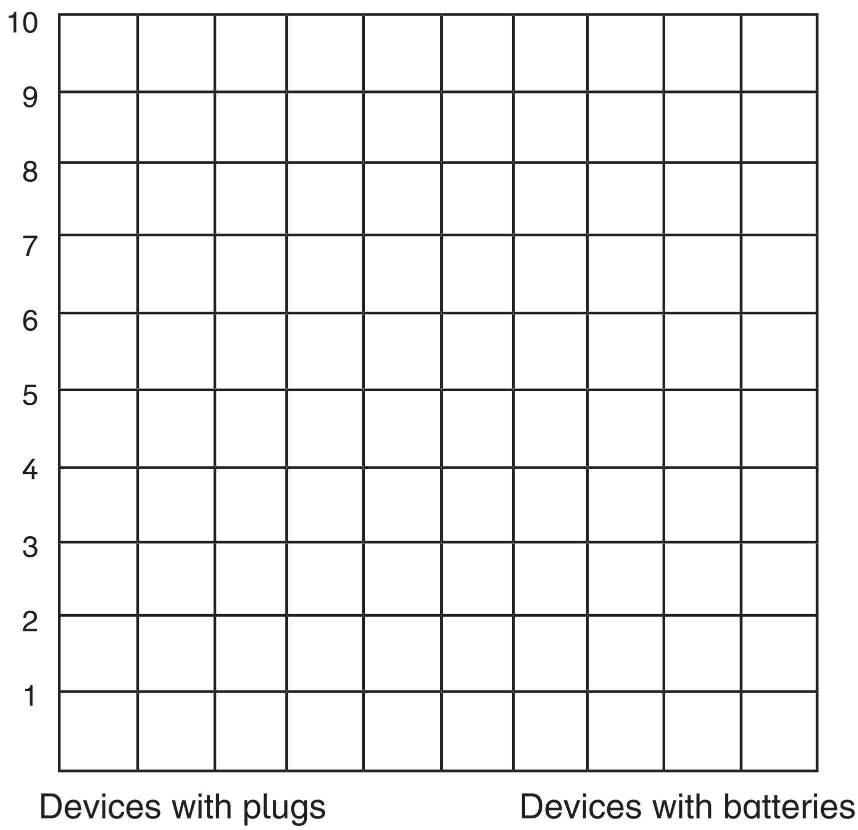
Look around your home.
How many things need electricity to make them work?
Some of these things have a plug attached to them.
They need mains electricity to make them work.
Smaller electrical devices have batteries to make them work.
How many of the electrical devices in your home have plugs?

___

How many of the electrical devices in your home use batteries?

___

Now use the data you have collected to draw this bar chart.



Safety: Do not touch plugs or sockets when you carry out your survey.

2. How bright is the light?

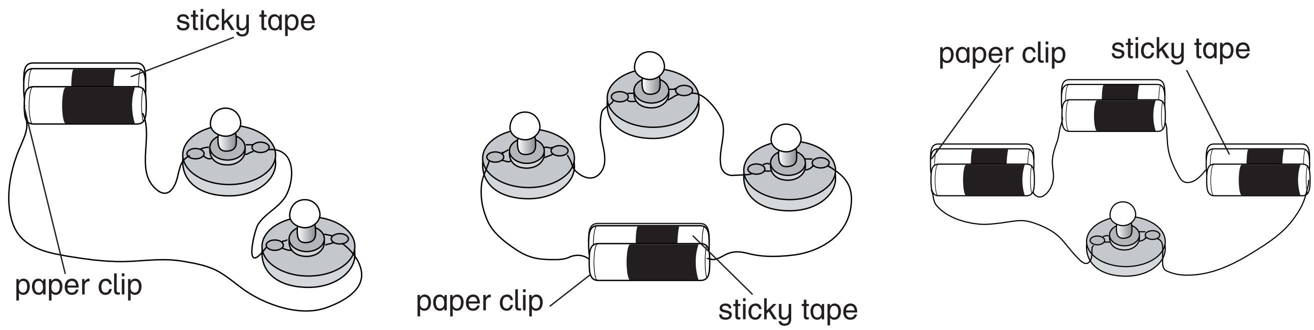
What effect does different number of bulbs and batteries have on the brightness of the bulbs in a circuit?

What you need:

- pencil
- paper clips
- sticky tape
- a small screwdriver
- three 1.5 volt torch batteries (cells)
- three 4.5 volt torch bulbs in bulb holders
- four pieces of wire with bare ends

What you do:

Begin by wiring the bulbs and batteries in series (in a row) like this.



Make all three circuits, one at a time and record your results in the table.
Say how bright the bulbs were (dim, bright or very bright).

Now make more circuits with different numbers of bulbs and batteries.

Number of batteries	Number of bulbs	Brightness of bulbs
1	1	
1	2	
1	3	
2	1	
2	2	
2	3	
3	1	
3	2	
3	3	

What affects the brightness of the bulbs?

____

____

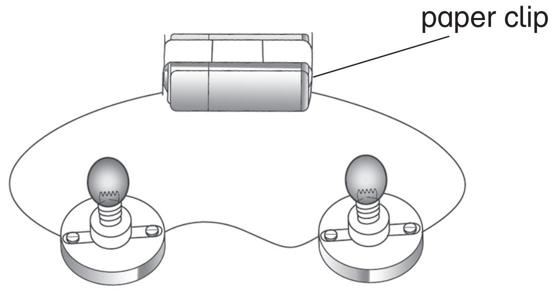
3. Series and parallel circuits

What you need:

- pencil
- 1.5 volt battery
- six pieces of wire with bare ends
- three torch bulbs in bulb holders
- a small screwdriver
- paper clips
- sticky tape

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.



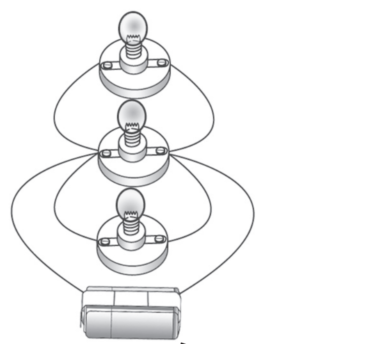
Now add an extra bulb to the circuit.

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 of your circuits on the back of this page.

What have you learned about series and parallel circuits?

____

____

____

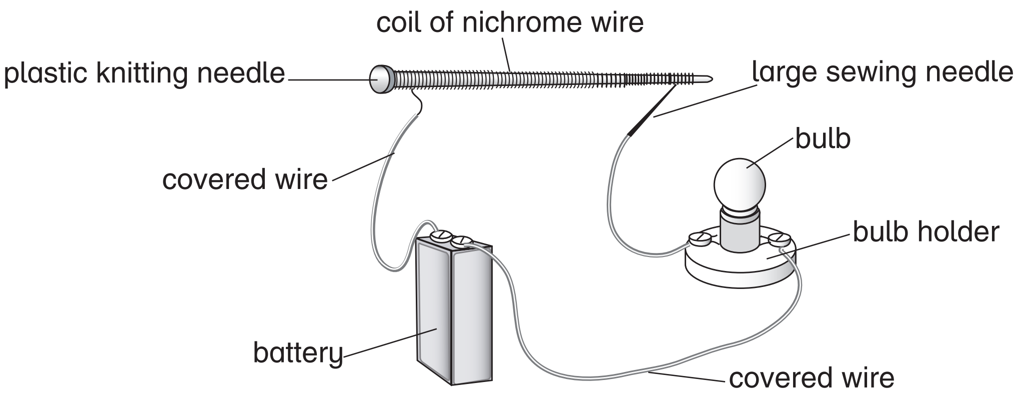
4. Changing the brightness

What you need:

- pencil
- thick plastic knitting needle
- nichrome wire or fuse wire
- 9 volt battery
- 6 volt torch bulb in a holder
- three pieces of wire with bare ends
- large, blunt sewing needle (bodkin)

What you do:

Carefully coil the nichrome wire or fuse wire neatly and evenly around the knitting needle.
The more turns of the wire you can put in the coil (without them overlapping or crossing), the better.
Connect the coil to the battery and bulb, as shown in the picture.
Fix the sewing needle to the end of one of the wires.
Watch what happens to the bulb as you touch different parts of the coil with the sewing needle.



When does the bulb light up? ____________________

What differences do you see in the bulb? ____________________

Explain what the coil does ____________________

____

____

Where would a coil like this be useful? ____________________

____

____

5. Make a model lighthouse

What you need:

- pencil
- paper clips
- scissors
- battery
- dry sand or soil
- paints and paintbrush
- clean washing-up liquid bottle
- modelling clay or Plasticine
- see-through plastic cup or beaker
- torch bulb in a holder
- sticky tape
- two pieces of covered wire 50 cm long with bare ends

What you do:

Carefully cut the top off the bottle. The hole that is left should be just large enough for the bulb holder to fit into it.

Make a small hole in the side of the bottle near the bottom.

Thread two pieces of covered wire in through the hole at the bottom of the bottle and out of the top.

Plug the space where the two wires go into the bottle with clay or Plasticine.

Put a little dry sand or soil in the bottom of the bottle to make it difficult to knock over.

Fit the bulb holder into the top of the bottle. Fix it in place with clay or Plasticine.

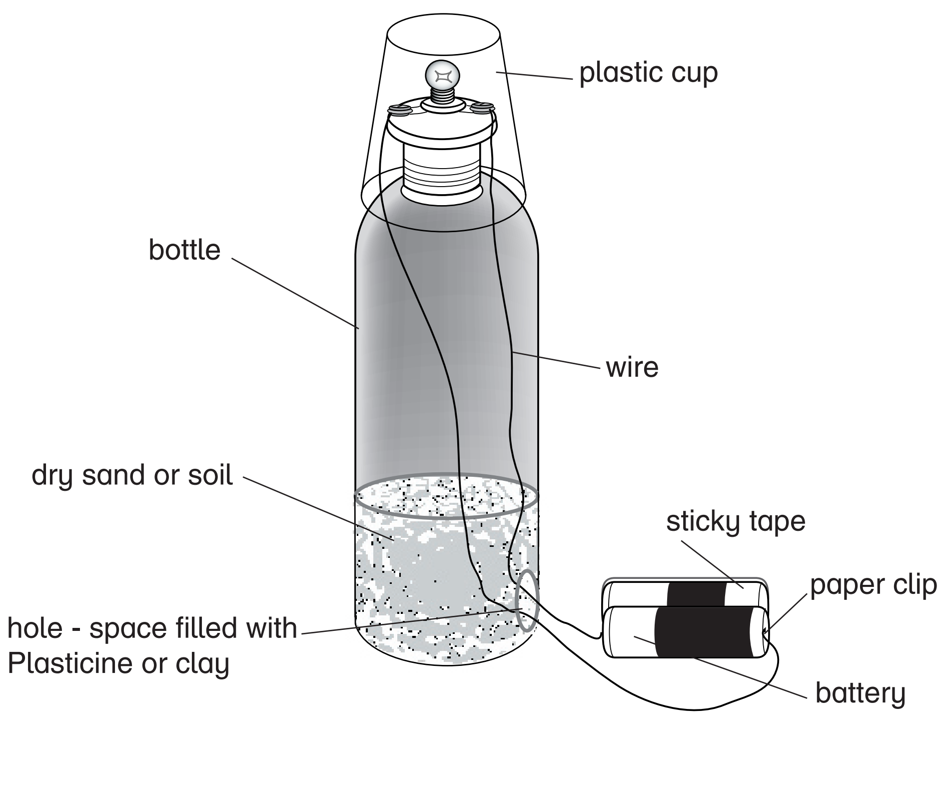
Carefully make a small cut in the bottle on either side of the bulb holder.

Join one end of each wire to each terminal on the bulb holder.

Join the other two ends of the wires to the terminals on the battery. The bulb should light up.

Cover the bulb holder with the plastic cup or beaker. Tape it in place.

Paint your lighthouse.



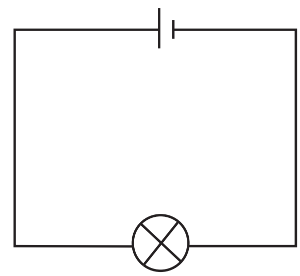
6. Circuit diagrams

What you need:

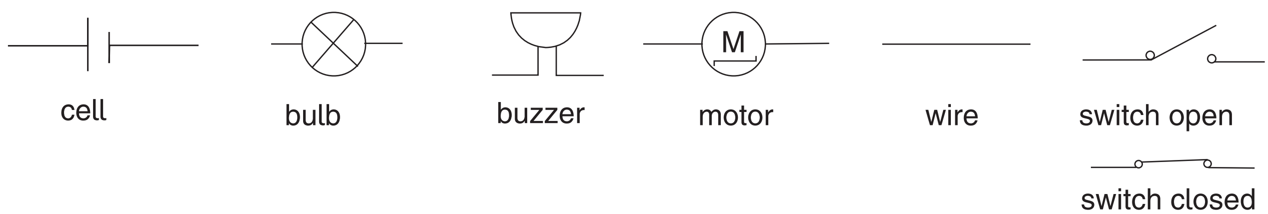
- pencil

What you do:

Look at this drawing of a circuit. This is a diagram of the same circuit.

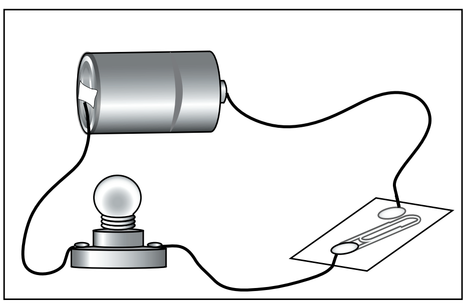


Circuit symbols



Use the circuit symbols above to draw diagrams of these circuits:

a)



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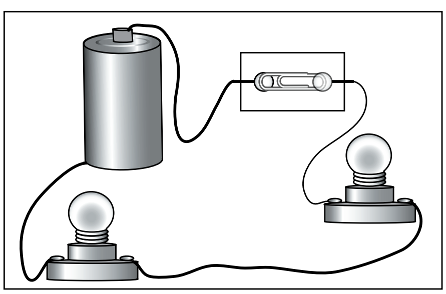

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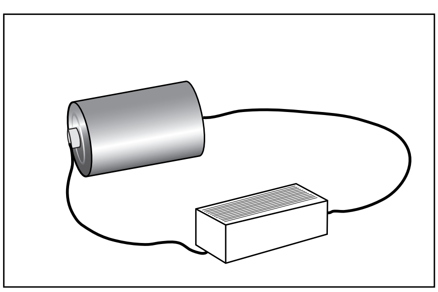


Notes on individual worksheets

1. Mains and battery electricity

Key idea To survey, and record graphically, the mains and battery-operated devices in the home.

Extension Make a block graph of the electrical appliances in the home to show how many produce light, heat, sound and movement.

Safety Warn the students not to touch electrical plugs and sockets when carrying out their survey.

2. Series and parallel circuits

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

Outcome In a series circuit, an extra bulb makes all the bulbs dimmer since they have to share the electric current. If one bulb is removed, the other bulbs go out. In a parallel circuit, all the bulbs are equally bright because they each have their own circuit back to the battery; if one bulb is removed, the others stay alight.

Extension Discuss which kind of circuit is used in the home or school for the lights. How can the students tell?

Safety To prevent accidents, the teachers should remove the bulbs from the bulb holders rather than allow the students to do it.

3. How bright is the light?

Key idea We can vary the brightness of electric lights by changing the number of bulbs or batteries in a circuit.

Outcome With each additional bulb, the lights are less bright. Each additional battery will make the bulbs brighter, but they will burn out quickly.

Extension Discuss how we know which bulb is appropriate for any given battery by matching the voltages marked on both.

4. Changing the brightness

Key idea The brightness of a torch bulb can be varied by changing the length of wire in a circuit.

Outcome When the distance the electricity has to flow is short, the ‘pressure’ of the electricity is high, and the bulb gives a bright light. When the distance is greater, the ‘pressure’ is lower, and the bulb gives a dim light. Dimmer switches like this are used to control the brightness of the lights in theatres, cinemas and some homes.

Extension Sharpen a long and a short lead pencil at both ends. Connect them one at a time in a circuit. Compare the brightness of the bulb.

5. Make a model lighthouse

Key idea Simple circuits can be used in working models.

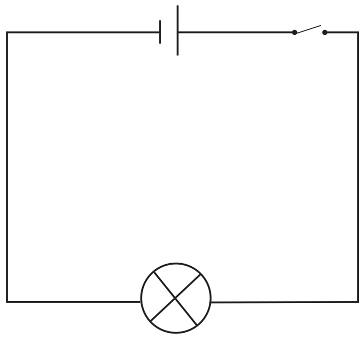
Extension Adapt your lighthouse so that the bulb will flash on and off like a real lighthouse. Make a circuit drawing of your lighthouse. Make your model if you can find the right materials. Find out what causes the light to turn in a real lighthouse. Why would it be difficult to get the bulb to rotate in your model lighthouse?

6. Circuit diagrams

Key idea An assessment exercise to test the use of symbols in representing electrical circuits.

Outcome

a)



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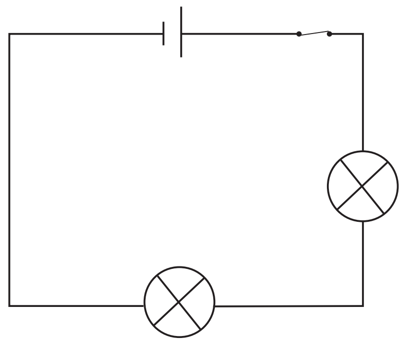

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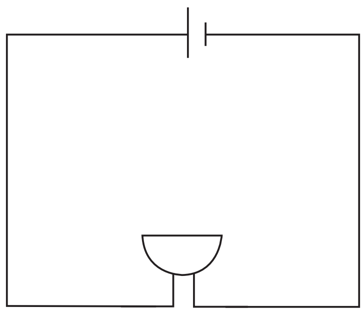

Extension Draw a number of circuit diagrams, then challenge a friend to explain them and decide whether or not they will work.

Lesson objectives

- To examine the application of a variety of forces, including gravity, air resistance, and buoyancy or upthrust
- To contextualize which objects are stationary because the forces on them are balanced
- To examine the changes in motion that occur when forces are not balanced
- To introduce the concept that forces have direction and can be measured

Background information

Forces always come in pairs, working in opposite directions. If one force is bigger than the other, something accelerates. If the forces in a tower, crane, bridge, or some other structure are unequal, then the structure will collapse. If the forces balance each other, they stay still.

Magnetism and gravity

Not all forces involve actual contact between the object being moved and the source of the push or pull. A magnet can exert an invisible pull on objects made of iron, steel, cobalt, or nickel, but it has no effect on other things. In addition, if two magnets are placed together with like poles (i.e. north and north or south and south poles) next to each other, they will push or repel each other.

The pull of the Earth, or the force of gravity as it is called, is another example of an invisible pull. In this case, the Earth attracts objects on or near its surface towards its centre. A stone or ball thrown up into the air will fall to the ground, being pulled by gravity. Gravity also gives people and objects weight.

The centre of gravity

The Earth's gravity pulls down on every single object with a force equal to the weight of the object. There is a point, inside or near every object, called its centre of gravity. This is the point where the forces acting on it seem to be concentrated. The centre of gravity of this book is its middle, at the point where diagonal lines drawn from opposite corners cross. The book can be balanced by supporting it on one firmly and steadily held finger at this point. The centre of gravity need not be in the solid part of an object. In a hoop, for example, it is the centre of the circle.

Gravity on the moon

If the Earth was smaller, then its force of gravity would be less. The moon is about one sixth of the size of the Earth, so the force of attraction between an object and the moon is only one sixth of that on Earth. In the case of an astronaut standing on the surface of the moon, there is six times less force of gravity between the moon and him and he would be able to jump six times as high as he would on Earth.

Force meters or newton meters

A force meter or newton meter is a device that allows objects to be weighed. It consists of a spiral spring inside a casing. How far the spring stretches is an indication of the weight of the object. When objects are hung from a force meter, gravity acts on the objects and pulls the spring down. The extension of the spring can be read on a scale.

If a brick is hung from a force meter, it will initially fall under the pull of gravity. As the spring stretches it exerts more and more force on the brick until the brick stops falling. When the brick has stopped falling and is still, then the upward force exerted by the spring must equal the downward force of gravity. The forces are balanced. The scale on the meter shows by how much the spring has stretched, and we can use this to tell us the weight of the brick.

Using air resistance

Air resistance is a form of friction. It 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. 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.

Floating and sinking

The density of a substance is determined by its mass compared to its volume. If two similar containers were filled, one with, say, lead and the other with feathers, the container with lead would have the greater mass even though the lead has filled up the same amount of space (the same volume) as the feathers. We, therefore, say that lead has a greater density than feathers. Fresh water has a density of one gram per cubic centimetre, whereas the density of gold is 19 grams per cubic centimetre. We say the relative density of gold (compared with water) is 19.

Whether an object floats or sinks depends on its relative density. An iceberg floats because ice has a density slightly less that that of water.

As can be seen by marking the water levels on the sides of boats and buckets, when an object floats it pushes aside water. This is because two objects cannot occupy the same space at the same time. When we float a ball in a bucket of water, the water level rises because the ball pushes aside, or displaces, some of the water. The weight of the water that is displaced is equal to the weight of the ball (or any other object placed in the water).

As the students will discover, the fact that a thing feels light or heavy is no indication of whether or not it will float or sink in water. The point for the students to appreciate is whether the object feels light or heavy for its size. Many floating objects, from sponges and balls to ocean-going ships, contain air. They do not, however, float specifically because they have air inside them, but rather because the air (inside) makes them light for their size.

At first sight it may be difficult to understand why floating and sinking are included within a section on forces, or pushes and pulls. The reason is that buoyancy, 'the apparent loss in weight of an object when it is wholly or partly immersed in water or some other liquid' is due to the upward push, or upthrust, of the fluid. This property is dealt with much later on in the students' science education, although there is no reason why they should not experience practical examples of the way in which water appears to push up on a ball, polystyrene block, or some other floating object at this stage. This topic also has important implications for an understanding of water safety.

Safety

Warn students that stretched elastic bands and springs can cause eye and facial injuries.

Answers

The force of gravity: **Rapid fire, p 45**

1) Gravity is a force which pulls objects towards the centre of the Earth. This means that any object thrown into the air will fall back down again. Weight is the force of gravity acting on an object.
2) Open answers.
3) a) The ball gradually slows up until it stops for a moment and then returns to Earth.
   b) There should be an arrow pointing upwards on the ball, showing the force of the throw acting upon it. An arrow in the opposite direction (downwards) will show the force of gravity acting upon the ball. Since the ball is thrown up, the arrow pointing upwards will be thicker as compared to the one pointing downwards.
   c) The ball falls back down again because the pull of the Earth's gravity is greater than the air resistance.
   d) The Earth's pull must be greater than the air resistance, otherwise the ball would not fall back to Earth.

How strong is a force: **Rapid fire, p 47**

1) Mass is the amount of a substance. It is measured in grams and kilograms. Weight is the pull of gravity on a mass. It is measured in newtons. You would weigh slightly less on the summit of a high mountain than you did at the foot of the mountain, because you are further away from the centre of the Earth.
2) TRUE: a), b, d), e), f, and g)
   FALSE: c), h)
3) The pull of gravity on a large hammer is greater than the pull of gravity on a small hammer as they fall on to the nut.

How strong is a force: **Try it out, p 47**

1) The easiest method would be to pull each of the objects in turn across the table using the same elastic band. The more the elastic band is stretched, the greater the force being applied to the object. It would be important to use the same elastic band each time and to ensure that the elastic band was not overstretched. It would also be important to ensure that all parts of the table were equally slippery.

Overcoming gravity: **Rapid fire, p 49**

1) It is dangerous to jump out of a window because the pull of gravity on your body is much greater than the air resistance which would tend to slow your body down. You would, therefore, hit the ground very hard and hurt yourself.
2) Your weight on Mars would be about half of your weight on Earth, because the pull of gravity on Mars is about half that on the Earth. In theory, Martians would be able to jump about twice as high as someone of the same weight and strength would on Earth.

Balanced and unbalanced forces: **Rapid fire, p 51**

1) The words which are used in connection with forces are: weight, friction, air resistance, twisting, newton, turning, gravity, movement, pushing and pulling.
   It could be argued that light is also a force word, if it is being used in the context of weighing little.
2) The elasticity of the trampoline allows your friend to bounce in the air while air resistance tends to slow her down. Gravity pulls your friend back down onto the trampoline again.
3) If any object is not moving or changing direction then any forces acting on it are balanced.

Forces that are unbalanced: **Rapid fire, p 53**

1) If you hit a ball with a cricket bat, the forces on the ball are unbalanced, otherwise the ball would not move. Air resistance, gravity and friction with the ground make the ball slow down and eventually stop.
2) TRUE: a), b), and c)
   FALSE: d), e), and f)

Forces in water: **Rapid fire, p 55**

1) The forces on a floating rubber duck are the weight of the duck pressing down which is balanced by the upthrust of the water. As a result the two arrows would be identical in size. If a hand pushes the duck underwater, then the weight arrow pointing down would be substantially larger than the upthrust arrow.
2) A Plasticine boat will float because it has a relatively low density. The material is spread out so that it displaces enough water to provide a large upthrust. If you now roll the Plasticine into a ball, its material is now packed together tightly, it displaces much less water, and sinks.
3) The materials which floated would all have a much larger volume and lower density than those which sank, even though all the materials had the same weight.

Forces in water: **Try it out, p 55**

2) All objects seem to get lighter when you immerse them in water, while the level of the water around them rises as it is displaced by the object being put into it.

Assessment: **p 56-57**

1) a) forces b) slow c) direction d) change e) gravity
   f) together g) balanced h) upthrust i) air resistance j) displaces
2) a) Person B; b) gravity; c) The arrow will be pointing down towards the ground.
   d) Air resistance; e) The arrow will be pointing upwards.
3) a) The units are newtons
   b) The pebble seems to weigh less because of the upthrust of the water
   c) The weight increases back to its original level
4) a) The flat piece of paper, the feather and the balloon fell to the ground slowly because these objects are light (have a low density) and the pull of gravity on them is tiny. The upward push of air resistance quickly balances the downward pull of gravity and the objects fall very slowly. The other objects are heavier (denser), and the force of gravity is much larger than the air resistance, and they fall to the ground equally quickly.
   b) Float: pencil, feather, plastic pen top, air-filled balloon, crumpled ball of paper and sheet of paper. (The latter two will float until they become waterlogged, when they will sink.)
   Sink: stone and marble
   c) upthrust

Going further

Obtain a cushion containing springs. Place it on the floor or a bench and invite a volunteer to sit gently on it. They should report that they can feel the springs pushing up as they sit on them. Allow several other students to try sitting on the cushion.

Make a plumb line by tying a small weight on to the end of a length of string. Invite the students to test out the plumb line to see which parts of the classroom or school building are vertical.

Examine various weighing machines to see how they work. Write down what you have discovered. For one of the machines, write instructions for a friend who does not know how to use the machine and draw diagrams to show how it works.

Provide the students with a force meter or newton meter with appropriate scales. Let them use the meters to record the force needed to open a door, a drawer, a pull-along toy, a blind or screen and perhaps even to open a can with a ring pull.

Find your mass in kilograms using a set of bathroom scales. Now work out your weight in newtons. To do this multiply your mass by 10. Now find out the weight in newtons of each member of your class. Make a bar chart of your results. Which is the most common weight?

Try to estimate the weight of small objects by comparing them with known weights.

Use reference books or the Internet to find out if the gravity on other planets is the same or different from the force of gravity on Earth. Say why.

Draw a hot-air balloon rising into the air. Draw arrows to show the forces acting on the balloon. Draw large arrows to represent large forces and smaller arrows to represent smaller forces. Label the arrows you have drawn.

Fiza squashes a large spring against a wall. Draw two arrows to show the force Fiza is using on the spring and the force exerted by the wall. Which of the two arrows will be larger?

Investigate whether pushing an object from a height makes it fall faster than just dropping it.

Create a Floating and Sinking display. Test common objects. Record sets of floaters and sinkers. What about a glass jar, will it float or sink?

Load a polystyrene tile with coins or washers until it sinks. Use inflated plastic bags or ping-pong balls to make the loaded polystyrene tile float again.

Make a string handle for a plastic yoghurt pot and drag the pot through water. Now make holes in the bottom of the cup and drag it through water. What difference is there? Can you explain this? (It is easier to pull the perforated pot because there is less water resistance.)

Show that an aluminium foil cake case will float. Fold it into a pellet and flatten it with a hammer. Does the solid aluminium float?

Push the end of some narrow plastic tubing right inside a small glass bottle. Tuck the tubing under an elastic band around the bottle's neck to stop it coming out. Sink the bottle in a bowl or sink of water. Use the tube to blow air into the bottle. The air drives the water out of the bottle, making the 'submarine' rise up.

Bend up 2 cm at one end of a drinking straw. Hold the bent over piece of straw in place with a paper clip. If you stand the drinking straw in water it should now float upright like a fisherman's float. Use this float as a hydrometer to compare the density (thickness) of different liquids such as fresh water, salt water and milk. The denser the liquid, the higher the float will rise in it.

Float an ice cube in a jar of water. How much of the ice is below the surface of the water? Find out about icebergs and say why they are dangerous to ships.

1. Investigating gravity

What you need:

- pencil
- Plasticine
- chair to stand on
- tape measure or metre stick
- four sheets of paper

What you do:

Make four balls with the Plasticine. Make sure they are all the same size.

Measure 50 cm up from a hard floor.

Drop one of the balls to the floor from that height.

Carefully pick up the ball and put it on a sheet of paper. Label the paper 1.

Drop the second ball from a height of 1 metre. Call this number 2.

Drop the other balls from 150 cm (number 3) and 2 metres (number 4).

Look closely at all four balls.

What differences can you see between them?

Describe what has happened to each of the balls:

ball 1 ____________________

ball 2 ____________________

ball 3 ____________________

ball 4 ____________________

Try to explain what you have discovered.

____

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____

2. An elastic band weighing machine

What you need:

- pencil
- ruler
- thin string
- paper clips
- sticky tape
- thick elastic bands, all the same size
- cup hook
- scissors
- clean yogurt pot
- small objects (e.g. marble, eraser, small pebble, beads)

What you do:

Tie a short piece of string to each end of an elastic band.

Make hooks from two paper clips. Tie these to the ends of the strings.

Make a string handle for the yogurt pot.

Hang the yogurt pot from the lower paper clip.

Hang the upper paper clip from a hook in a shelf.

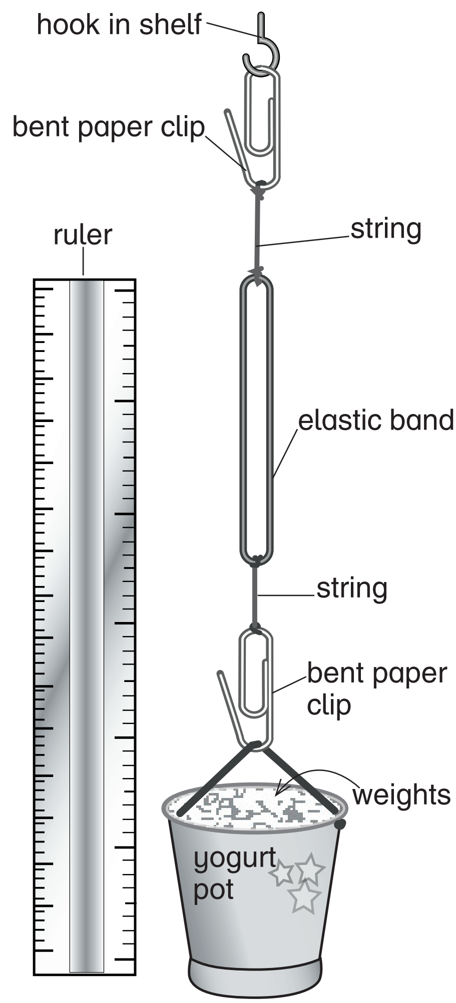
Use sticky tape to fix the ruler to the wall behind the yogurt pot.

Mark where the top of the yogurt pot comes to on the ruler.

Put a small object, such as a marble, in the pot. How much has the elastic band stretched?

Try other small objects.

If you have some real weights, you could use these to see whether your balance weighs accurately.



Record your results in this table:

Object	Distance the elastic band stretched
marble	

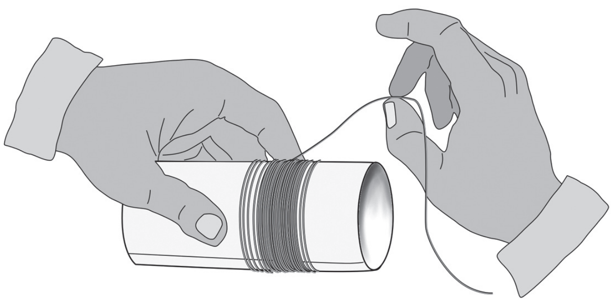
3. Weighing with a spring

What you need:

- pencil
- a large can and a small can
- cardboard tube
- thin wire
- sticky label
- coins or small weights
- ruler

What you do:

Make a spring by carefully winding a thin wire neatly and evenly around a cardboard tube.



Remove the tube and you have made a spring!

Squash the spring. It should go back to its original shape when you let go of it.

Put the spring in the large can.

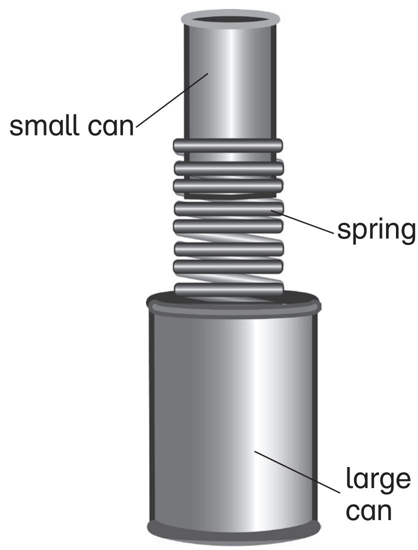
Rest the small can on top of the spring.

Put coins or small weights, one at a time, into the smaller can.

Use a ruler to measure how far down the smaller can goes as the spring is squashed.

Use your weighing machine to weigh small objects.

What have you discovered about using a squashed spring to weigh things?



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4. Testing parachutes

What you need:

- pencil
- pieces of tissue paper, newspaper, cotton cloth, plastic bag, cardboard, woollen cloth
- scissors
- cotton thread
- metal washer
- sticky tape

What you do:

Cut out a square of tissue paper with sides 15 cm long.

Tape a piece of thread 18 cm long to each corner.

Join the ends of the thread to a small metal washer.

Throw your parachute into the air away from windows and overhead wires.

Watch your parachute fall. How well does it work?

Make parachutes from pieces the same size of the other materials.

Use the same metal washer each time.

Record your results on this chart:

Material	How well the parachute worked
tissue paper	
newspaper	
cotton cloth	
plastic bag	
cardboard	
woollen cloth	

Which material made the best parachute?

Why was it important to use the same metal washer each time?

Make parachutes with sides 25 cm long. Are your results the same?

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5. Adding weights to a floating object

What you need:

- pencil
- empty coffee or cocoa tin, or any similar object
- bowl of water
- scales or spring balance
- Plasticine or clay
- waterproof marker pen

What you do:

Put the empty can in the bowl of water.

Does it float? ______________________________

Mark how high the water comes up the side of the can.

Mark how high the water comes up the side of the bowl.

Carefully put a piece of clay or Plasticine in the can.

Does the can float now? ______________________________

What has happened to the water level? ______________________________

____

Put more clay or Plasticine in the can. What happens to the water level?

____

What happens if you keep adding clay or Plasticine to the can?

____

Do this experiment again. This time weigh the empty can and the pieces of clay or Plasticine you put into it.

What weight of clay or Plasticine will the can hold and still remain floating?

____

What happens to the water level as you add more clay or Plasticine to the can?

____

What weight of clay or Plasticine makes the can sink?

____

6. Buoyancy

What you need:

- pencil
- small air-filled ball
- large air-filled ball
- bucket
- water
- waterproof marker pen

What you do:

Half fill the bucket with water. Mark the water level.

Float the small ball in the water.

Push the ball under the water. What do you feel?

____

____

Now float the large ball in the water.

Push the ball under the water. What do you feel?

____

____

What happens to the level of the water in the bucket each time?

____

____

What happens when you let go of the ball after you have pushed it down?

____

____

Which ball did you have to push hardest? ____________________

Try to explain why ______________________________

____

____

____

____

____

7. Measuring floating forces

What you need:

- pencil
- spring balance or newton meter
- small polythene bag
- bowl or bucket half-filled with water
- small objects that will not be damaged by water

What you do:

Take one of the objects and weigh it using the spring balance or newton meter.

If necessary, put the object in a small polythene bag to weigh it.

Record the weight of the object in the table below. This is its weight in air.

Lower the object on the spring balance or newton meter into the water. Record its weight now.

Weigh all the other objects, first in air and then in water.

Object	Weight in air	Weight in water

What happens to the weight of objects in water?

____

____

Which objects showed the greatest change in weight?

____

____

Notes on individual worksheets

1. Investigating gravity

Key idea The further an object falls under the influence of gravity, the greater the force with which it hits the ground.

Outcome The further the balls have fallen, the more they will have been damaged by the impact with the floor. Gravity makes all four balls accelerate uniformly, but the ball which has travelled the greater distance (number 4) has had time to reach the greatest speed and will, therefore, suffer the greatest damage on impact with the floor.

Extension Find out more about the life and work of Galileo.

2. An elastic band weighing machine

Key idea Objects have weight because gravity pulls on them. Elastic will stretch under the influence of a force and will return to its original shape as long as the elastic limit has not been exceeded.

Outcome Up to certain limits, the heavier the object weighed, the more the elastic will stretch.

Extension Make a weighing machine using a thin spring instead of an elastic band.

Safety Stretched elastic bands and springs can cause eye and facial injuries.

3. Weighing with a spring

Key idea The heavier the object placed on the spring, the more the spring is compressed.

Extension Examine various weighing machines, such as kitchen scales, spring balances and bathroom scales, to see how they work.

Safety Stretched elastic bands and springs can cause eye and facial injuries.

4. Testing parachutes

Key idea Parachutes push against the air as the force of gravity causes them to fall. Parachutes with a large surface area have more air resistance than those with a smaller area.

Outcome The larger the parachute, the slower it will fall, although parachutes made of flimsy materials such as tissue paper may well tear.

Extension Test shuttlecocks made from corks and feathers.

Safety If possible, carry out this experiment in the middle of the playing field or playground, away from windows and overhead wires.

5. Adding weights to a floating object

Key idea Adding weights to a floating object increases the downward force until eventually the object sinks. Floating objects displace water.

Outcome The more weights that are added to the can, the lower it floats in the water until eventually it sinks. As weights are added to the can, it displaces more and more water so that the level of the water in the bowl will rise.

Extension Repeat the experiment using salt water. Are the results exactly the same? Find out about the history and function of the Plimsoll line on ships.

6. Buoyancy

Key idea Water exerts an upward pressure, or upthrust, on floating objects, which can be felt. Floating objects displace water.

Outcome The harder the balls are pressed down, the greater the upthrust. The larger the ball, the greater the upthrust. The more the balls are immersed, the more the water level rises. The large ball displaces more water than the small one.

Extension Find out what is done to lifeboats to make them virtually unsinkable. Discuss why steel ships float but a steel screw sinks.

7. Measuring floating forces

Key idea Objects weigh less in water than in air because of the upthrust of the water.

Outcome Each of the objects will weigh less in water than it does in air. The greatest loss in weight will be by the largest object, as this displaces most water.

Extension Find out about, and discuss, the life and discoveries of Archimedes.

Lesson objectives

- An introduction to the way in which light travels and how the structure of the eye enables us to see things
- To show how mirrors and shiny surfaces can change the direction in which light travels
- To compare plane, concave and convex mirrors and their uses
- To compare and contrast reflection, refraction and shadow formation

Background information

Light is a form of electromagnetic radiation to which the human eye is sensitive. Without light we cannot see. The Sun, stars, electric lights, candle flames, and other forms of fire all give out light—they are luminous. But nearly everything else we see reflects at least some light. Even the moon is a reflector—it does not produce its own light but reflects that from the Sun.

Light is only one form of electromagnetic radiation. Radio waves and infrared waves are electromagnetic radiations with lower frequency than light, while ultraviolet waves, X-rays, and gamma rays have a higher frequency.

Unlike sound which can travel around corners, light travels in straight lines. Some modern inventions, such as the instruments that allow doctors to examine the interior of the human digestive system, give the impression that light can be made to move along a curved path, but this is not the case. Such instruments rely on large numbers of reflections from the source to the eye of the viewer. But each of the individual reflections is still a small straight line that, together with all the others, forms a zigzag path.

Vision

Light travels in straight lines from an object being viewed. Light, reflected or direct, coming from objects in our environment makes it possible for us to see things. On reaching the eye, the light is bent (refracted) by a flexible lens situated in the front of the eyeball. The lens can change its shape to focus an image of a near or distant object on the retina of the eye. The retina is sensitive to light and colour, and a message is transmitted, via a nerve, to the brain. In some people, the lenses of the eyes are not able to focus accurately and spectacles or contact lenses are worn to correct such defects of vision. In addition, the ability of the lens of the eye to adjust its shape declines with age. Again this can be corrected by spectacles or contact lenses.

Reflections and mirrors

When light strikes an object, several things may happen. The light may pass through the object, or the light may be absorbed. Another alternative is that the light is reflected and sent off in another direction. Usually light does some combination of these things. For example, most of the light that strikes clear glass passes through it. But some of the light may be reflected—that is why windows look shiny and we see reflections in them. In addition, a little of the light is absorbed, even though the glass appears completely clear.

Lots of things reflect light, including windows, glasses, highly polished cars, shiny shoes, pools of still water, and metal foil. Reflection is best in mirrors, because their highly polished surfaces reflect light rays falling on them in one direction only, rather than scattering the rays. Most ordinary mirrors consist of highly polished glass with a silvered backing. When rays of light from an object strike a flat mirror at an angle, they are reflected at the same angle. The result is that we see an image when we look back into the mirror, and the image appears to be the same distance behind the mirror, as the object is in front. The image in a mirror is reversed, or laterally inverted, so that when a page of print is held up to a mirror, the words go from right to left, and when you look at your reflection in a mirror, your right hand will seem to be your left hand. In all other ways, a flat mirror faithfully reflects the objects and scenes in front of it. A curved mirror, however, produces distortions of the image.

Since mirrors change the direction of light waves, they can be used to see around corners. A dentist uses a mirror to see behind the teeth, while a car mirror shows what is behind on the road. Two mirrors set at a suitable angle can be used to make a periscope.

The speed of light

Light travels extremely quickly, at a speed of 300,000 kilometres per second (186,000 miles per second). Indeed, scientists believe that nothing can travel faster than light. Even so, light takes eight minutes to reach us from the Sun. In other words, the sunlight entering our eye now left the Sun eight minutes ago. Light from the nearest star takes four years to reach the Earth, while light from some other stars has been travelling to us for hundreds or even thousands of years. Light travels much faster than sound, which is why we see the lightning before we hear the thunderclap that was produced at the same time. Similarly, from a distance, we hear the bat hit the ball after we see the impact of the two. In the case of a thunderstorm, we can tell how far away it is by the time difference between the lightning flash and the thunderclap. Since sound travels about three kilometres in 10 seconds in air, for every 10 seconds between the lightning flash and the thunderclap, the storm is three kilometres away.

Transparent, translucent and opaque objects

As we have seen, light goes through some materials and not others. When light goes through a material, such as spectacle lenses, window glass, air or clean water, and forms a clear image on the other side, the material is said to be transparent. Translucent describes a material, such as tissue paper or frosted glass, that allows some light to pass through, but not enough for objects to be seen clearly through it. Opaque materials, such as wood, brick, or cardboard, do not allow any light to pass through them.

Shadows

Everything that is visible is capable of casting a shadow. This is evidence that light travels in straight lines. Opaque objects, that let no light through, cast the darkest shadows, with sharp edges; translucent materials cast lighter shadows, and even objects made of transparent materials, such as a glass bottle, will cast feint shadows. If light was able to travel in curved lines, it would bend round the opaque objects, so that the edge of the shadow would be diffuse. However, dark shadows can be made lighter, or even be made to disappear, by shining or reflecting light on to them.

Refraction

Light waves can travel through transparent things but they slow down when they enter them. Light travels fastest in air (even faster in a vacuum), 25 per cent slower in water and 35 per cent slower in glass. As a result, when light passes through one material, such as air, and enters another such as glass at a slant, the rays are bent or refracted because the light has slowed down. Refraction explains how lenses and magnifying glasses work, as we shall see below. Another effect of refraction is that our brains can be tricked into thinking that swimming pools and rivers are shallower than they really are. This is because light coming from the bottom of a pool or river bends when it comes out at the surface when the rays change speed.

Lenses and magnifying glasses

Lenses and magnifying glasses cause light rays to bend (refract) when they enter the glass or transparent plastic. A convex lens is thicker in the centre than at the edge. This type of lens causes rays of light to come together, or converge, then spread out, forming an inverted image on a screen. This is known as a real image. The convex lens also acts as a magnifying glass with objects close to it. A concave lens is thinner in the centre than at the edges. It produces a smaller upright image.

Prisms and spectrums

When light passes through a triangular glass prism, the light rays are bent and separated into a colour spectrum. This results from the fact that white light contains all the colours of the rainbow. The colours are separated in the prism because each colour has a different wavelength and is bent (refracted) at a slightly different angle from the others. When it rains while the Sun is shining, raindrops may similarly split up the sunlight into its constituent colours. A rainbow is thus really a spectrum in the sky.

If a circular disc, divided into sectors each of which is painted with the colours of the spectrum, is rotated rapidly, the colours are mixed in the eye and produce the impression of white.

Coloured light

Our eyes contain just three types of colour sensors. One type responds to red light, a second to green light, and the other to blue light. Red, green, and blue are known as the primary colours of light. If our eyes receive red, green, and blue lights together, we see white light. This can be demonstrated by shining a red, a green, and a blue spotlight on to a screen so they overlap. Where the overlap occurs, we see white light. Where only two colours are added, we see the so-called secondary colours. Red and green lights combined, for example, produce yellow light, while red and blue produce magenta, and green and blue produce cyan.

The pictures produced by a colour television set are made up of only the three primary colours. The picture consists of thousands of tiny glowing dots, some red, some green, and some blue. Light from the glowing dots mixes to form all the different colours on the screen.

Safety

Use plastic mirrors wherever possible. If you have to use glass mirrors, ensure that they do not have sharp edges; bind the edges with masking tape or insulating tape.

Answers

Travelling light: **Rapid fire, p 59**

1) a) No light can pass through objects which are opaque. Opaque materials include wood, metal, rubber and cardboard.

   Transparent materials are completely see-through. Clear glass, clear-plastic and cling film are all transparent.

   Translucent materials let some light through although they are not completely see-through. Frosted glass, greaseproof paper, many curtains and lampshades, and porcelain and some other types of pottery are translucent.

   A shadow is a dark shape formed when an object blocks the light.

2) a) Shadows would be shortest near the middle of the day when the Sun is high in the sky.

   b) When the Sun is low in the sky, at the beginning or end of the day, objects have long shadows.

3) Some of the ways in which lights are used to send messages include: traffic lights, railway signals, the lights that warn about road works or accidents ahead, motor vehicle indicators, the warning lights on a vehicle’s dashboard, the lights on an electric oven, freezer or refrigerator to show that the device is operating, and the standby lights on a television or computer. In general, green lights show that something is safe while red lights warn of a possible hazard or danger.

Travelling light: **Try it out, p 59**

1) The arrow representing the light ray will go straight from the lighted candle to the eye.

Eyes and seeing: **Rapid fire, p 61**

1) The arrow representing the light ray will go straight from the lighted candle to the eye.
2) One method would be for everyone to stand at a set distance, say two metres, from a newspaper which is pinned on a notice board. Each person would be asked to read certain of the large and small printed words and the results recorded. It is important that the same lighting conditions are used throughout and that the individuals do not have prior view of the newspaper or the words to be read.
3) One way to see whether people are right-eyed or left-eyed would be to ask them to look though a telescope or microscope or, failing that, through a cardboard tube. Note whether the person immediately uses either the right or the left eye for this task.

Eyes and seeing: **Try it out, p 61**

3) Almost all animals which hunt (predators) have forward-pointing eyes which allow them to judge depth and distance accurately when they are hunting. Plant-eaters (prey animals) often have eyes that point sideways. This allows them to keep a lookout all around, so that they get the earliest possible warning of approaching danger. Both predator and prey need to see well if they are to survive.

Reflected light: **Rapid fire, p 63**

1) A plane mirror is flat, and is the kind of mirror most commonly seen in homes. Concave mirrors are curved inwards, like a cave or the bowl of a spoon. Concave mirrors magnify objects close to them and are often used for shaving or for make-up. Convex mirrors are curved outwards, like the back of a spoon or a dome. They reflect more, but smaller objects, and are often used as security mirrors in shops and sometimes by the roadside to reveal dangers that would otherwise by hidden from road-users.
2) Open answers.
3) A shadow is a dark shape formed when an object blocks rays of light coming from a light source. A reflection is produced when light rays bounce off an object. The picture seen in a mirror is a reflection.

Reflected light: **Try it out, p 63**

1) Shapes that look exactly the same when you see them through a mirror are said to be symmetrical. We say something is symmetrical if we can draw a line through it in some way to produce two or more identical parts. Such a line is called an axis of symmetry. Using a plane mirror, students can place it along the line of symmetry of, say, a drawing of a butterfly and see the missing half reflected. The students can also draw half people and match the missing half with a plane mirror. Playing cards can also be used to illustrate symmetry.

Using mirrors: **Rapid fire, p 65**

1) a) A plane mirror might be used as an ornament in a home or kept in a handbag. A periscope contains plane mirrors, while many cameras have a plane mirror in them to reflect light to the viewfinder.
   b) A concave mirror is often used for shaving or make-up. A dentist's mirror is also concave, as are the mirrors in a lighthouse or the reflector in a torch.
   c) Convex mirrors are used as the driving mirrors in motor vehicles, security mirrors in shops and by the roadside to reveal hidden dangers.
2) A dentist uses a concave mirror to examine our teeth because, up close, it produces a magnified image.
3) a) Reflective clothing reflects vehicle lights in poor visibility and so shows up workman, pedestrians and cyclists who might otherwise be difficult to see.
   b) Some of the people who wear reflective clothing as part of their job are police officers, firemen, ambulance crew, building workers, road and railway repair crews, and others who work where there is a danger from moving vehicles.

Using mirrors: **Try it out, p 65**

1) If you look at your reflection in the back of a spoon, your reflection appears small but a lot of your body is reflected. If you look at your reflection in the bowl of the spoon very close up, you see a magnified reflection of just your face which is the right way up, but from a distance there is a small reflection which is upside down.

Shadows, reflections and refraction: **Rapid fire, p 67**

1) Any material which can block light can produce a shadow. The darkest shadows are produced by opaque objects, but even a bottle made of transparent glass will create a pale shadow. Reflections are produced by smooth, shiny surfaces. The clearest reflections are produced by the highly polished surfaces of mirrors.

   Shadows are roughly the shape of the object making them, but the colour and texture of the object is not visible in its shadow. The size of a shadow depends upon the angle at which light falls on the object, although the shadow is not turned or reversed in any way.

   Reflections show every detail of the colour and texture of the object making them, but the reflection is reversed. If you close your left eye while looking in a mirror, your reflection appears to close its right eye. Your reflection also looks as far behind the mirror as you are in front of it.
2) If a beam of light hits a plane mirror, it will be reflected back at the same angle that it struck the mirror. The statement is, therefore, false.
3) It is not normally possible to see round a sharp corner because light travels in straight lines. You could see round a sharp corner if you placed a mirror at an angle near the corner. If you used a convex mirror, then the field of view would be much greater than that achieved with a plane mirror.

Assessment: **p 68-69**

1) a) A—eyebrow; B—eyelashes; C—iris; D—pupil
   b) The iris.
   c) The pupil is small in bright light.
   d) The pupil is large in dim light.
   e) The experiment shows that we need two eyes to be able to judge distances accurately.
2) a) Rays of light travel in straight lines.
   b) transparent
   c) translucent
   d) opaque
   e) opaque materials
   f) We do not see shadows out of doors on dull days because the clouds reflect and scatter the rays of light coming from the Sun.
   g) reflect
   h) A reflection
   i) dentists, hair dressers, beauticians, astronomers, photographers, lighthouse keepers, submariners
   j) A convex mirror is curved outwards (dome-shaped) and produces small images covering a wide angle.
   k) A concave mirror curves inwards and shows a magnified image over quite a narrow field of view.
   l) The lens of the eye is soft like jelly and its shape can be changed by muscles in the eye, allowing it to focus on near or far objects.
   m) The part of the eye which controls how much light enters the eye is called the iris.
3) The man would appear exactly the same when seen in a mirror except that the eye patch would appear to be covering his right eye.

4) The pencil would appear to be bent where it entered the water. (See page 67 of the student's book.)
5) Mr Hamid's glasses are fitted with light-sensitive lenses. They darken in bright light to protect his eyes from damage. In dim light the lenses become fully transparent to allow Mr Hamid to see clearly.
6) The ray of light would be reflected from the plant and would travel in a straight line to the boy's eye.
7) The man on the left would be able to see the candle because the holes are in a straight line, allowing rays of light to pass into the man's eyes. The holes in the cards on the right are not in a straight line, so that light rays could not pass through them and the man would not be able to see the candle.

Going further

Print the words HIAWATHA, AUTOMATA, MOTIVITY, MAXIMUM and WITHOUT vertically on a sheet of paper. Study their reflections in a mirror. You may need to look at the reflections from both sides of the sheet of paper. What do you notice? Make up some more words like these.

Collect pictures of interesting lighting effects, shadows, reflections, and images seen through glass and water. Make a wallchart with your pictures.

Draw one of your eyes from memory. Draw it again, using a mirror to improve accuracy. Compare results. Are you a better observer than your friend?

Look at the eyes of members of the class. What are the colours of their irises? How many students have eyes that are black, blue, grey, brown, green or hazel? Count them and make a block graph. Which is the commonest eye colour? Which colour is the least common?

Did you know that some people are left-eyed and some are right-eyed? Focus on a distant object using both eyes. Hold your finger up so that it covers the object. Now close your left eye and look only with your right eye. Does your finger seem to 'jump'? If yes, you are left-eyed. If your finger does not 'jump' you are probably right-eyed. Keep your finger in the same place. Now close your right eye and look at the object with your left eye. Does your finger 'jump'? If it does not, then it confirms you are left-eyed. If it does 'jump', you are right-eyed. Record the results for your class. Are right-handed people right-eyed? Are more girls right-eyed than boys? Does it matter what eye colour you have as to whether you are right- or left-eyed?

The size of the pupil varies automatically depending on how much light there is. The pupils expand in dim light to let in as much light as possible, and contract in bright light to prevent overexposure of the retina. Let the students work in pairs. One student should cover one eye for about a minute. The other student should compare the pupil size the moment the hand is removed. Shine a torch (not too close) into one eye. Watch the reaction of the pupil. Discuss how turning the light on suddenly, from total darkness, hurts. Why? How can very bright light cause blindness?

Investigate how well signs and posters can be read with increasing distance. Do the colours make a difference? Explain that contrasts are best seen at a distance, for example, black on yellow.

How well do you see to the sides? Rest a hoop between two tables or desks. Seat the person to be tested in the centre of the hoop. Try to arrange it so that the hoop is resting at the person's eye level. Tell the subject to look at a fixed mark in front of him. Slowly bring a small coloured object from behind his head and round one side of the hoop. When does he first see the object? When can he first make out the colour of the object? Mark this on the hoop. Test other people and make records. How far can people see to the sides? Discuss the implications of this for road safety.

Let the students work in pairs and let them try to clap in front of each other's eyes without blinking. (It is impossible to do, but they will love the challenge!)

Find the blind spot. Ask the students to draw a red cross and a circle about 6 cm apart. Close the left eye and with the right eye look hard at the cross. At the same time, slowly move the paper closer towards yourself. What happens?

Our eyes can retain images for a very short time. Cut out a piece of card 7 cm square and draw a fish on one side and a goldfish bowl on the other. Use sticky tape to fasten a pencil or a short stick to the centre of the lower side of the card. Rotate the card between your two hands and the fish will appear to be swimming in the bowl.

One inexplicable function of binocular vision is that when we look at the fingers close up, we see them twice. Hold your two hands with their palms towards you and make the tips of the two index fingers touch. Concentrate hard on the point where the two fingers touch, while slowly bringing the hands in close to the bridge of your nose. When the hands are very close to your nose, the image of a small sausage appears 'between' the fingers.

Not all people are fortunate enough to have a pair of eyes that work. Discuss what it is like to be blind. With suitable safety precautions, ask students to close their eyes and make their way to set places within the classroom.

Discuss why, if rain is colourless and clouds are droplets of water, we cannot see through the clouds? Crumple up a piece of clear cellophane to demonstrate why.

Use a transparent cylinder of water as a magnifier. Compare its magnifying power when filled with cooking oil or kerosene. Also try glass and plastic rods to see whether they magnify.

1. Materials and light

What you need:

- pencil

What you do:

a) Copy out this table and complete it to show which of these materials allow light to pass through them. The first one has been done for you.

Material	Lets some light through	No light passes through
glass	yes	
cardboard		
clear plastic		
tissue paper		
mirror		
wood		
diamond		
metal		

b) Light enters our eyes from many different objects. Here are a few examples of objects from which light may enter our eyes so that we see them.

moon Sun candle car headlamp fire television set torch mirror

Sort these different objects as to how the light that comes from them is produced. Copy out the table below and write the objects in the correct column.

Electric light	Light from flames	Reflected light

2. A pinhole camera

A pinhole camera works in a similar way to the eye. Make this simple camera to see how.

What you need:

- pencil
- cardboard tube
- black paper
- greaseproof paper
- sticky tape or elastic bands
- a pin

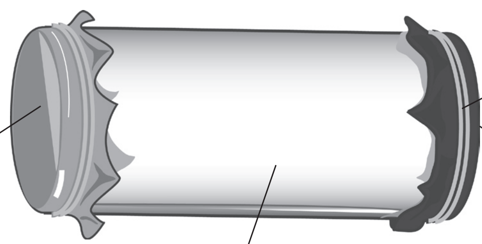
What you do:

Cut a piece of greaseproof paper so that it will fit over one end of the cardboard tube.

Pull the paper tight and hold it in place with elastic bands or sticky tape.

Do the same with black paper at the other end of the tube. Make sure that there are no gaps around the paper.

Use the pin to make a tiny pinhole in the middle of the black paper.



Now point your tube at a brightly lit object, with the pinhole nearest to the object. What do you see on the greaseproof paper?

Draw the object and the image that was reflected on to your greaseproof paper here:

What did you notice about the image?

___

___

___

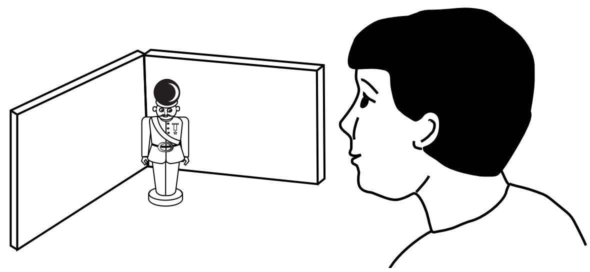
3. Reflections

What you need:

- pencil
- sticky tape
- toy figure
- two plastic mirrors
- Plasticine

What you do:

Use sticky tape to join the two mirrors at the back.
Stand them upright.
Put the toy figure in front of the mirrors, as shown in picture 1.
How many reflections of the figure can you see?

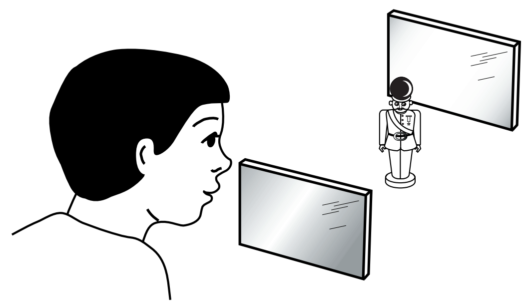


picture 1

Carefully move the edges of the mirrors towards you.
How many reflections of the figure can you see now?

Now stand the two mirrors so that they face each other.
Put the figure in between them, as shown in picture 2.
Peep over the top of one mirror into the other.

How many reflections of the figure can you see?



picture 2

Write or draw what happened.

Where in the street have you seen mirrors being used? Make a list and say what they are used for.

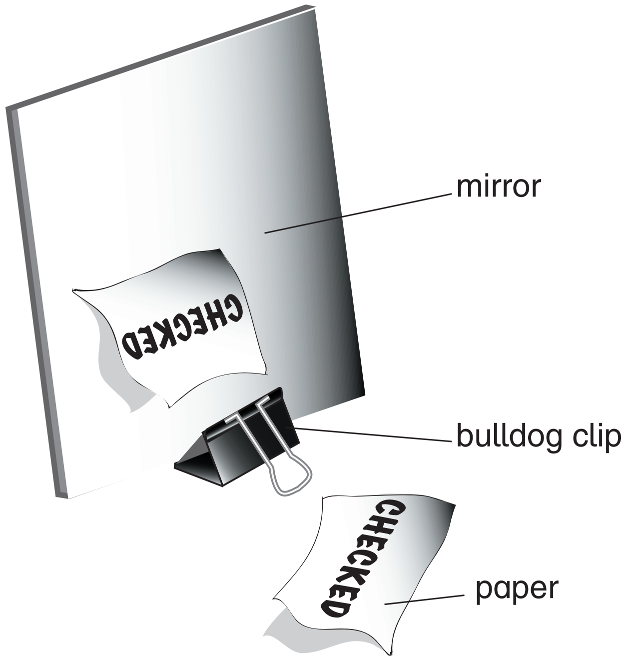
4. Mirror words

What you need:

- pencil
- mirror
- paper
- bulldog clip

What you do:

Make your mirror stand up with help of the bulldog clip.
Write the word CHECKED on a piece of paper.
Put it in front of the mirror as shown in the picture.



Read the word in the mirror.
What do you notice? ______________________________

____

____

Now write the word WRONG on a piece of paper.
Put it in front of the mirror and read the word in the mirror.
What do you notice? ______________________________

____

____

Try these words: ALL, AXIS, WORDS.

Experiment to see how many other words you can find which have a reflection that looks the same in a mirror.

Write a secret message to your friend in mirror writing. Can your friend read it?

5. Reflections in a spoon

The picture you see in a mirror is called a reflection.

What you need:

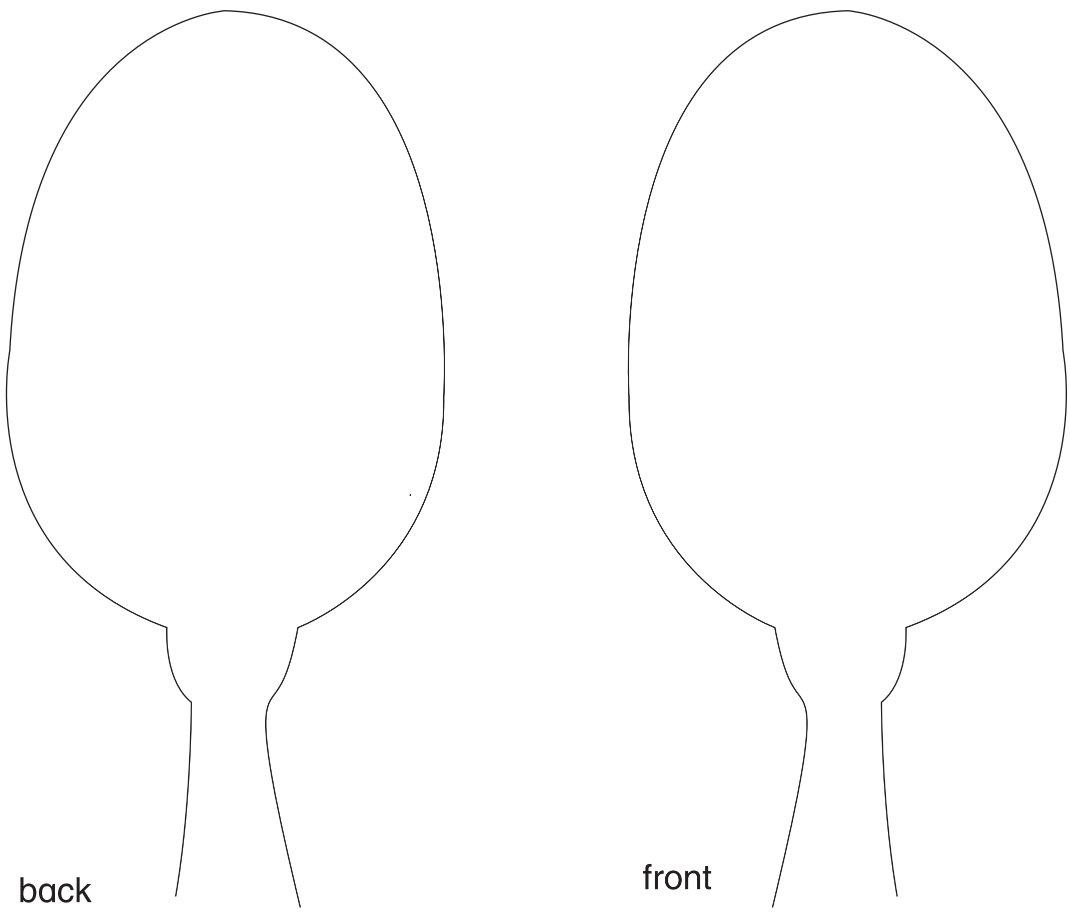
- pencil
- a large, shiny metal spoon

What you do:

Look at your face in the front of the spoon. Look carefully at your reflection.

Look at your face in the back of the spoon. Look carefully at your reflection. Is it the same or different?

Draw your reflections in the outlines of the spoons.



Look around your home or school. What other objects make funny reflections?

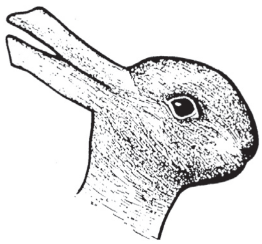
6. Can we believe our eyes?

What you need:

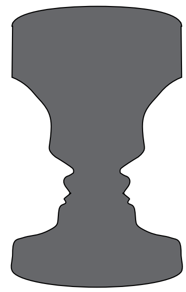
- pencil
- ruler

What you do:

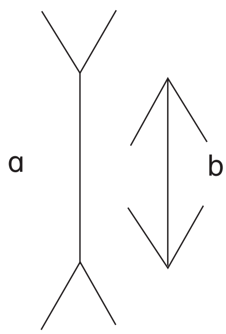
Work on your own and look at the pictures. Write down the first thing you see or the first answer you think of.



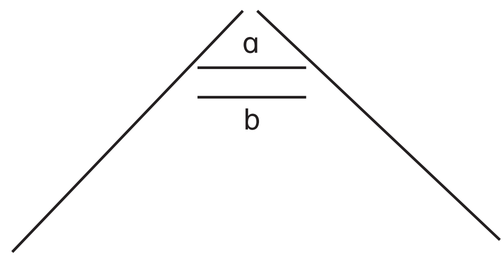
Duck or rabbit?



Two faces or a Greek urn?

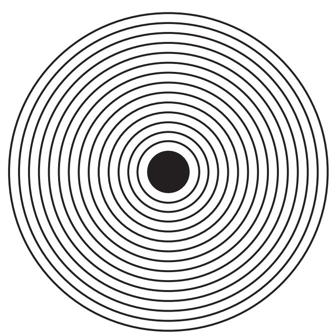


Which vertical line is longer, a or b?



Which horizontal bar is the longest, a or b?

Old woman or a young girl?



Does this figure move?

Use a ruler to check if you were right with the measuring activities.

Now compare your results with those of your friends. Did you all get the same answers?

Notes on individual worksheets

1. Materials and light

Key idea A revision activity on the sources and properties of light.

Outcome a) Lets some light through: glass, clear-plastic, tissue paper, diamond
No light passes through: cardboard, mirror, wood, metal
b) Electric lights: car headlamp, television set, torch
Light from flames: Sun, candle, fire
Reflected light: moon, mirror

Extension Expand both tables with objects and materials seen around the home and school.

2. A pinhole camera

Key idea To make a pinhole camera and to show that, like the eye, it produces an inverted image.

Outcome In bright light, the pinhole acts like a lens and an image will be formed on the greaseproof paper. Like the image on the retina of the eye, this is inverted.

Extension Take an old camera to pieces and investigate how it works.

3. Reflections

Key idea Using two mirrors it is possible to produce reflections of reflections.

Extension Compare the properties of a hand lens or magnifying glass with those of mirrors.

Safety Ideally use plastic mirrors. If not, edge glass mirrors with masking tape.

4. Mirror words

Key idea Some words look the same in a mirror as they do on paper.

Extension Do palindromes (e.g. PEP or POP) look the same in a mirror? Try OXO, SIS, MUM, DAD, ROTATOR. What about NURSES RUN? Are they mirror palindromes?

Safety Ideally use plastic mirrors. If not, edge glass mirrors with masking tape.

5. Reflections in a spoon

Key idea Curved surfaces produce a distorted reflection.

Outcome The bowl of the spoon acts like a concave mirror: the image is magnified and the right way up when the spoon is held close to the face, but inverted when it is seen from a distance. The back of the spoon acts like a convex mirror: the image is smaller but the right way up. It also provides a much wider field of view.

Extension Look for reflections in unusual places, such as in puddles, in the sides of tin cans, in bicycle handlebars and bells, and so on. Are the reflections the right way up and are they distorted?

6. Can we believe our eyes?

Key idea To show that it is your brain which interprets pictures, rather than your eyes.

Outcome The lines, a and b, are the same length.

Extension Find out more about animals with interesting eyes. For example, snails have eyes on stalks, earthworms have no eyes at all, spiders have many eyes, while chameleons can move each eye separately.

Lesson objectives

- To introduce simple ideas about the many small organisms, called microbes or micro-organisms, that are able to feed, grow and reproduce
- To introduce simple ideas on disease transmission by microbes and ways in which we can combat disease organisms or reduce their impact
- To illustrate the importance of certain microbes in food production and the decay and recycling of organic materials

Background information

Microbes or micro-organisms are living things that are too small to be seen with the naked eye. They include bacteria, viruses and fungi.

Bacteria

Bacteria are the smallest fully living things. They are also the most ancient forms of life on Earth. Each bacterium usually consists of a single cell, which is spherical, rod-shaped or spiral. The cell has a tough wall and is often surrounded by a glue-like substance or by sticky hairs which help to hold it in place. Most bacteria reproduce simply by dividing in two. Under favourable conditions they can do this every 20 minutes, which means a single bacterium can soon turn into millions.

Bacteria exist almost everywhere on Earth. They are nature's chief recyclers of living materials. Many of them feed on dead organic matter, which can be anything from the dead bodies of plants and animals to leftover food, and the warmer it is the faster they work. Other bacteria get their energy from sunlight, while a few use chemicals from rocks. Pathogenic bacteria invade living things and often produce disease.

Viruses

Viruses are the smallest things that show signs of being alive. Most viruses are much smaller than bacteria, and in many ways they are more like minute machines than living things. Viruses do not feed or grow, and they cannot reproduce on their own. Instead, they take over living cells which they force to make copies of themselves. Viruses attack all kinds of living things, including bacteria, plants and animals, and many of them cause disease. Viruses cannot move, so they rely on outside help to travel. Some are passed on by touch, while a few, including cold and flu viruses, are passed on when people cough or sneeze.

Fungi

When most people think of fungi, they think of mushrooms and toadstools. But these colourful objects are just a tiny part of the fungal world. Fungi are some of the most common living things on Earth. Many of them are microscopically small and, unlike plants, fungi can grow in the dark and need ready-made food to survive. Unlike animals, fungi do not swallow food and then digest it. Instead they digest the food that surrounds them, and then absorb the nutrients that are released. The structures that do this work are minute threads called hyphae, which spread throughout a fungus's food. Fungi reproduce and spread by means of spores and most feed on dead and decaying organic matter, although some are parasites and feed on living plants and animals.

Microbes and disease

Some of the illnesses caused by microbes are shown below:

- different bacteria cause
  - ❖ food poisoning
  - ❖ cholera
  - ❖ typhoid
  - ❖ whooping cough
  - ❖ boils
  - ❖ some kinds of pneumonia
  - ❖ leprosy
  - ❖ diphtheria
  - ❖ tooth decay
- different viruses cause
  - ❖ colds
  - ❖ influenza (flu)
  - ❖ measles
  - ❖ mumps
  - ❖ chickenpox
  - ❖ yellow fever
  - ❖ HIV AIDS
- different fungi cause
  - ❖ athlete's foot
  - ❖ ringworm

Avoiding dirt and germs

Sneezing and coughing can spread pathogenic bacteria and viruses, or germs, so can dirty skin and hands, and unbrushed teeth. If people are careless when they store, preserve or handle food, that can spread germs. Uncovered dustbins can attract flies, rats and mice which all spread germs. We can also catch some kinds of germs by drinking contaminated water or by touching a person who already has some kind of illness. Animals such as flies and cockroaches, which carry germs on their legs and mouthparts, can leave germs behind when they have been feeding, while mosquitoes leave germs behind when they feast on our blood.

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 burying beetles may feed on 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 down 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 of 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.

Composting

The compost heap is a way of artificially exploiting the activities of decomposing organisms. A compost heap consists of layers of vegetable matter from the kitchen or garden. Sometimes sulphate of ammonia or some other nitrogen-containing fertilizer is sprinkled between the layers to enhance the growth of the decomposing organisms. The latter will thrive only if they receive air, water, nitrogen, non-acidic conditions, and warmth.

The best compost is made from soft organic matter such as lawn mowings, dead leaves, straw, and vegetable peelings. However, any coarse material will decay more quickly if it is chopped up or crushed. This gives a larger surface area on which the bacteria can act. In dry weather the compost should be watered regularly, and in winter it may be covered with an old piece of carpet or plastic sheeting to keep it warm. Decomposition is also speeded up if the heap is turned every few weeks, moving the material on the outside of the pile into the centre. At the same time, dry areas are watered.

In a few months, the pile becomes a crumbly, manure-like material which can be dug into the soil where it helps to improve the texture. At the same time the compost forms humus in the soil which slowly decomposes, producing plant nutrients.

Sewage treatment

Sewage treatment also uses bacteria and other decomposing organisms to render a waste material harmless.

Until the middle of the nineteenth century, it was quite common for sewage to flow along open drains in the streets into rivers. Later it was realized that such open sewers could be linked to deadly diseases such as cholera and typhoid. Nowadays, most human waste is passed through underground sewers to sewage works where it is treated and, with the aid of special decomposing organisms, made relatively harmless.

When sewage arrives at the sewage works, any large materials, such as rags and pieces of wood, are removed by large metal screens and later incinerated. The sewage then flows slowly through channels, where any soil and sand sink to the bottom and are removed at regular intervals.

The sewage next flows into large tanks where the solid matter slowly sinks to the bottom to form sludge. This is removed for further treatment. The remaining liquid effluent is then sprayed on to circular beds of stone, clinker, or rock fragments. Sometimes it may be put in large tanks and churned round while air is blown into it. Either way, special decomposing bacteria feed on any organic waste matter in the effluent, turning it into harmless gases and water. The water is then clean enough to be pumped straight into a river or the sea.

The sewage sludge is pumped into other tanks containing different bacteria. These destroy the unpleasant materials in the sludge and change them into the gas methane. This can be burned for heating or to make electricity to power the machinery of the sewage works. The digested sludge may then be incinerated or spread on farmland, where it acts as a fertilizer.

Safety

Securely close (but do not seal) all containers in which micro-organisms are grown and do not uncover them for observation.

The students should wear disposable gloves while handling decaying material. Dispose of the decaying material safely.

Wipe up any spills with disinfectant.

Because of the possibility of contamination, teach students to wash their hands thoroughly with soap and water after handling any source of micro-organisms.

If possible, when disposing of cultures of micro-organisms, open the cultures under the surface of a freshly-prepared disinfectant solution so as not to release live spores into the air. Soak the culture for at least an hour, or overnight, before pouring away the disinfectant, placing the culture in an opaque plastic bag and putting this in the dustbin.

Answers

Death and decay: **Rapid fire, p 71**

1) If a tree fell to the ground, its leaves would probably be eaten by woodlice, insects and earthworms and the ground-up remains of the leaves deposited in or on the soil as faeces. The woody parts of the tree would be attacked by wood-boring insects, and again the ground-up remains would be deposited on the soil round about. Fungi would attack the wood causing it to rot away. Bacteria would eventually convert the faeces and decaying wood into mineral salts in the soil.
2) Any organic household waste could be put on a compost heap including vegetable and fruit peelings, tea leaves, egg shells, and even old newspapers. Meat, bones and the faeces of meat-eating animals should not be put on the heap since they will attract flies and rats and spread disease. Material put in the dustbin usually finishes up being put in a landfill site (a large hole in the ground) together with materials which will not decay so that the potential benefits of the compost are lost to the soil.
3) Two food chains containing scavengers or decomposers are:
   lettuce → slug → thrush → hawk → dead hawk → crow → dead crow → bacteria
   dead leaf → millipede → sparrow → hawk

Bacteria, fungi and food: **Rapid fire, p 73**

1) We keep food covered so that flies cannot land on it and spread bacteria.
   We heat food properly when cooking it to kill bacteria and make the food safe. Cooking also makes the food tender and easier to eat and it improves the flavour of the food.
   We store raw meat away from cooked meat so that bacteria in the blood and other fluids of the raw meat do not drip onto the cooked meat and make it unsafe to eat.
2) Open answers.
3)

Method	Reason
drying	food does not contain enough water for microbes to multiply
salting, smoking or preserving in vinegar	adds chemicals to the food which kill microbes
canning and bottling	when the can or bottle of food is heated the microbes are killed. The airtight seal prevents any other microbes from entering and attacking the food
freezing	does not kill the microbes but stops them growing
adding sugar or syrup	removes the water which microbes need to grow

Bacteria, fungi and food: **Try it out, p 73**

1) The main way in which foods are preserved by more than one method in a supermarket is by vacuum packaging. Cold meats, cheese, sausages and fish are wrapped in an impermeable plastic film and then the air is removed from inside the wrapping. This prevents the entry of microbes until the seal is broken. Such foods are normally stored in a refrigerator and may have chemical preservatives added to them so that they keep even longer.

2) germ: a micro-organism that can infect us and do us harm
   sterilize: to remove all forms of micro-organisms from an object or material
   preserve: to keep something safe or in good condition
   decay: what happens when dead plants and animals rot away. Decay is caused by bacteria and fungi
   bacteria: a group of micro-organisms, some of which are harmful germs while others are useful because they help dead materials to decay
   pasteurize: to purify milk by heating it
   microbe: a very small living thing that can be seen only with a microscope. Microbes include bacteria, viruses and some fungi
   decompose: to rot away or decay

Microbes, germs and disease: **Rapid fire, p 75**

1) People are more often ill during the winter, not because of the lower temperatures as such, but mainly because people tend to stay indoors more in the warm where germs can easily grow, breed and be spread in the warm, moist conditions. The most common illnesses that occur during the winter are colds and influenza (flu). These are spread partly by coughs and sneezes but also on the hands of people when, for example, they shake hands.
2) If our homes are dirty, then they attract mice, flies, cockroaches, ants and other pests that can spread germs. Waste food, in particular, will attract these pests. Germs could pass from a dirty towel to someone's face or hands while the crack or chip in a cup used by someone else could act as a breeding ground for germs that could be passed to the next person.

Microbes, germs and disease: **Try it out, p 75**

2) The action of a housefly is extremely likely to infect human food. When landing on food, it attaches itself by means of its sticky feet which may carry traces of faeces or decayed matter from its previous meals. When feeding, it secretes saliva mixed with some of its last meal onto the food. It then sucks up the partially digested food with its special mouthparts. It is also likely to defecate while feeding. Flies are thus responsible for the spread of a number of diseases including typhoid, paratyphoid, polio, food poisoning and a whole variety of other disorders. The best way to protect our food is to keep it covered. It is possible to control flies with insecticidal sprays, but the safest method of control is to prevent their entry to the home as far as possible and to use a fly swat to kill them.
3) Mosquitoes breed by laying their eggs in stagnant water. The larval and pupal stages of the life history are also aquatic. Male mosquitoes feed by sucking plant juices; it is only the females which suck blood. They do this to get extra protein before laying their eggs. When they feed on human blood, the female mosquitoes can spread malaria or yellow fever or dengue fever.

Attacking germs: **Rapid fire, p 77**

1) Open answers.
2) A graze is washed to clean away any dirt or stale blood. The antiseptic kills any germs already present on the graze, while the sticking plaster prevents other germs getting into the graze before the skin has healed.
3) A microbe is an organism, such as a bacterium, virus or certain kinds of fungi, which are too small to be seen without a powerful microscope. Some of the diseases caused by microbes can be found on page 73 of this book.

Attacking germs: **Try it out, p 77**

1) Vaccination is a means of protecting us against certain germs. Weakened or dead germs are introduced into the body so that the body starts to produce antibodies which kill those types of germs, if they later

try to attack the body. Vaccination is used against diseases such as measles, mumps, whooping cough, diphtheria, tuberculosis and polio.

An antibiotic is a special kind of medicine used against bacteria. Antibiotics cannot kill viruses, so they cannot be used for treating colds and influenza.

3) Alexander Fleming (1881-1955)—Scottish doctor and scientist who discovered penicillin, the first antibiotic, by accident in 1928.

   Joseph Lister (1827-1912)—English scientist who developed an antiseptic spray which was used to kill bacteria during operations. He was the first person to realize how important clean, sterile conditions were during surgical operations.

   Louis Pasteur (1822-1895)—French scientist who discovered that bacteria cause diseases. His process of pasteurization is still used today to make milk safe to drink.

   Edward Jenner (1749-1823)—English doctor who discovered vaccination and prevented the spread of the deadly disease smallpox.

Useful microbes: **Rapid fire, p 79**

1) Open answers.
2) The ways in which bacteria and fungi are useful to us include making bread (yeast, a fungus), making cheese (bacteria and also moulds which are fungi), making vinegar (bacteria), making yogurt (bacteria), making the soil more fertile by adding nitrates (bacteria), making antibiotics (bacteria and fungi), decomposing dead organic matter (bacteria and fungi).
3) Open answers.

Useful microbes: **Try it out, p 79**

2) Bread contains some proteins and a lot of carbohydrates. It contains vitamins B and E as well as the minerals iron (for healthy blood) and calcium and phosphorus (for healthy bones and teeth). Wholemeal or wholegrain bread is a good source of fibre.

   Cheese has quite a high content of protein and fat. It is a good source of vitamins A, D and B, and is high in the calcium and phosphorus minerals, so that it too is good for healthy bones and teeth.

   Yogurt is quite high in protein and is a good source of B vitamins and calcium and phosphorus minerals, so that it also is good for healthy bones and teeth.

Assessment: **p 80-81**

1) a) The following are microbes or micro-organisms: ii) viruses; iv) bacteria.
   b) A powerful microscope
   c) True: A, C, D, F, G and H. False: B, E.
2) a) Jar A
   b) The mould will grow in Jar A because it has warm, moist conditions.
   c) The moulds grow from spores that are carried in the air.
   d) Make sure that each jar contains exactly the same amount of bread and sand and that the same amount of water is added to Jars A and B.
   e) Moulds and bacteria that are harmful to health could have grown on the bread and Adil could breathe in the spores these produce.
3) Scientists working with germs wear gloves to prevent bacteria and fungi getting into scratches and cuts on their hands, or being passed to the food they eat. They wear masks so that they do not breathe in the germs or their spores.
4) One way the viruses that cause colds are spread is in the liquid droplets that come out of the mouth and nose during coughs and sneezes.

5) a) Chickenpox is caused by a virus.
   b) Chickenpox is a virus that causes red, itchy bumps. It is also often accompanied by coughing or sneezing. Chickenpox is contagious, which means that someone who has it can easily pass it on to someone else. The droplets in the coughs and sneezes, or which come out of the mouth when the infected person talks, are full of chickenpox viruses. It is easy for someone else to breathe in these droplets or to get them on their hands. Before you know it, the chickenpox has infected someone else.
   c) Other illnesses caused by viruses include colds, influenza, mumps and whooping cough.
6) a) Mould forms on the surface of the jam.
   b) For food
   c) Moulds grow on the surface of it.
   d) A decomposer is a living organism (usually a bacterium or fungus) which causes dead plants and animals to rot away or decay.
   e) Usually bacteria and fungi
   f) They prevent the accumulation of dead plants and animals and they also recycle nutrients.
   g) It will probably be eaten by a scavenger, buried by certain types of beetle and subsequently eaten by the beetle larvae, or slowly decomposed by bacteria and fungi.
   h) The soil may be contaminated with animal faeces or other germ-laden material. There may also be broken glass in the soil.
   i) The old meat, fish or cat or dog waste will attract flies, rats and other disease-carrying pests.
   j) The decomposers in a compost heap need moisture and air, as well as warm temperatures if they are to rot away the materials on a compost heap.
7) The low temperatures on Mount Everest mean that bacteria and fungi are not able to grow and multiply and decompose the fruit skins and food waste.

Going further

Mix 30 g of yeast with a teaspoon of sugar and 250 ml of water at approximately 38°C. Stir well, stand it in a warm place and leave for 15 minutes. This will activate the yeast. Measure the height of the froth produced. What happens to the height of the froth if you change the temperature of the water? Try using 250 ml of water at 10°C, 20°C, 30°C, 40°C and 50 or 60°C. Keep other variables the same. Now explore other variables. Change the amount of sugar. Try five or ten spoonfuls. Leave the yeast to stand in different temperatures. Change the time the mixture is left to stand. Try five or 25 minutes. Remember to change just one variable at a time so that it is clear which variable affects the results.

Add a level teaspoon of yeast to tepid water in a narrow-necked bottle. Add two teaspoons of sugar and stretch an uninflated balloon over the neck of the bottle. Stand the bottle in a warm place and see how the carbon dioxide produced by the yeast makes the balloon stand up. Have similar bottles, a) without sugar; b) with sugar and without yeast; c) with sugar and yeast but kept in a refrigerator.

Which kind of tree leaf do you think will decay fastest? Plan an investigation to find out.

a) When will you collect the leaves?
b) What will you do to them to make them decay?
c) What measurements will you take and how will you record your results?
d) How will you make sure that your investigation is fair?

Try out your ideas to see if they work. What did your investigation show?

Some waste materials and litter are said to be ‘biodegradable’. This means that they can be decayed by bacteria and fungi. Other materials, such as plastics, that will not decay are said to be ‘non-biodegradable'. Look around the neighbourhood of your school at the litter people drop. Which of the litter is biodegradable? Which of the litter is non-biodegradable? Make a chart to present your results. Do NOT touch the litter.

Look around the outside of your home or school. Can you see any examples of wood that is decaying? What can be done to prevent wood from decaying?

Imagine you lived 400 years ago. Do some research and then make an illustrated article to answer these questions:

a) How would you have preserved food to make sure your family had enough to eat during the winter?
b) What kinds of foods would you have preserved?
c) What foods that you eat now would not have been available then?

Place a variety of foods in sealed transparent containers and carry out regular observations over a period of weeks. Record your observations. (Ensure that the containers remain sealed and dispose of the contents safely.)

In your own words, explain why drinking water is treated with chlorine gas or other chemicals at the waterworks before it is pumped to our homes.

Ask the students to find out what happens to the litter they produce at home.

Keep a record of the things you throw away at home or at school. How many could you reuse? How many could you recycle?

Find out more about products made from milk. Answer these questions: What are curds and whey? How is cheese made? What are the blue veins in some cheeses? Why are some cheeses covered in red skin?

1. Microbes and food

What you need:

- pencil

What you do:

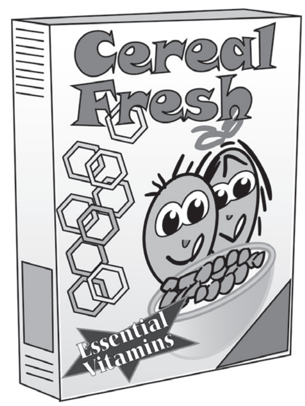
a) Some micro-organisms (or microbes) are useful to people, some are harmful. For each statement in the table below, put a tick in the correct box.

	Useful	Harmful
yeast in bread		
bacteria in plaque on teeth		
cold virus		
microbes in garden compost		
moulds on curdled milk		

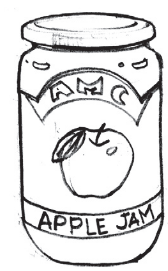
b) In a kitchen there are the following items:

baked beans

frozen peas



breakfast cereal



jam

Write down two reasons why the process of canning food (putting it into sealed tins) kills microbes.

i) ______________________________

ii) ______________________________

c) Explain how keeping the air out of the jar stops the jam from going bad.

____

d) Explain how freezing preserves the peas.

____

e) Explain how drying helps to preserve the breakfast cereal.

____

2. Moulds, bacteria and bread

What you need:

- pencil
- piece of bread
- clear-plastic bag without holes
- sticky tape
- hand lens

What you do:

Put a small piece of bread inside the plastic bag.

Seal the plastic bag and do not open it again.

That way the moulds and bacteria will not harm anyone.

Each day, record how the mould develops.

Day 1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

How long was it before you could see mould on the bread?

____

How long did the mould take to cover the whole piece of bread?

____

What was causing the mould to grow?

____

How did the mould get into the plastic bag?

____

____

3. Preventing decay

What you need:

- pencil

What you do:

Read these statements and then answer the questions below:

In 1991, the body of a man was found buried in ice and snow high in the mountains between Austria and Italy. Scientist believe that the man died about 5300 years ago.

Food sealed in metal cans will last for many years, but once the can has been opened the food decays within a few days.

In many parts of the world, fish, meat and fruit are dried in the Sun to be eaten later.

Many extinct mammals and birds which lived about 15,000 years ago have been found in tar pits in California in the United States, where the animals fell into the heavy tar and sank below the surface.

Salt is sometimes used to preserve meat, fish and vegetables.

a) Why do you think the body of the man had not decayed?

____

____

____

b) Why do you think that the bodies of the mammals and birds that fell into the tar pits had not decayed?

____

____

____

c) Why do you think it is important that cans for storing food are undamaged?

____

____

d) Why can salt be used to preserve meat, fish and vegetables?

____

____

e) Put a circle around the FOUR conditions below that you think would help bacteria and fungi to cause something to decay QUICKLY.

dry	with air	without air	with toxic chemicals
moist	warm	cold	without toxic chemicals

4. Biodegradable materials

What you need:

- pencil

What you do:

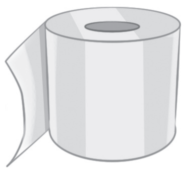
What do we mean by biodegradable?

____

____

Look at these pictures. Put a tick against those objects you think are biodegradable.

newspaper ☐



tissue paper ☐

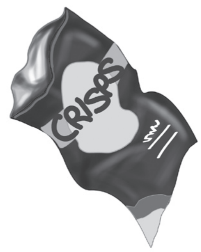
banana skin ☐

drinks can ☐

apple core ☐

plastic bag ☐

glass bottle ☐



crisps packet ☐

Draw some more biodegradable objects here:

Notes on individual worksheets

1. Microbes and food

Key idea To examine useful and harmful micro-organisms and the methods of controlling micro-organisms when preserving food.

Outcome
a) The yeast in bread, the microbes in garden compost and the moulds which grow on curdled milk are useful. (The latter are involved in the production of cheese). The other two microbes are harmful.
b) Heating the food kills the microbes and sealing the food in the can prevents air and further microbes reaching it.
c) Microbes need air and sealing the jar stops any microbes (or bacteria and fungi/moulds) reaching the jam.
d) Freezing stops microbes from growing, although it does not kill them.
e) Microbes need water if they are to feed and grow.

Extension Research the discovery of penicillin and why it was important.

2. Moulds, bacteria and bread

Key idea To investigate the growth of moulds on bread.

Outcome It is not possible to predict the rate at which moulds will grow on the bread; it depends upon the ambient temperature and the amount of moisture in the bread. The moulds require warmth, moisture and a source of food (the bread) if they are to grow. The moulds and bacteria develop from spores which were in the air in the bag and also present on the surface of the bread.

Extension Repeat this experiment with plastic bags containing identical amounts of bread. Leave one bag in a sunny place, another in a dark cupboard and a third in a refrigerator. Compare the growth of moulds in all three bags.

Safety Do not allow the students to open the bags and dispose of the bags either by incineration or in the dustbin after sterilizing the contents with disinfectant, as described on page 73. Clear glass or plastic jars can be used for this experiment, although, again, the students should not be allowed to open the lids.

3. Preventing decay

Key idea A comprehension-style exercise to test the understanding of the conditions that cause materials to decay.

Outcome:
a) The cold/low temperature prevented bacteria and fungi (or moulds) from growing or slowed their growth. (It does not kill the bacteria and fungi.)
b) The chemicals in the tar killed any bacteria or fungi (moulds).
c) While the cans are undamaged no bacteria and fungi (or moulds) can get into the food.
d) Bacteria and fungi cannot grow in the presence of salt. (The salt actually dehydrates them.)
e) moist, warm, with air, without toxic chemicals

Extension Investigate how sugar and syrup are used to preserve certain fruits.

4. Biodegradable materials

Key idea Biodegradable materials will decay and not damage the environment

Outcome Biodegradable: newspaper, paper tissue, banana skin and apple core
Non-biodegradable: glass bottle, drinks can, crisp packet, plastic bag.

Extension Carry out a litter survey around the school. Make a bar chart of the results, distinguishing between biodegradable and non-biodegradable litter.

Lesson objectives

- To extend the earlier learning on health and hygiene, with particular reference to the blood, digestive, and respiratory systems
- To introduce simple ideas on the differences between drugs and medicines and the dangers of the abuse of tobacco, caffeine and certain drugs and solvents

Background information

Body systems

An organ is a part of the body with a particular job to do. For instance, the heart pumps blood and the stomach and liver help to digest food. More than one organ is needed to digest food. The stomach does some of the work, but the mouth, intestines, liver, pancreas and other organs also help. Together, these various organs form the digestive system. A number of other systems go to make up the human body. They include the skeletal and muscular systems, which we met in an earlier book in the *Simply Science* series. There are also the respiratory, digestive, nervous, excretory, reproductive, endocrine, and blood or circulatory systems. In this unit, particular attention is paid to the respiratory and blood systems.

Breathing

The blood transports dissolved chemicals around the body. Most of the chemicals are dissolved foods that have entered the blood system as a result of digestion. However, oxygen, which is also transported around the body, is obtained from the air breathed in.

If you place your hands on your ribs and breathe in then out deeply, you can feel your ribs first of all moving upwards and outwards and then sinking back again to their original relaxed position. The rising and falling of the ribs when you breathe in and out happens because the ribs are attached to muscles. However, the ribs are not the only parts of the body that move during breathing. Underneath the ribs is a large sheet of tendon and muscle called the diaphragm, which stretches horizontally across the ribcage. When you breathe in, the diaphragm moves down, while the ribcage is moving upwards and outwards. This causes the air pressure inside the chest to be lowered, so that air passes down into the lungs. The diaphragm then moves upwards, as the chest relaxes, so increasing the air pressure in the chest and forcing the used air out of the lungs.

The rate of breathing changes according to the needs of the body. During exercise, the breathing rate increases so that more oxygen can be taken into the body, and more carbon dioxide can be removed from the body.

It is possible for air to enter the lungs through either the mouth or the nose. It is always advisable to breathe in through the nose, since dust particles are filtered out by thousands of tiny moving hairs, called cilia, and by sticky mucus inside the nasal cavity. The air is also warmed as it passes through the nose. When you breathe in through the mouth, dusty, cold air can enter the lungs. After the inhaled air has passed through the nose and nasal cavity, it travels down the windpipe.

The lungs are like two gigantic sponges. The windpipe branches into two, and then each branch (or bronchus) splits up into smaller and smaller branches. Eventually each tiny branch ends in a microscopic air sac. A lung contains millions of these air sacs.

The air sacs, and the lungs, are pink because every air sac is surrounded by blood capillaries. The blood in these capillaries has travelled in an artery from the heart. In both lungs, some of the oxygen from the air breathed in passes through the thin walls of the air sacs into the blood capillaries. At the same time, carbon dioxide passes from the blood capillaries into the air sacs. Eventually this carbon dioxide joins the air which is breathed out of the body.

Respiration

All food contains stored energy. If a peanut is held in a flame for a while, it starts to burn. The peanut continues burning even when the flame is removed. Burning releases the stored energy in the chemicals of the peanut as heat and light energy. In the body, stored energy in food can be released and used in many different ways.

Respiration is a process that goes on all the time in every cell of the body. Sugars from the digested foods we have eaten are burnt up slowly, using oxygen from the air we have breathed in. This releases the energy to keep our bodies working. The sugar and oxygen are used up inside the cells. Two chemicals are made as waste products—carbon dioxide and water. The carbon dioxide is breathed out, while some of the water may be used by the cells of the body.

The blood system

The blood system is the transport system of the body. It is possible to feel the blood moving through the body by finding a pulse in one's wrist. The regular beating of the pulse is caused by blood passing through a blood vessel (an artery). If you place a hand over your heart you will also feel a regular beat. This is caused by the pumping action of the heart.

The structure of blood

Blood is a living tissue. One drop contains about five million cells. Blood has four main components: red blood cells, white blood cells, and platelets, all floating in a watery liquid called plasma.
Red blood cells carry oxygen from the lungs to all parts of the body. They contain a chemical called haemoglobin which produces their red colour and which enables them to carry oxygen.

There are about 5000 times more red cells than white cells, but white cells are roughly twice as big. Unlike red cells, white cells each have a nucleus. White cells protect us in two different ways. Some white blood cells eat germs by engulfing them and destroying them. At the sites where this happens, dead bacteria, chemicals and white blood cells may accumulate, forming pus. Other white blood cells make chemicals called antibodies. These kill germs and change the poisonous substances (toxins) they produce into harmless substances. Some antibodies remain in the blood for months or even years after they have helped recovery from a disease. While they are there, the antibodies help to stop you catching that disease again. The process of vaccination against diseases involves placing antibodies in the blood artificially or stimulating their production without producing the symptoms of the disease.

Platelets are tiny pieces of cells released into the blood from the bone marrow. They are part of the body's puncture repair kit in that they help prevent loss of blood from wounds. When skin is cut it bleeds for a while, washing dirt and germs from the wound. Soon platelets form a pad of fibres over the wound in which red blood cells become trapped. As the red cells dry out, they make a solid plug (a scab) which stops the bleeding and keeps out dirt and germs until the wound heals.

The red and white blood cells and platelets float in a straw-coloured liquid, plasma. In the plasma are dissolved digested food, carbon dioxide and other important substances that have to be carried around the body. The plasma carries the chemicals which help platelets plug wounds. It transports dissolved food from the gut to the liver and from the liver to other parts of the body. Plasma also carries carbon dioxide from the body back to the lungs, and a waste chemical called urea from the liver to the kidneys, where it forms urine.

The heart

The heart is the pump that does the vital job of circulating blood throughout the body. The blood vessels which carry blood from the heart are the arteries, while those which return blood to the heart are the veins. The heart weighs about 300 grams and is about the size of a clenched fist. It is made of a powerful muscle which continually contracts and relaxes to produce the heartbeat.

The heart is really two pumps side by side. Each pump transfers blood from veins into a collecting chamber, the atrium or auricle, at the top of the heart. The atrium or auricle then pumps the blood into the ventricles below it. The ventricle pumps the blood under high pressure into arteries. Both ventricles pump at the same time, which causes the blood to spurt into the arteries.

The heart rate varies considerably. In an adult human it is about 70 beats per minute, but in a baby it may be nearly twice as fast. The smaller an animal, the faster its heart beats—about 500 beats a minute in a small bird and about 20 in an elephant. Vigorous exercise, strong emotions, and fear temporarily increase the rate of beat of the heart.

The right ventricle pumps blood that has given up its oxygen to the tissues (deoxygenated blood) through the arteries to the lungs. Here it collects oxygen (becomes oxygenated) and returns through the veins to the left ventricle to be pumped to the rest of the body before returning to the right side of the heart again. This double circulation is necessary because oxygenated blood leaves the lungs at too low a pressure to pass round the body quickly enough to supply the tissues with all the oxygen and food they need.

Between the auricles and ventricles, and at the exits from the heart, are small flaps of skin acting as one-way valves to prevent the blood going the wrong way. Any defect in these valves can seriously affect health. Another serious defect is a hole in the heart, which is a gap between the right and left sides of the heart, usually between the auricles. It allows oxygenated and deoxygenated blood to mingle, so that the tissues never get as much oxygen as they need. The heart itself needs a supply of oxygen, which it receives from the coronary artery. A blockage of this artery can cause a heart attack.

Blood and its circulation

Blood travels around the body by means of a network of blood vessels that extends throughout the whole body. Blood leaves the heart through large arteries, then travels through smaller and smaller ones, finally reaching networks of minute blood vessels, the capillaries, which have a diameter of only a few thousandths of a millimetre.

Capillaries have extremely thin walls through which a two-way exchange takes place: food and chemical substances pass into the body cells and waste products pass from them into the bloodstream.

On its return journey to the heart, the blood travels through veins and, as it has lost much of its oxygen, it appears bluish as it flows through them. At different stages of its journey, the blood collects necessary materials and unloads waste products. For instance, in the lungs carbon dioxide passes out of the blood and oxygen passes into it; in the small intestine glucose from the digested food is picked up and carried to the liver, and waste proteins are transported by the blood from the liver to the kidneys.

The blood travels in a closed system, that is, unless the person is injured in some way, the blood always remains within blood vessels. Arteries are thick-walled tubes in which blood flows under pressure from the heart. If an artery is cut, the blood flows out in spurts, and a great deal of blood will be lost in quite a short time. Most arteries are deep in the body, but some are nearer the surface and it is in these places that a pulse can be felt. Veins have one-way valves which help to keep the blood flowing towards the heart. When these valves do not work properly, the veins will swell and become varicose veins.

Heart disease

Heart disease is responsible for approximately one-third of the deaths of people aged 45 to 64 years. Medical opinion suggests that heart disease is caused by a variety of factors, of which one is poor diet, particularly a diet which is high in fats, and also lack of exercise. Smoking tobacco is another contributory factor and coronary heart disease kills twice as many smokers as non-smokers.

Drugs and medicines

A drug is any substance, natural or synthetic, which has an effect on the functioning of the human body. By this definition, substances such as alcohol, the nicotine from tobacco, the caffeine in tea and coffee, and the solvents of glues and other substances are drugs. A medicine has a much more restricted definition. It is any substance taken into the body which has a curative or beneficial effect, such as relieving pain or treating illness. Thus all medicines are drugs, but not all drugs are medicines.

The caffeine in coffee, and to a lesser extent in tea and some cola drinks, and the alcohol in some other drinks are stimulant drugs. In small doses they may not be harmful but large doses over a long period can be dangerous. Like alcohol, the nicotine in tobacco is an addictive drug which causes difficulty in breathing, a smoker's cough or even bronchitis. Sometimes during violent coughing the air sacs in the lungs burst. There is less surface area for oxygen and carbon dioxide to be exchanged, and the illness that results is called emphysema.

The problems do not end there. The poisonous carbon monoxide gas in the tobacco smoke gets into the blood and makes it harder for the red blood cells to pick up oxygen. At the same time, the tar in the tobacco smoke sticks to the air sacs of the lungs, irritating them, and eventually causing lung cancer in some people. There is definite evidence that people who smoke, or who regularly breathe in someone else's smoke, die on average, younger than non-smokers.

It should be remembered that all drugs are chemicals that can change the way the body works. All drugs involve a risk, and dose instructions must be followed carefully. The body can become tolerant to some drugs so that larger doses are needed to produce the same effect. And, as can be seen in the case of alcohol and nicotine, some people quickly become addicted to drugs.

Taking medicines

There are different ways of introducing medicines into the body. The three main ways that are used are by mouth, by injection, and through the skin.

The time taken for a medicine to work depends on the amount of medicine taken and the way it is put into the body. A larger amount will produce a quicker and longer lasting effect than a small one. A medicine that is injected will show its effect quickly as it is put straight into the blood. One that is swallowed may not produce its effect for half an hour or more as it has to pass through the wall of the gut to reach the blood.

A medicine put on the skin may also produce an immediate, if localized, effect. Zinc ointment for sore, moist skin or soft lanolin for itching and sunburn may produce their effects immediately. By contrast the nicotine patches, designed to help reduce the urge to smoke tobacco, leak the nicotine into the body slowly so that their effect is more prolonged.

Most children have had experience of injections in the form of vaccinations. A vaccine contains dead or harmless versions of the disease-producing organism. These do not produce the illness (though they may produce some of its minor symptoms), but they stimulate the body's immune system to produce the same defensive cells and antibodies that the active organism does. These cells and antibodies stay in the bloodstream, ready to defend the body if a real infection takes place. Today most children are offered a series of vaccinations, usually by injection, which prevent them developing such potentially dangerous infectious diseases as diphtheria, whooping cough, polio, tuberculosis, measles and rubella (German measles). Those planning to travel abroad may additionally be given vaccinations against such diseases as yellow fever, cholera, typhoid and meningitis.

Many other medicines are given in tablet or capsule form. This includes most of the different antibiotic drugs that are available to fight bacterial infections. Analgesic drugs (pain relievers) such as aspirin, paracetamol and codeine are also normally given in tablet form.

Another way to give a drug by mouth is in the form of an inhaler. An asthma attack, for example, can be relieved by breathing in a drug from an inhaler that relaxes the muscles in the airway walls, allowing them to open up.

Safety

Be sensitive to the differences between students.
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 students 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.
When carrying out measurements of breathing or pulse rates, ensure that individuals are not put into situations of physical or emotional stress.

Answers

Your body's organs: **Rapid fire, p 83**

1) A cell is a tiny unit of a living thing. A tissue is a group of cells of the same type. Blood, muscles, bone and nerves are examples of tissues. An organ is a particular part of the body, made up of different types of tissues, which has a particular function or job of work. The brain, heart, lungs and liver are examples of organs.
2) Eyes, ears, skin, tongue and nose
3) Skin (sweat), lungs and kidneys, get rid of wastes produced within the muscles and tissues of the body, while the rectum or bowel gets rid of waste food.
4) Brain
5) The skin
6) The ribs

The heart and blood: **Rapid fire, p 85**

1) a) An organ
   b) To pump blood around the body
   c) The ribs
   d) Arteries
   e) Veins
2) a) The rate at which the heart is beating
   b) The pulse beats faster when you are running because the heart is pumping faster to carry dissolved food and oxygen to the muscles and to carry away the waste materials being produced by the muscles.
   c) The pulse rate slowly returns to the normal resting rate.

The digestive system: **Rapid fire, p 87**

1) Food has to be digested to make it soluble so that it can be absorbed into the blood.
2) The teeth chew up the food, breaking it down into smaller pieces. Chemicals called enzymes are added to the food to dissolve it.
3) The small intestine
4) Fibre or roughage (mainly the insoluble cellulose cell walls from fruits and vegetables).
5) Enzymes

Lungs and breathing: **Rapid fire, p 89**

1) While you are running, you use up oxygen faster than your body can take it in. Breathing deeply after you have stopped running gives your body extra oxygen to replace that used up and to help clear away the waste chemicals that were formed while you were running.

2) At high altitudes on Mount Everest, the air pressure will be lower and there will be less oxygen available to the climber. It will be necessary to either take bottles of air or oxygen on the climb, or to move very slowly to avoid overtaxing the heart and lungs and the rest of the body.
3) You breathe faster after you have been running or carrying out some other exercise to give your body extra oxygen to make up for that used in burning up food to produce energy. The extra oxygen also clears away waste chemicals that have accumulated in the muscles during the exercise.

Lungs and breathing: **Try it out, p 89**

1) The temperature of the air breathed out on to the thermometer will be higher because the air has been warmed by the blood vessels in the nasal cavity and lungs.

Some health dangers: **Rapid fire, p 91**

1) A drug is a substance that has an effect on a person's body. A medicine is a substance we take to make us better, to prevent a disease or to cure a disease. All medicines are drugs, but not all drugs are medicines.
2) Smoking damages the lungs, and smokers get out of breath quickly. They are more likely to suffer from bronchitis, lung cancer and other lung diseases than non-smokers. Smokers are also more likely to suffer heart attacks.
3) a) 21 deaths per 10,000 men
   b) The rate of death from lung cancer increases steadily as the number of cigarettes smoked increases.

Assessment: **p 92-93**

1) a) A = brain; B = lung; C = heart; D = stomach; E = kidney
   b) The heart pumps blood around the body.
      The stomach stores and digests food.
      The kidney filters and cleans the blood.
      The lung exchanges gases.
      The brain controls the body's actions and behaviour.
2) a) Kashif's pulse rate begins to rise when he starts to run because his heart is beating faster. He needs more energy and the blood is carrying more food and oxygen to his muscles.
   b) approximately 12 minutes
   c) It is slowing down at the end of the exercise.
   d) Between 65 and 85 beats per minute
   e) To obtain more oxygen so that the food can be burned up more quickly in the muscles to produce energy.
   f) arteries
   g) veins
   h) capillaries
3) Good for the health: b) Having enough rest; d) Eating a balanced diet; e) Taking exercise; f) Taking care of the teeth
   Damaging to health: a) Smoking tobacco; c) Taking dangerous drugs; g) Taking medicines intended for someone else
4) Smoking would damage the athlete's lungs, making him out-of-breath more quickly and have less energy. It could lead to bronchitis, lung cancer or other lung disease and increase the risk of a heart attack.
5) a) Washing your hands   b) Inhaling solvents   c) Smoking cigarettes
   d) Fibre   e) Cleaning your teeth   f) Drugs
   g) Taking exercise   h) Medicines   i) Loud music

Going further

The traffic light system highlights the need for a balanced and healthy diet. What the students eat in a set period of time can be divided up into three main areas, represented by the three colours of traffic lights. Draw a set of traffic lights, consisting of three large circles overlying a rectangle. The ‘Green for go’ area should contain foods they are able to eat plenty of each day because they are beneficial to health (e.g. fruit and vegetables). The ‘Amber for caution’ section incorporates food items that should be eaten in moderation, with amounts kept under control (e.g. potato chips and pasta). In the ‘Red for danger’ category are foods that need to be monitored closely because they are the least healthy (e.g. sweets, chocolate, cakes and biscuits).

Ask the students to suggest reasons why, at the end of a race, runners have red faces.

Some people who have a weak heart have a pacemaker fitted. Find out what a pacemaker is and what it does.

Ask the students to devise some basic rules for a healthy heart.

Put your ear to a friend’s chest. Listen carefully. Can you hear the valves of the heart closing? What other sounds can you hear? Can you think of a device you can make that will let you hear the heart more clearly? Try out your idea and see if it works.

Keep an exercise diary for a week. Each time you do an exercise which makes your heart beat faster, like running, walking fast, skipping or jumping, make a note of it. Compare your diary with those of your friends.

Ask the students to demonstrate where their heart lies. Use a piece of tubing and a small plastic funnel (or the top cut off a plastic bottle) to make a model stethoscope, so that you can listen to the heart and lungs working.

A simple pulse meter can be made by carefully pushing a used matchstick on to the point of a drawing pin. If this device is rested on the appropriate part of the wrist, it will move backwards and forwards with each pulse beat.

Measure a volunteer’s lung capacity. To do this you will need a large plastic sweet jar, a large bowl of water (bigger than the sweet jar) and a length of PVC tubing. Calibrate the jar by pouring in 100 ml of water at a time and marking each level on the side. Now fill the jar completely with water (no air at all) and invert it in the bowl of water. Insert the tube into the jar. Sterilize the other end of the tube with a dilute solution of antiseptic and then ask the volunteer to take a deep breath and blow into the tube. The amount of air in the jar is the volunteer’s lung capacity. A normal breath into the tube will show how much air is normally used: only a small proportion of the lungs’ total capacity.
Safety warning: Children who suffer from lung conditions such as asthma and bronchitis should not be allowed to take part in this activity.

Make a model of the chest and lungs. Cut the base off a small plastic bottle (the chest). Plug the neck with Plasticine and push a small tube through it (the windpipe or trachea) that has a balloon (a lung) tightly fixed to the end. Cover the base of the bottle tightly with a sheet of burst balloon, to represent the diaphragm. Pull the centre of the diaphragm downwards. This reduces the pressure in the chest and the lung should expand as it fills with air drawn in from the outside. Release the diaphragm and the lungs will return to normal. Discuss why a puncture of the chest can lead to a lung collapsing. Point out that this is why the chest and lungs are so well protected with a cage of ribs.

Investigate drug abuse. Explore the ways that drugs can affect you, what it means to become addicted and the ways people try to break addiction. Ask the students to investigate one addictive drug and describe the symptoms and effects to the rest of the class. Choose drugs which the students may be likely to come across.

Make a large model cigarette from card, showing the ash and smoke. Attach this to the wall and add information labels about tar, nicotine and carbon monoxide and how these affect human health.

Make a class display of empty medicine bottles and packets and empty cigarette and tobacco packets. Discuss these and ask the students to comment on what they think is safe to take, and in what quantities. Compare the possible slow death resulting from smoking and the rapid death from taking a whole bottle of aspirins. How do the students know how much medicine to take? Who would they ask or what could they do to find out? Ask the students to name some medicines they have taken recently. Did they get the medicine from a doctor, a pharmacist or a parent? Would it be safe for another person to take their medicine? Is it safe for children to take the same medicines as their parents? Can some medicines make you ill? What other household substances could be dangerous if consumed?

Discuss the precautions necessary when taking medicines. Why are they to be taken in this way? Why could taking them all at once be harmful? Why should medicines be taken at set intervals? Why should you always finish the complete course of an antibiotic? Why are medicines locked away and given by adults? Devise some rules for the responsible use of medicines.

Ask the students to work in pairs to make a list of things they think would be harmful to their health if they were to take them. Share the lists with the whole class and compare the answers. Agree on a whole-class list of what would be harmful.

Make some basic hygiene rules. Discuss whether excessive cleanliness is a good thing. Challenge obsessive concerns that are encouraged by advertisers. Be aware of family backgrounds that make personal hygiene difficult.

1. Blood and blood system

Do you know what the different parts of the blood and blood system do?

What you need:

- pencil

What you do:

Look at the table below. Can you match the parts of the blood and blood system to the correct jobs they do?

Parts of the blood and blood system	Functions or jobs
heart	These vessels carry blood back to the heart.
veins	This regular throbbing in an artery shows how fast the heart is beating.
red blood cells	This is the muscular organ that pumps the blood.
white blood cells	These cells carry oxygen around the body.
platelets	These vessels carry blood away from the heart to the rest of the body.
capillaries	These cells help fight germs in the blood.
arteries	These tiny vessels connect the veins and arteries.
pulse	These help the blood to clot.

2. Pulse rates

How does your pulse rate change before and after exercise?

What you need:

- pencil
- stopwatch or clock or watch with a second hand
- graph paper

What you do:

To find your pulse, put one finger in the middle of your chin.
Run your finger down your neck but just before you reach your Adam's apple, move your finger a little way to the left.
Press your finger in and you should be able to feel your pulse.

a) Find your normal resting pulse rate.
Sit still and count how many times your pulse beats in 30 seconds. Multiply this number by two.
My resting pulse beat is __________ beats a minute.

b) Exercise for three minutes. You might, for example, run up and down on the spot or jump on and off a step or bench for three minutes. Record your pulse rate immediately and then every minute for ten more minutes.

Record your results on this chart:

Time after exercise	0 min	1 min	2 mins	3 mins	4 mins	5 mins	6 mins	7 mins	8 mins	9 mins	10 mins
Pulse rate per minute											

c) Record your results on a graph using squared paper.

d) How long did it take for your pulse rate to return to normal?

____

____

e) What would happen to your pulse rate if you exercised harder?

____

____

3. The digestive system

What you need:

- pencil

What you do:

a) Put these sentences in order to describe how food passes through the digestive system.

1. Food is stored in the stomach.	6. Food travels down the food pipe or gullet.
2. Waste food is passed out of the anus.	7. The food is put into the mouth.
3. Digestive juices break the food down.	8. The teeth chew the food.
4. Waste food passes into the large intestine.	9. The food enters the small intestine.
5. The dissolved food passes into the blood.	10. The sight and smell of the food make our mouth water.

Correct order: ________________________________

b) What does digestion mean?

____

____

c) In which organ does most digested food enter our blood?

____

d) Which part of our food is not digested?

____

4. Breathing rates

What happens to your breathing rate during and after exercise?

What you need:

- pencil
- stopwatch or clock or watch with a second hand
- graph paper

Work with a friend.

What you do:

a) You need to find your normal resting breathing rate. Sit still and ask your friend to count how many times you breathe in a minute. It is best if your friend does this three times and then finds the average.

My resting breathing rate is ___________ breaths per minute.

b) Exercise for three minutes. You might, for example run up and down on the spot or jump on and off a step or bench for three minutes. Ask your friend to record your breathing rate immediately and then every minute for ten more minutes.

Record your results on this chart:

Time after exercise	0 min	1 min	2 mins	3 mins	4 mins	5 mins	6 mins	7 mins	8 mins	9 mins	10 mins
Breathing rate per minute											

c) Record your results on a graph using squared paper.

d) How long did it take for your breathing rate to return to normal?

____

____

e) What would happen to your breathing rate if you exercised harder and for longer?

____

____

5. Smoking

What does smoking do to the delicate lungs inside our chests? This experiment uses a model to show what happens.

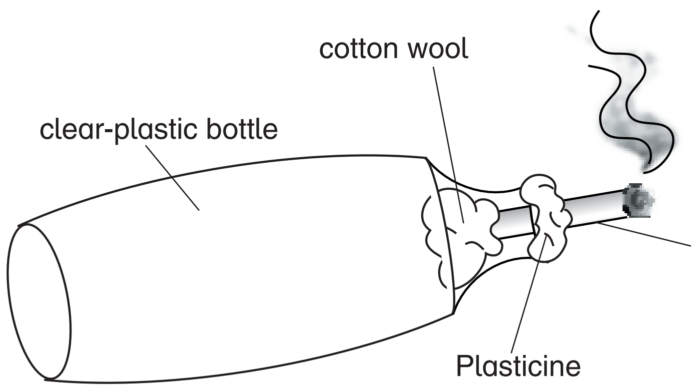
You should do this experiment only when your teacher or another responsible adult is with you.

What you need:

- pencil
- a cigarette
- matches or a lighter
- a clear-plastic bottle that you can squeeze easily
- cotton wool
- clay or Plasticine

What you do:

Make the model as shown in the picture below.



Ask your teacher or another adult to light the cigarette.

Gently squeeze the bottle and then let go.

Keep doing this.

Watch as the air is sucked back inside the bottle.

What happens to the cotton wool as the cigarette burns?

____

What would happen to the lungs of someone who smokes?

____

____

Do you think it is healthy to smoke?

____

____

Notes on individual worksheets

1. Blood and blood system

Key idea To examine the parts of the blood system and their functions.

Outcome

Parts of the blood and blood system	Functions or jobs
heart	This is the muscular organ that pumps the blood.
veins	These vessels carry blood back to the heart.
red blood cells	These cells carry oxygen around the body.
white blood cells	These cells help fight germs in the blood.
platelets	These help the blood to clot.
capillaries	These tiny vessels connect the veins and arteries.
arteries	These vessels carry blood away from the heart to the rest of the body.
pulse	This regular throbbing in an artery shows how fast the heart is beating.

Extension Use the Internet or reference books to find out more about the size and structure of veins, arteries and capillaries.

2. Pulse rates

Key idea To show how the pulse rate changes before and after exercise.

Outcome The pulse rate increases during exercise because the muscles use more oxygen and food. If you exercise harder the pulse rate will rise even higher. The quicker the pulse rate returns to its resting level, the fitter the person.

Extension Compare the resting pulse rates of a group of children of different ages and sizes. Do the pulse rates of large children differ from those of small children? Is there a relationship between age and pulse rate?

Safety When carrying out measurements of pulse rates, ensure that individuals are not put into situations of physical or emotional stress.

3. The digestive system

Key idea A comprehension exercise to help the students understand what happens to the food we eat.

Outcome
a) The correct sequence is: 10, 7, 8, 6, 1, 9, 3, 5, 4, 2
b) Digestion is the chemical breaking down of food to make it soluble so that it can pass into the blood.
c) small intestine
d) fibre or roughage

Extension Use the Internet or reference books to find out what work is done by the liver.

4. Breathing rates

Key idea To show how the breathing rate changes before and after exercise.

Outcome The breathing rate increases during exercise because the muscles use more oxygen and food. If you exercise harder and longer, the breathing rate will rise even higher. The quicker the breathing rate returns to its resting level, the fitter the person.

Extension Breathe into a small, clear-plastic bag and then quickly seal it. Look at the water vapour exhaled, then pour the contents of the bag over a lighted candle to see the effects of the exhaled carbon dioxide on the flame. Adult supervision is needed for this.

Safety When carrying out measurements of breathing rates, ensure that individuals are not put into situations of physical or emotional stress.

5. Smoking

Key idea To demonstrate how nicotine tar is passed into the lungs.

Outcome The cotton wool will become stained with nicotine tar as the cigarette is burned up. This tar contains carcinogenic substances, while the cigarette smoke contains more than 4000 different chemicals, many of them harmful to human health.

Extension Ask the school nurse or a doctor to visit to talk about the hazards of smoking.

Safety If this activity is to be carried out by students, adult supervision is necessary.

Lesson objectives

- To extend the earlier learning on solvents, solutes, solutions, and reversible and irreversible changes
- A simple examination of the uses of some solvents in everyday life
- A simple introduction to distillation
- An introduction to burning as a change that cannot be reversed and which, like other irreversible changes, produces new materials

Background information

Physical changes

Physical changes do not produce any new substances. The material keeps its original chemical composition and any change is reversible. The material may be folded, cut, bent, frozen, or compressed, but the matter you end up with is the same as the one you started with.

An excellent example of a physical change is the freezing of water and the melting of the resulting ice. Similarly, moulding clay or Plasticine (but not baking it) is an example of a physical change.

Chemical changes

A chemical change is more complicated. In a chemical change, you start with one material and end up with one of more new materials. What is more, the change is permanent and the new material has a different chemical composition from the one you started with. As a result, we say that chemical changes are irreversible.

Some common examples of chemical changes are burning, rusting, and the digestion of food. When a fuel such as coal or wood is burned it combines with oxygen from the air, and produces a great deal of heat and light energy, plus waste products such as ash, smoke, and other gases. There is no way in which these substances can be recombined to form the original fuel. Oil and natural gas, when burned, also produce heat and light energy, with waste products, including gases such as water vapour and carbon dioxide.

Cooking an egg, or any other food, is also an example of a chemical change. The taste, texture, and appearance of the food are changed by the heat. An iron nail or a piece of steel left outside soon starts to turn brown and crumbly on the surface. The iron or steel has reacted with water and oxygen in the air to produce a new chemical compound, rust, which is a form of iron oxide. We can slow down the process of rusting by reducing the contact of the iron or steel with oxygen. This can be achieved by coating the metal with oil, grease or Vaseline, painting it, or coating it with zinc (a process known as galvanizing) or tin. Zinc and tin do not rust and so protect the iron or steel underneath. We can similarly slow down burning by reducing the supply of oxygen to the fire by smothering it with a special fireproof blanket, by spraying it with water (which also cools down the burning materials), or by using a fire extinguisher which blankets the fire with heavy carbon dioxide gas or a special foam, both of which exclude oxygen.

There are many other simple examples of chemical changes that can be demonstrated to students. Adding a few drops of vinegar to baking powder or bicarbonate of soda produces a vigorous chemical reaction in which the gas carbon dioxide is produced. Chemically, plaster of Paris is a white solid called calcium sulphate. This occurs naturally as gypsum. On heating, gypsum loses water and becomes plaster of Paris. When mixed with water the plaster of Paris can be moulded before it sets hard.

Physical and chemical changes

Many common occurrences include both physical and chemical changes. When a sandwich is eaten, the biting and chewing are examples of physical changes, while the digestion of the food into new, simpler chemical substances that can be absorbed by the body, is an example of a chemical change. Similarly, when rock is broken down by alternate freezing and thawing, that is an example of a physical change. But limestone rocks slowly dissolve in rainwater which contains dissolved carbon dioxide gas, a weak acid, forming a chemical change. Indeed this type of weathering is called chemical weathering.

Obtaining materials

As we have seen earlier in the *Simply Science* course, a distinction can be made between natural materials, which come from animals and plants or from the Earth's crust, and synthetic or manufactured materials such as iron, glass, paper, and plastics, which are made from other natural materials.

In general, natural materials are used as they occur or are merely subjected to physical changes before use. In some salt mines, for example, water is pumped down the mine to dissolve the salt. The salt solution is then pumped up and evaporated to drive the water off, leaving the salt behind. In many countries with hot climates, salt is similarly obtained from sea water by evaporation.

Crude oil is a thick, black liquid occurring naturally deep under the Earth's surface. It is a mixture of many substances. When the crude oil is pumped to the surface, the different components are separated from each other by virtue of the fact that each chemical boils at a different temperature. Crude oil is heated slowly at the refinery, so that the chemical with the lowest boiling point is the first one to boil and form a gas. This gas is collected and cooled. As the heating continues, the other liquids are separated and collected one by one. In this way, heavy fuel oils, lubricants, diesel oil, paraffin or kerosene, petrol, and other substances can be obtained from crude oil by the physical process of fractional distillation.

By contrast, synthetic or manufactured materials are a result of chemical changes. Iron, for example, is extracted from its ore (a natural material) by heating the ore in a giant furnace with coke and limestone. A chemical reaction takes place between the three raw materials, forming iron, as well as slag and other waste products.

The commonest type of glass is produced by heating sand, soda ash (sodium carbonate), and limestone in a furnace. They melt and combine chemically to give a red hot liquid, which cools to form a new substance, glass.

Chemical changes by living things

Not all chemical, or irreversible, changes occur as a result of heating or mixing materials under specific conditions. Living things can also be used to produce new materials as a result of chemical changes. Certain bacteria, for example, turn the lactose or milk sugar in milk into lactic acid (a chemical change). The lactic acid makes the milk thicken, producing yogurt. Yeast, a simple fungus, grows in the presence of sugar, which it breaks down to form ethanol (alcohol) and carbon dioxide gas (a chemical change). This property is employed in making alcoholic drinks or in baking, where the carbon dioxide gas produced causes bread dough to rise prior to baking.

Safety

Students should not touch ice immediately after it has been taken out of a freezer.

Take great care with hot water or steam.

Whenever possible, use transparent plastic containers, rather than glass containers, particularly for holding water or other liquids.

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. Have a fire blanket or bucket of sand readily available in case of accidents.

Answers

Dissolving and solutions: **Rapid fire, p 95**

1) Soluble–able to dissolve
   Solute–a solid or gas that will dissolve in a liquid
   Solvent–a liquid that will dissolve a solid, liquid or gas
   Insoluble–something that will not dissolve in a liquid is said to be insoluble
   Solution–a mixture of a liquid with a dissolved gas or solid
   Solid–a material that holds its shape and which can be handled and cut
   Saturated solution–a solution in which no more solid will dissolve at that temperature
2) a) Salt and water: the salt will dissolve
   b) Sand and water: the sand is insoluble in the water and will sink to the bottom
   c) Oil and water: the oil will not dissolve but will float on the surface of the water
   d) Vinegar and water: the vinegar will dissolve in the water
   e) Rice and lentils: nothing happens
   f) Coffee and water: the coffee will dissolve
3) It is cheaper and safer to extract the salt from deep underground than to mine it. At the surface, the salt solution is evaporated to produce the salt it contains.

Dissolving and solutions: **Try it out, p 95**

3) Ideally, the water above the soil should be filtered to remove any floating particles and then it should be evaporated to dryness. The mineral salts will be left behind after the water has evaporated.

Speedy solutions: **Rapid fire, p 97**

1) The solutions are sea water, fresh water (unless it has been distilled), cola drink, lemonade, rainwater, and swimming pool water. The sea water contains salt and other dissolved minerals, the cola drink and lemonade contain dissolved carbon dioxide gas, the fresh water contains dissolved minerals from when it passed through rocks and soil, the rainwater contains gases it dissolved as it passed through the air, while swimming pool water contains dissolved chlorine gas. Only the sugar is not a solution.
2) A concentrated solution contains a lot of the solute. It is a strong solution. To make the solution weaker, you would add more of the solvent.
3) To make the jelly dissolve faster, Ameena should have broken the lump of jelly into small pieces and used hot water instead of cold.

Speedy solutions: **Try it out, p 97**

1) a) It is likely that the instant coffee powder will dissolve first.
   b) Use identical weights of the two types of coffee, use water at the same temperature and stir both to the same extent.
2) Use identical volumes of water at temperatures of, say, 10, 20, 30, 40 and 50°C.
   Add known weights (say 1 gram) of the salt or sugar and stir. Do not add any more solute when, after stirring, there is a tiny quantity of the solute left in the bottom of the container. Record the results in a table and on a graph.

Using solvents: **Rapid fire, p 99**

1) The water at the swimming pool sometimes stings your eyes because it has the gas chlorine dissolved in it. This gas is added to kill any germs in the water.

2) Collect a sample of the rainwater. Filter it if it contains any dirt or other particles and then evaporate the clear solution and see what is left in the container after heating.
3) The chemical fertilizers used by farmers have to be soluble if they are to dissolve in the water in the soil. Plant roots can only take up the fertilizers if they are in solution.

Obtaining pure water: **Rapid fire, p 101**

1) a) The impure water is being heated in the left-hand flask.
   b) When the water is heated, it gradually turns to water vapour or steam.
   c) The steam condenses when it passes through the condenser, which is basically a tube surrounded by cold running water.
   d) Any impurities which were present in the original water will be left behind in the flask that was heated.
2) When a saucepan of water is left to boil the water turns to steam or water vapour. The coldest part of a room is generally the windows, and the steam condenses on the cold glass to form a coating of water droplets.
3) We do not use distilled water in our homes for drinking, cooking and washing because it is expensive to produce. In addition, since distilled water has nothing dissolved in it, if we were to drink it we would find it has no taste.

Obtaining pure water: **Try it out, p 101**

1) When the steam touches the cold spoon, it condenses and droplets of water fall like rain. This is an imitation of what happens in nature during the water cycle.

Types of change: **Rapid fire, p 103**

1) A reversible change is one where the materials can easily be returned to how they were originally. Melting, freezing, dissolving, evaporating and condensing are examples of reversible changes. An irreversible change produces new materials that cannot be changed back to how they were originally.
2) reversible change: b), d), f)
   irreversible change: a), c), e)

Types of change: **Try it out, p 103**

1) Add the mixture to water and shake or stir thoroughly. Filter the mixture, when the sand will be left behind in the filter paper. Heat the clear liquid (the filtrate) to dryness, when the salt will be left behind in the container.
2) Dissolving involves a liquid solvent and a solute that may be a solid, liquid or gas. Melting involves heating a substance, which will then turn from a solid to a liquid. If the latter is cooled, it will turn back to the solid state again.

No changing back: **Rapid fire, p 105**

1) Reversible changes: changing shape, condensing, diluting, dissolving, evaporating, freezing, melting and mixing. In all cases, it is possible to return the substance to its original state. Burning and rusting are irreversible changes. New materials are formed which it is not possible to change back to how they were originally.
2) Some of the common foods which change colour when they are cooked include meat, sausages, egg, bread, scones, pies, potatoes (when fried or roasted), biscuits and cake mixture. Food is cooked to change its taste and texture and to make it easier to eat and digest.
3) The change when vinegar is added to bicarbonate of soda is irreversible, since the gas carbon dioxide is given off and this escapes into the air. A new substance is left behind.

No changing back: **Try it out, p 105**

1) The colour, texture and taste of both egg and bread change when they are cooked. The changes are irreversible since it is not possible to return the toast or cooked egg to how they were originally.

Burning: **Rapid fire, p 107**

1) Our early ancestors produced fire either by rubbing dry sticks together or by using the sparks produced when two flints were tapped together. Sometimes they could obtain burning materials from fires started by lightning. The first fuels were dried grass, wood and other plant materials. Early humans used fire to warm themselves, to cook their food and to frighten off wild animals. Later they discovered how to use fire for baking clay and making metals.
2) A candle needs a wax-impregnated wick to start the burning process off and to create temperatures high enough to cause the wax to boil and give off a gas which catches fire.

Burning: **Try it out, p 107**

1) a) The materials which will melt are: butter, wax and ice cream.
   b) The materials which will burn if they are put into a flame are: paper, butter, coal, wax and wood.
   c) The materials most likely to be labelled flammable are fabrics derived from plastics, such as those used in the padding of armchairs, settees and mattresses.

Assessment: **p 108-109**

1) a) evaporates b) melts c) condenses d) freezes e) boils
2) a) Mina could heat the water or stir the mixture to make the sugar dissolve more quickly.
   b) If Mina adds more and more sugar to the solution, eventually no more will dissolve. She will have made a saturated solution,
   c) The beaker will contain a clear sugar solution.
   d) To obtain the sugar, Mina will need to evaporate the solution. The water will be driven off as water vapour, and the sugar will be left behind in the heated container.
   e) Mina will need to add the mixture to water and shake or stir thoroughly. If she filters the mixture, the sand will be left behind in the filter paper. If Mina heats the clear liquid (the filtrate) to dryness, then the sugar will be left behind in the container.
3) a) The drops of liquid were of water.
   b) Water vapour in the air had condensed on the cold glass.
   c) Condensation
   d) The ice had melted into liquid water.
4) The reversible changes are: water to ice; water to steam. The rest all are irreversible changes.
5) a) The handle of the spoon becomes hot as heat is conducted along it from the hot water.
   b) The jelly cubes melt and dissolve in the hot water.
   c) The change is reversible.
   d) Either add more hot water or stir the mixture for longer.
   e) During the night in the refrigerator, the mixture has frozen and solidified.

Going further

Use reference books or the Internet to find out how the salt gets into sea water.

Obtain two equal-sized small pieces of white cloth. Make some stains, such as poster paints, grass, ink, gravy and fruit juice on both of them. Now wash one piece of cloth in cold water and the other in warm water. Which washes best? Now try the experiment again using two bowls of warm water, with a little soap or detergent added to one of the bowls. Which washes best?

MORE ABOUT DISSOLVING AND OTHER CHANGES

Investigate how much salt is needed to stop water from freezing. Half fill five yoghurt pots with equal volumes of water. Add one pinch of salt to the first one, two pinches to the second one, and so on. Do not add any salt to the fifth pot as this will act as a control. Label the pots and place them in a freezer. Examine the pots after two days.

Pour some full fat milk into a clean plastic jar and fasten the lid tightly. Shake it until the liquid separates into butter (a solid) and whey (a liquid which is mainly water). The movement makes the fat molecules in the milk combine to form butter. Can the students hear a difference as they shake and the solid butter begins to form?

Use reference books or the Internet to find out all you can about the dry cleaning of clothes.

Write a secret message using a clean pen or brush dipped in lemon juice. Warm the paper and the writing becomes visible.

Devise a way of obtaining pure water from ink. What equipment would you use? What would you do? How would you collect the pure water?

Look around your home, and particularly around the kitchen. How many examples of reversible and irreversible changes can you see? Make a table of them.

Gently heat chocolate over a bowl of hot water. Observe the change that takes place. When the chocolate is a liquid, pour it into moulds and allow it to cool. Record what happens.

Draw pictures and write about people who use irreversible changes as part of their work.

Under strict supervision, let the students see if they can make a candle from a few centimetres of string and some wax. Try other materials such as butter or margarine. Do NOT let them try this experiment at home, though.

Compare a piece of wood and a piece of charcoal. Try to draw with both of them. What differences do you see?

Make a fire extinguisher. Place a lighted night light or short stump of a candle in a shallow tray of sand. In a separate container, mix bicarbonate of soda and vinegar. The gas that is produced is carbon dioxide which is denser than air. If the container is carefully tipped towards the flame, the carbon dioxide will smother the flame and extinguish it.

1. Dissolving solids

How much of a solid can we dissolve in a certain amount of water? When no more of a substance will dissolve, we say that the solution has become saturated.

What you need:

- pencil
- sugar or salt
- small clean jars
- plastic spoons
- measuring cylinder or measuring jug
- equipment for measuring grams if possible

What you do:

You have to find out how much sugar or salt will dissolve in a certain amount of water.
Use 100 ml or 200 ml of water depending on the size of your jars.
If you cannot weigh the amounts of sugar or salt, use teaspoonfuls.
Here are some questions to help you carry out your test.

How much of the sugar or salt will you add to the water each time?

____

How will you know whether or not the sugar or salt has dissolved?

____

How will you know if the sugar or salt is no longer dissolving?

____

Will you stir the mixture? If so how can you make the test fair?

____

____

____

If you repeat the test, what will you need to keep the same each time?

____

____

____

What did you discover?

____

____

____

2. Heating materials

What you need:

- pencil
- plastic bowl of hot water
- small foil dishes, such as cake containers
- small pieces (all the same size) of solid materials such as chocolate, margarine, solid jelly, banana, bread, cheese, wax crayon, candle

What you do:

Place one of the materials to be tested in a foil dish. Carefully float the foil dish on the hot water. Record what happens.

Let the material cool again. Record what happens.

Now test each of the other materials.

Fill in the chart below.

The material I tested	Description of the material before heating	Description of the material after heating	What happened as the material cooled

Group and label the materials here into three groups according to what happened when they were heated and then cooled:

Group A ______________________________

Group B ______________________________

Group C ______________________________

3. Changing materials

What you need:

- pencil

What you do:

What changes happen to the materials below during these processes? Are the changes reversible or non-reversible?

Process	Material	What happens to the materials?	Reversible or non-reversible?
freezing	water		
baking	dough		
melting	chocolate		
burning	wood		
boiling	water		
mixing	salt and water		
baking	clay		
burning	paper		
melting	ice		
evaporating	water		
burning	wax		
mixing	sugar and water		
melting	wax		

4. Melting moments

What you need:

- pencil
- clean, dry jam jar
- a little soft margarine
- a teaspoon
- the handle of a wooden spoon
- small jug of hot water

What you do:

Make sure the jar is clean and dry.

Pick up a little margarine with the teaspoon.

Push the margarine off so that it drops into the middle of the bottom of the jar.

Use the handle of a wooden spoon to smear the margarine around.

Hold the jar up and look underneath. What do you see?

____

Stand the jar on the table.

Carefully pick up the jug of hot water.

Run the water down the side of the jar, until it is half full.

Put the jar back on the table.

Watch carefully from the side. Draw what you see here:

Describe what happens. You might want to use these words in your description:
insoluble soluble melt lighter float solid liquid

5. Burning materials

What you need:

- pencil
- small pieces of cotton, brick, wax, chocolate, paper, wood, and a steel paper clip
- metal tongs
- Bunsen burner or a stout candle standing in a candle holder or a tray of sand

Ask your teacher to help you.

What you do:

Pick up one of the materials with the tongs.
Carefully hold it in the flame for a few seconds.
Fill in the table below to show what happened.
Repeat this with the other materials.

Material	What happened
cotton	
brick	
wax	
chocolate	
paper	
wood	
steel paper clip	

Which two materials melted and then burned?

Which materials burned easily?

Which materials did not burn?

Does burning cause a reversible or irreversible change?

Safety: Do this experiment only when a responsible adult is present.

6. Weight changes during burning

What you need:

- pencil
- metal tray
- small pieces of wood (e.g. used matchsticks), paper, cotton cloth, candle
- matches or burner
- accurate weighing scales

What you do:

Weigh one of the materials on the metal tray.

Remove the tray and carefully set the material on it alight.

See that the material burns completely.

Let the metal tray and the burnt material cool completely.

Weigh it again.

Calculate the change in weight (increase or decrease).

Now do the same thing with the other materials.

Record your results on this table:

Material	How it changed when it was burnt	Is the change reversible or irreversible?
wood		
paper		
cotton cloth		
candle		

Safety: Do this experiment only when a responsible adult is present.

Notes on individual worksheets

1. Dissolving solids

Key idea To investigate how much sugar or salt will dissolve in a known volume of water.

Extension Repeat this experiment at different temperatures and compare the results.

2. Heating materials

Key idea To investigate what happens when some solid materials are heated.

Outcome The exact results will depend on the temperature of the water used. Some of the materials will be unchanged, some will melt and solidify on cooling, some will be changed by the heat irreversibly.

Extension Examine the changes which take place when small potatoes are boiled for different lengths of time. This is best done as a teacher demonstration.

Safety Use hot, not boiling water. Adult supervision is needed.

3. Changing materials

Key idea A revision exercise to examine the various changes that can occur to common materials.

Outcome

Process	Material	What happens to the materials?	Reversible or irreversible?
freezing	water	turns solid	reversible
baking	dough	changes colour and texture	irreversible
melting	chocolate	turns to liquid	reversible
burning	wood	smoke and ash produced	irreversible
boiling	water	turns to gas or vapour	reversible
mixing	salt and water	dissolves	reversible
baking	clay	turns solid	irreversible
burning	paper	smoke and ash produced	irreversible
melting	ice	turns to water	reversible
evaporating	water	turns to gas or vapour	reversible
burning	wax	smoky flame	irreversible
mixing	sugar and water	dissolves	reversible
melting	wax	turns liquid	reversible

Extension Investigate whether some liquids freeze more quickly than others. Liquids to test could include water, milk, fruit juice, cooking oil and vinegar.

4. Melting moments

Key idea A practical investigation into the melting of a solid that is immersed in a liquid.

Outcome The hot water melts the margarine, turning it into a liquid. Because the liquid margarine is less dense (lighter) than the water, the drops rise up through the water and eventually settle on the surface.

Extension Use the Internet or reference books to find out more about the pollution of the sea by oil and how the pollution is dealt with.

Safety Ensure that the water used is hot, but not boiling. If you repeat the experiment make sure that the jar is dry and not warm, otherwise the margarine will not stick to the bottom of it.

5. Burning materials

Key idea Burning brings about changes that are irreversible, although not all materials will burn easily.

Outcome The wax and the chocolate will melt and then burn.

The cotton, wood and paper will burn easily.

The brick and the steel paper clip will not burn although they will probably turn black. This is soot from the candle flame and not a change to the brick or steel.

Burning is an irreversible process, because you cannot turn the flames, smoke and ash back to the original material.

Extension Discuss what is the difference between heating and burning.

Safety You may decide it is safer to demonstrate this experiment to the class and to get individuals to act as recorders. Have a fire blanket or bucket of sand nearby in case it is needed.

6. Weight changes during burning

Key idea When materials burn there is a loss in weight.

Outcome All four materials will burn and, as long as accurate weighing scales are available (such as an electronic balance), then a loss in weight will be recorded. Although all materials combine with oxygen gas from the air when they burn, there is a loss in weight because carbon dioxide, water vapour, smoke and other vapours are lost to the air. All of the changes are irreversible.

Extension Make a list of all the changes the students can think of which are irreversible.

Safety You may decide it is safer to demonstrate this experiment to the class and to get individuals to act as recorders. Have a fire blanket or bucket of sand nearby in case it is needed. If the weather is fine this experiment could be carried out on the playground. Ensure that cotton cloth is used, rather than a fabric made of synthetic fibres, since some of the latter may give off toxic fumes when they burn.

Glossary

This glossary gives brief definitions of some of the most important scientific words in the text.

Acceleration the rate at which speed is increased

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

Acid rain rainwater that contains acids formed from harmful polluting gases that can kill plants and animals and damage buildings

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

Addicted to be addicted to something is to do it or use it because you cannot give it up

Air resistance the friction force which slows objects moving through the air

Amphibians animals with backbones that live on land and in the water, for example, frogs, toads, newts and salamanders

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

Antibodies chemicals released by some white blood cells that destroy germs

Artery a tube carrying blood from the heart to other parts of the body

Atmosphere the layer of air that surrounds the Earth

Axis an imaginary straight line around which objects such as the Earth appear to spin. The Earth's axis passes through the North and South Poles

Bacteria tiny living things, some of which are harmful germs, others of which are useful because they help dead materials to decay

Balanced diet a diet that includes the right amount of nutrients to keep the body alive and healthy

Battery a series of two or more electric cells which produce electricity when the chemicals within them react together

Birds two-legged, warm-blooded animals with backbones, feathers, wings and a beak

Boiling point the temperature at which a liquid starts to boil and become a vapour

Capillaries tiny blood vessels where oxygen and food pass from the blood into the cells of the body and carbon dioxide and waste materials are carried away

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

Carbon dioxide one of the gases present in small amounts in the air. Living things produce carbon dioxide as a waste product when they breathe. Plants use carbon dioxide to help make their food in the process called photosynthesis.

Carpel the carpel contains the female parts of a flower

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, new, material

Chlorophyll the substance that gives plants their green colour. Chlorophyll helps a plant to make its own food using sunlight.

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

Classification 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

Concave curved inwards like a cave

Condense to squeeze something into a smaller space; a vapour or gas condenses to form a liquid when it cools

Conductor a material that allows electricity, heat or sound to flow through it

Conifer a tree in which seeds develop inside a cone rather than inside a flower or fruit; most conifers have needle-shaped leaves

Consumer an animal which eats plants or other animals

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.

Glossary

Convex curved outwards, like the back of a saucer

Cotyledon a leaf found inside a seed

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

Decay what happens when dead plants and animals rot away; decay is caused by bacteria and fungi

Deciduous describes a tree which loses its leaves in the autumn and grows new ones the following spring

Decompose to rot or decay

Decomposer a living organism, usually a bacterium or fungus, which causes dead plants or animals to rot away or decay

Density a measure of how heavy something is for its size

Diaphragm the flat sheet of muscle under the ribs and lungs

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

Dispersal the spreading of a plant's seeds

Dissolve when a solid, liquid or a gas is taken into water or some other solvent and forms a solution

Distillation the process of purifying a liquid by boiling it and condensing the vapour

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

Embryo the tiny plant inside a seed before it has started to grow; in animals, the earliest stage of growth of the fertilized egg-cell

Energy the power and ability something has to do work

Environment the surroundings in which animals and plants live

Enzyme a chemical substance that helps to digest the food and also helps to speed up other chemical reactions in living things

Evaporate to turn a liquid into a gas by heating it

Evergreen a tree which does not lose all its leaves in the autumn, but instead loses them a few at a time throughout the year

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

Extinct not existing any more

Faeces the semi-solid waste left after food has been digested

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

Fats a group of oily or greasy substances in food that give the body energy

Fertile a good soil, which is capable of growing many crops, is said to be fertile

Fertilization the joining together of male and female cells to start the growth of a new living thing

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

Filament the thin wire inside a light bulb

Fish a large group of cold-blooded animals with backbones that live in water; they have gills to breathe with and fins to help them move or swim

Flower the reproductive part of a seed-bearing plant

Focus the point at which light rays meet to form a clear, sharp image after passing through a lens, or being reflected from a mirror

Food chain a series of living things that depend on each other for food energy; all food chains begin with green plants or their dead and decaying remains

Food web a linked series of food chains

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

Fossil fuels a fuel such as coal, oil or natural gas that formed long ago from the remains of plants and animals

Freeze when a liquid changes to a solid because it is cooled

Friction the rubbing of one object against another and the resistance felt between them

Fruit the part of a plant that contains the seeds

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

Fungus one of the group of living things that includes yeasts, mushrooms, toadstools and moulds

Fuse a safety device that contains a short piece of thin wire that melts if too much electricity passes through it

Gas one of the three states of matter; a substance that has no shape and can spread everywhere. Air is a mixture of different gases.

Generator a machine for changing mechanical energy into electrical energy

Geothermal energy energy that comes from heat deep inside the Earth

Germ another word for a microbe or micro-organism, especially one causing disease

Germination when a seed starts to develop or grow

Global warming the warming of the Earth due to pollution of the air

Gravity the force that attracts an object to the centre of the Earth

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.

Helium a light, colourless gas found in the air in tiny amounts; it is used to fill airships and balloons

Herbaceous plant a plant that is not woody, unlike a tree or shrub

Herbivore an animal that eats plants, especially a mammal; a herbivore's teeth are shaped for grinding plants

Humus the decayed plant and animal material in the soil

Hydroelectric power electricity produced using the energy of moving water

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

Image a view of an object in a mirror or through one or more lenses

Insoluble will not dissolve (become a solution), like sand or cork in water

Insulator a material which does not let electricity (or heat or sound) pass through it easily

Invertebrate an animal without an internal skeleton and backbone

Iris the coloured part of the eye which changes the size of the pupil in dim or bright light

Irreversible change a change that produces new materials that cannot be changed back to how they were originally

Irrigation a way of supplying water to the land by means of channels and sprinklers

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

Key a chart or list that enables you to place living things into their correct groups or to identify them

Lens a transparent object, which focuses light rays and makes an image

Life cycle the stages a plant or animal goes through from when it is first formed to when it dies

Liquid one of the three states of matter; a substance that can be poured and which spreads out to take the shape of its container

Loam a fertile soil formed from roughly equal amounts of sand and clay mixed with humus

Magnified when something is made to look bigger than it really is

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

Mass a measure of how much matter there is in an object

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

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

Glossary

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

Mirror a smooth piece of glass with a backing of silver, or another shiny metal, which reflects light and produces an image of objects placed in front of it

Mould a felt-like growth of a fungus over the surface of a living or dead organism. It causes the decay of the material the organism is or was made of.

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

National Grid a system of linked electricity pylons and cables that allows electricity to be sent over the whole country

Natural gas gas formed from the decayed remains of tiny plants and animals that lived millions of years ago

Neon a gas that has no colour or smell which occurs in minute quantities in the atmosphere; it is often used in electric signs

Newton the unit of force. It is named after the English scientist Sir Isaac Newton (1642-1727)

Nitrogen one of the gases in the air; roughly three-quarters of the air is nitrogen

Nutrients substances which provide food for a living thing

Omnivore an animal that eats both plants and animals

Opaque describes a material or object that you cannot see through because light does not pass through it

Orbit the path of a planet, satellite or moon as it moves around the Sun, the Earth or some other body in space

Organ a part of the body with a particular function, or job of work

Organism a living thing

Ovary the place where an animal's or plant's egg-cells are made and stored

Oxygen one of the gases found in the air; all living things need oxygen if they are to stay alive

Parallel circuit a circuit in which the components are connected to each other so that the electric current has a choice of routes

Petal a part of a flower. Flowers that are pollinated by insects often have brightly coloured petals.

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

Planet one of the eight large bodies in space that orbit around the Sun. Earth is a planet.

Plankton tiny plants and animals that float in the sea, lakes and ponds

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; but 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

Pollen the yellow dust produced by the stamens of a flower; the pollen grains contain the male cells of the plant

Pollinate the carrying of pollen by the wind or insects to other flowers

Pollution the act of spoiling and poisoning any part of the environment

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

Power station a building or place where electricity is produced

Predator an animal which eats other animals (also called a carnivore)

Prediction fortelling or prophesying; suggesting an outcome

Prey the animal hunted by a predator

Producer a green plant which uses the energy of the Sun to make food so that it can grow and reproduce

Protein one of the main body-building materials in foods

Pulse the throbbing you can feel in your wrist or neck caused by your heart pumping blood around your body

Pupil the black, circular 'hole' at the front of the eye where light enters

Ray one of the straight paths along which light travels

Reflect to bounce back; heat, light and sound can be reflected

Reflection light bouncing off an object; the picture in a mirror or some other shiny surface

Refraction the way in which a ray or wave is bent when it passes from one medium to another

Renewable sources energy sources that do not become exhausted when used

Reproduction the process by which living organisms produce offspring

Reptile a cold-blooded, scaly animal that lays eggs on land and which can live in warmer parts of the world, such as a snake, lizard, crocodile, turtle and tortoise

Reservoir a large natural or artificial lake used as a source of water supply

Resistance the property of some materials that reduce the flow of electricity

Respiration a sequence of chemical reactions, in which oxygen usually takes part, that releases energy in living cells

Retina a layer of nerve cells at the back of the eye which detects light and colour and sends information to the brain

Reversible change a change, such as a change of state, where the materials can be returned to how they were originally; melting, freezing, dissolving, evaporating and condensing are examples of reversible changes

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

Saturated solution a solution that contains all the dissolved substance it can hold

Scavenger an animal that feeds on the remains of dead animals and plants

Sepal a part of a flower; sepals surround and protect the flower while it is in bud

Series circuit a circuit in which the components are connected to each other so that an electric current has to flow through all of them before it gets back to the cell or battery

Sewage waste material and liquid from factories and houses, carried away by drains or sewers

Sewage works the place where sewage, the waste material and liquid from factories and houses, is cleaned before it is put into a river, a lake or the sea

Sexual reproduction reproduction that needs a male cell and a female cell

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

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

Solar power the use of energy from the Sun to produce heat or electricity

Solid one of the three states of matter; solids keep their shape unless a force is applied to them

Soluble able to be dissolved in a liquid to form a solution

Solute the substance that dissolves in a liquid to form a solution

Solution a liquid in which one or more substances are dissolved

Solvent the liquid part of a solution

Sound anything that can be heard; sound is a type of vibration

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

Sphere a globe; something which appears round like a ball, whichever way you look at it

Spore a special cell with which fungi, ferns, mosses, liverworts, lichens and some bacteria reproduce

Stamen one of the male parts of a flower where pollen is made

Star a huge glowing ball of gas in space

Starch an important part of the human diet found in carbohydrates

States of matter solid, liquid and gas are the three states of matter

Stigma part of a flower's carpel; it is where the pollen lands during the process of pollination

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

Glossary

Symbol a sign, letter or diagram that represents or stands for something

System a group of organs related to each other and performing certain functions

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

Terminal one of the parts of a cell or 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)

Tissue part of a living thing that is made up of many cells of the same type

Transformer a device that can increase or decrease the amount of energy carried by an electric current

Translucent a material that allows light to shine through, although you cannot see through it clearly because the light is scattered

Transparent a material that you can see through perfectly clearly

Turbine a type of fan which is turned by steam, water pressure or the wind

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

Upthrust the force which pushes objects up in water or air

Vaccination giving someone a dose of a germ that is too weak to cause the disease but which produces antibodies so that the body can fight the disease in future

Vapour a steam, mist or some other gas-like substance formed when a liquid is heated

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

Vein one of the thin-walled tubes which carry blood back to the heart

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

Virus a tiny, near-living organism, smaller than a bacterium, which causes certain diseases

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

Volt a unit of electrical power named after Alessandro Volta (1745-1827)

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

Water cycle the movement of water from the sea and other wet surfaces to the air, then back to the ground and sea again

Water vapour the gaseous form of water

Weight the effect of the pull of gravity on a mass; the measured heaviness of an object; weight is measured in newtons

Wind turbine a type of electrical generator which is turned by the wind

Womb the part inside a mother where her baby grows

Yeast a tiny fungus used to make bread, wine and beer