

TEACHER'S GUIDE

4

Simply Science

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OXFORD
UNIVERSITY PRESS

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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 out an experiment, then demonstrate it to them rather than risk an accident.

General safety precautions

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

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

What is science?

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

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

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

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

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

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

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

Another possible cause of difficulty is that sooner or later a student will ask a question to which the teacher does not know the answer. Teachers who are unsure about areas of science are then placed in a situation

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

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

Active learning

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

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

Lesson objectives

- To examine some aspects of keeping healthy, particularly with regard to diet and exercise
- To compare the distribution and functions of the main food groups and to show their importance in a balanced diet
- To examine the benefits of exercise

Background information

We need food not only to provide us with energy but also to keep us healthy and provide the materials for growth and the repair of damaged parts of the body. These functions are best fulfilled by eating a varied and balanced diet containing proteins, carbohydrates, fats, mineral salts, and vitamins, together with adequate fibre or roughage. The latter aids the movement of the food through the digestive system and so prevents constipation and possibly other diseases including heart trouble and bowel cancer.

Scientifically it should be remembered that there are no good or bad foods, only bad diets. All the foods we eat fall into the few basic categories listed above, and it is important for our health and well-being that we have a diet that contains a balance of these food categories.

Every process that takes place in the body is fuelled by energy derived from food. Every activity we perform, however small, requires energy. How much energy an individual needs depends upon his or her physical size, level of activity, and rate of growth. If a person regularly eats food containing more energy than is needed, then the extra food is stored in the body as fat. It is a sobering thought that one in three adults is overweight. The chart below shows the energy requirements of some males and females of different ages and of average weights.

Age in years	Body weight (kg)	Energy (kJ)
Males		
9-12	32	10,500
12-15	46	11,700
15-18	61	12,600
18-35	65	12,600
Females		
9-12	33	9600
12-15	49	9600
15-18	56	9600
18-35	55	9200

Weight for weight, fatty foods contain most energy, but many of us eat excessive amounts of sugary or starchy carbohydrate foods, such as cakes, biscuits, and sweets, all of which have a high energy content. These latter foods are also important agents in the formation of the acids in the mouth that lead to tooth decay.

KEEPING HEALTHY

It may be surprising how much energy is provided by relatively small quantities of some everyday foods, particularly those often eaten as snacks, as the chart below shows:

Food	Amount	Energy kJ
bread	100 gm	900
breakfast cereal	100 gm	1400
beefburger	100 gm	1070
fishfingers	100 gm	1000
egg	100 gm	310
potato chips	100 gm	630
baked beans	100 gm	270
spaghetti	100 gm	250
pizza	100 gm	1200
cheese	100 gm	1700
rice	100 gm	940
ice cream	100 gm	800
chocolate	100 gm	2090
potato crisps	100 gm	2090
chocolate biscuits	100 gm	2040
butter	100 gm	3000

In general, to achieve a balanced diet, we should eat more fruit, vegetables and cereals, and more low-fat sources of protein such as chicken, fish, eggs and beans. We should eat less fried foods, crisps, butter, sweets, jams and cakes, and less factory processed food, since the latter often contains preservatives and excessive amounts of sugar and salt. Finally, it should also be remembered that the body needs water to replace that lost during breathing, sweating and excretion.

Exercise and physical fitness

Unlike a machine, the human body wears out faster when it is idle than when it is used. If we laze around for a week, our muscles, heart, lungs and blood circulation adapt to that lethargic situation. Their efficiency decreases drastically because they do not need to be particularly efficient to supply our lower energy requirements. Even the bone marrow produces fewer red blood cells because fewer are being destroyed by activity. When we do start moving around, our body cannot easily adjust to the new situation and so we feel tired and listless.

Without adequate exercise, tendons and muscles shorten as we get older. This causes stiffening of the joints, making it more difficult to bend, twist and turn. The stance of many elderly people—back hunched, elbows and knees bent, feet apart to maintain balance—shows the effect of decreasing mobility. It is the typical posture of a body that has been allowed to seize up at the joints. It is often avoidable, except in the various forms of rheumatism where, through some body malfunction, the joints become inflamed, stiff and

ultimately non-functional.

Unfortunately, postural laziness is not confined to the old. Round shoulders are a posture defect found in all ages, including young children. Over the years the horizontal muscles across the upper back lengthen and the chest muscles contract, making it more difficult to straighten the shoulders. In the spine, the vertebrae may begin to move against each other on the rims rather than flat on top; the edges of the bones wear away and discs may be displaced or 'slipped'.

Most of these problems could be avoided by simple exercises or activities that stretch the muscles, tendons and ligaments of the body in order to achieve a full range of unrestricted movement at all major joints.

Fitness

There are, therefore, good physiological as well as psychological reasons for taking regular exercise. In the case of children and young people, exercise is essential if they are to achieve full and proper growth. In everyone, young and old, the increased blood flow helps all areas of the body, including the heart, lungs, nervous system, brain and other organs, to become more efficient. At the same time, we recover from injuries and illness more quickly if we are physically fit.

Regular exercise reduces the dangerous build-up of fatty substances in the blood vessels and fit people decline more slowly with age. And once physical fitness has been lost, it is difficult to regain. In addition, exercise may provide an essential relaxation from sedentary and stressful occupations, and certain forms of exercise provide social benefits. Finally, and perhaps most important, there is a feeling of well-being that comes from being fit.

Becoming physically fit simply means improving the condition of your body so that you can easily meet the demands of everyday life and still have something in reserve to cope with sudden or unexpected stress. The object, in essence, is to maintain or recapture (according to age) some of the health, strength and vitality of youth. Most people find, as they get older, that their physical condition deteriorates. However, as we have seen, much of this deterioration is caused not by the ageing process itself but by neglect of the body.

Exercise and diet

There is a close relationship between exercise and diet. The more physical exercise that is carried out, the more energy-giving foods are required. If the body receives insufficient food energy, then we quickly become fatigued. If the body receives more food energy than is required over a long period of time, then the excess food is stored as fat and obesity may eventually result. If we are trying to build up strength and fitness, and to increase suppleness, then we need to increase the intake of body-building protein foods. During increased activity we also need to increase water intake, to compensate for that lost by sweating.

Rest and sleep

Regular rest and sleep are just as important as regular exercise. However, although a great deal is now known about the physiology of rest and sleep, the necessity for them has not yet been fully explained scientifically.

What we do know for certain is that during periods of rest the cells of the body are replenished with fuel and building materials, while carbon dioxide and other waste products are removed from them. During sleep, the pulse rate slows, blood pressure falls, the body temperature drops by 3 to 4 degrees Celsius, the muscles relax and an essential sequence of sleeping and dreaming takes place. Although the brain becomes much less sensitive to external stimuli during sleep, its activities do not cease.

The traditional views about how much sleep is needed are given less and less credibility today. Research shows that there are very widely differing requirements for sleep in each individual, and social pressures and habits often determine when and for how long people sleep rather than their bodily needs. In the case

of children, only common sense observation will tell whether a child is starting the day refreshed or fatigued.

Safety

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 children, 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.

Answers

Why do we need food: Rapid fire, p 3

- 1) The things children do which use very little energy are probably read, watch television, play computer games and sleep. The activities which use lots of energy are any which make the heart beat faster and the rate of breathing increase, such as running, ball games, athletics, gymnastics, etc.
- 2) The least nutritious snack foods, the so-called 'junk foods', are those which contain a lot of sugar or fat, such as sweets and biscuits. The healthiest snack foods are raw fruits and vegetables, such as apples and carrots, dried fruits, and unsalted nuts.
- 3) Breakfast is the most important meal of the day because it comes after a long period of inactivity (sleep), during which digestion of food eaten the previous day has usually occurred, leaving the body with an 'empty' feeling about it. More importantly, breakfast normally precedes a period of physical activity. Breakfast, therefore, breaks the fast of perhaps ten hours or more, and provides an opportunity to build up usable energy stores by eating foods rich in carbohydrates (such as toast or cereals) for release during the day. If food is eaten late at night, it is likely to be converted to fat during sleep because the body does not need the energy at that time.

Foods for energy: Rapid fire, p 5

- 2) a) The food which gives most energy is butter, followed by chocolate and chocolate biscuit.
b) The foods with the highest amounts of energy all contain fats and/or sugars.
c) You would get 600 kilojoules of energy by eating 50 grams of pizza.

Foods for energy: Try it out, p 5

- 1) The foods which contain the most energy are likely to be those with a high sugar or fat content.

Foods for growth and repair: Rapid fire, p 7

- 1) Vegetarians generally have to eat quite large quantities of soya and other kinds of beans, as well as peas and cereals to provide them with the proteins that meat-eaters obtain from animal products. Soya beans contain nearly twice as much protein as the same weight of chicken. Vegans are people who will not eat, or use, any animal products, including eggs and milk.
- 2) Babies cannot eat solid foods straight away because they lack teeth and their digestive system is not yet adapted to solid foods. Babies need foods which contain a lot of proteins because they are growing rapidly. A baby cries to tell its mother it is hungry.

Foods for growth and repair: Try it out, p 7

- 2) Provided they are fit and active, old people enjoy the same foods as other grown-ups. The only reason why they may not eat and enjoy their food as much as younger people is if they do not have a full complement of teeth. Since older people are generally less active, they may also eat smaller quantities of food.

Vitamins, minerals and fibre: Rapid fire, p 9

- 1) A jacket potato is healthier than potato crisps, because the former contains protein and fibre whereas the crisps contain fat and have a much higher energy content.
Milk contains proteins needed for growth and calcium salts needed for healthy bones and teeth, whereas cola drinks contain nothing of nutritional value, apart from sugar or sweetener. They may also contain caffeine.
An apple is rich in minerals, vitamins and fibre, whereas a bar of chocolate has a high fat and sugar content.
Fruit sweets are mainly sugar whereas a raw carrot is rich in vitamin A and fibre. It can also clean the teeth to some extent whereas the fruit sweets produce the acids that cause tooth decay.
- 2) Foods for growth include lean meat and poultry, eggs, cheese, fish, beans, peas and soya.
Foods for activity include cereals, bread, pasta, cakes, honey, jam, glucose drinks and sweets.
Foods with fats include fat meat, milk, chocolate, margarine, butter, cheese, olive oil and other cooking oils, fried foods.
Foods to keep us healthy include fruits, vegetables, milk, and cheese.
Foods with sugar include cakes, biscuits, sweets, honey and jam.
Foods with fibre include fruits, vegetables, cereals (especially whole grain cereals) and wholemeal bread.

A balanced diet: Rapid fire, p 11

- 1) a) A diet of cream cakes would quickly lead to obesity, vitamin and mineral deficiency and severe constipation because of the lack of fibre.
b) A diet consisting of nothing but apples would provide energy, fibre and some minerals and vitamins, but it would lack the protein necessary for growth.
c) Even if it contained a variety of nutrients, a cupful of food a day would not supply enough essential nutrients for healthy growth and the person would quickly lose weight and become malnourished.
d) A person who ate no fruit or vegetables would become deficient in vitamins and minerals and, because of the absence of fibre, would suffer from severe constipation and ultimately, perhaps, bowel cancer or heart disease.
e) If it were possible to eat such a large meal, it would lead to severe indigestion and distension of the stomach. All of the excess food, beyond that needed for daily activity, would be stored as fat.
- 2) TRUE: c), d), and f). FALSE: a), b), e).

Stay fit: Rapid fire, p 13

- 1) When we exercise we breathe faster to obtain more oxygen. We need this gas to burn up our food to produce energy. Breathing faster also removes more of the carbon dioxide and water vapour which are produced as waste products of this respiration. Our heart beats faster to carry more dissolved food and oxygen to the muscles, where the food is used to produce energy, and to carry away the waste products including heat from the muscles. When we rest after vigorous exercise, we puff and pant as our lungs and blood system carry away the waste products produced in the muscles during exercise.
- 2) TRUE: b); c); e); f),and g). FALSE: a), and d).

Stay fit: Try it out, p 13

1) Every movement we make, however small, involves our muscles.

Assessment: p 14-15

- 1) a) carbohydrates b) protein c) fat d) mineral salt e) carbohydrates f) protein
g) mineral salts h) vitamins
- 2) a) beans, cabbage, spinach, oranges, apples.
b) chicken, fish, sausages, beans.
c) beans, cabbage, spinach, breakfast cereals, oranges, apples, wholemeal bread.
d) we need fibre to help our food to pass through our digestive system and so prevent constipation.
e) chicken, fish, beans, cabbage, spinach, oranges, apples.
f) sausages, chips, sweets, cakes, crisps.
- 3) Open answers.
- 4) a) proteins; b) fats; c) fibre; d) carbohydrates.
- 5) Bread—vitamin B; sausages—vitamin B; chicken—vitamin B; meat—vitamin B; egg—vitamins A, B and D; orange and lemon—vitamin C; cauliflower, lettuce and peas—vitamins C and E; carrot—vitamin A; milk—vitamins A and B; peanut and Brazil nut—vitamin E.
- 6) a) i) running; v) skipping.
b) When our heart beats faster it is usually because we are carrying out some vigorous exercise and our blood is carrying more dissolved food and oxygen to the muscles, where the food is used to produce energy. The blood also carries away the waste products, including heat, from the muscles. When we exercise we also breathe faster to obtain more of the oxygen we need to burn up our food to produce energy and to remove more of the carbon dioxide and water vapour which are produced as waste products.

Going further

Choose four foods—two fruits or vegetables and two grocery foods. Find out how much they cost in several shops. Work out the average cost of each item. Check the prices again in the same shops four weeks later. Have the prices gone up or down? Work out the new average cost of each item. Has this changed? Can you find out why the prices of foods change in this way?

Many foods, particularly those sold in packets, jars and bottles, contain added or extra vitamins. Read what is written on food labels. Make a list of all the foods which contain added or extra vitamins. Against the name of each food say what vitamins have been added to it.

Look carefully at your family's weekly food shopping list. Think about each of the food items on the list. Do you think your family is eating a healthy balanced diet? Why do you think so?

Keep a record of the different kinds of foods you have eaten over one week. Make a block graph showing how many foods for growth, how many foods with fibre, and how many foods for health you have eaten over the week.

Work with a friend. Write down everything you ate and drank yesterday. Put a little star (*) against the foods that are good for growth. Put a cross (x) against those foods that are good for providing energy.

Ask the students to bring the wrapping from their favourite snack to school. If they normally eat fruit as a snack, they can bring in the fruit label or a picture of the fruit. With the students' help, place the wrappers together in sets. The grouping can be by brand, ingredients or kind of snack. Discuss which snacks are healthy and why, and which are less healthy. Make a block graph or histogram of the different types of

snack the students consume.

Collect pictures from magazines and mount them to illustrate the foods rich in proteins, carbohydrates, fats, vitamins and mineral salts. Draw three large overlapping circles and sort some of your pictures, or the subjects of your pictures, into a Venn diagram. Label the three circles 'fats', 'proteins' and 'carbohydrates'. See which foods appear in the overlapping sections of the circles. For example, it is difficult, if not impossible, to find any foods that are pure protein or foods which are purely a mixture of fat and carbohydrate.

Students often find it difficult to envisage how much energy is contained within a food item. To give them some indication of the amount of energy in a tiny portion of food, put a peanut on a needle. Fix the needle in a blob of clay or Plasticine and place this on a saucer or metal tray. Use a match to set fire to the peanut to give the students an impression of how much energy a peanut can supply as heat.

Make a model stethoscope using two plastic funnels joined by a short length of plastic tubing, or just a length of cardboard packing tubing. Place one funnel over the ear and one on a friend's chest. Listen to the heartbeat.

Personal hygiene is an important aspect of healthy living. Discuss the importance of washing hands before eating, after touching animals or soil, after using the toilet and so on. Ask the students to make a list of other times they should wash their hands. Make a class display of their suggestions.

Conduct a survey of the amount (duration and type) of exercise done by the students each day for one week, including school PE and games lessons as well as after school activities. As part of your PE programme, carry out a set group of fitness activities in which the students can keep a record of their own personal scores. Review this half-termly to discuss the improvements noted. Exercises might include press-ups in 30 seconds, sit-ups in one minute, squats in one minute and the number of laps of the playground or hall in two minutes. The results could be graphed and encouragement given to the students to improve their personal scores.

Also use PE lessons to talk about the types of muscles in our bodies and the exercises we can do to help keep them working well.

1. Keeping healthy

What you need:

- pencil

What you do:

Make a list of all the things that are good and bad for the human body.

Use these words to help you make a start on your lists.

vegetables sleep too much salt exercise too many fats rest
smoking fruits too much sugar drugs too many sweets water

Good for my body	Bad for my body

2. At the supermarket

What you need:

- pencil

What you do:

Here are two trolleys.

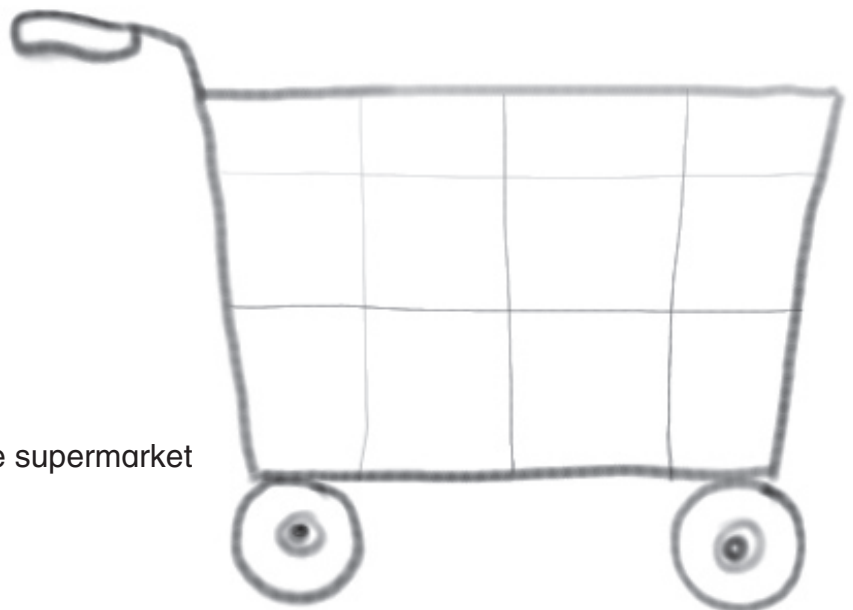
In one, draw healthy foods that you can buy from your local shop or supermarket.

In the other trolley, draw unhealthy foods you can buy at your local shop or supermarket.

Label the foods you have drawn.



Healthy foods at the supermarket



Unhealthy foods at the supermarket

3. Favourite foods

What you need:

- pencil
- food packets of favourite foods

What you do:

Do you have a favourite food?

Have you ever said, 'I love so much that I could live on it!'

Could you really live on it?

Find an empty packet from your favourite food.

Look at the label.

Copy down the contents here:

Food	Contents

Check the contents of your food against this list. Put a tick in the box if your favourite food contains:

- | | | | |
|--------------|--------------------------|---------------|--------------------------|
| Protein | <input type="checkbox"/> | Vitamins | <input type="checkbox"/> |
| Carbohydrate | <input type="checkbox"/> | Mineral salts | <input type="checkbox"/> |
| Fat | <input type="checkbox"/> | Fibre | <input type="checkbox"/> |

Could you really live on your favourite food?

Now do the same thing for your second-best food.

4. Sugar in foods

We need carbohydrates to give us energy, but some foods have a surprising amount of sugar in them or added to them. Sugar can cause tooth decay and it can also provide more energy than we need, when it is converted into fat. Sweets and sugary foods are only good for you if you are very active!

What you need:

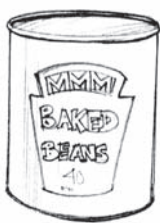
- pencil
- a variety of food packets

What you do:

Look at these foods.

They all contain sugar.

The labels show the amount of sugar in each 100 grams of the food.



baked beans
5 g per 100 g



biscuits
30 g per 100 g



cornflakes
8 g per 100 g



jam
60 g per 100 g



peanut butter
3 g per 100 g



chocolate bar
50 g per 100 g

How many grams of sugar are there in each of the following

- 150 g tin of baked beans? _____
- 200 g packet of biscuits? _____
- 400 g box of cornflakes? _____
- 500 g jar of jam? _____
- 500 g jar of peanut butter? _____
- 200 g bar of chocolate? _____

With permission, look in the food cupboard at home. Look at the labels on the foods. Record which have sugar in them, and how much. Which food contains the most sugar per 100 g?

Food	Sugar (g) per 100 g

5. An exercise diary

How much exercise do you and someone else in your family do? Carry out this survey to find out.

What you need:

- pencil

What you do:

Answer the questions yourself and then ask someone else in your family.

Question	Name:	Name:
How many hours do you sit down at school or work each day?		
How many hours do you watch TV each day?		
Do you walk to school or work each day?		
Do you ride a bicycle each day?		
Do you ride a bicycle sometimes?		
Do you play a sport each week?		
Do you train for a sport each week?		
Do you go swimming each week?		
Do you climb stairs every day?		
Do you go for long walks each week?		
Do you do PE or fitness activities each week?		

Compare your answers with those of your friends. Do you think you do enough exercise each week? If not, what else could you do?

6. Pulse rates

What you need:

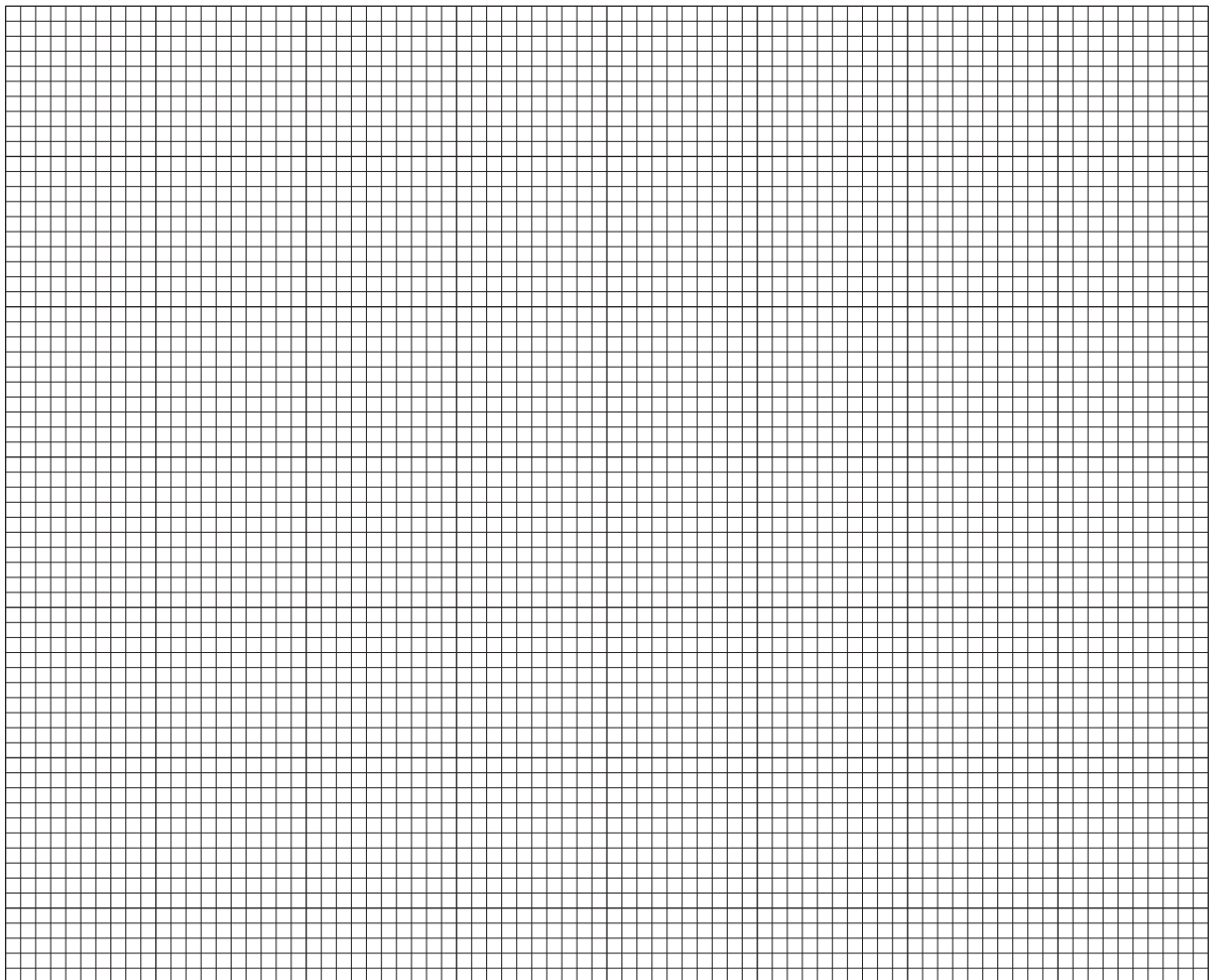
- pencil
- graph paper

What you do:

Ahmed measured his pulse rate while he was sitting quietly. It was 78 beats per minute. He ran up and down on the spot and then measured his pulse rate again. It was much higher than before. Ahmed decided to measure his pulse rate every minute until it was back to normal. These are the measurements of Ahmed's pulse rate:

Time after exercise (minutes)	0	1	2	3	4	5	6	7	8	9	10
Pulse rate (beats per minute)	130	125	115	100	95	90	85	84	82	78	78

- a) Use graph paper to make a line graph to show how Ahmed's pulse rate changed. Carefully label each axis and draw a smooth line through the points.



- b) How many minutes did it take for Ahmed's pulse rate to get back to normal?

- c) Do you think Ahmed is fit? Explain why.

7. Health benefits and hazards

Health benefits are things which are good for your health. Health hazards are things which can be dangerous for your health. How many health benefits and hazards do you know?

What you need:

- pencil

What you do:

Look at the list below. Try to match the activities on the left to the sentences that describe their effects.

- | | |
|----------------------------------|---|
| 1. Fibre | a) can cause hearing loss. |
| 2. Eating too much sugar and fat | b) are prescribed by a doctor to help you fight illness. |
| 3. Taking exercise including | c) can cause heart and respiratory diseases, cancer. |
| 4. Medicinal drugs | d) can cause skin cancer. Can be prevented by covering up or putting sunscreen on the skin. |
| 5. Sunbathing | e) are not prescribed by a doctor. They can cause serious damage and even death. |
| 6. Smoking tobacco | f) found in fruit, vegetables and cereals. Helps to keep our digestive system healthy. |
| 7. Recreational drugs | g) inhaling the vapours can damage the brain and liver. |
| 8. Loud music | h) strengthens the heart and other muscles. Improves the blood circulation and general fitness. |
| 9. Solvents | i) can lead to serious overweight (obesity) and put a strain on the heart and lead to other medical problems. |

Notes on individual worksheets

1. Keeping healthy

Key idea To identify some of the factors that enable you to keep healthy and some which are unhealthy.

Outcome The 'Good for my body' list should include fruits, vegetables, exercise, rest, adequate sleep, water. The 'Bad for my body' list should contain drugs, too many fats and sweets, too much sugar and salt, not enough exercise, smoking and not enough rest and sleep.

Extension Choose one of the 'Bad for my body' items and make a detailed study of why it is harmful.

2. At the supermarket

Key idea To encourage discrimination at the supermarket or shop between healthy and unhealthy food items.

Outcome The 'healthy' trolley is likely to contain fruits, vegetables, cereals, brown bread, rice, nuts, pulses, lean meat, fish, eggs, cheese and milk, amongst other items. The 'unhealthy' trolley will probably include sweets, chocolate, biscuits, cakes, fizzy drinks, crisps, and many packaged snack foods and other foods that are rich in sugars, fats or salt.

Extension Draw up a list of healthy snack foods.

3. Favourite foods

Key idea To examine the nutritional value of favourite foods.

Extension Plan a balanced diet that includes your favourite foods.

4. Sugar in foods

Key idea To draw attention to the amounts of sugar hidden in some foods.

Outcome

- 7.5 g of sugar
- 60 g of sugar
- 32 g of sugar
- 300 g of sugar
- 15 g of sugar
- 100 g of sugar

Extension Too much salt in your food is also bad for you. Look at food labels to see how much salt (sodium chloride) some processed foods contain. Some doctors say we should not consume more than 3.5 grams of salt (about half a teaspoon) a day.

5. An exercise diary

Key ideas People need exercise to stay healthy. A survey of the exercise carried out by two members of a family.

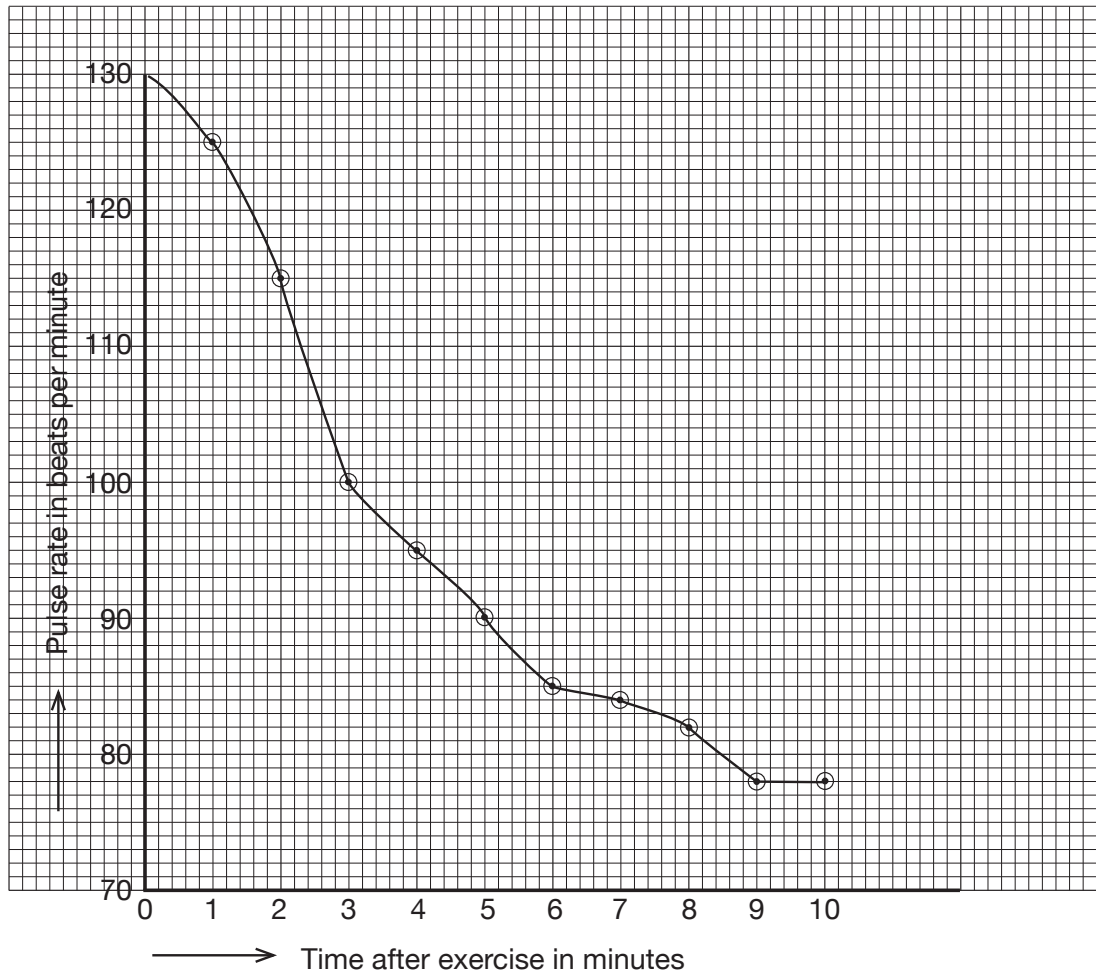
Outcome In general, the more positive responses there are to the fitness and activity questions, the more likely it is that the students are doing enough exercise to stay fit and healthy.

Extension Make block graphs of the whole class's responses to this survey so that comparisons can be made more easily.

6. Pulse rates

Key idea To examine the effects of exercise and rest on the pulse rate.

Outcome a)



b) 9 minutes.

c) Ahmed is reasonably fit since his pulse rate did not rise too high during exercise and it went back to normal quite quickly.

Extension Carry out a similar exercise on breathing rates before, during and after exercise.

7. Health benefits and hazards

Key idea An assessment exercise to identify some health benefits and health hazards.

Outcome 1. f) 2. i) 3. h) 4. b) 5. d) 6. c) 7. f) 8. a) 9. g)

Extension Use the Internet or reference books to find out why sunbathing can be harmful to some people.

Lesson objectives

- To show the main differences between solids, liquids and gases
- To show that gases can be distinguished from solids and liquids by their properties
- To show where gases are found and to examine the uses of some important gases
- To examine the possible contribution of carbon dioxide to global warming

Background information

Solids, liquids and gases

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

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

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

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

Air

We live at the bottom of an ocean of air, the atmosphere, which presses on us in all directions. The air is most dense at ground level, but thins out as one moves upwards until, at about 500 kilometres, there is no air at all. The air around us tends to fill all spaces not occupied by something else.

Air is not just one gas but a mixture of several gases. Two of them are oxygen (21 per cent) and carbon dioxide (0.03 per cent). These are colourless and odourless gases. All animals and all but a few simple plants need oxygen to live and grow. Fires also need oxygen to burn. All living things, and fires, produce carbon dioxide as a waste product, while green plants use carbon dioxide as a raw material when they produce their food in the process known as photosynthesis. Two other major gaseous constituents of the air are nitrogen (78 per cent) and water vapour. While the proportion of the water vapour in the air is very variable, the proportion of the other gases is remarkably constant. Over large cities or busy roads, air also contains gases such as carbon monoxide and sulphur dioxide, as well as smoke and dust. These pollutants come from motor vehicles, and from factory and power station chimneys.

Uses of oxygen and nitrogen

As we have seen, burning and breathing (technically the latter is respiration) both depend on oxygen. If a fire is given more oxygen, perhaps by increasing the draught, it burns more brightly and fiercely. If the supply of oxygen to a fire is cut off, it soon goes out. Living things need oxygen to release the energy from their food in a special kind of burning process called respiration. Respiration produces the energy that plants and animals need for their daily life processes. Green plants are also producers of oxygen which they give off as part of the process of making their food. This explains the importance of trees and other green plants in helping to provide us with a healthy atmosphere.

Oxygen and nitrogen can be liquefied and stored separately by compressing and cooling air to nearly -200°C . Oxygen is used in many industrial processes, such as welding torches for cutting or joining steel, and in hospitals to help patients who are too weak to breathe ordinary air. Firefighters, deep-sea divers, mountaineers, astronauts, and other people who work in places where there is insufficient oxygen for normal breathing also rely on cylinders of this gas. Nitrogen, combined with other chemicals, is a valuable fertilizer. It is also used for quick-freezing food and, since it is unreactive, it is pumped into oil storage tanks to prevent fires.

Properties of air

Although we cannot see air, we can feel it when the wind blows, for wind is moving air, and we can smell it when it is fresh or when it is badly polluted. Although air is invisible, it has substance in just the same way as solids and liquids. One cubic metre of air weighs about 1.25 kilograms, and because air has weight it exerts a pressure on all the surfaces with which it is in contact. The pressure of the air varies slightly from time to time and these changes, which can be measured with a barometer, are useful in weather forecasting.

The greenhouse effect

As we have seen, carbon dioxide is one of the gases that make up the air we breathe. The main sources of it are the decomposition of organic matter, deforestation by fire, the breathing and respiration of animals, and the burning of coal, oil and natural gas. Over the past 100 years or so, the amount of carbon dioxide in the world's atmosphere has increased dramatically, so too have the amounts of methane, nitrous oxide and certain other gases.

Normally most of the Sun's heat absorbed by the Earth is radiated away, some of it escaping back out into space, but carbon dioxide, methane, nitrous oxide and certain other gases high in the atmosphere absorb some of this heat, so warming the atmosphere. By behaving in this way, they act rather like the glass in a greenhouse. If carbon dioxide did not absorb this heat, the Earth would be too cold for life to exist. Unfortunately, most scientists now believe that the excessive amounts of carbon dioxide and the other so-called greenhouse gases in the atmosphere are warming the global climate. There is evidence that sea levels are rising, as the Polar ice caps and glaciers begin to melt, increasing the risk of flooding. At the same time, climatic belts are shifting, resulting in more severe weather, more damaging storms and more droughts and famine.

Safety

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.

Answers

Grouping materials: Rapid fire, p 17

- 1) The tiny particles in solids, liquids and gases react to changes of temperature. In a solid the particles are packed close together so that they can hardly move. When they are heated sufficiently, they begin to move around a little, the solid melts into the liquid state and the particles take up the shape of the container they are in. If the liquid is heated sufficiently, the particles move around freely at high speed, and the resulting gas spreads out until it fills the room, or whatever is containing it. Cooling reverses this process, slowing the particles down, so that a gas condenses into a liquid and a liquid freezes and becomes a solid.
- 2) Open answers.
- 3) Solids: ice, salt, granite and brick.
Liquids: petrol, oil, water, vinegar and alcohol.
Gases: oxygen, helium, carbon dioxide, steam, neon, methane and nitrogen.
The only substance there is likely to be an argument about is honey. Some types of honey are quite liquid, while other kinds of honey, particularly if they are quite old, solidify out.

Grouping materials: Try it out, p 17

- 1) Some solids used in a car include steel or stainless steel, rubber, plastic and glass.
The most common liquids are petrol, oil and water (for cooling the engine), while there is also acid in the car battery.
Air is used to keep the tyres of a car inflated properly while, to drive the engine, petrol is turned into a vapour and burned. Modern cars also have one or more 'air bags' to keep the driver and passengers safe in case of an accident.
- 2) The hot water heats the air inside the plastic bottle so that it expands, partly inflating the balloon as shown in the picture on page 17.

Gases in the air: Rapid fire, p 19

- 1) The reason why we are not squashed flat by the air pressing down on us is that there is air inside our bodies pressing back.

Gases in the air: Try it out, p 19

- 1) The obvious answer is that we see people breathing air, but we also see water vapour being produced in the home and school when water is heated or puddles dry up. Vehicle exhaust fumes contain gases and there are gases coming from fires, heating systems and factory chimneys.
- 2) An air bag is a safety device in a car consisting of a bag that automatically inflates and fills with gas in an accident to protect the occupant of the seat immediately in front of it. If the driver or passenger is thrown forward, the air bag acts like a cushion, preventing serious injury.
- 3) If bicarbonate of soda is added to some vinegar, the mixture fizzes violently as the carbon dioxide gas is produced. This is a chemical or irreversible change.

Oxygen: Rapid fire, p 21

- 1) Oxygen is vitally important to all living things because they need this gas to chemically burn up their food to produce energy. The technical name for this process is respiration.
- 2) Coal, coke, peat, anthracite and wood are some solid fuels. Liquid fuels include petrol, oil, paraffin, kerosene and alcohol. The main gaseous fuel is natural gas, but some other gases including methane, will also burn.

- 3) The water which is put on a fire not only cools the burning materials, it also acts as a blanket over the fire, preventing oxygen from reaching it. Often, though, foam-producing chemicals are added to the water. This foam is used to extinguish fires involving oil, petrol and tar and for fighting fires at airports, oil refineries and petroleum depots.

Some more everyday gases: **Rapid fire, p 23**

- 1) One way to catch the gas from a fizzy drink would be to stretch the mouth of a balloon over the neck of a bottle of drink and then to warm it slightly. As the gas came off the drink, it would inflate the balloon to a small extent. Another method would be to invert a funnel over the top of an open can or bottle of fizzy drink and then to invert a small bottle over the tube of the funnel. Since carbon dioxide is heavier than air it would push the air out of the funnel and the small bottle. You could tell that there was carbon dioxide in the bottle by 'pouring' the gas over a candle flame, when it would put the flame out.
- 2) Early airships used hydrogen, a gas that is lighter than air. However, hydrogen easily catches fire, and this led to some terrible disasters with loss of human life. For example, the famous German-built Hindenburg was destroyed by fire when it landed in New Jersey in the United States in 1937, killing 36 of its 92 passengers and crew.
- 3) The pale green gas put in swimming pools is chlorine. It is used to kill the germs in the water. It is also often added to drinking water, in smaller quantities, to kill germs. Chlorine is used to make lots of useful compounds, including PVC, a plastic used for pipes and waterproof fabrics. In its pure state, chlorine is poisonous.

Some more everyday gases: **Try it out, p 23**

- 1) When they are put in the lemonade, the raisins sink to the bottom, but the bubbles of carbon dioxide gas given off by the lemonade stick to the outside of the raisins. Since the raisins are now lighter, they rise to the surface. When the carbon dioxide has dispersed into the air, the raisins are heavier and sink to the bottom of the beaker again.
- 3) Yeast and sugar are added to bread dough, which is basically flour and water. In warm conditions, the yeast cells feed on the sugar, giving off carbon dioxide gas which makes the dough rise. It is this gas which creates the holes in the bread dough when it is cooked. Baking powder usually consists of sodium bicarbonate and a weak acid in dry form. When the two come into contact with moisture, they give off carbon dioxide gas which makes the bread or cake mixture rise.

Carbon dioxide and global warming: **Rapid fire, p 25**

- 1) There are a number of ways in which the individual can reduce their output of carbon dioxide. They include walking, cycling or using public transport, rather than travelling by car, and not wasting electricity by turning off lights when not needed, not leaving TVs, computers and other equipment on standby, not heating more water than is needed, and using long-life light bulbs instead of conventional bulbs. Other methods include putting on an extra jumper instead of turning up the heater and recycling or reusing materials whenever possible.
- 2) We are putting more and more carbon dioxide into the atmosphere by burning more and more fossil fuels (coal, oil and natural gas), and by clearing huge areas of forest. Forests are especially important to us because trees, like other green plants, take carbon dioxide from the air when they make their food by the process called photosynthesis. We are also adding other so-called greenhouse gases to the air including methane, nitrous oxide and substances called CFC, or chlorofluorocarbons. The methane comes from animal wastes, rotting rubbish heaps, rice paddy fields and oil and gas drilling rigs. Much of the nitrous oxide comes from car exhausts and chemical fertilizers, while the CFCs were used in the past in refrigerators, aerosol sprays and foam packaging. The result is that average world temperatures are rising.

Scientists believe that because of the higher average temperatures, we are experiencing more severe weather, including floods, droughts and hurricanes. The Polar ice caps and glaciers are melting, leading to rising sea levels and more flooding.

The raised temperatures may also mean that farmers will no longer be able to grow crops in parts of the world where they grow them now.

3) Open answers.

Carbon dioxide and global warming: Try it out, p 25

Some of the other so-called 'greenhouse gases' include methane, nitrous oxide and substances called CFCs, or chlorofluorocarbons. The methane comes from animal wastes, rotting rubbish heaps, rice paddy fields and oil and gas drilling rigs. Much of the nitrous oxide comes from car exhausts and chemical fertilizers, while the CFCs were used in the past in refrigerators, aerosol sprays and foam packaging. Methane is about 30 times more effective at trapping heat than carbon dioxide, but at present there is less of it in the air than there is carbon dioxide.

Assessment: p 26-27

- 1) The solids are the plastic bottle and its stopper. The liquid is the actual lemonade. The gases are the bubbles (of carbon dioxide) and the air above the lemonade,
- 2) Solids: a), b) and g). LIQUIDS: c) and f). GASES: d) and e).
- 3) a) water vapour; b) melting; c) water; d) solid; e) liquid; f) evaporation; g) condensation; h) gases.
- 4) Solids: steel, tin, glass, ice, copper, wood, iron, clay, coal, paper.
Liquids: petrol, water, oil, milk.
Gases: steam, carbon dioxide, nitrogen, helium, hydrogen, neon, oxygen.

Going further

Look around your kitchen at home. Think about each substance you see being used there. Is each one a solid, a liquid or a gas? Write the names of the substances in a table like this:

Solid	Liquid	Gas
Ice cubes	Water	Steam

Catch some air in a transparent plastic bag. Twist-seal the top. Let the children see through the air, feel it, describe what it feels like. Is it a real substance?

Wind is air in motion. You 'see' and feel it by noticing what it does. Go 'wind watching' on a windy day. Flags flap, trees sway, grass ripples, clouds scud across the sky. Record all the evidence you can that windy air exists.

Put a funnel into an empty bottle. Ask the students what is in the bottle? What shape is it? Pour water quickly into the funnel to fill it up. What happens? Now try pouring the water slowly down the side of the funnel. What happens? Which was the easiest way to fill the bottle? Can you explain what stopped the water when you poured it in quickly? What comes out of the bottle as the water goes in? (The bottle is in fact filled with air and if you pour the water into the funnel quickly, the air cannot escape to allow the water in. If you pour the water slowly, then the air can escape, as bubbles, and be replaced by the water.)

GASES AROUND US

Take two clear-plastic jars or glasses and immerse them upside down in water in a tank with transparent sides. Pour the trapped air gently out of one of the jars until it is empty to show that the air has a fluid quality—'it pours upwards'. Encourage the children to watch the bubbles and describe their shape. Continue to hold the two glasses upside down in the water and ask them what is in the first glass (the one that still has air in it) that stops all the water going in. Now pour the air from the first glass into the one full of water to show how the air pushes the water out of the glass. To help the children understand why it is that bubbles are spherical, explain that air has to make the smallest shape it can when it is released in the liquid because it is under pressure from all sides, and this round or spherical shape is the smallest shape the air can make. The students can check this for themselves by trying to blow soap bubbles of other shapes using bubble blowers made of thin wire twisted into non-circular shapes.

Blow up some balloons. Tie the ends. Draw the shape of the air in each balloon. Try squashing the balloons. Can you change the shape of the air? (Yes, if the balloons are not too fully inflated.)

Untie an inflated balloon and hold the open end against your face. What do you feel? What is the air inside the balloon doing? (The air is rushing out to try to fill the space around it, in this case, the room.)

How many gases can the students name in five minutes? Organize the class into small groups and ask them to list as many gases as possible—air, oxygen, nitrogen, carbon dioxide, helium, hydrogen, neon, argon, natural gas, methane, water vapour. Then ask them to write as many uses of each gas as they can think of.

Spray a little perfume at one side of the room. How long does it take for the smell to travel to different parts of the room? How do you think the smell travels? (The perfume is in fact a vapour and particles of it spread out through the air in the room until eventually they reach all parts of the room, in a very diluted form of course.)

Put an inflated balloon under a book. Inflate the balloon. What is in it? (Air). What happens to the book? (It is lifted up as the balloon is inflated.) Experiment to find what is the greatest mass that can be lifted with one balloon.

Make carbon dioxide gas by mixing vinegar with a teaspoon of sodium bicarbonate in a jar. Carefully pour the 'heavy' gas on to a candle flame. Watch what happens. (The gas is used in fire fighting because it forms a 'blanket' over a fire and smothers it.)

Collect pictures and newspaper cuttings of examples of severe weather conditions, including hurricanes, cyclones, tornadoes, floods and droughts, across the world. How many of these might be the results of global warming?

1. Solids, liquids and gases

What you need:

- pencil

What you do:

The table below shows some properties of solids, liquids and gases. Write 'yes' or 'no' in each box.

Property	Solids	Liquids	Gases
Hard and keep the same shape			
Can be poured easily			
Can be squeezed into a smaller space			
Can freeze if cooled enough			
Melt when heated			
Are often invisible			
Have a flat surface when in a container			

2. Compressing a solid, a liquid and a gas

Can you compress (squash) a solid (sand), a liquid (water) or a gas (air, which is a mixture of gases) into a smaller space?

What you need:

- pencil
- fine dry sand
- water
- syringe

What you do:

Put 5 cm³ of water into the syringe.

Carefully remove any air bubbles.

Put one finger over the nozzle end of the syringe, while you press the plunger down with the other fingers.

Press hard.



What is the reading on the syringe after you have squashed the water?

Now repeat this experiment with 5cm³ of sand.

What is the reading on the syringe after you have squashed the sand?

Do the experiment again, this time with 5cm³ of air.

What is the reading on the syringe after you have squashed the air?

Make a table of your results.

Substance	Reading on syringe after compression
5cm ³ of water	
5cm ³ of sand	
5cm ³ of air	

Which of the substances could you compress, a solid, a liquid or a gas?

3. Bubbles

What you need:

- pencil
- glass of fizzy drink
- clock or watch

What you do:

Draw the bubbles in these pictures.



Now draw the glass of fizzy drink.

What gas makes the bubbles in the fizzy drink?

Describe what is happening to the bubbles in the drink.

Why do the bubbles rise up to the surface?

How long does it take for the fizzy drink to lose all its bubbles?

4. Moving air

What you need:

- pencil
- balloon pump
- thin string
- sticky tape
- sausage-shaped balloon
- spring clip
- drinking straw

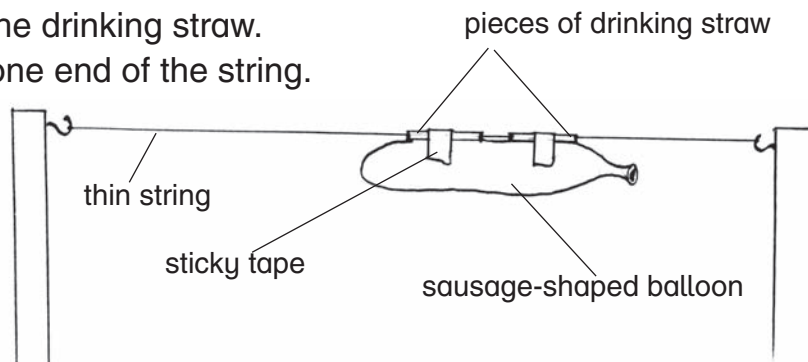
What you do:

Slide a drinking straw on to a piece of thin string and tie it tightly across the room.

Blow up a long balloon and clip the end.

Tape the balloon to the drinking straw.

Slide the balloon to one end of the string.



Unclip the end of the balloon. What happens?

Where has the air from the balloon gone?

What did it do to the balloon?

How far can the balloon travel on different amounts of air?

Number of puffs of air in the balloon	Distance travelled
2	
4	
6	
8	

How can you make the balloon go further?

5. Gases we use

What you need:

- pencil

What you do:

Study the table below.

Match up the gas with its use.

Helium	Makes soft drinks fizzy
Carbon dioxide	Puts people to sleep during operations
Oxygen	Helps a balloon to float in the air
Neon	Used for cooking and heating
Natural gas	Helps firemen to breathe in a smoky fire
Anaesthetic gas	Lights bright advertising signs

Can you think of one everyday food which contains carbon dioxide?

Can you think of two more uses for oxygen?

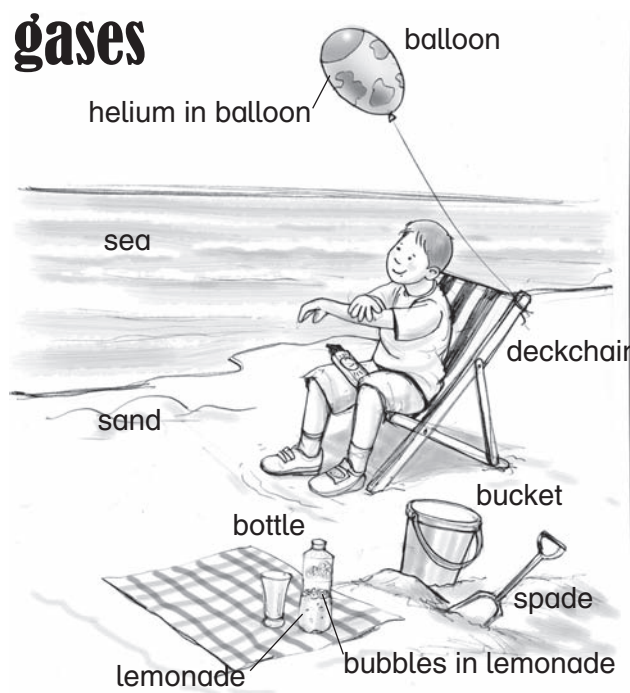
6. More solid, liquids and gases

What you need:

- pencil

What you do:

Look at the picture.



a) Put the labelled objects in the table under the correct heading.

Solid	Liquid	Gas

b) If you take a packet of butter from the refrigerator it is a solid. Give two properties of a solid that apply to butter. _____

c) If you heat butter in a pan, it turns into a liquid? What two properties does the liquid butter have that the solid butter did not? _____

d) Name one property that gases have which liquids do not have. _____

e) What property do dry sand, sugar and salt seem to have which is different from most solids? _____

f) Why do they have this property? _____

Notes on individual worksheets

1. Solids, liquids and gases

Key idea An assessment item to compare the properties of solids, liquid and gases.

Outcome Solids: hard and keep the same shape; melt when heated.

Liquids Can be poured easily; can freeze if cooled enough; have a flat surface when in a container.

Gases Can be squeezed into smaller space; can freeze if cooled enough (becoming a liquid first); are often invisible.

Extension Use the Internet and reference books to find out how a hot-air balloon works.

2. Compressing a solid, a liquid and a gas

Key idea Investigating whether it is possible to compress a solid, a liquid and a gas.

Outcome Only the air (a mixture of gases) can be compressed. How much it is compressed will depend upon the strength of the children's fingers and how good a seal the plunger makes inside the barrel of the syringe.

Extension Take a bicycle pump to pieces to see how it works.

3. Bubbles

Key idea Bubbles are small amounts of gas temporarily trapped in a liquid.

Outcome The bubbles should be shown rising from the mouth of the fish, rising from the boiling water and being blown from the wire wand. The bubbles of carbon dioxide in the fizzy drink rise to the surface and burst. They rise because the carbon dioxide gas is less dense (lighter) than the water. If there is not enough fizzy drink available for all the class, then demonstrate this part of the activity to the students. A fizzy drink could also be made by adding some vinegar or lemon juice to bicarbonate of soda.

Extension Find out how much carbon dioxide there is in a can of fizzy drink by weighing the can, opening it carefully to release the carbon dioxide and weighing it again the next day when it will have gone flat. If the drink is kept in a refrigerator or some other cool place overnight, this will reduce the losses due to evaporation.

4. Moving air

Key idea To show that moving air can create a force.

Outcome Air from the inflated balloon rushes out, as it tries to equalize the pressure with that of the atmosphere outside, pushing the balloon rocket along. Within reason, the more air that is pumped into the balloon rocket, the further and faster it will travel.

Extension Make balloon rockets using balloons of other shapes and sizes and using different kinds of thread and string. What do you discover? What pushes a real rocket along?

5. Gases we use

Key idea To determine the uses of some well-known gases.

Outcome Helium helps a balloon to float in the air.

Carbon dioxide makes soft drinks fizzy.

Oxygen helps firemen to breathe in a smoky fire.

Neon lights bright advertising signs.

Natural gas is used for cooking and heating.

Anaesthetic gas puts people to sleep during operations.

Everyday foods which contain carbon dioxide are bread and cakes which have been made with yeast or baking powder.

Other uses for oxygen include ordinary breathing (really respiration), breathing underwater and on high mountains, assisting breathing of people who have lung diseases or illnesses, oxyacetylene welding and cutting of metals, any type of burning, rocket fuels, explosives.

Extension Use the Internet and reference books to find out more about the properties and uses of nitrogen, the most abundant gas in the air.

6. More solids, liquids and gases

Key idea An assessment exercise to test knowledge of some of the properties of solids, liquids and gases in a new context.

- Outcome*
- Solid: sand, bottle, bucket, spade, deckchair.
Liquid: sea, lemonade, suntan lotion.
Gas: bubbles in lemonade, helium in balloon.
 - Any two of the following: solid butter can be cut and shaped, it keeps its own shape when left alone, it can be handled, and it cannot be poured.
 - Any two of the following: liquid butter can be poured, it takes up the shape of the container it is in, it remains level when the container is tipped, and liquid butter will flow to the lowest level possible.
 - Gases can be squashed or compressed and most gases are invisible, whereas you can see liquids.
 - and f) Dry sand, sugar and salt can be poured like a liquid. This is because these substances are made of fine grains which, when dry, hold their shape and so can be poured from one container to another. When these substances are damp, they stick together and then behave more like a typical solid.

Lesson objectives

- To show how sounds are produced by vibrations and to demonstrate the importance of sounds in imparting information
- To show that vibrations can pass through different materials
- To show how musical instruments can be classified and the methods by which pitch and loudness can be altered
- To introduce simple ideas on the structure and function of the ears in terms of hearing and of the larynx and vocal cords in producing sounds
- To describe noise pollution and show that insulators can be used to reduce unwanted sounds

Background information

Vibrations

Striking a tuning fork or plucking a guitar string makes a musical note. The prongs of the tuning fork and the strings of the guitar oscillate backwards and forwards. When anything moves back and forth rapidly, it produces vibrations. Vibrations in solids, liquids, or gases (including air) that can be detected by the ears of humans or other animals are called sounds. Sounds are a form of energy.

Frequency and pitch

If a ruler is held firmly against the edge of a table, and the free end is bent and then released, it vibrates producing sound. If the free end of the ruler is made shorter, the ruler vibrates more quickly and the note produced is higher. If a longer section of ruler is twanged, then it vibrates more slowly, making a lower note. The rate at which the ruler vibrates is called the frequency. How high or low the note sounds to the ear is called its pitch. The pitch of the note depends only on the number of times per second the sound-producer vibrates. A shrill high note is produced by rapid vibrations, a low note by low vibrations. Anything that vibrates with a frequency of between 20 and 20,000 times per second makes a sound that we humans can hear. The range varies from person to person however, and it becomes narrower with age. Sounds of higher frequency which are inaudible to humans can be heard by many animals, including the sound made by some dog whistles.

The speed of sound

Sound vibrations can travel only if they have a carrier—a solid, liquid or gas that can transmit them. Sound waves travel much more slowly than light waves, so we see the lightning before we hear the thundering noise of this outsize spark. Similarly, when watching a distant game of cricket, we see the ball being struck by the bat before we hear the crack of wood on leather. The speed of sound in air varies with the temperature, but is about 330 metres per second at 0°C. Sound travels at different speeds in different materials. It travels faster through water than through air, and fastest of all through solids such as glass, wood, and metal.

Sounds in air and space

Unlike light, sound cannot travel across an empty space. An electric bell kept in a jar that has had all the air pumped out of it cannot be heard, though it can be seen ringing. Similarly, astronauts on the surface of the moon cannot talk to each other because of the absence of air, they can only communicate using their radios. The inability of sounds to travel through space also explains why heat and light from the Sun reach the Earth in about eight minutes, whereas we never hear the enormous nuclear explosions that are taking place on the surface of the Sun. Similarly, films that are set in space and depict the sounds of explosions

are incorrect. Sound travelling through air diminishes with distance. The energy is spread out more and more widely the further one gets from the source of the sound.

Sounds and hearing

We hear sounds mainly through the air. When a guitar string is plucked, it vibrates and produces vibrations in the air around it. The back-and-forth movement of the vibrating guitar string alternately rarifies (spreads out) and compresses the air around it. The sound vibrations move out from the guitar, spreading in all directions, rather like the ripples on a pond when a stone is thrown into it. The sound waves spread over a bigger area, as they move away. Each human ear contains a stretched membrane, the eardrum. This is set in motion by vibrations of the air molecules close to it. The movements of the eardrum are minute, but they are made larger by a system of three bony levers in the ear which transmit the vibrations to the inner ear. There the vibrations are converted to a message that is transmitted to the brain, which, in turn, enables us to hear sounds.

Echoes

Echoes are produced when sound waves are reflected from a hard, bare surface and directed back towards their source. If a short pulse of sound is created, such as a shout or a shot, there is a time-lag before the echo is heard. As we have seen, sound travels in air at about 330 metres per second, and the time-lag is a measure of how long it has taken for the sound waves to travel to the reflecting surface and back again.

This principle is employed in the technique of echo-sounding used by submarines and other ships. The deeper the water, the longer a pulse of sound produced on the ship takes to return from the seabed or some other reflective surface. Ships use echo-sounding to measure the depth of the water or to find shoals of fish. Bats, porpoises, and some other animals also use sounds and their resulting echoes to enable them to navigate and find their food. As sounds can be reflected by uneven surfaces, they can travel around corners or around objects.

In the home, and in many parts of the school, curtains, carpets, and furniture absorb sound and stop it bouncing back and producing echoes. On the other hand, large empty halls, and corridors, particularly if they are uncarpeted, can produce distinct echoes.

The loudness of a sound

The loudness of a sound is the effect it has on the human ear. Loudness depends on the size (amplitude) of the vibrations, and the sensitivity of our ears. The larger the vibrations, the louder the sound. The amount of energy needed to produce the vibrations thus controls the intensity of the sound. The loudness of sounds is measured in units called decibels. A whisper has an intensity of about 20 or 30 decibels, normal conversation about 60 decibels, and a jet aircraft 30 metres away has an intensity of 140 decibels. This is the danger limit for the unprotected ear, and people exposed to this level of noise should wear some form of ear protection.

Musical notes

All objects will vibrate at one natural frequency rather than any other. To obtain different musical notes, the frequency of the vibrations of the sound producer must be changed. In the case of a guitar, the frequency of the note produced when one of the strings vibrates depends on three things:

- length: the frequency of the vibration is higher when the string is shorter.
- thickness: the frequency is higher when the string is thinner.
- tension: the frequency is higher when the string is tighter.

These three effects, which can all be imitated by plucking on rubber bands or angling line, are all used on the guitar. The musician produces different notes by placing his or her fingers on the frets to shorten the strings. Strings that produce the lower notes are made of thicker wire, while the strings are tuned by altering the tension.

A violinist similarly adjusts the tightness, or tension, of the strings of the instrument in order to tune them. The length of each string is altered by stopping it with the fingers to play different notes. In wind instruments the length of the vibrating air column can be altered to change the pitch of the note produced. The frequency is higher for a shorter air column. In the case of a trombone, the air is made to vibrate by blowing the instrument. Different notes are obtained by using the slide to alter the length of the air column.

The quality of sound

The same note on different instruments sounds different; we say the notes differ in quality or timbre. The variation arises because no instruments, except for tuning forks and signal generators, emit a pure note, in other words a note of one frequency. Notes produced by musical instruments consist of the main or fundamental frequency mixed with others, called overtones.

Musical instruments

The instruments in an orchestra can be divided into three groups: those that produce sounds by striking (percussion) as in the drum, cymbal, xylophone, and triangle; those that have vibrating columns of air (wind instruments) as in the trumpet, flute, and recorder; and those with vibrating strings (stringed instruments) such as the piano, violin, and bass.

A double-skinned drum has a stretched skin that vibrates when it is struck. This causes the air inside the drum to vibrate. In this way the vibrations are carried to the skin on the other side of the drum which also vibrates. The whole body of the drum then vibrates in sympathy, producing large vibrations of the surrounding air. The drum is tuned by altering the tightness of the skin.

In the brass instruments, such as the trumpet, bugle, and euphonium, the air is set vibrating by the player's lips. The players of woodwind instruments such as the bassoon, oboe, and clarinet blow against the sharp edge of a flexible reed in the mouthpiece. The reed vibrates, making the column of air inside the instrument vibrate in sympathy. The different notes are controlled by using the fingers to operate valves that cover and uncover valves in the body of the instruments, so varying the length of the column of air. In the recorder, the simplest of all wind instruments, there are no valves. The holes are covered and uncovered with the fingers.

An organ, the largest wind instrument, consists of pipes of different lengths into which air is pumped, controlled by the keyboard and foot pedals. The air creates low notes in the long pipes and high notes in the short ones.

The best-known stringed instrument is the piano. When a key on the keyboard is pressed, a felt-covered hammer strikes three tightly stretched metal wires, all tuned to the same note. (Some upright pianos have only two strings.) When it is not being sounded, each string is prevented from vibrating by a felt pad, or damper.

In a violin, the sounds made by bowing or plucking the strings are transmitted to the wooden body of the violin by the bridge which supports the strings. Under the bridge is the sound post which carries the vibrations from the belly of the violin body to the back. The whole body then vibrates in sympathy with the strings and causes large air vibrations.

Noise and sound-proofing

We live in an increasingly noisy world, and many people think of unnecessary sound as a form of pollution. Headaches can be caused by too much noise, but the long-term effects can be much more serious. A

loud sound, such as an explosion, can cause the thin membrane of the eardrum to split, causing pain and deafness. People who work in noisy factories, or who listen to very loud music for long periods, may suffer loss of hearing because the small bones of the ear, which transmit vibrations to the inner ear, are damaged by the constant vibrations. Where noise cannot be avoided, ear protectors should be worn.

It is interesting and valuable to consider ways of reducing unwanted sounds. In general, sound-proofing materials are soft and spongy and they absorb the pressure changes brought about by vibrations. In doing so, they become slightly warmer, although it is impossible to demonstrate this under classroom conditions. It is, however, helpful for the students to test the effects on their own hearing of wearing ear-muffs, anorak hoods, and Walkman-type headphones and to consider the road safety implications of these when they are out cycling or crossing roads.

Safety

Warn the students of the great danger of putting objects in their ears.

Very loud sounds can damage the eardrum and lead to deafness.

Be sensitive towards students with hearing impairments, and bear in mind that some students may have a hearing impairment without realizing it.

Answers

Sounds around us: Rapid fire, p 29

- 1) Open answers.
- 2) The speaker of the radio vibrated and this made the air around it vibrate. Some of these sound waves struck the balloon and made its tight skin vibrate in sympathy, and it was this 'shaking' that Michael felt.
- 3) a) When a door is banged, the vibrations make the air vibrate around the door and some of these sound waves travel to your ears and you hear the sound.
b) When you run your fingernails along the teeth of a comb, the teeth vibrate. They make the air around them vibrate and some of the sound waves travel to your ears and you hear the sound.
c) When the wind blows through the leaves of a tree, it makes the leaves vibrate. The vibrating leaves make the surrounding air vibrate and some of the sound waves travel to your ears so that you hear the rustling sound.

Sounds around us: Try it out, p 29

- 1) When you put your hand on the cover of a bicycle bell, it can no longer ring because your hand is damping or deadening the vibrations.
- 2) It is the vibrating mouth of the balloon which makes the squeaking sound.

How sounds travel: Rapid fire, p 31

- 1) The aircraft's engines make the air vibrate over a large area, and some of these sound waves travel to walls and windows of your home or school making them vibrate; the sound waves from the walls or windows reach your ears and you hear the sound.
- 2) High-pitched sounds make the air vibrate rapidly and these vibrations might make the thin glass vibrate so much that it breaks.
- 3) Some of the sounds that warn us of danger include the horns of cars and other vehicles, the sirens of police cars, fire engines and ambulances, and the bells or buzzers on road and railway crossings. Burglar, smoke and fire alarms also warn us of danger.

How sounds travel: Try it out, p 31

- 1) Sound travels better through a solid, such as wood, than it does through the air.
- 3) The string telephone works because when you talk into one of the yoghurt pots, the pot vibrates. The vibrations pass along the string as sound waves and make the second yoghurt pot vibrate. These vibrations pass to the ear of the second person, and he or she hears the sounds. String telephones work best if the string is relatively short and is pulled so that it is taut between the two yoghurt pots.

How we speak and hear: Rapid fire, p 33

- 1) It is not a good idea to cover the ears when you are walking near traffic or any other hazard. The earphones, scarf or coat collar will absorb the sound waves so that you cannot hear the traffic, or any other danger, approaching.
- 2) It is dangerous to put any object in the ears because the eardrums, on which we rely for our hearing, are extremely thin membranes and are easily damaged.
- 3) Open answers.

How we speak and hear: Try it out, p 33

- 3) Large model ears made from thin card will allow the user to hear soft sounds more easily, and also make it easier to tell the direction from which sounds are coming. A similar effect can be achieved by cupping the hands behind the ears, with the palms facing forwards.
- 4) It is not easy to tell the direction from which sounds are coming if one ear is covered. This is because sounds normally reach one ear a fraction of a second before the other and our brain works out the direction and distance of the sounds.

Differences in sounds: Rapid fire, p 35

- 1) Sounds are high when something vibrates fast and low when something vibrates more slowly. The violin, flute, bell and recorder will produce high sounds, while the kettledrum, side drum and cello will produce lower sounds.
- 2) Open answers.
- 3) In general, the more energy that is used in making a sound, or the closer you are to the source of it, the louder the sound will be. In the case of a musical instrument, if it is struck, beaten, bowed, strummed or blown harder, the sound will be louder. The harder we slam a door, the louder the sound it will make.

Differences in sounds: Try it out, p 35

- 1) The shorter the length of ruler projecting from the table, the higher-pitched the sound. Thus with 8 cm of the ruler projecting, the sound will be high pitched. With 30 cm of the ruler projecting, a low pitched sound will be produced.
- 2) When the jar containing very little water is tapped, a low note will be produced. The more water is added to the jar, the higher the note that will result.
- 3) When the sheet of paper is tapped gently, the rice grains will jump up to a small extent, as the paper vibrates. If the paper is hit harder, then the paper will vibrate more and the rice grains will jump higher.

Musical sounds: Rapid fire, p 37

- 1) Drum—beating; guitar—plucking; maracas—shaking; trumpet—blowing; violin—scraping.
- 2) A cello has long strings and so it will produce low notes. A small violin has shorter strings and will produce higher notes.
- 3) The pitch of the notes made by a guitar is changed by holding the fingers down on the fretboard in different places. Holding the strings down away from the body of the guitar will produce a low sound.

CHANGING SOUNDS

Holding the strings down near the body of the guitar will produce higher notes. In addition, the thicker strings will produce lower notes, while the thinner strings will make higher notes. Loose strings make a lower-pitched note than the same strings that are pulled tight.

Musical sounds: Try it out, p 37

- 1) All string instruments consist of what is basically a soundbox over which strings vibrate, either by being plucked or bowed.
- 3) The kind of sound made depends upon the size of the box; the bigger the box, the louder the sound. Thick elastic bands will make lower notes and thinner elastic bands will make higher notes.

Wind and percussion instruments: Rapid fire, p 39

- 1) The violin and cello are played with a bow or plucked.
The strings of the guitar and harp are plucked.
The strings of a piano are hit by hammers when keys are hit.
The trumpet, recorder, clarinet and French horn are blown.
The maracas are shaken, while the kettledrum, tubular bells and xylophone are tapped or banged.
The cymbals are banged together or struck with a stick.
- 2) a) The maracas and cymbals cannot be made to play notes that vary in pitch, nor can an ordinary drum. However, the notes on a kettledrum can be changed by tightening or loosening the skin. A tambourine can be either shaken or hit, and hitting the edge gives a different note from hitting the middle. The xylophone and guitar can produce many different notes.
b) You could make the sounds produced by a recorder louder by blowing harder. You could change the pitch of the notes by stopping (covering) the holes in the instrument, so varying the length of the column of air the instrument contains: the shorter the column of air, the higher the note produced, whereas the longer the column of air, the lower the note which is produced.
c) A guitar makes a sound when the strings are plucked so that they vibrate. The vibrating strings make the soundbox vibrate, and the vibrating soundbox makes a lot of air vibrate so that we hear a richer and louder sound. We can make the sound even louder by plucking the strings harder. The thin strings make high notes and the thicker strings make low notes. The person playing the guitar can also make the strings shorter by pressing on them in different places to produce different notes. A pipe organ consists of a series of pipes of different length and thickness. It works by pumping air through the pipes, rather like pan pipes. Short pipes make high notes and long pipes make low notes. Pipe organs also have a pedal board, where notes are played by the feet of the player.

It's a noisy world!: Rapid fire, p 41

- 1) Whisper 20dB; silence 0dB; rustling leaves 10dB; normal talking 60dB; space rocket 200dB; pneumatic drill 110dB; passing lorry 90dB.
- 2) Thick curtains would absorb some of the vibrations made by passing traffic on the road.
- 3) Some of the places where noise could be loud enough to damage the ears include music concerts, near to jet aircraft and noisy machinery, near to space rockets as they are launched, close to guns being fired, and near a pneumatic drill that is being used.

It's a noisy world!: Try it out, p 41

- 1) To ensure that the experiment is fair, all the pieces of materials should be of the same size and thickness. Either two identical radios would be needed, both playing at the same volume, or some method of measuring or estimating the sound produced after the insulation has been applied.
- 2) One simple way to measure the loudness of the sound would be to see how far away it can be heard. Loud sounds will carry much further than softer sounds.

Assessment: p 42-43

- 1)
 - a) The rice grains will jump up and down.
 - b) The rice grains will jump even higher.
 - c) The sound will be louder.
 - d) The skin of the drum vibrates and this makes the drum itself and the air inside it vibrate. The vibrations travel, as sound waves, to Huma's mother's ears, and she hears the sound.
 - e) The sound waves coming from the drum make the windows, walls and door of the house vibrate. Sounds can pass through all kinds of materials, wood, stone, brick and glass, and the denser the materials the faster the sound waves can travel. These vibrations then pass through the air, as sound waves, to the ears of Huma's brother Daniyal.
 - f) Sound is a form of energy and the further you are from the source of the sound the less energy the sound waves have.
- 2)
 - a) high
 - b) high
 - c) low
 - d) long
 - e) higher
 - f) vibration
- 3)
 - a) outer ear
 - b) ear canal
 - c) eardrum
 - d) inner ear.
 - e) nerves, brain
- 4) The skin of the drum is beaten with drumsticks, the drum skin vibrates, making the body of the drum and the air inside it vibrate, producing a sound.
When the tubular bells are struck they vibrate and make a sound. The long tubes make a low sound and the short tubes make a higher sound.
When the triangle is tapped, it vibrates producing a sound.
The flute and recorder are played by blowing. The length of the air column inside the tube is varied by blocking up the holes with the fingers. A long air column produces a low sound and a short air column produces a high sound.
The guitar strings are plucked to make a sound. The vibrating strings make the soundbox vibrate, producing a richer and louder sound.
- 5)
 - a) When the elastic band is plucked it vibrates, making the air around it vibrate, so producing a sound.
 - b) A thicker elastic band will produce a lower note.
 - c) The shorter (14 cm) elastic band will produce the higher-pitched sound.
 - d) The shorter the elastic band, the **higher** the pitch. The thicker the band, the **lower** the pitch.

Going further

Make up a collection of eight sealed yoghurt pots with pairs containing breakfast cereals, stones, pins, nails, etc. Can the students match the pairs just by shaking the contents?

Show the students a tuning fork and explain and demonstrate what it does. If you have a number of tuning forks, show that different ones produce different notes. Now sprinkle some dry sand, salt or sugar on a drum skin, vibrate the tuning fork and place it on the drum. Draw the students' attention to what happens to the sand, salt or sugar as the drum skin vibrates.

CHANGING SOUNDS

Blow up a large balloon and tie up the neck. Take the balloon into a room where there is a radio or television. Turn on the radio or television so that the sound is quite loud. Hold the balloon very near to the radio or television. Can you feel the balloon vibrating? Now hold a sheet of paper in front of the loudspeaker of a radio or television. Can you feel the vibrations made by the sound waves?

Ask the students to hold an inflated balloon a short distance from their faces (but nearer their mouths than their eyes, since a bursting balloon could cause eye damage). Ask them to talk at their balloon and then to write down what they feel. How do they think their voices made the air inside the balloon vibrate? Once they appreciate that their voices made the air vibrate and this vibrating air caused the wall of the balloon and the air inside to vibrate, suggest they investigate further. How far away can the balloon be held and still vibrate? What happens if they talk louder? What happens if they sing instead of talk? Which sounds make the balloon vibrate most—high ones or low ones?

Find five or six containers that make a ringing sound when you tap them. Think of two ways to stop this ringing sound. Describe what you did and explain why it worked. Record your findings. (Possible answers include: touch the ringing object with the hand, surrounding it with a sound insulation material, or filling the container with water.)

Investigate string telephones. How long can the students make the string before the telephone stops working? Does the phone work when the string is slack? What happens if a third pot is attached to the string? Can they make a three-way telephone? Does the telephone work round corners? What happens if they use different types of string and different size plastic pots?

Let the students work in pairs or groups of three to investigate 'water noises'. Have available a collection of containers made of different materials and of different sizes. Good ones to include are a large tin can, an expanded polystyrene coffee cup, a bucket, an empty box, a large plastic drinks bottle, a large empty saucepan and an inflated balloon. You also need a big plastic jug to hold water and something to catch the water in, such as a bucket or large sink. While one student in a group tries ways of making different sounds with water, by dripping it, a drop at a time, on each of the containers, the others have their eyes shut and have to guess what the water is dripping on to for each sound they hear. The students should then listen to the different sounds water makes when it is poured fast, in a stream from the jug and from the plastic drinks bottle.

Sit a blindfolded student in a chair. Can he or she identify the direction from which a small bell is rung? Is it easier to identify some directions than others? (Usually sounds from the sides are easier to identify.)

While blindfolded, can a student identify the voices of other members of the class if they each say a sentence in their normal voice? What happens if they try to disguise their voices by, for example, putting their head inside a clean bucket and speaking or singing into it? What happens? Why?

Experiment with 'Chinese whispers'. Get the students to work together in groups of four or five. Ask one of the group to make up a short message and then write it down so that the others cannot see it. The person who has compiled the message, whispers it to someone else in the group who then whispers the message to the next child and so on. The last person to receive the message writes it down. Is it exactly the same message as the first one?

Arrange the students in groups of three. One person is to be tested at a time. The other two people in the group should not let the person who is to be tested hear what is being discussed. Each one of the other two should decide on a short message such as 'The sausages are being fried,' or 'The cat is sitting on the wall,' or 'The boy is climbing up the pole.' Each time the test is done you will need different pairs of messages. Person A and Person B should stand on either side of the third person. At exactly the same time Person A and Person B should whisper their messages to the third person. The third person then has to repeat back both messages. How correct were the answers? Were both messages repeated correctly? Each person

can take it in turns to be tested and then the results for the whole group can be compared. (What usually happens is that the brain finds it difficult to cope with both messages. Sometimes only one message is heard correctly; often halves of two of the messages are combined to form one, incorrect, answer.)

Listen to recordings of music. Discuss the differences between 'music' and 'noise'. Identify the instruments in recorded music.

Choose four instruments of the orchestra, chosen from string instruments (plucked or played with a bow), brass or wind instruments (blown) and percussion instruments (hit or shaken). Make a branching key, with 'yes' or 'no' answers to help a friend identify the four instruments you have chosen.

Discuss where sound insulation might be used. Examples include concert halls, recording studios, houses near busy roads, schools, radio and television stations, and the padding around earphones.

There are hundreds of sound-related words. Some words, such as 'rustle', 'whirr', 'scrunch' and 'boom' even sound like the noise they are describing. Can the students write a sound poem using such sound-related words? Alternatively, write a sound poem that begins with quiet words and gets louder and louder.

1. Travelling sounds

What you need:

- pencil
- tape recorder
- large sheet of cardboard
- woollen coat or woollen blanket

Work with a friend.

What you do:

Ask your friend to record a short secret message.

Ask your friend to let you try to hear the message through all of these materials.

Make sure that the volume control is set in the same place all the time and that the tape recorder is standing the same distance from the materials each time to make it a fair test.

Record your results in the table below.

Material	What did you hear?	How well could you hear?
brick wall		
wooden door		
glass window		
metal door		
large sheet of cardboard		
coat or woollen blanket		

2. Sound and pitch

The pitch of a note is how high or low it is. Here we investigate the pitch of the sounds made by an elastic band.

What you need:

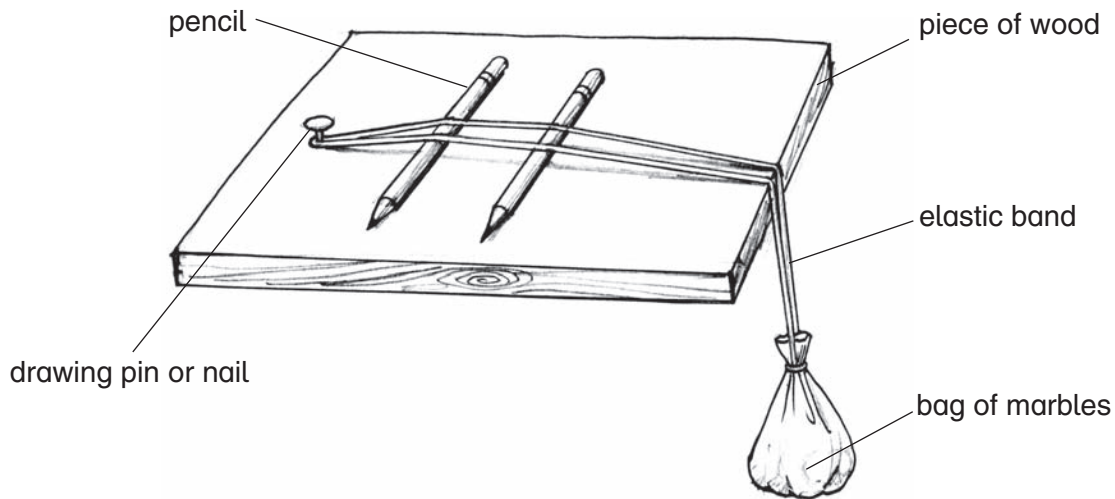
- three pencils
- thick and thin elastic bands
- small bag
- piece of wood
- drawing pin or small nail
- marbles

What you do:

Ask an adult to put a drawing pin or a small nail towards one end of the piece of wood. Hook a thick elastic band on to the nail or drawing pin.

Tie a small bag with a marble in it to the other end of the elastic band.

Slide two pencils under the elastic band.



Now pluck the elastic band between the pencils.

What kind of sound does it make?

How does the elastic band make a sound when you pluck it?

Now carefully put another marble in the bag.

Pluck the elastic band again.

What kind of sound does it make? Does it make a higher or lower note than before?

Replace the elastic band with a thinner one.

Put one marble in the bag and pluck the elastic band. Does it make a higher or lower note than the thick band?

Fill in the missing words in these sentences:

- The thicker the elastic band, the _____ the pitch.
- The thinner the elastic band, the _____ the pitch.

3. Musical pipes

What you need:

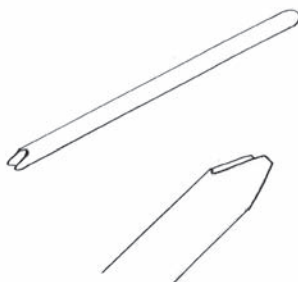
- pencil
- drinking straws
- scissors

What you do:

Flatten the end of a drinking straw.

Now cut the flattened end like this.

Play your musical pipe by blowing through the cut end.

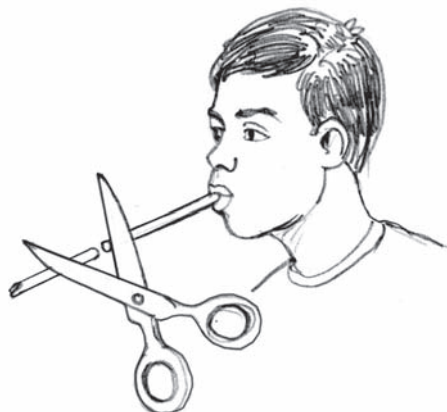


Answer these questions:

a) Why does the cut end of the straw make a sound when you blow it?

b) Does the musical pipe make a high or a low sound?

Now cut the straw in half and blow again.



c) What kind of sound does the straw make now? Is it higher or lower than before?

d) How could you make the sound from the musical pipe louder?

e) Explain how someone in the room near you is able to hear the sounds you make with your musical pipe.

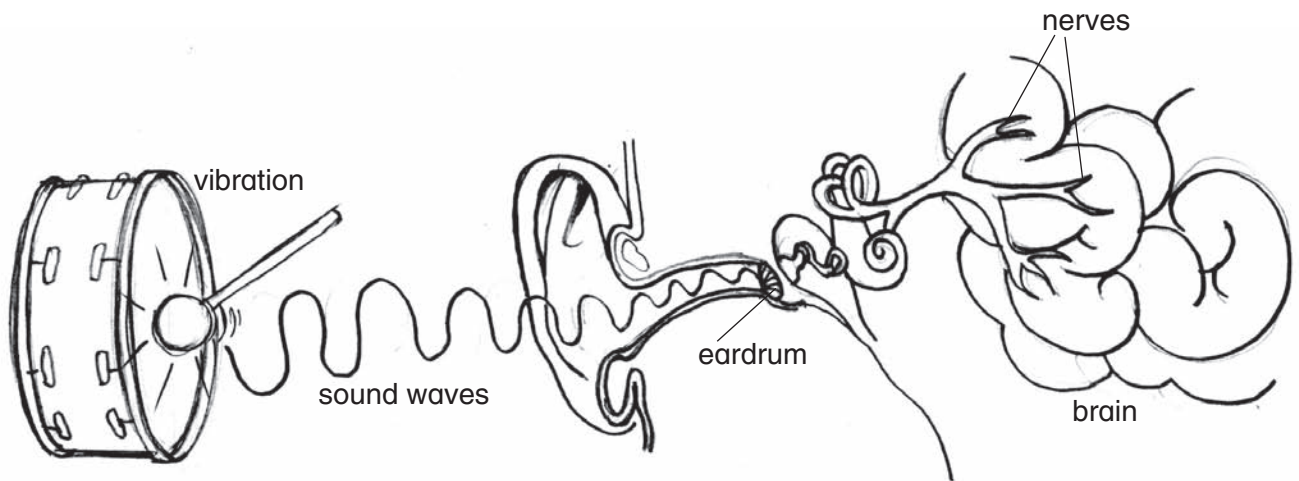
4. How we hear

What you need:

- pencil

What you do:

The picture shows a drum being hit and sound waves travelling to the ear of a person who is nearby.



Read the sentence in the boxes below.

A Nerves carry the message to your brain.

B Sound waves move through the air and enter your ear.

C The drum is hit and its top vibrates.

D Your brain tells you about the sound.

E Your eardrum begins to vibrate.

F Three little bones inside your ear begin to vibrate.

Now write out the letters of the sentences so that they are in the correct order.

i) _____ ii) _____ iii) _____ iv) _____ v) _____ vi) _____

5. Making a musical instrument

What you need:

- pencil
- 'junk' materials

What you do:

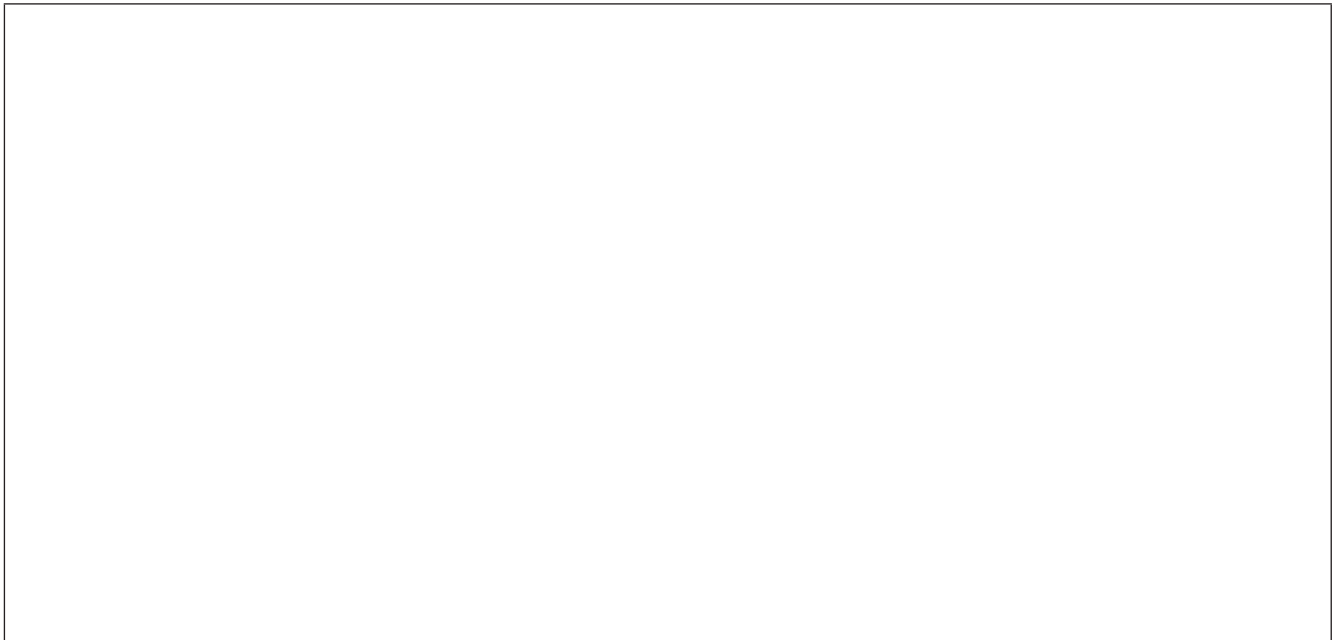
Design and make a simple musical instrument using 'junk' materials.

Materials you could use include plastic bottles, jars, cardboard boxes, scrap wood and elastic bands.

Your instrument could be something that you blow, hit, shake or pluck.

It could play only one note or several different notes.

Draw your instrument here before you make it:



Does your instrument work? _____

How could you improve it? _____

Make a list here of the materials you used.



6. Noise in school

What are the noisiest times of the day in your classroom and your school?

What you need:

- pencil
- computer with sound sensor and printer
- large sheet of paper
- clock or watch
- tape recorder

Work with a group of friends.

What you do:

Connect a sound sensor to your computer. Place the sensor as near to the centre of your classroom as possible.

Set your computer to take readings of the sound levels every 15 minutes during the school day.

Take a printout of the graph.

What are the quietest times of the day? _____

Can you say why? _____

What are the noisiest times? _____

Can you say why? _____

Now work with a group of friends. Make a large plan of the school.

Find out which are the busiest and noisiest parts of the school at different times of the day. _____

Which are the quietest places? _____

Use a tape recorder to record the noises children make in different parts of the school.

Which noises cause the most problems?

Discuss with your friends what can be done to reduce the noise.

7. Which materials make the best ear protectors?

What you need:

- pencil
- circles of cardboard about 10 cm in diameter
- scissors
- hairband
- cotton wool, paper towel, woollen cloth, plastic bag, bubble wrap
- glue or sticky tape
- small electric buzzer, bell or musical instrument such as a recorder
- long tape measure

Work with two friends.

What you do:

Cut a hole in each of the cardboard circles. Each hole should be large enough to fit over your ear.

Cut circles of each of the materials to be tested.

The circles should be the same size as the circles of cardboard, or slightly smaller.

Lay the two pieces of the first material to be tested on the table. Cover them with two of the cardboard circles and glue or tape them together.

Choose one person to wear the ear protectors.

Cover both ears with them and hold them in place with the hairband.

Ask one of the group to sound the buzzer or bell or to play a note with the musical instrument.

The person with the ear protectors should walk away slowly from the sound until he or she cannot hear the noise any longer.

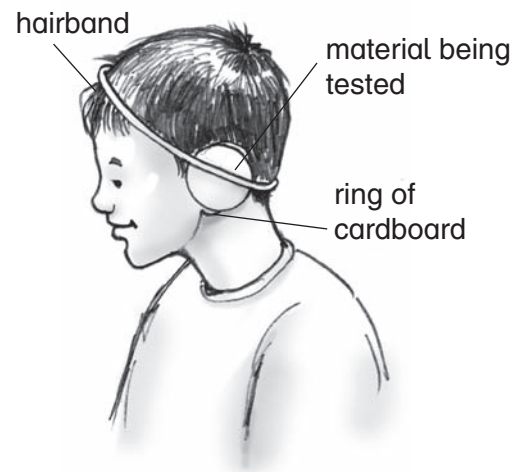
Measure that distance _____

The same person should then test the other materials and record the results.

The other members of the group can then have their turn.

The material which makes the best ear protector is the one where you walk the shortest distance before you can no longer hear the noise. Which is it?

The poorest ear protector is the one where you walk the greatest distance before you can no longer hear the noise. Which is it?



Notes on individual worksheets

1. Travelling sounds

Key idea To investigate the transmission of sounds through different solid materials.

Outcome The results will depend upon the thickness of the materials being investigated. The sounds will probably be heard best through the glass, followed by the door and the brick wall. The coat or woollen blanket will probably absorb the sound waves, and thus act as a sound insulator.

Extension Devise an experiment to see how well sounds travel through water.

2. Sound and pitch

Key idea Investigating the pitch of the sound made by vibrating elastic bands.

Outcome The elastic band vibrates and makes the air around it vibrate. The more the elastic band is stretched (within reason), the higher the note it will produce. A thin elastic band makes a higher pitched note than a thick band if they are both undergoing the same level of tension. Remember that pitch is not to do with the size of the vibrations but their frequency (how many there are in a second).

Extension Make a model guitar or double bass using a cardboard box, elastic bands and other junk materials.

Safety Remember that over-stretched elastic bands can cause injuries, particularly to the eyes.

3. Musical pipes

Key idea To make a simple wind instrument.

Outcome

- The end of the straw vibrates and this makes the air inside vibrate.
- With a long drinking straw the note will be quite low-pitched.
- When the drinking straw is cut in half, the note will be higher-pitched.
- To make a louder sound one would need to blow harder.
- The vibrating straw makes the air vibrate. These vibrations (or sound waves) pass through the air to the ears of people nearby.

Extension Make model pan pipes using drinking straws or a model xylophone using glass bottles filled with water to different levels.

4. How we hear

Key idea To test the students' understanding of the sequence of events involved in hearing a drum beat.

Outcome The correct sequence of events is: i) C; ii) B; iii) E; iv) F; v) A; vi) D.

Extension Ask the students to devise a test that they can use to compare each other's sense of hearing.

5. Making a musical instrument

Key idea To design and make a model musical instrument using junk materials.

Extension With permission, investigate the internal workings of a piano.

6. Noise in school

Key ideas To investigate which parts of the school are busy and which are quiet, and why. To find out how noise affects us.

Extension Investigate which are the quietest classrooms in the school.

7. Which materials make the best ear protectors?

Key idea An experiment to determine which materials are the best at muffling the sound of a buzzer, bell or musical instrument.

Outcome Assuming that the sound of the buzzer, bell or musical instrument was maintained at the same volume throughout, then the cotton wool, woollen cloth and bubble wrap are likely to have been best at muffling the sound. These materials are thick and will absorb the sound waves so that they cannot get through to the students' ears easily. The plastic bag and paper towel are thinner materials and sound vibrations can pass through them to the ears more easily.

Extension Investigate how good different types of earphones are at eliminating external sounds.

Lesson objectives

- To show that the Earth, Sun and moon are roughly spherical and to show how the movements of these bodies relevant to each other result in day and night and the seasons
- To show that the Sun is a star and to introduce simple ideas about the solar system and the exploration of the moon

Background information

The Earth in space

It used to be thought that the Earth was the centre of the universe. Until 1613 it was accepted that the Sun revolved around the Earth. Only in the last century did we come to realize that, on the scale of the whole universe, the Earth is a very unimportant object. It is one of eight major planets that revolve around the bright star we call the Sun. But the Sun itself, on which we depend for nearly all our energy, is a very insignificant body among the millions and millions of other stars scattered throughout space. We do not know how many of these stars have planets orbiting around them because they are too far away.

The Earth is a sphere, slightly flattened at the poles—a shape called an oblate spheroid. The diameter at the poles is 12,714 kilometres and it is 43 kilometres greater at the Equator. Like the other planets in our solar system, the Earth moves in its own orbit around the Sun. As the Earth orbits the Sun it also rotates on its own axis, an imaginary line through the centre of the Earth between the two poles. One complete rotation of the Earth on its own axis takes 24 hours. At any one time, the part of the Earth facing the Sun has day and the rest is in the area of dark shadow we call night.

The seasons

The Earth takes one year to complete a single orbit of the Sun. As a result of the Earth's passage around the Sun, we have the changes we call the seasons. These are caused by the fact that the Earth's axis is tilted about 23.5 degrees from the perpendicular. For part of the year, the North Pole is tilted towards the Sun, while the South Pole is tilted away from it. At that time, places in the southern hemisphere experience short days and lower temperatures of winter, while the northern hemisphere has longer days and higher temperatures of summer. Six months later, the North Pole is tilted furthest away from the Sun, while the South Pole is at its nearest to the Sun. The southern hemisphere then experiences summer, while in the northern hemisphere it is winter. Spring and autumn are the in-between seasons.

The planets

The planets, of which the Earth is one, together with the Sun, which is itself a star, form the solar system. Of the eight planets, five (other than the Earth) have been known for 5000 years or more. These are Mercury, Venus, Mars, Jupiter, and Saturn. The more distant planets were discovered only after the invention of the telescope. Uranus was first observed in 1781 and Neptune in 1846. Pluto was discovered in 1930 and, until 2006, was considered to be the ninth planet. In 2006, a meeting of astronomers decided that Pluto no longer merited the status of a planet and it is now classified as a 'dwarf planet'.

In addition to the eight major planets and Pluto, there is a region known as the asteroid belt, situated between the orbits of Mars and Jupiter. This consists of thousands of small bodies called asteroids, mostly less than one kilometre across.

All the planets, like the Earth and its satellite the moon, are roughly spherical in shape. Like the Earth, the planets have no light of their own. They shine by reflecting sunlight. The planets are very much nearer to the Earth than any of the stars in the constellations, which is why they appear larger.

Whereas the stars seem to have fixed positions in the sky, relative to each other, the planets seem to move slowly day by day, month by month, against the background of the constellations. Indeed, each planet has two motions. It rotates or spins on its own axis, and at the same time it also revolves around the Sun. The time for one complete rotation is called a day. The Earth's day is 24 hours, that of Jupiter less than ten hours. Venus is the slowest of the planets in its rotation, a single rotation taking 243 of our days. All the planets move in the same direction around the Sun and very nearly in the same plane. Pluto is different in that its orbit is slightly tilted so that it just crosses inside the orbit of Neptune. The time taken for a planet to make one complete revolution of the Sun is called a year. A year on Earth is just over 365 days (hence we need a leap year every fourth year). Planets closer to the Sun have shorter years. That of Mercury is shortest, with a year of only 88 days. A year on Neptune is 164 Earth years while that of Pluto is 247 of our years.

The planets vary considerably in size and composition. Although some planets would appear to be solid like the Earth, in fact Saturn, Jupiter, Uranus, and Neptune have low densities and are largely gaseous.

The average surface temperature of a planet depends largely on its distance from the Sun. A knowledge of these surface temperatures is particularly important when considering the possibility that life may exist other than on the Earth. Mercury, the nearest planet to the Sun, has a maximum mid-day surface temperature of about 350°C. At the greatest distances from the Sun, Uranus has a surface temperature of about -180°C and Neptune's is -210°C. Venus and Mars, the two planets on either side of the Earth, have too little water vapour, and Venus is too hot, to support life as we know it.

The moon

Several of the planets have satellites or moons. These moons, like the planets themselves, shine because they reflect the Sun's light. Our own moon has a roughly spherical shape with a diameter of 3500 kilometres compared to the Earth's diameter of 12,714 kilometres. The moon takes a month to orbit the Earth. Half the moon is always lit by the Sun. As the moon goes around the Earth, different amounts of its lighted part are visible to us. That explains why the phases of the moon occur in a regular and predictable sequence every 29.5 days. It is this orbiting by the moon that makes it difficult for spacecraft to travel there from the Earth. The journey takes three days, and to reach its moving target a spacecraft leaving the Earth has to aim for where the moon will be, 384,000 kilometres away, in three days' time.

The gravitational pull of the moon on our oceans and seas tends to heap up the water, causing the tides. The Sun has a lesser effect, but the high spring tides occur when the gravitational pull of the Sun and moon act in the same direction. When the two pulls are at right angles we have the low neap tides.

Long ago, people gave names to the easily visible shapes on the moon, such as the Sea of Tranquillity and the Ocean of Storms. We now know that the moon has no atmosphere to make storms, and no water. When the American astronauts first landed on the moon in July 1969, they confirmed much of what astronomers had expected: an acid, volcanic rocky surface with no vegetation or life of any kind. The rocks that these and later astronauts brought back to Earth are similar to the igneous rocks (formed by volcanoes) found on the Earth. The major source of change on the moon is micro-meteorites, which crash into its surface at speeds of up to 112,000 kilometres per hour, forming large craters.

Because the moon is much lighter than the Earth, the pull of its gravity is only one-sixth of that of the Earth. As a result, astronauts on the moon feel one-sixth as heavy. The moon is a most inhospitable place for people: no air, water or food, and with the temperature varying from 100°C during the day to -155°C at night.

The Sun

As has already been pointed out, our Sun is really a star, the nearest star to the Earth. The energy the Sun pours out as heat and light comes from nuclear processes, rather like those that occur when an atom bomb explodes. The Sun's outside layer has a temperature of about 6000°C, about twice as hot as white-hot metal. Although the Sun is the nearest star to the Earth, it is still 150,000,000 kilometres away, and its light takes about eight minutes to reach us. The other stars are much further away and the light from many of them takes years, sometimes hundreds of years, to reach us.

Stars

Stars seem to form recognizable patterns, or constellations, in the sky and these slowly turn during the night. In addition, the star positions seem to change from one night to the next. We now know that it is not the stars which are turning, but the Earth itself. The stars are immense spheres of glowing gases, like our own Sun, but because the stars are such great distances away, they appear to be tiny points of light. Sirius, the brightest and closest night-time star in the northern hemisphere of the Earth, is almost nine light years away. This means that if it were possible to travel in a spacecraft at the speed of light, it would take almost nine years to reach Sirius. Travelling at the same speed, it would take only about eight minutes to reach the Sun.

Safety

Warn children never to look directly at the Sun. It could damage their eyesight or cause blindness.

Answers

Beyond the Earth: Rapid fire, p 45

- 1) During the day the Sun appears to move across the sky. The Sun rises in the east and sets in the west. This apparent movement of the Sun is due to the rotation of the Earth about its axis. The fact that the Sun does not always seem to set in the same place is due to the fact that the days are much longer in summer than in winter because of the tilt of the Earth on its axis.
- 2) The light from the Sun is used by all green plants when they make their food by the process called photosynthesis. All of our food comes either from plants or from animals which feed on plants. We also obtain all of our timber and some of our clothing materials from plants. The heat from the Sun allows all kinds of living things to be able to live on our planet. In the distant past, living things which used the Sun's energy to help them feed and grow, died and formed the coal, oil and natural gas we use as fuels today.
- 3) The hottest places in the world are around the Equator. The coldest are in the polar regions.

Beyond the Earth: Try it out, p 45

- 1) A patch of sunlight on the wall appears to move because the Earth is rotating on its axis.
- 3) If the rays of the Sun are focused in one place for a few moments, they generate enough heat to cause the paper to start to smoulder. In a similar way, the lenses in the eyes can focus the Sun's rays on to the sensitive screen at the back of the eye (the retina), damaging it and perhaps burning it.

The solar system: Rapid fire, p 47

- 1) TRUE: a), b), e) and f). FALSE: c) and d).
- 2) One example of a mnemonic is: Many Vile Earthlings Munch Jam Sandwiches Under Newspaper Piles (include the latter only if you still consider Pluto to be a planet!).
- 3) Stars come in a variety of colours and a huge range of sizes, but every star, like our Sun, is a giant ball of glowing gas. The planets also shine in the night sky but they do not give out any light of their own. Like the moon, they shine because they reflect the light of the Sun.

Planet Earth: Rapid fire, p 49

- 1) TRUE: a), b), e) and f). FALSE: c), d) and g).
- 2) As well as rotating around the Sun, the Earth also spins in an anticlockwise direction about its own axis. The Earth makes one complete turn about its axis every 24 hours. Only one half of the Earth faces the Sun at any one time and that half of the Earth has day. The other half of the Earth is in the deep shadow we call night.

EARTH, SUN AND MOON

The white light from the Sun is made up of all the colours of the rainbow mixed together. When the Sun is directly overhead, its rays have a shorter distance to travel to reach us. Although the air scatters the sunlight in all directions as it comes towards us, it is the blue of sunlight that is scattered most, creating a brilliant blue sky on a sunny day. As the Sun sets, its rays have a much greater distance to travel through the atmosphere to reach us. Dust and water droplets in the atmosphere scatter the rays of light coming from the Sun. Because the blue light is scattered most, only the red and yellow rays of light are left by the time the sunlight reaches the ground. The Sun itself may appear like a crimson sphere. Its rays shining from a low angle tint the undersides of the clouds with beautiful colours. The same kind of thing sometimes happens at sunrise.

- 3) During the day the Sun appears to move across the sky, appearing to rise in the east and set in the west. This apparent movement of the Sun is really due to the rotation of the Earth about its axis. As the Sun appears to move across the sky, the shadows that stationary objects form also seem to move. The shadow of a stick is longest in the morning and evening, when the Sun is at its lowest position relative to Earth, and shortest at midday when the Sun is at its highest position relative to Earth.

Planet Earth: Try it out, p 49

- 2) As the Sun appears to move across the sky each day, from east to west, the shadows that stationary objects form also seem to move. The shadow of a stick is longest in the morning and evening, when the Sun is at its lowest position relative to Earth, and shortest at midday when the Sun is at its highest position relative to Earth.

The changing seasons: Rapid fire, p 51

- 1) TRUE: a) and c), FALSE: b) and d).
- 2) The Sun is much larger than the Earth and so Annette should use the football to represent the Sun and the tennis ball to represent the Earth.
 - a) To show how the Earth moves in a year, Annette should move the tennis ball in a circle anticlockwise around the football Sun.
 - b) To show what causes day and night, Annette would have to make a complete rotation of the tennis ball Earth, while keeping it in the same position in relation to the football Sun.

The changing seasons: Try it out, p 51

- 1) The fact that, on a clear day, a ship can be seen gradually disappearing over the horizon is evidence that the Earth is round like a ball, or sphere.
- 2) The countries where the weather remains almost the same throughout the year will be in the tropics, near to the Equator, although even in many of these places there is a dry season and a wet season.

The moon, our neighbour in space: Rapid fire, p 53

- 1) Because the same side of the moon always faces the Earth, we never see the other side of it. Sunlight makes the side of the moon facing the Sun shine. On this part of the moon it is daytime. The other half of the moon is in darkness and it is night. As the moon travels around the Earth in an anticlockwise direction, we see different amounts of its sunlit half. Night by night, the shape of the moon seems to change from a thin crescent to a complete disc and back again. The shape of the moon we see at any one time, called its phase, depends on where the moon is in relation to the Earth.
- 2) In the daytime the surface of the moon is extremely hot because the Sun is shining straight down on to it, and there is no atmosphere or clouds to shield the surface of the moon from the Sun's rays. At night the moon is in complete shadow and, because there is no atmosphere or clouds to insulate the surface of the moon, it loses heat into space very quickly and is extremely cold.
- 3) There is no weather on the moon because it has no water or air.

The moon, our neighbour in space: Try it out, p 53

- 1) Because the moon is much nearer to us than the Sun, the two look more or less the same size in the sky. When the Earth is between the moon and the Sun, the shadow cast by the Earth falls on the moon. At a full moon, if the Earth's shadow falls on the face of the moon, we have a lunar eclipse. If it is a total eclipse, the shadow of the Earth covers the whole face of the moon, and nearly all the sunlight to the moon is cut off. The moon does not disappear. Some light is refracted (bent) round by our atmosphere, and the moon looks an odd orange or red colour.

The moon also causes eclipses of the Sun, or solar eclipses, when it appears in front of the Sun. When that happens, the Sun's rays cannot pass through the moon and the Sun is blocked from our view.

Going to the moon: Rapid fire, p 55

- 1) Astronauts cannot use parachutes to help slow their spacecraft as it approaches the moon. This is because there is no air on the moon and parachutes rely on air resistance to slow them down. Instead, astronauts rely on rocket motors pointing towards the surface of the moon to slow them down.
- 2) Between July 1969 and December 1972, six crews of American astronauts made successful moon landings and twelve astronauts walked on the surface of the moon.
- 3) The moon's sky is always black because, without air, sunlight is not scattered.

Going to the moon: Try it out, p 55

- 1) Astronauts in space eat three meals a day and the food they eat is similar to the foods we might take on a long camping trip to some remote place. Some foods, such as fruit, can be eaten in their natural form, but most foods including cheese, spaghetti, macaroni and beef have to have water added. The water to hydrate the food comes from the fuel cells on the spacecraft, which combine oxygen and hydrogen gases making water and also electricity. There is an oven in the space shuttle and space station, but no refrigerator or freezer. It takes about 30 minutes to prepare a meal in space. The food containers have to be fastened to a table, a wall or the astronaut's lap. The astronauts use a knife, fork and spoon to eat their food and have a pair of scissors to open the packages. Washing-up is done with 'wet wipes'.
- 2) Many man-made satellites orbit the Earth. Communications satellites pass on all kinds of communications signals, including TV programmes and radio, telephone and email messages. Weather satellites take pictures of the clouds and measure the weather conditions in the air. Remote sensing satellites photograph the Earth's surface in light of different colours, showing up details that cannot be seen in ordinary photographs. Astronomy satellites carry telescopes into space, where they can see more clearly. Navigation satellites help ships, aircraft and motor vehicles to find their way and are even used by walkers in remote places. Satellites are launched into space using powerful rockets.
- 3) The moon appears to keep moving in the sky because it orbits the Earth, just as the Earth orbits the Sun.

Assessment: p 56-57

- 1) The shadow of the tree moves as the Sun appears to move across the sky. Really this is because the Earth spins in an anticlockwise direction around its axis.
- 2) TRUE: a) and d). FALSE: b), c) and e).
- 3) a) ii); b) v); c) i); d) iii); e) vi); f) iv).
- 4) a) The seasons result from the fact that the axis of the Earth is slightly tilted and the Earth is continually spinning around on its axis as it makes its yearly orbit of the Sun. Summer occurs in the part of the Earth that is tilted towards the Sun, while winter occurs in the part of the Earth that is tilted away from the Sun. Spring and autumn are the in-between seasons.
b) The four seasons (in temperate parts of the world) are spring, summer, autumn and winter.
c) There are 365 days in a year.
d) There are 366 days in a leap year.

- e) The Earth orbits the Sun.
 - f) The moon orbits the Earth.
 - g) A lunar (moon) month is the time between two New Moons or two full Moons. It is 29.5 days.
 - h) The main phases of the moon are: new, crescent, first quarter, gibbous, full, gibbous, last quarter, crescent, and then new moon again.
 - i) The moon's gravity pulls on the Earth's oceans and seas that are facing the moon. There is a weaker pull on the water on the Earth's opposite side. These are the areas where high tides occur. The highest and lowest tides occur when the Sun, moon and Earth are in a line. These so-called spring tides result from the Sun and moon's combined pull of gravity on the Earth's oceans and seas.
- 5) a) i) is the Sun; ii) is the Earth; iii) is the moon.
b) i) star ii) solar iii) planet iv) satellite v) reflects.

Going further

Use newspapers or the Internet to find out about the times of sunlight and sunset at different times of the year.

Gravity is the force that pulls things towards the Earth. It is gravity which gives things their weight. The Sun and moon have gravity too. Put the Earth, Sun and moon in order of their force of gravity. Put the weakest force first and the strongest force last (moon, Earth, Sun). How would your weight change if you could safely stand on the surface of the moon (weight would decrease) and the Sun (weight would increase)?

Use a diary, newspaper or the Internet to find out when the next new moon and full moon will be.

Use CD-ROMs, the Internet and reference books to produce 'Fact Books' about space travel and exploration.

Use the Internet or reference books to compile a solar system fact file. Include information on the name of each planet, its diameter, distance from the Sun, length of year in Earth days or years, time taken to spin once (length of day), and number of moons. Make a chart with the resulting data.

Ask groups of students to research the orbits of the planets around the Sun. They can then choose a planet and make a large label of it to wear. In a large open space, such as the school hall or school grounds, ask the students to work out how to recreate the orbits—using themselves as the orbiting planets. The student playing the role of the Sun should remain still, while the others—representing the moon, the Earth and the other planets must find the appropriate elliptical path to follow. Discuss who has to move the shortest distance (Mercury). Whose orbit is the largest? (Pluto, if you consider it still to be a planet, if not Neptune.)

Find the time difference between some major world cities and your country. Relate these time differences to the positions of the cities on a globe.

Ask the students to imagine going on vacation to the moon or another planet. Suggest that they design tourist brochures to encourage space travel.

Carry out a design activity to show in detail what the inside of a space station would look like. How would the living quarters be separated from the operational areas? What sort of beds would there be? Where would the supplies of water come from? How would people move around inside if there was no gravity?

Design a spacesuit for travellers to wear in space. It will need to be comfortable, yet highly protective. How will the space traveller move, breathe, and communicate?

Draw a large circle and divide it into four equal-sized segments. Head the segments: spring, summer, autumn and winter. In the segments write or draw how the four seasons are different from each other where you live. Think particularly of the climate, the foods available, and the plants and animals that you see in each season.

1. The solar system

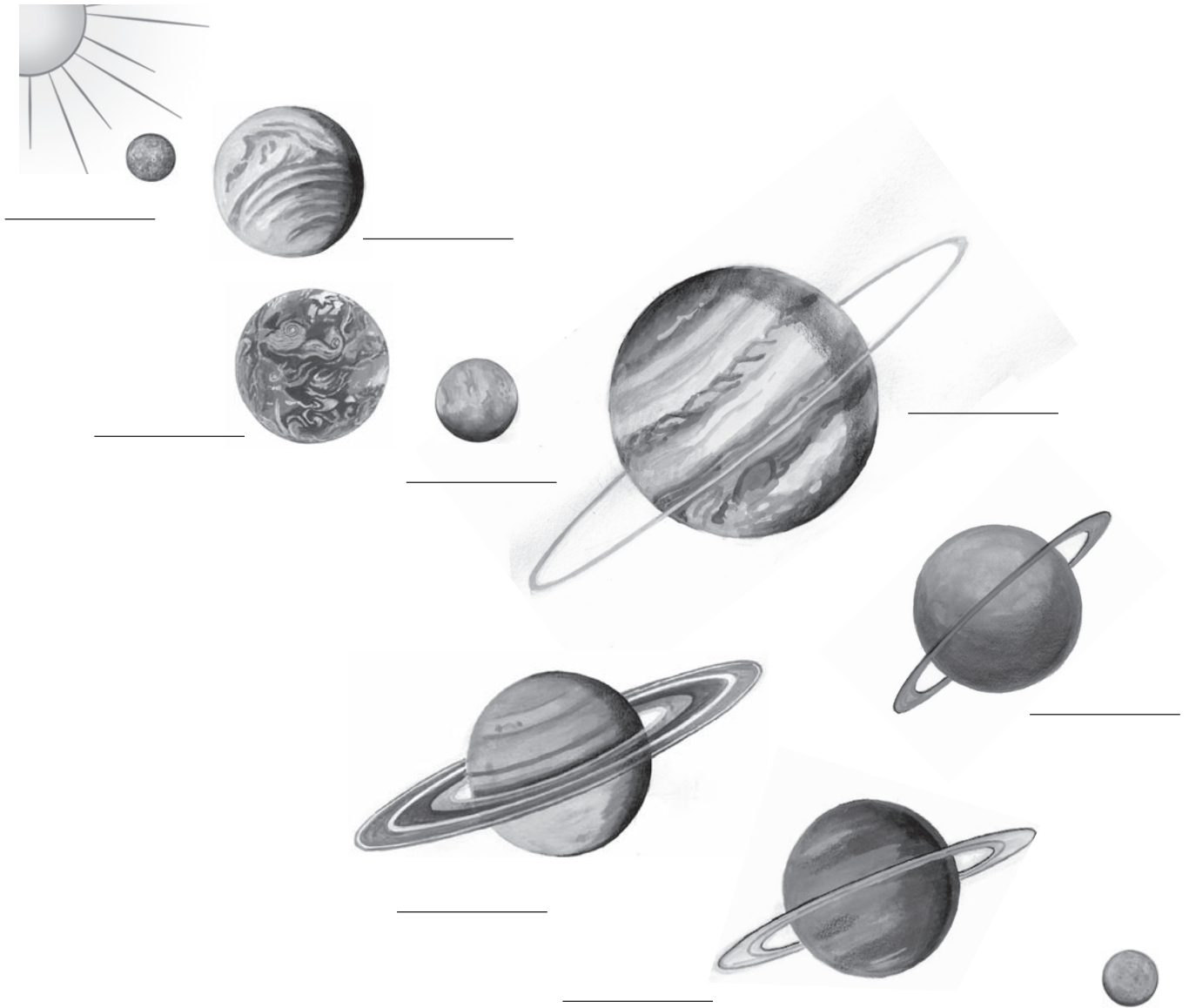
What you need:

- pencil

What you do:

Write the name of each planet beside its picture.

Remember the relative sizes of the planets are correct, but the distances between them are not to scale.



- a) Many scientists now say that one of the objects in the picture is not a proper planet. Which is it? _____
- b) Which of the planets shown is the hottest? _____
How do you know? _____
- c) Which of the planets shown is the coldest? _____
How do you know? _____

2. Earth, Sun and moon

Here are some facts about the Sun, moon and Earth:

- The Sun is a star, the nearest star to the Earth.
- The Sun is a great ball of burning gas, nearly 150 million kilometres from the Earth.
- The Sun is much larger than the Earth.
- The moon is much smaller than the Earth.
- The moon shines because it reflects the Sun's light.

What you need:

- pencil
- coloured pencils or crayons
- large beach ball, (ideally about half a metre in diameter)
- a marble
- long tape measure

What you do:

Label the Sun, moon and Earth in the picture below.

Colour the Sun yellow.

Colour the moon grey or silver.

Colour the Earth blue or green.



Go outside and place the large ball on the playground. This ball represents the Sun.

Place the marble about 35 metres from the ball Sun.

The marble represents the Earth.

What could you use to represent the moon? _____

Would the moon be nearer to the Earth than the Sun? _____

Think about the Sun and the Earth. What would happen if the Earth moved much nearer to the Sun? _____

What would happen if the Earth moved much further away from the Sun? _____

3. A shadow clock

Make a shadow clock. Do this activity on a sunny morning.

What you need:

- pencil
- strip of wood about 5 cm wide
- clay or Plasticine

What you do:

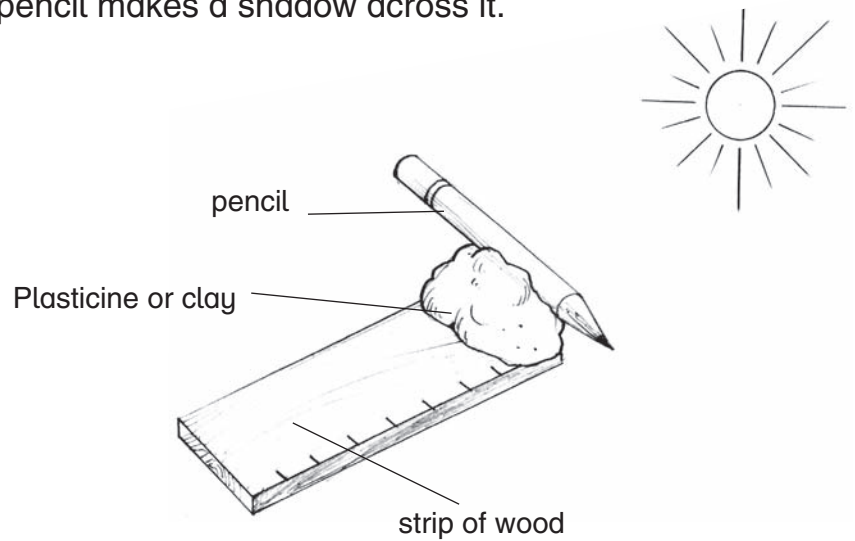
Stick a lump of clay or Plasticine at one end of the piece of wood.

Press the pencil into the clay or Plasticine. This is your clock.

Take the clock outside and put it down so that it faces the Sun.

Tilt the piece of wood until the pencil makes a shadow across it.

Mark the shadow on the wood.



One hour later, mark the shadow again.

Do this every hour.

How could you use your shadow clock to tell the time?

Can you design some other shadow clocks? Make them and see if they work. Which works best?

Safety: Do not look directly at the Sun. It could damage your eyes.

4. Where is the Sun?

How far does the Sun appear to move? Do this activity on a sunny day to find out.

What you need:

- pencil
- clay or Plasticine
- sheet of cardboard
- drinking straws

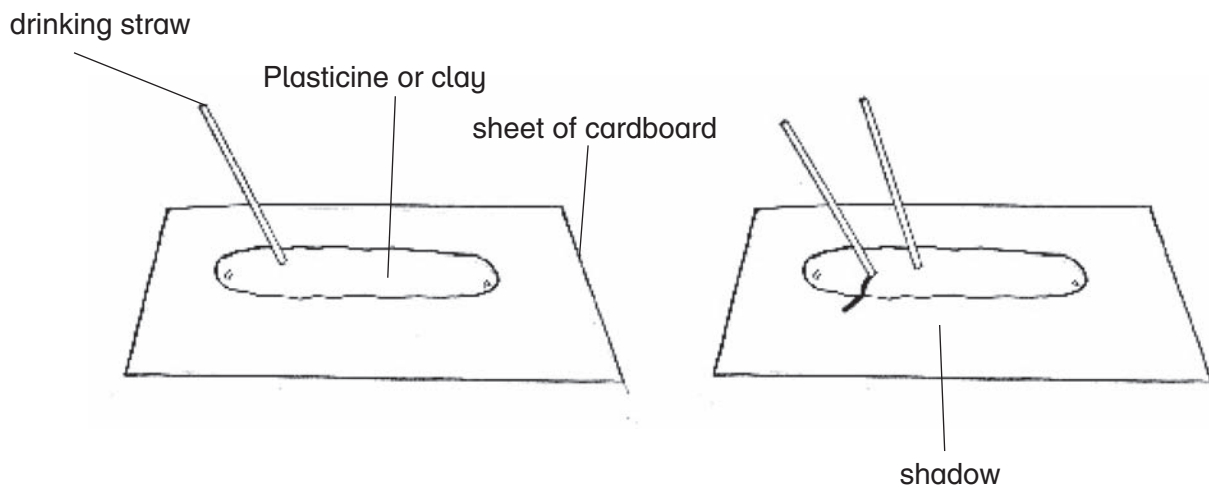
What you do:

Roll a piece of clay or Plasticine into a sausage shape.

Press it on to a sheet of card.

Take the card outside.

Stick a drinking straw at one end of the clay or Plasticine. Move it around until it does not make a shadow. The straw is now pointing straight at the Sun.



An hour later put another straw in the clay or Plasticine. Move the straw until it does not make a shadow.

Do the same thing every hour.

What do you notice? _____

Has the Sun really moved? _____

Safety: Do not look directly at the Sun. It could damage your eyes.

5. The Sun's rays

Sometimes the Sun seems to be directly overhead, while at other times the Sun seems to be low in the sky. What difference does it make whether we get direct rays or slanted rays from the Sun?

What you need:

- pencil
- desk lamp
- a thermometer
- a square of black felt or black paper
- a watch or clock with a second hand
- a globe

What you do:

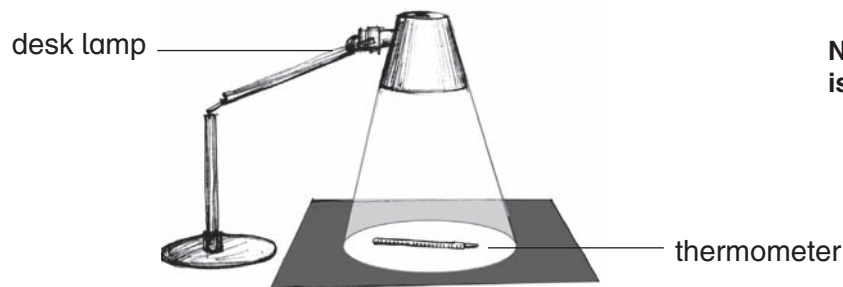
Lay the thermometer under the black felt or black paper.

What temperature does it show?

Move the desk lamp so that it shines straight down on the thermometer from a height of about 30 cm.

Switch on the lamp and leave it on for five minutes.

What temperature does the thermometer show? _____



Note: The thermometer is under the paper.

Leave the lamp to cool down. Then move its top so that it is directed at an angle towards the black felt or paper. Do not switch the lamp on yet.

What temperature does the thermometer show? _____

Now switch on the lamp and leave it on for five minutes.

What temperature does the thermometer show now? _____



Does the temperature rise most from the direct rays or the slanted rays?

Can you find places on the globe where the Sun's rays are direct and others where they are slanted? What kind of climate do you think these places might have. Use reference books to see if you were right.

6. A sunset diary

What you need:

- pencil
- clock or watch

What you do:

Have you noticed that at some times of the year the Sun has set and it is dark either before or just after you get home from play? At other times the lights come on and the Sun is still shining in the sky.

Keep a diary of when the Sun sets and when the street lights come on for the next four weeks.

To make your test fair, write in your diary on the same day of each week. Each week say what time you think the Sun will set. Then see if your prediction was correct.

Day and date	I think the Sun will set at	Time when the Sun actually set	Time when the street lights came on

Did the Sun set earlier or later each week or did it set at the same time?

Were your predictions correct? _____

Can you explain your results? _____

7. The shape of the moon

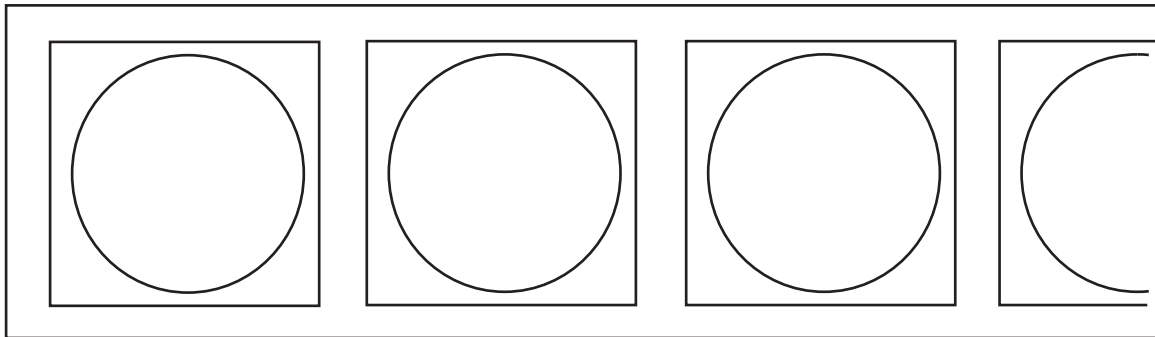
What you need:

- pencil
- a long narrow strip of paper or thin card
- work with a group of friends

What you do:

Draw squares, all the same size, along the strip of paper.

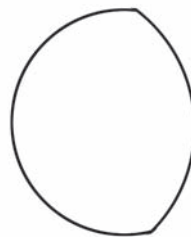
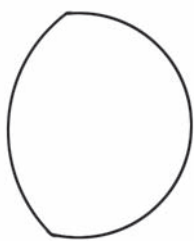
Inside each square draw a circle, all the same size. You might be able to find a coin you can draw round, or you could use a compass.



Look for the moon from any room window one evening.

Draw the moon's shape in the first of the circles. Write the date underneath.

Here are some shapes you might see. Find out what they are called.



Take it in turns to look for the moon on the following evenings. Draw the moon's shape each evening.

Colour the bright part of the moon in each picture yellow.

When you cannot see the moon, shade the circle black.

After four weeks look at your pictures carefully.

Does the moon's shape change gradually, or does it change shape suddenly?

Notes on individual worksheets

1. The solar system

Key idea To test the students' knowledge and understanding of the components of the solar system.

Outcome The planets, reading down the page are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto (if you wish to continue to call it a planet).

a) Many scientists now consider that Pluto is not a proper planet but a dwarf planet.

b) The hottest planet is Mercury since it is closest to the Sun.

c) The coldest planet is either Pluto (if you wish to continue to call it a planet) or Neptune, since they are furthest from the Sun.

Extension Use the Internet and reference books to find out how Mars has been investigated by scientists and what has been discovered about it.

2. Earth, Sun and moon

Key ideas The Earth, Sun and moon are distinct spherical objects in space. To give an indication of the relative sizes of these objects and their distances apart.

Outcome The diameter of the moon is about one-quarter of that of the Earth so that you would need to use a large pea or bead to represent the moon and the moon would have to be placed less than 10 cm from the Earth. If the Earth moved nearer to the Sun, then the Earth would become too hot for human and most other forms of life. If the Earth moved away from the Sun, it would become too cold for life to exist.

Extension Make a display of photographs of the Earth as seen from space.

3. A shadow clock

Key idea It is possible to tell the time by using the moving shadows created by the Sun.

Outcome The shadow of the pencil will move along the wood during the course of the day. If the times when the shadows are created are marked on the wood and it is placed in exactly the same position the next day, it could be used to tell the time.

Extension Discuss why shadows are not always visible outdoors.

Safety Warn the students not to look directly at the Sun.

4. Where is the Sun?

Key idea The Sun appears to move across the sky from east to west each day.

Outcome The drinking straws will form a fan shape by the end of the day, showing how the Sun appears to move across the sky, although it is really the Earth that is turning.

Extension Use a compass to find out the direction in which the Sun rises and sets.

Safety Warn the students not to look directly at the Sun.

5. The Sun's rays

Key idea Direct rays from the Sun have greater warming powers than the slanted rays which reach the Earth when the Sun appears to be low in the sky.

Outcome The thermometer will show a higher temperature when the desk lamp is shining straight down than when it is slanted towards the thermometer. The Sun's rays are direct over the equator which, therefore, has high temperatures. They are slanted over the much colder polar regions.

Extension Stand a table lamp, with its shade removed, in the centre of a darkened room. Use a small piece of clay or Plasticine to mark the position of your country on a globe, and move the globe

in a circle around the lamp, maintaining the same short distance from the lamp all the time. Stop at each of the four seasons to see whether the Sun's rays are overhead in your country or slanted. Explain that when your country is leaning towards the Sun, it is summer. When your country is leaning away from the Sun, it is winter.

6. A sunset diary

Key idea The length of the day varies through the year. Days are longer in summer and shorter in winter.

Outcome Sunset is earlier in winter and later in summer.

Extension Keep a chart of sunrise and sunset times, or lighting-up times (from a newspaper). Discuss why these vary in different parts of your country.

7. The shape of the moon

Key idea The moon's shape seems to change in a fixed sequence. This is because, as the moon orbits the Earth, we see different amounts of its lighted part.

Outcome The phases of the moon begin with a New Moon every 29.5 days. The phases are known as new, waxing, quarter, full, waning and crescent.

Extension Find out and discuss how astronauts are able to survive the extremes of temperature and the absence of air on the moon.

Lesson objectives

- To consolidate the students' ideas about changes of state which can be reversed, with reference to water
- To describe the water cycle and the importance of water to living things and for industrial processes
- To show the benefits and problems involved in irrigation and the importance of conserving our water supplies

Background information

Water and the water cycle

The air contains variable quantities of the invisible gas water vapour. Most of this water vapour is produced by evaporation from the oceans and seas that cover much of the Earth's surface. Large amounts of water vapour also come from rivers, lakes, ponds, puddles, and the aerial parts of plants, particularly trees. The water vapour rises, cools and condenses to form tiny water droplets. Clouds are collections of these water droplets.

The clouds are carried away by currents of air and eventually, when they are cooled, the water droplets in the clouds join to form larger drops. These fall as rain or, if the air is very cold, as hail, sleet, or snow.

Some of the rainwater flows along the ground as streams, while some soaks through the ground and then reappears as springs. The streams and springs join up to form rivers which flow back to the sea, completing the so-called water cycle.

Properties of water

Pure water freezes at 0°C, forming ice, and boils at 100°C, forming water vapour. The density of ice is less than that of cold water, with the result that ice floats. Natural water, such as rain, is never pure. It always contains dissolved substances. The hardness of water, when it is difficult to obtain a lather with soap, results from the water having dissolved underground chalk or limestone. Sea water is a solution of common salt (sodium chloride) and many other minerals.

Water always shows surface tension, behaving as if it has a tight, but elastic skin around it. Water always trickles from a tap in a smooth round rope or as smooth round drops. Its surface is round and smooth because the surface tension pulls it inwards. Surface tension is a consequence of the mutual attractive forces between water molecules.

Uses of water

As well as the vast quantities of water on the Earth's surface, there are also considerable amounts of water in living things. The human body is approximately 70 per cent water, a frog 78 per cent, a tomato and a jellyfish 95 per cent, and a water melon 99 per cent water. Each day the human body loses about three litres of water vapour. This loss must be replaced by water from our food and drink.

We also use huge amounts of water for cooking, washing, and flushing the lavatory. Outside the home, water is used in many manufacturing and industrial processes and for sport and leisure activities.

Tap water

Some of our tap water comes from rivers, some from underground wells and some from reservoirs. Water from these sources is never completely pure. It may contain dissolved substances and solid materials that must be removed. First the water is pumped through a screen, which removes the larger pieces of rubbish. It is then filtered through beds of coarse sand, which trap the larger particles of solid matter. Next the water flows into a sedimentation tank where chemicals are added to it. These make the smaller particles stick

together, so that they sink to the bottom of the tank. The water then goes through a filter of fine sand, which traps any particles still present. Finally a little chlorine gas is added to kill any remaining bacteria.

The water is now fit to drink. It is pumped into high storage tanks from where it flows to homes and factories.

Sewage and sewage treatment

All sorts of things get mixed with tap water when it is used in homes and factories: soaps, detergents, toothpastes, shampoos, body wastes, grease, foods, grits, and industrial and chemical wastes. This mixture goes down the drain and is called sewage.

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 bacteria and other 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 kinds of 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.

Pollution

Unfortunately not all sewage is cleaned before the water is returned to rivers, lakes or the sea. The water is often polluted with wastes from factories, farms and homes. Factory waste may contain poisonous chemicals, while fertilizers and pesticides used on farms can seep into lakes and rivers from the neighbouring fields. Pesticides are chemicals sprayed on to crops to kill off insects and other pests. In water, they can kill all kinds of animal life. Chemical fertilizers are often sprayed on to the soil to help crops grow better. If they are washed into lakes and rivers, they encourage the growth of green algae. When the algae die and rot away, the microbes which feed on them use up oxygen, leaving little for the other wildlife. Even slurry, a farm waste consisting of animal dung and urine which is used as a fertilizer, can pollute rivers and streams.

Oil sometimes spills from tankers or ships that are loading in harbours or are involved in accidents at sea. Sometimes oil is dumped in the sea deliberately when ships wash out their tanks. The oil kills sea birds, fish, shellfish and other marine life and it ruins beaches for people.

Even hot water can pollute lakes, rivers and the sea. Oil refineries and power stations often use water from rivers, lakes or the sea to get rid of unwanted heat. The water, which becomes hot, is put back where it came from, but the heat reduces the amount of oxygen the water can hold, and this can cause fish to die and prevent other fish from breeding.

Safety

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.

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

Answers

Water science: Rapid fire, p 59

- 1) Some of the water will sink into the ground, how much will depend upon what material the playground is made from. Some of the water will run away if the playground is on a slope and some will be taken up by any plants growing on or near to the playground. Some playgrounds have drains set in them and some of the water will go down these but, if the weather is hot, a lot of water will evaporate as water vapour.
- 2) Open answers.
- 3) Rainwater comes from clouds that were formed when water vapour that resulted from the evaporation of water on Earth condenses. The only substances dissolved in this rainwater are carbon dioxide and any other polluting gases that are present in the air. The water in the oceans and seas is full of dissolved minerals, and particularly salt. Some of these minerals have come from undersea volcanoes, but most of the salt was originally contained in rocks on land and this salt has been dissolved by rainwater and rivers and streams and carried down to the sea.

Water science: Try it out, p 59

- 1) The simplest method would be to take two leafy twigs from identical trees but the twigs must have the same number of leaves on them. The twigs should be stood in two identical containers each holding the same amount of water. A thin layer of olive oil or some other plant oil should cover the water to prevent evaporation. The two containers should stand next to each other so that the conditions of temperature and light are exactly the same. It is then a simple matter to see in which container the water level falls most. This experiment can never be completely fair because the leaves may have different areas or be of different ages.

Plants, animals and water: Rapid fire, p 61

- 1) Open answers.
- 2) The leaves of a cactus have been reduced to spines to prevent water loss by evaporation. The spines help prevent the cacti being eaten by animals and also catch droplets of dew. Cacti have deep and widespreading roots and these take in any water from the soil over a large area. The water is stored in the stem of the cactus, which uses the water slowly until the next time it rains in the desert.
- 3) Camels store fat in their humps. They can later break down this fat to produce water and energy. The camel has wide, cushion-like feet to spread out its weight and stop it sinking in the sand. The animal can also close its nostrils to keep out drifting sand. These adaptations enable the camel to go several weeks without water.

A gerbil hides away in a burrow during the day and only comes out to feed at night when it is cooler. It does not drink but obtains all the water it needs from its food. Gerbils store and eat food underground.

Water and industry: Rapid fire, p 63

- 1) There are still many thousands of watermills in use in Pakistan. The people living in the mountains in northern Pakistan, for example, grind their corn in traditional watermills which are still common in most villages.
- 2) The energy of falling water is used to produce electricity in a hydroelectric power station. Either a dam is built across a river valley to produce a reservoir, or water is taken from fast-flowing streams or is piped

down from high lakes. The water is used to turn turbines, which then rotate the generators that produce electricity.

- 3) As well as using water to help our crop plants and domestic animals to grow, we use water to clean our food. We may also use water to boil or steam the food to make it tender. Some foods, such as soups, are largely water as are all of the drinks we consume.

Water and industry: Try it out, p 63

- 2) Paper is made from tiny fibres from plants. You can see the fibres at the edge of a torn piece of newspaper. About 95 per cent of all the fibres used for paper-making come from soft woods such as pine that are especially grown for paper-making. The fibres are extracted by grinding the wood or by breaking it up with chemicals which are dissolved in water. Paper is made in two stages. The first stage is to get the fibres from wood and other sources and mix them with water to make a soup-like mixture, called pulp. The second stage is to spread out the pulp, roll and dry it. This makes the fibres stick together in thin sheets. Some paper is made by hand, but most is made by machines at factories called paper mills. It takes nine litres of water to make a single comic.

Clean water supplies: Rapid fire, p 65

- 1) Open answers.
- 2) The mountainous north of Pakistan has summer monsoon rains, while the east and south are arid (very dry). Balochistan is the driest region with an average annual rainfall of 210 mm. Islamabad has an average annual rainfall of 961 mm, and Karachi 198 mm.
- 3) There are several problems in attempting to tow icebergs from the polar regions to areas with a water shortage: many icebergs are enormous and huge tugs would be needed, making the transport expensive. Because of the slow speed of the tow, a lot of the ice would melt on the way. Many of the places which are suffering from drought are inland far from the sea. It would, therefore, be difficult and expensive to transport the water inland.

Clean water supplies: Try it out, p 65

- 2) Any material that successfully filtered dirty water would either have to be very thick (like the beds of sand and gravel used at the waterworks) or have very tiny pores like those in filter paper.

Ice, water and water vapour: Rapid fire, p 67

- 1) a) As the temperature of water approaches 100°C, it bubbles vigorously and water vapour rises to the surface and evaporates into the air.
b) When water vapour is cooled it turns back into liquid water.
c) Sea water contains large quantities of dissolved minerals, particularly salt, whereas fresh water contains much smaller quantities of dissolved minerals.
d) About 70 per cent of the human body is made up of water. Water is the major component of blood and there is water in your brain, heart, lungs, kidneys, liver, skin and other organs of the body. The digestive juices are largely water and we need to take in at least one and a half litres of clean water every day to make up for the water we lose in sweating, in our breath, and in our urine and faeces.
e) Water makes up such a large proportion of the body because it is the major component of our blood, digestive juices and all the organs of the body. All of the chemical reactions which take place in the body occur in water.
- 2) Two ways to speed up the process of evaporation are to raise the temperature and to allow air or wind to blow over the wet surface, or both of these things together. A large surface area of water also evaporates faster than the same volume of water with a small surface area.

CHANGING STATE

Ice, water and water vapour: Try it out, p 67

- 1) The easiest way to measure how much water evaporates from a puddle each hour would be to draw a chalk line around the puddle every hour and see how much smaller the puddle is each time.
- 2) The best weather for drying washing is warm or hot, windy weather.

The water cycle: Rapid fire, p 69

- 1) a) Pure water freezes at 0°C and boils at 100°C.
b) Ice changing to water is an example of melting.
c) The heat from the Sun makes water evaporate from the oceans and seas.
d) If steam is cooled, it condenses and turns into liquid water.
e) When water evaporates it turns into water vapour.
f) Clouds are made up of tiny water droplets. Mist and fog, which are really clouds down at ground level, are also made of tiny water droplets.
- 2) The sea water would need to be filtered to separate the insoluble sand from the water. The sea water would then have to be boiled, so that the water evaporated leaving the salt behind.
- 3) Open answers.

The water cycle: Try it out, p 69

- 1) The water would slowly evaporate from the open jar, eventually leaving the salt behind. In the closed jar, the water would not be able to evaporate completely, but the water vapour would condense on the cooler parts of the jar, forming a layer of condensation which would make it difficult to see into the jar.

Irrigation: Rapid fire, p 71

- 1) Irrigation is an artificial way of bringing water from lakes, rivers, streams reservoirs and wells to the land using channels or sprinklers. Irrigation makes crops grow a lot quicker and a lot bigger than they otherwise would do in places where water is scarce and the land is dry. Irrigation is often expensive, and the irrigation water may evaporate from the surface of the soil, leaving a layer of salt in which plants will not grow. Irrigation also lowers the levels of water in lakes, rivers, streams and wells and uses water that people might otherwise need for drinking, washing and cooking. When too much water was taken from the Aral Sea for irrigation, the sea began to dry up and the climate was changed for the worse, with hotter summers, colder winters and less rain.
- 2) One way in which desert countries near the sea could obtain drinking water and water for crops, would be to evaporate sea water and condense the water vapour to form pure water. This is done in a few places but it is expensive and the only countries that can afford to do it are those with large deposits of oil on their territories with which they can heat the sea water. There are more than 7500 desalination plants worldwide, with 60 per cent of them in the Middle East. The world's largest desalination plant is in Saudi Arabia.
- 3) Farmers living near the River Nile in Egypt were pleased when the river used to flood because not only did it irrigate the soil but, more importantly, it covered the soil with a layer of fertile mud in which crops grew much better.

Irrigation: Try it out, p 71

- 1) The crops in Pakistan which are irrigated include wheat, rice, maize, millet, sugar cane, gram, cotton, mangoes, citrus fruits, and oilseeds such as castor, groundnut, sesame and linseed.
- 2) The rice crops which need large quantities of water are those grown in paddy fields, where the field is flooded and then the young rice plants are planted out in the shallow standing water.
- 4) It is not possible to predict the exact results of this experiment, because it all depends upon the

temperature. The seeds in the pot with no water will not grow, while if the weather is not too hot and dry, the seeds in the pot which is watered once a week will grow well. The pot watered daily may well fail to thrive because it becomes waterlogged. If the weather is hot and dry, then daily watering may be necessary and the seeds watered only once a week may not receive sufficient water and will die.

Polluted water: Rapid fire, p 73

- 1) Acid rain forms because of polluting acid gases emitted when power stations and factories burn fuels such as coal and oil to produce energy. The fumes that pollute the air include sulphur and nitrogen oxides. These combine with oxygen and moisture in the air to form sulphuric and nitric acids. When it rains, or hails or snows, the precipitation is acidic. Acid rain falls into lakes and rivers, and can make them too acidic to support plant and animal life. Acid rain also kills trees and eats away the stonework of buildings, statues and monuments.
- 2) Open answers.
- 3) Chemicals such as pesticides in water can be absorbed by plants. These are then eaten by herbivores, which in turn are eaten by carnivores, which may be eaten by other larger carnivores or by people. At each stage of the food chain the amount of chemical poison increases and eventually the living organism at the end of the food chain may have so much of the poison in its body that it dies or is unable to breed.

Polluted water: Try it out, p 73

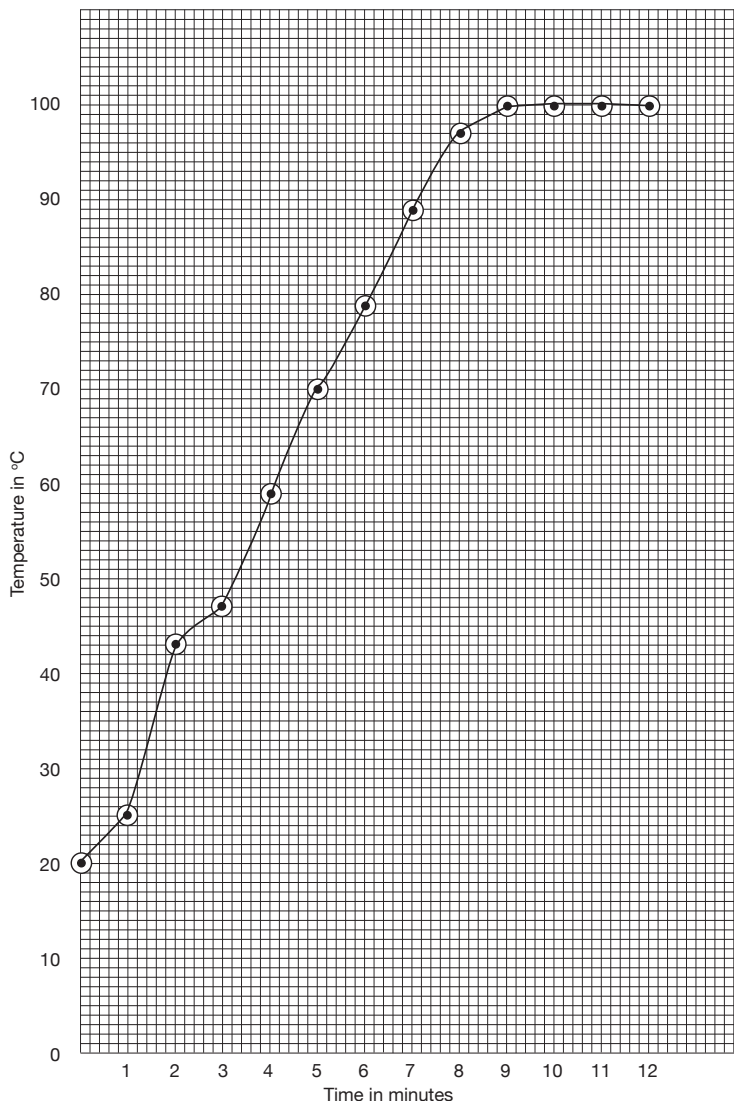
- 3) One way of collecting the rainfall that falls on the school playground is to stand a square container with straight sides and known area on the playground. Measure the volume of the rain that collects in the container over a given period, say 24 hours. If the volume of rain which fell in the container is multiplied by the area of the playground, you will have an estimate of the total volume of rain which fell on the whole playground.

Assessment: p 74-75

- 1) a) The puddle would be intermediate in size between those at 9.30 a.m. and 10.30 a.m.
b) The water evaporated from the puddle into the air as the invisible gas, water vapour.
- 2) The correct stages of the water cycle are: f), e), c), b), a) and then d).
- 3) a) rises; b) rises; c) rises, falls; d) falls, e) rises.
- 4) a) Evaporation;
b) Because salt is soluble (or in solution) and a filter does not separate soluble substances.
- 5) a) Nearly three-quarters.
b) Sea water contains large quantities of dissolved minerals, including common salt, whereas fresh water contains far fewer dissolved minerals and hardly any salt.
c) Roughly 70 per cent of your body is made up of water.
d) About 1.5 litres.
e) To replace the water we lose when we breathe out, sweat and go to the toilet.
f) Hydroelectric power stations use the power of running water to turn the machines that produce electricity. Power stations which burn coal, oil or natural gas turn water into steam to drive their generators, and they also use water for cooling.
- g) The sea may be polluted indirectly by chemicals, sewage, rubbish and other pollutants carried into it by rivers. It may be polluted directly by chemicals and sewage passed into it from factories on land or by the accidental or deliberate dumping of oil and rubbish from ships at sea.
- h) Acid rain forms because of polluting acid gases emitted when power stations and factories burn fuels such as coal and oil to produce energy. The fumes that pollute the air include sulphur and nitrogen oxides. These combine with oxygen and moisture in the air to form sulphuric and nitric acids. When it rains or hails or snows, the precipitation is acidic.

CHANGING STATE

- 6) a) 9 minutes.
b)



Going further

Invite the students to investigate the ways in which water is used in their homes. They could keep a 'Water Use' diary of a typical week. Research the amount of water that is used in everyday tasks so that the students can quantify their results. For example, it takes around 9 litres of water to flush a toilet and up to 160 litres to fill a bath, while a shower takes approximately 5 litres per minute.

What uses of water do the students think are essential (e.g. drinking and washing) and which do they think are optional (e.g. washing a car)? The students could perhaps extend their learning by devising a poster to encourage people to save water wherever possible.

Challenge the students to find out about water's journey—from when it falls as rain into the reservoir or river to when it flows out of the tap. Let them write a story describing the journey made by one raindrop from clouds to the sea, and back again.

Make a list of occasions when things need to be dried. For example, drying washing, dishes or hair. What types of equipment have been developed to speed up the process? Produce drawings and diagrams to show how they work.

Place some wet items of clothing on a washing line and another set crumpled in a pile. Observe and record how quickly the two sets of clothing dry. Which was quickest? (The clothes that were hung on a washing line, since they had the greatest area exposed to the Sun and wind.) How can you ensure that this is a fair test? (Make sure that the clothes are the same size, made of the same material and kept outside near to the washing line so that they are at the same temperature.)

Sometimes when you open the door of a refrigerator on a warm day, you see swirling clouds of water droplets. If you leave a glass of drink with ice cubes in it on a warm day, the outside of the glass soon becomes wet. In both cases explain in your own words what has happened.

Put equal amounts of water in two identical jars. Mark how far the water comes up the side of each jar with sticky labels. Put one jar in a warm place, such as near a radiator. Put the other in a cold place, such as in a refrigerator. Look at the jars each day. How quickly does the water evaporate from each jar? Investigate the rate of evaporation with the same volume of water in different shaped containers all placed near to each other.

Fill a small plastic tub to the top with water. Put on the lid, carefully. Stand the tub in a freezer overnight. Examine the tub the next day. What do you notice? (When the water in the tub freezes, it expands, pushing off the lid and possibly breaking the sides of the tub.)

Which will melt first—plain crushed ice or crushed ice which has had salt sprinkled on it? (the latter!) Plan an investigation to find out. How will you make your investigation fair?

Put one or two ice cubes in a saucer on warm window sill. Leave them to melt completely. Show the students the ice, melting ice, and water. Leave the water to evaporate. Talk to the students about the cycle of changes and the eventual evaporation of the water.

Find a clear container, such as a glass pudding basin or a plastic lunch box. As a class demonstration, put some hot water in the bottom and cover the top loosely with one layer of a plastic bag or cling film. Hold the covering in place with an elastic band or a strip of sticky tape. Place one or two ice cubes in the middle of the cover so that they are on the plastic but over the hot water. After a few minutes, show the class the underside of the plastic or cling film. Point out that the plastic or cling film has been cooled by the ice, but the air underneath was hot and damp. What has the coldness done? (The cold plastic or cling film has caused the water vapour underneath it to condense and form droplets of water on the underside of the plastic or cling film.)

What are the ideal conditions for drying clothes? Use wet paper towel 'clothes', an electric fire to represent the 'Sun' and an electric fan to represent the 'wind' (Safety!) (It is usually found that the best drying conditions are when the Sun shines and the wind is blowing.)

Tie a weight to one end of a long stick and a wet cloth at the other end. Hang the stick from a doorway or open window frame. Make sure that the stick hangs horizontally by sliding the string until the weight and the wet cloth exactly balance. Explain what happens as the cloth dries. (As water evaporates from the cloth into the air, the cloth loses weight and the stick tilts down on the side where the weight is suspended.)

Place a leafy stem in a small bottle of water. Carefully cover the surface of the water with olive oil or some other vegetable oil to prevent the water evaporating. Put the bottle and piece of plant in a sunny place, under a clear-plastic or glass jar. Where does the 'mist' which forms on the insides of the jar come from? (It is water which the leafy stem has taken up from the bottle and which has then evaporated from the leaves.)

Collect photographs, labelled pictures and diagrams of the components of the water cycle. Cut them into the different stages and ask the students to put them into the correct sequence. Discuss what happens at each stage.

Choose a local river and create an information book about it.

Consider examples of water pollution in the area. What forms does it take? Who is responsible for it? How does it affect people, water, animals and plants? What can be done to improve the situation?

Investigate the amount of rain that falls in your area. How do your own rainfall measurements compare with the official average monthly rainfall figures for your area?

1. What happens to the water inside a plant?

How does water get into the leaves of plants?

What you need:

- pencil
- stick of celery or white daisy-type flower
- clear-plastic jar
- food colouring
- knife
- hand lens

What you do:

Half fill the jar with water.

Add ten drops of food colouring. Be careful not to spill it, or it will stain your clothes.

Wash the celery in cold water to remove any dirt.

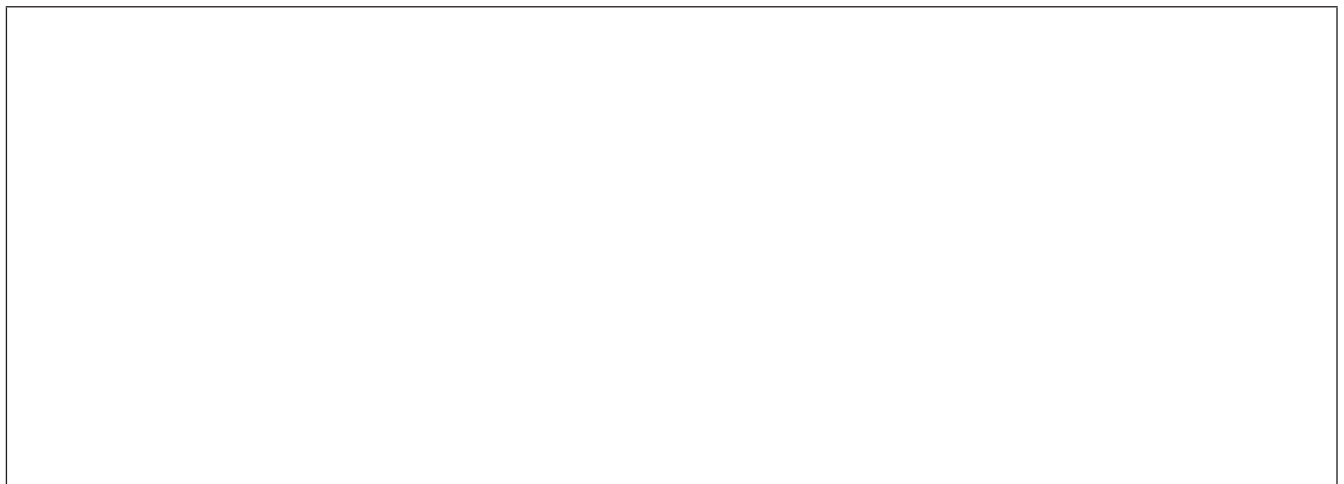
Place the celery or the flower in the coloured water.

Every 30 minutes measure how far the food colouring has travelled up the plant.

Record your results in this table:

Time	Height of food colouring

When the food colouring has reached the top of the celery or flower, cut through parts of the plant. Draw pictures of what you see.



2. Moving water

What you need:

- pencil

What you do:

Visit four places around your school where there is water that is moving.

Record what you saw on the chart below. Say where the water was coming from, what was making the water flow, and where it was going to.

Make a labelled drawing of the water flowing at each of the four places.

Place _____ Where the water comes from _____ What makes the water flow _____ Where the water flows to _____	Drawing
Place _____ Where the water comes from _____ What makes the water flow _____ Where the water flows to _____	Drawing
Place _____ Where the water comes from _____ What makes the water flow _____ Where the water flows to _____	Drawing
Place _____ Where the water comes from _____ What makes the water flow _____ Where the water flows to _____	Drawing

3. Investigating condensation

What you need:

- pencil
- three clear plastic beakers, all the same size
- ice cubes
- use of a refrigerator and freezer
- watch or clock

What you do:

Put the same number of ice cubes in each beaker.

Leave one beaker in the classroom.

Put one in the refrigerator.

Put the third one in the freezer.

Leave the beakers for 15 minutes.

What do you see happening to the ice in the beaker in the classroom?.

What do you feel if you touch this beaker?

What can you see and feel with the beaker in the refrigerator?

What can you see and feel with the beaker in the freezer?

Where did the condensation on your beakers come from?

How could you stop this condensation forming?

4. A model of the water cycle

Make a model of the water cycle.

What you need:

- pencil
- small jar
- elastic band
- small pebble or marble
- soil or food colouring
- large, clear-plastic jar
- cling film or clear plastic sheeting
- jug of water

What you do:

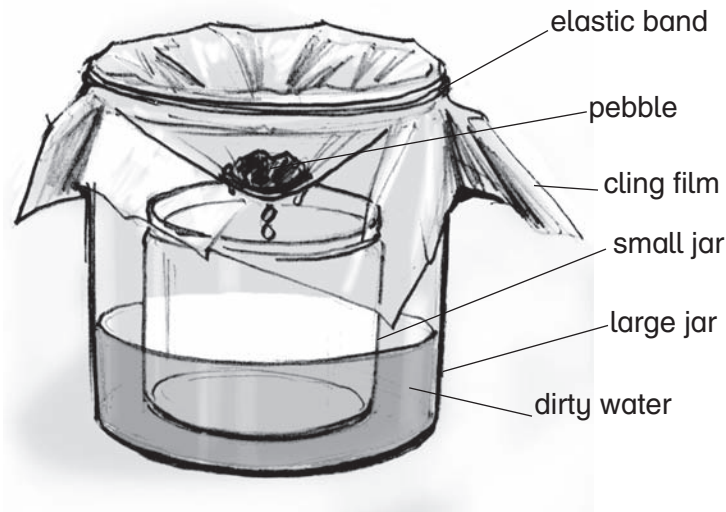
Shake up a little soil or food colouring with water in a jug.

Stand a small jar in the centre of a large clear-plastic jar.

Carefully, without splashing, pour some of the dirty water into the large jar to a depth of a few centimetres.

Cover the large jar with cling film or clear plastic sheeting. Press the centre of the cling film or plastic down so that it forms a cone shape. If need be, put a small pebble or a marble in the bottom of the cone to hold it down.

Fasten the cling film or plastic in place with an elastic band.



Stand the large jar in the Sun. Look at it carefully over the next day or so.

What has happened? Explain what you see, using these words in your explanation:

heat; Sun; evaporates; condenses; water droplets

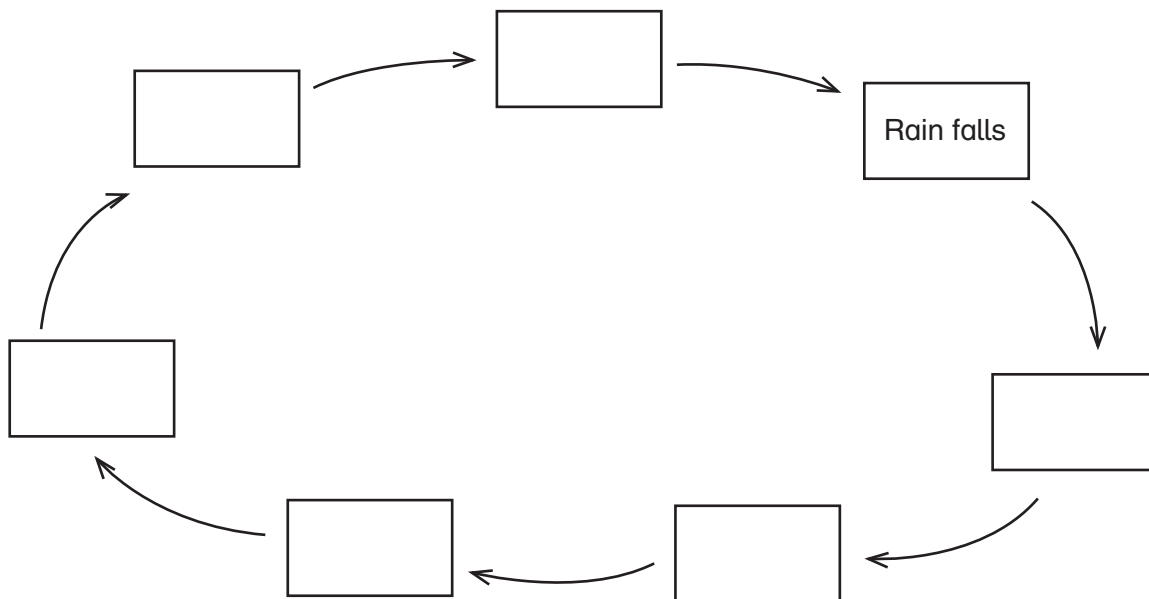
5. The water cycle

What you need:

- pencil

What you do:

The diagram shows the stages in the water cycle.



Write the letters of the sentences in the boxes in the correct order.

A Water flows into the sea.

B Water drains through the ground.

C Clouds form

D Water flows into a river

E Water vapour evaporates into the air.

F Condensation occurs and tiny droplets of water form.

a) Whereabouts in the cycle is the air warmest?

b) Whereabouts in the cycle is the air coolest?

c) What drives the water cycle?

6. How polluted is your local river or stream?

The kinds of animals living in a river or stream can show us how polluted the water is.

What you need:

- pencil
- net
- collecting pots and white dishes
- hand lens

What you do:










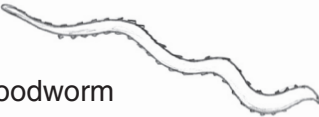

Carefully use a net to collect some of the small animals living in your river or stream. Place them in a shallow white dish containing some water. Return the animals to the river or stream as soon as you have examined them.

In a clean river or stream you may find all or many of the animals in Group A below.

If you find mainly animals from Group B, then the water has some pollution in it.

If you find only animals from Group C, then the water is quite badly polluted.

If you find no animals at all, then the water is very polluted and there is probably little or no oxygen in the water.

Group A – Clean water	Group B – Some pollution	Group C – A lot of pollution
 mayfly nymph  freshwater shrimp  stonefly nymph  water louse  caddis fly larva in its case	 freshwater shrimp  water louse  caddis fly larva in its case	 rat-tailed maggot  bloodworm  sludge worm or no living things at all

How polluted is your river or stream? _____

Where does the pollution come from? _____

ONLY carry out this activity when a responsible adult is present. Wash you hands thoroughly after touching river or stream water or the animals living in it.

Notes on individual worksheets

1. What happens to the water inside a plant?

Key idea To show how water rises up the stem of a plant.

Outcome The water will slowly rise up the stem of the celery plant or flower, as shown by the movement of the food colouring. If a white daisy-type flower is used, it will eventually be coloured by the food colouring.

Extension Use this experiment to turn other white or yellow flowers different colours.

2. Moving water

Key idea To examine some of the ways in which water can be moved from place to place.

Extension Discuss what life was like in the days when people did not have ready access to clean water.

3. Investigating condensation

Key idea To investigate the conditions under which water vapour condenses.

Outcome The outside of the beaker left in the classroom will feel cold and it will be covered in water droplets formed when water vapour from the air condensed on the cold surface of the beaker.

The outside of the beaker kept in the refrigerator will have much less condensation on the outside, although it will still feel cold to the touch.

The outside of the beaker kept in the freezer will have little or no condensation, unless the freezer door has been opened allowing in warm, moist air. Any condensation that does form will quickly freeze.

To stop condensation forming, you would need to equalize the temperatures between the contents of the beaker and the outside air, as has happened in the freezer.

Extension Investigate why a narrow strip of ice melts, and then later refreezes, when an ice skater passes over it. What benefit does this melting ice have to the skater?

Safety The students should not handle ice cubes that have come straight from a freezer.

4. A model of the water cycle

Key idea To give the students practical experience of evaporation and condensation in relation to the water cycle.

Outcome Water evaporates from the large jar as water vapour. This condenses on the cooler surface of the plastic or cling film and droplets of pure water fall into the smaller jar.

Extension Use this model to obtain fresh water from salt water.

5. The water cycle

Key idea An assessment item to examine the correct sequence of the stages of the water cycle.

Outcome The correct sequence is: B, D, A, E, F and C.

a) The air is warmest in the water cycle at ground level or immediately above the surface of the sea.

b) The air is coldest high up where the clouds form.

Extension Collect pictures of the different types of clouds and find out what kinds of weather result from them.

6. How polluted is your local river or stream?

Key idea To enable the students to investigate practically the level of pollution of the local river or stream.

Extension Investigate how the water of the local river or stream is used by people, e.g. angling, irrigation, industrial cooling, etc.

Safety The students should be warned of the dangers of water and of the need for strict hygiene precautions. Return the animals to the river as soon as possible after they have been identified.

Lesson objectives

- To show that plants and animals, including humans, reproduce as part of their life cycles, and that in every life cycle there are distinct processes and stages
- To show how reproduction is vital to the survival of the species and that when reproduction fails to equal or exceed mortality, then extinction results
- To investigate, in detail, the reproductive cycle of flowering plants, including pollination, fertilization, seed dispersal and germination
- To show the main stages in the human life cycle and the importance of the adult care of babies and children

Background information

Flowers

All living things reproduce, and flowers are the reproductive structures of a flowering plant. Each flower contains sexual organs which produce male or female sex cells. The male cell is in the pollen grain and the female cell (the ovule or egg cell) is in the ovary. After fertilization, the female sex cell forms the seed and the ovary forms the fruit.

Petals are usually brightly coloured, sometimes scented, structures. They are often arranged in a circle (buttercup) or a cylinder (tulip). Sometimes, as in the foxglove or dead-nettle, the petals are joined to form a tube, so that the individual petals cannot be seen. The colour and scent of the petals attract insects to the flower for pollination. Some flowers, including those of the buttercup, have a nectary at the base of each petal that produces sugary nectar. Petals of this type attract insects which come to drink the nectar. As the insects do this, they transfer pollen from flower to flower, thus cross-pollinating the ovules.

Outside the petals is a ring of sepals which are often green and much smaller than the petals. However, in tulips and some other flowers the sepals are coloured and indistinguishable from the petals. The sepals protect the flower when it is in the bud.

The stamens are the male reproductive organs. Flowers such as the buttercup and wild rose have many stamens, while others such as the tulip and daffodil have few. When they are ripe, the anthers on top of each stamen split open and release their pollen.

Carpels are the female reproductive organs and they are found at the centre of the flower. Buttercups have very simple carpels. Each has a hollow base, the ovary, which contains a single ovule. The ovule eventually becomes a seed and the ovary protecting it becomes a fruit. Above the ovary there is a narrow style, which ends in a stigma. Pollen grains stick to the stigma during pollination. Buttercups have several separate carpels, but in many flowers the carpels are fused together.

Pollination and fertilization

The process of transferring pollen from the stamens to the carpels is called pollination. The anthers split open exposing the minute pollen grains. These are then carried away on the bodies of insects or simply blown by the wind, when they may reach the stigma of another flower. In self-pollinating flowers, the pollen that reaches the stigma comes from the same flower. In cross-pollination, the pollen is carried from the stamens of one flower to the stigma of another of the same species. Flowers pollinated by insects, such as buttercups, peas, roses, dandelions, dead-nettles, and many more, usually have brightly coloured petals and produce nectar and scent to attract the insects. In flowers pollinated by the wind, such as grasses and the catkins of hazel, willow, and oak, the flowers are green, without petals, and no nectar is produced.

Fertilization occurs after pollination. The pollen grain produces a minute tube which grows down into the

ovule, where its tip bursts open, allowing the nucleus of the pollen grain to fuse with the nucleus of the ovule or egg cell, a fusion comparable to that between sperm and egg in humans and other animals.

After fertilization, rapid cell division takes place in the ovule and a miniature plant, the embryo, is formed. Food is transferred from the plant to the ovule and stored in structures called cotyledons or seed leaves. The outer wall of the ovule becomes thicker and harder, forming the seed coat or testa. As the seeds grow, the ovary also becomes much larger, the petals and stamens wither and fall off the flower, and the ovary is now called a fruit.

Dispersal of fruits and seeds

When flowering is over and the seeds are mature, the whole fruit or the individual seeds fall from the parent plant to the ground, where germination may take place. In many plants, the fruits or seeds are adapted in such a way that they are carried considerable distances from the parent plant. This helps to reduce the competition for light and water between members of the same species. It may also result in new areas being colonized by the plant.

The principal adaptations of fruits and seeds are those which favour dispersal by wind (e.g. pine, sycamore, elm, ash, dandelion, and thistle), or by animals (e.g. blackberries, elderberries, rose hips, hawthorn haws, acorns, nuts, and the hooked fruits of goosegrass, agrimony, herb bennet, and burdock). In addition, some plants have explosive pods or carpels that scatter the seeds (e.g. gorse, broom, peas, and violets), and others (e.g. water lilies) have fruits that are adapted for dispersal by water.

Germination of seeds

Flowering plants are divided into two groups depending on the form of the seeds. The seed of each species has either one or two seed leaves or cotyledons. If the seed has one cotyledon, the plant is called a monocotyledon. If the seed has two cotyledons, then the plant is a dicotyledon. The cotyledons help to feed the embryo plant while it is inside the seed and during the early stages of germination. The seeds of many monocotyledons, including grasses, onions, and cereal grains are quite small and the cotyledon is difficult to see until the seed has germinated. In the dicotyledons, such as peas, beans, acorns, marrows, and horse chestnuts or conkers, the cotyledons are relatively large and easy to see, particularly if the seed is first soaked in cold water for a few hours.

Conditions for germination

A number of conditions must be met for a seed to germinate.

Seeds need a supply of water to start them germinating and to continue their growth as seedlings and mature plants.

Most seeds require oxygen, from the air, for germination. The oxygen enables the seeds to respire, so that they have plenty of energy for germination and growth. The oxygen normally comes from the air spaces in the surface layers of the soil. If the soil is waterlogged or heavily compacted, the lack of oxygen may prevent germination from taking place.

Germination is slowed down or even stopped by low and high temperatures. The actual range of temperatures varies from species to species, but usually seeds will not germinate when the temperature is below about 5°C or above 45-50°C.

The effect of light is very variable. Most seeds will germinate in either the light or the dark. A few require light. The amount of light needed may be very small—sometimes a quick flash of light will suffice. Once the shoot is above the ground, light is needed for the seedling to make chlorophyll and to start photosynthesizing.

Stages of germination

The young root, or radicle, is always the first part of the seedling to begin growth. It responds positively to gravity and negatively to light, so that it grows down into the soil. The shoot, which emerges a few days later, responds negatively to gravity and positively to light, so that it grows upwards, whichever way up the seed has been planted. Once the seedling has used up the food stores in the cotyledons and elsewhere inside the seed, it starts to make food in its leaves. For this it needs energy from sunlight, carbon dioxide from the air, and water and mineral salts from the soil. In some seeds, such as those of the sunflower and onion, the cotyledons do not stay below ground but grow up above the surface. When they reach light they turn green and start to photosynthesize.

Growth, reproduction and life cycles

Living things change during the course of their lifetime. They grow larger, mature, produce offspring, and eventually die. Some individuals may die as a result of accidents, disease, starvation, cold, heat, lack of water, or the actions of predators. But as long as other individuals of the same species have reproduced themselves, the species continues its existence. If a species fails to reproduce itself sufficiently to maintain or increase its numbers, then the species will decline in numbers, and may eventually become extinct.

The life cycle of most animals begins with an egg from the female which has been fertilized by a sperm from the male; that of most plants begins with a seed, which also results from sexual reproduction. (Some plants, however, are able to reproduce themselves vegetatively or asexually. They produce identical copies of themselves, missing out the seed stage.) In many animals the egg grows directly into a smaller version of the adult animal. In others, the egg may hatch into an intermediate stage, often called a larva or nymph, whose prime function is to feed and grow. The tadpole that hatches from a frog's egg, the maggot that emerges from the egg of a fly, and the caterpillar that wriggles from a butterfly egg are all examples of larvae. There may be other stages before the adult or mature animal is formed. The main characteristic of the mature animal, or plant, is that it is able to reproduce itself. Reproduction often means the end of the life span of the animal or plant for, having reproduced themselves, many animals and plants die.

The life cycles of many plants and animals are synchronized to the seasons of the parts of the world where they live. In temperate regions of the world, many plants and animals complete their life cycles during the warmer, longer days of spring and summer, when there are ideal growing conditions and an abundance of food is available. In the wetter parts of the tropics, reproduction can occur all the year round because of the greater availability of food.

Parental care

There is often a connection between the amount of parental care and the number of eggs or young produced. Where there is little or no parental care, as in most invertebrates, fish, and amphibians, there is usually a large number of eggs. Because the parents do not protect the eggs or young, or bring them food, many of the offspring die. The large number of eggs, however, ensures that some offspring will survive to maturity. The parental care shown by birds and mammals, and most notably by our own species, gives the offspring a much better chance of survival and as a result they have smaller numbers of young.

Safety

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

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.

When discussing the students' rate of development and family tree, be sensitive to the range of possible family groupings.

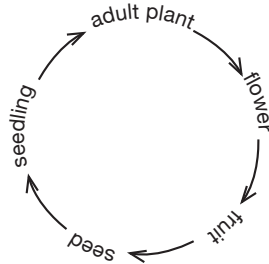
Use soils free from glass, nails and other sharp objects, and collect soil samples from places that are unlikely to be contaminated with dog or cat faeces. Wash hands after handling soils.

Wash hands after handling animals and plants.

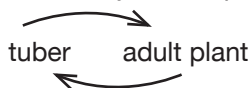
Answers

Reproduction: **Rapid fire, p 77**

- 1) If plants and animals did not reproduce, life on Earth would come to a halt. Reproduction allows plants and animals to replace themselves and increase their numbers. If they did not reproduce, their species would eventually become extinct. Reproduction also allows species to change, or evolve, over time.
- 2) a) The correct stages in the life cycle of a pea plant are:



- b) The adult plant bears flowers and these are pollinated either by insects or by the wind. A fruit develops in place of the flower and the fertilized egg cells grow into seeds (peas) inside the fruit (the pea pod). The seeds are dispersed when the pea pod dries unevenly and bursts open, shooting the seeds out. If the pea seeds encounter the right conditions of warmth and moisture, they will start to germinate and grow into seedlings.
- 3) The life cycle of a potato plant when grown from tubers would have only two stages:



Reproduction: **Try it out, p 77**

- 3) The gestation period of the animals is:

human	9 months (or 40 weeks)
mouse	21 days
blue whale	1 year
elephant	2 years
sheep	145 to 153 days

Not enough copies: **Rapid fire, p 79**

- 1) Open answers.
- 2) Frogs are becoming rarer because the ponds and marshes where they live are being drained to make more farmland or else the water is becoming polluted. The insects and other invertebrates frogs feed on are becoming scarce because farmers use a lot of pesticides.

- 3) Answers might include that the dolphin is a beautiful animal, we have no right to allow a species to become extinct, and we do not know when the Indus dolphin, or its genes, might prove useful to human beings. In addition, if the dolphin, as a top carnivore is allowed to become extinct, a whole food chain or food web of other species could collapse or become unbalanced.

Not enough copies: Try it out, p 79

- 2) Many scientists believe that 66 million years ago, a giant meteorite struck the Earth. After the impact, dust and ash filled the air for months, blocking out the Sun. The plants died out and so did the herbivorous dinosaurs. With their food gone, the carnivorous dinosaurs also became extinct.

Plant reproduction: Rapid fire, p 81

- 1) Open answers.
- 3) One example of a mnemonic to help you remember plant names is Some People Sit Cross-legged (sepals, petals, stamens, carpels).

Plant reproduction: Try it out, p 81

- 1) Plants differ in the number of sepals, petals, stamens and carpels. This is an accurate way of telling one plant flowering species from another.

Pollination and fertilization in plants: Rapid fire, p 83.

- 1) An annual plant completes its life cycle of growing from seed, flowering and producing seeds of its own in one year or less. It then dies.
A biennial plant takes two years to grow from seed, flower and produce seeds before it dies. Usually it flowers and produces seeds in the second year.
A perennial plant grows, flowers and produces seeds each year for several years.
- 2) A bee might be attracted to a flower by the colour of the petals or by the scent it produces, or both. The bee might then sip at the nectar produced in the nectaries at the base of the flower or it might collect some of the pollen for food. Either way, some of the pollen will probably stick to the bee's body and may well be transferred to the stigma of another flower of the same kind.
- 3) Open answers.

Pollination and fertilization in plants: Try it out, p 83

- 1) The pollen grains of different plants differ in shape and markings. Plant experts can tell, by looking at a sample of pollen, which species of plant it came from.
- 2) Insect-pollinated flowers are usually brightly coloured and often produce scent and nectar. The pollen grains are often quite large and sticky. Wind-pollinated flowers are generally dull, green and inconspicuous. They often lack petals and do not produce scent or nectar. The stamens often have long filaments (stalks), so that the anthers can sway in the wind. The pollen is very small and light and blows easily.

Seed dispersal: Rapid fire, p 85

- 1) Seeds need to be scattered away from the parent plant to prevent competition between the parent plant and its offspring and to give the species chance to colonize new places. If the new seedlings grew too near the parent plant they might suffer from lack of light or of water or mineral salts from the soil.
- 2) The simplest seeds to investigate would be those of, say, a thistle or dandelion. A fan could be used to see how far the seeds would travel when they are wet and when they are dry.
- 3) The seeds of all wind-dispersed plants, including dandelions, thistles and pine trees, have a large surface area in relation to their weight. Often they have wings, as in the case of pine, or structures resembling parachutes, as in the case of dandelions and thistles. The seeds then make use of air

resistance to ensure that they float in the wind. Burdock fruits have hooks on them so that they cling to the fur or feathers of a passing animal, or the clothes of a person, and are later pulled off, hopefully in a suitable new place to grow.

How do seeds grow?: Rapid fire, p 87

1) A fruit is the part of a plant that contains the seeds.

A seed is a ripe, fertilized egg-cell that will grow into a new plant under suitable conditions.

When a seed starts to develop or grow it is said to germinate.

A cotyledon is one of the modified leaves that store food inside a seed.

An embryo is the tiny plant inside a seed before it has started to grow. In animals, an embryo is the earliest stage of growth of the fertilized egg-cell.

A shoot is the stem of a young plant that eventually bears leaves and flowers. It is also a new stem that grows out from the base of a leaf.

Root hairs are the tiny outgrowths from near the tip of a root which take up water and mineral salts from the soil.

- 2) In temperate parts of the world, seeds formed in autumn do not grow until spring because most seeds need a period of rest before they will grow. More important, seeds will not grow until they experience suitable conditions of temperature and moisture, and these occur in spring. In the same way, seeds formed in dry weather will not grow until there is rain because of the need for moisture as well as suitable temperatures.
- 3) For a seed to stay dormant for many years can be an advantage because it can wait until suitable conditions of temperature and moisture occur.

How do seeds grow?: Try it out, p 87

- 1) One method would be to set up four identical pots of soil or compost and sprinkle the same number of mung bean seeds over each. One pot could be watered and placed on a sunny window sill. The second pot could be placed next to the first, but not watered. The third pot could be watered and placed in a warm cupboard, while the fourth pot is watered and placed in a refrigerator. The seeds in the first pot are receiving light, water and a suitable temperature. The seeds in the second pot are receiving light, a suitable temperature but no water. The seeds in the third pot are receiving water, a suitable temperature and no light, while the fourth batch of seeds are receiving water but no light and a low temperature.
- 2) If seeds are planted too close together, they and the seedlings compete for light, water and mineral salts. Generally the seedlings grow tall and straggly and only the strongest survive.
- 3) Usually seeds grow best in a loam soil, (of the kind found in the topsoil of a well cared-for flower or vegetable garden). This kind of soil contains roughly equal parts of sand and clay and substantial amounts of humus. Sandy soils are well aerated but they are too well drained and lack mineral salts. Clay soils contain ample mineral salts but the soil particles are small and the soil is easily compacted so that it lacks air. In dry weather a clay soil becomes hard and cracked. A chalky soil is not good at holding moisture and it lacks essential mineral salts.

The human life cycle: Rapid fire, p 89

1) The stages of life are:

newborn baby → infancy → childhood → adolescence → young adulthood → middle age → old age.

2) The main difference between the baby and the adult in the pictures is the difference in proportions between the head and the rest of the body. In an adult, the head fits into the body about eight times, whereas in the baby the head fits into the body about four times. The arms and legs of the adult are also longer in relation to the size of the body.

The human life cycle: Try it out, p 89

2) Lifespan is the average length of life of a living thing. The average lifespan, in years, of these animals is:

human	65
horse	20-30
dog	12-15
cat	15
cow	20
rabbit	5-8
duck	10
goat	12

The average lifespan of humans in different parts of the world varies according to the diet, income and type of healthcare available.

Assessment: p 90-92

- 1) a) produce young b) die c) A male and a female d) no care e) extinct
- 2) a) sepal—E; petal—A; stamen—C; stigma B; ovary —D.
b) i) A; ii) E; iii) D; iv) C; v) B.
- 3) a) petal b) stamen c) pollination d) ovary e) carpel f) sepal g) style h) stigma
i) fertilization j) pollen
- 4) a) Tomatoes are eaten by animals and the pips (seeds) are either spat out or passed out, undigested, in the faeces, when they grow if the conditions are suitable.
Dandelion seeds have a fluffy 'parachute' which is blown along by the wind.
Acorns are buried by some birds and mammals for consumption during the winter. If the animal forgets where the acorn is buried it may later grow.
In hot, dry weather, pea pods dry unevenly, forcing out the seeds some distance from the parent plant. If the peas land on soil and the conditions are suitable, they may grow.
b) Tomatoes are fleshy and brightly coloured; dandelion seeds have a fluffy 'parachute'; acorns contain a large store of food which is attractive to animals; pea pods have a line of weakness along their length.
c) i) The seeds which would grow are those in Pot A, and Pot B.
ii) The seedlings in Pot B grew best.
iii) The seedlings in Pot B received light, warmth and moisture; the seedlings in Pot A received warmth and moisture, but no light and so they would be yellow and etiolated (straggly). The seeds in Pot C received warmth and light but no water and so would not germinate. The seeds in Pot D received water but low temperatures and no light. They would not germinate.
- 5) a) i) A life cycle is the changes through which a plant or animal passes in its development from a fertilized egg-cell to an adult.
ii) Extinction is when a plant or animal species no longer exists.
iii) Reproduction is the process by which living things produce copies of themselves, or offspring.
iv) The stages in the human life cycle are: adult → egg → baby → toddler → child → teenager → adult. (There are other, shorter versions of the life cycle, such as adult → egg → baby → child → adult.)
v) Human babies have a long period of dependency because there are many things they have to learn before they are able to fend for themselves in the modern world. They also need a great deal of care in the early days because they are unable to clean or feed themselves.
vi) The main stages in the life cycle of a frog are:
adult → egg → tadpole → young frog → adult

- vii) The main stages in the life cycle of a butterfly are:
adult → egg → caterpillar → pupa or chrysalis → adult
- viii) In general, those animals which do not look after their eggs or young produce large numbers of eggs and/or young.
- b) i) The five stages of human life are:
baby → toddler → child → teenager → adult
- ii) Normally the adult stage lasts longest, perhaps 40 years or more.

Going further

Get the students to list or collect photographs of all the different ways in which one plant, e.g. a potato or rice plant, can be processed and eaten.

Make a display or collage of pictures of all the products you can find that come from plants.

Make a collection of flowers that vary in form, size and colour. Give each student a flower and ask them to draw it in detail and colour it carefully. Then, using scissors and tweezers, they should carefully take their flower apart and attach the individual parts to a sheet of white paper. Ask them to label and describe the functions of each part.

Make a graph to show when wild flowers can be found. Obtain a large sheet of squared paper and draw in two thick lines as axes. Write in the months of the year along the vertical axis. As you see or read about a wild flower, write its name on the horizontal axis of the graph. Fill in the square or squares to show when it can be seen flowering.

Lay out a selection of flowers on a large table or stand each flower in a paper cup. Ask the students to decide which flower they would visit if they were a bee. How did they make their choice? Discuss scent, colour, size, markings and the shape of the flower. Show the students' choices as a bar chart. If possible, follow up the activity by observing bees in the school grounds or at home in a garden. Which flowers did the bees appear to prefer and how did these compare to the students' choices?

Find a thistle or dandelion seed head and blow on it in the wind. How far do the seeds travel? Now repeat this with another seed head which has been wetted before you blow on it. How far do the seeds travel now? Which is the best weather for a plant to disperse its seeds with the help of the wind?

Use a fresh peanut or soaked broad bean seed to examine the interior structure of a seed. It is easy to take apart and discover the beginnings of root and shoot and see the stored supply of food. Sow some of the seeds in pots of moist compost indoors and see how they grow. Remember, though that a few children suffer from a serious nut allergy, and so they should be warned not to eat the peanuts. At the same time, use this opportunity to warn against poisonous seeds which might be encountered locally during the summer and autumn.

Discover how the amount of light a plant receives affects its growth. Place the same type of plant in different areas, one with plenty of light, one with little light and one with no light. Let the students record their observations at regular intervals. It will be found that only the plant which receives plenty of light has dark green, healthy-looking leaves. The leaves of the plant which receives little light will be pale and its stems straggly, while the plant in darkness will have yellow or white leaves and straggly stems. It will eventually die, unless it is put back in full light.

Ask the students to create a family tree, putting in the birth dates of their brothers and sisters, parents and grandparents, looking at the ages and stages of growth represented by the family.

Choose an endangered plant or animal that is found in your country. Find out why it is threatened with extinction. Make a list of things that could be done to save your chosen species.

Draw four large circles and link them together with arrows. Draw one of the stages in the human life cycle in each of the circles. Make sure the stages are in the correct order. Label your drawings.

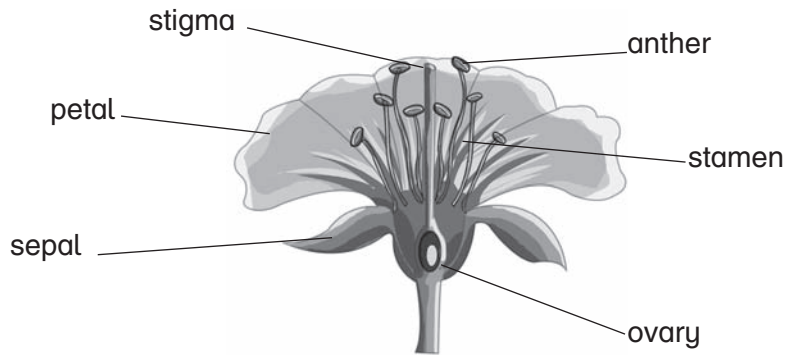
1. The parts of a flower

What you need:

- pencil
- hand lens
- a flower

What you do:

Look at this picture of the parts of a flower. Match the words with the sentences below.



- The female part of the plant is the _____.
- The male part of the plant is the _____.
- Pollen grains are made in the _____.
- Insects brush pollen grains on to the _____.
- The _____ attract insects and protect the male and female parts of the flower.
- The _____ protect the flower when it is in bud.

Now look at your flower carefully and identify the different parts.

Draw and label your flower here. Fill in this chart about your flower.

Name	
Where found	
Colour	
Height	
Number of petals	
Number of sepals	

2. A dandelion life cycle

What you need:

- pencil
- scissors
- glue or paste
- sheet of paper

What you do:

Cut out the pictures below.

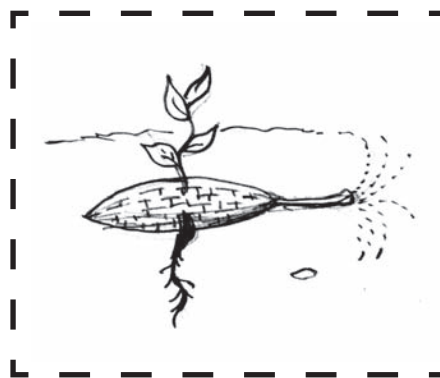
Arrange them in the correct order to show the life cycle of a dandelion plant.

Start with the tall dandelion plant.

Glue or paste your pictures on a sheet of paper in the correct order.



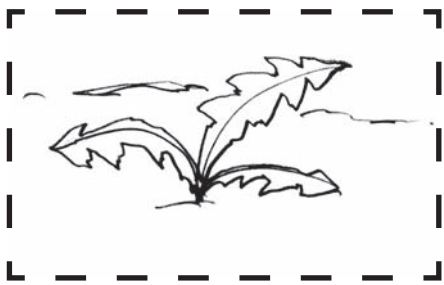
Dandelion seeds blowing in the wind



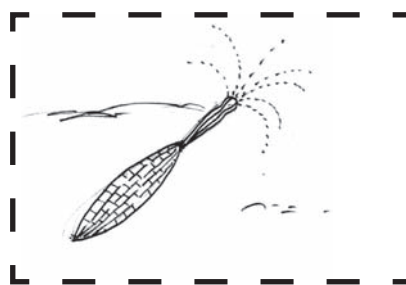
A seed growing a root and shoot



A tall dandelion plant with flowers



A small dandelion plant



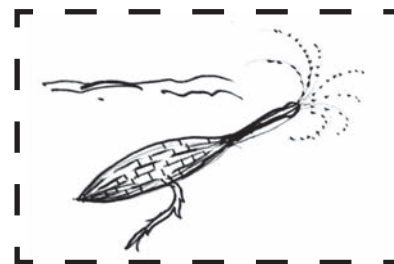
A dandelion seed landing on the soil



A bee visiting a dandelion flower



Seed head of a dandelion plant



A dandelion seed growing a root

What will the next stage in the life cycle be? _____

3. Seeds and germination

What you need:

- pencil
- labels
- use of a refrigerator
- seeds of cress, grass, mustard or wheat
- four small pots of soil or compost

What you do:

Set up the four pots of soil or compost.

Moisten the soil or compost in three of the pots.

Leave the other pot dry.

Sprinkle some seeds on the top of all four pots.

Put the dry pot and one of the moist pots on a sunny window sill.

Label these 'warmth, light and no water' and 'warmth, light and water'.

Put one pot in a dark cupboard.

Label this pot 'warmth, water and no light.'

Put the fourth pot in the refrigerator.

Label this pot 'cold, water but no light'.

Record each day how your seeds are growing.

Day	Warmth, light and no water	Warmth, light and water	Warmth, water and no light	Cold, water and no light

What conditions do these seeds need if they are going to germinate?

What conditions do these seedlings need if they are going to grow into healthy plants?

5. Animal life cycles

What you need:

- pencil
- reference books, CD-ROMs, the Internet

What you do:

Choose an animal. Use books, CD-ROMs and the Internet to find out about the life cycle of your chosen animal.

Animal name _____

Animal group (mammal, bird, reptile, amphibian, fish, insect, other _____)

In what countries does it live? _____

In what kind of habitat does it live? _____

How many eggs or young do the adults have? _____

Do the adults look after the eggs or young? (If yes, say how.)

At what time of the year are the young usually born? _____

Are the young born in a special place, such as a nest? Describe it.

How long does it take the young to become adults? _____

What do the young animals eat?

What do the adult animals eat?

Does the animal ever migrate or hibernate? (If yes, say how, when and where.)

How long does the animal usually live? _____

Did you find any other interesting information about this animal?

6. Developing babies

What you need:

- pencil

What you do:

How long does it take for these baby animals to be ready to be born?
Join each picture to the correct time.



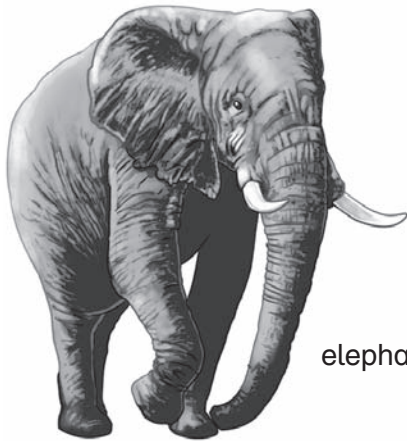
human

nine weeks

two years



golden hamster



elephant

sixteen days

nine months



dog

one year



mouse

blue whale



twenty-one days

7. Stages in human development

What you need:

- pencil
- scissors
- glue or paste
- sheet of paper

What you do:

Arrange the following stages of the human life cycle in the correct order.

Stages	Correct order
adulthood	
childhood	
the end of life	
puberty or adolescence	
babyhood	
old age	
middle age	
retirement	

Notes on individual worksheets

1. The parts of a flower

Key idea To identify the parts of a flower and their functions.

- Outcome*
- The female part of the plant is the ovary.
 - The male part of the plant is the stamen.
 - Pollen grains are made in the anther.
 - Insects brush pollen grains on to the stigma.
 - The petals attract insects and protect the male and female parts of the flower.
 - The sepals protect the flower when it is in bud.

Extension Make a chart showing the numbers of sepals, petals, stamens and carpels on as many flowers as you can find.

2. A dandelion life cycle

Key idea To determine the correct sequence in the life cycle of a dandelion plant.

Outcome In actual fact the life cycle of a dandelion plant can begin with any stage, since it is a cycle. If we begin with the mature plant then the sequence of the eight stages is:

A tall dandelion plant with flowers

A bee visiting a dandelion flower

Seed head of a dandelion plant

Dandelion seeds blowing in the wind

A dandelion seed landing on the soil

A dandelion seed growing a root

A seed growing a root and shoot

A small dandelion plant

The next stage in the life cycle will be the adult plant

Extension Collect some dandelion seeds and grow them in pots of moist soil or compost to actually see the stages in the life cycle of the dandelion plant.

3. Seeds and germination

Key idea To investigate the conditions necessary for seeds to germinate and grow into healthy young plants.

Outcome The seeds deprived of water and those kept at a low temperature in the refrigerator will not germinate. The seeds deprived of light will germinate but the seedlings will be yellow and straggly (a condition called 'etiolated'), and they will not grow into healthy plants unless they receive light. The seeds that receive warmth, light and water will germinate and produce healthy seedlings.

In order for seeds to germinate, then, they need water and a suitable temperature. If the seedlings are to grow into healthy plants, they also need light.

Extension Choose large seeds, such as broad beans and smaller seeds, such as radish or cress, and investigate what happens when they are planted at different depths in moist soil or compost. What is the best depth for each type of seed?

4. Studying roots

Key idea To study the germination and growth of the roots of a seedling.

Extension Repeat this experiment but place the seeds upside down and in other positions and see if the roots still grow downwards.

5. Animal life cycles

Key idea To investigate the life cycle of a chosen animal species.

Extension It might be a valuable exercise to carry out a similar study on a plant species.

6. Developing babies

Key idea To provide an indication of the wide variation in the lengths of the gestation period of some well-known mammals.

Outcome mouse–21 days; human–9 months; elephant–2 years; blue whale–one year; dog–9 weeks; golden hamster–16 days. (The latter is the shortest gestation period of any mammal.)

Extension Use reference books and the Internet to find the gestation periods of some other mammals.

7. Stages in human development

Key idea To test the students' understanding of the stages in the human life cycle.

Outcome The correct order of the stages is:

babyhood

childhood

puberty or adolescence

adulthood

middle age

retirement

old age

end of life

It may be necessary to explain the meaning of 'retirement' to the students.

Extension Use reference books and the Internet to find out the average length of life of some chosen animal species, including both birds and mammals.

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

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.

Acquired characteristics Characteristics, such as knowledge, skills and scars, that are acquired during a person's lifetime.

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.

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

Asteroid One of the many thousands of small, rocky planets that orbit the Sun.

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.

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 the battery react together.

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

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.

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

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

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.

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

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.

Cotyledon A leaf found inside a seed.

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

Decibel A measure of the loudness of sound, written as dB for short.

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.

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

Echo A sound that is heard again as it is bounced off, or reflected from, a hard surface.

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.

Evaporate To turn a liquid into a gas by heating it.

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.

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.

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.

Flower The reproductive part of a seed-bearing plant.

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

Freeze When a liquid changes to a solid because it is cooled.

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.

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.

Gene A small part of a chromosome which controls or causes the development of a characteristic of an organism.

Generator A machine for changing mechanical

energy into electrical energy.

Germination When a seed starts to develop or grow.

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

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

Irrigation A way of supplying water to the land by means of channels and sprinklers.

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

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

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.

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.

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.

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

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

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

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.

Nitrogen One of the gases in the air. Roughly three-quarters of the air is nitrogen.

Noise Unwanted or unpleasant sound.

Nutrients Substances which provide food for a living thing.

Orbit The path of a planet, satellite or moon as it moves around the Sun, the Earth or some other body in space.

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.

Petal A part of a flower. Flowers that are pollinated by insects often have brightly coloured petals.

Phase A gradual change throughout one month in the appearance of the illuminated part of the moon's surface.

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.

Pitch The highness or lowness of a sound.

Planet One of the eight large bodies in space that orbit around the Sun. Earth is a planet.

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.

Prediction Fortelling or prophesying; suggesting and outcome.

Protein One of the main bodybuilding materials in foods.

Puberty The age at which a human becomes able to reproduce.

Pulse The throbbing you can feel in your wrist or neck caused by your heart pumping blood around your body.

Reflect To bounce back. Heat, light and sound can be reflected.

Refraction The way in which a ray or wave is bent when it passes from one medium to another.

Reproduction The process by which living organisms produce offspring.

Reservoir A large natural or artificial lake used as a source of water supply.

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

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

Sepal A part of a flower. Sepals surround and protect the flower while it is in bud.

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 system The Sun, and the eight planets, including the Earth, that orbit the Sun.

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

Sound Anything that can be heard. Sound is a type of vibration.

Sound waves The way sound travels through air, solids or liquids.

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.

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.

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.

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

Universe Everything that exists, including the Sun,

Earth, planets, galaxies and other bodies in space.

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.

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

Vibrate To move rapidly backwards and forwards.

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

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

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.

Womb The part inside a mother where her baby grows.

Yeast A tiny fungus used to make bread, wine and beer.