Oxford Secondary Science 1

Teaching Guide

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Introduction

Aims and content of the course

Learning science is fundamental to understanding the world in which we all live and work. Science helps people to ask questions, test explanations through measurement or experimentation, and assists people to clarify their ideas. Science is important to everyone—young or old, male or female, city or rural dweller. It is science that has brought our world to where it is today. Science has created the comforts we enjoy and the problems with which we must deal. Used wisely, science can make the world a better place; science used unwisely can lead to global disaster. An added reason for learning science is that we need more scientists, technicians, and engineers to run the complex world of the future.

Science involves mental discipline. As with so many other things, people must be exposed to that mental discipline when they are young. If children do not learn to think in a scientific, systematic way, they grow up blindly accepting all they are told, confusing science and superstition, and depending on hasty judgement rather than considered opinion. We have to learn to recognise that science is not something done to us, for us, or at us, by experts. We must do it. Each individual should be scientifically literate enough to keep abreast of developments throughout their lives. We must also learn to use scientific skills to make intelligent decisions. Life in an advanced technological society is driven by scientific decision-making. Should we build more nuclear power plants? Which diseases should receive research funding? Is it safe to use genetically engineered crops to increase food supplies? What is global warming and how do we deal with it?

Children and teenagers want to know everything about everything. The ***Oxford Secondary Science*** series of books is designed to provide a straightforward approach to the teaching of science in the first three years of secondary education. It develops and extends the learning acquired in the primary school from the use of such courses as ***New Oxford Primary*** Science by Nicholas Horsburgh and ***Science Success*** and ***Simply Science***, both by Terry Jennings.

Oxford Secondary Science covers the requirements of the Pakistani National Curriculum for General Science at Grades VI, VII, and VIII. The course aims to meet the needs of teachers and students by developing and building on the core scientific themes studied in primary school in carefully graded stages, thereby providing a comprehensive introduction to science for students aged 11 to 14 years.

The course is designed to do four main things:

1. To give students a solid body of knowledge in the natural, physical, and Earth and space sciences
2. To develop and extend their knowledge of the nature of scientific enquiry
3. To enable students to explore values and attitudes through science
4. To encourage them to think about how we can use science for the best

These four elements are developed side by side through the books which make up the complete Course. It is hoped that both students and teachers will find ***Oxford Secondary Science*** an exciting and stimulating learning experience. ***Oxford Secondary 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.

The Course has been written specifically to help the teacher deliver science lessons in a stimulating and engaging way. Its flexibility allows the teacher to tailor the work to meet the known abilities and needs of the students, as well to make best use of what materials and resources are available. In addition, it allows the teacher to use his or her own strengths and to employ strategies that have proved effective in the past. To this end, it is hoped that the course will save the teacher time, money, and preparation.

Using this Teaching Guide

The Student's Books are intended to provide core material on the four broad themes of:

- life and living processes
- materials and their properties
- physical processes
- Earth and space science.

The themes chosen are based firmly on the student's own experience and cover areas affecting their everyday lives.

The overall objectives of the course are that the students should acquire:

A) Knowledge and understanding of science

i. knowledge of some facts and concepts concerning the environment
ii. knowledge of the use of appropriate instruments in scientific experiments
iii. an adequate scientific vocabulary
iv. an ability to communicate using this vocabulary
v. an understanding of some basic concepts in science so that they can be used in familiar situations
vi. an ability to select relevant knowledge and apply it to new situations
vii. an ability to analyse data and draw conclusion
viii. an ability to think and act creatively

The student should acquire:

B) Attitudes

ix. an awareness of the inter-relationship of the different scientific disciplines
x. an awareness of the relationship of science to other areas of the curriculum
xi. an awareness of the contribution of science to the economic and social life of the country
xii. an interest and enjoyment in science
xiii. an ability to become objective in observation and in assessing observations

The student should gain:

C) Practical skills

xiv. some simple science-based skills

xv. some experimental techniques involving several skills

The units within any one Students' 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 units. The teachers could acquire the materials for their particular unit and then, after the work is completed, they could exchange materials and ideas, and discuss any problems that arise.

Lesson planning

This Teaching Guide does not attempt to specify a rigid strategy for teaching the topics covered in the Students' Book. Schools vary greatly in the time and resources they have available for science work. Instead of detailed lesson plans, notes for possible lessons are included in each chapter. However, it is important to remember that these are just notes and observations which it is hoped will prove helpful in planning lessons and activities. No doubt you will want to develop lessons of your own, hopefully based on the materials in the Students' Book. Some of the suggested activities are spelt out in detail in the form of photocopiable worksheets. It is intended that these worksheets will extend students' knowledge and understanding of the topic, or prove useful when assessing students' basic skills in the laboratory. Some of the other suggested activities are short, fairly simple experiments, while others consist of more open-ended investigations which can be used to assess a student's ability to design scientific investigations and draw conclusions from the results. The use of these will depend upon the apparatus and equipment available and/or the particular characteristics of the teaching group. If equipment and materials are scarce, or if the students cannot be trusted to work without close supervision, then it may be necessary for the teacher to demonstrate some of the experiments rather than allow the students to work on them individually or in small groups.

Science practical work

Most teachers of science see practical work as an essential feature of their everyday teaching, believing that students learn better from doing than simply being told. However 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. Many teachers find that relatively short practical tasks, embedded in a lesson rather than taking up the entire lesson, are more effective in giving the teacher time to introduce students to, and fully discuss, new scientific terms and ideas. In this connection, the experimental 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.

Organisation

For practical activities, it may be necessary to divide the students 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 **Things to do** activities in the Students' Book.

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.

Things to do

Each chapter of the Students' Book contains a number of suggestions for extension work or open-ended investigative work. The suggestions are designed to give students the opportunity to demonstrate creativity in their approach to tackling scientific problems rather than responding to detailed instructions.

There is no definitive answer to many of the tasks set and teachers will need to assess individually the quality of the students' responses. For example, many of the tasks involve the design of experiments, and these can be assessed by looking for examples of good scientific practice. Has the student understood the problem and identified relevant facts? Does the solution offered allow a degree of scientific control? Have appropriate safety factors been taken into account? Does the suggested investigation offer a reasonable chance of success?

Experimental design can be a pen and paper exercise. In many cases lack of resources or the complexity of the problem will make this a necessity. However, wherever possible, the students should be given the opportunity to put their design into practice. For this to be successful, it may be necessary for teachers to define the task much more closely than has been done here and to spell out any constraints which must be taken into account. Finally, it is not recommended that all the suggestions are used with any one group. Many of the open-ended tasks will place great demands on the teacher, so the emphasis placed on these activities is left to the teacher's discretion.

Notes for further investigations and extension work

Each chapter of this Teaching Guide contains a number of suggestions for further investigation and extension work. These are mainly practical or experimental activities and they are offered as suggestions to extend the 'core' practical investigations described in the lesson plans. Depending on the local circumstances and the availability of equipment, the teacher may find that they are more suitable alternatives to the experiments suggested in the outline lesson plans.

Equipment and materials

Essential materials and equipment are listed under 'Materials needed' on each worksheet. Nearly all the items are readily available in a fairly basic school laboratory. 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 Teaching Guide and in the Students' Books mainly use standard 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 students 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. Be sensitive to different dietary requirements.
- Young students have little say or control over what they are given to eat at home. When discussing a healthy or balanced diet, for example, take care to ensure that students do not feel that you disapprove of their dietary habits. Similarly, when comparisons are made between the physical characteristics and intellectual abilities of students, it is important to emphasize that we are all different. Students are built differently, grow at different rates, and have different backgrounds and likes and dislikes and they are particularly sensitive to these differences during the often difficult years of adolescence.
- 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. Warn them also of the dangers of inadvertently looking at the Sun through binoculars, telescopes and even microscopes.
- Some students are allergic to certain plants, e.g. some flower bulbs, and pollen (from flowers), and remember that some plants are poisonous. Many students 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 unless they wear gloves. 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 collecting living things outside. Particular care is needed not to leave microscope slides or cover slips in sinks and on work surfaces.
- In the absence of Bunsen burners, 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.
- Students should not touch ice immediately after it has been taken out of a freezer.
- Take great care with hot water or steam.
- Great care should be taken when using mercury thermometers (recognizable by the silver colour of the liquid inside them), 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.

Assessment

Teachers express considerable concern over assessment. The Students' Book contains questions to support the learning from the units and to build confidence. Many of these questions test factual recall for, without a knowledge of the basics of the topic, it is difficult or impossible for the student to later apply the learning. Answers to these questions are given in this Teaching Guide. In addition, each chapter of the Teaching Guide includes an Assessment section and a list of answers. The multiple choice questions are again primarily included to test the recall of facts, but the structured questions contain more subjective elements, allowing students to reveal a greater depth of understanding. A marking scheme has not been suggested for these assessment items. Again, the aim is to be as flexible as possible. The teacher may wish to set the whole test at the end of the topic, or he or she may want to use the shorter questions for short, sharp tests, or set one or more of the longer questions for homework.

Cells, tissues, and organs

CHAPTER 1

Teaching Objectives

- To revise the earlier learning on the properties of living things
- To introduce the idea that the cell is the basic unit of living matter
- To examine the importance of the microscope in our understanding of the structure of cells
- To examine and compare plant and animal cells
- To show how cells are adapted to their function
- To examine the distinction between tissues and organs
- To show that organisms are made up of cells, tissues, organs, and organ systems
- To introduce simple ideas on the main systems of the human body

Learning Outcomes

After studying this chapter students should be able to:

- understand that living things are made up of cells
- describe the different parts of a light microscope
- identify different kinds of cells using a microscope
- tell the difference between plant and animal cells
- know that cells vary in size, shape, and function
- explain how some cells are adapted to carry out their function
- distinguish between tissues and organs
- recognise that organisms are made up of cells, tissues, organs, and organ systems
- state the main functions of the major systems of the human body
- describe the cellular hierarchy from cell to organ systems in animals and plants

Introduction

All living organisms consist of one or more cells. These microscopically small structures, each under the control of a single nucleus, are the basic structural and functional units of life.

Students are usually fascinated by the considerable range and shape of cells once they have been able to produce a worthwhile microscope slide of their own. Early attempts at slide making are often hurried and rarely produce good results. It is therefore desirable to provide material that is both easy to prepare and observe. Perhaps then, once success has been achieved, work on more difficult materials can be attempted. Having studied individual cells, prepared slides of plant and animal tissues can be looked at so that students see cells not just as individual units of life, but also as part of more complex structures. From this, the concept of organ structure should become clear, followed logically by that of the whole organism itself.

Of course, the ideal is for only one student to have the use of a microscope at any one time, or possibly a group of two or three students. However, if insufficient microscopes are available, it is still possible to demonstrate the variety of cells and tissues using secondary sources such as pictures, films, DVDs or projected colour slides of biological materials.

Lesson suggestions

1. Being alive

Starter suggestions

Show the students a living plant or animal (or if not available, pictures of living plants and animals) and a picture of a motor vehicle such as a car or motor cycle.

Main lesson

This is very much a revision or recapitulation lesson.

Ask the students to think of the various features which make them, and the plant or animal they have just seen, living things. With the help of the students, make a list of the characteristics of living things:

- Living things move.
- Living things respond to stimuli.
- Living things grow.
- Living things feed.
- Living things produce energy.
- Living things get rid of waste substances.
- Living things reproduce.

You may or may not want to add to the list the fact that living things eventually die.

Discuss the reasons why a motor cycle or car is not a living thing.

Explain that there is an extra characteristic of living things: they are all made up of cells! Show the students pictures of different types of cells if these are available.

2. The microscope

Refer to page 10 of the Students' Book.

Starter suggestions

Students should write down a sentence which contains the word 'cell' or 'cells'. They should then discuss their sentences, drawing out the difference between the everyday meanings of the word and the scientific meaning.

Main lesson

Point out to the students that many parts of living things are too small to see, so we need to magnify them. A hand lens or magnifying glass can make things look about ten times bigger. To see even smaller things clearly we need to use a microscope.

Show the students a microscope. Name each part in turn, explaining the name and how to remember it. The eyepiece for example is next to the eye. The objective is the part nearest to the object we are looking at.

Show the students how to carry the microscope properly and how to focus it without damaging the objectives, the microscope slide, and the cover slip.

Explain the magnification in terms of eyepiece power × objective power. Give the students a copy of Worksheet 1.1 to help them to remember how to use a microscope.

Let the students fill in Worksheet 1.2 to label the parts of a microscope.

If time and equipment permit, let the students examine a wide range of common objects, such as salt crystals, a hair, and the tip of a pin or needle. If available let them look at prepared slides of such subjects as insect mouthparts and wings, and bees' legs and stings.

Safety: Demonstrate the safe handling of the microscope, using its body and base. Stress the care needed in handling and packing away of microscope slides and cover slips.

3. Plant cells

Refer to page 2 of the Students' Book.

Starter suggestions

Show the students a wilted plant. Discuss what has happened to the plant. Hold another potted plant, such as a geranium, against the raised forearm of one of the students. Ask the students what would happen if you took the bones out of the volunteer's forearm.

Main lesson

Look at plant cells under a microscope or, if insufficient microscopes are available, at photographs, drawings, or colour slides of plant cells.

If the students carry out the onion epidermal cell slide activity (Worksheet 1.3), demonstrate each of the stages in preparing the slide before they attempt to make their own slides.

At the end of the lesson, refer back to the wilted plant. Ask the students to explain why a plant does not need bones to keep it upright and what happened to the wilted plant to make it floppy.

4. Animal cells

Refer to page 3 of the Students' Book.

Starter suggestions

Ask the students what their bodies are made of. Get them round eventually to the idea of cells. Show the students a PowerPoint slide of an animal cell, or examine the picture of an animal cell on page 3 of the Students' Book, so that they know what they are looking for.

Alternatively, show the students a small piece of paper with drawings and squiggles on it. Tell them that you have the plans to make a new living thing. Roll it up and put it inside a plastic film canister or some other small container. Place it inside an uninflated wide-necked balloon. Partially fill the balloon with a gooey liquid, such as glycerine or washing-up liquid, and tie the top. Explain that the liquid contains the substances needed for life. Ask them to sketch the balloon and write down what each part does—the plans, the container, the gooey liquid and the balloon.

Main lesson

Demonstrate how the students should wipe the inside of their cheeks with a cotton bud (or a clean fingernail can be used). This might be a good time to discuss with the students how DNA samples are collected as evidence after crimes or for identification purposes. Demonstrate how to wipe the cotton bud on a slide to give an even covering. A drop of methylene blue dye will stain the nuclei of the cells and make them more visible. Point out to the students that, unlike plant cells, the cheek cells have an irregular shape and 'floppy' appearance.

Safety: Eye protection should be worn at all times. You may also wish the students to wear disposable gloves.

Take care with methylene blue as it can permanently stain skin and eye tissues.

If cotton buds are used, they should be disposed of safely in containers of disinfectant solution after each individual use.

At the end of the lesson refer to the balloon you demonstrated at the beginning of the lesson and compare it with an animal cell. Then go on to discuss how plant cells and animal cells differ.

5. Special cells and tissues

Refer to page 3 of the Students' Book.

Starter suggestions

With textbooks closed, give the students a piece of paper and ask them to draw and label a plant cell and an animal cell from memory and to label and state the functions of the parts.

Main lesson

Discuss how a house is built from different components such as bricks, timber, glass, plastic piping, etc. Point out that, in a similar way, living organisms are built up of groups of cells (called tissues) which have special jobs to do.

Draw specialised cells on the board or use Worksheet 1.4. Possible cells are leaf palisade cells, root hair cells, red blood cells, white blood cells, nerve cells, sperm cells, and ciliated epithelial cells. Discuss with the students whether these cells are from plants or animals. After you have named the cells and stated where they come from, the students should copy these cells into their books and for each one, state how it is adapted for its function, or again use Worksheet 1.4 for this purpose.

6. Organs and organ systems

Refer to page 6 of the Students' Book.

Starter suggestions

Write the word 'ALIVE' on the board. From it draw a series of lines coming down from the centre. Ask the students what we need to stay alive. Write down their suggestions as the next layer of the diagram. Pick one and if, for example they say 'breathe', draw lines underneath it showing what we need to breathe. Once this upside-down tree pattern has been established, ask the students to draw a neat version of it.

Alternatively, write the words, 'cell', 'tissue', 'organ', and 'system' on the board. Ask the students to write a sentence containing each word. Stress that it does not matter whether they are scientific sentences or everyday sentences. Ask some students to read out their sentences and build up a picture on the board of the common uses of these words and their everyday meanings. Examine these sentences and show that, for example, the tissues on which you blow your nose are all made of the same material; prison cells are identical single 'boxes'; a musical organ has a number of parts, such as a keyboard, pipes, etc., but they all work together to perform one job—producing musical sounds. A system is a set of parts, things, or ideas that work together, or a well-organised way of doing something. Everyday examples include the members of a football team, a computer, or the Solar System. In the case of the musical organ mentioned above, the system it could be regarded as being part of, is an orchestra.

Main lesson

Show the students a chart, PowerPoint slide, or a torso model of the levels of organisation within the human body. Emphasise that the basic level of organisation is the cell. Cells are grouped into tissues, while a number of tissues make up an organ. Organs work together in an organ system and a number of systems make up the living organism—in this case the human body.

Ask the students to think of the names of some of the human organs they know. Draw a table on the board showing each system with the names of the main organs and the main functions of that system:

Name of system	**Main organs in the system**	**Main functions**
digestive system	intestines, stomach, liver and pancreas	to digest and absorb food
respiratory system	windpipe and lungs	to take in oxygen from the air and get rid of carbon dioxide
blood or circulatory system	heart, blood vessels	to carry dissolved food and oxygen around the body and to protect the body against disease organisms
excretory system	kidneys, bladder, liver	to get rid of poisonous waste substances
nervous system	brain, spinal cord, nerves	to carry messages from one part of the body to another
skeletal system and muscular systems	bones and muscles	to support and move the body

If time allows, it would be stimulating and informative to show the students examples of some organs, such as a heart, lungs, kidneys, and liver, obtained fresh from a butcher. If the students are allowed to touch these organs, then strict attention to hygiene is vital.

Stress that plants are also made up of organs. The main organs of a flowering plant are the roots, stems, leaves, and flowers. Show the students these organs on a living plant.

Finish the lesson by repeating the stages or levels of organisation of a living thing:

CELL – TISSUE – ORGAN – ORGAN SYSTEM – ORGANISM

Ideas for investigations and extension work

Pond weed cells

Make a microscope slide of cells scraped from one of the leaves of a pond weed. If a number of slides are examined it may be possible to see cytoplasmic streaming, in which the cytoplasm moves around inside the cell. Questions to ask include: How are these cells different from onion cells? What do you think makes pond weed leaves green? Draw a diagram of one of your cells. Try to point out the differences between it and the onion cells.

Potato tuber cells

Cells from a cut potato are also easily prepared. Scrapings of tissue can be put on to a drop of water on a microscope slide. Stain the cells with a drop of iodine and cover with a cover slip. Observations at higher magnification should reveal starch grains (the potato's food store) stained blue-black inside a mass of tightly packed cells.

Root tip cells

Another plant tissue where cells are visible (and comparisons can be made with cells from other plants) is in the root tip of a growing seedling. The usual procedure is to sprinkle seeds of mustard or cress on damp blotting paper, filter paper or paper towelling in a petri dish or saucer, or inside a wet earthenware flower pot. Do this three of four days before the tissue is needed. On the day of the experiment, cut off the last centimetre of the root tip and transfer it to a microscope slide. Cover it with a drop of water and a cover slip. Put the slide on a flat surface and press the root tip with the thumb until the root tip is squashed flat.

Safety: To avoid accidents, wear a plastic glove when squashing the root.

Single-celled organisms

Cut hay into short lengths and leave it in water for a few weeks. Drops of the liquid (a so-called hay infusion) will contain unicellular organisms. A drop of pond water from an unpolluted source may also reveal unicellular plants and animals including possibly euglena and amoeba.

WORKSHEET 1.1

Using a microscope

Eyepiece

Look through the eyepiece to see the image.

Check the number on the side of the eyepiece to see by how much it magnifies.

X10 = ten times magnification

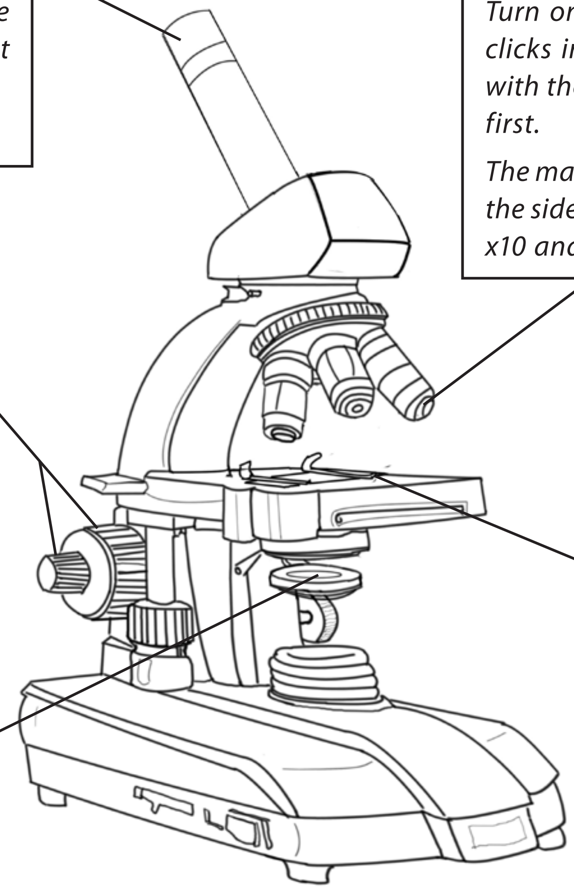
Objective lenses

Turn one of the lenses until it clicks into place. Always start with the lowest magnification first.

The magnification is shown on the side of the lens (usually x4, x10 and either x20 or x40).

Focusing

Turn the coarse focusing wheel or ring until the slide is almost in focus. Use the fine focus to obtain a sharp image.



Stage

Use the clips to hold the glass slide in place. Make sure that the cover slip is facing upwards.

Mirror

Angle the mirror until a bright circle of light bounces through the glass slide on the stage.

Some microscopes will have a built-in electric light to illuminate the object on the slide.

Magnification

Total magnification = eyepiece magnification $\times$ objective lens magnification

Setting up the microscope

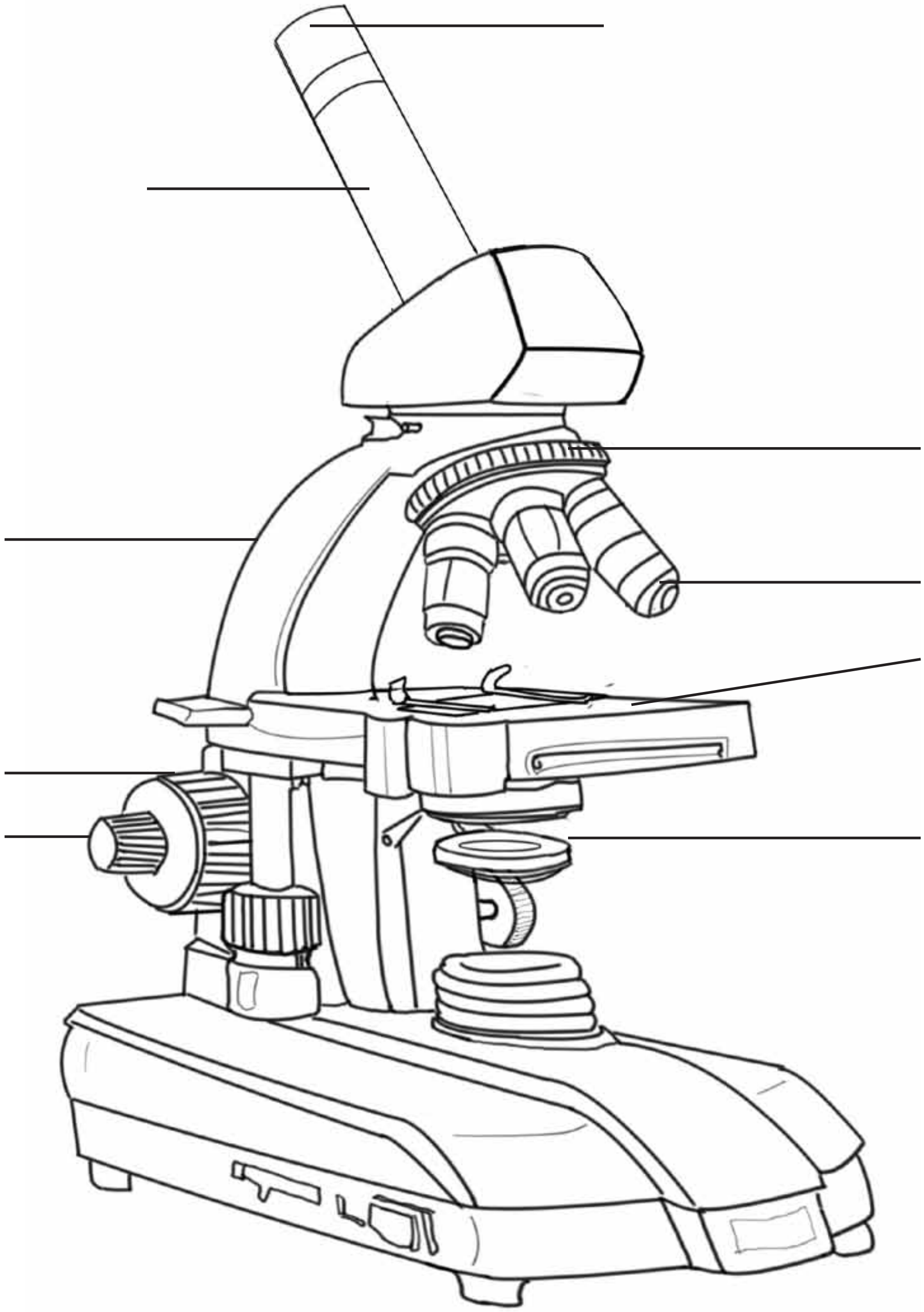
1. Place a glass slide on the stage.
2. Turn the objective lenses so that the one with the lowest magnification clicks into place over the slide.
3. Adjust the mirror so that light passes through the slide and into the lens.

4. Look at the slide from the side of the stage. Turn the coarse focus wheel anti-clockwise to move the lens down so that it is just above the slide. Take care not to hit the slide with the objective lens.
5. Look down the eyepiece and turn the coarse focus clockwise so that the lens moves away from the slide until the slide looks as if it is in focus.
6. Increase the magnification by turning the objective lens until it clicks into place. Do not change the focus as the slide should be nearly in focus. Look down the eyepiece lens and make any fine adjustments with the fine focus wheel.

WORKSHEET 1.2

The optical or light microscope

Label the parts of this drawing of a light or optical microscope.



WORKSHEET 1.3

Looking at onion skin cells

Safety

Scalpels, scissors, mounted needles, glass slides, and cover slips have sharp edges.

Wear safety glasses when handling iodine solution. Quickly wash off any that gets onto your skin. It will stain yellow-brown.

Materials needed: microscope, an onion, microscope slides, cover slips, dropper, scissors, forceps, iodine solution, shallow dish of water

1. Cut an onion into sections and peel a piece of the outside (shiny), transparent skin (epidermis) from the surface of one of the sections. Put it into a shallow dish of water right away.
2. Using scissors, cut the strip of epidermis into pieces about 2 cm × 2 cm square.
3. Select one piece of epidermis and move it with forceps onto a clean microscope slide.
4. Use a dropper to put one drop of iodine solution onto the piece of epidermis.
5. Using the forceps, carefully lower a cover slip over the onion epidermis.
6. Remove any surplus water or iodine solution from the slide using the edge of a paper towel. Examine it with the low power of the microscope. Once some cells have been found, move on to higher power so that you can see more detail.

Answer these questions;

a) What shape are the cells? ____________________

b) Are they all the same? ____________________

c) What is the dark patch inside each cell? ____________________

d) Why do you think you have to put the onion epidermis into water as soon as you have removed it from the onion? ____________________

e) What did the iodine solution do? ____________________

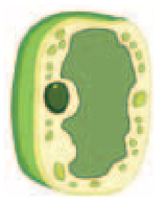
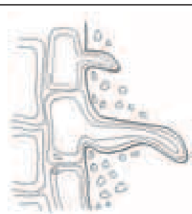
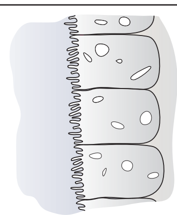
f) Draw a large clear diagram of one of your cells.

WORKSHEET 1.4

Special cells

Complete this chart which shows some cells that are adapted for special jobs or functions.

The first one has been done for you.

Type of cell	Drawing of cell	Job or function of cell	Special features of cell
leaf palisade cell		where most photosynthesis occurs	tall thin shape; lots of chloroplasts
root hair cell			
red blood cell			
white blood cell			
ciliated epithelial cell			
nerve cell			

Answers to questions in the Students' Book

Page 12

1. **D** $\times$ 100
2. **D** stomach (it is an organ)
3. So that the material is thin enough for light to be able to pass through it.
4. To show up the different parts, and particularly the nucleus and other organelles.
5. One. Amoeba and chlorella are common unicellular organisms.
6. Appropriate answers include blood cells, nerve cells, root hair cells, palisade cells and stomata. The nucleus of a cell determines how it will specialise.
7. The cell membrane controls the movement of materials into and out of the cell.
8. chlorophyll
9. (i) **a** = nucleus; **b** = cell wall; **c** = cytoplasm; **d** = vacuole; **e** = chloroplast
   (ii) nucleus, cell membrane
   (iii) A tissue is a group of similar cells with a similar function. An organ is a group of tissues working together to carry out a particular job or function.
10. cell, tissue, organ, organ system
11. One example of the sequence is red blood cell, blood (a tissue), the heart (an organ), the blood or circulatory system (an organ system), the human body (a living organism).

Assessment

Question 1

Complete the passage below using words from this list. You may use the words more than once.

reproduction	excretion	sensitivity	seven	respiration

Living organisms differ from non-living objects in that they carry out __________ vital processes. These are often called the characteristics of living things. The release of energy from food molecules is called __________ . The ability of living things to produce copies of themselves is known as __________ , while the ability to respond to changes in their surroundings is called __________ . The removal of the waste products that have been produced by the organism is known as __________ .

Question 2

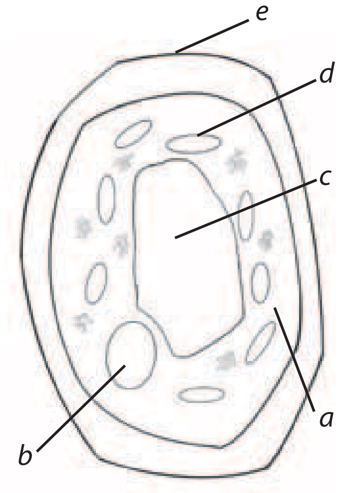
Complete the passage below using words from the list below. You may use the words more than once.

specialised	chloroplasts	nucleus	cells	photosynthesis
cellulose	cell membrane	cell wall	cell	

All organisms are made up of units called __________ . These units are surrounded by a __________ that controls what enters and leaves the __________ . The __________ controls all the activities of the cell. Plant cells differ from animal cells in that they have a __________ made of __________ . Many plant cells also contain tiny organelles called __________ that make food for the plant by __________ . Most cells are __________ for the job they do.

Question 3

This cell is from the leaf of a plant. Five parts of the cell are labelled with letters of the alphabet.



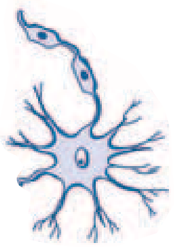
a) Match each name in the list below to the correct letter of the diagram:

cell wall	cytoplasm	nucleus
vacuole	chloroplast	

b) Name TWO labelled parts of the diagram which are also present in animal cells. Give the correct letters from the diagram.

c) This diagram has been drawn using a light microscope. Name one structure found in cells that is too small to be seen with a light microscope.

What evidence is there in the diagrams below to show that each cell is adapted for its particular job or function?

i) 

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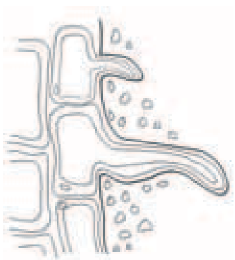
ii) 

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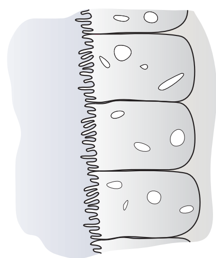
iii) 

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Question 4

What is the main difference between plant and animal cells?

(A) Plant cells have a nucleus, animal cells do not.
(B) Animal cells move about.
(C) Plant cells have a cell wall which is easily seen.
(D) Animal cells are always bigger than plant cells.

Question 5

Which one of the following substances in a cell traps sunlight?

(A) cytoplasm (B) cell sap (C) cellulose (D) chlorophyll

Question 6

The job of the cell membrane is to:

(A) give a plant cell its shape
(B) control what happens inside the cell
(C) control what substances go into and out of the cell
(D) stop water entering the cell

Question 7

The job of the cell wall in a plant is to:

(A) control what substances go into and out of the cell
(B) give a plant cell its shape
(C) allow photosynthesis to happen
(D) store food for the plant

Question 8

What sort of structure is the heart?

(A) a tissue (B) an organ (C) an organ system (D) a group of cells

Question 9

Which of the following is not an organ system?

(A) circulatory system (B) nervous system (C) one-way system (D) digestive system

Question 10

The diagram shows :

(A) a virus (B) a red blood cell (C) a white blood cell (D) a bacterium

Question 11

Cells of the same type are grouped together to make a:

(A) tissue (B) organ (C) organ system (D) organelle

Question 12

An organ is made up of several different:

(A) organelles (B) cells (C) tissues (D) nerves

Question 13

Decide whether each of the following statements is TRUE or FALSE.

a) Only plant cells have chloroplasts.
b) Animal cells are rigid, but plant cells are floppy.
c) The nucleus of a cell controls its actions.
d) A group of similar cells is called a tissue.
e) The chloroplasts in a plant cell carry out respiration.
f) An organ is made up of different tissues.

Question 14

a) What is an organ system? ____________________

b) List five organ systems of the human body. ____________________

Name and give the function of ONE organ in animals that

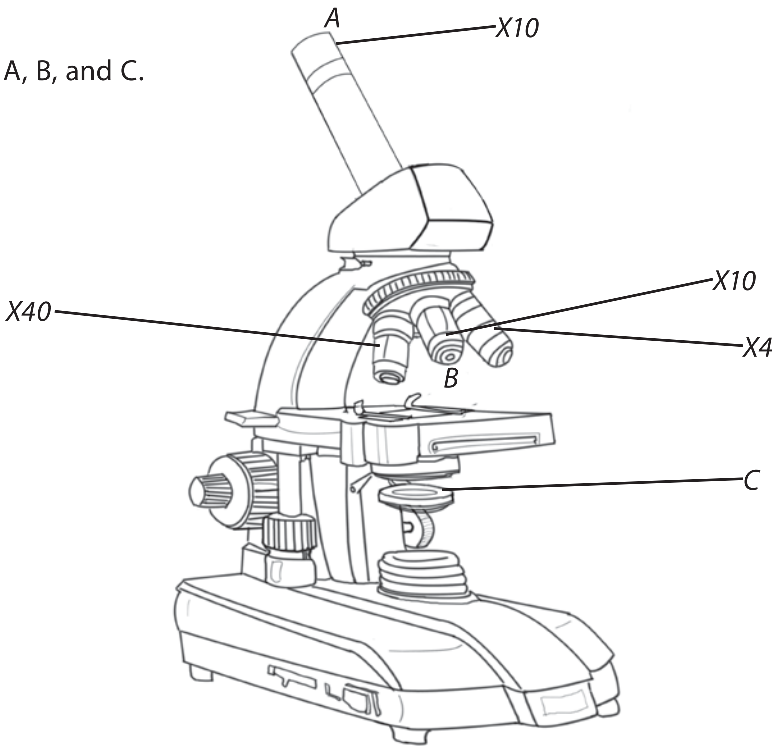
i) helps the blood to circulate ____________________

ii) enables digestion to take place ______

Question 15

The diagram below shows a microscope.

(i) Name parts A, B, and C.



A ______ B ______ C ______

(ii) Calculate the magnification being used on the microscope in the picture. **Show your working**.

(iii) Zohra has been studying the organism shown in the picture below. It is called euglena. It is made of only one cell. It lives in ponds and streams. Euglena has some features of animals and some features of plants.

a) Look carefully at the picture of euglena. Give TWO reasons why you think it is an animal and not a plant.

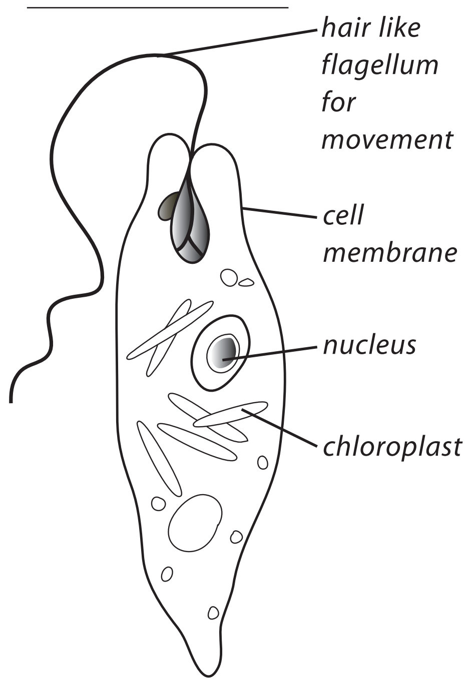
______

______

b) Plant cells can carry out photosynthesis. How can you tell from the picture that euglena can carry out photosynthesis?

______

______



Answers to Assessment questions

Question 1

Living organisms differ from non-living objects in that they carry out **seven** vital processes. These are often called the characteristics of living things. The release of energy from food molecules is called **respiration**. The ability of living things to produce copies of themselves is known as **reproduction**, while the ability to respond to changes in their surroundings is called **sensitivity**. The removal of the waste products that have been produced by the organism is known as **excretion**.

Question 2

All organisms are made up of units called **cells**. These units are surrounded by a **cell membrane** that controls what enters and leaves the **cell**. The **nucleus** controls all the activities of the cell. Plant cells differ from animal cells in that they have a **cell wall** made of **cellulose**. Plant cells also contain tiny organelles called **chloroplasts** that make food for the plant by **photosynthesis**. Most cells are **specialised** for the job they do.

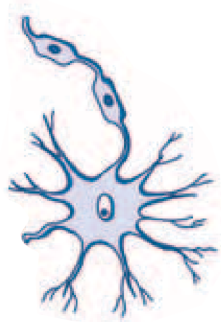
Question 3

a) Cytoplasm labelled a; nucleus b; vacuole c; chloroplast d; cell wall e.

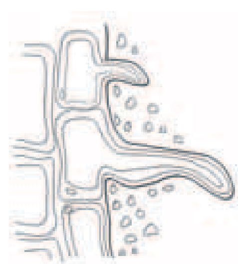
b) a cytoplasm; b nucleus

c) Choose from mitochondria and ribosomes.

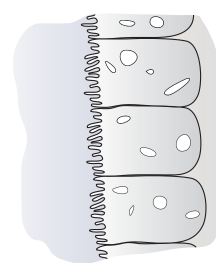
i) Long and thin; connections at both ends.



ii) No chloroplasts; long and thin to provide a large surface area for absorbing water and mineral salts from the soil.



iii) Tiny hairs, called cilia, along the upper surface. These sweep along mucus and other fluids.



Question 4

(C) Plant cells have a cell wall which is easily seen.

Question 5

(D) chlorophyll

Question 6

(C) control what substances go into and out of the cell

Question 7

(B) give a plant cell its shape

Question 8

(B) an organ

Question 9

(C) one-way system

Question 10

(C) a white blood cell

Question 11

(A) tissue

Question 12

(C) tissues

Question 13

a) TRUE b) FALSE c) TRUE d) TRUE e) FALSE f) TRUE

Question 14

a) An organ system is a series of organs working together for a common purpose, e.g. to circulate the blood or digest the food.

b) Choose any five organ systems from digestive, blood or circulatory, respiratory, nervous, skeletal, muscular, endocrine or hormonal, reproductive, and excretory systems.

i) The heart pumps the blood in the circulatory system.

ii) The stomach, liver and pancreas are organs which help digestion to take place. The stomach churns the food and also begins the digestion of proteins. The liver produces bile, which breaks fats down into small droplets. The pancreas produces several enzymes which, between them, digest starch, proteins, and fats.

Question 15

(i) A = eyepiece; B = objective; C = mirror/light source

(ii) The magnification is 10 (eyepiece) × 40 (objective) = 400

(iii) a) Euglena has the following animal-like characteristics: it moves/swims, it has no cell wall, only a cell membrane, and it takes in solid particles of food.

b) Euglena has chloroplasts and therefore can carry out photosynthesis.

Senses and Sense Organs

CHAPTER 2

Teaching Objectives

- To name and examine the main senses of the human body
- To show how the structure and function of the nose, tongue, ear, eye, and skin are interrelated

Learning Outcomes

After studying this chapter students should be able to:

- name the main senses of the human body
- explain the structure and function of the nose, tongue, ear, eye, and skin

Introduction

Our senses make us aware of changes in our surroundings and in our own bodies. We have a number of kinds of sense cell, called receptors, and each is sensitive to a particular kind of stimulus. A stimulus is a change in light, temperature, pressure, etc. which produces a reaction in a plant or animal. Some of our receptors are scattered throughout the skin, some are deep inside the body, while others are concentrated into special sense organs, such as the eye and ear.

The purpose of this unit is to introduce the student to the receptor mechanisms in his or her own body and to their limitations. The physics of optics and sound is dealt with in more detail in Students' Book 1 and in later books in this series.

One of the big advantages of this topic is that, unlike the one dealing with cells, there are a number of simple investigations the students can carry out, either individually or in small groups, which need only minimal apparatus and equipment.

Lesson suggestions

1. The senses

Refer to page 14 of the Students' Book.

Starter suggestions

Ask the students to list in their notebooks the five main senses and the organs where they are located, or write up a list on the board. Give them a few minutes to write down what each does and how it makes life safer.

Alternatively, present the students with a number of scenarios, such as: 'You are in a restaurant. You think the fish stew might be bad. How would you find out?' 'You are about to enter a building when you are told there might have been a gas leak. How could you tell?' 'You have pulled your hat over your ears because it is snowing heavily when you think you can hear a vehicle coming on the road behind you. What would you do?' Get the students to appreciate the role that our senses play in keeping us safe. Discuss the value of the sense of pain.

Main lesson

Draw a chart on the board showing the main senses and where they are located. Point out that we have more than five senses because in the skin, as well as the sense of touch there are also senses of pressure, pain, and temperature.

Sense	Location
sight	eyes
hearing	ears
balance	ears
smell	nose
taste	tongue
touch	skin and tongue
pressure	skin (including hairs on skin) and tongue
temperature	skin
pain	skin and most tissues and organs of the body

Either discuss with the students what effect it would have on their lives if they lost one of their senses at a time for a short period, or draw up a list of sporting activities and ask the students which are the most important senses necessary to be proficient in each of these sports.

2. The skin

Refer to page 15 of the Students' Book.

Starter suggestions

Show the students a model of a vertical section through the skin, or a PowerPoint slide of a section through the skin, or a wallchart of it. If not, refer to the diagram on page 15 of the Students' Book. Emphasise that the skin is made up of layers, containing sensory receptors and other structures. It is not simply a covering for the body.

Alternatively, ask a volunteer student to lie on a large sheet of paper and draw round his or her outline. Use this outline of the body to estimate the total area of skin on the volunteer's body.

Main lesson

Explain the function of each of the parts on a vertical section of the skin and its role in detecting stimuli.

Then carry out the ‘Temperature and touch’ activity described on page 25 and, if time permits, the activity on the sensitivity of fingertips described on Worksheet 2.1.

3. Touch and temperature

Refer to page 16 of the Students’ Book.

Starter suggestions

It is important for the students to realise that our senses are limited and we can easily be fooled into sensing things that are not really as we think they are. They also have to realise that, even though the skin is sensitive to touch, not all parts are equally sensitive. It is helpful at the start of the lesson to point out that other members of the animal kingdom have senses that we lack, while some animals have better-developed senses than our own. Show the students a picture of a bat or a dolphin and point out that it uses sounds to navigate. Similarly, a dog may not have eyesight as good as ours, but it can smell scents that we cannot smell and hear sounds that we cannot hear.

Main lesson

Investigate the sensitivity of different parts of the skin to touch and also investigate the sense of temperature described in Worksheet 2.2. If space or facilities are limited, it may help class organisation to have the temperature activity set up at the side of the room and for students to take it in turns to visit that activity, before returning to continue with the skin sensitivity experiment.

To find the sensitivity of the skin to touch, you need either a hair grip or a piece of wire bent into a U-shape for each pair of students. If the latter is used, then it is important to make sure that the two ends of the wire have been filed down so that they are blunt. The students should take it in turns to act as the experimenter and the subject of the experiment.

Start with the points of the apparatus about 1 cm apart. The experimenter touches the two points simultaneously on parts of the skin of the subject whose eyes are closed. The subject has to say whether he can feel one point or two points. In the more sensitive regions of the skin, the two points are felt as separate stimuli. Elsewhere, for example, on the neck or the back of the hand, only a single stimulus is felt because there are fewer touch receptors. By reducing the distance between the points from time to time, the degree of sensitivity of different areas of the skin can be mapped out.

It is also a good idea to vary the stimulus, using sometimes one point and sometimes two, so that the subject does not know in advance which is being used.

4. Taste and smell

Refer to pages 16 and 17 of the Students’ Book.

Starter suggestions

Tell the students that their brain has 100 billion nerve cells, each of which connects to thousands of others. These nerve cells process information from our senses so we can detect the world around us. Making sense of information is difficult. The short-cuts our brain takes make it easy to create the wrong impression, and nowhere is this more evident than in the senses of taste and smell, which are closely related.

Use a teat pipette to put a few drops of cheap perfume or aftershave onto a shallow dish at the front of the classroom. Ask the students to put up their hands when they first smell the perfume. Explain how the particles of perfume are gradually spreading, or diffusing, through the air of the classroom. After a few minutes, when the students have forgotten about the perfume, ask them if they can still smell it. Most will say no. Point out that the perfume has not gone away. We cannot smell it because our sense of smell tires easily.

Main lesson

Carry out the sense of smell test described on Worksheet 2.3 and the taste test experiment described on Worksheet 2.4. A point which is worth mentioning when you discuss the results of the experiment is that as food enters the mouth, it comes into contact first with the front of the tongue and it is this region which is most sensitive to taste.

Now carry out a simple test to show how limited our sense of taste is and the role played by our sense of smell in detecting the flavour of food. For this experiment the students work in pairs and use small cubes of apple, onion, potato, and turnip. The subject of the experiment closes his or her eyes. Using forceps, a cube of each of the foods is placed, one at a time, on his or her tongue. Can the subject identify the foods. Now repeat the experiment, this time with the subject holding his or her nose, while still keeping his or her eyes closed.

Can the subject identify the foods? Does your nose help you to taste?

Remind the students of the experience of 'tasteless' food when they have had a heavy cold. Refer also to the effect of smoking on the taste buds on the tongue. A heavy smoker may have great difficulty in distinguishing between tastes and may even be unable to detect them at all.

Safety: Strict hygiene rules need to be applied to the preparation and handling of the food items.

5. Eyes and eyesight

Refer to page 17 of the Students' Book.

Starter suggestions

Ask the students to either use a mirror or to work in pairs and examine the external features of the eye. How many of the structures shown on page 18 of their textbooks can they identify? Ask them to draw and label an external view of their own or their partner's eyes.

Ask the students to keep both eyes open and to hold up a pen or pencil at arm's length and consciously focus on this. Now ask them to place the forefinger of the other hand between their eyes and the pen or pencil. What do they see when they are still focusing on the pen or pencil? Do they see two images of their forefinger? Explain that we have two eyes and they each produce an image of what we see. It is the brain which processes the two images into one.

Main lesson

Examine a model of a section through the eye, a wallchart of the eye, a PowerPoint slide of it, or the picture on page 19 of the textbook. Explain the function of each of the parts of the eye.

One of the facts that students find hardest to accept is the fact that the image formed on the back of the eye is upside down, or inverted. You can demonstrate how this occurs if you can borrow an old focusing film camera. The camera must not have a film in it. Darken the room and leave only one window without the blinds down. Now open up the camera and put a piece of greaseproof paper at the back of the camera where the film should be. It can be held in place by a small piece of adhesive tape. Open the shutter and point the lens at the window. Turn the camera lens until the window frame is sharply focused on the paper screen. You may need to put a cloth or jacket over your head to see the inverted image of the window clearly. If the camera can be fixed onto a tripod, this will make it easier for everyone to see the image on the greaseproof paper screen.

Explain that some years ago, in an experiment, scientists asked volunteers to wear special glasses that made everything look upside down. After two or three days, everything started to look the right way up again—until the volunteers took the glasses off!

Go on to explain that in some people the lenses of the eyes do not focus a clear image onto the retina. If it can be done tactfully and sensitively, ask some students who are long-sighted or short-sighted to explain the problems their condition presents and how it is corrected by spectacles or contact lenses.

6. Ears and hearing

Refer to page 20 of the Students' Book.

Starter suggestions

People tend to think of the ear as just a flap on the side of the head. Explain that the flap is in fact a device for catching sounds and directing them into the tube that leads down into the main part of the ear. Show the students a collection of photographs of animals' ears. Explain that the ears are adapted to the animal's way of life. Desert animals, such as bat-eared foxes have large ears to radiate heat and cool their bodies, while elephants flap their ears to cool themselves. Some animals, including dogs and cats, can move their ear flaps to pick up sounds from different directions. Most people cannot do this, although some of us can 'waggle' our ears. Can anyone in your class do this?

Discuss with the students how some sounds assure us that all is going well. Others like the siren or fire alarm tell us that something is wrong. Discuss what kinds of sound tell us that something pleasant is happening (laughter and singing, for example). How can we identify new sounds? (by looking at the source and listening to the sound) Point out that when we hear those sounds again, we have the associations of pictures in our mind and we can tell what is happening. In other words, as with sight, the brain plays an important part in what we hear.

Main lesson

Show the students a model or large picture of a section through the human ear. Explain that after the outer ear has caught sound waves, they are guided down the ear canal to the ear drum. The ear drum vibrates and the way it does this can be demonstrated by placing an inflated balloon near to the speaker of a radio that is playing loudly.

The ear drum is connected to three tiny bones which act as a series of levers. If you balance a ruler on a pencil or eraser, with the pencil or eraser near to one end of the ruler, you can show that a small movement of the short part of the ruler can make the other end make a large movement. In the same way, the bones in the middle ear make the vibrations of the ear drum bigger before they are passed on to the inner ear.

The inner ear looks like a snail's shell. It contains nerves which pick out the different sounds and pass them on to the brain. Deafness can result if any of these three main parts of the ear are damaged. Temporary deafness can occur if large quantities of wax accumulate in the ear canal. Although this wax may sometimes seem a nuisance, it has the useful function of keeping the ear canal moist. Excess quantities of wax can be removed by a nurse or doctor using a syringe containing warm water.

Go on to explain the sense of balance. It may be helpful to have a spirit level to explain how the ears are sensitive to the position of the head.

If time permits carry out the activity on Worksheet 2.5

Ideas for investigations and extension work

Temperature and touch

Draw a 2 cm square on the back of your partner's forearm before you blindfold him or her. Remove a <u>blunt</u> mounted needle from either a beaker of hot water or a beaker of ice. Dry the needle and lightly touch the skin within the square with the needle. Ask your partner whether he or she feels, heat, cold, or just touch. Touch different points within the square with hot and cold needles. Map the results. Now swap places and repeat the experiment. Are both sets of results the same?

An animal's eyes

This activity is probably best demonstrated by the teacher.

Examine an animal's eye which has come from the butcher.

Point out and name the structures that the students could not see when they examined their own eyes.

With sharp scissors carefully cut a hole in the side of the eyeball.

What comes out of the hole?

What effect does making the hole have on the shape of the eyeball?

Find the lens and the retina. What other structures are visible?

Carefully remove the lens. What does the lens feel like? Why has it become almost spherical in shape?

How good is your eyesight?

If you normally wear spectacles, then wear them for these activities.

Hang a sheet of white card on the wall on which you have drawn two black parallel lines one millimetre apart.

Gradually back away from the card until the two parallel lines appear as one, then stop.

Ask a friend to measure how far you are from the card. Compare your distance with that of other people in your class.

Hang an eyesight test card on the wall.

Stand six metres away from the card facing it.

How many lines can you read?

Repeat the eyesight test for each eye separately.

Can you see better with one eye than the other?

How does your eyesight compare with that of the rest of your class?

Range of vision

Work in pairs. The subject should focus on the classroom wall while the experimenter should hold a pen in front of him or her and then move it gradually to one side. The subject should ask the experimenter to stop moving the pen just when the subject loses sight of it. The subject should now turn his or her head to see where the pen is. This will give the subject some idea of how far he or she can see 'out of the corner of your eye' when he or she is looking straight ahead. Repeat the experiment with the pen moved to the other side, then upwards and downwards. The subject and experimenter should then swap places. You will normally find that when looking in front we are very limited regarding what we can see to the side and above. Discuss the implications of this for road safety.

Can you judge distances with one eye?

Work with a partner. Your partner should stand facing you but about four or five paces away from you. Your partner should then stretch out one hand with all the fingers clenched together except the first finger. The first finger should be pointing straight up. Stretch out one hand towards your partner with all your fingers clenched except the first finger which should be pointing straight downwards. Close one eye and walk slowly towards your partner and try to place your downward-pointing finger directly on top of your partner's upward pointing finger. Do you find this easy to do?

Now repeat the experiment keeping both eyes open. Do you find it easier or more difficult to locate the exact position of your partner's finger?

Another similar experiment is to close one eye and then hold out the body of a pen at arm's length. Now with the other hand try to fit the cap on the pen.

Finding an object by sound

This experiment is best done as a class activity with one volunteer acting as the subject.

Blindfold the subject outside the classroom.

Place a ticking clock somewhere in the room.

Bring the subject in and ask him or her to find the clock. Have someone standing close to the subject to prevent him or her bumping into the furniture.

Watch the subject's head movements to see how he or she tries to locate the clock.

In what ways do the students think that the movements of the subject's head help him or her to find the clock?

Ask the students what they think the subject would do if one of his or her ears was plugged with cotton wool. Find out by repeating the experiment with one of the subject's ears blocked.

WORKSHEET 2.1

How sensitive are your fingertips?

Materials needed: some sandpaper of different degrees of coarseness; scissors; a ruler; a scarf to use as a blindfold.

Work in small groups, ideally of two people—one to be the experimenter, the other as the subject.

1. Cut out one square of each of the different grades of sandpaper. The squares should be all the same size, and 6×6 cm will work well.
2. Number the backs of the pieces of sandpaper. Call the one with the coarsest (roughest) grains number 1.
3. One of your group should wear a blindfold. He or she is the subject.
4. The experimenter then mixes the squares of sandpaper up. The subject then has to arrange them in order, with the coarsest grade on the left, the finest grade on the right at the other end of the row. Remember the subject is using only his or her sense of touch.
5. Now remove the blindfold and see whether the subject put the sandpapers in the correct order.
6. Change places and see if the other partner can do any better. Test each of your friends. Who has the best sense of touch?

Try to devise your own experiment to test the sense of touch. One idea would be to try to separate small squares of orange, lemon, and grapefruit peel while you are blindfolded.

Can you find out how blind people use their sense of touch when reading a Braille book or magazine?

WORKSHEET 2.2

How good is your sense of temperature?

Materials needed: three similar-sized washing-up bowls; a towel; hand-hot, warm and iced water.

1. Put the three bowls in a row.

hot water *warm water* *iced water*

2. Into one bowl put hand-hot water.
3. Into the second (middle) bowl put warm water.
4. Into the third bowl put the iced water.
5. Put your right hand in the hot water, your left hand in the iced water.
6. Count to 100. Then put both hands in the warm water. What do you feel?

   Dry your hands.

How did your right hand feel in the warm water? ______________________

How did you left hand feel in the warm water? ______________________

Can you always rely on your skin to tell you about the temperature of water? ______________________

WORKSHEET 2.3

How good is your sense of smell?

Materials needed: clean yoghurt pots; elastic bands; squares of muslin or old tights; small pieces of foods that have a strong smell, such as lemon, orange; banana, custard apple (*shareefa*), cheese, turnip, and onion.

1. Put one piece of food in a clean yoghurt pot. Cover the top with muslin or tights held in place with an elastic band. Label this pot 'A'.
2. Do the same for each of the other pots, labelling them consecutively, 'B', 'C', and 'D', etc.
3. The teacher or the experimenter should keep a record of what is in each pot.
4. Mix the pots up and then ask each of the members of the class to identify what is in the pots by smell alone.

Which foods are the easiest for people to identify? ____________________

Which foods are the hardest to identify by smell alone? ____________________

Who in the class has the best sense of smell? ____________________

WORKSHEET 2.4

The sense of taste

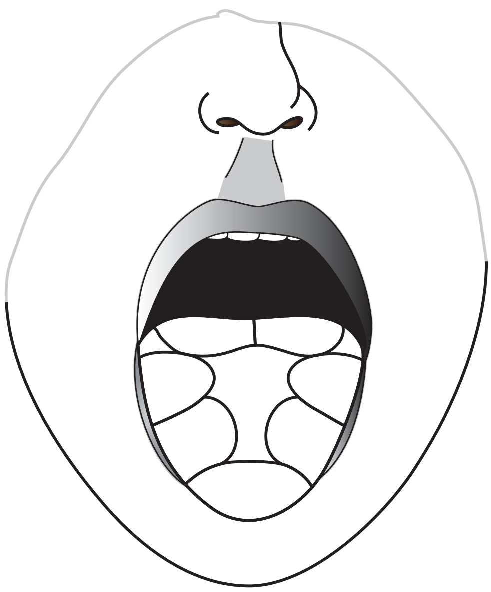
Materials needed: small mirror, small torch; paper tissues; toothpicks; salt solution; sugar solution, lemon juice or vinegar (sour); onion juice or tonic water or a weak solution of instant coffee powder (bitter); water.

1. The taste buds on the tongue are important for detecting the flavour of food.

   Look at the upper surface of your tongue in a mirror. If necessary, shine a torch into your mouth, to show your tongue more clearly.

   Can you see your taste buds?

2. How many different kinds of taste bud can you see?
3. Make a map of the tongue like the one below.



   Which parts of the tongue are most sensitive to the different characteristics of food (salty, bitter, sour, sweet)?

4. Carefully dry the upper surface of the tongue with a clean tissue. Dip a toothpick into one of the solutions and **lightly** touch your tongue with it. Repeat this test on different areas of the tongue. It may help to drink a little water between tests. Also be careful in testing the back part of the tongue...some people may gag!
5. Now repeat the experiment with each of the other test substances in turn.

   Are parts of the tongue more sensitive to specific flavours, or are all parts of the tongue equally sensitive to all flavours? If so, indicate on a drawing of the tongue the areas that are most sensitive to the different tastes.

   Compare your tongue map with the maps made by other people. Are they all the same, or different?

WORKSHEET 2.5

How well can you hear?

Materials needed: A quiet room to work in; cotton wool or ear plugs; a ticking watch; a long tape measure or a length of string and a ruler.

Work in pairs with one person acting as the subject.

1. The subject should sit down and plug one ear with cotton wool or an ear plug.
2. Hold a watch close to the subject's ear and gradually move it away until he or she can no longer hear it.
3. At what distance does the subject just cease to hear the watch? ____________________
4. Hold the watch out of hearing range, then gradually move it towards the subject's ear until he or she can just hear it.

At what distance does the subject start to hear the watch? ____________________

Are the two distances which you have measured the same? ____________________

If not, which one is the furthest? ____________________

How would you explain the difference? ____________________

Now repeat the experiment with the subject's other ear. Are the results you obtain the same as before?

____

Change places and repeat the experiment with you as the subject. Make a chart of your own and your partner's results.

	Name ____________		Name ____________	
	left ear	right ear	left ear	right ear
Distance at which hearing ceases moving away from the ear				
Distance at which hearing begins moving towards the ear				

Answers to questions in the Students' Book

1. their shape, texture, and whether they feel warm or cold
2. People born without a sense of pain might be unaware of an injury or illness, and so not seek first aid or treatment.
3. Sensitive cells which detect pressure, temperature, pain, and the sense of touch must also be present on the tongue.
4. Taste is a sense detected by chemoreceptors on taste buds on the tongue; smell is detected by the olfactory organ (organ of smell) in the nose, while flavour is a mingled sensation of smell and taste given off by foods.
5. The senses of smell and taste are linked, so that a head cold affects your sense of smell and also the way your food tastes.
6. a) iris b) pupil c) cornea
   d) lens e) pupil f) suspensory ligaments
   g) retina h) optic nerve
7. In long-sighted people, light from a near object is brought into focus behind the retina. This defect of vision is corrected by wearing converging or convex lenses which focus the image onto the retina.
8. Short-sightedness is usually caused by eyeballs that are too long, so that light from a distant object is focused in front of the retina. Short sight is corrected by wearing diverging or concave lenses. Long-sightedness is caused by short eyeballs or 'weak' lenses. Light from a distant object is brought to focus on the retina, but from a close object it is focused behind the retina. This defect of vision is corrected by wearing converging or convex lenses which focus the image onto the retina.
9. The eye is like a camera or camcorder in that it has a lens, a light-sensitive screen (the retina), and a means of regulating the amount of light reaching the retina (the iris). The eye is different because, whereas a camera or camcorder focuses by moving the lens nearer or further away from the film or sensor, the lens of the eye is able to change shape to focus on near or distant objects.
10. Sound waves are collected by the funnel-shaped pinna or earlobe of each ear. The sound waves pass down to the ear drum and make it vibrate. Behind the ear drum is a chain of three small bones, called the hammer, anvil, and stirrup. These bones connect the ear drum with another sheet of skin called the oval window. When the ear drum vibrates, the three small bones move against each other in such a way that they lever the oval window in and out. This causes vibrations to pass along a tube called the cochlea. As vibrations move along the fluid-filled cochlea, they cause a layer of nerve endings to move up and down. This stimulates the nerve endings into sending nerve impulses along the auditory nerve to the brain, where they are interpreted as sounds.
11. It would be dangerous for someone with faulty semicircular canals to ride a bicycle because it is in the semicircular canals that the sense of balance is located.

Assessment

Question 1

Complete the following sentences using the words in the box below.

pressure	cold	pain	organs	texture
touch	tongue	brain	receptors	temperature

Human skin has nerve endings sensitive to ________ , pressure, pain, and ________ . These, and other sensory nerve endings are called ________ because they 'receive' signals or stimuli from the outside world. Most touch and ________ receptors are concentrated in the skin of the ________ and fingertips. These receptors detect the ________ of objects: whether they are hard or soft, rough or smooth. Touch receptors are also attached to the roots of hairs. Pain receptors are more evenly spread across the skin. They are also found inside the body in most ________ and tissues. ________ acts as a warning signal. It tells the ________ that something is wrong with the body. There are separate heat and ________ receptors in the skin. These are used to detect changes in temperature. Your fingertips can detect temperature differences as small as 0.5°C.

Question 2

The amount of light entering the eye is controlled by the:

(A) iris (B) lens (C) cornea (D) retina

Question 3

The cornea of the eye is the transparent part of the:

(A) iris (B) lens (C) sclerotic (D) retina

Question 4

A cricketer loses the sight of one eye in a car crash. The other eye is not affected. When he plays cricket again, the effect will be that:

(A) he can see the ball only half the time
(B) he cannot focus on the ball
(C) he cannot judge how far away the ball is
(D) the ball looks smaller

Question 5

A boy is told to shut his eyes and some food is put on his tongue. He would best be able to guess what it is by using:

(A) taste only (B) smell only (C) taste and feel (D) taste, smell, and feel

Question 6

A man with a heavy cold finds his food does not taste because:

(A) the cold germs kill the taste of the food
(B) the cold germs numb the taste buds
(C) his blocked nose cuts out his sense of smell
(D) he has lost his appetite

Question 7

The three tiny bones in the middle ear are there to:

(A) stop the eardrum from collapsing
(B) transmit sound vibrations
(C) transmit the sense of balance
(D) stop the ear from vibrating too much

Question 8

A girl who is going to a wedding sprays some long-lasting perfume behind her ears. A few minutes later she realises she cannot smell the perfume any more. This is because:

(A) it has all evaporated
(B) she cannot smell behind her ears
(C) perfume only smells for a very short time
(D) her sense of smell has become used to that smell

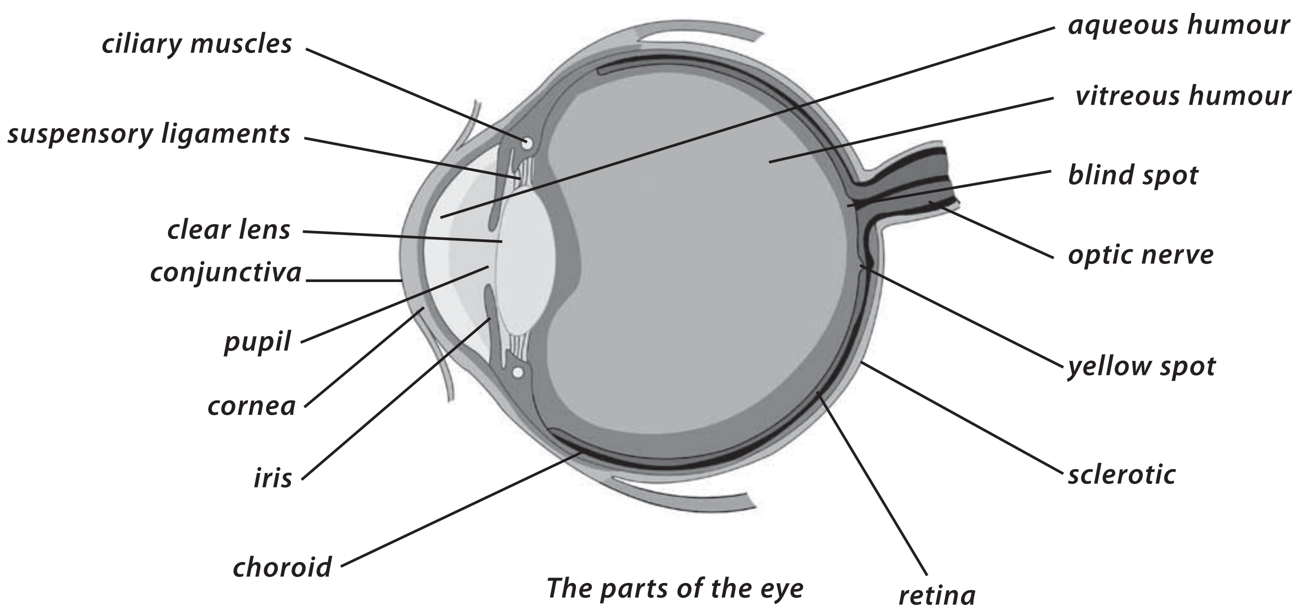
Question 9

The four basic tastes to which your tongue is sensitive are:

(A) sweet, sour, salt, and bitter
(B) acid, sour, salt, and bitter
(C) sweet, sour, salt, and pepper
(D) sweet, sour, salt, and creamy

Question 10

The diagram below shows a section through the human eye. Study the diagram and then answer the questions that follow.



The parts of the eye

A) What is the job or function of the pupil?

B) Which part of the eye carries nerve impulses to the brain?

C) What is the job or function of the ciliary muscles?

D) Name the two types of light-sensitive cells in the retina?

E) Which three parts of the eye are transparent?

Question 11

A student was blindfolded and then the skin of her fingertips, palm of her hand and arm was touched many times with two needle points. The points of the needles had been blunted so that they did not hurt the student. Sometimes the points of the needles were 1.0 cm apart, and sometimes they were 0.5 cm apart. Each time the needles touched her skin, the student was asked if she thought one or two points were being used. The table below shows the number of times she was **correct** when she said that two points were touching her.

Needle points	Arm	Palm of hand	Fingertips
1.0 cm apart	12	18	25
0.5 cm apart	9	13	15

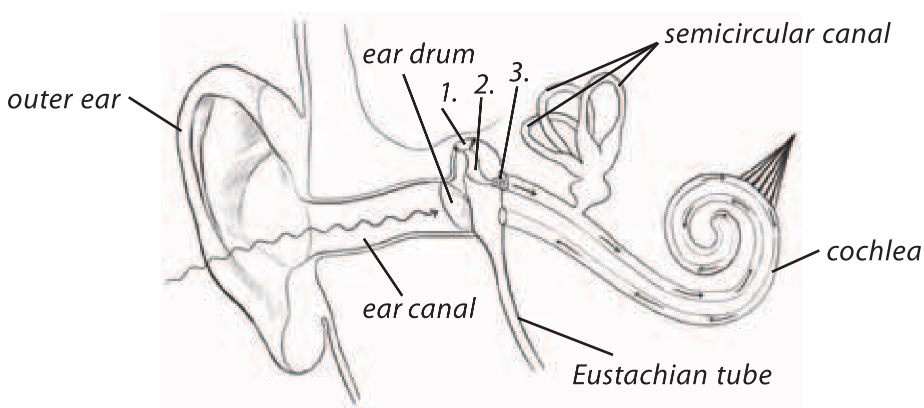
Think about the results of this experiment.

i) Where are the touch sense receptors closest together in the skin of the arm, palm, and fingertips?

ii) Where are the touch sense receptors furthest apart in the skin of the arm, palm, and fingertips?

Question 12

The diagram below shows a section through the human ear.



1. hammer

2. anvil

3. stirrup

a) Sound waves enter the ear and move towards the ear drum. What happens to the ear drum when a sound wave hits it?

b) Which part of the ear generates or makes electrical signals to send to the brain?

c) Shahid is playing his stereo in his bedroom. He turns the volume down to make the sound quieter.

   i) What effect will this have on what is happening to his ear drum?

   ii) The next track on his CD has a much lower pitch. What difference will this make to the way that Shahid's ear drum moves? ______

   iii) Shahid's grandma does not notice the noise of the stereo very much because she has poor hearing. Give three possible reasons why her hearing is poor.

Answers to Assessment questions

Question 1

Human skin has nerve endings sensitive to **touch**, pressure, pain and **temperature**. These, and other sensory nerve endings are called **receptors** because they 'receive' signals or stimuli from the outside world. Most touch and **pressure** receptors are concentrated in the skin of the **tongue** and fingertips. These receptors detect the **texture** of objects: whether they are hard or soft, rough or smooth. Touch receptors are also attached to the roots of hairs. Pain receptors are more evenly spread across the skin. They are also found inside the body in most **organs** and tissues. **Pain** acts as a warning signal. It tells the **brain** that something is wrong with the body. There are separate heat and **cold** receptors in the skin. These are used to detect changes in temperature. Your fingertips can detect temperature differences as small as 0.5°C.

Question 2

(A) iris

Question 3

(C) sclerotic

Question 4

(C) he cannot judge how far away the ball is

Question 5

(D) taste, smell, and feel

Question 6

(C) his blocked nose cuts out his sense of smell

Question 7

(B) transmit sound vibrations

Question 8

(D) her sense of smell has become used to that smell

Question 9

(A) sweet, sour, salt, and bitter

Question 10

A) allows light into the eye

B) optic nerve

C) to change the shape of the lens and focus light on the retina

D) rods and cones

E) conjunctiva, cornea, and lens

Question 11

i) The touch sense receptors are closest together in the skin of the fingertips.

ii) The touch sense receptors are furthest apart in the skin of the arm.

Question 12

a) It vibrates.

b) the cochlea

c) i) The vibrations will be smaller/have lower amplitude/less energy.

ii) It will vibrate more slowly/the vibrations will have lower frequency.

iii) any three from: hearing deteriorates/gets worse with age; her ears may have been damaged by loud noise/illness/infection; there might be wax blocking her ears; the nerves in her ears might be damaged.

Photosynthesis and respiration in plants

CHAPTER 3

Teaching Objectives

- An examination of the internal structure of a leaf and its importance in the process of photosynthesis
- To introduce the idea that photosynthesis is the process by which plants make food using water, carbon dioxide, and light energy from the Sun
- To identify the factors that affect the rate of photosynthesis
- To show experimentally that photosynthesis takes place in a leaf
- To show that aerobic respiration is the process of breaking down glucose in the presence of oxygen to release energy from food
- To explain the differences between photosynthesis and respiration

Learning Outcomes

After studying this chapter students should be able to:

- describe the internal structure of a leaf
- define photosynthesis
- explain the importance of photosynthesis in plants
- describe the effects of different factors on the process of photosynthesis
- explain how the structure of leaves facilitates photosynthesis
- prove experimentally that photosynthesis takes place in a leaf
- explain the process of respiration in plants and its importance
- compare and contrast the processes of photosynthesis and respiration in plants

Introduction

Photosynthesis is vital for virtually all forms of life on Earth. It is the route by which energy enters every ecosystem. Although the chemical reactions which take place during photosynthesis are complex, it is possible to give students a general knowledge of the process and its significance. This chapter also deals with respiration in plants—the process by which plants release the energy for growth, movement, and other functions from the food they have stored. This is also an opportunity to dispel the popular myth in the minds of many young (and some not so young!) people that plants photosynthesise by day and breathe by night or, equally common, that plants breathe in carbon dioxide and animals breathe in oxygen!

It should be mentioned here that many of the experiments which seek to discover whether photosynthesis has occurred rely on testing the leaves of the plant for the presence of starch. In order to do this, it is necessary to first remove the chlorophyll from the leaves or other plant parts being tested. Hot ethanol is used for this purpose, and it is important **not to use ethanol near a lighted Bunsen burner**. There have been a number of accidents in school laboratories involving fire and burns arising from the ignition of ethanol vapour. As in all experiments with an element of risk, if you are in doubt about the ability of your students to follow instructions to the absolute letter, then it is better if the teacher demonstrates these experiments.

1. Photosynthesis

Refer to page 24 of the Students' Book.

Starter suggestions

Write the word 'photosynthesis' on the board. Split it into its two parts 'photo' and 'synthesis'. Ask the students whether they can think of any other words that use one or other of these two parts of photosynthesis. 'Photo', 'photography', 'synthesiser', 'synthesis', and 'synthetic' may be mentioned. Establish that the word 'photosynthesis' really means 'making things with light'.

Alternatively, show the students a piece of white clothing, such as cricket trousers or shorts or a white T-shirt that has grass stains on it. Alternatively rub a piece of white rag on the grass to stain it green. Establish that there is green colouring called, chlorophyll, in grass and other plants. Write the word 'chlorophyll' on the board and tell the students how to pronounce it.

Explain that the job of the green pigment chlorophyll is to absorb sunlight energy and to manufacture the plant's food. It is one of the most important substances in the world. Without chlorophyll we would not be here!

Main lesson

Demonstrate how we can extract chlorophyll from a plant. Cut up some grass or a green vegetable such as lettuce, spinach, or water cress into small pieces. Place it in the bottom of a mortar with a little sharp sand. Add a teaspoon or so of ethanol (**Safety:** remember, no naked flames!) and grind the plant material to a pulp. Filter the mixture into a test-tube and hold it in front of a bright light. Normally the solution will appear a bright green colour.

Place a filter paper on top of a clean beaker and, using a pipette, slowly and carefully place two or three drops of the chlorophyll solution in the centre of the filter paper and allow it to diffuse outwards. When the filter paper has dried, it will be seen that chlorophyll is not, in fact, one green colour but a combination of colours. This may help the students to understand why leaves change colour in the autumn.

If time permits, extract and make chromatograms of different coloured leaves. The results should show that chlorophyll is present but masked by other pigments. Show the students some examples of variegated leaves, such as those of spider plant or a variegated geranium or ivy plant. Establish that the white or yellow parts of these leaves do not contain chlorophyll.

2. The raw materials and products of photosynthesis

Starter suggestions

This lesson requires a series of demonstration experiments which are best set up before the lesson.

Start the lesson by explaining that carbon dioxide and water are the raw materials of photosynthesis. They react in some way to produce glucose and oxygen and the glucose is eventually turned into starch which the plant is able to store.

Main lesson

Demonstrate how we test for starch. Shake a little starch powder with water in a test-tube and then add two or three drops of iodine solution. Hold the test-tube against a light and the characteristic blue-black colour will be present. The plants used in the following experiments also have to be de-starched. This is done by putting them in the dark for a few days so that they use up their reserves of starch.

Testing a leaf for starch

a) In order to test a leaf for starch, the leaf is first dipped into a beaker of boiling water for about 10 seconds. This kills it and softens it.

   Turn out the Bunsen burner and move it right away. Put the leaf in a test-tube of ethanol. Stand the test-tube in the beaker of hot water for about 10 minutes. The ethanol will boil and will remove the chlorophyll from the leaf.

   Wash the leaf by waving it to and fro in the beaker of hot water.

   Put the leaf in a petri dish or lay it on a white tile. Carefully cover it with dilute iodine solution. A blue-black colour will show that starch is present.

b) Do plants need chlorophyll to make starch?

   You need a potted plant with variegated leaves, such as a geranium or coleus plant. Do not use grass or some other plant with narrow strap-shaped leaves as these do not make starch. The plant you use should have been kept in the light for several days.

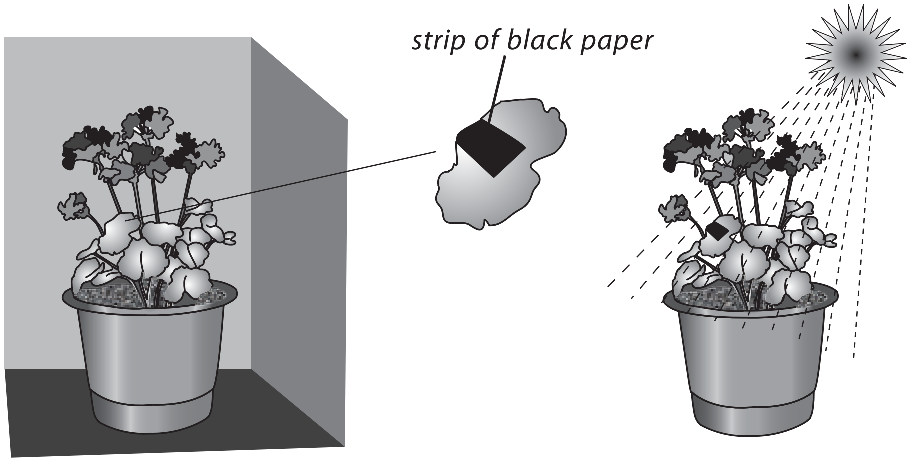
   Detach one of the larger leaves and draw its upper surface, perhaps on graph paper. Make a clear distinction between the green and yellow areas of the leaf.

   Now carry out the starch test on the leaf, as described above. Point out that starch is only present in the areas of the leaf where there was chlorophyll.

c) Do plants need light in order to make starch?

   You will need a potted geranium plant which has been de-starched by keeping it in the dark for two or three days.

   Attach a strip of black paper or metal foil to the upper and lower sides of one of the leaves.



Put the plant in a well-lit place.

After several days, detach the leaf and test it for starch. Make a drawing of the leaf to show where starch was present and where it was absent.

d) To find out whether a plant needs carbon dioxide to make starch

You need two potted geranium plants which have been de-starched.

Put a small dish of dampened soda lime on the soil beside one of the plants. Cover the plant with an unperforated, clear, plastic bag. Secure the bag with elastic bands or sticky tape. The soda lime will absorb carbon dioxide from inside the bag, so the plant will have little or no carbon dioxide.

Put an identical small dish of saturated sodium bicarbonate solution on the soil beside the second plant. Cover the plant with an identical, clear, plastic bag, as before. The sodium bicarbonate solution will slowly release carbon dioxide into the air in the bag, so this plant will have plenty of carbon dioxide.

Place both plants in a well-lit place for about 48 hours. After 48 hours, remove a leaf from each plant and test them for starch.

Which plant contains starch? Is carbon dioxide needed for starch-formation?

e) Do water plants give off oxygen?

Put some Canadian pondweed, or some other suitable water plant, or a sprig of mint, into each of two separate beakers of water.

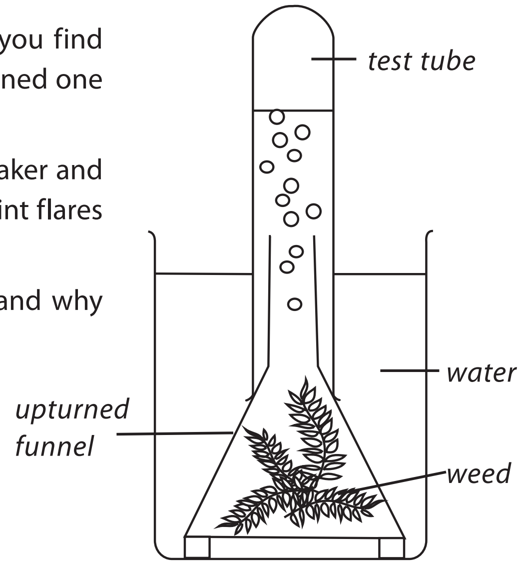
Cover the weed with an upturned funnel and test-tube, as shown in the illustration on page 43.

Place one of the beakers in the light and the other one in the dark.

After a few days, compare what has happened in each case. Do you find that the illuminated plant has produced some gas, while the darkened one has not?

To show that the gas is oxygen, remove the test-tube from the beaker and quickly insert a glowing splint to the bottom of the tube. If the splint flares up, there is a high proportion of oxygen in the tube.

Discuss what the controls are in each of the above experiments and why they were necessary.



3. Leaves and photosynthesis

Refer to page 24 of the Students' Book.

Starter suggestions

Bring a collection of leaves of different types into the classroom, or ask the students to bring in small collections of their own. Examine the shapes of the leaves and notice, in particular, the arrangement of the veins on the undersides of the leaves. There are in fact two main arrangements of the veins in flowering plants: parallel veins in the leaves of grasses and other plants with narrow, strap-shaped leaves (these are called monocotyledons) and branching veins in most other plants (called dicotyledons).

Remind the students that we have shown that, during photosynthesis, light is necessary and that starch and oxygen are products.

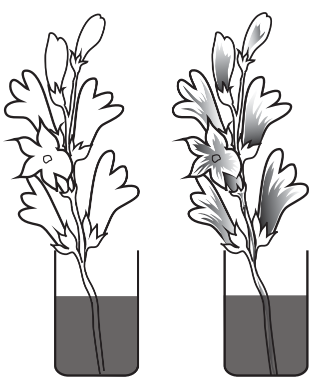
The word equation for photosynthesis is:

$$\text{carbon dioxide + water} \longrightarrow \text{glucose + oxygen}$$

Ask the students how the water gets into the plant. How does the carbon dioxide get into the plant? In the case of the water, the students may well say that the water gets into the leaves. This misconception is easily dismissed by showing them that water will run off a leaf—leaves have a waterproof layer called the cuticle.

Main lesson

Ask the students to make drawings of some of their leaves, showing the veins on the undersides. Point out the large surface area of most leaves. If there is time, the students could estimate the surface area of one or two leaves by laying them on squared paper and drawing around the outline of the leaves and then counting the squares covered by the leaves.



Now return to the subject of how the water needed for photosynthesis gets into a plant. Show the students a tuberose stem and the veins on it. You could, if you wish, stand the tuberose stem in water stained red with ink or food colouring, and show how the coloured water passes up the veins into the leaves and flowers of the tuberose. Ideally this should be set up several days before the lesson. Alternatively, stand a white flower in water with red colouring added to it and notice that eventually the flower turns red.

Ask the students how air (containing carbon dioxide) might get into the leaves of the plant. You could give them a clue by plunging a geranium leaf, or some other large leaf, in near-boiling water. Air bubbles will rise from the underside of the leaf.

Well before the lesson also, paint transparent nail varnish on the underside of leaves of tradescantia plants. During the lesson, get the students to carefully peel off the hardened nail varnish and examine the leaf, first under the low power of a microscope, and then under a higher power. Explain that the little pores they see are called stomata (singular: stoma). The two sausage-shaped cells either side of the pore are called guard cells. They bend to allow oxygen and surplus water out of the leaf, and air into it. Mention that some leaves have very large numbers of stomata, more than a thousand per square millimetre in some cases.

Show the students a prepared microscope slide of a vertical section through a leaf so that they can see its internal structure. Alternatively, use a PowerPoint slide, photograph, or the diagram on page 26 of their textbook. Point out the waterproof cuticle, the palisade cells containing lots of chloroplasts, and the spongy mesophyll cells with the large air spaces in between. Explain that the section that they are looking at is highly magnified—most leaves are less than a millimetre thick. This cuts down the distance the carbon dioxide has to diffuse after it has entered the leaf.

4. Plants and respiration

Refer to page 27 of the Students' Book.

Starter suggestions

Show the students a collection of photographs, or better still, a time-lapse film, of plants moving. Suitable pictures could include an insectivorous plant catching insects, a sensitive plant (mimosa) folding its leaves when it is touched, a daisy or some other flower closing up for the night, the tendrils of a pea or runner bean attaching to some support, or seedlings pushing their way through the soil. Emphasise that plants, like animals, are able to move and lift things but, unlike animals, plants move very slowly. Therefore, they do not need large amounts of energy and we cannot expect them to respire large amounts of food in the way that an animal would.

Remind the students that the word equation for respiration in both plants and animals is:

$$\text{glucose} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water} + \text{energy}$$

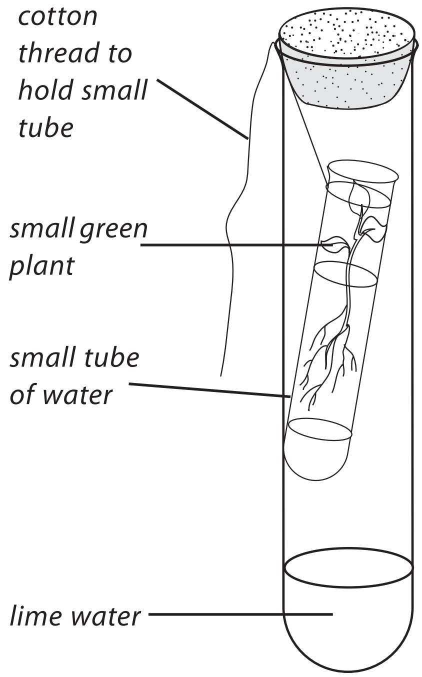
Again, remind them that this equation is the opposite of that for photosynthesis.

Main lesson

If a supply of oxygen is available, it would be informative to show the students that glucose can release energy, although in this demonstration, the energy is being released much faster than it would be in either a plant or animal. This is what you do:

Prepare a gas jar of oxygen (this must be completely dry). Put a small piece of glucose in a deflagrating spoon and heat it strongly until it begins to burn with a blue flame. Quickly plunge the burning glucose into the jar of oxygen, when the glucose will rapidly burn away.

You could then go on to set up an experiment to show that green plants produce carbon dioxide, or you could show the students the results of an experiment set up the previous day. Either way, you need at least two sets of the apparatus shown to the right:



Prepare two sets of the apparatus, the only difference between the two being that there is a little lime water at the bottom of one of the large tubes and an equal volume of distilled water at the bottom of the other. Put the tubes in a dark cupboard and leave them for a few hours. If the tubes are properly sealed, the lime water should have gone milky in the experimental tube, showing that carbon dioxide has been produced. The control tube should be unchanged.

You could emphasise that the amount of carbon dioxide produced when plants respire is very small and, of course, in sunlight, it is used up in photosynthesis. This is an opportunity to dispel another myth, that you should remove plants from a hospital ward or bedroom at night in case they use up the oxygen you need to breathe!

If there is time, demonstrate some of the other experiments on plant respiration and growth described in the next section.

Ideas for investigations and extension work

Sun and shade leaves

Collect several leaves of the same species of plant (ivy is ideal), one growing in the shade and the other growing in full sunlight. Measure the areas of some of the leaves from each location and see whether there is any difference. If there is, can you explain it? (Usually the leaves from the shade are larger in area than those growing in full sunlight. The plant has produced larger leaves in the shade to gain the maximum amount of light for photosynthesis.)

Testing a leaf for glucose

Cut up a leaf into small pieces and put them in a mortar. Add a pinch of sharp sand and cover the leaf fragments with water.

Grind up the leaf fragments with a pestle.

Filter the contents of the mortar into a test-tube to a depth of about one centimetre.

Add an equal volume of Benedict's solution to the test-tube. Stand the test-tube in a beaker of boiling water until its contents boil.

As a control, instead of the plant mixture, place about one centimetre of water in a second test-tube, add Benedict's solution and boil.

What happens to the solutions in the two test-tubes? A green, red, or brown colour means there is glucose present.

What effect does raising the light intensity have on the rate of photosynthesis?

Cut off a sprig of Canadian pondweed about 5 cm long.

Attach one or more paper clips to its tip to weigh it down.

Put it in a beaker or jar of water.

Add a pinch of potassium bicarbonate to the water to ensure the pondweed receives plenty of carbon dioxide.

Have a desk lamp or microscope lamp ready and place it to one side.

Fill a narrow aquarium with water or a tall, narrow, storage jar of water and place it between the pondweed and the lamp. This will act as a heat shield and stop the water around the pondweed from warming up.

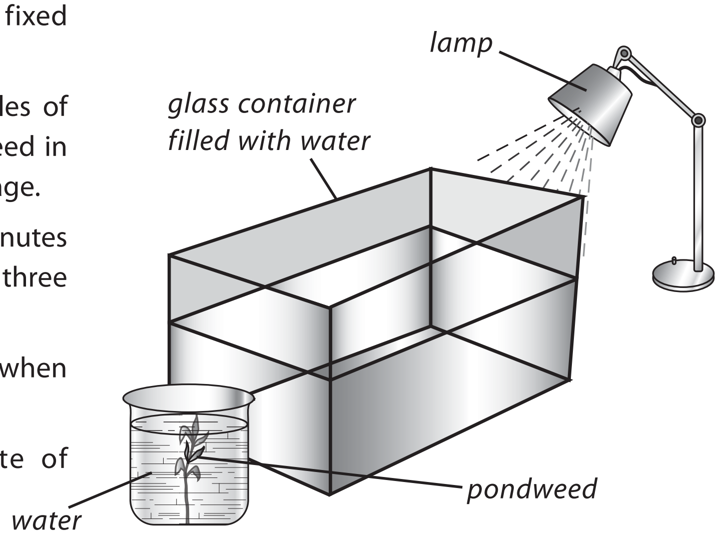
Darken the room, turn on the lamp and move it a fixed distance (say 50 cm) from the pondweed.

Wait a few minutes and then count how many bubbles of oxygen are given off from the cut stem of the pondweed in one minute. Do this three times and work out the average.

Now bring the lamp closer, say to 25 cm. Wait a few minutes and then count the number of bubbles again. Do this three times and find the average.

Does the rate at which bubbles are produced increase when the lamp is nearer to the pondweed?

Does raising the light intensity increase the rate of photosynthesis? (Yes, it does.)



Stored food

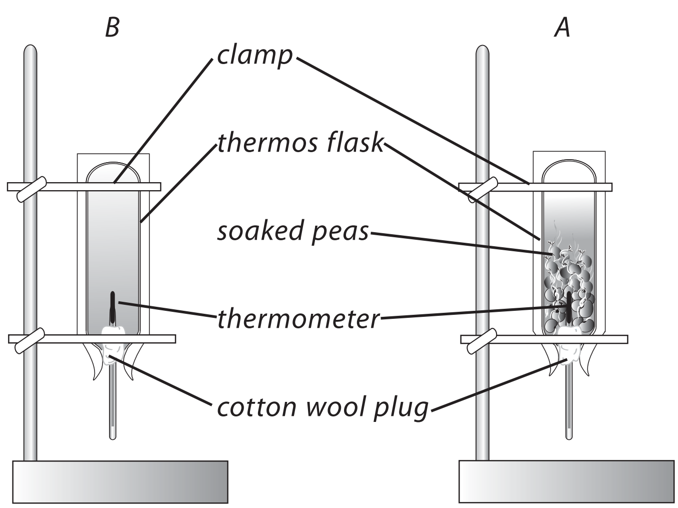
Test some fruits and root vegetables such as carrots and potatoes for the presence of starch and glucose, as described earlier.

Do plants set free heat energy?

For this experiment you need two identical thermos flasks and some soaked pea seeds which are just beginning to grow and which have their tiny roots beginning to show.

Put a handful of the peas in one flask and label it 'A'. Put a thermometer into the flask and plug the mouth of the flask with cotton wool. Read the temperature shown by the thermometer and write it down.

Set up the second flask in the same way but without any pea seeds in it. Read the temperature shown by the thermometer and write it down. Label this flask 'B'.



Turn both flasks upside down and fix them in retort stands as shown. Make sure that the thermometer in flask A is in the middle of the seeds.

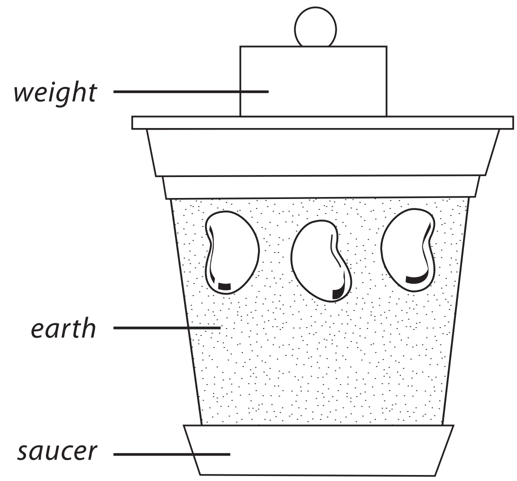
Leave the apparatus for about four hours and then read the temperature in both flasks again.

Does the temperature change? In which flask does it change most? (flask A) Do living plants set free heat energy? (Yes, they do.) What was the reason for setting up flask B? (as a control)

The lifting power of seedlings

You could, if you wish, demonstrate the lifting power of seedlings with this experiment:

Soak some bean seeds in cold water until they are just beginning to grow. Fill a plant pot nearly to the top with damp soil and then carefully push in the seeds until they are well covered. Stand the pot in a saucer to which a little water is added daily.



Lay a piece of wood a little bigger than the top of the pot over it and place a weight (say 100 g) on top of it. Leave the experiment for several days until the shoots of the seedlings break through the soil and push up the wood and the weight resting on it.

Again, stress that the seedlings are using energy (from respiration) to push up the wood and the weight.

Answers to questions in the Students' Book

1. The main difference between plants and animals in the way they obtain their food is that plants make their own food from simple raw materials (carbon dioxide and water) during the process of photosynthesis. Animals need ready-made food and obtain it either by eating plants, or by eating animals that have fed on plants.
2. The two raw materials for photosynthesis are carbon dioxide gas from the air and water from the soil (or from the surroundings if the plant is aquatic).
3. The chemical process that provides a plant with its energy is respiration. This process occurs all the time, by night and by day.
4. It is an advantage for leaves to be broad, so that they expose the maximum area to the sunlight needed for photosynthesis. It is an advantage for leaves to be thin, so that the sunlight can penetrate through to the chloroplasts and carbon dioxide and oxygen can diffuse into and out of the leaf.
5. Photosynthesis usually stops at night, because light is necessary for it to occur, and it stops in very cold weather because the enzymes responsible for photosynthesis will only carry out their chemical reactions between certain (warm) temperatures.

6. The leaf in the experiment may have been photosynthesising (taking in carbon dioxide and giving out oxygen), but at a slower rate than respiration was occurring. The temperature or amount of light may have been too low for photosynthesis to occur at a rate where the amount of oxygen given out exceeded the amount being used by the leaf for respiration.
7. The amount of oxygen in the atmosphere stays more or less constant because the oxygen produced by plants during photosynthesis balances the amount of oxygen used by plants and animals during respiration.

Assessment

Question 1

The raw materials for photosynthesis are:

(A) nitrogen and water
(B) nitrogen and carbon dioxide
(C) carbon dioxide and water
(D) carbon dioxide and oxygen

Question 2

The products of photosynthesis are:

(A) carbon dioxide and oxygen
(B) carbon dioxide and glucose
(C) glucose and oxygen
(D) starch and carbon dioxide

Question 3

The energy for carrying out photosynthesis is obtained from:

(A) chlorophyll
(B) oxygen
(C) sunlight
(D) carbon dioxide

Question 4

Green plants produce carbon dioxide:

(A) only at night
(B) only during the day
(C) all the time
(D) none of the time

Question 5

Many plants change the glucose produced during photosynthesis into:

(A) starch
(B) carbon dioxide
(C) fats
(D) mineral salts

Question 6

A leaf is tested for the presence of starch. When is most starch likely to be present?

(A) after rain
(B) first thing in the morning
(C) after several hours of darkness
(D) after a long sunny day

Question 7

The products of respiration are:

(A) carbon dioxide and starch

(B) carbon dioxide, water, and energy

(C) oxygen and carbon dioxide

(D) oxygen, carbon dioxide, and energy

Question 8

Pervez set up an experiment to investigate photosynthesis and respiration. He set up four test tubes, all the same size. The four test tubes are shown in the picture on the right. The test tubes were sealed to make them completely airtight and placed next to each other on a sunny window sill.

a) In which test tubes will oxygen be produced?

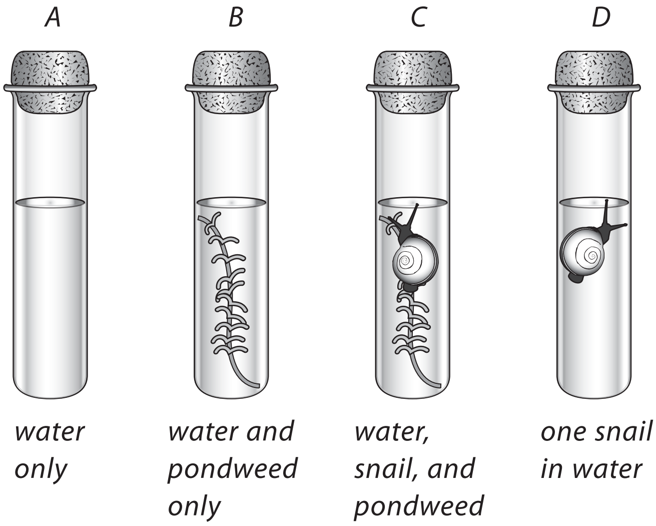
____

b) In which test tube will there be the greatest amount of oxygen left over?

____

c) In which test tube will the snail be able to live the longest?

____



Question 9

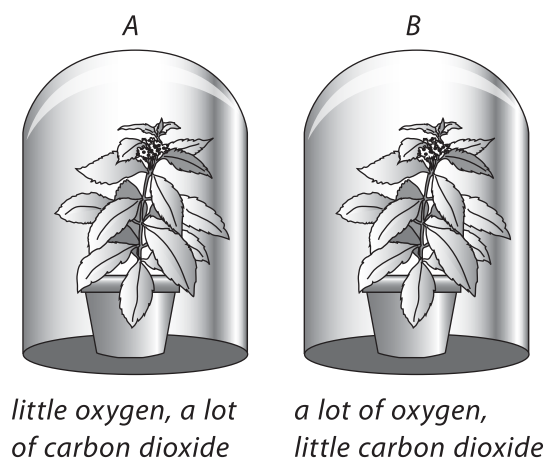
Two similar green plants were placed under bell jars, as shown in the picture on the right. One was placed in the dark and the other in the light. After a few hours, the air in the jars was tested for oxygen and carbon dioxide. The results are shown in the picture:

i) Which bell jar was placed in the light?

____

ii) Explain your answer.

____



Question 10

In the 1980s a group of scientists lived inside a sealed dome called a biosphere in the desert in Arizona in the United States. The biosphere covered 1.27 hectares and had 6,500 sealed glass windows. The scientists managed to grow enough crops to feed themselves. The crops they grew also provided them with the oxygen they needed to breathe.

a) Name the process by which plants make their food.

b) Glucose is made from carbon, hydrogen, and oxygen. Explain where plants get the carbon from to make glucose.

c) The diagram shows a section through one of the leaves from the biosphere.

A piece of a leaf (magnified)

i) Draw an arrow on the diagram to show where the leaf adds oxygen into the atmosphere.

ii) Label the structures that are responsible for trapping the energy in sunlight.

iii) Explain why these structures are mainly found in the upper layers of the leaf.

d) One of the worries the scientists had was whether the plants would remove oxygen from the air during the night. Explain how the plants might remove the oxygen.

e) The experiment was eventually stopped because the level of oxygen in the biosphere began to drop. The reason was that not enough light was entering the biosphere. Explain why a shortage of light would reduce the oxygen level in the biosphere.

Question 11

a) Complete the word equation for photosynthesis by picking out the correct word from each box:

oxygen nitrogen carbon dioxide	+	glucose water oxygen	⟶	nitrogen glucose carbon dioxide	+	oxygen water nitrogen

i) Explain why chloroplasts which absorb light energy are found mainly near the upper surface of a leaf.

ii) What is the name of the green pigment that traps light for photosynthesis?

iii) Plants carry out photosynthesis only during daylight, but they respire all the time. Explain why plants are able to produce a surplus of oxygen when they spend longer respiring than they do carrying out photosynthesis.

iv) What happens to most of the oxygen produced during photosynthesis?

v) Glucose is made from carbon, hydrogen, and oxygen. Explain where plants get the carbon from.

vi) Write down **two** ways in which the shape of a leaf helps it to carry out photosynthesis.

Question 12

Khalid found a blackberry plant growing in a shady place and another blackberry plant growing in a sunny place.

i) Khalid found that the plant in the shady place had larger leaves. Why is it an advantage for plants in the shade to have leaves with a larger area?

ii) Both blackberry plants had green leaves. Which part of the leaf cells makes the leaf green?

Question 13

a) A large area of forest is cut down. The branches are then burnt. Give **two** reasons why this may increase the amount of carbon dioxide in the air.

b) Write down the chemical reaction for respiration as a word equation.

c) Which substance in the equation is a reactant in photosynthesis and a product of respiration?

d) Open spaces with lots of trees and green plants are sometimes called the 'lungs of a city.' Suggest why this is.

e) Why is it possible to grow plants in a closed glass bowl or jar, but a goldfish bowl must be open to the air for the goldfish to survive?

Question 14

a) Ahmad grew some sunflower plants in his garden. He planted some under a tree and some in full sunlight. The plants in full sunlight grew much better than those under the tree.

Explain why the plants grew better in full sunlight.

b) Ahmad planted some sunflowers in a greenhouse. He noticed that they grew much faster than the plants outside, even though they received the same amounts of sunlight and water.

i) Suggest a reason for this.

ii) Ahmad's teacher said that the sunflowers in the greenhouse had more **biomass** than the sunflowers outside in the garden. What does biomass mean?

Answers to Assessment questions

Question 1

(C) carbon dioxide and water

Question 2

(C) glucose and oxygen

Question 3

(C) sunlight

Question 4

(B) only during the day

Question 5

(A) starch

Question 6

(D) after a long sunny day

Question 7

The products of respiration are:

(B) carbon dioxide, water, and energy

Question 8

a) Oxygen will be produced in test tubes B and C.

b) The greatest amount of oxygen will be left in test tube B.

c) The snail will be able to live longest in test tube C.

Question 9

i) Bell jar B was placed in the light.

ii) Bell jar B contains less carbon dioxide and more oxygen because the plant has carried out photosynthesis in the light.

Question 10

a) photosynthesis

b) carbon dioxide from the air

c) i) stoma (the pore at the bottom of the leaf)

ii) chloroplasts inside the cells near the upper surface

iii) to trap as much sunlight as possible

d) Because there is no light at night the plants will respire and use oxygen.

e) The rate of photosynthesis increases as light levels increase. If light levels fall, the rate of photosynthesis will slow and less oxygen will be produced.

Question 11

b) The word equation for photosynthesis is:

$$\text{carbon dioxide + water} \longrightarrow \text{glucose + oxygen}$$

i) The chloroplasts which absorb light energy are found mainly near the upper surface of a leaf because that is where sunlight normally strikes the leaf.

ii) The green pigment that traps light for photosynthesis is chlorophyll.

iii) Plants are able to produce a surplus of oxygen because, unlike animals, they do not move around and therefore do not use a great deal of energy which would require the use of oxygen.

iv) Most of the oxygen produced during photosynthesis diffuses out of the leaf pores (stomata) into the air.

v) The carbon in glucose comes from the carbon dioxide which green plants use during photosynthesis.

vi) The broad shape of a leaf helps it to carry out photosynthesis because a large area is exposed to sunlight. The fact that the leaf is thin means that gases can diffuse into and out of the leaf easily. The veins in the leaf bring water and mineral salts to the leaf and carry away glucose.

Question 12

i) It is an advantage for plants in the shade to have leaves with a larger area to absorb the maximum amount of light for photosynthesis.

ii) The chloroplasts are the part of the leaf cells which make the leaf green.

Question 13

b) Glucose + oxygen $\longrightarrow$ carbon dioxide + water + ENERGY

c) Oxygen is a reactant of respiration and a product of photosynthesis.

d) In sunlight, green plants take in carbon dioxide and give out oxygen. Our lungs take in oxygen from the air and give out air containing more carbon dioxide. Photosynthesis thus provides a continuing supply of oxygen for the people and other animals in the city. It also takes away the carbon dioxide produced by people and other animals and also the carbon dioxide produced by the combustion of fossil fuels.

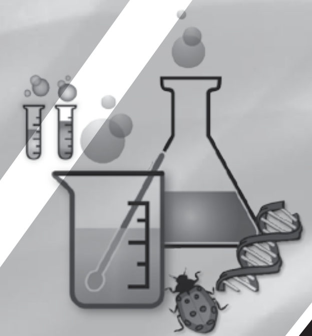
e) Plants carry out both photosynthesis and respiration. During photosynthesis, plants take in the carbon dioxide produced by respiration and give out oxygen to be used for respiration. Goldfish and other animals have no way of removing carbon dioxide and replacing it with oxygen, so the goldfish will die unless there is a constant source of oxygen to replace the oxygen it is using during respiration.

Question 14

a) The sunflowers under the tree would have less water and sunlight, so their rate of photosynthesis would be lower than that of the ones in sunlight. The plants under the tree would also have fewer mineral salts.

b) i) It is likely to be warmer in the greenhouse which would make the sunflower plants grow faster.

ii) Biomass is the total mass of living organisms in an area.



Living things and the environment

CHAPTER 4

Teaching Objectives

- To explain the components of the environment
- To explain and compare the biotic and abiotic components of the environment
- To illustrate how living things depend on one another for food, shelter, and protection
- To examine some of the different relationships between organisms
- To illustrate how living organisms interact with each other and with the non-living or abiotic parts of their environment

Learning Outcomes

After studying this chapter students should be able to:

- identify the components of the environment
- compare the physical factors which make up the environment of a desert and a rainforest
- describe the relationship between biotic and abiotic components of the environment
- understand that living things depend on one another for food, shelter, and protection
- explain the different relationships between organisms
- give examples of how organisms interact with each other and with non-living parts of their environment

Introduction

Living things are found almost everywhere on Earth: on land and in the air, in water, and underground. You will find them in the most unlikely places, such as hot, dry deserts and the freezing cold Polar regions. There are living organisms in salt lakes and in hot springs where the water is almost at boiling point. Many organisms live inside or on the bodies of other organisms.

The place where an organism lives is called its habitat. The conditions which exist in its habitat make up the environment, and there are both living (or biotic) and non-living (or abiotic) components of the environment. Every organism is suited, or adapted, to live in its particular environment. For example, some animals are wonderfully camouflaged so that they cannot easily be seen by their predators. Organisms can survive only if they are suitably adapted. But not only are organisms adapted to their environment, they are also dependent on one another for food, shelter, and protection.

Ideally students need first-hand experience of habitats and the populations of living things they support. But of course, not all schools are located in areas where there are opportunities for extensive fieldwork. School grounds are probably the most likely choice, especially if time is limited. Many urban schools may have access to a park or public garden or an area of waste ground, however small. However, there is no denying the advantage of taking students away from their immediate environment and into a 'natural' community if time and finance permit. For these reasons, the lesson suggestions given here are rather general, dealing with preparation and techniques, rather than giving detailed suggestions for work to be carried out.

Preparation

Before embarking on any fieldwork activity, it is also important that the teacher consult his or her employing authority to obtain the appropriate guidelines for school visits, particularly those relating to the health, safety, and number of supervising adults needed for a group of students working away from school.

It is also very important that the teacher is familiar with the area to be studied. It is a big advantage if he or she can visit the site several times before taking students. In that way, any health or safety issues can be identified and a background knowledge of the plants and animals living on the site can be gained.

It is essential that the students be appropriately dressed for fieldwork. It is inevitable that at least some students will get dirty, so informal clothing is best. It should, however, be sensible enough to provide protection from the heat, cold, wind or rain, and from abrasions. Strong shoes or boots are essential if serious walking is to be included in the work. Each student should also have a shoulder bag, such as a small rucksack, in which notebooks, identification guides, pencils, plastic bags, labels, and the all-important packed lunch can be carried.

Woodland habitats are ideal for investigative work and to demonstrate the complexities of a natural or semi-natural community. It is relatively easy to observe and record the distribution of individual species within it and to compare the effects of light and shade on plant distribution. There are, however, many other suitable habitats where comparisons can be made, including waste ground, coastal habitats and marshy areas (Take care here.) Teachers will no doubt think of many more suitable habitats. Provided students are given the opportunity to count populations and relate the distribution of populations to each other, then almost any area will do, even the school playing field.

However, if all else fails, it is important to remember that there are many suitable films, television programmes, and DVDs which demonstrate the plant and animal life and important differences in physical conditions between ecosystems, including deserts and tropical rainforests.

Lesson suggestions

1. The value of plants

Refer to page 30 of the Students' Book.

Starter suggestions

Review the reasons why plants are essential for the existence of life on Earth, and how animals and plants depend on each other.

Ask the students to work in small groups and to discuss why humans may need to take plants into space with them if they are to be away from Earth for long periods. Discuss the reasons they give and ask them to suggest which plants would be suitable for such a project.

Main lesson

In order to continue to stress the importance of plants to living things, move on to consider the importance of plants to people. Let the students work individually or in small groups to copy and complete the table below. It may be necessary to adjust the size of the boxes and the numbers of examples asked for in the light of local circumstances. Some of the work could be carried out for homework if desired.

The value of plants	
List ten local shops that sell plant products	
List twenty foods from your kitchen. Put a circle around those which come directly from plants.	
List ten things from your bathroom used for health and cleanliness. Put a circle around those which are made from plants.	
Look at your own and the school's sports equipment. How many items are made at least partly from trees?	
Look at your own and the school's musical instruments. How many items are made at least partly from trees?	
What plants were used to make the clothes you are wearing?	
Look in the local telephone directory. Find ten jobs which rely on plants.	
What parts of a car are made from plants?	
List five birds and five insects which could not live in the school grounds or the local park if there were no plants.	
In what other ways do we depend on plants?	

2. Natural resources we need

Starter suggestions

Explain to the students that before humans began to change their environment, 60 per cent of the Earth's surface was covered by forests. Now less than 30 per cent is forested, and the forests are still being cut down at an alarming rate. Discuss with the students why forests, and particularly tropical rainforests, are being cleared. What impact is this going to have on people, wildlife, the world's climate?

Main lesson

Write the following on the board:

Forests are being cleared because people want natural resources such as:-

- **SPACE** for houses, farms, factories, roads, etc.
- **ENERGY** for cooking, lighting and heating.
- **MINERALS** for industry, jewellery and ornaments, and fertilizers.
- **WATER** for farms, houses and industry
- **ORGANISMS** for food, drugs and medicines, and materials such as wood and paper.

Ask the students to work in pairs and to list twenty ways in which they have helped to use up the natural resources of the world. At the end of the allotted time, compile a class list of natural resources you and the students have used.

Ask the students to imagine they are stranded in a rainforest. What would they need to survive? How would they fulfil their needs? Ask them to write their answers in the form of a table like the one below.

My survival kit

My needs	How I would fulfil them
1. food	
2. shelter	
3.	
4.	
5.	

3. Woodland or forest plants

Starter suggestions

Draw this chart on the board. It shows the typical composition of the vegetation in an area of rainforest measuring 30 m × 5 m.

Plant form	Trees more than 10 cm in diameter	Trees less than 10 cm in diameter	Shrubs	Herbs	Climbers and epiphytes	Total
Number of different species	3	10	5	6	12	36
Percentage of total	8.3	27.8	13.9	16.7	33.3	100 per cent

Explain that shrubs are woody plants, often called bushes, which are smaller than trees. Herbs are non-woody plants, and epiphytes are non-woody plants which use trees and other plants so grow on. They are not, however, parasites, but produce their own food by photosynthesis.

Main lesson

If possible, study a small area of woodland and compare it with a similar area of tropical rainforest in terms of numbers and types of plants and their size.

SAFETY: Some students are allergic to certain plants, e.g. some flower bulbs, and pollen (from flowers), and remember that some plants are poisonous. Beware also of any animals that may bite or sting. Take a first aid kit with you on fieldwork.

You need: graph paper ruled in centimetre squares; rulers; clipboards; metric tape measure; plastic bags; four poles; 70 m of string and labels or a spirit marker pen.

What to do:

1. Mark out a plot of woodland 30 m × 5 m, using poles at the corners and string.
2. Draw a scale diagram of the plot on graph paper.
3. Record the position of each tree on the paper. This should be done systematically, starting at one end of the plot and working across it.
4. For each tree, record a) its species, b) whether the diameter of its trunk is less than 10 cm or greater than 10 cm.
5. Label five plastic bags for
   a) trees greater than 10 cm in diameter
   b) trees less than 10 cm in diameter
   c) shrubs
   d) herbs
   e) climbers and epiphytes
6. It is not absolutely necessary to identify all the various plants. For those which you cannot identify, take one leaf of each different species in the plot and place it in the appropriate bag.
7. Back in the laboratory, count the number of leaves of each plant form.

8. Copy out the table below and fill in the number of species of each plant form.

   Complete the table by working out the percentages.

Plant form	Trees more than 10 cm in diameter	Trees less than 10 cm in diameter	Shrubs	Herbs	Climbers and epiphytes	Total
Number of different species						
Percentage of total						100 per cent

- From your survey, which plant form has the greatest number of species?
- Which plant form has the fewest species?
- Compare the total number of plant species in your survey with the number in the rainforest survey. Which has the greater number of species?
- Compare the number of species of each plant form in your survey and the rainforest survey.

4. The tree preferences of woodland animals

Refer to page 31 of the Students' Book.

Starter suggestions

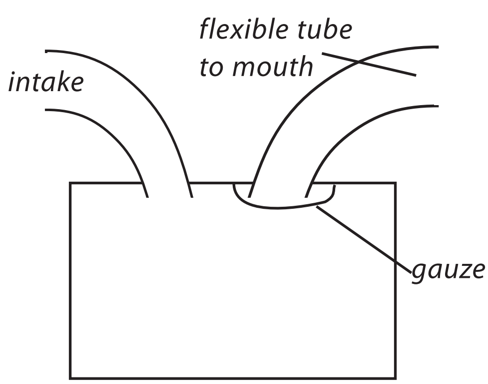
Refer back to Lesson 2, where we saw what humans need from their environment and what effect this has on the environment. In this lesson we are going to investigate the numbers and species of invertebrate animals found in different tree species and to try to decide why these invertebrate animals have selected these particular tree species.

Main lesson

SAFETY: Some students are allergic to certain plants, e.g. some flower bulbs, and pollen (from flowers), and remember that some plants are poisonous. Beware also of any animals that may bite or sting. Take a first aid kit with you on fieldwork.

For this investigation you need access to four or five different tree species; a beating sheet (a large sheet of plastic); large petri dishes (one per tree species); pooters (one per tree species); plastic spoons and small paint brushes; hand lenses; square repli dishes (one per tree species – since these are expensive and not widely available, a number of plastic pots with lids can be substituted; labels or spirit marker pen; a stop clock.

1. Select a tree and ask four volunteers to hold the beating sheet under a low branch.



A pooter, used for collecting insects

2. Shake the branch so that the invertebrate animals fall into the sheet.
3. Repeat this for other branches of the same tree for exactly 10 minutes.
4. Lay the sheet on the ground. Collect the small insects in a pooter. Use a repli dish or small plastic pots to collect spiders and a large petri dish to collect larger insects. The plastic spoon and brush may be useful for picking up the spiders and some of the smaller insects.
5. Label the containers with the name of the tree.
6. Repeat steps 1 to 5 for each of the other tree species.
7. For each invertebrate sample, sort the animals into groups and count the numbers of animals in each group.
8. Record your findings in a table like the one below, or use the recording sheet (Worksheet 4.1) on page 64.

Animal group	**Tree 1** ______	**Tree 2** ______	**Tree 3** ______	**Tree 4** ______	**Tree 5** ______
spiders					
aphids					
beetles					
flies					
moths					
caterpillars					

a) Which tree has the greatest variety of animal groups?
b) Which tree had the greatest number of animals?
c) Which of the animals were camouflaged? How?
d) Vertebrate animals, and even plants, may use the trees for food or shelter. Suggest five examples and say why the tree might be important to them.
e) Many different parts of the tree may provide microhabitats for animals, e.g. inside the leaf, under the bark and on the roots. List as many other microhabitats as you can think of, that might be found on or in a tree.
f) From the results of your investigation, which tree would it be most important to conserve? Give your reasons.

IMPORTANT: It is vital that the invertebrate animals you have collected are returned immediately after study to the tree from which they were collected.

5. The habitat preferences of woodlice

Refer to page 31 of the Students' Book.

Starter suggestions

If possible, set the students the task of locating and collecting woodlice, reminding them that these animals are fragile and are best put in collecting pots with the aid of a plastic spoon and small brush. Woodlice normally live under logs and stones in damp places.

Alternatively, build up a stock of woodlice in the laboratory. They can be kept in a small aquarium or old plastic sandwich box or clean ice cream container with perforations in the lid. Some damp moss, a piece of tree bark, and a potato or two with holes cut in them (a cork-borer is ideal for this) will keep the woodlice happy. Keep the container in a cool place. Use the opportunity of the collection to explain that woodlice are crustaceans (members of the same group as crabs and lobsters) and they breathe with gills which have to be kept moist.

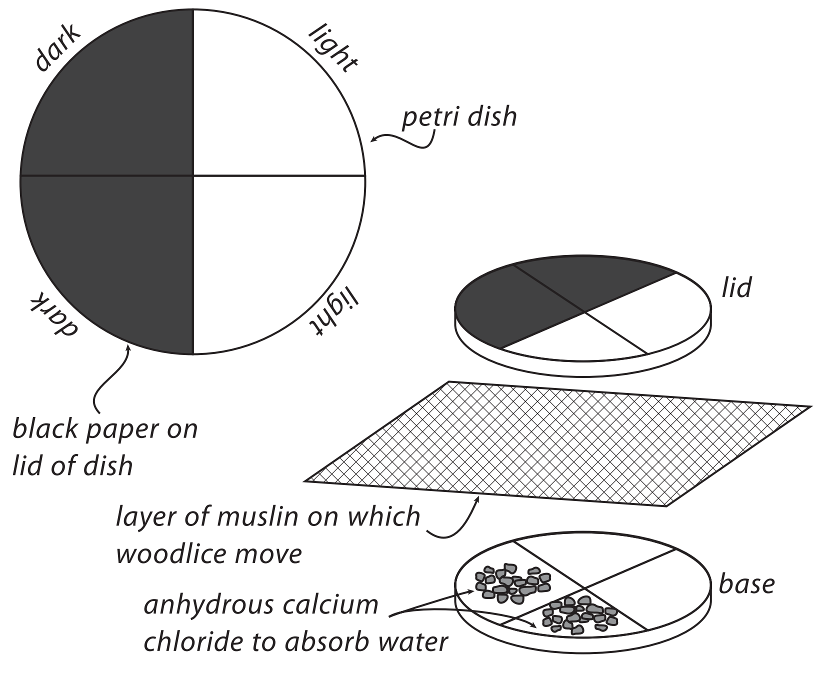
Main lesson

Ask the students how they think woodlice will react to being given a choice between wet and dry conditions and light or dark.

a) Wet and dry

Explain that they can find out by setting up a choice chamber containing, first of all a wet area and a dry area.

Set up the choice chamber as shown in the picture below. Anhydrous calcium chloride powder absorbs water, so the air on that side of the choice chamber will become very dry. By contrast, the air above the dish of water will become relatively damp. Wait at least 10 minutes for these conditions to develop.



Put about five woodlice in each side of the choice chamber. Observe the woodlice over the next 30 minutes or so. Which end of the choice chamber do woodlice seem to prefer?

On what observation do you base your answer?

Repeat this experiment with another ten woodlice. Do you obtain the same result?

b) Light and dark

Use the same choice chamber as before, having cleaned it. This time put water in both of the small dishes.

Cover one side of the choice chamber with black paper or black cloth to prevent any light entering.

Leave the choice chamber for a few minutes. Then put five woodlice in each side.

Leave the woodlice for 30 minutes or so. Which end of the choice chamber do the woodlice seem to prefer?

On what observation do you base your answer?

Repeat this experiment with another ten woodlice. Do you obtain the same result?

Devise an experiment to see whether woodlice prefer warm or cool conditions. If your teacher approves of your suggestion, try it out.

Relate the findings of all the choice chamber experiments to the conditions that exist in the animals' natural habitats.

Ideas for investigations and extension work

IMPORTANT: With all investigations where small animals are caught or trapped, it is important that they are released back into their natural habitat, or a closely similar one, as soon as possible after your work is finished.

Animal life of leaf litter

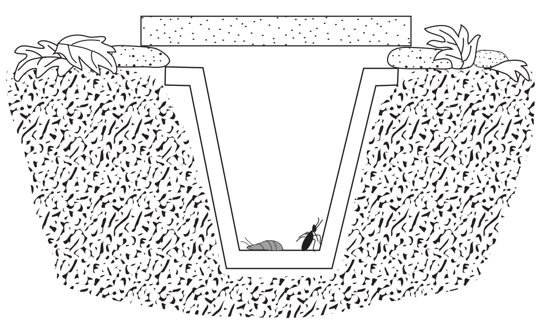
The leaf litter which accumulates under trees often contains a large variety of invertebrate animals. These can be extracted by standing a large funnel over a jar or bottle. Put a handful of the leaf litter in the funnel and shine the light from a disk lamp about 20 cm above the litter. The heat and light from the lamp will make the small invertebrate animals move down deeper into the funnel, until they eventually fall through into the jar below. Compare the invertebrate animals living in the leaf litter from different species of trees.

Animal life in long grass

Use a strong net to sweep through long grass or other herbaceous plants. Examine and count the different invertebrate species caught. How many of them are camouflaged?

Using a pitfall trap

Make a series of pitfall traps like the one on the right to catch the insects and other small animals that crawl across the ground at night. Investigate the animals that live under different types of trees or in grasses of different heights. It is important to check the traps several times each day. Remember to immobilise the traps, or dig them up, immediately after you have finished using them.



Using a line transect

You may have noticed that the plants growing in one place seem to differ from those in another. The vegetation growing where a playing field is regularly trampled may be different from the vegetation either side of this path. You can map the changes by using a line transect. A length of string or plastic clothes line is stretched across the area you want to examine. You then record all the plants (and animals too, if you wish) that grow along the line. If the distances involved are too great, then map the plants which occur every 10 cm or 20 cm.

How many weeds are there in a field?

It would be impossible to answer this question in a short space of time, so instead we sample the vegetation using a quadrat. In this case, a wooden frame 1 metre square would be ideal.

Decide which particular weeds you want to investigate, or perhaps it is all of them. Lay the quadrat on the ground and count the number of weeds inside it. If a weed is partly inside the quadrat and partly out of it, follow this rule: If half or more of the weed is inside the quadrat, then count it. If less than half of the weed is inside the quadrat, then ignore it.

Repeat the above procedure with the quadrat in at least five different places chosen at random, perhaps by throwing a cane and using where it lands as the base for the quadrat. Work out the average number of weeds per square metre in the field. If you know the area of the field, then you can, using a calculator, work out how many weeds there are in the whole field.

Discuss the main reasons for any inaccuracies in the results (mainly the tendency for people to be selective as to where the quadrat is placed).

The vegetation in a pond

If it is safe to do so, make a line transect across a small pond or at the edges of a shallow lake. Map the vegetation along the transect to see how it forms zones according to the depth of the water. Use a net to sample the animal life in the different vegetation zones.

Choice chamber experiments

Repeat the choice chamber experiments with other small invertebrate animals, including earthworms, millipedes, slugs, and snails. Relate your findings to the habitats of these animals.

WORKSHEET 4.1

Animal group	Tree 1 ______	Tree 2 ______	Tree 3 ______	Tree 4 ______	Tree 5 ______
spiders					
aphids					
beetles					
flies					
moths					
caterpillars					

Answers to questions in the Students' Book

1. A community is all the plants and animals living within a defined area or habitat. A habitat is the place in which an organism or a community of organisms lives. An ecosystem is a biological community and the physical environment associated with it.
2. The biotic environment is the living things and their activities which affect the environment in which they live.
3. Animals that do not eat plants might still depend upon trees and other plants for shelter, protection, nest sites and, of course, the oxygen they breathe.
4. The things which make up the abiotic or physical environment of an organism include climatic factors, such as sunlight, rainfall, temperature, and humidity, and such factors as the oxygen content of the water, and humus content, moisture level and acidity or alkalinity of the soil, and the degree of air pollution.
5. It is probable that humans have the biggest effect on the biotic environment, because of hunting, the destruction of habitats, the effects of pollution, and the use of chemical pesticides to control weeds, pests, and diseases. Even when human activities affect the abiotic environment, this still has an impact on the plants, animals, and other organisms living in an ecosystem.
6. The camel's long eyelashes protect its eyes from wind-blown dust and sand. Its hump contains fat which can be used during respiration to produce energy and water. The camel's padded feet spread its weight so that it does not sink into the sand. Because it produces little sweat or urine, the camel does not lose much water by excretion. The camel's rapid and large consumption of water, when available, allows it to travel long distances between drinks.
7.

producers	primary consumers	secondary consumers	parasites	scavengers	decomposers
buttercup plant lettuce	cow caterpillar	lion fox	flea tapeworm leech	crow	bread mould mushroom earthworm

8. The teeth of a herbivore are adapted for eating plant materials, especially grass. The incisor teeth have chisel-shaped edges for cutting grass and other plants, while the molars and premolars have flat surfaces with ridges on them for grinding up the plant material. Canine teeth are either absent, very small, or present as tusks. The herbivore's digestive system is long to enable it to digest the cellulose walls of plant cells. Certain herbivores, such as sheep, cattle, deer, and antelopes 'chew the cud'. The food is not chewed immediately, but is swallowed whole into a special stomach, called a rumen. The food is later brought back into the mouth and chewed when the animal is in a safe place from which it can watch out for predators.

   The teeth of carnivores are adapted to catching and eating other animals. The small, close-fitting incisors are used to clean fur and cut away pieces of flesh close to bones. The long, dagger-like canines are used to pierce the prey when it is captured, thus preventing its escape. The pointed premolars and molars are used for shearing flesh from bones and cracking them open to obtain the marrow inside. The digestive system of carnivores is quite short, because flesh is relatively easy to digest. The short digestive system gives the animal a sleek, streamlined appearance.

9. Most carnivores, including wolves, jaguars, cheetahs, leopards, tigers, and other large members of the cat family are camouflaged, so that they can approach their prey without being seen. Most carnivores are larger than their prey, so they can easily overwhelm it. There are exceptions, however. Wolves and lions hunt in a group and so can capture prey that is larger than each individual predator.
10. Herbivorous animals are generally poor fighters because their bodies are quite large or plump and most of them lack the sharp teeth, claws, or other weapons used by carnivores when hunting. Many herbivores are, however, camouflaged and some, such as deer and antelopes, can run quite fast over short distances.
11. With the exception of lions and wolves, most carnivores live on their own so that they can use stealth to approach their prey. Many herbivores live in groups, because there are then many eyes and ears to keep alert for approaching danger.
12. A tapeworm living in the human gut is protected from changes to its environment and it receives a ready supply of already-digested food. On the whole, the effect of the tapeworm on humans is so slight that the victim may be unaware of its presence. Some people suffer a loss of appetite, abdominal pains, loss of weight, nausea, and dizziness. Occasionally the tapeworm's head may tear the wall of the intestine, causing wounds that can then be infected with bacteria.
13. The most effective way to prevent infection by tapeworms is to dispose of sewage safely so that the eggs do not contaminate the food and drink of cattle. Tapeworms can also be controlled by the careful inspection of meat, while thorough cooking of beef will kill the young stages of the parasite. All types of tapeworm infections can be treated with a drug called quinacrine. This kills the worms, which then pass out of the body in the faeces.
14. The biggest problem a parasite has is in finding the correct host plant or animal. This is because most parasites have evolved to only feed on one particular type of host plant or animal.
15. If all the bacteria on Earth suddenly died, there would be no more bacterial diseases such as tuberculosis, leprosy, cholera, diphtheria, pneumonia, and typhoid fever. However, only a small proportion of all bacteria are harmful, and many are useful or even vital to this planet. For example, bacteria, along with fungi, are responsible for most of the decomposition of waste organic matter and the formation of humus. Without them the bodies of dead plants and animals would accumulate rapidly. Bacteria also play a part in digesting food, particularly in the guts of herbivores and omnivores. They can also be used to ripen cheese, make sewage harmless, produce vinegar, acetone, and yoghurt, produce silage (for cattle food), and soften the flax fibres used to make linen. Bacteria living on the roots of certain plants, particularly those of the pea, bean, and clover families, can also 'fix' nitrogen from the air into nitrates. When they die they increase the nitrate content of the soil to the benefit of other plants.
16. When bees and other nectar-seeking insects visit flowers, the insects benefit by finding a supply of food in the form or nectar and pollen. The flowers benefit by being cross-pollinated with the pollen from another flower of the same species while, at the same time, having their pollen taken to another flower of the same kind.

Assessment

Question1

All the plants and animals living in one place, such as a park, make up a:

(A) habitat (B) ecosystem (C) collection (D) community

Question 2

Everything around a living thing that affects its way of life is called its:

(A) environment (B) home (C) habitat (D) community

Question 3

Which of the following does NOT form part of the physical environment of a living thing:

(A) climate (B) soil (C) plant life (D) light

Question 4

Because plants are almost the only living things in the world which can make their own food, they are often called:

(A) eaters (B) producers (C) consumers (D) scavengers

Question 5

Animals which eat plant food are called:

(A) primary consumers (B) secondary consumers
(C) scavengers (D) carnivores

Question 6

The main decomposers which bring about the decay of dead organisms are:

(A) green plants (B) parasites
(C) bacteria and fungi (D) fungi and invertebrates

Question 7

Bacteria and fungi in an ecosystem:

(A) return energy to the plant (B) use up the nutrients in the ecosystem
(C) use up carbon dioxide (D) release nutrients from dead plants and animals

Question 8

A lichen, which consists of a fungus and an alga living together for the benefit of both, is an example of:

(A) community living (B) mutualism

(C) parasitism (D) decomposition

Question 9

A plant or animals which lives at the expense of another living thing is a:

(A) carnivore (B) producer (C) parasite (D) insect

Question 10

Plants and animals are adapted to the environment they live in.

Explain how each of the following characteristics helps the organism survive.

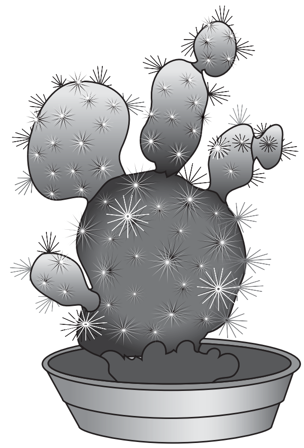
i) Camels store large amounts of fat in their humps.

ii) Some cacti have shallow roots that spread out over long distances.

iii) Most tropical rainforest trees are evergreens.

iv) Many climbing plants grow on the taller rainforest trees.

Question 11



The picture on the right shows a cactus plant. Cacti are adapted to live in deserts and other very dry places.

a) The leaves of the cactus plant are reduced to spines. How does this help it to survive?

b) The stem is large with a space in the centre. How does this help the cactus to survive?

c) The stem is also covered with a thick, waxy layer, called a cuticle. How does this help the cactus to survive?

d) The root system is long and branching. How does this help the cactus plant to survive?

Question 12

The picture on the right shows a hawk. Hawks feed on small animals like rats, mice, voles, shrews, and beetles.

a) Give TWO ways, shown in the picture, that the hawk is adapted to catch small animals.

i) ______________________________

ii) ______________________________

b) The shape of its wings allow the hawk to dive very fast and quietly through the air. How does this help it to catch animals?

____

____

c) Unlike the adults, the baby hawks have soft, fluffy feathers while they are in the nest. Why do they need these feathers? ______

Question 13

Thousands of trees are cut down in forests every year for human use.

a) Suggest TWO reasons why fewer birds and other small animals can survive in the areas left after trees have been cut down:

i) ______

ii) ______

b) Give a reason why weeds and other small plants can grow well in the areas left after trees have been cut down. ______

c) Fungi and bacteria feed on the wood that has been left behind after tree cutting, and release mineral salts back into the soil.

i) What is this process called? ______

ii) Why is it important? ______

d) Suggest a reason why it is important to plant new trees to replace those that have been cut down.

______

Question 14

Polar bears live in the frozen wastes of the Arctic. Choose TWO characteristics that help polar bears to live in their habitat.

A) a good sense of smell

B) thick fur to trap heat and keep the bear warm

C) sharp claws to help grip on icy surfaces

D) small ears as it is quiet on the polar ice

E) blue eyes to contrast with the white fur

Question 15

Imagine a habitat where:

it is very hot and wet in summer;

it is very cold and wet in winter;

there are lots of trees that grow very lush in summer but are all deciduous so they have no leaves in winter;

the ground is always wet and muddy;

there are many species of insect including those which feed on the blood of other animals

a) Choose ONE adaptation which you think would be important for an ANIMAL living in this habitat. Say why you have chosen it.

______

______

b) Choose ONE adaptation which you think would be important for a PLANT living in this habitat. Say why you have chosen it.

____

____

Question 16

Some students investigated the sort of conditions that woodlice prefer. They used a 'choice chamber' for this work. Half of the chamber was light and the other half was dark. Each of these halves was divided exactly in half into a wet and dry area. This gave the woodlice four choices:

- dark and wet
- light and wet
- dark and dry
- light and dry

The students placed five woodlice in the centre of each of the four compartments of the choice chamber. They then recorded where the woodlice were every 2 minutes for 10 minutes. Their results are shown in the table below:

Time (minutes)	0	2	4	6	8	10
dark and wet	5	10	15	17	18	19
light and wet	5	4	2	1	1	1
dark and dry	5	4	2	2	1	0
light and dry	5	2	1	0	0	0

a) What factors have to be kept the same in order to make this a fair experiment? __________

b) Which conditions do woodlice like least? __________

c) What conclusions can you draw from the experiment? __________

d) i) If the experiment had been done with only four woodlice, would the results have been as useful?

____

ii) Explain your answer. ____

Answers to Assessment questions

Question1

(D) community

Question 2

(A) environment

Question 3

(C) plant life

Question 4

(B) producers

Question 5

(A) primary consumers

Question 6

(C) bacteria and fungi

Question 7

(D) release nutrients from dead plants and animals

Question 8

(B) mutualism

Question 9

(C) parasite

Question 10

i) The fat in the camel's hump acts as a store of food. When the fat is respired, it produces water as well as energy, helping the camel to travel long distances without drinking.

ii) By having shallow roots which spread out over large distances, cacti are able to absorb any dew or rain which collects near the surface of the ground.

iii) Deciduous trees lose their leaves in winter when the ground is cold and it is difficult to absorb water from the soil. In the tropics, there are high temperatures and abundant rainfall all the year round, so there is no need for the trees to lose their leaves. Rainforest trees can, therefore, photosynthesise and grow all the year round.

iv) The trees in a rainforest are extremely tall and the canopy is dense. Many climbing plants grow on the trees, using their support to help them reach the light which they need for photosynthesis.

Question 11

a) It reduces evaporation/water loss from the leaves.

b) It helps the cactus to store water.

c) It prevents water evaporating from the surface of the stem.

d) The deep, branching root system helps the cactus to absorb as much water as possible.

Question 12

a) any two from: curved/sharp beak; sharp claws/talons; eyes facing forward

b) It gives the hawk the speed it needs to catch/ambush/surprise animals.

c) to keep warm as the baby hawks do not move very much

Question 13

a) i) and ii) any two from: there is less/no food; there are fewer places to nest/breed/shelter; there are fewer places to hide from predators.

b) any one from: there is/are more light/water/space/nutrients/mineral salts; the small plants can photosynthesise more easily; there is less competition from trees

c) i) decomposition ii) It forms humus or provides mineral salts that the plants need to grow.

d) any one from: to provide food for animals; to provide shelter/nesting sites/habitats for animals; trees use up carbon dioxide (a greenhouse gas) and produce oxygen; tree roots bind the soil and prevent soil erosion/soil being washed away

Question 14

B)

C)

Question 15

a) There are very many possible answers to this question, so award a mark for each sensible answer that relates to any of the features of the habitat for an animal and for a plant. The obvious answers for the animal would for them to be able to swim, hibernate or migrate in winter, store food for the winter, feed on insects, live in the trees, feed on tree bark, etc.

b) For a plant one important adaptation would be to complete its life cycle during the summer and to store food for the winter months. The plant could also be aquatic, grow on the trunks or branches of trees, or feed on insects.

Question 16

Answers to woodlouse experiment:

a) The number of woodlice placed in each part of the choice chamber at the start; the woodlice should not be damaged during the process of putting them in the chamber; the size of the chambers should be equal; the choice chamber should be level, so that the woodlice are not tipped in one direction; the two-minute intervals would have to be timed accurately.

b) light and dry

c) Woodlice prefer dark and wet conditions.

d) i) no

ii) The results would not have been so reliable, or the more subjects that are tested the more reliable the results.

Atoms, molecules, mixtures, and compounds

CHAPTER 5

Teaching Objectives

- To explain the difference between atoms and molecules
- To explain that the molecules of elements are made up of only one kind of atom
- To introduce the idea of symbols as a way of representing elements
- To show that elements can be classified into metals and non-metals
- To show that the uses of elements are related to their physical properties
- To explain the differences between elements, compounds, and mixtures and to illustrate the properties of some common examples of compounds and mixtures
- To show where the carbon dioxide in the atmosphere comes from and how its levels are maintained in nature
- To demonstrate a variety of techniques for separating the components of mixtures
- To demonstrate how scientific experiments should be carried out safely

Learning Outcomes

After studying this chapter students should be able to:

- differentiate between an atom and a molecule
- recognize the symbols of some common elements
- classify elements into metals and non-metals
- relate the physical properties of elements to their uses
- differentiate between elements and compounds and compounds and mixtures
- identify examples of compounds and mixtures from their surroundings
- explain the uses of some common mixtures in daily life
- explain why air is considered to be a mixture of gases
- identify the sources of carbon dioxide and how its level can be maintained in nature
- separate mixtures using a variety of techniques
- choose a technique to separate and identify different components in dyes
- demonstrate with an experiment how to separate soluble solids from mixtures
- carry out science experiments safely

Introduction

Everything in the world can be organized around two concepts, matter and energy. If something is not matter, then it is energy.

Properties are the characteristics by which we can tell objects or kinds of matter apart. No two kinds of matter have exactly the same set of properties, but all matter has mass and takes up space.

Many properties of matter, such as colour, odour, texture, and taste can be determined by the senses. These properties can be determined without changing the composition of matter and are called physical properties. Other physical properties, however, must be determined by tests of measurements. But the composition of the matter still does not change. For example, to determine the melting point of ice (a physical property of water), ice is melted and the temperature of the mixture of ice and water is measured. But still the composition of the water is not changed.

To determine certain other properties, the composition of the matter must be changed. For example, to determine whether magnesium burns, we must heat it strongly. It does burn and a new material—a white, crumbly powder—is formed. The ability to burn is a chemical property of magnesium.

More than a hundred substances cannot be separated into simpler substances by chemical or physical means. These substances are called elements. The smallest part of an element that has the properties of the element is called an atom. A compound consists of two or more elements chemically joined together.

Young students find it very difficult to grasp the abstract concepts of atoms and molecules (or if we want to be more general, of 'particles'). It is necessary to ensure that the students understand that the concept of the atom is purely an idea or a guess. No one has ever seen an atom or ever will. But it is a very good guess because not only does it explain satisfactorily all observed phenomena, it has also been used to predict certain possibilities, and these predictions have always been found to be correct by experiment. The students will use the theory in a predictive way in dealing with the general behaviour of matter later in this unit and also in the next one.

Lesson suggestions

1. Searching for matter

Refer to page 42 of the Students' Book.

Starter suggestions

Do not explain what 'matter' is. Just give the instruction: 'Find some matter, but do not show anyone.' The students can look around the classroom to find a small piece of matter—a pencil, an eraser, a book, a shoe, an apple, a strand of hair. With eyes closed, each person tries to guess what a partner's object is by feeling it. After each person has guessed his or her partner's object, examine all the objects. Was anything found that is not matter? Explain what matter is and that it is found everywhere.

Alternatively, run a race. Everyone has a set amount of time (e.g. 3 minutes) to find matter with certain characteristics (e.g. hard and rough; hard and smooth; too large to hold in one hand; small enough to balance on one finger). Then the guessing game described above begins.

Main lesson

Explain that a piece of rock, a jelly, a doughnut, your finger, and an aeroplane all have something in common. They are all matter—something which occupies space and has mass. If something is not matter, then it is energy.

Everything alive, dead, and never living is made up of atoms. Atoms are microscopically miniscule units of matter. Pretend you could take anything you wanted—the rock, the jelly, the doughnut, your finger or an aeroplane—and divide it up. Pretend you could divide it up smaller and smaller, until you could not even see the pieces any more. You would eventually get down to an atom.

The universe is a collection of atoms and the space between them. The same atoms have been here since the day the universe began and they will be here until the day it ends. When anything new appears in the world, it is only the old atoms arranging themselves in a new way. Matter cannot be created and it cannot be destroyed.

Go on to demonstrate (or let the students find out) what happens when a solution of potassium permanganate is diluted.

Potassium permanganate makes a purple solution in water. You will dilute a mixture of these two substances and watch what happens to the colour.

Put eight test-tubes in a rack and number them 1 to 8. Add 10 ml of a concentrated potassium permanganate solution to tube 1. Add 9 ml of water to the other tubes.

Use a syringe to remove 1 ml of the mixture from tube 1. Add this to tube 2. Stopper the tube and shake to mix it well.

Wash the syringe and remove 1 ml of the diluted mixture from tube 2 and add it to tube 3. Stopper, shake and mix, as before.

Repeat all of these actions until you reach tube 8.

Look at the row of tubes. What changes as you go along the row? (The solution becomes paler with each dilution.) What does this tell you about the permanganate in the tubes? Is there any permanganate in tube 8? If you continued with more tubes, would there eventually be a tube which contained no permanganate?

Explain that potassium permanganate is made up of small pieces which separate in water. Some pieces from tube 1 were added to tube 2. Some of the mixture from tube 2 was added to tube 3. As you go along, each tube has fewer and fewer particles of permanganate. Finally there can be a tube with no particles of permanganate.

2. More puzzles with particles

Refer to page 42 of the Students' Book.

Starter suggestions

Demonstrate to the students that some materials, such as pencil lead and chalk, are useful because tiny particles rub off them easily. Why is this a useful property?

Use a blackboard duster to show that particles of chalk dust are so small they settle slowly in the air. They seem to disappear, but a beam of light makes the dust visible. Why?

Some materials, such as a sugar cube, can be broken down into smaller and smaller particles. What do these particles look like when they are magnified?

Add a teaspoonful of sugar to a clean glass of water. Stir the mixture. Point out that the particles of sugar have disappeared in the water. Ask a volunteer if he or she can still taste the sugar. Is the sugar still there?

Main lesson

From the previous observations, we know that visible bits of matter can be made smaller and smaller. In fact they become so small that we cannot see them. But, as with the sugar and chalk dust, we can prove that the tiny bits, or particles, of matter are still there.

Demonstrate another example of a small amount of matter being made smaller and smaller—in this case the matter is being made thinner and thinner!

Half fill a large glass dish with water. Sprinkle a fine powder, such as talcum powder, over the surface. Add one tiny drop of cooking oil or pure olive oil to the centre of the patch of powder. What does the oil do to the powder? What happens to the particles in the oil when the oil touches the water? In the layer of oil, how many particles of the oil do you think are piled on top of each other? (The answer is one particle—the oil forms what is called a monomolecular layer!). You may wish to repeat the experiment with another completely clean glass trough, and this time use a known volume of the oil. If you measure the area over which the oil spreads on the water, you can, with the help of a calculator, work out the thickness of the oil layer.

The fact that solids can be spread out to cover large surfaces can be shown by passing a piece of gold leaf, protected by two cover glasses, around the class. The gold leaf is so thin that, although it appears golden, it is actually transparent.

Finally, finish the lesson with a 'scientific mystery.' Take two identical measuring cylinders, in one put exactly 50 cm^3 of ethanol and in the other exactly 50 cm^3 of distilled water. Pour the water into the ethanol. Wait for a moment or two until the mixture gets cold and then read the volume of the mixture.

- Ask the students what volume they would expect the mixture to have.
- Does it actually have this volume?
- In fact, the final volume will be less than that of the combined volumes of the separate solutions. Can the students explain the result?

If they are baffled by the experiment, give them a clue. Put 50 cm^3 of peas in a measuring cylinder. Then add from another cylinder 50 cm^3 of rice or barley.

- Can they guess what must have happened to the ethanol and water?

Safety: Ethanol is highly inflammable and harmful. Keep away from naked flames.

3. Atoms and elements

Refer to page 43 of the Students' Book.

Starter suggestions

Remind the students that an atom is the tiniest particle of a substance it is possible to have. There are literally billions of different substances in the universe. Scientists are discovering about 5000 new substances every day. And yet there are only just over one hundred different types of atom in the world. If the students express surprise at this, point out that all the thousands of words in a large dictionary are made up of just twenty-six letters of the alphabet.

Main lesson

Explain that materials that have only one kind of atom in them are called elements. Ask them if they know of any such materials.

Show the students examples of elements. Explain that a piece of pipe made of pure copper contains only copper atoms.

An aluminium foil pie dish is made of pure aluminium and contains only atoms of aluminium.

A piece of pure black charcoal contains only atoms of carbon.

Oxygen gas contains only atoms of oxygen, while hydrogen gas contains only atoms of hydrogen.

Copper, aluminium, carbon, oxygen, and hydrogen are all elements.

Show the students some more examples of elements and let them group them into metals and non-metals using the table on page 43 of the Students' Book to help them.

Explain that some elements have long names and that scientists use symbols as a shorthand way of writing about or describing elements. Give the students a list of the symbols of the elements they have seen during the lesson.

4. Compounds

Refer to page 47 of the Students' Book.

Starter suggestions

Show the students pictures (or if available, examples of the real thing) of sulphur, iron, gold or silver, and water. Ask them which is the odd one out and why. (The answer is that the sulphur, iron, and gold or silver are elements, whereas water is not an element. It consists of two elements—hydrogen and oxygen—joined together. Water is a substance we call a compound.)

Main lesson

If the apparatus is available, demonstrate how we can split water into its two component elements, hydrogen and oxygen using the technique called electrolysis. Two gases will collect in the apparatus, but there will be about twice as much of one gas as the other. Test the gas in one tube with a glowing splint. If the splint bursts into flame, the gas is oxygen. If the gas makes a tiny 'pop,' it is hydrogen. Explain that the formula for water is H_2O. Can they use this information to explain the results?

Water and hydrogen peroxide

You have learned that water molecules have two kinds of atoms—hydrogen and oxygen. These atoms are chemically joined together, because water is a compound. The formula for water is H_2O. There is a common substance called hydrogen peroxide. Hydrogen peroxide is used for bleaching, as an antiseptic and disinfectant, and to propel some rockets. It is a very pale blue liquid, but colourless like water when it is in a dilute solution. Hydrogen peroxide also has hydrogen and oxygen atoms chemically joined. The formula for hydrogen peroxide is H_2O_2.

The properties of water and hydrogen peroxide are very different, even though they are made of the same two kinds of atoms. Ask the students how they know, using the formula H_2O_2, that water and hydrogen peroxide differ.

Compare the chemical properties of water and hydrogen peroxide. You need a 3 per cent solution of hydrogen peroxide. Wearing eye protection, pour a small amount into a test-tube and show it to the students. Into another test-tube pour about the same amount of water. Then, to each tube, add a pinch of dry powdered yeast.

Use a glowing wooden splint to test for any gas that is produced.

The test-tube containing hydrogen peroxide and yeast will give off oxygen which makes a glowing splint burst into flame. There is no evidence of a gas given off in the test-tube containing water and yeast.

If there is time, you could explain that there are many substances with different properties that are made of atoms of carbon, hydrogen, and oxygen.

- The formula for ethanol is C_2H_5OH.
- The formula for glucose is $C_6H_{12}O_6$.
- Vinegar is CH_3COOH.

Show the students samples of each of these three substances. Point out that they are all made of the same three kinds of atoms. How is glucose different from vinegar? How is ethanol different from vinegar?

5. Mixtures

Refer to page 48 of the Students' Book.

Starter suggestions

Remind the students that a mixture is two or more substances that are not chemically combined. Show them some sulphur and some iron filings. Then mix them together. Demonstrate that at this stage it is possible to separate the iron filings from the mixture with the help of a magnet. Stress that most materials are mixtures.

Examine the labels and packets from foods. Look at the detailed contents lists. Notice that many of the foods we buy in cans or packets are not 'pure', but are in fact mixtures of ingredients.

Main lesson

Explain that you are going to investigate a solution—a liquid mixture. In a solution, the solvent is the liquid in which another substance dissolves, and the solute is the substance which dissolves.

The details of the experiment are given on Worksheet 5.1.

The results should show that the mass of the salt solution is the mass of the salt plus the mass of water (1 g + 100 g = 101 g). The volume of the water should be unchanged.

Remind the students what happened in the ethanol and water experiment in Lesson 2, if you carried out this demonstration. If the students are still baffled, show them what has happened in the salt solution with the aid of a 500 cm^3 beaker. Half-fill the beaker with dried peas (or similar). Explain that the peas represent water. Add a handful of dried rice or dried lentils to represent the salt. Stir the mixture. Show the students that the rice or lentils (representing the salt) occupy spaces between the dried peas (the water particles).

6. Separating mixtures : sieving, filtering, and evaporating

Refer to page 50 of the Students' Book.

Starter suggestions

Remind the students that a mixture consists of two or more substances which are not chemically combined. In order to separate the substances, a suitable technique must be found.

Go on to ask them how they would separate a mixture of sand and gravel quickly. Hopefully, someone will come up with the answer 'sieve it'. If so, produce a small quantity of the gravel and sand mixture and pass it through a sieve with a mesh that will let the sand through but not the gravel. This will demonstrate that sieving can be used to separate particles of different sizes. Go on to ask the students how they would separate salt from sugar cubes. The answer is to use a sieve—the salt particles would go through but the sugar cubes would be held back by the sieve.

Main lesson

Explain that filtering can also be used to separate an insoluble solid from a liquid. In this case the filter paper we use is like a very fine sieve, and the holes are too small to see unless you have a microscope.

As a class exercise, separate salt and sand, using Worksheet 5.2. The students will probably need reminding how to fold a filter paper.

It may be worth reminding them that filtration is often a slow process, because the tiny holes in the filter paper can get clogged up with the insoluble substance, in this case sand. Prodding the wet filter paper will not speed up the process. It will only tear the filter paper.

The answers to the questions on Worksheet 5.2 are:

- The salt solution passes through the filter paper.
- The liquid which goes through a filter paper is called a filtrate.
- The sand is left in the filter paper.
- We call a substance that is left behind in a filter paper the residue.
- Salt is left in the evaporating basin.
- The process of heating a solution to dryness is called evaporation.

The key idea of this experiment is an appreciation that to separate a mixture of substances we have to know something of the properties of the individual substances.

If time permits, repeat the above activity using a mixture of either powdered cork or gravel with sugar.

7. Separating mixtures : chromatography

Refer to page 53 of the Students' Book.

Starter suggestions

Ask the students to imagine that they have to produce a painting urgently for someone's birthday. They only have three colours of paint: red, yellow and blue. Ask them how they would produce the other colours they need, such as green (by mixing yellow, and blue), orange (yellow and red), and brown (red, yellow and blue).

Explain that many of the colours used in foods, dyes, and inks are not pure colours but were made by mixing colours together.

Main lesson

Remind the students that earlier we saw that chlorophyll in plants is not a pure green substance, but is in fact a mixture of colours. We used a technique called chromatography to separate the colours in chlorophyll. Chromatography works if all the coloured substances in the mixture dissolve in one solvent.

Let the students carry out the experiments on Worksheet 5.3 so that they begin to understand the uses of chromatography.

Finish the lesson by explaining to students that there are different types of chromatography, and the example we have been using is a simple one. Police forces use a form of chromatography to identify the DNA of suspected criminals and to find out how much alcohol is in a blood sample from a suspected drink-driver. Chromatography can also be used to look for traces of explosives on the body hair and clothes of suspected bombers.

8. Separating mixtures : distillation and evaporation

Refer to pages 51 and 52 of the Students' Book.

Starter suggestions

Remind the students of the experiment where we separated salt and sand. We obtained the salt by heating the salt solution until all the water had evaporated. Ask them now how we could get water from the salt solution. Pretend, for example, we are trapped on a desert island where the only water available is sea water. How could we obtain water fit to drink, assuming we had matches and plenty of firewood? The answer would be to filter the sea water, perhaps using a shirt or some other item of clothing, and then to boil the water and collect and cool the steam.

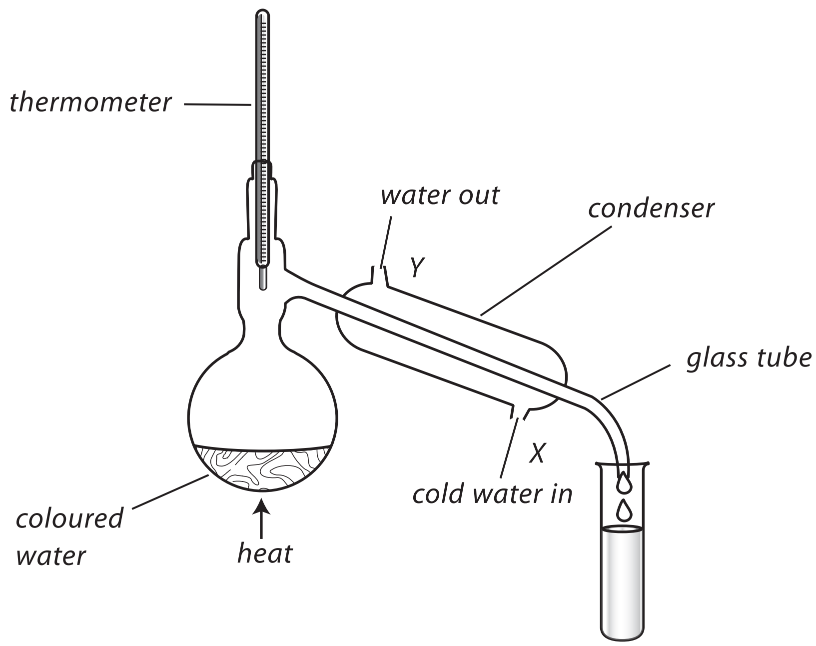
Main lesson

Explain that they are going to obtain pure water, not from sea water but from water which has had ink or food colouring added to it.

The class experiment is described on Worksheet 5.4.

If the apparatus is not too hot, a few drops of distilled water (the distillate) will collect in the receiving tube. The boiling-tube will contain a concentrated form of the ink or food dye.

Now demonstrate how salt water is distilled using the standard distillation apparatus shown in the picture on the right.



apparatus A

It is essential that teacher and students wear eye protection while carrying out and observing this activity.

At the end of the lesson, sum up by reminding the students that solutions are a type of mixture made of a solute and solvent particles.

Solvents can be separated from solutions using distillation.

In evaporation, only the solute is collected. In distillation, both the solvent and solute can be collected.

Ideas for investigations and extension work

Where does salt go to in water?

The students could try this experiment at home. Fill a drinking glass to the brim with water. Slowly and carefully add a teaspoonful of salt to the water. Does the water overflow? If not, where is the salt going? Is it still there? How do they know?

Making sodium chloride, a compound

If a fume cupboard and a supply of chlorine are available, fill two gas jars with this gas and place a lid on top of each. Leave the two jars in the fume cupboard. Wearing eye protection, place a small cube of sodium, measuring approximately 2-3 mm each side, in a deflagrating spoon. Ignite the sodium with a Bunsen burner. Immediately slide the lid off the gas jar and place the spoon and burning sodium into the chlorine gas. White fumes of sodium chloride (common salt) will be seen. The fumes may be grey if the sodium is contaminated with oil. Repeat the experiment with the second gas jar of chlorine and another small piece of sodium if the first fails.

Explain that we have combined two poisonous elements, sodium and chlorine, and made common salt, sodium chloride.

- The word equation for the reaction is: sodium + chlorine $\longrightarrow$ sodium chloride
- The equation using symbols is: $2Na + Cl_2 \longrightarrow 2NaCl$

Making a compound, iron sulphide

This experiment can be carried out by the students if the room is well ventilated and there are no asthma sufferers in the class. This is because, if the sulphur ignites, it becomes an irritant. If in doubt, the teacher should demonstrate this experiment.

Provide each group with half a spatula of sulphur powder and half a spatula of iron filings. They also need a magnifying glass, a magnet, an ignition tube (use an old one as it will probably get broken), a small piece of mineral wool to plug the ignition tube, Bunsen burner, heatproof mat, spatula, test tube holder, matches and eye protection.

Examine the sulphur powder and then the iron filings with a magnifying glass. Mix half a spatula of iron filings and half a spatula of sulphur in the test-tube. Examine the mixture with the magnifying glass and then hold a magnet against the outside of the tube. (Iron filings are very difficult to remove from the surface of a magnet).

Place a small plug of mineral wool loosely in the top of the tube. Make sure there is no sulphur on the outside of the tube.

Using a test tube holder, and wearing eye protection, heat the mixture with a blue Bunsen flame until the mixture glows orange. Immediately after this happens, take the tube out of the Bunsen flame and leave it to cool on a heat-proof mat.

The new substance formed is iron sulphide. Examine it again using a magnifying glass and a magnet. You may have to wrap the tube in an old cloth and break it with a small hammer for students to examine the iron sulphide properly.

The word equation for this chemical reaction is: iron + sulphur $\longrightarrow$ iron sulphide

- The equation using symbols is: $Fe + S \longrightarrow FeS$

Safety: Beware of fragments of glass from the broken ignition tubes.

The important point to emphasise about this chemical reaction, as with the one making sodium chloride above, is that compounds do not have the same properties as the elements they are made from.

WORKSHEET 5.1

Investigating salt solution

Materials needed per group: 100 cm^3 measuring cylinder, 100 cm^3 of distilled water; 1 g salt, spatula, 250 cm^3 beaker, access to a balance, weighing to 1 decimal place (or ideally 2 decimal places)

1. Find the mass of a 100 cm^3 measuring cylinder. Record the mass here. __________
2. Measure 100 cm^3 of distilled water into the measuring cylinder.
3. Measure the mass of the distilled water plus measuring cylinder on an electronic balance. Record your results here. ______________________________
4. What is the mass of the distilled water? __________
5. Clear up any spillages, and then on the electronic balance, measure 1 g of salt into a dry beaker. Record the mass of the beaker and salt here. ____________________
6. What do you think the mass and volume of the mixture will be when you add the salt to the distilled water? Mass ____________________ Volume ____________________
7. Carefully add the distilled water to the salt in the beaker. Stir until you can no longer see any salt.
8. Measure the mass and volume of the mixture. Mass ____________________ Volume ____________________

Were your predictions made in 6. above correct?

If not, how were your results different from what you expected?

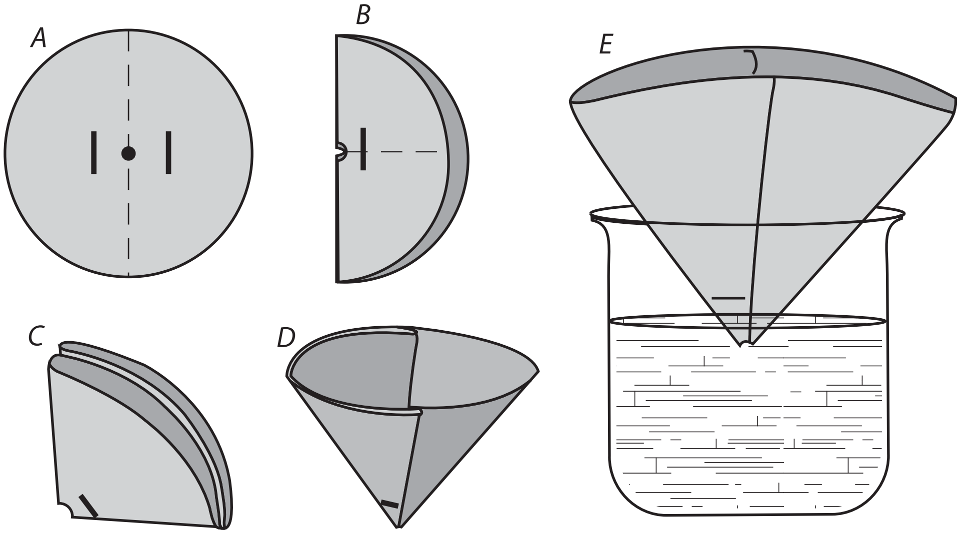
WORKSHEET 5.2

Separating salt and sand

Materials needed per group: a mixture of equal parts of clean sand and salt, two clean jars or beakers, filter funnel, filter paper, evaporating basin, stirring rod, spatula, Bunsen burner, heatproof mat, tripod, and gauze.

Safety: Wear eye protection.

1. Put four spatulas of the sand and salt mixture in a clean jar or beaker. Add a little warm water to the mixture and stir it thoroughly. Observe what happens.
2. Fold the filter paper (see the diagrams below) and place it in the filter funnel. Rest the funnel on a tripod stand and place the evaporating basin underneath the funnel.



3. Slowly and carefully pour the sand and salt mixture and water into the filter paper in the funnel. Observe what happens.

   What goes into the evaporating basin? ______________________________

   What do we call the liquid which goes through a filter paper? ______________________________

   What is left in the filter paper? ______________________________

   What do we call a substance that is left behind in a filter paper? ______________________________
4. Carefully place the evaporating basin on the gauze on the tripod. If the evaporating basin is more than half full, pour some of the liquid into a beaker to use later.
5. Slowly and carefully heat the liquid in the evaporating basin until all of the liquid has gone.
6. What is left in the evaporating basin? ______________________________

   What do we call the process of heating a solution to dryness? ______________________________

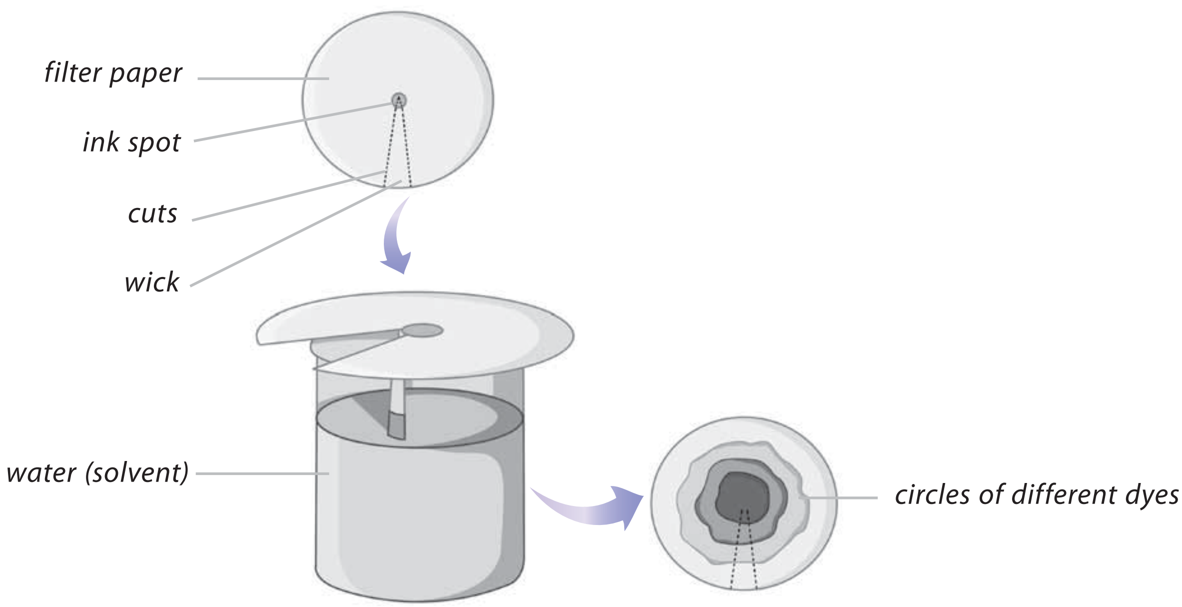
WORKSHEET 5.3

Simple chromatography

Materials needed per group: circular filter papers, sheets of filter paper or white blotting paper, scissors, beakers, water-based felt-tipped pens, pencils, water.

Method 1

1. Make a dot with a black felt-tip pen in the centre of the filter paper.
2. When the ink has dried, make two cuts as shown in the diagram below about 1 cm apart towards the centre of filter paper. This is your wick.
3. Half fill a beaker with water and bend the wick so that it is just in the water. Be careful not to splash water on the ink spot.

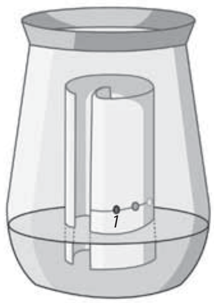


4. Watch what happens as the water rises up the wick and reaches the ink spot.
5. When the water has passed any circles of colour that form, remove the chromatogram and allow it to dry in a warm place.
6. Examine the chromatogram carefully. Was the black ink made of one colour or more? If the latter, what colours were they? ______________________________

____

Method 2

1. Cut a narrow rectangle of filter paper or white blotting paper that is about 2 cm longer than the depth of your beaker.
2. Draw a line across the strip 1 cm from its end.
3. Put a spot of, say, green felt-tip pen ink in the middle of this line.
4. Put about 1 cm of water in the beaker. Rest the strip of filter paper in the beaker so that the water comes up the paper a little way below the line you have drawn.



5. Watch and record what happens as the water rises up the paper past the ink spot. ______________________

   ____
6. When the water has risen up the paper, remove the chromatogram and dry it in a warm place.
7. Is the ink you tested made of one colour or more? ______________________

   If the ink is made of more than one colour, what are they? ______________________

   Now try other felt-tip pens, ground-up spinach leaf, and a coloured sweet which has been soaked in a few drops of water to produce a coloured solution.

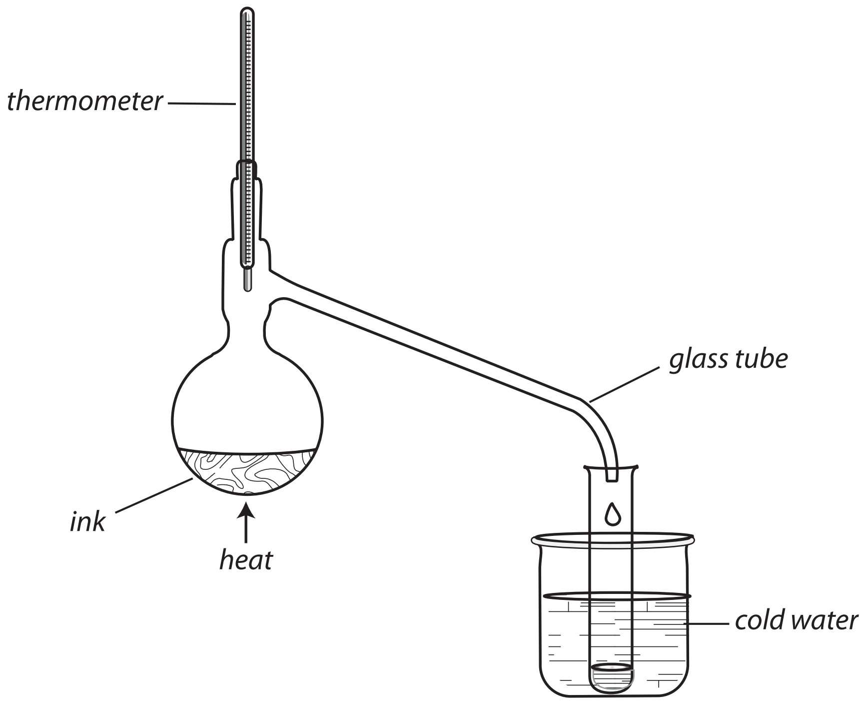
WORKSHEET 5.4

Simple distillation

Materials needed per group: two boiling tubes, glass delivery tube with a 90° bend and a bung already fitted, a large beaker, ice-cubes, test-tube holder or retort stand, Bunsen burner, heatproof mat, water coloured with food colouring or ink, eye protection.

Safety: Wear eye protection

1. Measure out 20 cm^3 of coloured water into one of the boiling tubes.
2. Set up the apparatus as shown in the diagram.



3. Using the Bunsen burner, heat the coloured water gently. If you heat the water strongly steam may shoot up the delivery tube.
4. Record what happens. ________________________________
5. What is left in the boiling tube? ________________________________
6. What is the distillate (the liquid in the receiving tube)? ________________________________

Answers to questions in the Students' Book

1. An element is a substance that cannot be broken down into two or more simpler substances by chemical means. It is not possible to list all the possible uses to which single elements are put, but the most common elements used on their own are gold, silver, iron, copper, mercury, lead, tin, zinc, and carbon.
2. Typically a metal is strong, has a high density, is durable (hard wearing), is malleable and ductile (can be made into sheets or pulled out into wires), is sonorous (produces a sound when struck), and it conducts heat and electricity well. Some common metals include iron (Fe), lead (Pb), tin (Sn), copper (Cu), zinc (Zn), aluminium (Al), potassium (K), sodium (Na), mercury (Hg), gold (Au), and silver (Ag)

   Common non-metals include carbon (C), sulphur (S), phosphorus (P), hydrogen (H), oxygen (O), nitrogen (N), chlorine (Cl), argon (Ar), helium (He), and neon (Ne).
3. Because the element is solid, conducts heat and electricity and is shiny when it is cut, it is almost certainly a metal.
4. An alloy is a mixture of two or more elements (usually metals except for carbon in steel). Alloys are often stronger than their constituent elements.
5. An alloy is considered to be a mixture rather than a compound because the components can vary in quantity, rather than being in a fixed ratio as they are in a compound. In many cases, it would be fairly easy to separate out the components of the alloy, but this could not be done with a compound.
6. A compound is the substance formed by the chemical combination of elements in fixed proportions. Common compounds include chalk or limestone (calcium carbonate), table salt (sodium chloride), washing soda (sodium carbonate), copper sulphate, and Epsom salts (magnesium sulphate). A mixture is a combination of two or more substances that have not reacted chemically and can be separated using physical processes such as dissolving, distillation, evaporation, crystallisation, etc. Mixtures are not pure substances and examples are air, soil, petroleum, and alloys of metals.
7.

Elements	**Mixtures**	**Compounds**
sulphur	ink	water
hydrogen	air	table salt
mercury	sea water	glucose
sodium	soil	copper sulphate crystals
copper	milk	washing soda crystals

8. A (ii); B (iii); C (vii); D (i); E (ix); F (vi); G (viii); H (v); I (iv)
9. a) oxygen (44 kg), carbon (12.15 kg), and hydrogen (6.75 kg)

   b) elements in decreasing order of mass: oxygen, carbon, hydrogen, nitrogen, calcium, phosphorus, potassium and sulphur, sodium, magnesium, chlorine

   c) The total mass of the body is 67.39 kg.

   d) The percentage of the body mass which is non-metals is $65.71/67.39 \times 100 = 97.5$ per cent.

Assessment

Question 1

Use the words from the list below to complete the seven sentences.

element	gases	compound	molecule	atom	symbol	metals	iron

a) The smallest particle that makes up a substance is called an __________.

b) Atoms can combine to make a bigger particle called a __________.

c) Each different type of atom is called an __________.

d) Each element has its own chemical __________, such as Fe for iron, S for sulphur, and Na for sodium.

e) The largest number of elements are __________ like __________ which is used in making steel.

f) A smaller number of elements are non-metals, which are usually __________ like oxygen.

g) Atoms of different elements can join together to form a new substance called a __________.

Question 2

Which of the following substances is an element?

(A) coal (B) sand (C) petrol (D) diamond

Question 3

Metals:

(A) make up more than three-quarters of all elements

(B) never occur uncombined in nature

(C) all rust or corrode

(D) react vigorously with all non-metals

Question 4

Sulphur is an example of:

(A) an element (B) a compound (C) a sulphide (D) a mixture

Question 5

Copper sulphate is an example of:

(A) a mixture (B) an alloy (C) an element (D) a compound

Question 6

Water is a compound rather than an element because it:

(A) is not easily broken down by heat

(B) has a definite boiling point

(C) is formed when hydrogen combines with oxygen

(D) is a pure substance

Question 7

Carbon is an element rather than a compound because it:

(A) is formed when wood is heated in air
(B) has been known for many centuries
(C) combines with oxygen to form a gas
(D) cannot be broken down into two or more substances

Question 8

Which of the following **cannot** be used to separate a mixture?

(A) chromatography
(B) sublimation
(C) distillation
(D) decomposition

Question 9

Two substances can be separated by distillation if they differ in:

(A) solubility
(B) melting point
(C) boiling point
(D) density

Question 10

Crude oil can be separated by fractional distillation because each fraction has a different:

(A) composition
(B) density
(C) boiling point
(D) melting point

Question 11

Chromatography is a:

(A) method of separating chemically similar substances
(B) process used to make photographic colour slides
(C) process in which metal objects are coated with chromium
(D) process for removing stains from paper during its manufacture

Question 12

A sample of ink is put in the centre of a circle of filter paper. Several drops of ethanol are then put on the ink mark. Two concentric rings of colour are obtained. What is the **best** conclusion about the ink we can come to?

(A) It contains two coloured substances only.
(B) It is a compound.
(C) It contains at least two coloured substances.
(D) It is broken down by ethanol.

Question 13

According to the scientist's way of grouping or classifying substances, a substance must be either:

(A) a solid or a liquid
(B) an element, a compound, or a gas
(C) a pure substance or a compound
(D) an element, a compound, or a mixture

Question 14

If an element called X combines with another element called Y, to form a compound called XY, the properties of XY will probably be:

(A) similar to those of X
(B) similar to those of Y
(C) a mixture of the properties of X and Y
(D) different from those of X or Y

Question 15

Here is a list of substances:

water	**glucose**	**hydrogen**	**gold**	**silver**
iron	**carbon dioxide**	**nitrogen**	**copper sulphate**	

Which of the substances in this list are made up of:

a) only one kind of atom?
b) two different kinds of atoms?
c) three different kinds of atoms?

Question 16

Look at the list of substances below. One substance is an element and one substance is a compound. Draw a line to link the word 'element' to the correct substance and another line to link the word 'compound' to the correct substance.

element	**Substances**
	orange juice
	magnesium oxide
	compound
compound	nitrogen molecule
	salt solution

Question 17

Nitrogen and oxygen are gases. They do not conduct electricity.

Sulphur is a yellow solid. It does not conduct electricity.

Sodium, magnesium, and iron are elements. They conduct electricity and have a shiny surface when they are cut.

(a) Name an element from the substances above which:

(i) is a non-metal ______________________________

(ii) exists as molecules ______________________________

(iii) is a metal ______________________________

(iv) will rust if it is exposed to air or oxygen and water ______________

(b) When iron and sulphur are heated together, a new substance is made called iron sulphide. Is the new substance an element, a mixture, or a compound? ______________

Question 18

A, B, C, and **D** are some methods used for separating substances from each other.

A chromatography

B crystallization

C distillation

D filtration

(i) Which method would you use to separate sugar from broken glass? ________

(ii) Which method would you use to separate petrol from oil? ________

(iii) Which method would you use to separate grease from dry-cleaning fluid? ________

(iv) Which method would you use to remove the mud from muddy water? ________

(v) Which method would you use to separate the blue and yellow dyes in a mixture? ________

Question 19

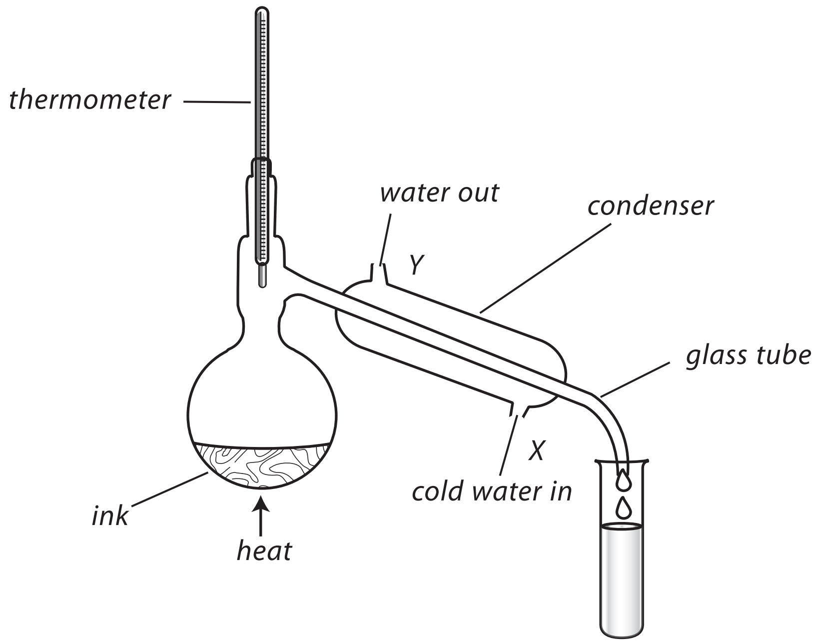
Draw a line to match each element to the reason why it is used in that particular way.

Element and its use	**Reason why the element is used**
aluminium for aeroplanes	It does not react very much and can be easily bent into new shapes.
mercury for thermometers	It is strong and hard.
iron for bridges	It is lightweight.
copper for water pipes	It is a liquid which expands when heated.

Question 20

Lubna used the apparatus below to distil 100 cm³ of water-soluble ink.

Apparatus A



Apparatus A

(a) Which processes occur during distillation?

Tick the correct box.

i) condensation then evaporation ☐

ii) evaporation then condensation ☐

iii) melting then boiling ☐

iv) melting then evaporation ☐

(b) Give the name of the colourless liquid that collects in the test tube.

(c) What would the temperature reading be on the thermometer when the ink has been boiling for two minutes? __________ °C

(d) (i) Water at 15°C enters the condenser at X.

What do you think the temperature of the water will be when it leaves the condenser at Y? __________ °C

Explain this change of temperature.

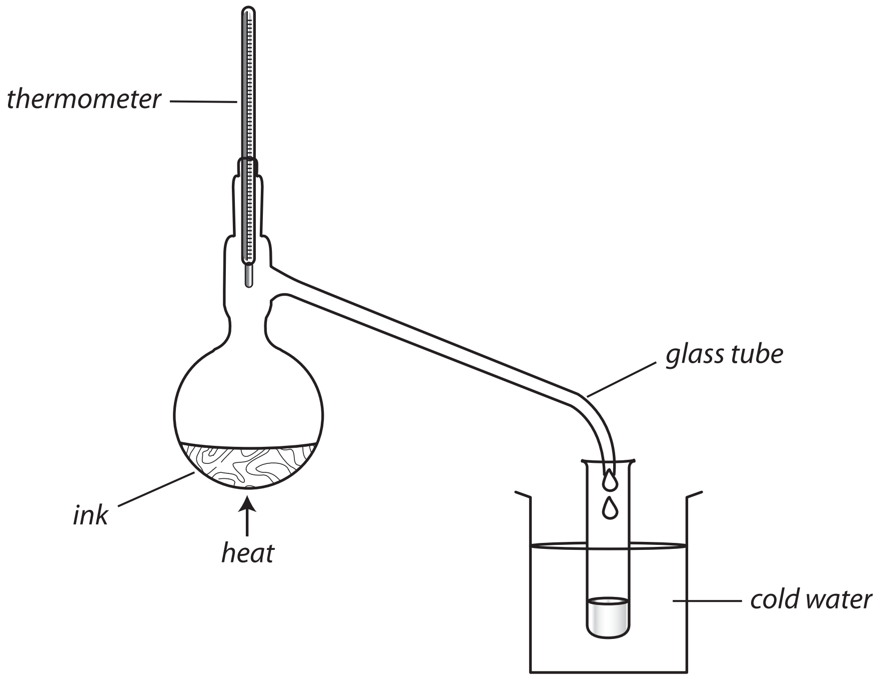
(ii) Give **two** ways in which the water vapour changes as it passes down the glass tube in the condenser.

(i) ______________________________

(ii) ______________________________

(e) Imran used the apparatus below to distil 100 cm^3 of water-soluble ink.

Apparatus B



Apparatus B

Why is the condenser in **apparatus A** better than the glass tube and beaker of water in **apparatus B**?

Answers to Assessment questions

Question 1

a) The smallest particle that makes up a substance is called an **atom**.

b) Atoms can combine to make a bigger particle called a **molecule**.

c) Each different type of atom is called an **element**.

d) Each element has its own chemical **symbol**, such as Fe for iron, S for sulphur and Na for sodium.

e) The largest number of elements are **metals** like **iron** which is used in making steel.

f) A smaller number of elements are non-metals, which are usually **gases** like oxygen.

g) Atoms of different elements can join together to form a new substance called a **compound**.

Question 2

(D) diamond

Question 3

(A) make up more than three-quarters of all elements

Question 4

(A) an element

Question 5

(D) a compound

Question 6

(C) is formed when hydrogen combines with oxygen

Question 7

(D) cannot be broken down into two or more substances

Question 8

(D) decomposition

Question 9

(C) boiling point

Question 10

(C) boiling point

Question 11

(A) method of separating chemically similar substances

Question 12

(C) It contains at least two coloured substances.

Question 13

(D) an element, a compound, or a mixture

Question 14

(D) different from those of X or Y

Question 15

a) Hydrogen, gold, silver, iron, and nitrogen are made up of only one kind of atom.

b) Water and carbon dioxide are made up of two different kinds of atoms.

c) Glucose and copper sulphate are made up of three different kinds of atoms.

Question 16

element __________ nitrogen molecule

compound __________ magnesium oxide

Question 17

Nitrogen and oxygen are gases. They do not conduct electricity.

Sulphur is a yellow solid. It does not conduct electricity.

Sodium, magnesium, and iron are elements. They conduct electricity and have a shiny surface when they are cut.

a) (i) Nitrogen, oxygen, and sulphur are non-metals.
   (ii) Nitrogen and oxygen exist as molecules.
   (iii) Sodium, magnesium, and iron are metals.
   (iv) Iron will rust if it is exposed to air or oxygen and water.

b) Iron sulphide is a compound.

Question 18

(i) To separate sugar from broken glass you would use filtration—D.

(ii) To separate petrol from oil you would use distillation—C.

(iii) To separate grease from dry-cleaning fluid you would use distillation—C.

(iv) To remove the mud from muddy water you would use filtration—D.

(v) To separate the blue and yellow dyes in a mixture you would use chromatography—A.

Question 19

Element and its use	**Reason why the element is used**
aluminium for aeroplanes	It is lightweight.
mercury for thermometers	It is a liquid which expands when heated.
iron for bridges	It is strong and hard.
copper for water pipes	It does not react very much and can be easily bent into new shapes.

Question 20

(a) The processes which occur during distillation are:
   ii) evaporation then condensation

(b) The colourless liquid that collects in the test tube is water.

(c) The temperature reading on the thermometer when the ink has been boiling for two minutes would be 100°C.

(d) (i) Water at 15°C enters the condenser at X.

The temperature of the water when it leaves the condenser at Y will be more than 15°C and perhaps as much as 20°C. The increase in temperature is due to the cold tap water having absorbed heat as it cooled the water vapour passing through the condenser.

(ii) (i) As the water vapour passes down the glass tube in the condenser it is cooled.

(ii) It then condenses to drops of water which flow out of the tube into the test tube.

(e) The glass tube in apparatus B is cooled by the air which is at room temperature. The equivalent tube in apparatus A has a jacket around it (the condenser) through which cold water flows.

Air and the atmosphere

CHAPTER 6

Teaching Objectives

- To show that air is a mixture of gases
- To demonstrate the importance of air
- To explain the composition of air
- To examine the separation, properties, and uses of the gases in air

Learning Outcomes

After studying this chapter students should be able to:

- explain why air is considered to be a mixture of gases
- recognize the importance of air
- identify the composition of the air
- relate the properties and uses of the gases in air to the composition of air

Introduction

In this chapter, the unconfined air around us is examined. It presses on us and everything around us. We are not normally aware of this pressure. However, if it did not exist, we would not be able to drink through straws, use a vacuum cleaner on a rug, or attach things by suction cups. Above all else, if we did not have this layer of air around us, we would not be able to breathe.

Much of the material in this chapter will already be familiar to the students. To avoid needless repetition, and consequent boredom, just a few aspects of the physics and chemistry of air are covered, mainly in practical terms.

Lesson suggestions

1. Our invisible surroundings

Refer to page 57 of the Students' Book.

Starter suggestions

Show the students a collection of empty containers—bottles, jars, cans, packets, etc.—some with lids and some without. Ask the students what these containers all have in common. The answer is that they all contain air.

Explain that, like fish in the sea, we live in an ocean—a vast invisible ocean of air! We recognise air only through its effects, the blowing of the wind, the changes in atmospheric pressure, and the need for it for breathing.

Main lesson

Remind the students that all the air around the Earth makes up the atmosphere, and the atmosphere stretches above us for more than 500 km. Suppose you had a container that had a base 1 cm square but stretched upwards for 500 km, the air in that container would have a mass of about 1 kg.

Now demonstrate some of the simple activities that show how this mass of air presses down on us.

Lay an old 30 cm ruler on the table so that about 10 cm of it projects beyond the table top. Lay a newspaper or large sheet of thin card over the part of the ruler which is on the table. Ask a volunteer to try to knock the ruler off the table by striking on the projecting end of the ruler as hard as possible with the side of his or her hand. It is very difficult because of the mass of air pressing down on the paper or card and holding the ruler in place. Measure the area of the newspaper or card in centimetres and multiply that figure by 1 kg. This will give you the mass of the air pressing down on the paper or card.

Ask the students to predict what would happen if you pushed down on the ruler slowly. The answer is that air will enter the space between the ruler and the paper, making it much easier to remove the ruler.

Completely fill a drinking glass with water and lay a postcard-sized piece of card over the top. Over a sink or bowl, turn the glass upside down and remove your hand from the card. Providing there are no air bubbles in the glass, the water will be held in place by the air pressure on the card.

Next obtain a jar large enough to put your hand in and a plastic bag without holes in it. Push part of the plastic bag inside the jar, using an elastic band or string to hold the bag inside the jar. Ask a volunteer to pinch the bottom of the bag and try to pull the bag out of the jar. It is extremely difficult because there is little air between the plastic bag and the inside of the jar. There is, however, a lot of air pushing down into the jar and plastic bag.

Finally, see what happens when all the air is removed from inside a can. You need a large screw-topped metal can. Do not use an old petrol can or a can that has contained any inflammable liquid. Remove the lid and wash the can out thoroughly.

Pour water into the can to a depth of 4 to 5 cm. Wearing eye protection, place the can on a hot-plate or over a Bunsen burner, with the lid off. Heat the can until the water boils and steam comes from the top of the can. Explain that the steam is driving air from inside the can.

Turn off the heat and, wearing protective gloves, carefully remove the can and place it on a heatproof surface. Screw the lid on the can tight, again using gloves or a cloth to protect yourself from the steam and hot metal.

Allow the can to cool and watch carefully to see what happens. The can should collapse in a spectacular fashion, the reason being that as the can cools, the steam condenses back to water, leaving a partial vacuum inside the can. Because the air pressure outside the can is much greater than the air pressure inside the can, the can collapses.

You can compare the can with a human body and, hopefully the students will begin to appreciate that it is the air inside our bodies which helps to prevent us collapsing under the great mass of air above us.

If there is enough time and suitable facilities, you could carry out the activity on Worksheet 6.1. In this activity the students will find that the mass of the ball increases slightly as you inflate it and then decreases slightly as you deflate it, proving air has mass or substance. The circumference of the ball does not change very much in the different stages of inflation, showing that the air inside the ball is being compressed.

2. The gases of the air

Refer to page 58 of the Students' Book.

Starter suggestions

The students should already be familiar with the names of some of the gases of the air and the importance of oxygen and carbon dioxide in photosynthesis and respiration. Ask them to produce a list of as many of these gases as they can think of, and then study the table on page 58 of the Students' Book which shows the percentage composition of air by volume. You can, if you wish, ask them to draw a pie chart in their notebooks, using colours to indicate the proportion of each gas in the air.

Main lesson

The major variable in the composition of air is water vapour. You can demonstrate the presence of water vapour in air with this simple activity. Obtain a metal can with a tight-fitting lid and remove all traces of the label from the outside. Fill the can with ice-cubes and replace the lid. Make a big show of drying the outside of the can and then leave it to stand for a few minutes. Quite quickly, droplets of condensation will form on the outside of the can. Ask the students whether these came from inside the can. If not, where did they come from?

You can demonstrate the presence of air dissolved in water, by heating a beaker of water on a tripod and gauze. Bubbles of air will quickly appear as the water is heated. Ask the students why this dissolved air is so important to fish and other aquatic life.

Go on to compare the properties of the three main gases in the air: oxygen, nitrogen, and carbon dioxide, using Worksheet 6.2. Ideally, the students should be provided with gas jars of the three gases. If supplies of the gases are not available, you may be able to generate small quantities of oxygen and carbon dioxide, or the students could fill in the chart as a homework exercise using reference books or the Internet. You will need to explain, simply, that moist litmus paper turns blue in the presence of an alkali and red in the presence of an acid.

The results of this activity are that all three gases are colourless. Oxygen is the only gas to relight a glowing splint and to keep a burning splint burning for a short time.

Carbon dioxide will turn moist litmus red (It is acidic in solution.) and it turns lime water milky.

There is no simple specific test for nitrogen.

Magnesium is a highly flammable metal and once ignited it is difficult to extinguish. It burns in oxygen to form white magnesium oxide, it continues to burn in nitrogen and forms magnesium nitride, while in carbon dioxide it forms magnesium oxide and carbon (seen as black specks).

3. Burning and rusting

Refer to pages 59 and 60 of the Students' Book.

Starter suggestions

The students should already know the importance of air in breathing or respiration. There are two more processes for which air is important, burning or combustion and the rusting of iron. Explain to the students that both combustion and rusting involve oxygen from the air. Combustion is of vital importance to us because most of our energy comes from the burning of fossil fuels or wood. Iron and steel are among the most widely used materials in our society. This is because iron is one of the easiest and cheapest of metals to extract from its ore. And both iron and steel rust if exposed to damp air for even a short time, resulting in enormous damage to structures that contain either of these metals, unless of course the metal is protected from air and water.

Main lesson

Use Worksheet 6.3 to show the connection between air and burning.

Safety: Strict supervision of this activity will be necessary. The students should also use eye protection.

The expected result of this activity is that the larger the jar, the longer the candle flame will burn, proving there is a connection between air and burning.

It used to be thought that a candle went out when it had used up all the oxygen in a jar. It is now known that the candle goes out long before all the oxygen has been used up. Scientists are not sure why. It could be because the carbon dioxide and water vapour produced when the candle burns helps to extinguish the flame.

Use Worksheet 6.4 to show the conditions that cause iron to rust.

The expected result is that only in tube C, in which the nail is exposed to both air and water, will rust form.

The experiment could be extended if you wish, to use salt water instead of tap water for the experiment, to see if it speeds up the rusting process. (It does.)

Discuss how the various methods of preventing iron and steel from rusting, such as paint, grease, and galvanizing, actually work.

4. The greenhouse effect

Refer to page 63 of the Students' Book.

Starter suggestions

Show the students newspaper headlines relating to the greenhouse effect and global warming. Remind the students that many human activities have consequences and what you want them to think about is what happens to the products of burning or combustion when they pass into the atmosphere. Explain that the greenhouse effect is a natural process, which helps to make the world climate fit for us to live in. Without the greenhouse effect, the world climate would be, on average, 35°C cooler than it is today. But many scientists believe that the carbon dioxide produced when fossil fuels and wood are burned, is adding to the natural greenhouse effect. It is making the world average temperature rise—the so-called global warming.

Main lesson

Use Worksheet 6.5 for this part of the lesson.

The expected result is that the thermometer under the glass jar will show a higher temperature than the uncovered thermometer.

Go on to discuss whether the 'greenhouse effect' is going to be a good thing or a bad thing if it going to raise the temperature in Pakistan and other parts of the world.

Ideas for investigations and extension work

Exhaled air

Use a drinking straw to blow into a test tube of lime water and show that exhaled air contains carbon dioxide.

Burning and exhaled air

Burn two identical candles, one in a jar of ordinary air and the other in an identical jar of exhaled air. Show that the candle burns for a longer time in the ordinary air because the exhaled air contains less oxygen and more carbon dioxide.

The greenhouse effect

Collect pictures and magazine articles about the greenhouse effect. Make a scrapbook or wallchart with them. What will happen to the world's oceans and seas if the world becomes warmer, as scientists believe it will? What would happen to Pakistan? What can we do to slow up or stop the greenhouse effect?

WORKSHEET 6.1

Does air have mass and density?

Materials needed per group: basketballs or large beach balls, air pumps with needles, access to a top pan balance accurate to at least one decimal place, measuring tape or rulers and string, calculators (optional).

1. Use the balance to find the mass of the deflated basketball or beach ball: ____________________
2. Inflate the ball slightly and find its mass: ____________________
3. Measure the circumference of the ball: ____________________
4. Partially inflate the ball. Find its mass: ____________________
5. Measure the circumference of the ball: ____________________
6. Inflate the ball until it is firm (able to bounce well). Be careful not to over-inflate it and explode it.
7. Weigh the ball: ____________________
8. Measure the circumference of the ball: ____________________
9. Using the mass of the deflated ball (see 1. above), find the mass of the air in the ball at each stage of the inflation process.

What happens to the mass of the ball as you inflate it and then deflate it? Why? ____________________

____

Does the circumference of the ball change very much in the different stages of inflation? ____________________

____

Does this mean that air can be compressed? ____

WORKSHEET 6.2

Three gases from the air

Materials needed per group: stoppered test tubes of nitrogen, oxygen, and carbon dioxide, lime water, litmus paper, wooden splints, Bunsen burners and heatproof mats, magnesium ribbon and tongs for use by the teacher, eye protection.

Safety: Wear eye protection throughout this activity.

Carry out the tests suggested in the table below and complete the table.

Test	**Nitrogen**	**Oxygen**	**Carbon dioxide**
Colour of gas			
Hold a glowing splint in each gas.			
Hold a burning splint in each gas.			
Put a piece of moist litmus paper in each gas.			
Add a little lime water to a tube of each gas and shake.			
Your teacher will show you the effect of burning magnesium in each gas.			

WORKSHEET 6.3

What has air to do with burning?

Materials needed per group: short lengths of candle (about 5 cm long), small metal lids (or petri dishes filled with sand), glass jars of three or more different sizes, matches, a clock or watch with a second hand, a measuring jug, eye protection.

Safety: Do not leave burning candles unattended and use extreme care when covering the lighted candles with the jars. Wear eye protection.

1. Stand one of the pieces of candle in one of the metal lids or in a petri dish containing sand.
2. Light the candle and carefully cover the candle with the smallest jar. At the same time, one of the other members of your group should start timing to find out how many seconds the candle burns for. Record the results in the table below.
3. When the jar you have used has cooled down, measure its volume. Take the jar and completely fill it with water. Pour this water into a measuring jug to give you the volume of the jar. Record your results in the table.
4. Repeat these processes for each of the other glass jars. For each jar, record the length of time the candle burned for (in seconds), and the volume of the jar.

	Volume of jar (cm^3)	Length of time the candle burned (seconds)
Jar 1		
Jar 2		
Jar 3		
Jar 4		
Jar 5		

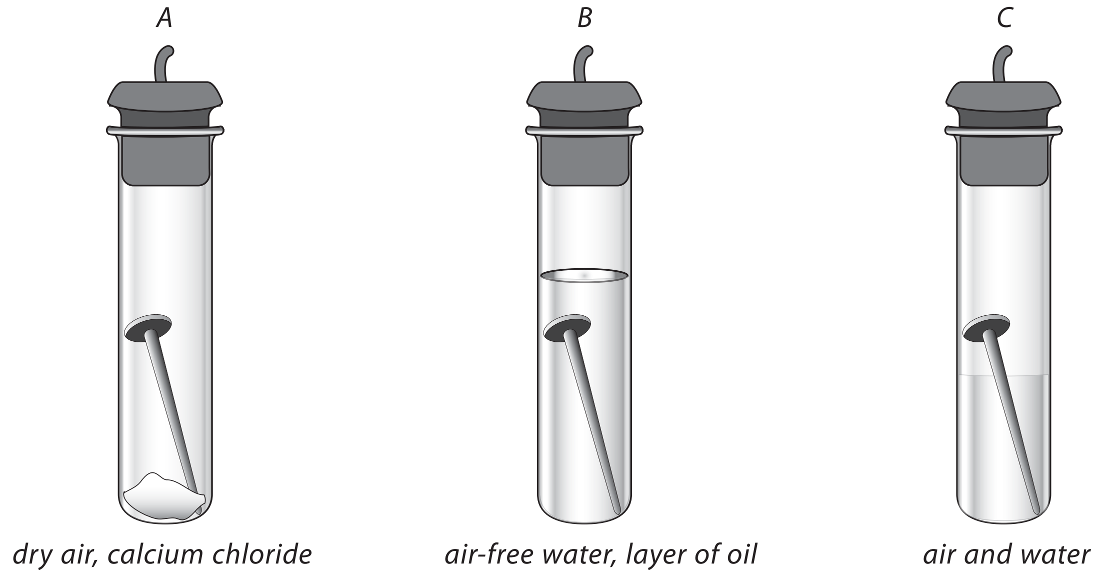
If you do not have enough results of your own, obtain the results of other groups who have jars of different volumes to the ones you used. Plot a graph of your results.

WORKSHEET 6.4

What causes iron to rust?

Materials needed per group: three test tubes with rubber stoppers, three clean iron nails, calcium chloride, a spatula, water which has been boiled to remove the air from it, mineral or vegetable oil, dropper, test tube rack.

1. Use the spatula to put a small quantity of calcium chloride in the bottom of one test tube. Calcium chloride absorbs water. Put a clean nail in the tube and push the rubber stopper firmly on the tube. Label this tube A.
2. Half fill a second tube with water which has been boiled to drive off the air. Put a clean nail into the water, making sure that the nail is covered. Use the dropper to put a thin layer of oil on the surface of the water to keep out the air. Put a rubber stopper on the tube. Label this tube B.
3. Put water which has not been boiled in the third tube and add a clean nail. This time, see that the nail is partly in the water and partly out of it. Put a stopper on the tube. Label this tube C.



4. Leave the tubes for about a week, looking at the nails through the glass each day in the meantime. Which nails show signs of rusting?

   What conditions are necessary for an iron nail to rust?

WORKSHEET 6.5

What does a greenhouse do to the temperature?

Materials needed per group: 2 thermometers, a large clear-glass jar. Work on a sunny day.

1. On a sunny day lay two thermometers side by side on the same kind of surface, outdoors. Write down the temperature shown by each thermometer:

   Thermometer 1 __________ Thermometer 2 __________

2. Cover one of the thermometers with a large clear-glass jar. This is your greenhouse.
3. Read the temperature of the two thermometers after 30 minutes and again after an hour. What difference in temperature is there, if any? ____
   ____
4. What happens to the temperature inside a real greenhouse on a sunny day?

Answers to questions in the Students' Book

1. Air is considered to be a mixture and not a compound because its constituents vary from place to place and from time to time and they are not chemically combined.
2. If you blow up a balloon, the air inside the balloon is exhaled air and it will contain less oxygen and more carbon dioxide and water vapour than the outside air. It will also contain less dust and impurities because these will have been filtered out when the air was breathed in.
3. Air pumps are fitted to many fish tanks to add oxygen to the water and also to keep the water circulating so that it does not become stagnant.
4. Without nitrogen in the air, the percentage of oxygen would be much higher and materials would burn better and for longer in it.
5. Because nitrogen is an inactive gas, it is sometimes used to replace the air in packets of snack foods to prevent them oxidising or decaying, which they would do in the presence of oxygen.
6. A fire extinguisher containing carbon dioxide is better than water for putting out oil and electrical fires because oil floats on water and would continue burning, while water conducts electricity. Carbon dioxide, being 'heavier' (denser) than air would form a blanket over the fires, keeping oxygen out.
7. The proportion of water vapour in the air is higher in places near the sea, because water evaporates from the sea (and lakes, rivers, and other wet areas) as part of the water cycle. The proportion of carbon dioxide in the air is higher in industrial areas because all forms of combustion produce carbon dioxide.
8. Three different processes which result in more carbon dioxide going into the atmosphere are respiration and any of the different forms of combustion or burning which take place in, for example, motor vehicles, power stations, incinerators, etc. The clearance of forests by fire for farmland, roads or industry also adds carbon dioxide to the air.
9. If the sea level surrounding Pakistan rose by two metres as a result of global warming, much coastal land would be flooded and cities such as Karachi and Pasni would be inundated. The floodwaters would also swamp much of the low-lying land and cities in the basin of the Indus River and its tributaries.

Assessment

Question 1

Use the words from the list below to complete the seven sentences.

mixture	combustion	nitrogen	oxygen	atmosphere	sounds
photosynthesis	weather	carbon dioxide			

i) Our Earth is surrounded by a layer of air called the __________.

ii) Air is a __________ of gases.

iii) The most abundant gas in the air is __________.

iv) Without __________ from the air, most living things would die.

v) Air causes changes in the __________, and provides a medium for __________ to travel through.

vi) __________ from the air is used by plants to make their food in the process called __________.

vii) Respiration and __________ use up oxygen from the air and add carbon dioxide to it.

Question 2

We know that air is a mixture because:

(A) it supports combustion.
(B) nitrogen and oxygen are both gases.
(C) humans breathe oxygen and not nitrogen.
(D) liquid air can be fractionally distilled.

Question 3

The most common element in dry air is:

(A) oxygen (B) nitrogen (C) water vapour (D) carbon dioxide

Question 4

Which of the following is NOT a property of nitrogen?

(A) It is very reactive.
(B) It does not support combustion (burning).
(C) It is slightly less dense than air.
(D) It is colourless and odourless.

Question 5

Which of the following is NOT a property of carbon dioxide?

(A) It is colourless and odourless.
(B) It is produced during respiration and combustion.
(C) It has a lower density than air.
(D) Plants use it to produce food during photosynthesis.

Question 6

The amount of oxygen in the air is kept roughly constant by the process called:

(A) respiration (B) osmosis (C) photosynthesis (D) combustion

Question 7

Which of the following is the correct word equation for respiration?

(A) carbon dioxide + glucose $\longrightarrow$ oxygen + water + energy
(B) carbon dioxide + water $\longrightarrow$ glucose + oxygen + energy
(C) carbon dioxide + oxygen $\longrightarrow$ glucose + water + energy
(D) glucose + oxygen $\longrightarrow$ carbon dioxide + water + energy

Question 8

Which of the following does the humidity of the air tell us the quantity of?

(A) oxygen (B) carbon dioxide (C) nitrogen (D) water vapour

Question 9

Oxygen and nitrogen are obtained in large quantities from air by a process called:

(A) chromatography (B) fractional distillation (C) partial evaporation (D) filtration

Question 10

The test for oxygen is that it:

(A) turns lime water milky.
(B) relights a glowing splint.
(C) puts out a flame.
(D) turns lime water green.

Question 11

Oxygen combines with most other elements to form:

(A) oxides (B) carbonates (C) sulphates (D) sulphides

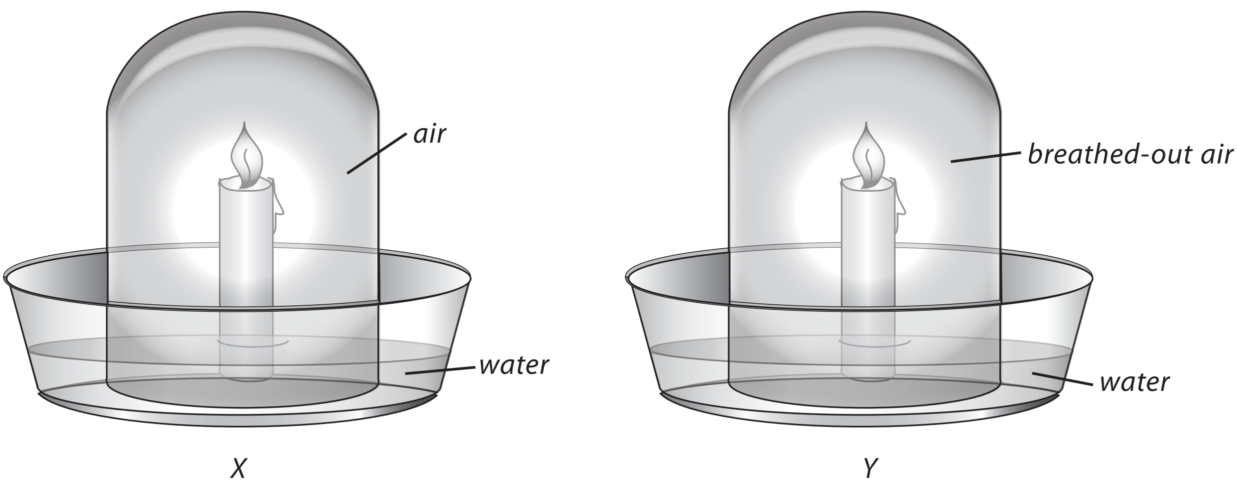
Question 12

Which of the following are ALL inert or noble gases?

(A) oxygen, water vapour, neon, argon
(B) carbon dioxide, oxygen, neon, argon
(C) neon, argon, xenon, water vapour
(D) neon, argon, helium, krypton

Question 13

The diagram shows candles burning in two gas jars. The jars are inverted over water. Which of the following statements is correct?



(A) Candle X will go out first.
(B) Candle Y will go out first.
(C) Both candles will go out at the same time.
(D) X will go out but Y will not.

Question 14

A piece of wood is burnt in a jar of oxygen. There is some lime water at the bottom of the jar. After the wood has burnt for a while the jar is shaken and the lime water is seen to go cloudy or milky. This is because

(A) the smoke, which consists of carbon particles, dissolves.

(B) carbon dioxide is produced when the wood burns.

(C) an acid is produced when some substances burn.

(D) wood contains carbon dioxide which is set free when the wood is heated.

Question 15

To prepare large quantities of oxygen it is separated from nitrogen by a process which depends upon the fact that

(A) oxygen is chemically more reactive than nitrogen.

(B) liquid nitrogen turns to a gas at a lower temperature than liquid oxygen.

(C) nitrogen is cooled more quickly than oxygen.

(D) liquid oxygen is denser ('heavier') than liquid nitrogen.

Question 16

Complete the following table which lists the properties of some important gases in the air.

Important gases in the air	**Nitrogen**	**Oxygen**	**Carbon dioxide**
colour and odour	colourless and odourless		
density	slightly less dense than air	approximately the same density as air	
chemical reactivity	inactive: does not combine readily with other substances		inactive
supports combustion			

Answers to Assessment questions

Question 1

i) Our Earth is surrounded by a layer of air called the **atmosphere**.

ii) Air is a **mixture** of gases.

iii) The most abundant gas in the air is **nitrogen**.

iv) Without **oxygen** from the air, most living things would die.

v) Air causes changes in the **weather**, and provides a medium for **sounds** to travel through.

vi) **Carbon dioxide** from the air is used by plants to make their food in the process called **photosynthesis**.

vii) Respiration and **combustion** use up oxygen from the air and add carbon dioxide to it.

Question 2

(D) liquid air can be fractionally distilled.

Question 3

(B) nitrogen

Question 4

(A) It is very reactive.

Question 5

(C) It has a lower density than air.

Question 6

(C) photosynthesis

Question 7

(D) glucose + oxygen $\longrightarrow$ carbon dioxide + water + energy

Question 8

(D) water vapour

Question 9

(B) fractional distillation

Question 10

(B) relights a glowing splint

Question 11

(A) oxides

Question 12

(D) neon, argon, helium, krypton

Question 13

(B) Candle Y will go out first.

Question 14

(B) Carbon dioxide is produced when the wood burns.

Question 15

(B) Liquid nitrogen turns to a gas at a lower temperature than liquid oxygen.

Question 16

Important gases in the air	**Nitrogen**	**Oxygen**	**Carbon dioxide**
colour and odour	colourless and odourless	colourless and odourless	colourless and odourless
density	slightly less dense than air	approximately the same density as air	has a higher density than air
chemical reactivity	inactive: does not combine readily with other substances	very active: combines readily with many substances to form new substances	inactive
supports combustion	no	yes	no

Solutions and suspensions

CHAPTER 7

Teaching Objectives

- To demonstrate the nature of solutions and suspensions by carrying out simple laboratory tests
- To explain the formation of solutions with the help of a particle model
- To show experimentally that there is a limit to the amount of solute which can dissolve in a given amount of solvent at a given temperature
- To distinguish between aqueous, dilute, and concentrated solutions
- To distinguish between unsaturated, saturated, and supersaturated solutions
- To illustrate the uses of solutions and suspensions in daily life

Learning Outcomes

After studying this chapter students should be able to:

- differentiate between a solute, solvent, and solution
- identify the solute and solvent in a solution
- use the particle model to explain the formation of a solution
- distinguish between aqueous, dilute, and concentrated solutions
- demonstrate the use of water as a universal solvent
- prepare saturated and unsaturated solutions
- define solubility
- investigate the effects of temperature on solubility using a variety of compounds
- differentiate between solutions and suspensions
- identify the uses of solutions and suspensions in daily life

Introduction

The students will already have some knowledge of this subject area from their work in Chapter 5: Atoms, molecules, mixtures and compounds. They should already know that a solution is a uniform mixture of two or more substances, with salt or sugar dissolved in water being common and well-used examples. As a result, it is probably best to concentrate on the meanings of some of the scientific words that students find confusing, including solute, solvent, solution, concentrated, dilute, and saturated.

Lesson suggestions

1. Soluble and insoluble

Refer to page 68 of the Students' Book.

Starter suggestions

Show the students some samples of water from different places: tap water, a pond, a river, a lake, sea water (if sea water is not available, the teacher can make a suitable substitute by adding about 5 g of salt to 1 litre of water). Ask the students which of these samples are solutions? How can we find out? The answer is that we would need to filter the samples to remove any insoluble matter and then evaporate the filtrates to dryness in clean evaporating basins. Any solutes will be left in the basin.

Alternatively, stress that a solid dissolved in a liquid is not the only kind of solution. Open a can or bottle of fizzy drink and pour some into a beaker. Show the bubbles of carbon dioxide gas (solute) rising from the liquid (solvent). Ask for ideas on how we could measure the amount of carbon dioxide dissolved in a given volume of the drink. Try them out if there is time and the suggestions seem reasonable.

Main lesson

Use Worksheet 7.1 to allow the students to distinguish between a solution and other types of mixtures. Hopefully, this experiment will help the students to know and understand the characteristics of a solution.

The expected results are as follows: The copper sulphate will form a clear blue solution which will not leave a residue when it is passed through a filter paper. The situation regarding the powdered milk and soil is more complicated. They will both form a suspension which will slowly settle on standing. When they are filtered, they will both leave a residue in the filter paper. However, if the clear filtrate was heated to dryness, there would be a solute left in the evaporating basin in both cases. The solute left from the soil solution consists of the mineral salts which plants use to help make their food.

2. Unsaturated, saturated and supersaturated solutions

Refer to page 69 of the Students' Book.

Starter suggestions

Sprinkle a little water on a cloth and ask the students to describe it. Hopefully they will say that the cloth is now damp. Now dip the same cloth in a bowl or sink full of water, and ask the students how they would now describe the cloth. The word you are looking for is 'saturated'. Ask them when else in their everyday lives they would use the word 'saturated', and then go on to tell them that we also use that word to describe certain solutions.

Main lesson

It is suggested that you use Worksheet 7.2 to illustrate the differences between an unsaturated solution, a saturated solution, and a supersaturated solution, either as a demonstration experiment or as a class practical exercise. The activity uses sodium thiosulphate crystals, the substance called 'hypo' by photographers.

The answers to the questions on the worksheet are

a) You know that, after adding just three sodium thiosulphate crystals, the solution was unsaturated because more of the crystals later dissolve at that temperature.

b) You know that you have made a saturated solution because no more of the crystals will dissolve.

c) Warming the saturated solution allows it to dissolve more of the crystals.

d) You know you had made a supersaturated solution because more of the crystals dissolve in the solution at the higher temperature.

e) If you were given a solution of sodium thiosulphate in a test tube, adding one crystal of the sodium thiosulphate would tell whether the solution was unsaturated, saturated, or supersaturated. If the crystal dissolves the solution is unsaturated. If the crystal does not dissolve, the solution is saturated. If the solution crystallises out, it is supersaturated.

f) The students probably will not know where the heat came from in step 8 of the experiment. In fact, the process of crystallisation gives off heat and is what is called an exothermic reaction.

3. Factors affecting the speed of solution

Refer to page 72 of the Students' Book.

Starter suggestions

Tell the students you have a pretend substance that only seems to dissolve slowly. Ask them for ideas on what you could do to speed up the dissolving process. Useful answers might be to warm the solvent, to stir or shake the mixture, or to crush the solute into smaller pieces.

Main lesson

The following small experiments could be carried out by the whole class, although it will be necessary for the students to wear eye protection during the heating of solutions.

a) How much salt will dissolve in 20 cm^3 of water?

Measure out 20 cm^3 of water into a large test tube. Have ready some little packets or heaps of salt, each weighing 1 g. Add one of these to the water and shake the tube. Repeat with another 1 g of salt. Go on doing this until some salt remains undissolved. How many grammes of salt will dissolve in 20 cm^3 of water?

b) Does a given quantity of water dissolve the same weight of all solutes?

Repeat the experiment above with different solutes. Different groups in the class can try copper sulphate, potassium nitrate, alum, ammonium chloride, sodium thiosulphate, sodium sulphate, or even sugar.

What conclusion does the class come to? The expected answer is that the solubility of solutes in water at the same temperature varies greatly. Ammonium chloride and potassium nitrate are particularly soluble in water.

c) Does hot water dissolve more of a substance than an equal weight of cold water?

Heat 20 cm^3 of water in a test tube to about 70°C. Now repeat the experiment with salt described in Experiment a) above.

Does temperature make any difference to the weight of solute that dissolves?

Is the effect the same for all substances? (The solubility of solids in liquids increases with temperature, although for salt, the increase is quite small.)

Can the students put forward a theory to explain their observation that solubility increases with temperature? (In simple terms, at higher temperatures, the particles of solvent move around faster and so there is more space between them for particles of solute to fit in.)

d) Does size of crystal and stirring affect the speed of solution?

Choose two crystals of copper sulphate as nearly as possible of the same size. Crush one of them to a fine powder in a mortar. Put 100 cm^3 of water into each of two beakers. Take the temperature of the water in the two beakers and check that it is the same. Add the whole crystal to one and the powder to the other. Which dissolves more quickly? (The powdered copper sulphate because it has a larger surface area exposed to the water.)

Repeat this experiment with two beakers each containing 100 cm^3 of water at the same temperature. Weigh out two lots of 1 g of copper sulphate powder, and add one lot to each beaker. Leave one alone, and stir the other vigorously with a glass rod. Which one dissolves first? (The one that was stirred.)

Ideas for investigations and extension work

Dissolving salt

Put a drop of water on a microscope slide and focus with the low power on the water drop. Carefully add one or two crystals of salt to the water drop and watch while they dissolve. Then gently warm the slide over a radiator or Bunsen burner until the water begins to evaporate. Watch through the microscope as the salt crystals reappear.

Mineral water

Some bottles of mineral water have the word 'pure' on the label. Investigate whether this claim is true, or are there substances dissolved in the water?

Sugar

Collect samples of several kinds of sugar: icing sugar, cube sugar, granulated sugar, brown sugar, etc. Compare the solubility in water of the different kinds of sugar at two different temperatures.

Torch testing

With the beam of a powerful torch, test dilute mixtures of common substances found around the home, e.g. instant coffee, tea, ink, toothpaste, etc. Put the samples tested on one side to see if they settle. From your observations, classify the substances tested as a true solution or a suspension.

WORKSHEET 7.1

What are the differences between solutions and other mixtures?

Materials needed per group: distilled water, powdered milk, copper sulphate, garden soil, 3 test tubes and a rack, rubber stoppers, filter paper, filter funnel, desk lamp or microscope lamp, magnifying glass, spatulas, eye protection.

Safety: Wear eye protection.

1. Half fill each of three clean test tubes with distilled water.
2. Add a spatula of powdered milk to one, of copper sulphate to another, and of garden soil to the third.
3. Stopper the tubes and shake them.
4. Examine each mixture with a magnifying glass. Look for individual particles in each mixture. Record your observations. ____________________
5. In a dark cupboard, hold each mixture in turn, in the beam from a desk lamp or microscope lamp. Note whether any of the mixtures scatter light. ____________________
   ____
6. Do any of the mixtures show signs of settling? ____________________
7. Try to filter each of the mixtures. Record what happened in each case.
   powdered milk ____________________
   copper sulphate ____________________
   soil ____________________

You already know that a substance breaks down into extremely small particles when it dissolves. Because of the minuteness of these particles, all solutions have four characteristics.

- The solute particles cannot be seen, even with the help of a magnifying glass or ordinary microscope.
- The solute cannot be filtered out of the solution. The particles are so small that they pass through the tiny holes in the filter.
- The solution is transparent, even when it is coloured.
- The solute does not settle at the bottom of the container when the solution is left standing.

Based on your observations, which of the mixtures may correctly be called a solution? State your reasons.
____

How would you find out whether any of the filtrates from stage 3 above were solutions? ____________________
____

WORKSHEET 7.2

Unsaturated, saturated, and supersaturated solutions

Materials needed per group: balance, test tubes (20mm × 150mm), cocktail sticks, lolly sticks or toothpicks, beaker, test tube holder, Bunsen burner and heatproof mat, sodium thiosulphate ('hypo') crystals, distilled water, spatula, eye protection.

Safety: Wear eye protection during this experiment.

1. Pour distilled water into a test tube to a depth of about 1 cm.
2. Using the balance, measure out 15 g of sodium thiosulphate crystals.
3. Using a spatula, place three crystals of sodium thiosulphate in the test tube and stir until they dissolve.
4. Add sodium thiosulphate crystals, one at a time, each time stirring until the crystal dissolves. Stop adding crystals when the last one will not dissolve. Now you have made a saturated solution.
5. Using a test tube holder, gently warm the saturated solution. Carefully add a few more crystals, one at a time, making sure they dissolve completely. Record what you observe. ______________________________
____
6. Cool the solution by standing it in a beaker partially filled with cold tap water. The solution is now supersaturated, since it contains move sodium thiosulphate than would normally dissolve at the lower temperature.
7. Drop one crystal of sodium thiosulphate into the supersaturated solution and observe what happens. This is called 'seeding'. ______________________________
8. Lift the test tube from the cold bath just after the sodium thiosulphate crystals have formed and feel it with your hand. What do you notice? ______________________________
   a) How did you know that the solution, after adding just three sodium thiosulphate crystals, was unsaturated? ______________________________
   b) How did you know you had succeeded in making a saturated solution? ______________________________
   c) What was the effect of warming the saturated solution? ______________________________
   d) How did you know you had made a supersaturated solution? ______________________________
   e) If you were given a solution of sodium thiosulphate in a test tube, how would you tell whether the solution was unsaturated, saturated, or supersaturated? ______________________________
   f) Where did the heat come from in step 8? ______________________________

Answers to questions in the Students' Book

1. A solution is a uniform or homogeneous mixture in which the particles of solute and solvent are evenly spread out. Examples of common solutions include salt and sugar solutions, vinegar, fizzy drinks and drinks such as tea, coffee, and cocoa. In a salt solution, water is the solvent and the salt is the solute.
2. Another name for a weak solution is dilute; a strong solution is also called a concentrated solution.
3. The most plentiful liquid solution on Earth is the water in the oceans and seas. Rain water feeds the world's lakes and rivers. As this water makes its way down to the oceans and seas it dissolves salt and other solutes from the rocks in the Earth's crust. Gradually, as a result of evaporation of the water, the solution becomes more and more concentrated.
4. The characteristics of a solution are that it is a uniform mixture, no chemical change is involved between the solvent and the solute, the solute is still present although it may be difficult to see, and the mass of a solution is equal to the mass of the solvent added to the mass of the solute. A solution also allows light to pass through it.
5. You could make a concentrated solution weaker by adding more of the solvent.
6. The copper sulphate is the solute and the water is the solvent. The mass of the resulting solution is 102 g.
7. An alloy is a mixture of two or more elements (usually metals except for the carbon in steel). Some common alloys include steel and stainless steel, brass, bronze, and solder.
8. One common solvent other than water is ethanol.
9. If the blue water is left to stand, the copper sulphate will settle on the bottom of the container if it is part of a suspension. If the blue liquid is a solution and it is passed through a filter paper, there will be no residue in the filter paper (unless of course the solution is saturated).
10. A saturated solution is one which will not dissolve any more solute at a particular temperature. If a saturated solution is warmed, then it will dissolve more of the solute until it again forms a saturated solution at the new temperature.
11. The higher the temperature the less gas will dissolve in a liquid such as water.
12. If a crystal of the solute is added to an unsaturated solution, the crystal will dissolve. If the crystal of solute is added to a saturated solution, it will not dissolve but simply lie at the bottom of the container. If the solution is supersaturated, adding a crystal of the solute will make crystals form on the bottom of the container until the normal level of saturation is reached.
13. The solubility of a substance is the maximum amount of that substance which will dissolve in a given volume of water (or some other solvent) at a particular temperature. With most solid solutes, the solubility increases with temperature, although with a few solutes, including sodium chloride (table salt) there is little change.
14. A suspension is a mixture of small particles suspended in a gas or liquid. Calamine lotion, used to sooth insect stings and bites, sunburn and some rashes, is a suspension. Many cough mixtures and medicines used to treat indigestion are suspensions, so too is the mixture formed between cement and water. A suspension can be separated into its components by filtration.

Assessment

Question 1

How well do you understand the words used in connection with solutions?

Draw lines to join each word to its correct definition.

solute	the liquid that a solid dissolves in to form a solution
solution	a solid that dissolves in a liquid to form a solution
solvent	describes a substance that dissolves in a solvent
soluble	the mixture formed when a solid dissolves in a solvent

Question 2

Use these words to fill in the gaps in the sentences.

evaporate	insoluble	soluble	saturated

a) Aziz added sugar to his tea until no more would dissolve. He had made a __________ solution.

b) Sugar will dissolve in water or tea because it is __________.

c) Flour will not dissolve in water because it is __________.

d) To produce sugar from a sugar solution you need to allow the water to __________.

Question 3

A solution is made by:

(A) filtering it.
(B) evaporating it.
(C) heating it until it melts.
(D) adding a solute to a solvent.

Question 4

In order to decide whether tap water contained any dissolved solids, you would:

(A) filter it. (B) crystallise it. (C) evaporate it. (D) freeze it.

Question 5

Which one of the following substances is insoluble in water?

(A) table salt (B) oil (C) sugar (D) washing soda

Question 6

The solubility of a solid in a liquid is the amount of solid which can dissolve in:

(A) 100 g of that liquid. (B) 75 g of that liquid.

(C) 50 g of that liquid. (D) 25 g of that liquid.

Question 7

What is the weight of the solution when 20 g of salt is dissolved in 100 g of water?

(A) 100 g (B) 120 g (C) 75 g (D) 20 g

Question 8

You are given four different liquids and one solid. You wish to discover which liquid will dissolve the solid fastest. In setting up the experiment, which one of the following rules is WRONG?

(A) Take the same volume of each liquid. (B) Always take the same weight of the solid.

(C) Keep all the liquids at the same temperature. (D) Stir only those mixtures which require it.

Question 9

Two powders have been mixed by mistake. They can be separated if:

(A) they dissolve in water.

(B) a liquid can be found which will dissolve both equally well.

(C) they have different boiling points.

(D) a liquid can be found which will dissolve one and not the other.

Question 10

Some students were given a mixture of sand, salt, and iron filings which they were told to separate.

a) Put these statements in the correct order to show how they did this.

i) Filter the mixture of sand, salt, and water to separate the sand from the salt solution.

ii) Add water to the sand and salt.

iii) Use a magnet to extract the iron filings.

iv) Heat the salt solution so that the water evaporates leaving the salt behind.

____

b) List the apparatus you would use at each stage.

____

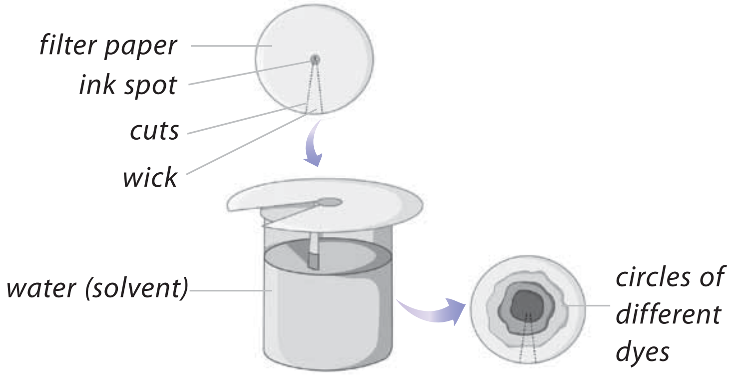
____

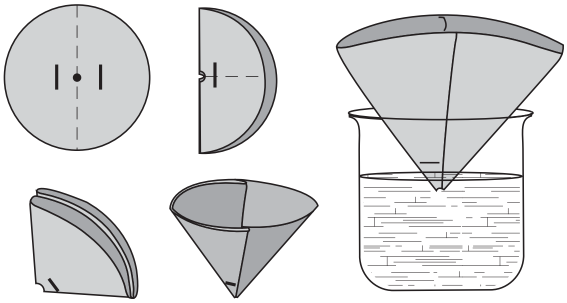
____

____

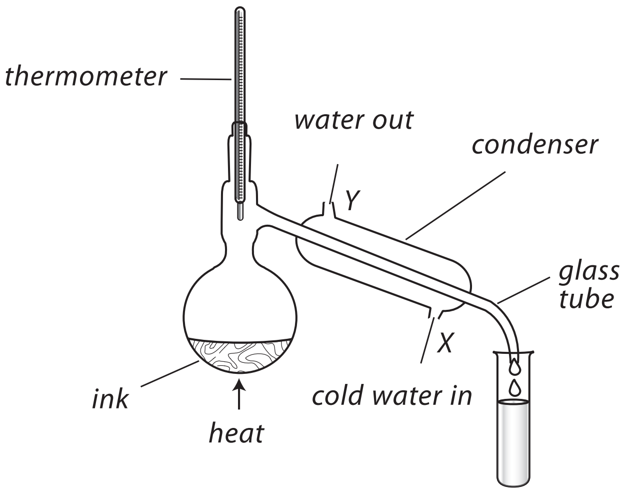
Question 11

Look at the diagrams below which show different methods of separating substances.





___________________________ ___________________________



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a) Choose from the following words to label each method of separating substances with its correct name.

chromatography	distillation	filtration

b) Match the correctly named technique to the mixture it could be used to separate.

i) Separating the different coloured dyes that make up the colour of a purple felt-tipped pen ____________

ii) Separating the water from the dye in black ink ____________

iii) Getting a solution of dissolved coffee in water from large pieces of coffee beans ____________

iv) To get blue copper sulphate crystals from a solution of copper sulphate in water ____________

Question 12

When copper sulphate is stirred in water, the water turns blue. What two tests would you carry out to find out if this new mixture is a solution?

i) ______________________________

ii) ______________________________

Question 13

Salman experimented with three substances, A, B, and C, to see how much would dissolve in 100 cm^3 of water at two different temperatures. Here are his results:

Solid	Grams dissolving at 20°C	Grams dissolving at 80°C
A	21.1	57.0
B	34.8	52.1
C	35.8	38.6

i) What effect does temperature have on the amount of these solids that can dissolve in water? ____________ ______________________________

ii) Which substance is the **most** soluble in water at 20°C? ______________________________

iii) Which substance is the **least** soluble in water at 80°C? ______________________________

Question 14

Tanya added table salt to water and stirred it. The salt dissolved in the water.

a) Complete the table below:

Scientific term	Substance
solute	
solvent	
	salt water

b) Tanya measured the maximum amount of salt that would dissolve in 100 ml of water at room temperature. She then repeated his experiment with 100 ml of water heated to 60°C.

(i) What name is given to a liquid that cannot dissolve any more solid? ____________

(ii) Was Tanya able to dissolve more or less salt at the higher temperature?

Tanya was able to dissolve ____________ salt in the water at the higher temperature, because the particles ______________________________ .

(iii) Tanya found that she could dissolve 36 g of salt in 100 ml (100 g) of water at room temperature. What is the mass of the mixture? ______________________________

Question 15

Some students did an experiment to find out if fruit jelly dissolved more quickly in water at a higher temperature. This table shows their results:

Temperature (°C)	Time for jelly to dissolve (minutes)
30	12.4
40	10.8
50	9.2
60	9.1
70	5.8
80	4.1

a) Name TWO factors or variables that should have been kept the same in order to make sure that the experiment was a fair test.

i) ______________________________

ii) ______________________________

b) i) Plot a graph of the students' results. Label the axes of the graph and draw a line of best fit through the points.

ii) There is one result which seems to be wrong. Draw a circle around this point on your graph.

c) One of the students wrote this conclusion in his book:

'The temperature of the water did affect how quickly the jelly dissolved'.

The other students said that this was not a very scientific conclusion.

i) Why do you think they said that? ______________________________

ii) Write a more scientific conclusion for this experiment. ______________________________

Question 16

Nail varnish does not dissolve in water but it does dissolve in acetone. Which of the following statements are correct? Tick the correct options.

(A) Nail varnish is soluble in water. ☐

(B) Nail varnish is soluble in acetone. ☐

(C) Water is a good solvent for all substances. ☐

(D) Water is a good solvent for many, but not all, substances. ☐

(E) Acetone is a better solvent than water for nail varnish. ☐

Answers to Assessment questions

Question 1

solute	a solid that dissolves in a liquid to form a solution
solution	the mixture formed when a solid dissolves in a solvent
solvent	the liquid that a solid dissolves in to form a solution
soluble	describes a substance that dissolves in a solvent

Question 2

a) Aziz added sugar to his tea until no more would dissolve. He had made a **saturated** solution.

b) Sugar will dissolve in water or tea because it is **soluble**.

c) Flour will not dissolve in water because it is **insoluble**.

d) To produce sugar from a sugar solution you need to allow the water to **evaporate**.

Question 3

(D) adding a solute to a solvent

Question 4

(C) evaporate it.

Question 5

(B) oil

Question 6

(A) 100 g of that liquid

Question 7

(B) 120 g

Question 8

(D) Stir only those mixtures which require it.

Question 9

(D) a liquid can be found which will dissolve one and not the other.

Question 10

a) iii) Use a magnet to extract the iron filings.

ii) Add water to the sand and salt.

i) Filter the mixture of sand, salt and water to separate the sand from the salt solution.

iv) Heat the salt solution so that the water evaporates leaving the salt behind.

b) List the apparatus you would use at each stage.

iii) magnet

ii) flask or beaker; stirring rod or spoon

i) funnel; filter paper; flask or beaker to catch filtrate (possibly a tripod or retort stand to hold the funnel)

iv) evaporating basin; tripod; wire gauze; Bunsen burner or some other heater

Question 11

a) distillation; chromatography; filtration

b) i) chromatography

ii) distillation

iii) filtration

iv) evaporation

Question 12

Tests you could carry out to find out if a mixture of copper sulphate and water is a solution are:

i) Shine a light through the mixture to see whether it is homogeneous (to see if it looks the same in all parts). Pass the mixture through a filter paper. If the mixture is a solution, there should be no residue in the filter paper.

ii) Leave the mixture to stand for several hours. If it is a solution, none of the solute will settle out.

Question 13

Salman experimented with three substances, A, B, and C, to see how much would dissolve in 100 cm^3 of water at two different temperatures. Here are his results:

Solid	Grams dissolving at 20°C	Grams dissolving at 80°C
A	21.1	57.0
B	34.8	52.1
C	35.8	38.6

i) With all three substances, more dissolves in the water at 80°C than dissolves in the same volume of water at 20°C.

ii) C is the substance which is the **most** soluble in water at 20°C.

iii) C is also the substance which is the **least** soluble in water at 80°C.

Question 14

a)

Scientific term	Substance
solute	**salt**
solvent	**water**
salt solution	salt water

b) (i) a saturated solution

(ii) Tanya was able to dissolve **more** salt in the water at the higher temperature, because the particles **were moving faster**.

(iii) The mass of the mixture is **36 g + 100 g = 136 g**

Question 15

a) The factors or variables that should have been kept the same in order to make sure that the experiment was a fair test are:

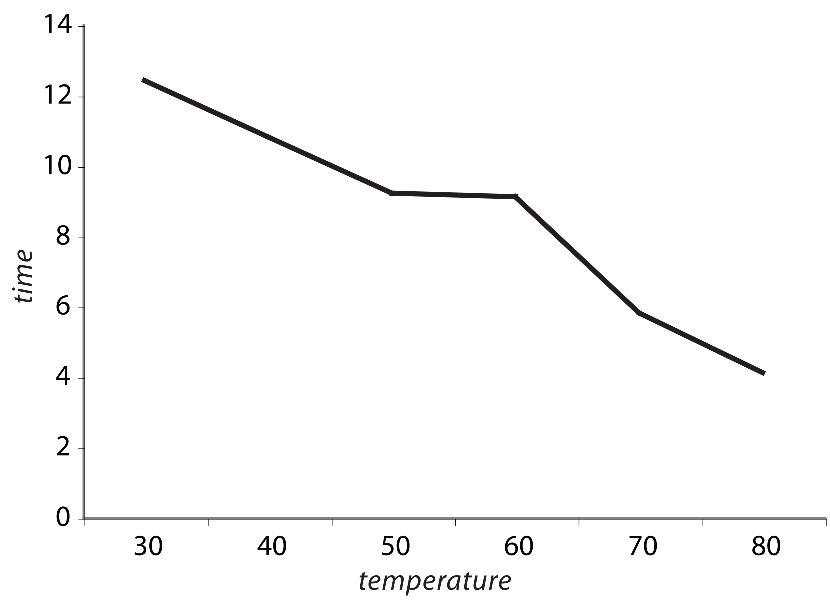
Use the same volume of water each time.

Make sure that the pieces of jelly are all exactly the same size.

Make sure the external temperature does not vary.

Use the same size container each time.

Either do not stir the mixture or stir the same amount at each temperature.



b) i) Plot a graph of the students' results. Label the axes of the graph and draw a line of best fit through the points.

ii) The time of 9.1 minutes at 60°C appears to be wrong.

iii) The student's conclusion does not tell us whether the amount of jelly which dissolved increased or decreased with changing temperature.

iv) The time it takes jelly to dissolve decreases with increasing temperature.

Question 16

Nail varnish does not dissolve in water but it does dissolve in acetone. Which of the following statements are correct? The correct options are

(B) Nail varnish is soluble in acetone.

(D) Water is a good solvent for many, but not all, substances.

(E) Acetone is a better solvent than water for nail varnish.

Energy

CHAPTER 8

Teaching Objectives

- To explain, with examples, that energy is the ability to do work
- To compare and contrast the different forms of energy—potential (gravitational and elastic), kinetic, heat, chemical, electrical, light, sound, and nuclear energy
- To show that energy can be converted from one form to another
- To identify devices or processes which convert energy from one form to another and to show that some energy is dissipated into the atmosphere
- To explain that energy is conserved during the conversion of different forms of energy

Learning Outcomes

After studying this chapter students should be able to:

- explain that energy provides the ability to do work and can exist in different forms
- identify different forms of energy with examples
- differentiate between kinetic and potential energy
- demonstrate how one form of energy is converted into other forms of energy
- recognize that energy is dissipated into the atmosphere
- explain that energy is conserved during the conversion of different forms of energy
- explain the importance of energy in improving the quality of life
- identify energy converters in their surroundings
- illustrate energy conversion to other forms using an energy converter

Introduction

The words ‘work’ and ‘energy’ are closely associated with each other, even in the minds of people who have never studied physics. Both words are part of our everyday experience; we use both in our daily conversation.

When we rise each morning, we may say we feel full of energy. But when we have been at work for eight hours or more, we become tired and say we have lost energy and cannot continue. A good night's rest and a hearty breakfast soon make us brimful of energy again. From these everyday experiences it is clear that energy is something that must be available to our muscular system if we are to do work, and it is something that is added to that system from the food we eat.

Ages ago, man used muscle power—his own and that of his slaves and beasts of burden—to do various jobs. Much later he learned to use the energy released in machines from burning fuels, to replace muscular energy. Nearly all of the energy we use comes from the Sun but, if you think about the energy we use today, you soon realise that it is something we have to pay for, either directly or indirectly, when we pay our bills for electricity, gas, fuel oil, coal, or wood for our homes, food for ourselves, and fuel for our cars.

It is quite easy for young students to understand that everything that moves or lives needs energy. We need energy to do activities such as eating, walking, sleeping, and travelling in a car. What students find much more difficult is defining 'energy'. The usual scientific definition of energy is that it is 'the ability to do work'. Even though students may seem to accept this definition, they often become confused when they consider the various forms of potential energy. The only solution seems to be to make them aware of as many examples of potential energy, and other forms of energy, as possible.

When we move on to consider the various forms of renewable and non-renewable sources of energy, we are entering an area that has a great deal of social and economic relevance. It is important that students develop a scientific understanding of the issues involved, so that they can take part in public debates about the use of fossil and nuclear fuels and their alternatives for our national energy supply. In particular, it is important for students to realise that the human use of fossil fuels is causing immediate and worldwide concern. Acid rain, atmospheric pollution, and global warming pose threats to all countries, not just our own. Similarly, it is important for young people to realise that supplies of natural gas and crude oil could easily run out in their own lifetimes. This may make them appreciate the urgency of the search for alternative energy sources.

Lesson suggestions

1. What is energy?

Refer to page 76 of the Students' Book.

Starter suggestions

Ask the students 'How do your families use energy?' (Students may discuss lighting, heating, perhaps air conditioning, cooking, water heating, car use, holiday travel, etc.) Then ask: 'How do we use energy at school?' (lighting, heating, air conditioning, school bus or other forms of transport, etc.) If the use of food has not already arisen, ask 'Where do you get the energy to walk, run, eat, breathe, or sleep?'

Main lesson

Explain that energy is being used when anything is happening. Ask them to look around the room and make a list of all the examples they see where energy is involved because something is happening. Make a list on the board and discuss the students' suggestions as to what is happening in each case and what form the energy is taking.

Introduce the students to some of the forms that energy can take by asking them to complete Worksheet 8.1.

The answers to this worksheet are:

- The useful energy a light bulb gives out is **light** energy.
- The energy that comes from a radio is **sound** energy.
- The energy that makes a wind turbine turn is **kinetic** or movement energy.
- The energy that a plant needs to grow is **light** energy.
- The energy we use cars for is **kinetic** energy.
- The energy that works the fire is **electrical** energy.
- The energy in the beefburger is **chemical** energy
- The wasted energy the light bulb gives out is **heat** energy.

In connection with the beefburger example, this is a good opportunity to point out that our bodies are able to change the energy in foods into energy we can use. While the students are moving about, playing games, swimming and so on, the chemicals in the food they have eaten provide the energy they need to be able to do these things.

Now that the students are aware of these six forms of energy, let them work in small groups and find other examples of these forms of energy. Encourage them to make a table of their findings.

2. What is potential energy?

Refer to page 77 of the Students' Book.

Starter suggestions

At the beginning of the lesson place a football, or some other kind of large ball, on the floor. Ask the students whether the ball has energy. The answer, hopefully, will be 'No'. Now raise the ball above your head and repeat the question. If someone answers 'Yes', then question them as to why they have given that answer. At the appropriate point, say that you will show them the ball has energy and then let it fall. Ask the students what kinds of energy the ball has while it is falling and when it hits the floor (kinetic while it is falling, and sound energy is produced when it hits the floor). Ask why the ball bounced after it hit the floor and why it did not bounce to the same height from which it was dropped.

Main lesson

Explain that when you raised the ball above your head, the ball gained a type of energy called potential energy.

Ask them if they have heard the word 'potential' before. They may have been told that they have the potential to be a good scientist, or a good athlete. Or they may have been told that they are not working to their full potential. Used like this, the word 'potential' means capable of happening or being used. In other words, if they work hard they might become good scientists, if they train hard they may become good athletes.

In science, too, the word 'potential' also means capable of happening or being used. Potential energy is energy that is there waiting to be used. No work is done until that energy is released. The ball does not release its energy until it is dropped from a height.

Really, chemical energy is a form of potential energy. It is the energy stored in food, batteries, dynamite, gunpowder, fireworks, coal, oil, gas, and wood.

However, to return to the example of the ball, explain that there are two types of potential energy other than chemical energy. Gravitational potential energy is the energy that is stored when an object is raised above the Earth. So the raised ball demonstrated an example of gravitational potential energy.

When a hammer is raised, it will do the work of knocking in a nail as soon as it is allowed to fall. When water is held back by a dam, it is ready to do the work of turning a water wheel or electric generator as soon as it is released.

The other kind of potential energy is elastic potential energy. It is the energy that is stored when springs are stretched or squashed, when elastic bands are stretched, when a diver bounces on a springboard or someone bounces on a trampoline.

This might be a good point to investigate the energy acting in bouncing balls, as described in Worksheet 8.2. The expected results of the activity are that all of the balls dropped from 2 m instead of 1 m will have more gravitational potential energy and are therefore likely to bounce higher.

It is unlikely that the heaviest ball bounce will bounce the highest. What is more important is the type of material the ball is made from. The explanation is that when a ball hits the ground, its kinetic energy is converted to elastic potential energy as the ball is deformed. As the ball returns to its original shape, this energy is released and is converted back to kinetic energy. These transformations cause some energy to be lost to the surroundings (as heat), and the ball does not bounce back to the height from which it was dropped.

The balls will bounce higher on a hard surface than on a softer surface because the hard surface will deform the ball more, producing more elastic potential energy, whereas a soft surface will absorb some of the energy as the ball hits it and the ball will not be deformed so much.

What normally happens if you place a small ball on top of a larger ball and drop both together onto a hard surface, is that as the balls fall they become separated. The larger ball bounces on the ground and starts travelling upwards while the small ball is still falling. When they collide, a lot of the kinetic energy is transferred to the smaller ball, which then bounces much higher than expected.

If the students have read Chapter 8 or their textbook, they will now know that there are nine different forms of energy. This might be a useful time to set them to complete Worksheet 8.3, possibly for homework. The answers to this worksheet are:

1.

the Sun	a light bulb	main form of energy: **light**
a speeding bullet	a running horse	main form of energy: **kinetic**
a stretched bow	a catapult	main form of energy: **elastic potential**
a nuclear power station	an atomic bomb	main form of energy: **nuclear**

a bonfire	a Bunsen burner	main form of energy: **heat**
a megaphone	a singing bird	main form of energy: **sound**
a pylon	an electrical plug and socket	main form of energy: **electrical**
a rock climber	a vase on a high shelf	main form of energy: **gravitational potential**
a piece of coal	a sandwich	main form of energy: **chemical**

2. Some of the objects in the pictures give us more than one form of energy. Three such examples are:
   a) The Sun and the light bulb both give out heat energy.
   b) A bonfire and a Bunsen burner also give out light energy and sometimes sound energy.
   c) A speeding bullet and a running horse may also give out sound energy.

3. Transfer of energy

Refer to page 82 of the Students' Book.

Starter suggestions

Remind the students that we are surrounded by different forms of energy. But often energy changes from one form to another. We have already seen that a ball raised above the head has gravitational potential energy, but when it is dropped this changes to kinetic energy, and when the ball hits the ground there is another change to elastic potential energy. This latter makes the ball bounce and the remaining energy is transformed back to kinetic energy:

gravitational potential energy ⟶ kinetic energy ⟶ elastic potential energy ⟶ kinetic energy

Show the students a wind-up clock or watch, or a clockwork toy. Wind up the object and ask what energy change is taking place (kinetic to elastic potential energy). Now let the clock, watch, or toy run. What energy change is taking place now? (Elastic potential to kinetic and probably sound energy as well) You could, if you wish, extend this discussion by asking where the kinetic energy for winding the watch, clock, or toy came from. The answer is from the chemical energy in food, and the food was produced originally using light energy from the Sun (during photosynthesis).

light energy → chemical energy → kinetic energy → elastic potential energy → kinetic and sound energy
(from the the Sun) (food) (winding) (in spring) (as spring unwinds)

Main lesson

Now let the students carry out (or the teacher can demonstrate) the simple experiments below.

Safety: Wear eye protection in any experiments that involve heating or the use of stretched elastic bands.

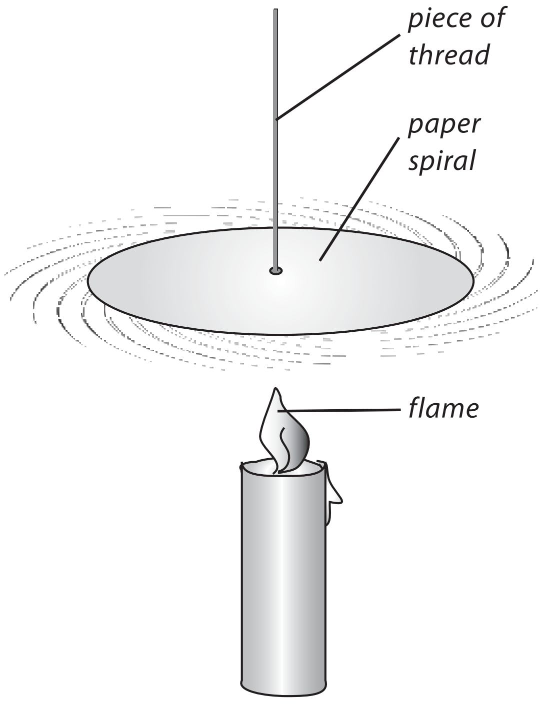
a) Rub a finger backwards and forwards on the bench. In what form is the energy you are supplying? (Kinetic). How do your fingers feel after you have done this for some time? (Warm). What kind of energy have you been able to produce? (Heat and possibly sound.) Remind the students that originally fire was made using friction and that heating arises in brakes and machinery in this way.

b) A circuit has been set up for you consisting of a torch bulb, a battery, and a switch. What happens when you close the switch? What form of energy transfer or change is taking place? (chemical energy in the battery into light energy in the bulb).

c) Lay a piece of wire gauze on a tripod and heat it with a blue Bunsen flame. What happens to the colour of the gauze? (It goes from a grey colour to red-hot.) If you were able to heat the gauze in a much hotter flame, it would glow yellow or even white. What energy conversion has taken place? (heat to light energy)

d) Shake a tin or plastic box with a few nails in it. What kind of energy do you supply? (kinetic). What kind of energy is produced? (Sound; of course heat energy is also produced but the students have no means of detecting this.)

e) Cut a paper spiral from a circle of paper. Make a pin-hole in the top end of the spiral and suspend the spiral from a piece of thread. Hold the spiral about 10 cm above a Bunsen burner flame, a candle flame, or, better still, a hot radiator. (**Careful!**) If you use a Bunsen burner be careful that the flame does not set the paper alight. What happens? (The paper spiral spins round.) What energy change is taking place? (Heat energy is being changed to kinetic energy.)



f) Push a friction-powered toy car along the bench or on the floor. Inside this type of car is a big disc or wheel, like a large coin, called a fly-wheel. When you push the toy this wheel starts spinning. Because it is a heavy wheel for the size of the car, the fly-wheel, once set spinning, tends to keep on doing so, and it stores energy. What energy change is taking place? (This is not as simple as it seems. It takes kinetic energy to get the fly-wheel turning. The energy is stored as potential energy in the fly-wheel, and then converted back to kinetic energy to make the car move.)

g) Look at a photographic light meter. Point the meter at a source of light—a lighted electric lamp or a window. What happens to the needle? What energy change is taking place? (Light energy is changed to electrical energy, which is changed to kinetic energy to move the needle.)

h) Blow up a balloon. Hold the neck of the balloon slightly open. Let out the air. What energy changes are there? (Kinetic energy of moving air is used to blow up the balloon, then elastic potential energy, then sound energy and also the kinetic energy of the air as it rushes out of the balloon.)

The students can use copies of Worksheet 8.4 to record the results of these experiments and any of those from **Ideas for investigations and extension work** that you demonstrate to them.

Sum up what the students should have learned so far:

- Everything that happens needs energy.
- Energy can be stored.
- One kind of energy can be changed into another.
- At every change some energy does work and some is wasted as heat.
- Energy cannot be made and it cannot be destroyed.

4. Energy and combustion

Starter suggestions

Remind the students that most of the energy we use in our everyday lives comes from combustion or burning. Most power stations burn coal, oil, or gas, the so-called fossil fuels, to produce electricity, and motor vehicles burn oil or petrol in their engines. We use fossil fuels or wood to heat our homes and to cook our food. Even if we use electricity for these purposes, it has probably come from a power station that burned oil, coal, or gas.

Not only is combustion of great benefit to mankind, as we shall see later, it also produces serious problems for our health and the environment.

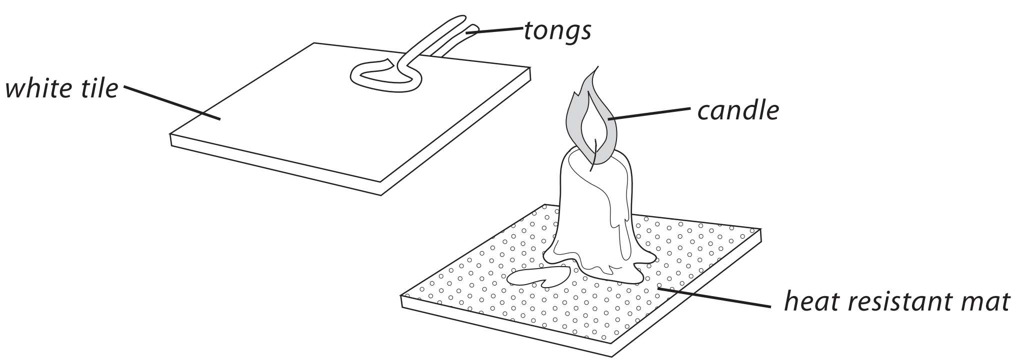
Main lesson

Explain that coal, oil, natural gas, and wood all contain the elements carbon, hydrogen, and oxygen. We call these substances hydrocarbons. When they burn completely they produce mainly carbon dioxide and water.

It is not convenient or safe to carry out experiments on burning coal or oil. Instead we are going to investigate the burning of a candle, because candle wax is also a hydrocarbon just like coal, oil, gas, and wood.

The teacher should wear eye protection when demonstrating the following experiments:

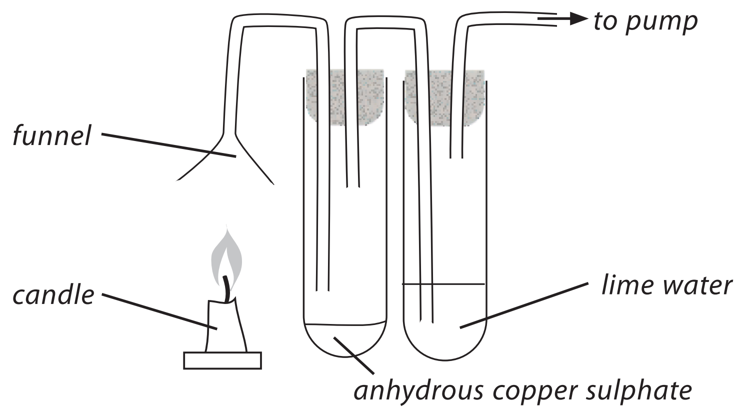
a) Set up a short length of candle on a heat-resistant mat.



- Light the candle.
- Hold a piece of clean, white tile (or a clean evaporating basin) in a pair of tongs.

- Hold the tile, with the white side down, about 5 cm above the flame for about 5 seconds.
- Look at the surface of the tile. (Do not touch it as it may be hot!)
- If there is no change, put the tile back over the flame for a few more seconds.
- Ask what do you see on the tile. (The black substance on the white surface is carbon, which has come from the partial combustion of the candle.)
- What chemical element do you think this is?
- Blow the candle out.

b) Set up the apparatus shown below.



- Light the candle and adjust the height of the funnel so that it is at least 5 cm above the flame and does not crack.
- Turn the pump on.
- Blow the candle out and turn the pump off when distinct changes have taken place in the two test tubes.
- You may have to explain that anyhydrous copper sulphate is blue copper sulphate crystals which have been heated to drive all the water off.

The students should answer these questions:

i) What was the colour of the anhydrous copper sulphate before and after the experiment? (White and then blue)

ii) What made the anhydrous copper sulphate change colour? (water produced by the combustion or burning of the candle)

iii) What did the lime water look like before and after the experiment? (clear and then milky white)

iv) What caused the lime water to change? (carbon dioxide)

Repeat these two experiments using a yellow Bunsen burner flame for the white tile experiment and a small, blue Bunsen burner flame for the second experiment. Again, take great care not to crack the funnel.

Ask the same questions as you asked for the candle experiments.

5. Renewable and non-renewable energy sources

Refer to page 83 of the Students' Book.

Starter suggestions

Discuss with the students why fossil fuels are useful. Write the words 'Why are fossil fuels useful?' in a box in the centre of the board, and then radiating out from it, write out the students' suggestions. Examples they might come up with include:

- burnt in power stations to produce electricity
- used for cooking and heating at home
- used to make tar for roads
- used to make plastics
- burnt in Bunsen burners at school
- use to make petrol, diesel oil, and lubricating oil
- used for central heating
- used to make chemicals

Main lesson

Ask the students to read the sections of Chapter 8 which deal with the various aspects of non-renewable and renewable resources, and then ask them to give their reactions to the imaginary points of view expressed on Worksheet 8.5.

Ask some of the students to read out their replies to the various statements, and see if you can find a majority view for each of them.

If there is time, move on to explain that motor vehicles are major polluters of the air, as well as being one of the main users of the fossil fuel, oil. Ask them to comment on the imaginary points of view expressed on Worksheet 8.6, and then again see if you can find the majority viewpoint on each item.

Ideas for investigations and extension work

The exploding match head

Perhaps best demonstrated by the teacher wearing eye protection: Wrap up a match head tightly in a piece of aluminium foil, such as that used in cooking. Rest the match on a crucible lid on a pipe-clay triangle on a tripod stand. Heat the crucible lid with a Bunsen burner. What happens? (Often there is a small explosion and the piece of foil jumps off the crucible lid.) What kinds of energy transfer are taking place? (heat energy of the flame $\longrightarrow$ kinetic energy of the match head + sound) This experiment needs a little adjustment to get the best results; the aluminium foil must be neither too tightly wrapped around the match head, nor must it be too loose.

Heating ammonium dichromate

This experiment should only be demonstrated by the teacher wearing eye protection. Make a **small** heap of orange ammonium dichromate crystals in a dry evaporating basin. Stand this on a wire gauze on a tripod. Heat a thick piece of copper wire in a Bunsen burner flame until the wire is red hot and then plunge it into the crystals. A chemical change begins which then continues on its own without further heating. The crystals begin to splutter, crackle and spit fire, like a miniature volcano. Soon a fine smoke of green powder rises upwards to spread over the surrounding bench. What energy changes take place? (Heat energy sets off chemical energy which gives rise to heat, light, and sound.)

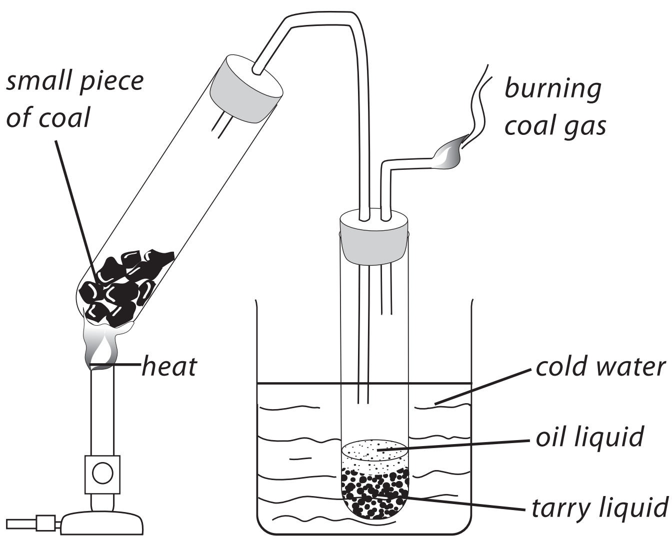
Safety: It is important that you use only small quantities of the ammonium dichromate as the dust and fumes produced are harmful. If one is available, carry out the experiment in a large fume cupboard, or even outdoors on a fine, calm day.

Heating magnesium ribbon

Wearing eye protection, the teacher should hold a small piece (3 to 4 cm) of magnesium ribbon in tongs and then heat the other end of the ribbon in a Bunsen burner flame. Warn the students not to look directly at the flame, but only out of the corner of an eye. What are the energy conversions here? (heat energy to chemical energy to light energy)

Distillation of coal

Coke, a relatively smokeless fuel, can be made by heating coal. Coal gas, which used to be a common fuel for heating homes and lighting the streets, is produced as a by-product. The oily liquid which also forms contains ammonia, an important chemical. The apparatus below shows how the teacher can demonstrate what happens when coal is heated.



The important thing for the students to realise is that when coal is burned on an open fire or in a furnace or power station, some of the poisonous coal gas, tar, smoke, and other pollutants can enter the atmosphere.

Energy and the environment

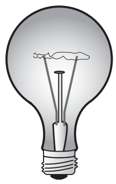
Examine or collect pictures of different ecosystems. Draw diagrams of food chains within those ecosystems showing how energy from the Sun is passed from one organism to another along the food chain. Find out what the length of a food chain has to do with the energy transfer which takes place along it. (In a food chain, as energy passes from one organism to the next, much of the energy is lost to the environment as heat. Food chains are never more than four or five organisms long, because as you go further along a food chain there is less and less energy available.)

Worksheet 8.1

What type of energy?

Here is a list of some of the forms that energy can take. Write the correct one in each box.

light	heat	sound	electrical	kinetic (movement)	chemical

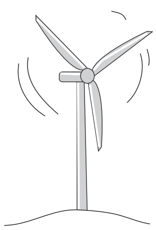


- the useful energy a light bulb gives out

____

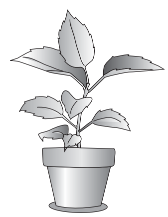
- the energy that comes from a radio

____



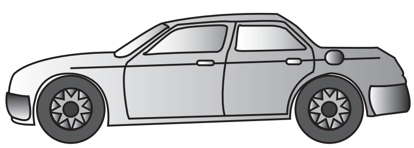
- the energy that makes a wind turbine turn

____



- the energy that a plant needs to grow

____

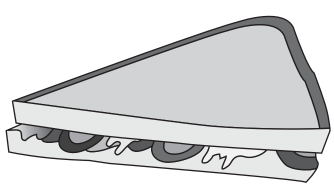


- the energy we use cars for

____

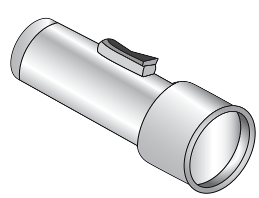
- the energy that works this fire

____



- the energy in this sandwich

____



- the wasted energy this torch gives out

____

Worksheet 8.2

The energy acting in bouncing balls

We are going to test the bounciness of different kinds of balls. Carry out this activity somewhere where there is plenty of space and away from vulnerable windows—the playing field, playground, gymnasium, or school hall.

Materials needed per group: a selection of balls of different kinds, a long strip of wood or card (or a long tape measure) and some means of fixing this to a vertical surface, access to a balance.

Safety: Great care will be needed to avoid injury to other people or damage.

1. You need to have a graded scale. This can be a strip of wood or card, marked in centimetres, a long tape measure, or a very long ruler such as the kind used on classroom boards.
2. Fix the scale or ruler to a wall.
3. Choose one of the balls and find its mass.
4. Hold the ball 1 metre above the ground, in front of the scale, and then drop it. Measure the height of its first bounce.
5. Do this two more times and find the average of the three measurements.
6. Now raise the ball to 2 metres above the ground and then drop it. Measure the height of the first bounce.
7. Do this two more times and find the average of the three measurements.
8. Repeat these actions with other kinds of balls.
9. Record your results on the table below.
10. Now repeat the experiment on a different kind of surface and record your results.

Type of ball	Mass of ball (g)	Type of surface	Average bounce from 1 metre	Average bounce from 2 metres

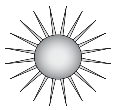
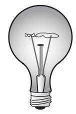
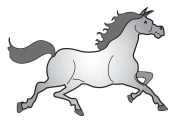
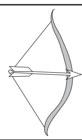
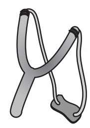
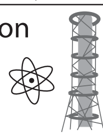
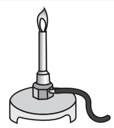
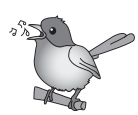
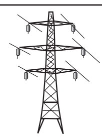
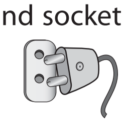
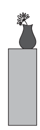
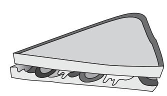
- What difference does dropping the ball from 2 m instead of 1 make to the height of the first bounce? ______
- Does the heaviest ball bounce the highest? ______
- Do any of the balls bounce to the same height as that from which they were dropped? Explain your answer. ______
- What difference does the type of surface make? ______
- If you place a small, lighter ball on top of a larger ball and drop both together onto a hard surface from a height of 2 m, what do you think will happen? ______
- Now try it. What does happen? ______

Worksheet 8.3

Types of energy

There are nine forms of energy. They are heat, light, sound, electrical, kinetic (or movement), elastic potential, gravitational potential, chemical, and nuclear energy.

1. Look at each pair of pictures and decide which is the MAIN form of energy they represent.

the Sun 	a light bulb 	main form of energy ____________________
a speeding bullet 	a running horse 	main form of energy ____________________
a stretched bow 	a catapult 	main form of energy ____________________
a nuclear power station 	an atomic bomb 	main form of energy ____________________
a bonfire 	a bunsen burner 	main form of energy ____________________
a megaphone 	a singing bird 	main form of energy ____________________
a pylon 	an electrical plug and socket 	main form of energy ____________________
a rock climber 	a vase on a high shelf 	main form of energy ____________________
a piece of coal 	a sandwich 	main form of energy ____________________

2. Some of the objects in the pictures give us more than one form of energy. For example, an atomic bomb gives off heat, light, and sound energy. Write down three more examples like this:

a) ________________________ b) ________________________ c) ________________________

Worksheet 8.4

Energy change experiments

You are going to carry out, or be shown, a number of simple experiments that show energy changes or conversions.

Record your observations or results on this table:

Experiment	Energy change
1.	
2.	
3.	

Worksheet 8.5

Here are some people's answers to the question 'Should we all be using renewable energy sources instead of non-renewable energy sources?' In the space provided, say what you think about each statement.

	'America, Britain and other developed countries tell us not to use fossil fuels as energy sources. They have been using them for years and have caused most of today's pollution problems.' I think ______________________________ ______________________________ ______________________________
	'Renewable schemes are often expensive to set up and they too can harm the environment. Wind turbines can kill birds and spoil beautiful views, while hydroelectric schemes often flood huge areas of land in valleys.' I think ______________________________ ______________________________ ______________________________
	'Why should we use renewable energy sources? Fossil fuels are relatively inexpensive and there are enough reserves of them to last my lifetime.' I think ______________________________ ______________________________ ______________________________
	'Burning non-renewables causes forms of pollution such as acid rain, smog, and global warming. Using renewable energy sources will reduce these problems.' I think ______________________________ ______________________________ ______________________________
	'Non-renewable energy sources will eventually run out, so the quicker we start using renewable the better we will be prepared to meet our future energy needs.' I think ______________________________ ______________________________ ______________________________
Summary: ______________________________ ______________________________ ______________________________ ______________________________	

Worksheet 8.6

Cars and other motor vehicles are major users of oil and petrol and major causes of air pollution problems such as acid rain, smog, and global warming. Scientists are working to develop cars that are less harmful to the environment. Here are some people's answers to the question 'Which is the best energy source for use by cars?' In the space provided, say what you think about each statement.

	'Solar cells should be used to fuel cars. This energy is renewable, it is free and it doesn't pollute the air.' I think ______________________________ ______________________________ ______________________________
	'Electric cars are quiet and do not pollute the air. All you do is plug them into the mains each night and they are ready to use next day.' I think ______________________________ ______________________________ ______________________________
	'Fuels from biomass are the answer. You just grow more crops when you need more fuel.' I think ______________________________ ______________________________ ______________________________
	'Most cars were designed to run on petrol and there are thousands of petrol stations all across the country.' I think ______________________________ ______________________________ ______________________________
	'I think the answer is to use cars as little as possible. For short journeys walk or cycle, for longer journeys use public transport such as trains and buses.' I think ______________________________ ______________________________ ______________________________
Summary: ______________________________ ______________________________ ______________________________ ______________________________	

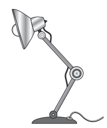
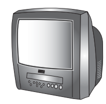
Answers to questions in the Students' Book

1. Possible answers include the following:

Things with			
chemical energy	**kinetic energy**	**potential energy**	**heat and light energy**
▪ food ▪ fuels such as coal, oil, and natural gas ▪ burning match or candle ▪ electric cell or battery ▪ explosives ▪ fireworks	▪ moving people and other animals ▪ moving cycles and motor vehicles ▪ the wind ▪ windmills, steam turbines, wind turbines, and water turbines	▪ any object raised above the ground ▪ a stretched spring or elastic or rubber ▪ food and other forms of chemical energy	▪ the Sun and stars ▪ lightning ▪ fire ▪ glow worms and fireflies ▪ certain deep-sea fish ▪ light bulbs and light tubes ▪ electric fires, cookers, and hair driers ▪ television set

2. The energy wasted in a machine because of friction is in the form of heat.
3. The disadvantage of burning both fossil fuels and biomass is that they produce carbon dioxide, a greenhouse gas.
4. Coal is the remains of dead plants, often trees, which died many millions of years ago. While they were alive, these plants used the Sun's energy to produce their food. When they died, they fell to the ground in swampy places and as they rotted they were gradually covered by mud. The weight on top gradually forced out the oxygen and hydrogen from the plant remains, leaving carbon. This changed the partly rotted plants first to peat, then to lignite, and finally to coal.

   Oil is the remains of tiny plants and animals, called plankton, which lived in the sea. While they were alive, the tiny plants used the Sun's energy to make their food by photosynthesis. The tiny animals fed on the tiny plants. When the plankton organisms died, they sank to the bottom and were covered by layers of mud and sand. As there was no oxygen, they could not rot and so their energy remained trapped inside them. As millions of years went by, the remains were buried deeper and deeper, and bacteria, heat and the pressure of the water, mud and sand above them slowly changed them to oil.
5. At present most of our electricity is produced by burning fossil fuels or using nuclear fuels. All of these fuels are non-renewable. They have a limited lifespan and their extraction does great damage to the landscape. New ways of generating electricity are necessary to make the existing supplies of fossil fuels and nuclear fuels last longer and to replace them when they eventually run out.
6. It is not possible to show all possible ways in which electrical energy can be changed into other forms of energy in the home. However, a few examples are shown here:

ELECTRICAL ENERGY	hair drier 	sound and heat energy
	electric cooker 	heat energy
	electric lamp 	light and heat energy
	television set 	light and sound energy
	radio 	sound energy
	vacuum cleaner 	sound and kinetic energy

7. The main energy changes at a fun fair are the conversion of electrical energy into light, sound, and kinetic energies.
8. Some of the ways to save energy in the home include the following.
   - Switch off lights, fans, heaters or air conditioning units when no one is in the room.
   - Switch off television sets, radios, and computers when no one is watching them, listening to them, or using them. Do not leave these appliances on ‘stand by’.
   - Choose and buy electrical appliances which use less energy but do the same work as other less-efficient ones.
   - Wherever possible, use energy-efficient light bulbs.
   - Put on a jumper rather than turn up the heating in cold weather.
   - Do not waste water.
   - Take a shower rather than a bath.
   - Open the fridge door as little as possible. When warm air gets in, extra electricity is needed to cool it down again.
   - Recycle cans, bottles, and waste paper, and also, where possible, plastic.

- When leaving home, walk or cycle short distances rather than travel by car. For longer distances, trains and buses use less energy per person than a car does.
- Take your own strong bag when you go shopping, rather than use a flimsy plastic bag which has been made from oil.

9. Heat is a form of energy. It is really the effect of the movement energy of molecules. If we heat a substance we make its molecules move faster. Heat flows between things that have different temperatures—it flows from hotter things to cooler things. The hotter something is, the more energy it has. Temperature is a measure of the average energy of molecules or, in simple terms, it is a measure of how hot or cold an object or material is.
10. a) When you talk on the telephone you are changing sound energy to electrical energy. The receiving telephone changes electrical energy back to sound energy.
    b) A solar-powered calculator converts light energy from the Sun into electrical energy. When you press the keys of the calculator, you are changing chemical energy in your food into movement or kinetic energy.
    c) A wind turbine is turned by the kinetic energy of the wind and so produces electrical energy.
    d) As the skydiver prepares to jump from the aircraft he has a lot of gravitational potential energy because of the height or altitude of the aircraft above the ground. As the skydiver falls, the gravitational potential energy is changed to kinetic energy.
11. An aircraft in flight has kinetic energy and gravitational potential energy. Its unused fuel is also a store of chemical energy.
    - A slice of bread has chemical energy.
    - A bungee jumper about to jump off a bridge has gravitational potential energy.
    - A car at the top of a rollercoaster also has gravitational potential energy.
12. If you drop a plate on the floor, gravitational potential energy changes to kinetic energy.
13. Water at the top of a hill has gravitational potential energy. It has gained this energy either by being pumped up to the top of the hill or, more likely, because the fall of rain from the clouds above (which had gravitational potential energy) was interrupted by the presence of the hill.
14. Wind farms built on land are relatively less expensive to construct, although some people think they are an eyesore. They can also be noisy, affect television reception, and kill birds in flight. However, it is relatively inexpensive to move the electricity that has been generated to where it is needed.

    Wind farms built offshore are more expensive to construct and it is more expensive to move the electricity to the land where it is needed. Migrating birds can also be killed by the wind turbines and they can be a hazard to shipping. However, the wind usually blows more often and more strongly offshore than on land, and so more electricity can be generated.
15. The main uses of energy in a large office block would be in the heating or air-conditioning of the building, the use of electricity to work the computers, telephones, fax machines, photocopiers and other devices, and the use of electricity to clean the building.

16. Biomass is a renewable fuel, but not a 'clean' fuel because, when it is burned, biomass produces carbon dioxide, a greenhouse gas, as well as smoke and soot (particulates).
17. The renewable energy sources that would be suitable for schools are most likely to be solar power and wind power.
18. Three sources of energy which do not come directly or indirectly from the Sun are nuclear energy, geothermal energy, and energy from the tides.
19. Apart from causing congestion and road accidents, cars that are fuelled by petrol or oil are major polluters of the air.

Assessment

Question 1

Match each key word with its meaning. One has been done for you:

A)	renewable energy	i)	This cannot be created or destroyed, only changed.
B)	kinetic energy	ii)	In a power station, it changes kinetic energy into electrical energy.
C)	geothermal energy	iii)	This can reduce the amount of heat energy lost from a building.
D)	generator	iv)	type of energy resource that can be easily replaced
E)	fossil fuels	v)	Coal, oil, and natural gas are examples.
F)	energy	vi)	the type of energy possessed by moving objects
G)	insulation	vii)	the energy stored in food and fuels
H)	chemical energy	viii)	heating of the Earth as a result of polluting gases
I)	global warming	ix)	energy from hot rocks deep inside the Earth's crust

Question 2

Scientists say energy is

(A) the total work done (B) the ability to do work

(C) the need to do work (D) how much a body moves

Question 3

Which of the following is NOT a form of energy?

(A) electricity (B) gravity (C) sound (D) light

Question 4

Which one of the following is a fossil fuel?

(A) coal (B) wood (C) uranium (D) hydrogen

Question 5

Batteries store

(A) electrical energy (B) mechanical energy (C) nuclear energy (D) chemical energy

Question 6

Food is a source of

(A) kinetic energy (B) chemical energy (C) mechanical energy (D) sound energy

Question 7

Which one of the following does NOT have kinetic energy?

(A) a ball at the highest point when thrown up (B) a rock falling down a cliff

(C) a jet plane taking off (D) the wind blowing

Question 8

The Earth's main energy source is

(A) fossil fuels (B) electricity (C) the Sun (D) nuclear power

Question 9

Which one of these energy sources is likely to run out if the world continues to use energy at the present rate?

(A) tidal power (B) wind power (C) solar power (D) oil

Question 10

At a hydroelectric power station in Wales, during the night when few people are using electricity, extra electricity is used to pump water back to the reservoir. Choose what you think is the BEST explanation for this

(A) It prevents the generators from wearing out. (B) It stores energy for use the following day.

(C) Water is a good conductor of electricity. (D) It keeps the pipes full of water.

Question 11

A toy police car has an electric motor powered by a battery. The car has lights and a siren, as well as the motor.

a) What is the energy source in the toy police car?

(A) the lights (B) the motor (C) the siren (D) the battery

b) What kind of useful energy is produced by the car's motor?

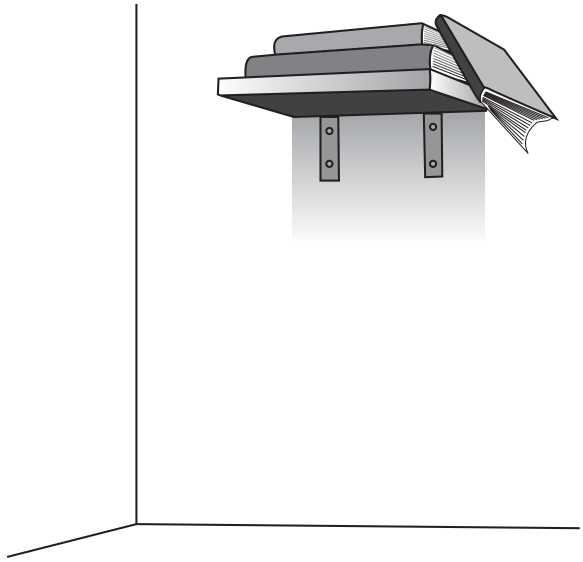
(A) heat energy (B) light energy (C) kinetic energy (D) sound energy

c) What kind of energy is wasted by the car's motor?

(A) heat energy (B) light energy (C) kinetic energy (D) sound energy

Question 12

Look at the book about to fall off the shelf.



a) What form of stored energy does the book have while it is still on the high shelf?

____

b) What form of energy will it have if it falls?

____

c) What forms of energy will this become when the book hits the ground?

____

Question 13

a) Which of these stores of energy is the odd one out?

A) food we eat B) petrol for a car

C) the string in a bow D) the wax of a candle

b) Why have you chosen that particular one as the odd one out? ____________

c) What form of potential energy is stored in the others? ____________

Question 14

Which of these statements about energy are TRUE and which are FALSE?

a) Energy is not made or destroyed, it is just moved from place to place. ________

b) Energy is sometimes used up, such as when a battery runs out. ____________

c) When energy is moved or transferred it is not always in the form we want. ______

d) Most of the energy moved or transferred by a light bulb goes into lighting the surroundings. ____________

e) Most of the energy we use comes directly or indirectly from fossil fuels. ______

Question 15

a) Where does almost all of the Earth's energy come from?

____

b) How can this energy source be used directly?

____

c) What is the disadvantage of using this energy source directly?

____

d) Why are coal, oil, and natural gas called fossil fuels?

____

e) Are fossil fuels renewable or non-renewable?

____

f) Explain your answer.

____

g) Which gas is released when both fossil fuels and biomass are burned?

____

h) What do we call the effect this gas has in the upper atmosphere?

____

i) What do scientists believe this effect is doing to the world's climate?

____

Question 16

Most power stations use fossil fuels to provide the energy to turn their generators. Fossil fuels are non-renewable.

The table below gives some estimates of the length of time some of the different energy sources will last if we go on using them at the present rate.

Energy source	Renewable or non-renewable	Time before supplies run out (years)
coal	non-renewable	200
oil	non-renewable	40
natural gas	non-renewable	60
wind energy	renewable	never
solar energy	renewable	never

a) Which fossil fuel has the largest supplies? ______________________________

b) Suggest two reasons why the energy sources might last longer than predicted.

i) ______________________________

ii) ______________________________

c) What is meant by renewable? ________________________

d) Explain why it is important to make greater use of renewable energy resources.

____

____

Question 17

The Wazir family are attending a firework display at their son's school.

a) Apart from the gunpowder burning in the fireworks, name one other material that is burning in one of the fireworks? ________________________

b) What energy changes take place when one of the fireworks is set alight? ________________

____

c) After the firework has finished burning, what is the name of the black substance that is left in the casing of the firework? ________________________

d) One rocket came down onto some rubbish and started a small fire. Apart from water, name ONE other material that could be used to put out the fire? ________________________

e) Explain how the use of this material stops fires. ________________________

Answers to Assessment questions

Question 1

A)	renewable energy	iv)	type of energy resource that can be easily replaced.
B)	kinetic energy	vi)	the type of energy possessed by moving objects.
C)	geothermal energy	ix)	energy from hot rocks deep inside the Earth's crust.
D)	generator	ii)	In a power station it changes kinetic energy into electrical energy.
E)	fossil fuels	v)	Coal, oil, and natural gas are examples.
F)	energy	i)	This cannot be created or destroyed, only changed.
G)	insulation	iii)	This can reduce the amount of heat energy lost from a building.
H)	chemical energy	vii)	the energy stored in food and fuels.
I)	global warming	viii)	heating of the Earth as a result of polluting gases.

Question 2

(B) the ability to do work

Question 3

(B) gravity

Question 4

(A) coal

Question 5

(D) chemical energy

Question 6

(B) chemical energy

Question 7

(A) a ball at the highest point when thrown up

Question 8

(C) the Sun

Question 9

(D) oil

Question 10

(B) it stores energy for use the following day

Question 11 a

(D) the battery

Question 11 b

(C) kinetic energy

Question 11 c

(A) heat energy

Question 12

a) gravitational potential energy

b) kinetic energy

c) sound and heat energy

Question 13

a) the string in a bow; (C) is the odd one out.

b) The string in a bow and arrow has to be stretched before it gains elastic potential energy.

c) The others are stores of chemical energy.

Question 14

a) Energy is not made or destroyed, it is just moved from place to place. TRUE

b) Energy is sometimes used up, such as when a battery runs out. FALSE

c) When energy is moved or transferred it is not always in the form we want. TRUE

d) Most of the energy moved or transferred by a light bulb goes into lighting the surroundings. FALSE

e) Most of the energy we use comes directly or indirectly from fossil fuels. TRUE

Question 15

a) the Sun

b) solar panels

c) It can only be used in the daytime/when the Sun is shining.

d) Coal, oil and natural gas are called fossil fuels because they were formed millions of years ago from the remains of prehistoric plants and animals.

e) Fossil fuels are non-renewable.

f) It is not possible to make any more as they took millions of years to form.

g) Carbon dioxide is released when fossil fuels and biomass are burned.

h) greenhouse effect

i) Making the Earth warmer

Question 16

a) coal

b) i) People may use the fuels more carefully or use them at a slower rate than at present. ii) New supplies of the fossil fuels may be found.

c) Energy sources which will not run out, or energy sources that can be renewed

d) Non-renewable sources are running out, this makes them more expensive. Most renewable sources do not pollute the environment.

Question 17

a) paper or cardboard

b) Chemical energy is converted to light, heat, and sound energy.

c) carbon

d) sand or soil or carbon dioxide

e) It stops oxygen getting to the fire.

Forces and machines

CHAPTER 9

Teaching Objectives

- To examine and classify a variety of simple machines
- To compare wheels, axles, pulleys, and gears and their uses in everyday life
- To design and make simple pulley or gear systems
- To identify common devices and systems that involve pulleys and gears
- To examine the structure of a bicycle and the function of its parts

Learning Outcomes

After studying this chapter students should be able to

- recognise wheels and axles and identify their uses
- identify the uses of pulleys in everyday life
- describe the functions of pulley systems and gear systems
- describe how motion in a system of pulleys of different sizes is transferred to motion in another system of gears in the same structure
- investigate with the help of an experiment the effort required by different gear systems to lift the same load
- find out how the action of a pulley system is altered by changing the tension of the band connecting two pulleys
- design and make a system of pulleys and/or gears for a structure that moves in a prescribed and controlled way and performs a specific function
- identify and make modifications to their own pulley and gear systems to improve the way they move a load
- describe how a bicycle functions
- identify common devices and systems that incorporate pulleys and/or gears

Introduction

Machines are devices for making work easier. They may be as simple as a bottle opener or screwdriver, or as complex as a motor car or spacecraft. And there are various ways in which a machine may make work easier. A machine may have the effect of increasing the effort, or force, that is applied to a given task. Or it may increase the speed with which a task is performed. Or it may transfer and change the direction of a force, to make the force effective in a certain way.

Machines make a job easier but do not reduce the amount of work that must be done to accomplish it. When you change gear on a bicycle to go up hill, you gain in force but lose in distance. This means you exert less effort but have to pedal faster. You could say the same amount of work is done, but that it is spread out, to make it easier.

So a machine can make work easier by transferring a force from one place to another, or by changing the direction of a force, or by increasing the amount of force applied, or by increasing the speed. The simplest machines have one moving part. We look at them first because they are used in larger machines where there may be many moving parts.

To teach the subject of machines effectively, you will need to amass a collection of household items, such as hand food mixers, bottle openers, scissors and nutcrackers, and tools such as claw hammers, wrenches, spanners, screwdrivers, and hand drills. It is possible to buy such machines as pulleys for science lessons, but suitable ones can often be made from toy construction kits such as those made by Meccano and Lego.

Lesson suggestions

1. Looking at levers

Refer to page 96 of the Students' Book.

Starter suggestions

Show the students a claw hammer, a bottle opener, a screwdriver, a spanner, a pair of scissors, and a wrench. If possible, add a wheelbarrow (or a toy one) to the collection. Ask the students what all these things have in common. The answer, which may surprise the students, is that they are all machines. Explain that a machine is simply a device which makes a job easier. And the most complicated machines, such as a motor car or space craft, are made of many of these simple machines we will be studying in the next few lessons.

Main lesson

Demonstrate the use of levers and how they reduce the effort to do a job. For example, jam the lid on an empty paint or syrup tin and ask a volunteer to try to remove the lid using only his or her fingers. Then demonstrate how easy it is using the blade of a screwdriver or the handle of a spoon. Explain that the screwdriver or spoon is being used as a simple machine.

Show the class an old piece of wood with a nail knocked in it. Ask a volunteer to remove the nail using his or her fingers. Then show how easy it is to remove the nail with a claw hammer.

During these two examples, you should use the words 'effort', 'pivot or fulcrum', and 'load' as much as possible.

Demonstrate some more examples. Before the lesson, glue the stopper on an empty plastic bottle with superglue. Ask a volunteer to remove the stopper with his or her fingers. Now show how easy it is with a wrench. Demonstrate that you can exert more turning force on the stopper if you hold the handle of the wrench nearest its end, rather than nearest to the bottle stopper.

Ask a volunteer to show the students whether it is easier to close a heavy door by pushing on the outer edge or by pushing the door near the hinge. If you can obtain a large rubber sucker with a hook attached, you can use a force meter to compare the force needed to open the door when the sucker is attached near the hinges and when it attached near the outer edge of the door.

Ask a volunteer to try to cut an old piece of cloth, first using the tips of the scissors, and then using the parts of the blades near the pivot. The volunteer should find it easiest to cut the cloth using the parts of the blades nearest the pivot.

Finally, ask the students to sketch the examples of the use of levers they have been shown and ask them to label the pivot or fulcrum, load and effort in each example.

2. Levers at work

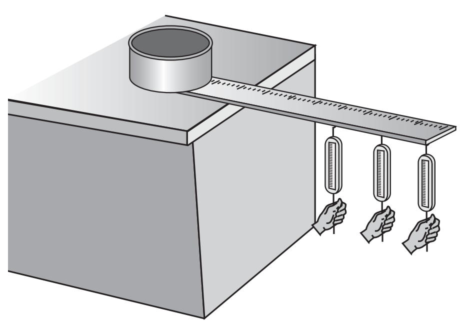
Refer to page 98 of the Students' Book.

Starter suggestions

Use a see-saw, or rest a plank of wood on a log or something else which will act as a fulcrum. Place a fairly heavy object (weighing about 5 kg) on one side of the see-saw near the fulcrum. Ask the students how the heavy weight could be balanced using a much smaller object (weighing about 1 kg). Ask the students to draw a sketch of their ideas. Then show them that you can balance the large and the small object by moving the smaller object much further away from the fulcrum.

Use a length of wood and a small stone (to act as fulcrum) and show the students how you could lever a large object, even one that was too heavy to lift without help.

Main lesson



Let the students discover for themselves that the closer a load is to the fulcrum of a lever, the less effort is needed to move the load.

The students need a metre ruler or metre stick, and a load such as a film canister filled with soil or a 100 g mass.

Have the students put the ruler on a desk or bench with different lengths of the ruler projecting over the edge of the desk or bench. The edge of the desk or bench is acting as the fulcrum.

Begin by putting the 10 cm mark on the edge of the desk. Put the load on 100 cm. Push down on the end of the ruler (or, better, pull down with the help of a force meter). Measure how far you have to push or pull down to lift the load 8 cm.

Now put the 20 cm mark at the edge of the desk and push down, or pull down with the force meter. Measure how far you have to move the ruler to lift the load 8 cm.

Continue with the fulcrum at the 30, 40, 50, 60, and 70 cm marks. Each time, measure how far you have to push down to lift the load 8 cm.

If you were able to use a force meter for each position of the fulcrum, ask the students to calculate the work done, using this formula:

Work (lifting the load) = **Effort** (how hard you had to pull down on the ruler) × **Distance** (how far down you had to move the end of the ruler down)

Now ask the students to read about the three different classes of lever in their textbook and then look for examples in the classroom or the laboratory, or their home.

3. Looking for machines

Refer to page 98 of the Students' Book.

Starter suggestions

Ask the students to read Chapter 9 of the textbook or remind them that there are six simple machines: the lever, the ramp or inclined plane, the wedge, the screw, the wheel and axle, and the pulley. Explain that they are going to look for some simple machines and identify which of the six types of machine each is.

Alternatively, set them the task of looking for examples of each of the six machines around their home.

Main lesson

Arrange a collection of household items, such as hand food mixers, bottle openers, scissors, nutcrackers, a pedal bin, a fishing rod, a hockey stick or cricket bat, and tools such as claw hammers, wrenches, spanners, screws, nuts and bolts, screwdrivers, hand drills, crowbars, and pulleys or block and tackle around the room. Ask the students to examine each item and decide what it is used for and which of the six types of machine it is. Let them record their results on Worksheet 9.1.

If they look around their home for simple machines, they can use Worksheet 9.2 to record their findings.

4. Looking at slopes

Refer to page 102 of the Students' Book.

Starter suggestions

Explain that each time they climb the stairs at home or at school, they are changing chemical energy into kinetic energy and then into potential energy. Ask them, when they are doing work in climbing the stairs, what is the size of the force they are using.

To answer this, they must know their own mass in kilograms. The amount of work they do in climbing the stairs is the product of the force and the vertical distance through which it is raised.

Work done = Force × Vertical distance moved

Sometimes you might climb the stairs slowly, particularly if you are going to a lesson you do not like. Or you might run up the stairs because you are late for a lesson. Ask the students if the amount of work they do is the same in both case. (The answer is yes. It is because they are climbing the same vertical height, although the amount of energy they expend is different.) You could, if you wish, weigh a volunteer on a set of bathroom scales and then get him or her to climb onto a stool or step ladder and calculate the work done. To do this, and later calculations, you need to remember that the weight of 1 kg mass can be taken as 10 N.

You also need to explain that one joule (J) or one newton-metre of work is done when a force of one newton moves an object one metre in the direction of the force.

Main lesson

Use Worksheet 9.3 to carry out a simple investigation into the work done in raising a toy truck loaded with a small rock or small brick up ramps of three different lengths made from planks of wood.

The answers to the questions on the worksheet are:

e) The ramp on which the truck required least pull was the longest one (100 cm).

f) The efficiency was less than 100 per cent in each case because the truck and its parts have weight and because of the friction between the truck's wheels and the ramp.

g) The mechanical advantage measures the number of times that a machine, in this case the ramp, is able to increase the force that is applied to it. In simple terms it is the load divided by the effort.

h) The 100 cm ramp had the greatest mechanical advantage.

i) The 40 cm ramp had the smallest mechanical advantage.

j) A ramp is useful because it is easier to push or pull a heavy load up a slope than it is to lift it vertically. The smaller effort moves a greater distance, equal to the length of the slope, to achieve this.

5. Pulley power

Refer to page 108 of the Students' Book.

Starter suggestions

If there is a pulley available, show it to the students. Point out that a pulley is a wheel that turns freely on an axle. Usually there is a groove in the rim of the wheel to keep the rope from slipping off. Sometimes two or more pulleys are arranged side by side on the same axle.

There are two principal types of pulleys—the fixed pulley and the moveable pulley. The fixed pulley, such as that on a clothes line, roller blind, flagpole or the mast of a yacht, merely changes the direction of a force. It has a mechanical advantage of 1. If a fixed pulley is being used to raise a load of cement that has a gravity force of 100 N acting on it, the operator must pull down with a force of 100 N. Because of friction it will actually take slightly more than 100 N. When the effort moves down by a metre, the load moves up by a metre. The only advantage is that of direction: it is easier to pull down than to lift.

The pulley, like all other machines, does not do work for you. It gives you an advantage of force, which you lose in distance. With a single movable pulley, for example, if the effort moved up 50 cm, the load was raised by only 25 cm. You used only 50 N to move a load of 100 N, but you had to move it twice as far. Remember, pulleys can also be used in combination to increase the mechanical advantage.

Main lesson

Carry out the experiments on Worksheet 9.4.

Answers to the questions on the worksheet.

a) The advantage of using a single fixed pulley is that it changes the direction of the force. It is easier to pull down on a string than lift the bucket.

b) The effort used with a single fixed pulley is slightly larger than the load or resistance because of the friction of the string and the pulley wheels.

c) The advantage of using a single movable pulley is that it has a mechanical advantage of 2. It halves the effort needed to lift the load, but the effort string has to be pulled twice as far.

d) A pulley does not decrease the amount of work to be done. It gives you an advantage of force, but you lose it in the distance over which the force has to be applied.

e) Of the pulley systems tested, the single fixed and double movable combination have the greatest mechanical advantage.

If you do not have suitable pulleys available for class use, you can carry out the experiments on Worksheet 9.5, which uses a length of cord or rope and a piece of broom handle instead of pulleys. The students will find that the more times the rope is looped through the bottle and over the broom handle, the less effort is needed but the further they have to pull on the rope to raise the bottle.

6. Gears and bicycles

Refer to page 110 of the Students' Book.

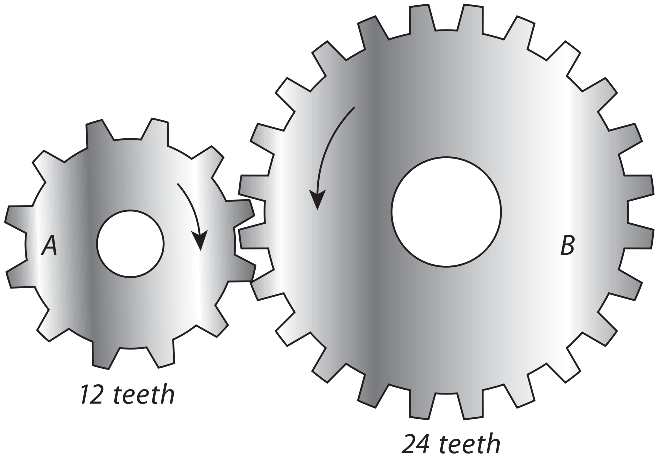
Starter suggestions

Pass a hand food mixer or a hand drill around the class. Let the students turn the handle of this simple machine and see how the gear wheels interlock and rotate each other. Explain to them that the gears do two things. First they change the speed of a rotating shaft and second, they alter the force produced by it. The force increases as the speed decreases.

Draw on the board two interlocking gear wheels, one small gear (labelled A) with 12 teeth and the other larger gear (labelled B) with 24 teeth. Show with arrows that as gear A turns, its teeth mesh with those of gear B and make it turn in the opposite direction. Since gear A has only half as many teeth, by the time it has gone round once, B has only made half a turn. Explain that the speeds of gears are given by the formula:

$$\frac{\text{speed of gear A}}{\text{speed of gear B}} = \frac{\text{number of teeth on B}}{\text{number of teeth on A}}$$

Notice that the fastest turning gear is the one with the smallest number of teeth.



Count the number of teeth in the two gear wheels of the food mixer or drill and calculate their speeds.

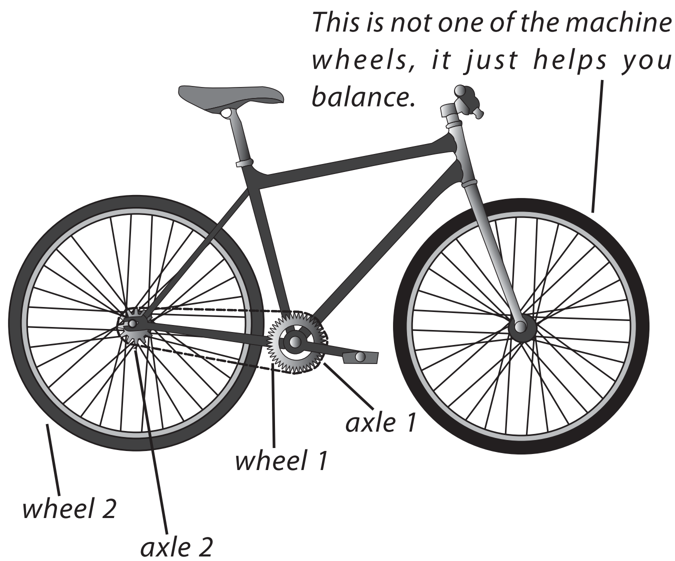
If three gears are used, the third one rotates in the same direction as the first one. Draw three interlocking gear wheels on the board (there is no need to show the teeth). Say the larger left-hand one has 30 teeth, the small, middle one 10 teeth, and the medium-sized, right-hand one 20 teeth. Show the direction of movement of the gears if the left hand one is turned clockwise. The speed of the gears can be worked out from the formula above.

Main lesson

Use a simple bicycle for the next part of the lesson, ideally one without gears.

Explain that a bicycle is two wheel-and-axle machines joined by a frame and linked together with a chain. The front wheel is not one of the machine wheels, it just helps the rider to balance.

The first 'wheel' is the circle made by the pedals as they are turned. Measure the length of the pedal crank and this will give you the radius of the first 'wheel'. Calculate how far your foot moves in one complete circle of the pedal. (The circumference of a circle = $2 \pi \times$ radius. Take π as 3.14 or 3 if the students find the calculation difficult.)



Using chalk and a meter rule or tape measure, find out how far the cycle moves for one turn of the pedal. Record your results:

- Radius of pedal 'wheel' = __________ cm
- Distance foot moves in one pedal turn = $2\pi r$ cm = __________ cm
- Distance cycle moves in one pedal turn = __________ cm

Ask these questions:

- Which do you think is greater, the force of the back tyre on the road or the push on the pedal? (the force on the back tyre)
- How many times does the back wheel turn round for one pedal turn?
- A bicycle handlebar is a simple machine. What sort of machine is it? (a wheel and axle—an example of a first class lever)
- What would you notice when steering a bicycle with very short handlebars? (You would have to pull harder on them to change direction.)
- When the pedal axle turns the chain, there is a force trying to pull the rear wheel and axle towards the pedals. Another force is needed to stop this happening. What is this other force? (friction)

Now repeat this activity with other bicycles with different sized wheels and with gears.

Ideas for investigations and extension work

Rulers and force meters

Stand a 1 metre stick upright on the ground. Place a weight of 1 newton at the base. If you lift that weight to the top of the metre stick you have done 1 joule (1 J) of work. Repeat this using weights of 10, 20, 50, 100, and 200 newtons. How much work would you do in each case? (10 J, 20 J, 50 J, 100 J, and 200 J)

Use a force meter or newton meter to measure the force it takes to lift a textbook to the top of the metre stick. How much work is needed to do this? How much work would be needed to lift 20 books of the same size to that height? If each book was lifted separately, would the same amount of work be done as if the books were lifted together? Check you answer by measuring.

Model windmills

Design and make a model windmill, in which the vertical turning force of the windmill blade or fan is changed by gears so that it will turn a heavy millstone (a heavy wheel) in a horizontal direction.

A model lift or elevator

A lift or elevator uses a pulley system to raise and lower the lift car. The weight of the lift car is balanced by a counterweight. As the lift car goes down, the counterweight rises, and vice versa. Design and make a model lift or elevator using string, a cotton reel, a small box, clay or Plasticine, thin string, a knitting needle, a plastic pot, and some sand.

Model cranes

Collect photographs of different types of crane. Choose one type and make a working model of it.

Worksheet 9.1

A survey of simple machines

Object	What it is used for	Type of machine

In the spaces below, draw one example of each type of machine and label your drawing. Show where the fulcrum, effort, and load are in each example, using the letters F, L, and E.

lever	**inclined plane**	**wedge**
wheel and axle	**screw**	**pulley**

Worksheet 9.2

Simple machines around my home

Try to find one example of each type of machine around your home.

Simple machine	Object	Room
lever		
inclined plane		
wedge		
wheel and axle		
screw		
pulley		

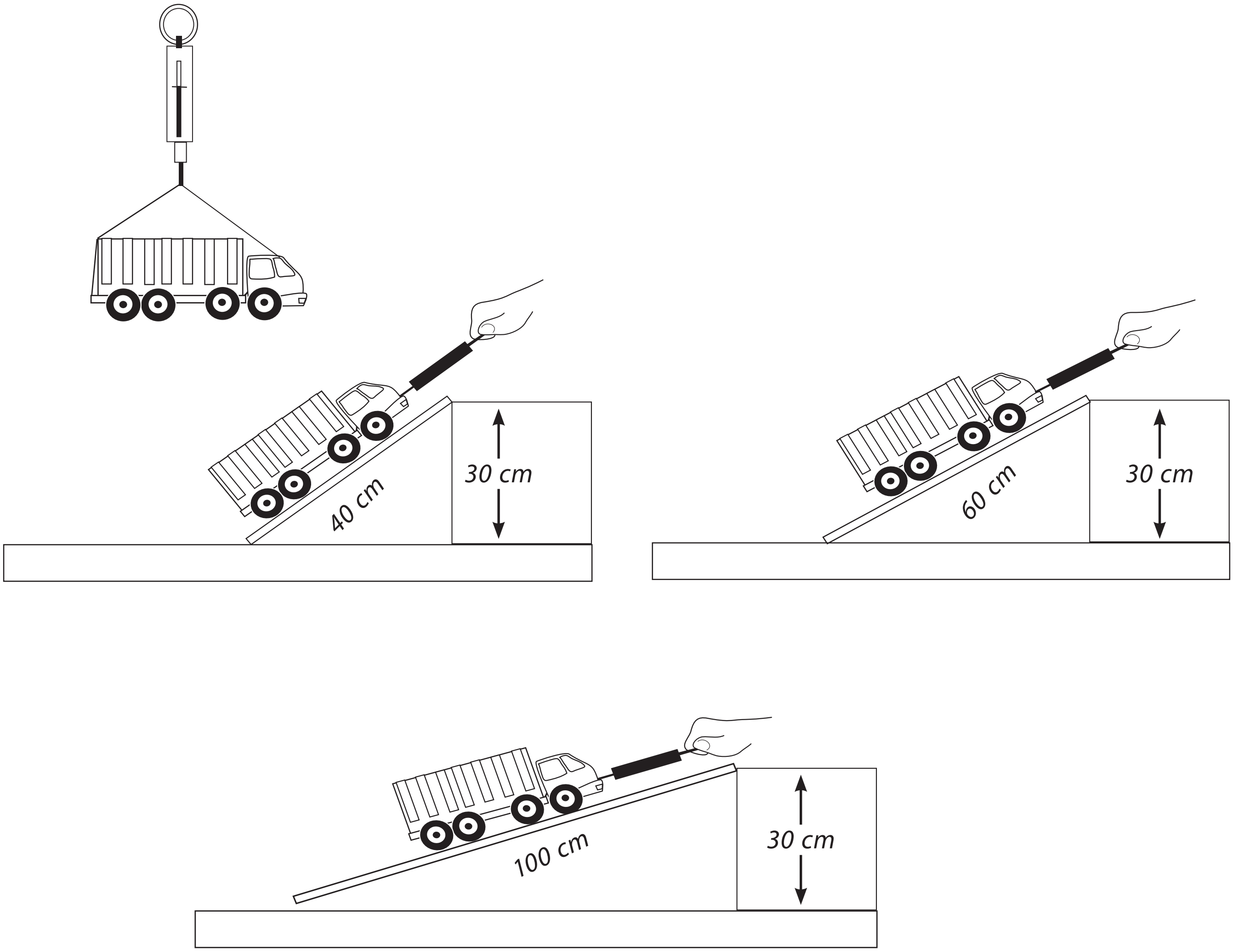
1. Which room in your home had the most simple machines? ___________
2. Which room in your home had the fewest simple machines? ___________

Worksheet 9.3

Raising a load up a ramp

Materials needed per group: Stack of books (or bricks) about 30 cm high, three boards 40 cm, 60 cm, and 100 cm long, toy truck loaded with rock or brick, string, newton meter.

1. Set up the three ramps or inclined planes, as illustrated.



2. Use the newton meter and some string to determine the force (resistance = R) needed to lift the truck and its load vertically.
3. Slowly pull the truck up the first ramp and measure the effort (E) it takes to do this, again using the newton meter.
4. Repeat this last step for each of the other two ramps.

5. For each of the ramps, calculate the following:
   a) the work input
   b) the work output
   c) the efficiency
   d) the mechanical advantage

Fill in your results on this table:

	Resistance (R)	Effort (E)	Resistance distance (d)	Effort distance (D)	Work input (E×D)	Work output (R×d)	Efficiency $\frac{\text{output}}{\text{input}} \times d$	Mechanical advantage $\frac{(R)}{(E)}$
Units	N	N	m	m	J	J		
1			0.30	0.40				
2			0.30	0.60				
3			0.30	1.00				

e) For which ramp did the truck require least pull? ____________________

f) Why was the efficiency less than 100 per cent in each case? ____________________

g) What does the mechanical advantage measure? ____________________

h) Which ramp had the greatest mechanical advantage? ____________________

i) Which ramp had the smallest mechanical advantage? ____________________

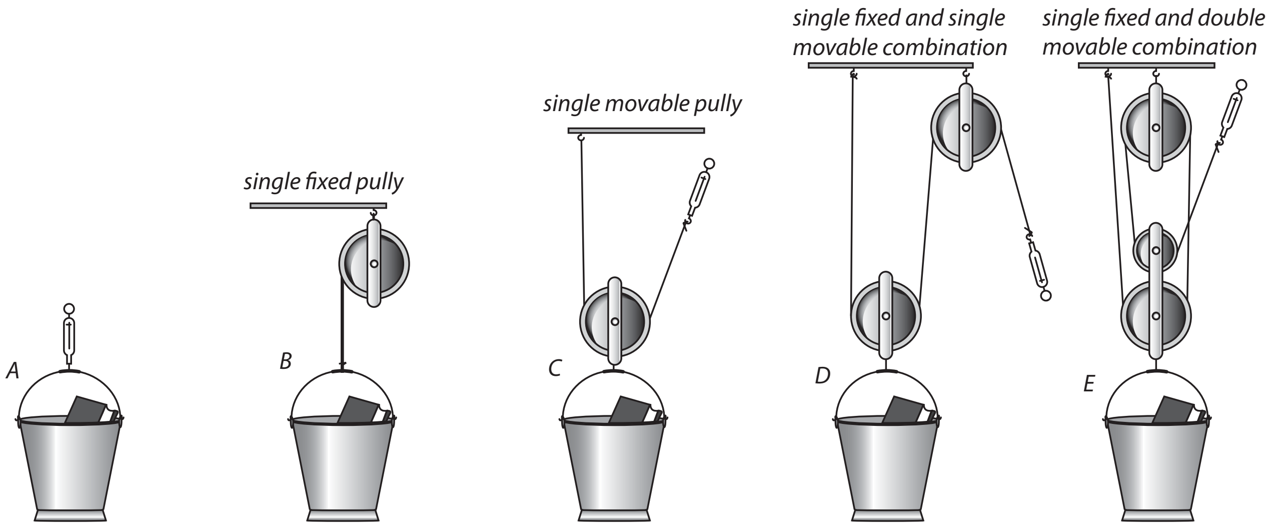
j) Describe how a ramp is useful. ____________________

Worksheet 9.4

Experimenting with pulleys

Materials needed per group: strong string or cord, newton meter or force meter, pulleys, plastic bucket (real or toy), book.

1. Place the book in the plastic bucket and measure the gravity force of the load in newtons. Do this by suspending the bucket from the spring balance (illustration A).
2. Suspend the load from a single fixed pulley and measure the effort needed to raise the bucket (illustration B).
3. Measure the effort needed to raise the bucket, using each of the other pulley arrangements shown (illustrations C, D, and E).



4. Record your results in the table below.

Pulley system	Load or resistance (R) in newtons	Effort (E) in newtons	Mechanical advantage $\frac{(R)}{(E)}$
single fixed			
single movable			
single fixed and single movable			
single fixed and double movable			

Answer these questions:

a) What is the advantage of using a single fixed pulley? ______________________

b) Why is the effort used with a single fixed pulley slightly larger than the load or resistance? ______
____

c) What is the advantage of using a single movable pulley? ______________________

d) Does a pulley decrease the amount of work to be done? Explain your answer. ____________
____

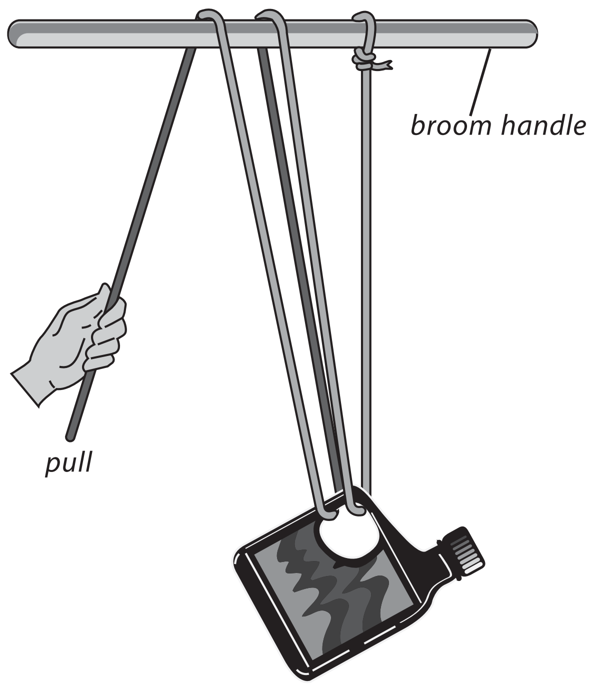
e) Which of the pulley systems has the greatest mechanical advantage? ______________

Worksheet 9.5

Ropes and pulleys

Materials needed per group: piece of broom handle, plastic bottle with looped handle, sand or water, rope or strong cord, masking tape, newton meter or force meter.

1. Tape the ends of the broom handle between two desks or benches.
2. Fill the plastic bottle with sand or water and screw the lid on.
3. Try to lift the bottle from the floor using the rope and broom handle. Make a drawing of how you did it.



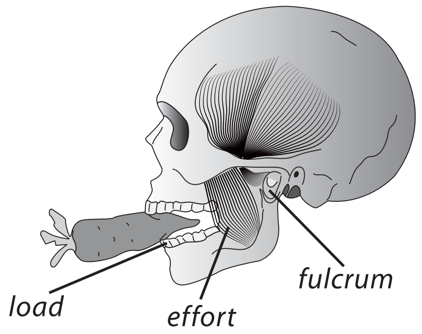
4. Tie one end of the rope to the broom handle. Loop the rope through the bottle handle, and lift by the free end of the rope with the weight in the middle. This is equivalent to a movable pulley.
5. Loop the rope over the broom handle and pull down on the free end of the rope. Record the effort. ______________________________.
6. Now loop the rope through the bottle handle another time and then up and over the broom handle. You will now have two loops over the broom handle and the original knot (see picture above).
7. Pull on the free end of the rope and see what effort is required to raise the bottle from the floor. Record the effort. ______________________________

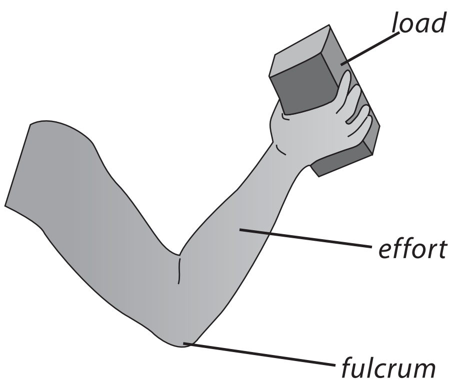
Answers to questions in the Students' Book

1. To a scientist, the word 'work' means what happens when a force moves an object a certain distance in the direction of the force.
2. Using a crowbar or some other lever to move a large log is making use of the turning effect of forces to produce a larger force. This does not mean that you are doing less work, because work is force multiplied by distance. In this case, you are using a smaller force but moving it over a greater distance.
3. A machine is a device which makes work easier. In most machines a small force, the effort, is used to overcome a larger force, called the load.
4. The effort is the force that you apply to a simple machine, such as a lever, to move the resisting force, called the load.
5. The advantages of a first class lever are that it produces a large force from a small force. To achieve this, the fulcrum is further from the effort than the load. This increases the turning effect of the effort. The disadvantage is that the effort has to be moved a longer distance than the load moves.

   A second class lever also produces a large force from a small force. To achieve this, the load is between the fulcrum and the effort. This increases the turning effect of the effort. Again, the effort has to be moved a longer distance than the load moves.

   In a third class lever, the effort is between the fulcrum and the load. This produces a large movement from a small movement in that the effort moves a shorter distance, but the load moves a longer distance. The disadvantage is that a large force is used to move a small load.
6. When you chew your food you are using a third class lever. The fulcrum is the two points where your lower jaw bone pivots at the side of your head. The effort comes from the contraction of the muscles in the sides of your jaws. The load is the crushing effect as your jaws come together to chew your food.





7. When you use your arm to lift an object, you are using a third class lever. The fulcrum is your elbow joint, the effort comes from the muscles in your forearm, and the load is the object in your hand.
8. The advantage of a single fixed pulley is that it can change the direction of a force. It can be used, for example, to raise a flag on a flagpole, or clothes on a clothes line. It can also be used to raise a bucket of sand or cement by pulling down on a rope, rather than lifting the heavy bucket straight up.

9. A wheel and axle is an example of a first class lever. The fulcrum is the axle and the arms of the lever are the spokes or disc of the wheel. In a wheel the lever can turn through 360° around the fulcrum or axle, rather than the limited up and down or see-saw movements in the usual type of lever.
10. A screw is an inclined plane wrapped around a cylinder. The inclined plane forms ridges in a spiral along the cylinder. These ridges are the so-called threads of the screw.
11. A wedge consists of two inclined planes back to back. When viewed from the side it has a triangular shape.
12. A tinsmith's shears have long handles and short blades because they are used for cutting sheets of metal. In this case the load is large and the effort has to move a large distance to overcome it. A large force is being produced from a smaller force. A tailor's scissors have short handles and long blades because cloth is much easier to cut. Only a small effort is needed to move the blades and make a large cut.

Assessment

Question 1

Complete the following sentences using the words in the box below:

lever	axle	see-saw	load	energy	scissors	work	effort	machine	fulcrum

A machine is any tool that makes __________ easier. In fact, even something as simple as a hammer is a __________, so too is your elbow or a pair of __________. Scientists agree that there are six kinds of simple machine. They are the __________, inclined plane, wheel and __________, screw, pulley, and wedge. A lever is a straight rod or bar that rests on a single point, like a __________. The support that the lever rests on is called the __________. In a see-saw, the fulcrum is in the middle. The person pushing off the ground provides the effort. He is applying __________ to make the see-saw move. The person being lifted on the other end of the see-saw is the load. But the fulcrum does not have to be in the middle. The fulcrum of a wheelbarrow is the wheel. The __________ is the bucket where the heavy items are carried. The __________ is at the handles, where a person can lift the wheel barrow up.

Question 2

What unit is used to measure forces?

(A) newtons (B) grams (C) kilograms (D) pounds

Question 3

What is a simple machine?

(A) a tool that gives energy to other machines
(B) a machine that does only one job
(C) any tool that makes work easier
(D) a machine that is made up of many smaller parts

Question 4

How many kinds of simple machine do scientists recognise?

(A) 7 (B) 6 (C) 2 (D) 4

Question 5

Which of the following is NOT a simple machine?

(A) engine (B) screw (C) inclined plane (D) lever

Question 6

A lever is supported on a single point called the

(A) axle (B) rod (C) wedge (D) fulcrum

Question 7

To undo one of the nuts on the wheel of a car, it would be best to use a

(A) screwdriver (B) hammer

(C) short-handled spanner (D) long-handled spanner

Question 8

The name moment is given to the turning effect of a force. The units of a moment are usually:

(A) newtons (B) newton-metres

(C) kilograms (D) grams

Question 9

You need to move a heavy piano up to the second floor of your school. Which simple machine would NOT work?

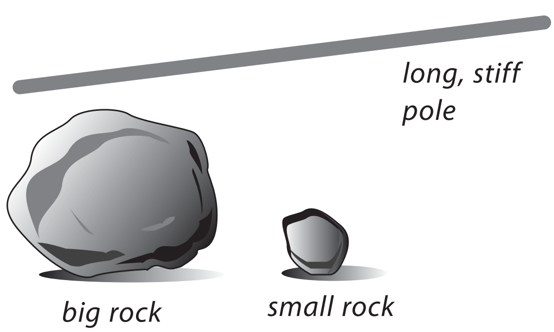
(A) pulley (B) lever (C) inclined plane (D) wedge

Question 10

Suppose there is a big rock in your school playground that needs to be moved but it is too heavy to lift. Nearby there is a small rock and a long, rigid pole.

a) Draw a sketch to show how you would move the heavy rock yourself using the small rock and pole.

b) What is the scientific name for the machine you have designed?



Question 11

Read the name of each tool in the list on the left. Decide what kind of simple machine it is and write the correct letter against it in the space provided.

drill ______	A. lever
chisel ______	B. inclined plane
playground slide ______	C. wheel and axle
bicycle ______	D. screw
spade ______	E. pulley
flagpole ______	F. wedge

Question 12

Complete the following sentences using the words in the box below:

screw	block and tackle	load	inclined plane	wheel and axle	wedge

a) The three parts of a lever are fulcrum, effort, and ______.

b) A ______ is a simple machine used to join or press objects and materials together.

c) An escalator moves people up or down a sloping surface. It is an example of an ______.

d) A ______ is a simple machine with one sloping edge that may be very sharp.

e) A ______ is a simple machine with two circular parts that turn together to move loads.

f) The ______ is a type of pulley system used in cranes and lifts.

Question 13

Complete the following sentences by choosing words from those below.

constant	six	weighs	varies	same	lower	change

The force of gravity ______ from place to place. It is ______ up a mountain than at sea level. Mass does not ______. It is ______. The force of gravity is ______ times larger on Earth than on the Moon. A man on Earth ______ six times more than he would on the Moon. His mass is the ______ on Earth as it is on the Moon.

Answers to Assessment questions

Question 1

A machine is any tool that makes **work** easier. In fact, even something as simple as a hammer is a **machine**, so too is your elbow or a pair of **scissors**. Scientists agree that there are six kinds of simple machine. They are the **lever**, inclined plane, wheel and **axle**, screw, pulley, and wedge. A lever is a straight rod or bar that rests on a single point, like a **see-saw**. The support that the lever rests on is called the **fulcrum**. In a see-saw, the fulcrum is in the middle. The person pushing off the ground provides the effort. He is applying **energy** to make the see-saw move. The person being lifted on the other end of the see-saw is the load. But the fulcrum does not have to be in the middle. The fulcrum of a wheelbarrow is the wheel. The **load** is the bucket where the heavy items are carried. The **effort** is at the handles, where a person can lift the wheelbarrow up.

Question 2

(A) newtons

Question 3

(C) any tool that makes work easier

Question 4

(B) 6

Question 5

(A) engine

Question 6

(D) fulcrum

Question 7

(D) long-handled spanner

Question 8

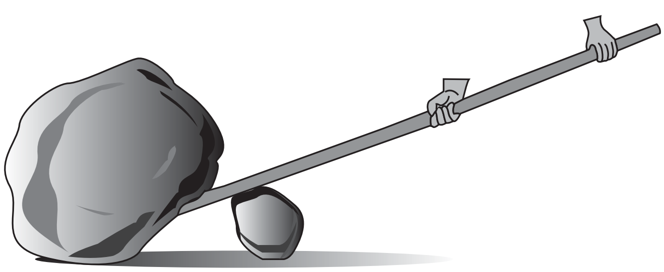
(B) newton-metres

Question 9

(D) wedge

Question 10

a)



b) lever

Question 11

drill…D. screw

chisel…F. wedge

playground slide...B. inclined plane

bicycle…C. wheel and axle

spade …A. lever

flagpole…E. pulley

Question 12

a) The three parts of a lever are fulcrum, effort, and **load**.

b) A **screw** is a simple machine used to join or press objects and materials together.

c) An escalator moves people up or down a sloping surface. It is an example of an **inclined plane**.

d) A **wedge** is a simple machine with one sloping edge that may be very sharp.

e) A **wheel and axle** is a simple machine with two circular parts that turn together to move loads.

f) The **block and tackle** is a type of pulley system used in cranes and lifts.

Question 13

The force of gravity **varies** from place to place. It is **lower** up a mountain than at sea level. Mass does not **change**. It is **constant**. The force of gravity is **six** times larger on Earth than on the Moon. A man on Earth **weighs** six times more than he would on the Moon. His mass is the **same** on Earth as it is on the Moon.

Properties of light

CHAPTER 10

Teaching Objectives

- To explain the difference between the transmission, absorption and reflection of light
- To explain the laws of reflection and how they apply to different surfaces
- To investigate the images formed by a plane mirror
- To compare the images formed by a plane mirror and a pinhole camera
- To explain the structure and function of a kaleidoscope and a periscope
- To investigate the images formed by concave and convex mirrors
- To examine the everyday uses of plane, concave, and convex mirrors

Learning Outcomes

After studying this chapter students should be able to:

- differentiate between the transmission, absorption, and reflection of light
- demonstrate the law of reflection
- demonstrate the difference between smooth, shiny, and rough surfaces
- compare regular and diffused reflection
- identify everyday applications which involve regular reflection and diffused reflection
- draw ray diagrams for light reflected from a plane mirror at different angles of incidence
- describe image formation by a plane mirror
- compare characteristics of the images formed by a plane mirror and a pinhole camera
- explain the use of reflecting surfaces in different devices
- design an experiment to make an optical instrument using mirrors
- explain the principle of reflection in a kaleidoscope
- describe the relationship of angles between two mirrors and the number of images they can see in a kaleidoscope
- explain the types of mirror and their uses in our daily life
- investigate the image formation by convex and concave mirrors

Introduction

The students will already have some knowledge of the properties of light, not only from work done in their primary school days but also from Chapter 2 of the textbook, where they looked at the eye and the sense of sight.

Now is the opportunity to clear up some misconceptions about the nature of light. The students will probably have been told, or heard, that light is a form of wave. At the same time, they will have been told that light travels as rays. At first, it would seem that the ideas of light as a wave and light as a ray are not compatible. In this context, it may be helpful for the students to think of a beam of light from the Sun in terms of a wavefront steadily advancing through space. They should now imagine a point on that wavefront advancing steadily forwards. If they were to draw a line tracing the path of this point, they would have drawn a ray. Rays then will always be drawn at right angles to wavefronts.

Students may also be puzzled at why the light from a torch or some other source spreads out if it only travels in straight line. The explanation is, of course, that the light sources produce a very large number of rays which spread out in straight lines. Hopefully the work covered in this chapter on light sources and reflection will help to produce a better understanding of the nature of light.

Lesson suggestions

1. Seeing the light

Refer to page 115 of the Students' Book.

Starter suggestions

Try to get over the idea of light rays by showing the students a low power laser light such as a laser pointer pen or one of the modern laser measuring devices. Clamp the device in position and point it at a matt black surface so that the students can see the intense light spot. They will not be able to see the beam itself, so it is necessary to use a little chalk dust or talcum powder to reveal this.

Safety 1: Laser light can be very damaging to the eyes. Point the laser device away from the students at all times and do not let them handle it.

Safety 2: Warn the students NEVER to look directly at the Sun, either with their eyes or with instruments such as binoculars and telescopes. Serious and permanent damage to the eyes can result.

Main lesson

For a long time people thought that the eyes sent out 'feelers' of light or rays of light which were able to sense objects around them. Some comic books still use this device when one of the characters is staring at an object or person. We now know that we see objects when light rays are reflected off them and enter our eyes.

Ask the students to make a list of light sources—objects and materials that give off their own light. This will include the Sun, candles, electric lights, fires, and some chemical reactions such as when magnesium burns.

A few animals such as glow-worms, fireflies and certain deep-sea fish, and some fungi can also produce light. Ask the students what most of the non-living light sources have in common—the answer is that they are also hot. If there is time, you could also show the students pictures, or part of a film or DVD, that show the light-production by certain deep-sea fish.

Emphasise that most objects simply reflect light from the actual sources of light. The Moon is a case in point. The Moon is not a light source. The Moon appears to shine because light from the Sun is reflected off the Moon's surface. The Moon itself is just a large dark ball of rock.

Move on now to either investigate or demonstrate how light travels (Worksheet 10.1).

The expected results of the experiment are that when one of the cards is moved a little way to one side you can no longer see the light. Similarly, you can see the light through the hose when it is straight, but not when it has a slight bend in it.

From these results we learn that light travels in straight lines.

When a hunter aims his gun, he assumes the light is travelling from his target straight to his eye, and that when he fires the gun the bullet will also travel in a straight line.

2. Reflecting light

Refer to page 116 of the Students' Book.

Starter suggestions

Ask the students how many of them have ever looked at themselves in a plane (flat) mirror.

Presumably they will all say they have. Ask them whether they noticed anything about their reflection. They may have noticed that their reflection is left-right reversed. Explain that we are now going to carry out further investigations into the reflections produced by plane mirrors.

Alternatively, if you have a photograph of the distorted images produced by a fun fair mirror or, better, have a bendy piece of very shiny metal that will produce distorted reflections, you can ask the students to explain what they see. This is also an opportunity to introduce the students to the correct terminology, such as 'reflection' and 'image' and 'distorted'. Again, explain that we are going to investigate reflections further.

Main lesson

For this lesson and further investigations into light and mirrors, we need either a ray box or a torch with a file card with a slit in it stuck or held in front of the lens of the torch.

Safety: Ray boxes can get very hot. Check mirrors to see they do not have chipped edges. If they do, put masking tape or insulating tape around the edges.

Place a ray box, or the torch fitted with the slit file card, on your exercise book or a flat sheet of card. Shine a single ray of light across your book or the card onto a mirror, a piece of glass (a microscope slide), and a piece of white paper in turn. Notice the appearance of the reflected 'ray' in each case. Both the mirror and the glass make what is called a regular reflection, whereas the white paper gives what is called a diffused reflection—the reflected rays go in all directions.

Now use the ray box or torch fitted with the slit card to carry out the experiment on Worksheet 10.2. If the students work accurately and measure the angles from the normal, then they should find that the angle of incidence and the angle of reflection are always the same. Tell them that this is known as the Law of Reflection.

3. Curved mirrors

Refer to page 120 of the Students' Book.

Starter suggestions

Make a collection of curved mirrors and show them to the students. Explain that those mirrors which have the shiny surface on the inside of the curve are called concave mirrors. Those with the shiny surface on the outside of the curve are called convex mirrors.

Alternatively, look for concave and convex mirrors in use in shops, on buses, at the dentist's, in torches, and headlights, etc. Make lists of the uses of the two types of mirror.

Main lesson

If you have a ray box fitted with a lens and three or more slits, you can show the students how a cylindrical concave mirror and a cylindrical convex mirror reflect light rays.

If you do not have access to concave and convex mirrors, let the students experiment with shiny metal spoons. The inside of the bowl of the spoon behaves like a concave mirror while the back of the spoon acts like a convex mirror. Let them examine their reflection while holding each side of the spoon close to their face and then further away. They will see that when they are very close to a concave mirror, it produces an image which is upright and larger than the object. It is also virtual. If they hold the concave mirror at arm's length, then the image is real, inverted (upside down) and smaller than the object, in this case their face. By contrast, the image formed in a convex mirror is virtual, upright, and smaller than the object.

4. The pinhole camera

Refer to page 118 of the Students' Book.

Starter suggestions

It is interesting to compare the image formed in a plane or flat mirror with the image formed by a pinhole camera. Give the students plane mirrors and let them remind themselves of the image such a mirror forms. They will notice that the images:

a) are virtual and appear to be behind the mirror
b) are the same size as the object
c) seem to be the same distance behind the mirror as the objects are in front of the mirror
d) are laterally inverted.

You may need to remind the students what is meant by the word 'virtual' in connection with mirrors. Explain that a virtual image is one which cannot be focused on a screen because rays of light do not actually pass through the image.

The students can prove for themselves that the image in a plane mirror appears to be the same distance behind their mirror as the object is in front of the mirror with this simple activity. They should hold a 30 cm ruler under their nose with their ruler pointing towards the mirror. If they move forwards slowly until the ruler is just touching the mirror, they will see that their reflection appears to be 30 cm behind the mirror. They can repeat this with longer or shorter rulers if they wish.

Main lesson

Make a pinhole camera and see how it works by using Worksheet 10.3.

Expected results:

a) The candle flame was inverted on the waxed paper screen.

b) When the candle flame was blown to the left, its image moved to the right.

The image formed by the pinhole camera is:

- real because it can be formed on a screen
- smaller than the object
- inverted (upside down).

Ideas for investigations and extension work

The television remote control

The television remote control (and that for some DVD players and music centres) works by sending out a beam of infrared rays, a form of light which we cannot see. Can the students devise an experiment to show that infrared rays travel in straight lines, just like visible light?

Periscope and kaleidoscope

Use two plane mirrors to make a periscope and then a kaleidoscope.

Worksheet 10.1

How light travels

Materials needed per group: thick card or old postcards, scissors, ruler, Plasticine or modelling clay, knitting needle, torch or slide projector, string, rubber hose (about 1 m).

1. Cut four pieces of card, each about the size of a postcard. Find the centres by drawing diagonal lines. Punch a neat round hole in the centre of each with the point of a pencil or the point of compasses.
2. Hold one of the cards up at arm's length. What do you see? ____________________
3. Move the card slowly towards your eye. What do you see? ____________________
4. Using Plasticine or modelling clay, stand the four card in a row about 20 cm apart.
5. Push a knitting needle through the holes to make sure that all four cards are in a straight line.
6. Take the knitting needle away without moving the cards.
7. Shine the torch or projector from the far end of the row of cards. Can you see the light when you look through the holes? ____________________
8. Keep the torch or projector where it is, but move one of the cards a little way to one side. What can you see? ____________________
9. Use a piece of rubber hose and the torch to carry out a similar experiment, first with the hose straight and then with a slight bend in it. What do you notice? ____________________

Answer these questions:

a) What have you learned about the path light takes when it travels?

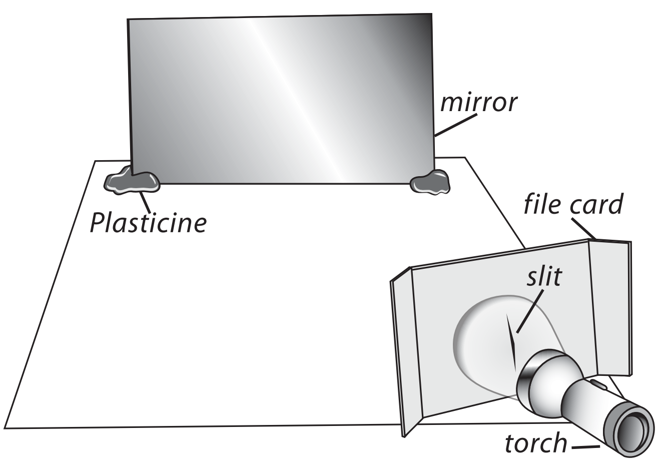
b) When a hunter aims his gun, what does he assumed i) about light and ii) about a bullet?

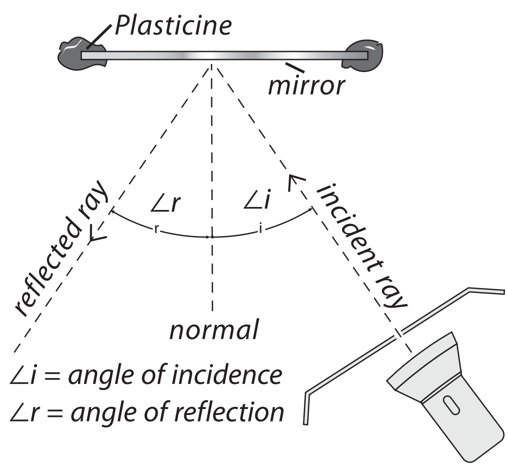
Worksheet 10.2

How light rays are reflected

Materials needed per group: plain paper, small plane mirror, Plasticine or modelling clay, torch or ray box, file card (if torch is used), protractor, set square, ruler

1. Draw a line near the edge of a blank sheet of paper and parallel to the edge of the paper.
2. Stand the back of the mirror on this line. Use Plasticine or modelling clay to make the mirror stand upright.
3. If you are using a torch, cut a slit in one edge of the file card. The slit should be about 2 mm wide and 4 cm long.
4. With the room darkened, position the torch about 5 cm behind the file card so that a narrow beam of light will shine through the slit and strike the mirror. Alternatively shine a narrow beam of light from the ray box onto the mirror. In both cases you should be able to see the reflected ray as well as the original one, which is called the incident ray.





5. Mark the path of the light with a ruler and pencil, and put arrowheads on the path to show the direction in which light travelled.
6. Label the ray travelling towards the mirror the 'incident ray' and the ray bouncing off the mirror the 'reflected ray'.
7. Use your protractor or a set square to draw in the 'normal' on your diagram. The normal is a line drawn at right angles (90°) to the mirror at the point where the incident rays strikes it.
8. Measure the angle of incidence (i) and the angle of reflection (r) as shown in the diagram.
9. Repeat the investigation three times more, using a fresh sheet of paper each time. Shine the light at the mirror from a different angle each time.

10. Record your observations in the table below:

TRIAL	angle of incidence (i)	angle of reflection (r)
1		
2		
3		
4		

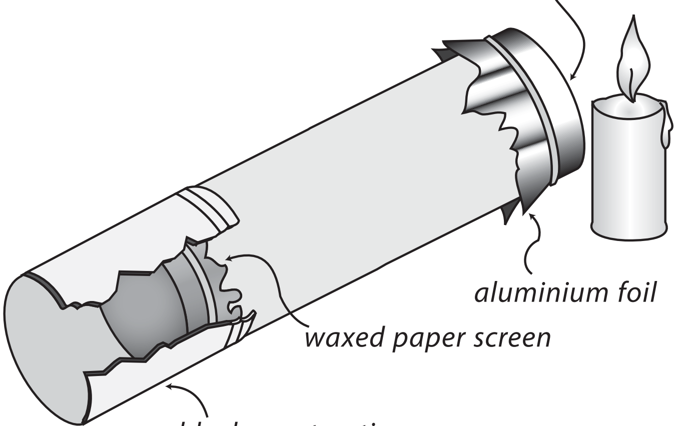
From your results, what is the relationship between the angle of incidence and the angle of reflection?

Worksheet 10.3

Make and use a pinhole camera

Materials needed per group: cardboard tube or empty can (about 20 cm long and 10 cm in diameter, aluminium foil (cooking foil), waxed paper, elastic bands or masking tape, black construction paper, a pin, candles, dish of sand or candle holder, matches.

1. Cover one end of the tube with aluminium foil. Hold the foil in place with an elastic band or masking tape.
2. Poke a pinhole in the centre of the foil. If you are using a can, make a small hole in the base with a hammer and thin nail).
3. Cover the other end of the tube with waxed paper, fixed in place with an elastic band or masking tape.
4. Extend the tube beyond the waxed paper, using black construction paper and an elastic band or masking tape (see diagram below).



5. Darken the room and point the pinhole at a bright object such as a candle flame. (The candle should either be in a candle holder or standing in a dish of sand.)
6. Have your partner blow the candle flame gently to one side. To which side does the image move?
7. Point your camera through a window, and try to observe an image of a tree, a lamp post or some other object.

Questions

c) What did the candle flame look like? ______________________ Draw a diagram of it.

d) Describe what happened to the image when the candle flame was blown to the left. ______________________

____

e) Draw picture of what you saw when you pointed the camera through the window. ______________________

____

Answers to questions in the Students' Book

1. We know that light travels in straight lines because we can see the rays when they stream through the trees or when we look at the light travelling from a projector on its way to the screen. Because light travels in straight lines, it cannot go round opaque objects, which explains why opaque objects make shadows.
2. Opaque describes objects and materials which absorb, scatter, or reflect light and do not allow any light to pass through. You cannot see through opaque objects.

   Transparent describes objects or materials that allow light to pass through them with little or no diffusion or scattering of the light. You can see clearly through a transparent object or material.

   Translucent describes objects or materials that allow light to pass through them, but which diffuse or scatter the light as it passes through. You cannot see clearly through a translucent object or material.

   Luminous objects are objects which give off their own visible light.
3. Some luminous objects include the Sun and other stars, fires and flames, lighted candles and matches, fireflies, glow-worms, light bulbs and tubes, and fireworks. Certain deep-sea fish and some fungi also produce visible light.
4. Certain deep-sea fish and some insects are luminous, either to attract a mate or, if they are predators, to attract their prey.
5. There are too many opaque objects and materials to list, but the students may include bricks, wood, and concrete, as well as most ceramic materials. Transparent objects and materials include glass or windows, clingfilm, and some kinds of polythene. Translucent objects and materials include obscure glass and plastic, and some kinds of paper, such as tissue paper and greaseproof paper. Lampshades are also usually translucent.
6. Almost all non-luminous objects and materials reflect some of the light that falls on them. We can see the pages of a book because they reflect some of the light that falls on them into our eyes.
7. A reflection is caused when light changes direction after it has hit a surface and bounced off. When light hits a shiny surface almost all of it is reflected in a regular and predictable way. We see an image, such as when we look at ourselves in a mirror. A shadow is an area of darkness on a surface. It is formed when an opaque object prevents light from a source from falling on that surface.
8. A plane mirror reflects light from its surface at the same angle as the light strikes the surface. In other words, the angle of incidence is the same as the angle of reflection.
9. Diamonds sparkle from so many directions and in so many colours because when the light enters a diamond it is bent, or refracted, in many different directions. White light is made up of all the different colours of the rainbow, and the light leaving a diamond is bent enough for it to split into a rainbow of colour.
10. If a boy's nose is 30 cm in front of a plane mirror, the reflection of his nose will appear to be 30 cm behind the mirror.

11. The images in the vehicle's plane mirror will be the same size as the objects it is reflecting, but they will be laterally inverted. The convex mirror will give a wider field of view than a plane mirror of the same size. However, the images will be upright but smaller.
12. If an object is a long way from a concave mirror, the image is real, upside down, and smaller than the object. It is because the images are inverted that a concave mirror could not be used as the rear-view mirror in a car.
13. A convex mirror forms an image that is virtual, upright, and smaller than the object. An object that is close to a concave mirror produces an image that is virtual, upright, and larger than the object. If the object is moved a long way from the concave mirror, the image changes. It becomes real, inverted (upside down), and smaller than the object.
14. Uses for plane mirrors include mirrors for dressing, periscopes, and kaleidoscopes.

    Uses for concave mirrors include shaving and make-up mirrors, dentists' mirrors, car headlights, and reflecting telescopes. Uses for convex mirrors include rear-view mirrors in cars, staircase mirrors on double-decker buses, and security mirrors in supermarkets to detect shoplifters.
15. A regular reflection is like that produced by a mirror in that all the light is reflected in one direction. When light hits a rough, uneven surface, some of the light is absorbed, but the rest is scattered in all directions. This is a diffuse reflection.
16. The image formed in a plane mirror is virtual and appears to be behind the mirror. It is the same size as the object and appears to be the same distance behind the mirror as the object is in front of the mirror. The image is also laterally inverted. By contrast, the image formed in a pinhole camera is real, because it can be formed on a screen. The image is also smaller than the object and inverted (upside down). The image formed inside the pinhole camera is also less bright than that formed in a mirror. If the pinhole is made larger, the image becomes brighter but also becomes more blurred.

Assessment

Question 1

Which of the following objects will NOT make a dark shadow?

(A) metal spoon (B) wooden spoon (C) woolly hat (D) glass jar

Question 2

The type of reflection produced by a plane mirror is called a

(A) regular reflection (B) irregular reflection (C) uneven reflection (D) multiple reflection

Question 3

Which of the following statements about the images produced in a plane mirror is NOT true?

(A) They are virtual and appear to be behind the mirror.

(B) They are smaller than the object.

(C) They appear to be the same distance behind the mirror as the object is in front of the mirror.

(D) They are laterally inverted.

Question 4

A periscope contains two plane mirrors, one above the other. What is the angle at which each of the two mirrors reflects the light?

(A) 60° (B) 45° (C) 90° (D) 180°

Question 5

An eye looks at the image of a burning candle in a pinhole camera. The candle flame will point

(A) up in the camera and down on the retina.
(B) up in the camera and up on the retina.
(C) down in the camera and up on the retina.
(D) down in the camera and down on the retina.

Question 6

Which of the following instruments or devices does NOT contain a mirror?

(A) a microscope
(B) a reflecting telescope
(C) a refracting telescope
(D) a kaleidoscope

Question 7

Which of the following statements is TRUE? In a pinhole camera

(A) only a large hole gives a sharp image.
(B) only a small hole gives a sharp image.
(C) only a large number of small holes give a sharp image.
(D) only near objects can be focused.

Question 8

Look at the statements below and then say whether you think each one is TRUE or FALSE.

a) Light can pass through any type of material. ________
b) We can only see objects which give out their own light. ________
c) The Moon gives out its own light. ________
d) The Sun gives out its own light. ________
e) A mirror can reflect light. ________
f) Shadows are caused by objects blocking the path of light. ________
g) Light from the Sun is a mixture of different colours. ________
h) Light travels in straight lines. ________

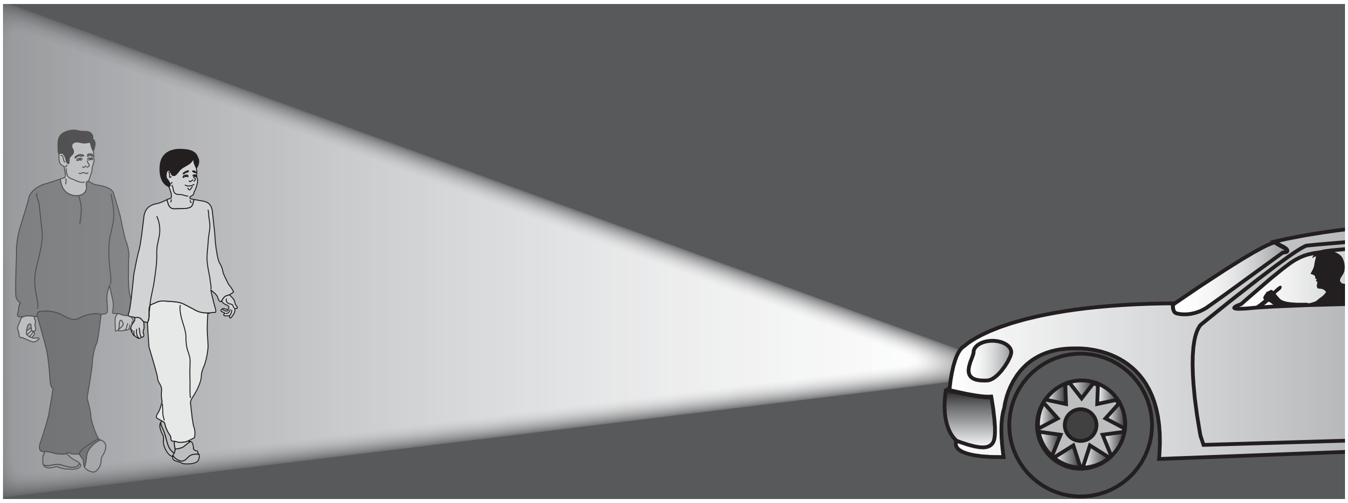
Question 9

Match the scientific word to its definition.

translucent	light rays that bounce off a surface
transparent	an area where there is no light
opaque	an image that cannot be focused on a screen
reflection	an object that gives out its own light
virtual	a ray that strikes a surface
luminous	describes a material that allows light to pass through it
incident ray	describes a material that does not allow light to pass through it
normal	describes a material that allows some light to pass through it
shadow	light reflected in all directions
scattering	a line drawn at right angles to the surface of a mirror at a point where an incident ray hits that surface

Question 10

Two boys are walking along a dark road at night. One is wearing light-coloured clothes, the other is wearing black clothes.



A car comes up behind the boys. Light from the car headlights shines on them.

a) What happens to the light when it reaches the light-coloured clothes?

b) On the diagram above, draw a ray of light to show how the light from the headlights reaches the driver so that he can see the boy in the light-coloured clothes. Draw arrows to show the direction of the light.

c) What happens to the light when it reaches the boy wearing black clothes?

Question 11

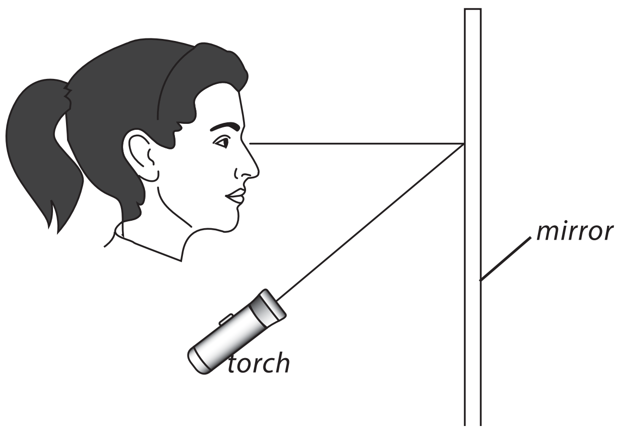
Complete the following sentences using the words in the box below:

food	lightning	fireflies	electricity	fuels	chemical	Sun	energy	fire	see

Light is a form of __________. It is needed for us to __________ things and for plants to make their __________. Most of our light energy comes directly from the __________. Other natural sources of light include the stars, __________, and __________. Animals such as __________, glow-worms, and some deep-sea fish give out light as a result of __________ reactions in their bodies. Light energy is also given out by burning __________ and passing __________ through light bulbs.

Question 12

The picture shows Myra looking at the light of a torch reflected in a flat or plane mirror.



Draw two arrows to show the direction the light must travel for Myra to see the light from the torch in the mirror.

Question 13

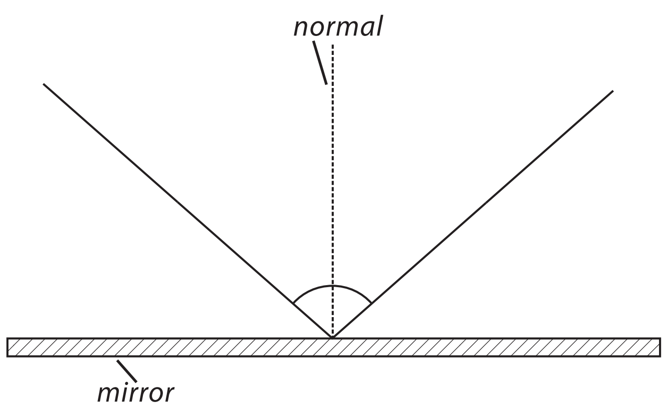
The diagram below shows how rays of light are reflected off a flat (plane) mirror.

a) Label the incident ray.

b) Label the reflected ray.

c) What is the angle between the line marked 'normal' and the surface of the mirror?

d) What can you say about the angle of the incident ray and the angle of the reflected ray to the normal? __________________________



Question 14

a) The image formed by a concave mirror is virtual, upright, and larger than the object. What does this tell you about the distance between the object and the mirror?

____

b) The image formed by another concave mirror is real, inverted (upside down), and smaller than the object. What does this tell you about the distance between the object and the mirror?

____

c) Describe the image formed by a convex mirror.

____

d) Give two uses of convex mirrors.

i) _______________

ii) _______________

e) Give two uses of concave mirrors.

i) _______________

ii) _______________

Answers to Assessment questions

Question 1

(D) glass jar

Question 2

(A) regular reflection

Question 3

(B) They are smaller than the object.

Question 4

(B) 45°

Question 5

(C) down in the camera and up on the retina

Question 6

(C) a refracting telescope

Question 7

(B) Only a small hole gives a sharp image.

Question 8

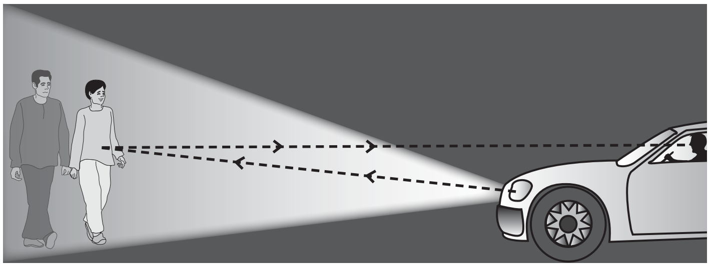
a) Light can pass through any type of material. FALSE
b) We can only see objects which give out their own light. FALSE
c) The Moon gives out its own light. FALSE
d) The Sun gives out its own light. TRUE
e) A mirror can reflect light. TRUE
f) Shadows are caused by objects blocking the path of light. TRUE
g) Light from the Sun is a mixture of different colours. TRUE
h) Light travels in straight lines. TRUE

Question 9

translucent	describes a material that allows some light to pass through it
transparent	describes a material that allows light to pass through it
opaque	describes a material that does not allow light to pass through it
reflection	light rays that bounce off a surface
virtual	an image that cannot be focused on a screen
luminous	an object that gives out its own light
incident ray	a ray that strikes a surface
normal	a line drawn at right angles to the surface of a mirror at a point where an incident ray hits that surface
shadow	an area where there is no light
scattering	light reflected in all directions

Question 10

a) It is reflected.

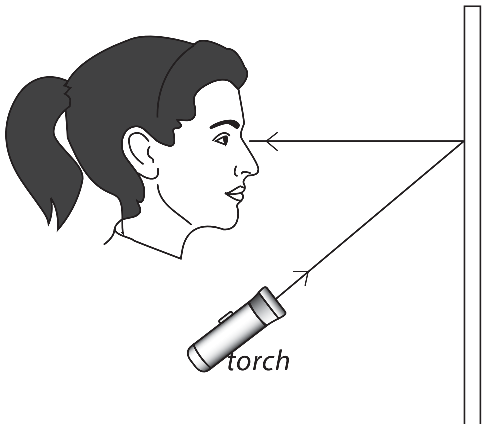
b) 

c) It is absorbed.

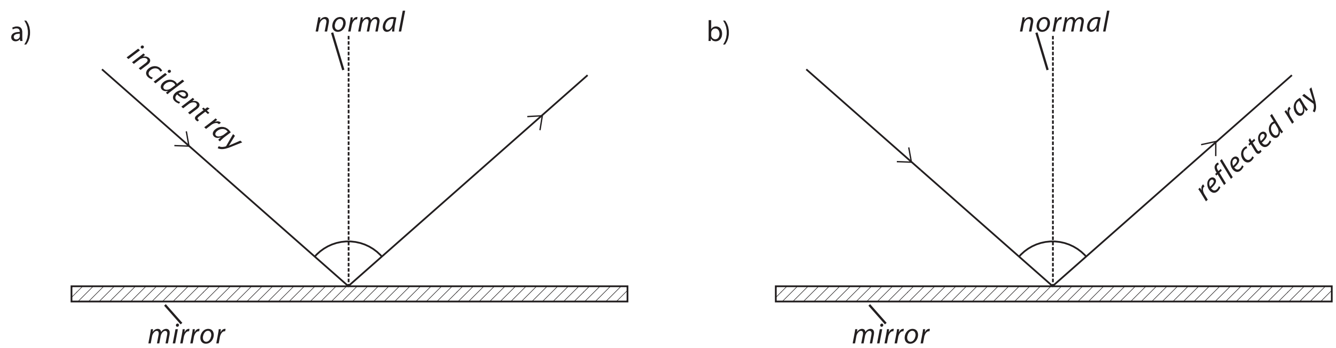
Question 11

Light is a form of **energy**. It is needed for us to **see** things and for plants to make their **food**. Most of our light energy comes directly from the **Sun**. Other natural sources of light include the stars, **lightning**, and **fire**. Animals such as **fireflies**, glow-worms, and some deep-sea fish give out light as a result of **chemical** reactions in their bodies. Light energy is also given out by burning **fuels** and passing **electricity** through light bulbs.

Question 12



Question 13



c) 90° or, It is a right angle.

d) The angle of the incident ray and the angle of the reflected ray are equal.

Question 14

a) The object is very close to the mirror.

b) The object is a long way from the mirror.

c) The image formed by a convex mirror is virtual, upright, and smaller than the object.

d) Uses of convex mirrors include rear-view mirrors in cars, staircase mirrors in double-decker buses, and security mirrors in supermarkets.

e) Uses of concave mirrors include shaving and make-up mirrors, dental mirrors, the reflectors in torches and headlights, and in reflecting telescopes.

Sounds all around

CHAPTER **11**

Teaching Objectives

- To explain that sounds are produced by vibrating objects
- To recognise that sound transfers energy from one place to another
- To examine the speed of sound in different media
- To explain how the human ear detects sound
- To recognise the importance of sound and music in our society

Learning Outcomes

After studying this chapter students should be able to:

- describe sound as a form of energy
- compare the speed of sound in solids, liquids, and gaseous media
- identify the variety of materials through which sound can travel
- explain how a human ear receives sound waves

Introduction

The students should already have a basic knowledge of the topic of sound, not only from their earlier work in the primary school, but also from their work this year on both the sense of hearing and on sound as a form of energy. The fundamental need is for them to understand that sound is carried along, or propagated, as a wave, and that vibrating objects are sources of sounds. A bell, for example, vibrates when it is struck. Both the metal of the bell and the air inside it contribute to this vibration effect. The vibration is transmitted to the air surrounding the bell, and this disturbance is passed through the air. Sounds can travel through liquids and solids, as well as gases.

To return to the subject of the vibrating bell, the metal shell changes shape slightly, getting slightly larger and then slightly smaller. When the bell gets slightly larger it pushes the adjacent air away. This air in turn pushes the next layer of air away, and the push is transmitted throughout the surrounding air. Similarly when the bell contracts slightly, the adjacent layer of air is pushed by the pressure of the surrounding air so that it moves back slightly towards the bell. The effect is as if the bell were pulling the air with it. This 'pull' is also transmitted through the air surrounding the bell. The layers of air move in a sideways direction away from the bell, in what is called a longitudinal wave. When layers of air are close together in the sound wave, we have what is called a compression. In terms of air, this means that we have a region of higher-than-normal pressure. When we have layers of air that are further apart, we have a region of lower-than-normal pressure which we call a rarefaction. In fact, when talking to students about sound, it may be more helpful to talk of the pressure variations being produced as pressure waves rather than as sound waves. It is the variation in pressure of the air to which the ear is sensitive, and this enables us to interpret longitudinal waves as sounds.

Lesson suggestions

1. Sound waves

Refer to page 126 of the Students' Book.

Starter suggestions

Demonstrate the sounds produced by a vibrating ruler or a bicycle bell. Show that when you place your hand on the ringing bicycle bell, the ringing stops because you are suppressing the vibrations. Strike on of the prongs of a tuning fork, and then place the vibrating tip in a bowl of water and watch the waves produced. Ask the students to gently feel their throats while they are speaking and notice the vibrations that are produced in the larynx or voice box.

Alternatively, ask the students to bring a range of musical instruments to the lesson and request that they each play a note in turn. Ask the students which part of each instrument is vibrating. Ask how a louder note is played and what this does to the vibrations produced. Place a few grains of salt or sand on the skin of a small drum. Gently tap the drum and watch what happens to the salt or sand grains. Hit the drum harder, and ask what happens to the sound and the salt or sand grains.

Main lesson

If you have a signal generator, demonstrate it to the students. Explain that it makes sounds of a different pitch (how high or low the sounds are) and different volume (how loud or soft the sounds are), which you hear as very clear notes. Ask the students to make a table to describe the notes they hear. Ask them to record whether they hear loud or soft sounds. What is the lowest note they can hear? What is the highest? Does everyone in the class have the same hearing limits? Now ask the students to listen to several notes of the same volume, but different pitch. Did all the notes seem equally loud? Which notes seemed loudest? Could you always tell these notes apart?

If you have an oscilloscope, connect it up to the signal generator or a microphone. Explain that the oscilloscope shows a trace of sounds on its screen. Start by watching how the trace changes when the sound produced by the signal generator or a musical instrument gets louder and then quieter. Then change the pitch of a note. What change in the pattern can you see?

It is important that students understand the relationship between pitch and the frequency (the number of vibrations per second) and also between amplitude and volume. In terms of vibration, amplitude means the maximum distance from the resting position. On an oscilloscope screen, it is measured from the central point of the wave to its peak and not from the top to the bottom of the wave form.

1. How sound travels

Refer to page 128 of the Students' Book.

Starter suggestions

Show the students photographs (or a short film) of an astronaut on the surface of the Moon and a swimmer or diver under water. Explain that the astronauts on the surface of the Moon could not speak directly to each other because of the absence of air—they had to communicate with radios. Swimmers under water have so many sounds reaching their ears that they find it difficult to separate them.

Main lesson

Refer back to the previous lesson and the fact that sounds are produced by objects vibrating. When these objects vibrate, they push away the air away in front of them, and then pull it back, setting up waves in the air. These pulsations in the air reach our ears, where they set the ear drum vibrating. It is useful to compare the way sound travels in air with the way that waves are created by a wave machine at the deep end of a swimming pool. The machine pushes the water backwards and forwards and waves travel along the surface of the pool to the shallow end. Water does not travel along the length of the pool, but the waves do. A rubber duck floating in the water at the deep end will bob up and down but it stays where it is!

You can carry this explanation forward with a slinky spring. Ask two volunteers to hold the ends of the spring and to stretch it out a little. Place a piece of sticky paper on one of the coils roughly half way along the spring. Ask one of the volunteers to move one end of the spring in and out and you will have created a longitudinal wave. You will be able to see the 'compressions' and 'rarefactions' and notice that, while the piece of paper moves backwards and forwards, it does not actually go anywhere. This shows that while energy is passing along the spring, the material stays where it is. Stress that it is particles in the air, or in solids or liquids, that are passing on the energy of the vibrations but not moving any great distance themselves.

Now carry out some of the simple activities that show how sound is transmitted through solids, liquids, and gases. These are described under the heading of **Ideas for investigations and extension work** on page 199. The activity described on Worksheet 11.1 could be carried out at the same time. The materials for these activities can be set up around the room and the students can work their way round until they have tried all of them.

Finish off the lesson by presenting the students with this list showing the approximate speed of sound in different materials. Ask the students to plot these speeds graphically and then to explain them in terms of particles. (Sound travels quite slowly in air and other gases because the particles are widely spaced and cannot easily collide and pass on their energy. Sound speeds are faster in liquids where the particles are closer together, and fastest of all in solids where the particles are packed tightly together.)

Material	Speed of sound in the material in m/s (approx)
steel	6,000
aluminium	5,100
stone	5,000

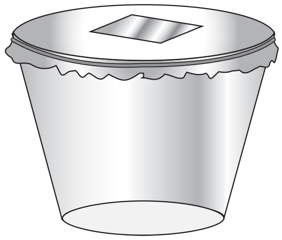
glass	4,500
copper	3,700
water	1,500
oil	1,500
air	340
oxygen	316
carbon dioxide	260

Ideas for investigations and extension work

The wobble board

Obtain a rectangle of flexible material such as thin metal, thin perspex or thin plywood measuring about 80 cm × 50 cm. Hold one end of the board so that it is horizontal and then wave it up and down. A strange 'wobbling' sound will be heard and the students will be able to see the longitudinal wave passing along the sheet of material. Some practice with this may be needed before you demonstrate it to the students!

Seeing sound waves



Cut the bottom from a plastic pot and discard it. Stretch a piece of cling-film over the mouth of the pot and hold it in place with an elastic band. Cut a piece of aluminium foil about 0.5 cm square. Put a dab of glue on the dull side of the foil. Stick this to the cling-film about one third of the way across the diameter of the pot.

Sit in a room facing the Sun and draw the curtains until a gap of about 5 cm is left for sunlight to stream through. Sit in the sunlight fairly close to the curtains, and hold the cup close to your mouth. Move the end of the pot slightly until the cling-film and piece of aluminium foil reflect a patch of sunlight onto the wall of curtains. Speak into the bottom of the pot. What happens to the reflection as you speak? (It moves backwards and forwards slightly.) What purpose does the piece of aluminium foil serve? (It helps to show up the movements of the cling-film.) How does this experiment help to prove that sound is the result of particles passing on vibrations? (The vibrations from the larynx or voice box make the cling-film vibrate, although there is no actual contact between the two.)

The portable telephone

Make a portable telephone. Pierce the bottom of each of two plastic pots or cups. The holes should be just large enough to pass a length of string through. Cut about 10 m of the string. Thread one end through the hole at the bottom of one pot or cup. Tie a large knot in the string so it will not pull out of the hole. Repeat this with the other pot and the other end of the string. The telephone is now complete.

Work with a partner and answer the following questions.

a) When does the telephone work best, with tight or slack string?

b) Over what distance will your telephone work?

c) Will it work round corners?

d) Will it work through closed doors and up and down stairs?

Sounds and water

Partly fill an unperforated plastic bag with water and tie the top. Carefully place the water-filled part of the bag against your ear and then rest a ticking watch or clock against the other side of the bag. Can you hear the watch or clock through the water?

Vibrating forks

Collect a selection of metal table forks. Hold one of the forks in the middle with one hand. Gently hit the forked end on a wooden board. Now hold it close to your ear. It should resonate at its own natural frequency. Try a different fork. Can you arrange a set of forks according to their pitch?

Vibrating air

Blow across the top of a bottle. Now add a little water so that there is less air in the bottle. Blow across the top again. Does this air produce a sound, and is its pitch the same as before? Repeat this with more and more water in the bottle and see what happens when you blow across the top of the bottle each time. (The shorter the length of the air column, the higher the pitch of the note produced by the vibrating air.)

Testing your hearing

Work with a partner. Put a watch near your ear and move it gradually further away until you just cannot hear it. Ask your partner to measure the distance from your ear to the watch. Now bring the watch towards you from a distance until you can just hear it. Measure how far the watch is from your ear. Repeat this twice more and find the average of your three pairs of results. Repeat the experiment with the other ear. Are the results the same? Now repeat the experiment holding the watch at different positions around your head. Can you hear as well in every position? Swap places with your partner and compare results.

Sound travels

What is the maximum distance over which the human voice can be heard distinctly? Plan an investigation to find out.

Reflecting sound waves

Find two cardboard tubes, such as those that come from inside kitchen rolls. You also need a heavy book, a protractor and a loudly ticking clock. Can you use these objects to prove that sound waves can be reflected in the same way as light rays? Record what you did, what happened, and what measurements you took. Draw a diagram of the way you set up the experiment.

Worksheet 11.1

The roaring cup

Materials needed per group: a paper or foam cup, scissors, string.

1. Cut a piece of string about 40 cm long and tie a large knot at one end of it.
2. Make a tiny hole in the middle of the bottom of the paper cup.
3. Run the unknotted end of the string through the inside of the cup and poke it through the hole. The knot should prevent the string from going completely through the hole.
4. Hold the cup in one hand and rub your thumbnail down the string, while squeezing and pulling the string tightly. You should hear a roaring sound. Can you explain why?

The explanation is that the cup acts as a cavity which increases the sound. It helps to amplify the sound and make it last longer because sound waves hit the walls of the cup, bounce back and make each other stronger. This is called 'resonance'. Musical instruments such as bells have cavities. Others, such as guitars and violins, have sound boxes. In a musical instrument, the walls of the cavity or sound box vibrate at the same frequency as the source of the sound (such as the clapper of the bell or the strings of the violin or guitar). If this were not so, the sound wave would cause an echo when it bounced back instead of reinforcing or strengthening the original sound.

Answers to questions in the Students' Book

1. Unlike light, sound cannot travel through a vacuum. This is because sound travels by making particles (of solid, liquid, or a gas) vibrate in a series of compressions and rarefactions. Where there are no particles, sound cannot travel.
2. The human ears detect vibrations in the air. These vibrations make the eardrum vibrate. The eardrum makes three tiny bones in the ear vibrate and they amplify the vibrations. The bones pass the vibrations on to a liquid deeper in the ear—in the cochlea. There are tiny hairs in the liquid in the cochlea. These vibrate and make tiny electrical impulses in the auditory nerve. The brain interprets these electrical impulses as sounds.
3. It is important that governments set rules and regulations about noise levels because loud sounds can damage the victims' hearing and general health.
4. You often see smoke coming from a starting gun before you hear the bang because, in air, the speed of sound is about 330 metres a second, depending on the temperature. Sound is much slower than light, which travels at 300,000 kilometres per second.
5. The boy's eardrum will also vibrate 256 times each second.
6. Sound cannot travel on the Moon because the Moon has no atmosphere, and as we saw in question 1 above, particles of solid, liquid, or gas are needed for sound to travel. Astronauts on the Moon communicate with each other by radio, since radio waves can pass through a vacuum.
7. The vocal cords in the larynx or voice box are two folds of membrane, one on each side of the larynx. When air is breathed out, whether you are talking or singing, the air makes the vocal cords vibrate. These vibrations produce sounds. The mouth and tongue shape the sounds into words.
8. We use an instrument called an oscilloscope to measure the loudness, or amplitude, of sounds. Sound is seen on the screen of the oscilloscope as a series of waves, and the amplitude is the height of the sound wave. Loud sounds are made by sound waves with large amplitude and a lot of energy. Small sounds are made by sound waves with a low amplitude and little energy.
9. We use sound waves in our daily life every time we communicate with each other either directly or over the telephone. We also use sound waves when we listen to the radio or television or musical instruments.

Assessment

Question 1

Which of the following is NOT part of the human ear?

(A) the eardrum (B) the cochlea (C) the saddle (D) the auditory nerve

Question 2

The hammer, anvil, and stirrup are three tiny bones found in the

(A) outer ear (B) middle ear (C) inner ear (D) cochlea

Question 3

When sound travels through the air, the air particles

(A) do not vibrate (B) vibrate in all directions
(C) vibrate in the direction of the sound wave (D) vibrate up and down

Question 4

Sound waves do NOT travel through a

(A) solid (B) liquid (C) gas (D) vacuum

Question 5

The pitch of a sound is how

(A) pleasant it is (B) high or low it is (C) loud it is (D) far away it is

Question 6

The loudness of a sound is called its

(A) pitch (B) frequency (C) amplitude (D) measurement

Question 7

The instrument used to show the loudness or amplitude of a sound is called a

(A) endoscope (B) microscope (C) telescope (D) oscilloscope

Question 8

In air the speed of light is about

(A) 130 metres per second (B) 230 metres per second
(C) 330 metres per second (D) 430 metres per second

Question 9

a) What is meant by the word 'vibration'? ____________________

b) Your ears can tell the direction a sound is coming from. How do they do this? ____________________

____

c) Why is it more difficult to tell where a sound is coming from in water? ____________________

____

d) Describe how a violin produces sound. ____________________

e) How does the sound from the violin travel through the air? ____________________

Question 10

Sounds are made by something vibrating, Match each object to the part that vibrates to make a sound. For example, in a flute, air in a tube vibrates to make the sound.

Object	**Part which vibrates**
guitar	vocal cords
drum	paper cone
piano	wings
flute	metal prongs
voice	skin
tuning fork	wires
loudspeaker	air tube
bumblebee	strings

Question 11

Which of these statements about sound and light are TRUE and which are FALSE?

a) Sound and light both need a substance to travel through. ___________

b) Light travels about a million times faster than sound. ___________

c) Light and sound both travel as waves, moving energy from place to place. ___________

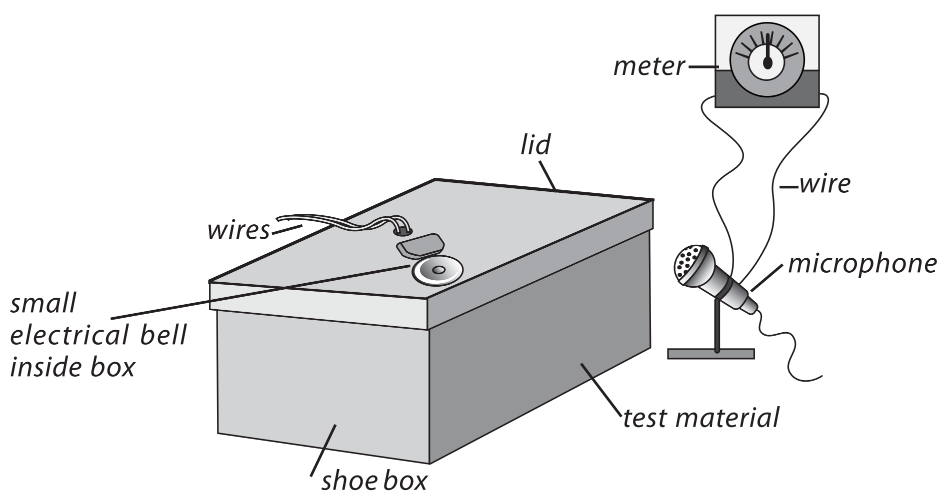
d) Older people are better at hearing high-pitched sounds than younger people. ___________

e) Astronauts on the Moon can only talk to each other using radios. ___________

f) Light and sound can both travel through solids, liquids, and gases. ___________

Question 12

Ahmed investigated which material would be best for soundproofing. He put a small electric bell inside a box. He covered the bell with each material in turn. He put a sound sensor outside the box to record the sound level.



He tested different materials and got the following results:

Material	Sound level (decibels)
No material added	65
A	40
B	58
C	35
D	50

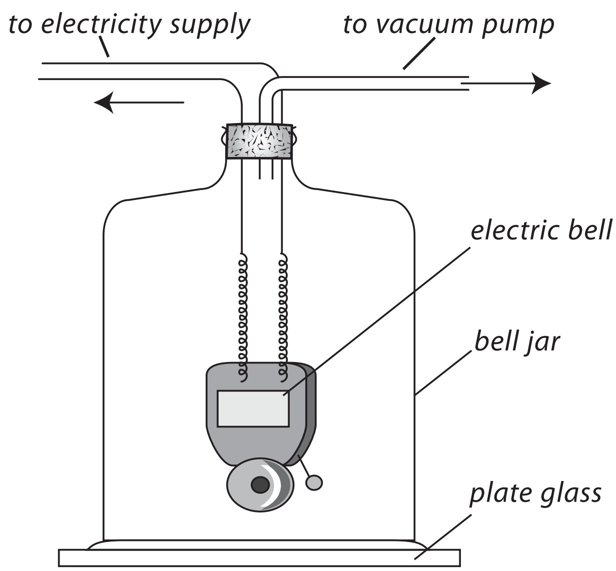
i) Which **three** things should Ahmed have done to make his test fair. Tick the **three correct boxes**.

- Use the same box each time. ☐
- Make sure a different person recorded the results each time. ☐
- Use the same area of material each time. ☐
- Use the same material each time. ☐
- Keep the distance between the sound sensor and the bell the same each time. ☐
- Test each material in a different room. ☐

ii) Which material was best at stopping the sound going through? Give the correct letter.

Question 13

Nawaz has put an electric bell in an airtight glass jar. The bell and jar are shown in the picture below. At first, Nawaz could hear the bell ringing. But when his teacher pumped the air out of the jar, Nawaz could not hear the bell.



a) What is a vacuum?

____

____

b) Why couldn't Nawaz hear the bell when the air had been pumped out of the jar?

____

____

c) Explain why sound travels faster through water than through air.

____

____

Answers to Assessment questions

Question 1

(C) the saddle

Question 2

(B) middle ear

Question 3

(C) vibrate in the direction of the sound wave

Question 4

(D) vacuum

Question 5

(B) high or low it is

Question 6

(C) amplitude

Question 7

(D) oscilloscope

Question 8

(C) 330 metres per second

Question 9

a) Vibration is a backward and forward or to and fro movement.

b) Your ears can tell which direction a sound is coming from because they can sense which ear is closer to the sound.

c) It is more difficult to tell where a sound is coming from in water because the sound travels faster and reaches both ears almost at the same time.

d) A violin produces sound because the vibrating strings and wooden case cause the air to vibrate.

e) The vibrations are passed along the air particles. The particles themselves do not travel, they only vibrate. The sound energy travels.

Question 10

guitar – strings; drum – skin; piano – wires; flute – air tube; voice – vocal cords; tuning fork – metal prongs; loudspeaker – paper cone; bumblebee – wings.

Question 11

a) Sound and light both need a substance to travel through. FALSE

b) Light travels about a million times faster than sound. TRUE

c) Light and sound both travel as waves, moving energy from place to place. TRUE

d) Older people are better at hearing high-pitched sounds than younger people. FALSE

e) Astronauts on the Moon can only talk to each other using radios. TRUE

f) Light and sound can both travel through solids, liquids, and gases. FALSE

Question 12

i) Use the same box each time.

Use the same area of material each time.

Keep the distance between the sound sensor and the bell the same each time.

ii) material C

Question 13

a) A vacuum is a space in which there is no air or any other matter.

b) Nawaz couldn't hear the bell when the air had been pumped out of the jar because sound cannot travel through a vacuum.

c) Sound travels faster through water than through air because the particles which make up water are closer together than the particles which make up air. Because the particles are closer together in water, they carry vibrations faster.

Beyond the Earth

CHAPTER 12

Teaching Objectives

- To compare and contrast the physical features of comets, asteroids, and meteors
- To describe the different kinds of meteor
- To explain the term satellite and to examine the structures, orbits, and functions of artificial satellites
- To explain the key milestones in space technology

Learning Outcomes

After studying this chapter students should be able to:

- define the term satellite
- compare the physical characteristics of comets, asteroids, and meteors
- describe the different kinds of meteors
- inquire into the sighting of Halley's Comet and describe what they would feel if they saw it
- define the terms artificial and geostationary satellites
- explain the key milestones in space technology
- describe the uses of various satellites in space
- investigate how artificial satellites have improved our knowledge about space and are used for space research
- explain how satellites tell us where we are

Introduction

The Moon is the Earth's natural satellite, about 384,000 km away. The Moon is relatively small and could easily fit into Canada. It takes approximately twenty-eight days to orbit the Earth. At 4,600 million years old, the Moon is the same age as the Earth. Although it looks round, it is slightly egg-shaped, and the pointed end, which has a thinner crust, always faces the Earth. Some scientists think that the Earth's strong gravitational pull may have 'sucked' the Moon into this shape. Because the Moon has almost no atmosphere, the temperature of its surface varies much more widely than the temperature on Earth. The Moon's surface temperature can reach 100°C by day and drop to as low as -150°C at night. The Moon may have formed when a planet about the size of Mars crashed into Earth and caused a large amount of rock to blast into space around our planet. Over time this material collected into a body about one-quarter the size of Earth's diameter. Our Moon is not the only moon in the Solar System. Mars, Neptune, Uranus, Jupiter, and Saturn all have moons.

The Moon and the Earth are constantly on the move. This means that landing on the Moon involves great challenges of timing. Exact calculations must be made so that a spacecraft escapes the Earth's force of gravity at the precise instant which gives the spacecraft the correct direction to travel towards the Moon and actually meet it.

There are believed to be hundreds of artificial satellites orbiting the Earth each day. The ones we use every day for telecommunications are in geostationary orbit around the Earth. They orbit the Earth at a height of approximately 35,900 kilometres. They orbit at the same speed as the Earth rotates, so they stay in a fixed position above the Earth's surface.

Lesson suggestions

There are many possible lessons based on Chapter 12 of the textbook. Some of them will inevitably have to be theory lessons. The starting points could be the news of some new aspect of space exploration, such as the launch of a new satellite, the latest happenings on the International Space Station, or the latest space shuttle launch. Only two suggested lessons are given here.

Safety: Any observations of the daytime sky MUST avoid looking directly at the Sun. Under no circumstances should the Sun be viewed through binoculars or telescopes. Severe damage to the eyes can result from looking directly at the Sun, even when using sunglasses, smoked glass, or old photographic negatives.

If the students study the night sky, it should either be from their own home or garden, or in the company of a responsible adult.

1. The Moon—the Earth's natural satellite

Refer to page 135 of the Students' Book.

Starter suggestions

Show the students a film or a recording of a television programme describing the exploration of the Moon and the first Moon walks.

Alternatively, look at large photographs of the surface of the Moon, or maps of the Moon's surface, showing the craters and other obvious features.

Main lesson

Discuss the exploration of the Moon and what astronauts and other scientists have discovered about its surface and physical conditions.

Carry out some of the simple investigations of the Moon under the heading of **Ideas for investigations and extension work** in this chapter. You could perhaps finish the topic by setting the research questions on Worksheet 12.1 for homework.

1. Satellites and communication

Refer to page 139 of the Students' Book.

Starter suggestions

Show the students a satellite navigation system, either in a motor vehicle or one of the hand-held devices used by walkers, sailors, and explorers. Some mobile telephones also have a satellite navigation system built into them. Show the students how the system works and explain the importance of the satellite's geostationary orbit.

Main lesson

Ask a volunteer to send an email message from a computer to a friend. Ask what part a satellite played in sending the message. The answer is that a sequence like this took place:

- The computer user sends an email.
- The email signal travels through a cable (often a fibre optic cable) which is part of the telephone network.
- A ground station (with a satellite dish) transmits the signal.
- Radio waves carry the signal to a satellite.
- The satellite relays the radio signal.
- A ground station (with another satellite dish) receives the signal and transmits it.
- The signal travels through another cable to reach the receiving computer.

Ask the students to draw a large semicircle in their books to represent part of the surface of the Earth and then to draw in the various stages in sending an email.

Discuss the other uses of satellites in everyday life—such as the transmission of radio and television programmes, remote sensing, and weather forecasting.

Carry out the demonstration of centripetal force in the **Ideas for investigations and extension work** section of this chapter.

Ideas for investigations and extension work

How far is the Moon from the Earth?

All you need for this activity is a coin, a tape measure, a ruler and some sticky tape. You also need a helper and a clear night with a full Moon!

Find a window from which you have a clear view of the Moon. Tape a coin on that window. Step back slowly until the coin appears to be the same size as the Moon and seems to cover the Moon. Ask a helper to measure the distance (in centimetres) from the coin to your eye.

Measure the diameter of the coin in centimetres.

The Moon's diameter is, in round figures, 3,500 km.

We know the ratio of the Moon's distance from your eye to its diameter is the same as the ratio of the distance of the coin from your eye to its diameter.

Thus $\dfrac{\text{Moon's distance}}{\text{Moon's diameter}} = \dfrac{\text{coin's distance}}{\text{coin's diameter}}$

Or, more simply, the Moon's distance = $\dfrac{\text{Moon's diameter} \times \text{coin's distance}}{\text{coin's diameter}}$

If you have used centimetres throughout, your answer above will be in centimetres. If that is the case, divide the Moon's distance by 100,000 to change it to kilometres.

The changing Moon

Observe the Moon over a period of twenty-eight days, using the naked eye and, if possible, binoculars or a telescope. Draw its shape daily during this period. Check the moonrise times in the weather section of a newspaper. Does the Moon always seem to rise in the same place?

The phases of the Moon

In a darkened room, set up in a straight line a metre or two apart, a strong light (a desk lamp or projector) a person A and then another, B, who is holding a large white ball. The light represents the Sun, A the Earth, and B the Moon. The 'Moon' moves in a circle (anticlockwise) around the 'Earth', who keeps turning to face the 'Moon'. This will enable A (Earth) to see the various phases of the Moon lit by the Sun.

Craters on the Moon

Fill a tray with damp sand to represent the surface of the Moon. Stand on a chair and drop a cricket ball, hockey ball, or golf ball into the sand. Note what happens and the shape of the 'craters' formed. Compare them with the craters shown in a photograph of the Moon. Investigate the effect of dropping the ball from different heights, different angles and different materials, such as Plasticine, wet and dry papier mache, plaster of Paris and soil.

Centripetal force

Natural and artificial satellites and all other heavenly bodies are attracted to one another by gravity. The bigger the bodies involved, the stronger the force of attraction. The closer the bodies involved, the stronger the force of attraction. Orbiting occurs when one body wants to go in one direction but is attracted by another body, such as a star or planet. This causes it to be continually pulled off course into a circular path or orbit. This force towards the centre is called the centripetal force.

Demonstrate the effect of centripetal force by putting a little water in a plastic bucket. Tie a strong string firmly to the handle, and then swing the bucket in a vertical circle. As long as the rate of rotation is great enough, the water stays in the bucket, held there by centripetal force.

Safety: This activity is best done outside away from buildings. Keep onlookers well clear!

Worksheet 12.1

Moon facts

Use the Internet, encyclopedias, and other reference books to find the answers to these questions about the Moon.

1. Who were the first people to land on the Moon and when did they land?

 ____

2. Why did the astronauts on the Moon wear special suits with an oxygen supply?

 ____

3. Where was Michael Collins when the other two astronauts were walking on the Moon?

 ____

4. What would make it possible for Neil Armstrong to break the high jump record?

 ____

5. Why were astronauts orbiting the Moon the first people to see the other side of it?

 ____

6. Why could you not swim in the seas on the Moon?

 ____

7. What is the temperature variation on the Moon's surface? Why is it so large?

 ____

8. How long does it take the Moon to orbit the Earth once?

 ____

9. How far away is the Moon from the Earth?

 ____

10. Why are there so many craters on the surface of the Moon?

 ____

11. How old is the Moon believed to be?

 ____

12. What connection is there between tides and the Moon?

 ____

Answers to questions in the Students' Book

1. The planet in our Solar System which receives light from the Sun in the shortest time is the planet whose orbit takes it nearest to the Sun, namely Mercury.
2. The distance between the Earth and the Sun is roughly 300,000 × 8 × 60 km = 144 million km. (The actual distance is approximately 143 million km.) The average distance of the Moon from the Earth is 384,400 km. Therefore reflected light from the Moon would take approximately 384,400 divided by 300,000 seconds to reach us = 1.28 seconds.
3. Another name for the natural satellite of a planet is a moon.
4. The boot prints left on the surface of the Moon by Neil Armstrong in 1969 are still there because, with no air or water on the Moon, there is no wind or rain to remove them.
5. A geostationary orbit is one in which the satellite orbits anticlockwise high above the Equator at a speed to match the speed of rotation of the Earth on its axis. A geostationary satellite, therefore, makes one complete orbit of the Earth every 24 hours and appears to be hovering in the same spot of sky and in the same position above the Earth all the time. This is important for navigation satellites and those used by phone and radio networks and satellite television. The ground receivers either point towards the satellite without moving themselves, or else they rely on the satellite sending time signals so that the satellite navigation devices of other navigational aids on the ground can calculate their position.
6. Artificial satellites are used to receive and send television programmes, radio and telephone signals and email messages. Weather satellites photograph clouds and measure the conditions in the air, so that forecasters can predict the weather. Remote-sensing satellites take pictures of the Earth's surface using light of different colours, to study crops and vegetation types, rocks and soil, and to monitor pollution incidents.

   Navigation satellites send out signals about their position to ships, aircraft, and road vehicles. Rescue satellites respond to radio distress signals, while astronomy satellites carry telescopes into space. Military satellites study and photograph other countries' weapons and military bases.
7. The Hubble Space Telescope can see things in space that we cannot see from Earth because it is above the Earth's atmosphere and not affected by the air movements or air and light pollution that occur on Earth.

Assessment

Question 1

We can see stars like the Sun because they:

(A) reflect light (B) give out light (C) are near (D) are far away

Question 2

Which of the following statements is NOT true?

(A) The Sun follows the same path in winter as in summer.

(B) The Sun's path goes high across the sky in summer.

(C) The Sun rises in the east.

(D) The Sun sets in the west.

Question 3

99 per cent of the mass of our Solar System is contained in the:

(A) planets (B) Sun

(C) asteroid belt (D) moons of our Solar System

Question 4

A natural satellite of the Earth is:

(A) the Moon (B) the Sun

(C) another planet (D) a space station

Question 5

The Moon has less gravity than:

(A) a house (B) a mountain

(C) a continent (D) the Earth

Question 6

The first person to travel in space was:

(A) Alan Shepard (B) Neil Armstrong

(C) Yuri Gagarin (D) Buzz Aldrin

Question 7

The first person to set foot on the Moon was:

(A) Neil Armstrong (B) Buzz Aldrin

(C) Alan Shepard (D) Yuri Gagarin

Question 8

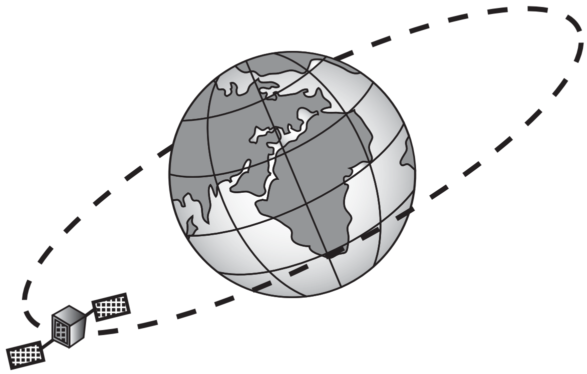
Another name for a 'shooting star' is a:

(A) comet (B) meteorite

(C) meteor (D) moon

Question 9

The diagram shows a satellite in orbit around the Earth.



Which of the following statements is true?

(A) The satellite has no weight.

(B) There are no forces acting on the satellite.

(C) The force of gravity holds the satellite in orbit.

(D) The satellite is travelling at a steady velocity.

Question 10

What kind of orbit does a satellite have which is above the Equator and which goes around the Earth at the same speed as the Earth?

(A) high (B) polar (C) geostationary (D) equatorial

Question 11

A satellite which is in a polar orbit can be used for:

(A) forecasting the weather (B) telecommunications

(C) spreading fertilizer (D) to shade the Earth

Question 12

The International Space Station is one of many satellites which orbits the:

(A) Sun (B) Earth (C) Moon (D) stars

Question 13

What does a planet orbit?

(A) another planet (B) the Sun (C) the Earth (D) the Moon

Question 14

The orbit of a comet has this shape:

(A) spherical (B) circular (C) elliptical (D) square

Question 15

When does a comet move at its fastest?

(A) when it is nearest to the Sun (B) when it is nearest to the Earth

(C) when it is farthest from the Sun (D) it always moves at the same speed

Question 16

Match each word with its meaning.

Solar System	a small piece of matter from space which enters the Earth's atmosphere and burns up
asteroid	a body in space made of dust particles frozen in ice
comet	the Sun and the eight planets that orbit the Sun
planet	one of many lumps of rock orbiting the Sun between the orbits of Mars and Jupiter
Moon	a lump of rock or metal that has not burned up completely as it falls through the Earth's atmosphere
meteor (or shooting star)	an extremely large object which orbits the Sun or some other star
meteorite	the Earth's only natural satellite

Question 17

The table below shows the names of the eight planets of the Solar System and the number of their natural satellites:

Planet	**Number of natural satellites (moons)**
Mercury	0
Venus	0
Earth	1
Mars	2
Jupiter	more than 60
Saturn	at least 56
Uranus	27
Neptune	13

a) What is the name of the Earth's natural satellite?

b) Which two planets have no natural satellites?

i) ______________________ ii) ______________________

c) Which planet is believed to have most satellites? ______________________

d) Arrange the names of the planets which have natural satellites in order of the number of satellites they have, starting with the least first: ______________________

____

Question 18

Artificial satellites can sometimes be seen at night. They look like stars moving slowly across the sky.

a) We can see stars because they are light sources. They give out their own light. Satellites do not give out their own light. Explain why we can see satellites as they move across the night sky. ________________

____

b) A satellite suddenly seems to disappear. However, we can usually see it again in another part of the sky later the same night. This can happen when there are no clouds in the sky and the satellite is overhead. Why does the satellite suddenly seem to disappear? ________________

____

c) Give TWO uses of artificial satellites in orbit around the Earth.

i) ____

ii) ____

d) In 1610, the Italian scientist Galileo observed four bright moons near Jupiter. Each night the moons moved.

i) The Sun and stars are light sources, and the planets reflect the Sun's light. Explain how we can see the moons of Jupiter. ________________

____

ii) The four moons are all approximately the same distance from the Earth. However, they are not all equally bright. Suggest ONE reason for this.

____

Answers to Assessment questions

Question 1

(B) give out light

Question 2

(A) The Sun follows the same path in winter as in summer.

Question 3

(B) Sun

Question 4

(A) the Moon

Question 5

(D) the Earth

Question 6

(C) Yuri Gagarin

Question 7

(A) Neil Armstrong

Question 8

(C) meteor

Question 9

(C) The force of gravity holds the satellite in orbit.

Question 10

(C) geostationary

Question 11

(A) forecasting the weather

Question 12

(B) Earth

Question 13

(B) the Sun

Question 14

(C) elliptical

Question 15

(A) when it is nearest to the Sun

Question 16

Solar System	the Sun and the eight planets that orbit the Sun
asteroid	one of many lumps of rock orbiting the Sun between the orbits of Mars and Jupiter
comet	a body in space made of dust particles frozen in ice
planet	an extremely large object which orbits the Sun or some other star
Moon	the Earth's only natural satellite
meteor (or shooting star)	a small piece of matter from space which enters the Earth's atmosphere and burns up

meteorite — a lump of rock or metal that has not burned up completely as it falls through the Earth's atmosphere

Question 17

a) The Earth's natural satellite is the Moon.

b) i) Mercury   ii) Venus

c) Jupiter is believed to have most satellites.

d) The names of the planets which have natural satellites in increasing order of the number of satellites they have: Earth (1); Mars (2); Neptune (13); Uranus (27); Saturn (at least 56); Jupiter (more than 60).

Question 18

a) We can see satellites in the night sky because they reflect sunlight.

b) A satellite may appear to disappear from view because it moves into the Earth's shadow, or moves so that it is below the horizon due to the Earth's rotation, or moves so that the only part lit by the Sun is the part that faces away from the Earth.

c) Uses of artificial satellites include navigation, weather forecasting, telecommunications, mapping, and detecting weapons and military installations.

d) i) We can see Jupiter's moons because they reflect sunlight.

   ii) Possible answers to explain the fact that the moons are not of equal brightness is because they differ in size, or because they are made of different materials.

NOTES