Science In Daily Life

Book 2

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Foreword

Curricula must be flexible enough to respond to the existential needs of the children in a changing society. Textbooks which are aids in the delivery of those curricula must be revised and edited as often as the need arises to make them contemporary in information and presentation.

Because of these things one welcomes the revised editions of the secondary school textbooks.

We wish to commend all those persons responsible for this painstaking effort for having done a worthwhile job. The nation's children and their teachers will benefit significantly because of this effort.

May the industry of the editors be suitably rewarded by the wise use of the revised secondary school texts.

Dale Bisnauth
Minister of Education
Preface

This series of secondary textbooks has evolved from the first set of secondary textbooks which was planned for students in General Secondary Schools. An important modification is that the new secondary books have been designed for students exposed to all types of secondary education (General Secondary Schools, Community High Schools and the secondary divisions of Primary Schools).

The books have been prepared with the common curriculum in focus and will be found to be consistent with most of the concepts dealt with in the curriculum guides for these schools. It is hoped that the introduction of these books to the different levels of secondary education now evidenced in Guyana, will help to remove some of the disparities which exist in accessing suitable learning materials.

There was a deliberate attempt to involve the experiences of teachers of the existing Community High Schools, the secondary divisions of Primary Schools, the General Secondary Schools, teacher educators and university lecturers.
Unit 1

Cells - building blocks of life

Introduction

The cell, the basic and smallest unit of life that can survive independently, is made up of a mass of living protoplasm. This cell theory was established after the light or compound microscope was developed. Eminent scientists such as Robert Hooke (1635-1705); Anton Van Leeuwenhoek (1632-1723) and Theodore Schwann (1810-1882) made outstanding contributions to the establishment of the Cell Theory.

In this unit we will learn about

- Cells - the building blocks of life. These cells are like living machines which require an energy supply for their functioning. Cells can also multiply themselves or reproduce. In later units, we will examine certain functions of cells.

1. Read up from an encyclopedia, the life histories (biographies) of the three scientists mentioned above.

2. Write a brief account of their life's work in the area of science.

Some organisms are made up of only one cell and are called unicellular organisms while others which are made up of many cells are called multicellular organisms.

Cells vary in size, shape, arrangement and functions, but basically they all have the same structure when compared. What are some of the parts that make up a cell? What is the basic substance that forms this amazing structure?

We can answer some of these questions by carefully examining cells under the microscope.

(a) The red cell in blood

(b) Nerve cell

(c) Muscle cell

(d) White cell in blood

(f) Egg cell of hen

(e) Sperm cell

Fig. 1.1 Cells of different shapes
The microscope

The microscope is an instrument that magnifies materials so that we can see structures more clearly. The compound or light microscope shown in Fig 1.2 is made up of two convex lenses (the eye piece) magnifying up to 10 to 20 times (x10 or x20) and the objective lens (objective) magnifying within the following ranges of x4, x10 and x40. The combination of the two lenses gives a greater magnification e.g. a x10 eye-piece and a x40 objective gives a total magnification of 10x40=400 times.

The most powerful magnification obtainable from the light microscope is x1000 times. Look at the diagram of a microscope and find out the use of each part.

The knowledge of how to use the microscope would enable us not only to identify the structures of the cell but to understand what other activities take place in the cell.

Caring for the microscope

The microscope is an expensive instrument and should be handled with great care to maintain its precision. Here are some hints to follow:

- Always use both hands to carry the instrument. Hold the limb with one hand and place the other hand under the base.
- When placing the microscope on a bench or a table, place it down carefully so that the delicate mechanism is not jarred.
- Clean the lenses by wiping them with lens paper or soft tissue. Never touch the lens with finger or coarse cloth. Never wet the lens.
- Keep the stage of the microscope dry and clean. Wipe it immediately if it becomes wet.
- Do not tilt the microscope when using wet preparations on the slide.
- Always cover the object with a cover slip to protect the objective lens.
- Always move the lens upwards when focussing to avoid breaking the slide.

Fig. 1.2 The structure of the microscope
How to use the microscope

Your teacher will guide you through the steps.

- Place the microscope on a flat surface with limb/arm towards the user and with the low power objective positioned over the stage.

- Identify the following components: eye-piece, objective lens, coarse adjustment, fine adjustment, microscope stage and clips, condenser, illuminating mirror or built-in light source.

- Position mirror and adjust until light is reflected through objective lens and eye piece. Do not use direct rays of the sun.

- Put slide on stage and clip it. Looking at the side of the low power objective lens, turn the coarse adjustment so that the objective lens moves downwards.

- Looking through the eye piece, turn the coarse adjustment slowly so that the objective lens moves upwards and the object on slide comes into focus.

Looking at cells of the onion skin

Your teacher will focus objects under the high power of the microscope for you when this is necessary.

Activity

We will prepare a slide of onion skin and examine the cells under the microscope.

- Using forceps, strip off the thin translucent material from the inner surface of a fleshy onion scale, place it in a dish of water and cut a small portion with scissors.

- Transfer the strip with a needle to a clean microscope slide.

- Spread the strip out in the centre of the slide and add one or two drops of iodine solution to stain the cells of the strip.

- Leave for two minutes.

- Carefully lower a cover slip onto the strip.

![Fig. 1.3. How to use the microscope](image-url)
Fig. 1.4 Preparing a slide of onion cells

- Examine the slide under the low power of the microscope.
  What can you say about the shape of the onion cells?
- Make a drawing of a group of five cells and compare your drawing with Fig. 1.5

Looking at prepared slides — plant and animal cells

Prepared slides are specimens of organisms or parts of organisms specially prepared by science supply houses. These are done by skilled personnel and give a great amount of detail.

Look at samples of prepared slides of plant and animal cells available in your laboratory. Here are two drawings which show the general parts of animal cells and plant cells.
Tissues

When the onion scale cells were examined, several cells were bonded together, and they were all alike. The grouping of similar cells forms tissues. These cells are grouped together because they perform similar functions.

Tissues are of different types and perform different functions. In animals they are grouped as epithelial tissues, connective tissues and nervous tissues.

Epithelial tissues cover the outside of the body and the lining of many internal passages such as the mouth and oesophagus. Connective tissues include bones, cartilage, tendons and ligaments and they serve to support the body and to bind various structures together. Nervous tissue however, is specialised to transmit electrical impulses (messages).

Both the brain and the spinal cord are made up of nervous tissues.

In plants, tissues are:
- protective i.e. they cover the surface of plants.
- conductive i.e. they transport materials such as food materials and water between the root
and leaves. There are also meristematic (dividing) tissues at the tips of roots and stems and these are responsible for growth. Below are diagrams of groups of cells. Can you tell what kind of tissues they form?

(a) Onion cells

(b) Muscle cells

(c) Xylem cells

(d) Cells from human cheek lining

Fig. 1.7 - Some tissues.

---

**Exercises**

Answer the following questions

1. Which of the following are conductive tissues?
   (i) xylem  (ii) phloem  (iii) meristem  
   (iv) bones  
   (A) i and iii only  (B) i and ii only  
   (C) i and iv  (D) ii and iv

2. Draw samples of nerve cells, bone cells, muscle cells, blood cells and sex cells of plants and animals.

3. Give examples of the following tissues in plants.
   (a) conductive  
   (b) protective  
   (c) meristematic

4. (i) The living mass that makes up cells is
   (A) cytoplasm  (B) protoplasm  
   (C) nucleus  (D) mitochondrion

   (ii) The instrument that enables us to study cells is the:
   (A) hand lens  (B) microscope  
   (C) needle  (D) telescope

   (iii) Which of the following is not a connective tissue?
   (A) cheek cells  (B) ligaments  
   (C) muscles  (D) bones
5. Label the microscope using these words.

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<td>handle</td>
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WE HAVE LEARNT THAT

- cells are made of a living mass of protoplasm and are the building blocks of life.
- plant and animal cells have basically the same structure but are also different in some ways.
- the microscope is the important instrument that enables us to look at the organelles of cells. It is an expensive and delicate instrument and should be given special care.
- prepared slides help to give detailed description of cells.
- tissues are made up of groups of similar cells which together perform similar functions.
- there are different types of tissues.
Carrying on the species

Introduction

Living things may be killed by other organisms, or die of old age. Where do new ones come from? It is the process of reproduction that replaces those that die. Different species may differ in the way they reproduce, however, there are only two broad types of reproduction, namely, *asexual reproduction* and *sexual reproduction*. In this unit we will look at the two types of reproduction in relation to plants and animals. Both plants and animals can reproduce by *asexual* and *sexual* means. In asexual reproduction, the new offspring may be produced from the specialised reproductive organs or other parts. Usually, only one organism is involved and there is no fusion of cells to produce new offspring. In contrast, sexual reproduction involves the fusion of cells, called gametes, to produce new offspring. These gametes are often produced in sexual reproductive structures. For example, flowers are the reproductive organs of flowering plants.

In this unit, we will learn about:

- reproduction
- the types of reproduction
- asexual reproduction in plants and animals
- vegetative propagation as a form of asexual reproduction
- sexual reproduction in plants and animals
- the flower and its functions
- pollination
- the types of pollination
- fertilization in plants
- seeds and their structure
- germination
- types of germination.

---

**Fig. 2.1** Asexual reproduction in amoeba by binary fission

---

This is a fully grown amoeba (single cell)  
Its nucleus starts to divide  
The nucleus is divided as well as the cytoplasm  
A new amoeba  
A new amoeba
Reproduction

This is the process whereby new offspring are produced from their parent or parents. There are two types of reproduction:

(i) Asexual reproduction

(ii) Sexual reproduction

**Asexual reproduction:** This form of reproduction only involves one parent to produce new lives. Some types of plants and animals can reproduce asexually. For example, the amoeba. This is illustrated in Fig. 2.1

In plants asexual reproduction occurs by various ways. It is referred to as vegetative propagation in which new plants can be produced naturally or artificially from outgrowths, runners or bulbs, a piece of stem cutting or by grafting.

**Asexual reproduction**

**VEGETATIVE PROPAGATION**

A new sweet potato plant, which is a runner, can be produced as shown in Fig. 2.2. The parent plant grows long stems, called runners. New plants grow from the buds along the runner. The new plant will acquire food and water from the parent plant until they have grown their own roots. Many new plants can be produced via this natural method.

The shallot plant that we use to season food can also reproduce asexually from its main parent bulb. A bulb is really a special type of shoot with a very short stem and fleshy leaves. The stem has buds which sprout. This bulb is underground but will produce side shoots with leaves which grow above the ground. Eventually, the leaves provide food for the young bulbs which grow into new shallot plants.

Other common plants that can reproduce naturally by asexual means are cedo, ginger, banana, yam, Irish potato etc. Vegetative propagation by artificial means includes the use of cuttings, budding and grafting.

![Fig. 2.2 Asexual reproduction of a plant by runner](image)
Fig. 2.3 Asexual reproduction of shallot plant by bulb

**CUTTING**

This involves the use of a part of a plant, which is placed into a rooting medium to form roots and leaves; for example, the sugar cane plant. The stem is cut into small pieces, which will have a few buds attached to them. These pieces of cutting are then planted, and new plants develop. See Fig. 2.4

A cutting is made by cutting off a shoot from a plant. The best place to cut is just below a node. The leaves near the bottom of the cutting should be removed. If the cutting is left in a jar of water or in moist soil, roots will begin to grow from it after a few days.

Fig. 2.4 Asexual reproduction by cutting
Fig. 2.5 Asexual reproduction by budding

**GRAFTING**

This is the joining of one plant with another, to which it is closely related. Instead of using a bud as in budding, a whole shoot or branch of the plant is used. See Fig. 2.6. Avocados, mangoes, and cocoa plants are often grafted.

**BUDDING**

This process involves the insertion of a bud of a plant beneath the bark of another plant. This method is often used by farmers to bud citrus fruits. See Fig. 2.5

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**Sexual reproduction**

In sexual reproduction, there is the fusion of cells called gametes to produce new offspring. These gametes may be produced by one parent or two parents. For example, among flowering plants, some flowers may produce both male and female gametes on any one plant. In animals, for example, frogs, fishes and humans, the male produces male gametes or sex cells (sperm) while the female produces female gametes or sex cells (eggs or ova). In both plants and animals, there are special mechanisms for bringing gametes together so that they can fuse and produce new offspring.

**PRODUCING NEW PLANTS BY SEXUAL REPRODUCTION**

Producing new plants sexually, means producing new seedlings. New seedlings are produced from seeds which were produced from the flowers of the plant. The flower is the reproductive organ of the plant and will produce sex cells.
The structure of a typical flower

Activity: Examining a hibiscus flower.

Let us look at a Hibiscus flower. Do you see a few green or red leaf-like structures at the bottom of the flower? These are special leaves called the **sepals**. The sepals protect the flower while it is developing. Just inside sepals are the **petals**. They are brightly coloured. Some flowers have pale petals. The petals also protect the young flower while it is developing. In the middle of the petals are the **reproductive parts** of the flower. The reproductive parts are the **stamens** which look like pins, and the **pistil**. All these structures are situated at the end of a stalk which is slightly swollen to form the **receptacle**. The base of each petal is slightly thicker than the rest of it. This area is called the **nectary**. It produces a sugary liquid called **nectar**.

The pistil, the **female reproductive part** of the flower, consists of three parts: a slightly swollen **stigma**, a thin stalk called the **style** and at the bottom, the **ovary**. The ovary contains small seed-like bodies called **ovules**. In the ovules are the **egg cells**. There is a small hole in the wall of the ovule called the **micropyle**.

The stamen is the **male reproductive part**. The stamen is made up of two main parts. These are the **anther** and the **filament**. The filament is the part which holds up the anther. The anther produces the pollen grains. These contain the male reproductive cells. We can examine a variety of flowers and look for the main parts outlined. Pride of Barbados and Flamboyant are common examples.

Activity: Examining the pollen grains.

Remove the stamen from the flower. Make a drawing of the stamen.

If the anther is not yet ripe and split open, open it carefully and shake the tiny yellow dust on to a piece of white paper. Examine the pollen grains with a hand lens.

When both the stamen and pistil are in the same flower, there is usually one pistil surrounded by many stamens, as in the Pride of Barbados or Flamboyant.

In Hibiscus, many filaments fuse to form a stamen tube which surrounds the pistil. There are five stigmas and the five styles are partially fused.
Making new plants

In order to produce new plants, sexual reproduction may take place. During this process the male reproductive cells in the pollen grains must unite with the female reproductive cells in the ovules to produce seeds from which we can get new plants. Do you know how this happens? Where do the cells unite?

The pollen grains must get onto the stigma. How does this happen? The pollen grains from a ripe anther of a flower can fall on to the stigma when the anther splits open or the pollen grains can move from the anther of one flower to the stigma of another flower of the same species. This can be done by means of the wind, and even water, by insects and other animals, like bats and birds.

The process or movement by which the pollen grains get from the anther to the stigma is called pollination. There are two types of pollination. Self-pollination occurs when the pollen grains move from an anther to a stigma of the same flower, or to another flower on the same plant. In most of these flowers, the stamens are taller than the pistil, so that the pollen grain can easily fall off and land on top of the pistil (stigma). Fig. 2.8(a).

In some plants, the pollen grains from the anther of one flower must be carried by some means, for example an insect, to the stigma of another flower of the same kind on a different plant. This process is called cross-pollination. Fig. 2.8(b). Some plants have only the male or female parts in separate flowers, for example, the pawpaw and banana; while in other plants the male and female reproductive parts ripen at different times. Therefore cross-pollination must occur in these plants. Do you know why insects, some kinds of birds and bats visit the flowers? How do they carry pollen grains from one flower to another?

Flowers which are visited by animals such as insects, generally have brightly coloured petals and are scented. The flowers have nectaries which produce nectar. They face upwards and the stamens and stigma are inside the ring of petals. What other features will help you to identify an insect-pollinated flower? As the insect feeds on flowers, they transfer pollen from one to the other.

Wind-pollinated flowers are not attractive. Their petals are dull and are not scented. These flowers hang down for easy shaking and the stamens and stigma hang out of the ring of the petals.

Examine as many flowers as you can and see if you can find other features which will help you to tell the difference between an insect-pollinated flower and a wind-pollinated flower.

---

**Self-pollination:** flowers on the same plant.

The features shown also aid cross-pollination

**Cross-pollination:** flowers on different plants of the same species

Fig. 2.8 (a) Self-pollination

(b) Cross-pollination
**Fertilization** takes place after pollination. After the pollen grain lands on the stigma, it grows down through the style until the end of the tube meets the ovary. The tube then enters the little hole, micropyle, in the ovule. The male cell unites with the egg cell which is in the centre of the ovule. This is **fertilization** (See Fig. 2.9). Fertilization is therefore the process in which the male reproductive cell unites with the female reproductive cell.

After fertilization, the fertilized ovule develops into a seed, and the ovary walls develop and become the fruit. Within the seed is the embryo. The embryo is the new young plant. It is made up of two main parts—the young shoot or **plumule** and the young root or **radicle**.

The seed has a tough outside covering called the **seed coat or testa**. This testa protects the embryo. The creamy wing-like structures are called the seed leaves or cotyledons. These cotyledons provide food for the embryo when it starts to grow into a new plant. The young root is called the radicle, while the young shoot is called the plumule. There is a tiny hole called the micropyle which allows air and water to enter the seed.

During the process of germination, the seed absorbs water and oxygen which enable the seed to convert starch into sugar. The seed now utilizes the energy from the cotyledons and the formation of a root system follows. The plant now starts to absorb water and minerals from the soil for its own maintenance.

Soon after, the shoot emerges, but it differs depending on the type of seed germinated. For example, monocotyledonous seeds, when germinated, would have their cotyledons left in the soil whereas some dicotyledonous seeds, when germinated, would have the cotyledons above the soil. Fig. 2.11 and Fig. 2.12 illustrate the two types of germination.

**Germination**

This is the process in which seeds become seedlings (new plants). Seeds are produced from flowers which are the reproductive organs of the plant. The structure of seeds is well adapted to carry out the process of germination. See Fig. 2.10.
Fig. 2.11 Germination process of a corn seed (hypogeal germination)

Fig. 2.12 Germination process of a bean seed (epigeal germination)
Sexual reproduction in animals

Like flowering plants, most animals reproduce by the fusion of the sex cells of the male and female parents. This process is called fertilization, and the new cell formed is called a zygote, which continues to grow into a new organism. A more detailed look at sexual reproduction in animals will be looked at, in a further level of study.

Exercises

1. Why is the process of reproduction very important?
2. What is vegetative propagation?
3. All of the following are artificial methods of vegetative propagation except:
   (a) use of stem cutting
   (b) budding
   (c) use of runner
   (d) grafting
4. Which plant can be produced by asexual propagation only?
   (a) Ginger
   (b) Orange
   (c) Pepper
   (d) Pear
5. The organs of sexual reproduction in plants are:
   (a) roots
   (b) stems
   (c) flowers
   (d) leaves.
6. Define pollination and fertilization.
7. What kind of pollination occurs between flowers on different plants?
8. What happens when a pollen grain lands on the stigma?
9. What do you think would happen if the process of pollination does not take place?
10. Copy the crossword and then complete it.

Down
1. where seed was attached to ovary
2. food in seed
3. male reproductive organ in flowers
4. female reproductive organ in flowers
6. stem of stamen
8. result of fertilisation of ovule
9. undeveloped plant or animal
10. result of fertilization of ovule

Across
4. movement of pollen from stamen to pistil
5. male reproductive organ in stamens
7. used to test for starch
10. where pollen lands
11. where pollen forms
12. what seeds store
13. ripened ovary
WE HAVE LEARNT THAT:

- new organisms are produced by the process of reproduction.
- there are two types of reproduction - asexual and sexual.
- vegetative propagation can be natural, e.g. the use of a runner or a bulb; artificial, e.g. cutting, budding and grafting.
- animals can also reproduce asexually.
- the reproductive organ of flowering plants is the flower.
- flowers are adapted to carry out the process of pollination.
- there are two types of pollination - self-pollination and cross-pollination.
- pollination is the transfer of pollen grain to the stigma.
- fertilization is the fusion of male and female sex cells.
- after fertilization the ovules develop into seeds and the ovaries into fruit.
- the structure of the seed is well suited to carry out the process of germination.
- germination is the development of seeds to seedlings.
- there are two types of germination (1) epigeal (ii) hypogeal.
- fertilisation in plants and animals produces a zygote which continues to grow into a new offspring.
Unit 3

The nature of matter

Introduction

All materials can be considered to be matter. In this unit, we will be looking at the various forms of matter, and the particles they contain. If these particles are of the same type, they are referred to as elements. If the particles are different, they are called compounds. Elements and compounds have their own properties.

These elements and compounds can be used to manufacture many other important substances. Only a few of these substances will be looked at in this unit. We will also look at processes that break down compounds, and are of importance in many industries.

In this unit we will learn about:

- matter
- the forms of matter
- the arrangement of particles in the various states of matter
- atoms and sub-atomic particles
- compounds, their formulae, their laboratory and industrial preparation
- compounds and their decomposition.

These particles differ in size, mass, arrangement and behaviour. Robert Brown had discovered that particles of matter were in constant motion in his experiment, which is illustrated in Fig. 3.1. The movement of the particles as seen by the pollen grains was initiated by the movement of water particles, hence he (Brown) referred to the motion as Brownian Motion.

![Experiment to demonstrate the Brownian movement](image)

States of matter

There are several states of matter, but the most common forms are: solid, liquid and gas. These common forms will be dealt with comparatively in relation to their physical properties. The arrangement of the tiny particles of matter is very important to the chemist. The comparative arrangements of these particles are shown in Fig. 3.2.
Atoms and elements

Atoms

- What is an atom?
- Facts about atoms
- Kinds of atoms

WHAT IS AN ATOM?

Centuries ago, a Greek philosopher, Democritus, believed that all matter was composed of extremely small particles to which he gave the name "atoms", from the Greek word "atomos" meaning not to be divided.

Then during the early nineteenth century an English scientist, John Dalton, did some careful experiments. His results convinced others that atoms were not all alike. They differ in size, mass and chemical behaviour. For example, oxygen atoms are bigger and have a greater mass than hydrogen atoms. The model of the atom has changed over time as a result of new discoveries by scientists. These models are shown in table 3.1.

In Book One, we learnt that particles of crystals like potassium permanganate could diffuse or spread out when put in water. Chlorine is a gas. Chlorine is used in many parts of the world to purify water. One gram of chlorine would purify one hundred thousand grams of water. That one gram of chlorine must have many particles, so that even when it diffuses so much, the effect of chlorine is still evident. The smallest particle of chlorine is the atom. Chlorine is an element. An element is a substance which has no other substances in it. An atom is the smallest particle of an element.
Table 3.1 The various discoveries of the model of an atom

<table>
<thead>
<tr>
<th>Year</th>
<th>Scientists</th>
<th>Model of the Atom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1807</td>
<td>Dalton</td>
<td>Atom is a hard dense sphere.</td>
</tr>
<tr>
<td>1903</td>
<td>Thompson</td>
<td>Atom is a mass of positive charges containing negative electrons.</td>
</tr>
<tr>
<td>1911</td>
<td>Rutherford</td>
<td>Atom has dense nucleus surrounded by electrons.</td>
</tr>
<tr>
<td>1913</td>
<td>Bohr</td>
<td>Atom has a dense nucleus, Electrons move in fixed orbit around the nucleus.</td>
</tr>
</tbody>
</table>
FACTS ABOUT ATOMS

Other scientists since Dalton continued investigations during the century. From the work of Niels Bohr, the Curies, Earnest Rutherford, and others during this century, we now know that atoms have even smaller particles in them. These particles are called electrons, protons and neutrons. These sub-atomic particles are not found in a haphazard manner in atoms. Each atom has a nucleus in its centre. Protons and neutrons are always found in the nucleus. Electrons are found moving in paths around the nucleus. Protons have positive electric charge. Electrons have negative electric charge. Neutrons have no charge. An atom has the same number of protons as electrons. Atoms are therefore not charged.

Nuclear power is released when atoms are broken.

KINDS OF ATOMS

All atoms are made up of smaller particles namely electrons, protons and neutrons.

Atoms of the same element are similar. Atoms of different elements differ. Look carefully at Fig. 3.3. What differences can you see between the atoms of hydrogen, carbon, and calcium? Does each one have a nucleus? Do they have the same number of electrons? Are the electrons moving in the same paths or orbits around the nucleus?

Atoms of elements differ in the number of electrons, protons and neutrons. No two elements have the same number of protons and electrons.

Elements

- What is an element?
- Facts about elements.
- Common elements and their symbols.

WHAT IS AN ELEMENT?

An element is a substance which is composed of one type of atom. Iron, copper, aluminium, silver, carbon and oxygen are some of the elements that you may know. An element cannot be separated into anything simpler.

FACTS ABOUT ELEMENTS

The discovery of some elements took place after the Stone Age. Early man found these elements in rocks accidentally. These elements, mostly metals, were used by “early man” to make weapons, jewellery and ornaments. Early man first discovered gold and silver occurring in rocks. About 3500 B.C., copper was obtained by accident. Then tin was discovered. It was not until 1000 B.C. that iron was discovered. Then in the nineteenth century between 1808 and 1827 magnesium and aluminium were obtained.

There are about ninety-two (92) natural elements, but there are a few artificially made in nuclear reactions. Some of these elements occur in the earth’s crust in large quantities either by themselves or in compounds.

Scientists have estimated the percentage by mass of the various elements which occur by themselves or in compounds in the earth’s crust. These figures are represented in the pie-chart (Fig. 3.4)
Looking at the symbols, it is evident that the symbols of the elements are derived from the abbreviations of their names, or the abbreviation of the Latin word.

Usually the symbol for an element is the first letter of its name. But often, a second letter is added to distinguish between elements whose names begin with the same letter. For example, hydrogen is represented by H, and helium by He. Some of these symbols come from Latin words, for example, ferrum is the Latin word from which the symbol of iron, Fe, is derived. The symbol for sodium comes from the Latin word natrium.

- Atoms are the smallest particles of elements.
- Atoms are made up of smaller particles—electrons, protons and neutrons.
- An element is a chemical substance that cannot be broken down into anything simpler.
- There are about 92 natural elements.
- Elements are abbreviated by the use of symbols.

**Compounds**

**What are compounds?**

Can you remember earlier that in Book One, we heated or burnt some substances? Yes, indeed! We heated iron filings and sulphur. What did we get? We burnt a piece of magnesium ribbon in air. Can you remember what new substance was formed? Now let us see what happens in the following experiment.
Activity: Heating copper and sulphur

- Put a little sulphur in the bottom of a test tube.
- Coil up a length of thin copper wire and slip it into the tube so that it is just above the sulphur as shown in Fig.3.5.
- Now heat the sulphur carefully and watch what happens to the copper.
- Does it get hot?
- Does the wire look like copper when you take it out of the tube?

Fig.3.5 Heating sulphur and copper wire.

It is no longer copper. It has combined with the sulphur to form the compound copper sulphide.

We observed that two different elements combined, or we can say reacted together chemically to produce a completely new substance. This new substance is called a compound.

Compounds may have more than two elements. Each molecule of a compound is made up of two or more different kinds of elements. Can you name the elements that combined to produce copper sulphide?

Compounds are called molecules because they consist of different types of elements or atoms bonded together. However they can be broken down into elements.

Common compounds

In our everyday activities we may have used a variety of compounds such as salt, vinegar, sugar and baking soda to name a few. Do we know the chemical names for these compounds?

Here is a list of some common household compounds and their chemical names.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Chemical name</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glauber’s salt</td>
<td>sodium sulphate</td>
<td>laxative</td>
</tr>
<tr>
<td>vinegar</td>
<td>acetic acid</td>
<td>preservative</td>
</tr>
<tr>
<td>sodium chloride</td>
<td>ethanoic acid</td>
<td>seasoning</td>
</tr>
<tr>
<td>sodium bicarbonate</td>
<td>salt (table)</td>
<td>raising agent</td>
</tr>
<tr>
<td>sugar</td>
<td>sucrose</td>
<td>sweetening</td>
</tr>
<tr>
<td>water</td>
<td>hydrogen oxide</td>
<td>universal solvent</td>
</tr>
<tr>
<td>salt petre</td>
<td>potassium nitrate</td>
<td>preservative</td>
</tr>
<tr>
<td>Epsom salts</td>
<td>magnesium sulphate</td>
<td>laxative</td>
</tr>
</tbody>
</table>

Do you know of others?

Elements present in compounds

Since a compound is a substance which contains two or more elements chemically combined, it is usually easy to tell what elements are present in the compound by just looking at their
names. Compounds made from two elements bear names which end in —ide. e.g. sodium chloride, magnesium oxide. The names of the elements present are easily identifiable. In sodium chloride, the two elements are sodium and chlorine. What are the elements in magnesium oxide?

Compounds that contain three elements, which usually include oxygen, have names sometimes ending in —ate. However, some compounds have names ending in —ite, sodium sulphite and potassium sulphite. The compound, potassium nitrate, contains three elements—potassium, nitrogen and oxygen.

Activity: What elements are present in the following compounds?

- Calcium carbonate
- Sodium chloride
- Potassium hydroxide
- Sodium sulphite
- Carbon dioxide
- Zinc nitrate
- Copper sulphate
- Potassium sulphite

**Formulae of compounds**

The formulae of compounds are referred to as chemical formulae. A chemical formula denotes one molecule of the compound. It is represented by using chemical symbols and numbers. Earlier, we looked at the chemical names of compounds to identify the elements present. Here we can also look at the formula to identify the elements and the proportions in which each element is present. For example, the formula for water is H₂O. The H indicates that the element hydrogen is present and O indicates that oxygen is the other element. Therefore, present in the compound water are hydrogen and oxygen. Apart from the elements present, the formula also tells the number of each atom needed to make up the compound. The formula H₂O tells us that two atoms of hydrogen combined with one atom of oxygen to make up one molecule of water.

The little number just after each symbol is a subscript and it shows how many atoms of each element are present.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Chemical formulae</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon dioxide</td>
<td>CO₂</td>
</tr>
<tr>
<td>sodium chloride</td>
<td>NaCl</td>
</tr>
<tr>
<td>magnesium chloride</td>
<td>MgCl₂</td>
</tr>
<tr>
<td>potassium nitrate</td>
<td>KNO₃</td>
</tr>
<tr>
<td>sodium sulphate</td>
<td>Na₂SO₄</td>
</tr>
<tr>
<td>aluminium oxide</td>
<td>Al₂O₃</td>
</tr>
</tbody>
</table>

How are chemical formulae written? It is impossible to write the formulae of compounds from names alone. We need to know more about the elements of which these compounds consist.

Earlier in this Unit, we saw that the atoms of different elements differ. When elements combine, the nucleus of the element is not changed. The electrons in the outer paths or shells rearrange during the reaction. Look again at Fig. 3.3. How many electrons are in the shell furthest from the nucleus in calcium? These two electrons are used in bonding during a reaction. How many electrons are in the shell furthest from the nucleus in carbon? These four electrons are involved in a reaction.

In oxygen, there are six electrons in the shell furthest from the nucleus. If that shell had two more electrons then the element would be totally unreactive. When calcium combines with oxygen, each calcium atom gives up the two outer electrons to each oxygen atom. By the combination, each element becomes, as it were, unreactive.
The formula for calcium oxide is CaO. When electrons are given from atoms or received by atoms the particles produced are called ions. Although atoms are neutral, ions are charged. Why do you think ions are charged?

Before reacting, the calcium atom had twenty protons and twenty electrons. How many protons are in the compound? How many electrons still 'belong' to calcium in the compound? After the reaction the calcium ion still has twenty protons but now it only has eighteen electrons.

The calcium ion has two more units of positive charge than negative charge. Its formula is Ca²⁺. The oxide ion has two more units of negative charge than positive charge. Its formula is O³⁻. The compound calcium oxide is neutral CaO. This is illustrated in Fig.3.6.

![Diagram of calcium oxide formation](image)

Fig.3.6 An atom of calcium combining with an atom of oxygen to give calcium oxide

Making and breaking down compounds

COMBINING MORE THAN ONE ELEMENT

Earlier in this unit, we made a few compounds, e.g. when we burnt magnesium ribbon and produced a white ash called magnesium oxide. We also made copper sulphide in Fig. 3.5.

The reactions that occurred can be expressed in the form of a chemical equation. To obtain magnesium oxide, magnesium must combine with oxygen. Thus the word equation:

-magnesium + oxygen = magnesium oxide.

The word equation for the reaction between copper and sulphur is:

sulphur + copper = copper sulphide.

Now we are going to make a few more compounds.

Activity: Burning aluminum in oxygen

You will need a clean piece of aluminium foil, a gas jar of oxygen, and a heat source.

- Heat the aluminium foil in air.
- What do you notice?
- Reheat strongly and drop into a gas jar of oxygen.
- What do you notice?

The compound aluminium oxide is formed.
Therefore the word equation is:
Aluminium + oxygen = aluminium oxide

**Note:** The color of aluminium is white and it is a solid

**Activity: Heating copper in Oxygen**

- Heat a piece of clean copper foil in air.
- What do you notice?
- Reheat the copper foil and drop into a glass jar of oxygen.
- What do you notice?
- Write a word equation for this reaction.

**MAKING COMPOUNDS IN INDUSTRIES**

**SUGAR**

Cane-sugar (sucrose - C\(_{12}H_{22}O_{11}\)) is manufactured from the juice of sugar cane. The juice is extracted from the cane. Then the chemical, calcium hydroxide, is added to the juice and the mixture is boiled. This chemical causes the impurities to collect in such a way as to make their removal easy (clarification). The mixture is then filtered. The clear syrup that is left is boiled in a special way until a mixture of brown sugar crystals and molasses is formed. The mixture is cooled and molasses is separated from the crystals by a machine called a (centrifuge).

**RUM**

Rum is mainly ethanol or ethyl alcohol.

Rum is made by the process of fermentation followed by distillation.

Most of us may have had the experience of making home-made wine. We may have noticed that, when the ripe fruit, such as jamoon, is mixed with sugar, yeast and a little water and left in a sealed jar, that there are some changes. The amount of liquid in the jar seems to increase and later bubbles rise to the surface of the liquid. When this happens we say the mixture has fermented. This process is caused by the presence and action of yeast. What else is yeast used for? Is a gas given off during these processes?

Spores of yeast are floating about in the air all the time. The fruits you put into the jar would have had some on them. The yeast cells then grow on the sugar and produce alcohol. This is anaerobic respiration (see Unit 5).

![Fig 3.7 A rum distillery](image)

When molasses is allowed to ferment, rum is produced. After some time, it is distilled. The distillation process is carried out in stills and the rum is stored in casks to mature. This adds to its flavour.
AMMONIA

This very important gas (NH₃) is manufactured from the elements nitrogen and hydrogen. Ammonia in turn is used in the manufacture of nitric acid, fertilizers, nylon and other man-made fibres. Nitric acid is also used in the manufacture of explosives, fertilizers, dyes and many more chemicals.

SEPARATING THE ELEMENTS

Can you remember earlier in this unit we made a compound, copper chloride? This compound gives a blue solution when dissolved in water. What are the elements present in this compound? Surely, they are chlorine and copper. Do you know of a method we can use to get back each element?

As the chlorine passed over the copper, the metal got red hot. This showed that a lot of energy was given out during the reaction. Therefore, we have to use a method which will put back the energy that was given off. You may have suggested heating the solution strongly, but heating does not always break up compounds. Certainly it does not work with copper chloride.

However, another form of energy can be used. Do you know which form? Yes! of course, electricity.

![Diagram of electrolysis setup with carbon rods, switch, and copper chloride](image)

Fig 3.8 Breaking down copper chloride

Activity: Breaking down of copper chloride.

- Put some copper chloride solution into a beaker.
- Connect two carbon rods from old batteries to a battery or a low voltage supply of electricity.
- Place the rods in the solution as shown in Fig. 3.8. Close the switch. Observe.

After a few minutes you may see one of the electrodes covered with a reddish coloured substance and the other covered with tiny bubbles of gas.

What is the reddish substance? Copper, of course. Copper will be on the electrode connected to the negative terminal of the battery. At the positive terminal of the battery, bubbles of the gas, chlorine, will form. You may even smell chlorine. Bleach smells like chlorine.

Compare the solid copper chloride with the two elements we got from the electrolysis of copper chloride solution. Do you see any copper or smell any chlorine in copper chloride?

The process we have just observed is electrolysis. Electrolysis is the process by which an electric current passes through a solution and breaks it up. The solution contains ions (charged particles). Your teacher may demonstrate the separation of elements from other substances.

Importance of electrolysis in Industry

Electrolysis is not only a process we carry out in our schools’ laboratories, but is also a very important process in industries like the Bauxite Industry.
Electrolysis in the bauxite industry

Do you know what bauxite looks like? If not, your teacher will show you a sample of bauxite.

Bauxite is reddish brown rock found in some parts of Guyana. Bauxite is impure aluminium oxide. It was quite difficult for aluminium to be separated from aluminium oxide, until the method of electrolyzing aluminium oxide was devised during the nineteenth century. Only since then was it possible for aluminium to be manufactured.

Bauxite in Guyana

The two lines of electrolytic cells can be seen inside an aluminium smelter

Fig. 3.9 The production of aluminium.

HOW ALUMINIUM IS MADE

The impure aluminium oxide is boiled with sodium hydroxide solution in order to purify it. This purification is done in the country where the bauxite is mined, such as Guyana and Jamaica. The impurity removed is brown iron oxide. The pure alumina is a white powder. Alumina is insoluble in water and has a very high melting point. How then can a solution of this substance be made? What solvent can be used for electrolysis?

An unusual solvent, a mineral cryolite, which itself contains aluminium is used. The alumina is dissolved in molten cryolite at a temperature of about 900°C in iron tanks. A very high current, about 10000 A, is used. Aluminium and oxygen are produced. The carbon burns away and has to be replaced from time to time. The high temperature in this electrolysis is sufficient to keep the contents of the tank molten. The aluminium runs off from the bottom of the tank and is cast into bars.

It is not economical to do this type of refining in countries like Jamaica and Guyana, since electricity is not cheap in these countries. This process is done overseas. However, it would have been beneficial to countries in which bauxite is mined, since it would mean more jobs and money.
Exercises

1. Copy and complete the table

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Takes the shape of the container</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>fixed</td>
<td></td>
</tr>
<tr>
<td>Arrangement of Particles</td>
<td>closely packed</td>
<td></td>
</tr>
</tbody>
</table>

- What does the formula of a compound tell one about a compound?

- List the elements and the numbers of each atom present in the following compounds:
  - CuSO₄
  - CuCl₂
  - CuO
  - ZnS

- Write the formula for each of the following:
  - (a) copper chloride
  - (b) sodium carbonate
  - (c) aluminium sulphate
  - (d) potassium chloride

- (a) What is the product when sulphur is heated in oxygen?
  - (b) Write the word equation for reaction between sulphur and oxygen.

- Use of substances which are waste products from industries is highly recommended. Find out what are the "waste" products during the manufacture of cane sugar. How are these waste products used?

- What materials can be manufactured from ammonia?

- (a) List two properties of alumina.
  - (b) How is aluminium obtained from bauxite?
  - (c) How would a country like Guyana benefit if aluminium were manufactured here?
  - (d) Find out some ways in which aluminium is used.

2. What is meant by (a) an element (b) an atom (c) a compound

3. Give the names of:
   - (a) ten common elements and their symbols.
   - (b) three household compounds and also state their chemical names.

4. Fill in the blanks:

<table>
<thead>
<tr>
<th>Elements</th>
<th>Numbers of Protons in atom of element</th>
<th>Numbers of electrons in atom of element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helium</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>Oxygen</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Aluminium</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>Chlorine</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>Copper</td>
<td>29</td>
<td>-</td>
</tr>
<tr>
<td>Tin</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Barium</td>
<td>-</td>
<td>56</td>
</tr>
</tbody>
</table>
WE HAVE LEARNT THAT:

- all materials are matter.
- there are several states of matter.
- atoms are the smallest particles of elements.
- atoms are made up of smaller particles - electrons, protons and neutrons.
- an element is a chemical substance that cannot be broken down into anything simpler.
- there are about 92 natural elements.
- elements are abbreviated by the use of symbols.
- a compound consists of two or more elements combined together chemically.
- the formula of a compound tells what elements are present in the compound.
- the formula also tells how many atoms of each element are present in one molecule of the compound.
- the little numbers at the bottom right of the element are called the subscripts.
- the formula of a compound does not change.
- compounds are made when two or more elements react together. Sometimes a large amount of heat energy is given off or absorbed during the reaction.
- word equations can be used to represent the reactions which occur.
- compounds such as sucrose, rum and ammonia are manufactured.
- it is sometimes very difficult to separate the elements in a compound; therefore the process of electrolysis is used.
- electrolysis is the process of breaking up a compound by passing an electric current through a solution.
Unit 4

Food for plants and animals

Introduction

All living organisms need energy to keep alive. They get the energy from food, therefore all plants and animals need food to live. How do plants and animals get their food? Plants make their own food and thus they are called producers. Animals, however, depend on other organisms for their food. They are called consumers.

In Book One, we went on a field trip and collected many interesting animals and plants. This shows us that plants and animals in their respective habitats live together and affect each other’s lives in many ways. Generally speaking, a habitat provides suitable conditions, including food for those organisms which live there. While the animals in a community will feed on other organisms in that community, the plants will be manufacturing their own food.

In this unit therefore we will discuss:

- how plants make food
- plant storage organs
- how we can test for foods in plants
- the classification of feeders as producers, consumers and decomposers
- identifying food chains and food webs
- the energy we get from foods.

Plants make food

Plants make their food by means of a process called photosynthesis. This long word simply means using light energy from the sun to make food materials with the main reactants being water and carbon dioxide. While the process is occurring, oxygen is given off. The process of photosynthesis can be summed up in the following equation:

\[ \text{Water} + \text{carbon dioxide} + \text{sunlight} = \text{glucose} + \text{oxygen} \]

Let us do a few activities that will help us to observe that plants do make food material in their leaves.

Activity: Testing green leaf for starch.

You will need:
- two potted plants labelled A and B
- beaker
- tap water
- ethanol
- iodine
- boiling tubes
- petri dishes
- burner
- tripod and gauze
- tea pipette (dropper)

31
NB. Two days before the experiment, place plant A in a dark cupboard. Place plant B near a window to receive light.

Remove a leaf from plant A. Treat as shown in stages (a) to (d) of Fig. 4.1.

Remove a leaf from plant B. Treat as shown in stages (a) to (d) of Fig 4.1.

Activity: Testing variegated leaf for starch.

Things you will need:
- Leaves which are partly green and partly white e.g. variegated leaves of Hibiscus.
- Other materials and apparatus will be the same as in the previous activity.
- First make a sketch of the leaf to show the green and white parts.

Test the leaf for starch as demonstrated in the previous experiment. (See Fig 4.1)

![Diagram showing how to test a leaf for starch]

Fig. 4.1 Diagram showing how to test a leaf for starch

Questions

1. What is the colour of the leaf from plant A after iodine was added?
2. What is the colour of the leaf from plant B after iodine was added?
3. Which leaf made starch? (A blue-black colour in iodine indicates the presence of starch)
4. Why didn't the leaf in the dark make starch? Try this other experiment.

Questions

1. After iodine was added to the leaf what colour did the green parts become?
2. What is the colour of the white portion after iodine was added?
3. (a) Which part of the leaf indicates that starch was present?
   (b) How do you know?
4. What do the results indicate?
The results of this second activity indicate that starch is found in the green parts of leaves. This means that chlorophyll, the green pigment in leaves, is necessary for photosynthesis. In both activities, we have observed the presence of starch in leaves. Starch is a carbohydrate, one of the food nutrients.

What did the plant need to make this food material?

Carbon dioxide, water, the green pigment and light are all necessary for the manufacture of starch during the photosynthetic process.

Carbon dioxide in the air is taken into the leaves through small holes - stomata - and then through air spaces in the leaves. Can you explain how the green plants get water for photosynthesis?

During respiration, which occurs all the time in plants, carbon dioxide is produced, but it is used up during the day in photosynthesis.

Plants store food

We have just seen that green plants make their own food during photosynthesis. Some of that food is used at once to carry out basic activities in the plant. We will now see what happens to the food that is not used immediately by the plant.

Storage structures in plants

Do you know what is in a seed? Try to remember the activity on germination in Book 1.

During the first few days after planting, the radicle grows downward to become the root, while the plumule pushes upwards and its leaves enlarge, becoming green.

How does a seedling get food to supply energy before the green leaves appear? It must have used stored food. Where was the food stored?

What would you do to find out if starch is present in a seed? Try this activity with the seeds of some fruit which you have eaten.

Activity

You will also need:
- petri dishes
- a knife or a razor blade
- a pipette (dropper)
- iodine

1. Cut a piece of the seed and place it in a petri dish.
2. With the dropper, place a drop of iodine on the cut surface.
3. Write down your observation.
4. Repeat steps 1 - 3 using at least two other kinds of seeds.

Did you make similar observations with seeds of mango, genip, fat pork, malaka pear or whytee?

Many plants store food in seeds. The stored food enables the seedling to grow while the root system is forming and before the foliage leaves appear. Name some plants which do not get new ones by seeds, or in other words, are not propagated by seeds. Do those plants store food for the new ones? We will do another activity later on in this chapter, to find out if such plants do store food, and if they do, in what form.

Besides propagation, there are other reasons for the storage of food by plants. Storage organs may keep plants alive during unfavourable conditions like in drought. The leaves may wither, or much of the upper part of the plant may die off while the storage organ remains alive in the ground. What happens when the rains come
### Table 4.1

<table>
<thead>
<tr>
<th>Plant parts</th>
<th>Example</th>
<th>Food(s) stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>seeds</td>
<td>corn</td>
<td>starch, protein</td>
</tr>
<tr>
<td></td>
<td>coconut</td>
<td>fats</td>
</tr>
<tr>
<td></td>
<td>peanuts</td>
<td>fats, protein</td>
</tr>
<tr>
<td>fruits</td>
<td>orange</td>
<td>sugar, protein, Vit. C</td>
</tr>
<tr>
<td></td>
<td>tomato</td>
<td>sugar (in some)</td>
</tr>
<tr>
<td>leaves borne on small</td>
<td>onion</td>
<td>carotene, Vit. K</td>
</tr>
<tr>
<td>underground stem</td>
<td>shallot</td>
<td>starch</td>
</tr>
<tr>
<td>stems</td>
<td>yam</td>
<td>starch, vitamins</td>
</tr>
<tr>
<td></td>
<td>irish potato</td>
<td>starch, vitamins</td>
</tr>
<tr>
<td></td>
<td>ginger</td>
<td>starch, vitamins</td>
</tr>
<tr>
<td></td>
<td>eddo</td>
<td>starch, vitamins</td>
</tr>
<tr>
<td>roots</td>
<td>carrot</td>
<td>starch, protein, carotene</td>
</tr>
<tr>
<td></td>
<td>radish</td>
<td>starch</td>
</tr>
</tbody>
</table>

The plant could grow up again, quickly, using the stored food energy. Such a plant would have an advantage over a plant growing from seed because there is more stored food than in a seed. In dry weather, a plant may shed its leaves to reduce its loss of water. Food, stored in other parts of the plant, makes rapid leaf-growth possible when the rains come. Let us make a table to show the parts of plants where food is stored and the type of food stored.

Below are some drawings of food storage organs of plants. Study each drawing and try to identify features that show whether the storage organ is a stem or a root.

(a) The rhizome of canna lily (canna)

(b) The stem tuber of the yam - an underground stem

Fig.4.2 Storage organs
Now list the features that show that an organ is either a stem or a root. Take note of the direction in which growth takes place. For example, where is the terminal bud, in eddo and in a canna lily? Are the nodes beside each other, or above each other? Some stems are very short as in the carrot; don't let short stems confuse you.

Testing for foods in plants

Plants make a variety of types of food. The sugar made in green leaves could be stored as sugar e.g. in onions and sugar-cane. But it could be changed into other high-energy substances like starch, for example, in corn, or like fats, for example, in peanuts. By further synthesis, proteins are manufactured.

We could test for the types of food stored.

Activity: Testing for food in plants

During this activity, include parts of plants which are not propagated by seeds e.g. the 'sucker' of a banana or plantain; the cutting of a croton or of cassava; the bulb of a lily; the stem of the eddo and a piece of fresh (not dried) ginger. Test peanuts for fat.

The following illustration states clearly how to test for starch, protein and fat. Read all the instructions before you begin the activity. Carry out the tests. Record your observations in a table. Are you surprised by them?
Fig. 4.3 Testing for starch.

Fig. 4.4 Testing food for protein.

Fig. 4.5 Testing food for fat.
Animals are consumers

All the animals in a community are consumers. They eat plants or other animals as food. We are going to explore the habitats of some animals and find out what they feed on.

As we moved around the school yard we may have noticed a caterpillar feeding on the leaves of the plant on which it lives; a butterfly visiting a flower to suck the sweet nectar or a mother bird feeding worms to her fledgelings; and even still, a crane perched on the back of a cow feeding on the organisations which live on the cow’s body.

![Images of a butterfly, mother bird feeding, crane feeding, and a snake swallowing a frog.]

Fig. 4.6 Animals feeding on different kinds of organisms

Identifying feeding partners

Let us once again go out into the school yard and visit the habitats of some organisms. This time we are going to observe what they feed on. Remember, we are to observe also, the larger animals which we did not collect on our previous field trip.

Did you notice any animal feeding on the dead remains of other organisms?

Classifying feeders

Now let us classify the animals according to what they feed upon. Use a table like the one below:

<table>
<thead>
<tr>
<th>Name of animals</th>
<th>What the animals eats</th>
<th>Animals that feed on plants</th>
<th>Animals that feed on animals</th>
<th>Animals that feed on plants and animals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

37
The animals that feed on plants only are called **herbivores**. The animals that feed on other animals are called **carnivores** and those animals that feed on both plants and animals are called **omnivores**. Man is an omnivore. Can you tell why? Yes, because man may eat parts of plants, like banana and callaloo; he may also eat meat from the cow or sheep. Then there are some animals, like the carrion-crow and earthworms, that feed on the dead remains of animals and plants. These animals are called **scavengers**.

Microscopic organisms such as bacteria and fungi obtain their energy from dead or decaying material. They help to break down such material and are called **decomposers**.

### Food chains and food webs

Animals and plants do not live alone in their natural habitat, but in groups along with other animals and plants. This association of plants and animals living together and affecting each other’s life results in a **community**. The community may be **aquatic** (occurring in streams, trenches, etc.) or **terrestrial** (found on land). In every community there are green plants that use the energy from the sun to manufacture their own food. Therefore in the community, plants are the **producers**. The animals consume (feed on) the producers. Thus the animals are referred to as **consumers**. The animals (herbivores) that feed on the producers are called the **primary consumers**; while the animals (carnivores) that feed on the primary consumers are called **secondary consumers**. Some animals feed on the secondary consumers. They are called **tertiary consumers**.

We are going to study the association of animals and plants in a few communities by tracing the transfer of energy from the sun to the to the consumers and finally to the decomposers.

### Food chains

In a community, animals depend on plants for their source of energy. But from where do the plants get their energy? The sun, of course, is the main source of all energy. The radiant energy from the sun is trapped and stored as chemical energy in green plants. We have already learnt that not all animals feed on plants. They may feed on other animals. But those other animals may have fed on plants. Thus the energy from the sun is transferred from one organism to another: to plants first, and from plants to animals. (At each transfer much energy is lost, since only a portion is stored in body tissues.)

Now let us look back at Fig.4.6, where we observed a bird perched on the back of a cow. What is the cow doing? What is the crane doing? The cow is, most probably, feeding on the green grass, while the crane is feeding on the tiny organisms e.g. ticks living on the cow’s body.

What are the ticks and/or other tiny organisms feeding on? Can you trace the transfer of energy among such organisms? Let us see! The cow is eating the grass. The ticks and other organisms are feeding on the cow’s blood. And finally the crane is feeding on the ticks and other organisms.

Now we can show this feeding relationship like this: grass → cow (blood) → tick → crane. (‘→’ means ‘is eaten by’). This diagram is called a **food chain**. The arrows indicate the direction in which the energy is flowing. But this food chain might not end with the crane. The crane could be eaten by a larger carnivore e.g. an eagle. Can you recognise the producer, and each level of consumer in the food chain above.

In a community there are numerous food chains. Here are some others found in a terrestrial habitat.
(As you would have noticed, pictures can be used to illustrate a food chain.)

(2) Grass → Sheep → Humans

(3) Leaves → Grasshopper → Frog → Snake

(4) Green plant → Slug → Bird → Mongoose

Have you noticed that a food chain always starts with green plants? Could you explain why?

There are other food chains where the habitats are aquatic. The water could be fresh or it could be salt. In the water, there may be tiny microscopic plants and animals called plankton. The organisms of plant plankton contain chlorophyll which enables them to use sunlight. They trap the energy of the sun. The organisms of animal plankton feed on the plant plankton. The animal plankton is in turn eaten by small fishes. The small fishes are then eaten by bigger fishes and this could go on and on. We can show this feeding relationship like this:

plant plankton → animal plankton → small fish → large fish

Food chains could also end with human beings. Refer to Fig. 4.8. In nature, some animals survive by catching and eating other animals. For example, the owl catches and eats mice. The animal, in this example, the owl, that catches and eats another animal is called the predator. The animal that is caught and eaten, in this case, the mouse, is the prey. Name other predators and prey that you know.

A food chain could end at any point when the organism dies. The body of the organism is either broken down by decomposers or is eaten by scavengers. The scavengers e.g. the turkey buzzard or John Crow, ants, crabs, shrimps and snails act quickly, in that they eat the dead plants and animals.

Decomposers, e.g. fungi and bacteria, on the other hand, act very slowly.

As a result of the action of decomposers, chemical substances such as nitrates, phosphates, potassium and calcium are released and can be used by plants.
**Food webs**

In a community of living things there can hardly be only simple food chains, since many organisms are eaten by consumers of different levels. In other words, most organisms get food from different sources and, therefore, from different food levels. For example, birds eat insects, but they also eat worms, small fish, spiders and parts of plants. Therefore one organism could be a part of more than one food chain. The food chains in this case would overlap. When food chains overlap they form a web, which is referred to as a **food web**. Food webs show the interaction of different kinds of organisms. In both food chains and food webs we observe that plants play a major role as the producers.

Here is an example.

![Food web diagram](image)

**Fig. 4.9** A food web showing the interdependence of organisms in a community.
Energy from food

Do you remember what you learnt about energy in the Form 1? All living things need energy to keep alive. Even when you are resting, basic functions are going on in your body. Can you name some of these functions? These non-controllable functions or activities in animals include heart-beat, breathing, circulation of blood, and regulation of body temperature.

Non-controllable activities also go on in plants. They include movement of solutions from the soil, through the roots, to various parts of the plant, and movement of manufactured food from the leaves to other parts of the plants. All these activities of animals and plants require energy.

Food as a fuel

A fuel is any substance which, when combusted or burned, releases energy. This burning does not always take place at a high temperature or with a flame. Burning or combustion is an example of oxidation. Oxygen from the air combines with the particles of fuel, changing those particles and giving energy.

In living things, this process of oxidation takes place gradually. It supplies energy at the rate at which it is required. It is the food which is oxidised to produce energy. Here are some activities to demonstrate that energy is released when food is burned. Study the diagram in Fig 4.10 and the outline of the activity before you start the activity.

Activity: Energy is released when food is burned.

Here are some things you will need.
- test tube
- retort stand and clamp
- thermometer
- pin or needle mounted on cardboard to help you to hold it.
- spoon or spatula
- matches
- cotton wool
- balance
- water
- measuring cylinder
- samples of food—peanut (raw or parched), cooking oil.

Fig. 4.10. Diagram showing how peanut is burned.
Now follow these instructions.

(a) Using the measuring cylinder, measure 20 cm³ of water and pour the water into the test tube.

(b) Put the thermometer into test tube and place the cotton wool in the neck. Clamp the test tube as shown in Fig. 4.10.

(c) Take and record the temperature of the water as shown in Fig. 4.10.

(d) Find and record the mass of the peanut.

(e) Stick the peanut with the mounted needle, then light the peanut with a burning match.

(f) Place the lighted peanut under the test tube of water. Record the temperature of the water after all the peanut has burnt.

(g) Repeat steps (a) to (f) with the cooking oil contained in a spoon or spatula.

Use the same mass of oil as the peanut, if possible.

Record your results in a table like the one below.

Table 4.2

<table>
<thead>
<tr>
<th>Food substance</th>
<th>Mass</th>
<th>First temperature of water °C</th>
<th>Second temperature of water °C</th>
<th>Increase in temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooking Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From the activity answer the following questions.

- What collective word do we give to the things we need to carry out such an activity?
- Why was the cotton wool used?
- Which instrument did you use to find the mass of the samples of food?
- Why was it suggested that the same mass of food be used in each case?
- Why did the temperature of the water in the test tube increase?
- Which food caused the greater increase in temperature?
- Which food would supply more energy if we ate it?

We can calculate the amount of energy released from the burning food.

The energy in foods used to be measured in **calories** but now it is measured in joules and **kilojoules**.

The calorie is the amount of energy required to raise the temperature of 1g of water by 1°C.

The unit for measuring energy is the **joule** and there are **4.2 joules** in 1 calorie.

Here is how the amount of energy released from the food is calculated.

1. Find the mass of the water. In this case it is 20g because the density of pure water is 1g cm\(^{-3}\) (1cm\(^3\) of water weighs 1g)
2. Find the temperature increase. (Final temperature (B) minus initial temperature (A)) The terms \(t_1\) and \(t_2\) could be used instead of A and B.
3. The formula to calculate the amount of energy in the food (energy absorbed by the water) is:

\[
\text{temperature increase \times mass of water \times 4.2 joules} = \frac{1000}{1000} \times 4.2 = 4.2 \text{ joules}
\]

4. 1 KJ = 1000 joules, therefore dividing by 1000 will give the answer in kilojoules. Your result will be the amount of energy contained in the nut that was burned.

The calculation above will apply for any food that is used to measure the amount of energy that is released when the food is burned.

**Food waste as fuel**

In the process of manufacturing and extracting food substances from plants some unwanted substances are produced. Some of these, if left about and if not properly disposed of, could be health hazards. Animals also produce waste. A major development in the use of food waste as fuel is that of biogas production.

Countries such as India, Germany and China have invented digesters. This device uses the dung of cows and pigs as well as vegetable matter to produce biogas. Biogas is essentially methane. This gas is produced by the process of fermentation caused by bacteria. Fermentation not only releases trapped energy in the wastes, but it also kills harmful organisms during the process. The further waste produced by this process is used as fertilizers.

The biogas is used in stoves, refrigerators and lighting systems e.g. gas lamps. The biogas digester is gaining popularity in the country areas of Guyana and also in other Caribbean countries. See Fig.4.11.

In the sugar industry, after the sucrose is extracted from the stems of sugar cane, the remains are called “bagasse”. This is compressed and used as fuel in boilers in the very industry.

In the coconut industry, the fibre of the coconut husk is made into brushes and mats. The husk also may be used as fuel. The hard outer covering of the kernel- the endocarp or “shell”-
could be used to make charcoal. The charcoal works efficiently in ‘coal pots.’

Fig. 4.11 The biogas digester

Exercises

1. Name two organisms and the habitat of each of them.
2. What does each organism named in the exercise above feed upon?
3. Name two carnivores and two herbivores.
4. To which class of feeders does each of the organisms illustrated in Fig. 4.12(a) - (e) belong?

(a) Elephant  (b) Housefly  (c) Human
(d) Hawk  (e) Moth

Fig. 4.12 Examples of consumers.
5. Put the following groups of living things in the correct order to show the transfer of energy in a food chain.
   (a) kiskadee, grasshopper, grass
   (b) cow, green grass, man
   (c) mouse, grain, owl

6. Construct a food web from the food chains we have studied earlier. Can you identify the producers and the consumers? Can you identify the feeding partner of each organism? Make up some more food webs of your own. Include human beings in a few of them.

7. Define a community.

8. Explain and give examples of each of the following:-
   (a) producer (b) primary consumer
   (c) secondary consumer
   (d) tertiary consumer (e) decomposer
   (f) scavenger.

9. What does a food chain show?

10. Think about a meal you had recently.
    Write down three items of that meal e.g. bread. Trace how the energy got to you from that meal.

11. Read this statement carefully and comment on it.
    "All flesh is ... grass."

12. Visit a nearby farm that has a biogas digester. Carry out a study of how it works. Write up your findings. Cues—Choice of site for digester. Type of matter used in digester. Treatment of matter before it is fed into digester. Reasons for such treatment. Size of digester. Factors that affect size. Time taken before gas can be tapped off. Constancy of supply of gas. Regulation of supply. Can the gas be stored? Safety precautions. Maintenance.

Questions 13-17 are multiple choice items.

13. Plant parts store food for all the following reasons—EXCEPT
   (A) germination
   (B) propagation
   (C) active transport
   (D) transpiration

14. Which of the following is NOT an underground stem?
   (A) eddo
   (B) yam
   (C) carrot
   (D) ginger

15. One of the following is NOT a feature found in underground stems.
   (A) buds-apical, lateral
   (B) scale leaves
   (C) roots
   (D) flowers

16. The name of the gas produced in the biogas digester is
   (A) argon
   (B) methane
   (C) nitrogen
   (D) oxygen

17. In the sugar industry, “bagasse” is used in boilers to produce steam.
    What waste is used in the rice industry to produce steam?
    (A) broken rice
    (B) paddy shell
    (C) rice straw
    (D) ‘bran’
WE HAVE LEARNT THAT

- plants store excess food. These resources may be used later. They help plants to survive drought and winter. They assist in the formation of fruits and seeds.
- food storage organs may be fruits, seeds, stems, leaves or roots.
- the plant parts that store food have been modified for that purpose. They are classified as fruits; seeds; rhizomes; tubers; corms; bulbs.
- plants store carbohydrates, fats, proteins, vitamins, mineral salts. Plant parts could be tested for these products.
- animal refuse and vegetable matter could be converted into methane by bacteria by the process of fermentation.
- energy is required for both basic and controllable activities. When food is combusted, energy is released. Energy is measured in joules.
- when combustion of food takes place in living things, it is done gradually and without flame.
- green plants are termed producers because they make food during the photosynthetic process. Animals are consumers.
- iodine turns blue black in starch.
- the animals and plants interacting in a common habitat are known as a community.
- habitats may be ‘terrestrial’ or ‘aquatic’ N.B. Aquatic habitats are either fresh water or ‘marine’.
- in a community there are producers; green plants, and consumers; animals.
- the herbivores that feed on the producers are primary consumers. The secondary consumers are the carnivores that feed on the primary consumers.
- tertiary consumers feed on the secondary consumers.
- food chains show the transfer of energy from producers to the consumers and eventually to decomposers or scavengers.
- food webs show the overlapping of a number of food chains.
- both food chains and food webs occur on land and in water.
Unit 5

Respiration

Introduction

Living organisms must have energy to be able to do work. They get this energy from food materials. How does this occur? By means of respiration, which is the process whereby chemical energy stored in food is released to allow organisms to do work. The purpose of respiration therefore is to release energy from food materials. It is a process that takes place in every cell of every organism.

This unit on respiration is intended to:

- explain simply how respiration releases energy in foods for use by animals and plants
- show that oxygen is often used in respiration and carbon dioxide is given off
- write word equations for aerobic and anaerobic respiration, naming reactants and products
- test for respiratory gases - oxygen and carbon dioxide
- compare aerobic and anaerobic respiration
- describe breathing mechanisms in humans, fishes, insects and plants
- describe respiratory surfaces in humans and other animals
- compare inhaled and exhaled air.

Definitions

A purely biological definition of respiration is 'the process by which living cells oxidise food or burn food and release energy, at the same time giving off carbon dioxide'. In organisms, respiration is accompanied by gaseous exchange, better known as breathing. It should be understood that respiration is the process whereby potential energy, stored in food, is released in steps as energy to do work. Respiration takes place in each and every cell of every organism, and the energy in food is released with the help of enzymes - special chemicals that speed up reactions.

Respiratory enzymes control the rate of the release of energy from the food. The enzymes ensure that the reactions occur at body temperature which is much lower than temperatures at which fuels burn. The 'burning process' or oxidation of food in order to release energy, usually needs oxygen which is in the air organisms breathe in.

What percentage of the air is oxygen? Table 5.1 and Fig. 5.1 will show clearly how much oxygen is in the air we breathe.
Table 5.1 Composition of air

<table>
<thead>
<tr>
<th>Constituents of air</th>
<th>% by volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>78</td>
</tr>
<tr>
<td>Oxygen</td>
<td>21</td>
</tr>
<tr>
<td>Other gases: Carbon dioxide</td>
<td></td>
</tr>
<tr>
<td>Inert gases</td>
<td>1</td>
</tr>
<tr>
<td>Water vapour</td>
<td></td>
</tr>
</tbody>
</table>

Other gases 1%
Oxygen 21%
Nitrogen 78%

Fig. 5.1 Composition of air

Table 5.2 Processes of respiration

<table>
<thead>
<tr>
<th>Aerobic</th>
<th>Anaerobic</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Oxygen is one of the reactants</td>
<td>- Without oxygen present</td>
</tr>
<tr>
<td>- Oxidation of food nutrients</td>
<td>- Food nutrients broken down without oxygen</td>
</tr>
<tr>
<td>- The products are CO₂ and water</td>
<td>- The products are</td>
</tr>
<tr>
<td>- Complete breakdown of the glucose</td>
<td>- lactic acid (in animal cells)</td>
</tr>
<tr>
<td>molecule</td>
<td>- CO₂ and ethanol (in plant cells such as yeast)</td>
</tr>
<tr>
<td>- High output of energy</td>
<td>- Incomplete breakdown of the glucose molecule</td>
</tr>
<tr>
<td></td>
<td>- Low output of energy</td>
</tr>
</tbody>
</table>
Processes of respiration

There are two main kinds of respiration-aerobic and anaerobic.

Aerobic respiration

When oxygen is one of the reactants in the process of respiration, the respiration is said to be aerobic.

Respiration in humans is of the aerobic kind and we are referred to as aerobes.

Anaerobic respiration

When energy, stored in food, is released without oxygen being a reactant in the process, the respiration is said to be anaerobic. Organisms which carry out anaerobic respiration are called anaerobes. The respiration in the bacteria causing tetanus (or lockjaw) is anaerobic. Should oxygen be supplied, anaerobes would die.

<table>
<thead>
<tr>
<th>Food</th>
<th>Energy - kJ/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>margarine</td>
<td>32.2</td>
</tr>
<tr>
<td>butter</td>
<td>31.2</td>
</tr>
<tr>
<td>peanuts(roasted)</td>
<td>24.5</td>
</tr>
<tr>
<td>chocolate(milk)</td>
<td>24.2</td>
</tr>
<tr>
<td>rice</td>
<td>15.0</td>
</tr>
<tr>
<td>white bread</td>
<td>10.6</td>
</tr>
<tr>
<td>chicken(roast)</td>
<td>7.7</td>
</tr>
<tr>
<td>eggs(fresh)</td>
<td>6.6</td>
</tr>
<tr>
<td>potatoes(boiled)</td>
<td>3.3</td>
</tr>
<tr>
<td>milk</td>
<td>2.7</td>
</tr>
<tr>
<td>beer</td>
<td>1.2</td>
</tr>
<tr>
<td>cabbage(steamed)</td>
<td>0.34</td>
</tr>
<tr>
<td>pork sausages</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Energy in foods

We learnt that potential energy, in the form of chemical energy is stored in food. How do we measure the energy that is released by certain nutrients?

A known mass of a food e.g. a peanut, could be burned in controlled conditions, and the heat evolved could be measured. The energy stored in that mass of food could then be calculated. You may recall how you yourself did this experiment.

Table 5.3 shows the amount of energy in kilojoules released per gram of various foods.

Breathing

Breathing describes the combined action of inhaling (taking in) and exhaling (giving out) air. The purpose of breathing is to bring air close to the respiratory surface, be it the surface of trachea as in insects, or of gills as in fishes, or of lungs as in mammals. Breathing is external respiration and it involves movement of respiratory structures; yet plants do not ‘breathe’, they respire.

Breathing in a fish

The movements in a fish, aimed at getting air, which is dissolved in the water, close to the gills are: the opening and closing of the mouth, and the raising and lowering of the gill cover or operculum.
The water which enters in when the mouth is opened, flows out over the gills when the operculum is raised and the mouth closed. The oesophagus is closed before the mouth is closed and the floor of the mouth raised so that the water does not enter the digestive system. The water flows in one direction only. As it passes over the gills, oxygen diffuses into the blood in the gills. Carbon dioxide in the blood in the gills diffuses into the water before the water passes out of the operculum.

**Breathing in a mammal**

The movements that bring air into the lungs in mammals are **inhalation** and **exhalation**. During inhalation the thoracic cavity enlarges.

Look at the drawing of the side or lateral view of the thorax. The breast bone or sternum rises. Ribs move up and out. The dome-shaped diaphragm is flattened. The tissue of lungs is elastic. The lungs expand and fill the larger space.

As a result, the pressure in the lungs falls. Atmospheric air is therefore at a higher pressure than the air in the lungs and it flows in, filling the air sacs. (See Fig. 5.4).

During exhalation the thorax returns to its original size. The sternum is lowered. Ribs move in and down. The diaphragm resumes its dome-shape. The space is less and air is squeezed out of the lungs.
Try and make a model of the chest.

Things you will need.

- a bell jar
- one-holed rubber bung
- long delivery tube
- a balloon
- a rubber sheet

Set up the model as shown in Fig 5.5. The rubber sheet representing the diaphragm can be pulled down and pushed up. That makes the chest larger and smaller. Record the movements of the balloon which represents the lung.

Fig. 5.5  The model lung

Fig. 5.6  Respiratory tract of man
Look at Fig. 5.6 which shows the respiratory tract in man. Trace the path that air follows from the beginning of an inspiration to the end of the expiration. While the alveoli are full of air, oxygen diffuses into the blood in the capillaries that line the alveoli. Look again at Fig. 5.4.

Carbon dioxide in the blood in those capillaries diffuses into the alveoli. The composition of the air is now very different to what it had been. Look at Table 5.4 and contrast it with Table 5.1.

From the diagram we have just studied, it is seen that a number of organs make up the tract through which air gets in and out of the lungs. These organs make up the respiratory system. While providing the body with oxygen the respiratory system also removes carbon dioxide as waste.

Table 5.4 Differences between inhaled and exhaled air.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Inhaled (%)</th>
<th>Exhaled air (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Oxygen</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Noble gases</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>0.03</td>
<td>4</td>
</tr>
<tr>
<td>Water vapour</td>
<td>varies</td>
<td>1</td>
</tr>
</tbody>
</table>

Respiratory surfaces

Respiratory surfaces are needed for the exchange of gases in an organism. Breathing describes the ways in which air is brought close to the respiratory surface. In fishes, water with air dissolved in it, streams over the gills. In mammals, air flows in and out of the lungs.

In this section, the way in which oxygen from air reaches cells for internal respiration is discussed.

Let us examine Fig. 5.7(a),(b) and (c) which illustrate features of a fish’s gill and Fig. 5.8 of a mammal’s lung respectively. What features do gills and lungs have in common?

Fig. 5.7 Gill system of a fish
Fig. 5.8  Respiratory surfaces of lung

Table 5.5  Features of respiratory surfaces

<table>
<thead>
<tr>
<th>Fish's gill</th>
<th>Mammal's lung</th>
<th>Common feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The gill lamellae are delicate structures</td>
<td>The walls of the hollow alveoli are thin, just one cell thick.</td>
<td>THIN</td>
</tr>
<tr>
<td>2. Gills are continuously bathed with water.</td>
<td>Certain cells in the alveolar walls secrete mucus.</td>
<td>MOIST</td>
</tr>
<tr>
<td>They are wet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The numerous lamellae greatly increase the</td>
<td>The 'numerous' alveoli greatly increase the surface area of the lungs. It is said that if the lungs of an adult man were spread out, the tissues would cover an area of about 90m²</td>
<td>EXTENSIVE</td>
</tr>
<tr>
<td>surface area of gills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The gills of a freshly caught fish are bright red. Each lamella has a network of blood vessels.</td>
<td>There are many capillaries around each alveolus.</td>
<td>VASCULAR</td>
</tr>
</tbody>
</table>

From the exercise just done, we see that respiratory surfaces are: \textbf{thin, moist, extensive and vascular}

Of what benefits are these features? Refer to Table 5.6

53
Table 5.6 Benefits of the characteristics of respiratory surfaces.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td>In this structure, the distance across which gases and other solutes have to diffuse is small.</td>
</tr>
<tr>
<td>Moist</td>
<td>Gases have to be in solution before they can diffuse through cell walls.</td>
</tr>
<tr>
<td>Extensive</td>
<td>Chemical reactions take place at atomic and at molecular levels. If there is a large surface, the reactants could spread thinly. Their particles would then be closer together for chemical combination.</td>
</tr>
<tr>
<td>Vascular</td>
<td>Blood is an agent of distribution. With many capillaries close to the continuous air supply, gases can diffuse into the blood stream very easily.</td>
</tr>
</tbody>
</table>

Other respiratory surfaces

Small organisms have larger surface area/volume ratio than larger organisms. A single-celled organism, like an amoeba, has a large surface area/volume ratio. It can absorb substances, e.g. oxygen, efficiently by diffusion through its entire body surface. A large organism, such as a mammal, with its smaller surface area/volume ratio cannot get enough oxygen through its body surface and to all its cells quickly enough. Such large organisms have special respiratory surfaces, e.g. lungs in mammals and trachea in insects for absorption of oxygen.

Large plants have branches with many leaves, pores (stomata) and air spaces (lenticels) for movement of gases.

In addition they have branching root systems which also act as respiratory surfaces.
Surface area/volume ratio

We noted in the preceding section that small organisms tend to have larger surface area/volume ratios than larger organisms.

A single cell with its very small size has a large surface area compared with its volume. Let us illustrate this by considering the two cubes A and B in Fig.5.11.

![Cube A](1cm x 1cm)

![Cube B](2cm x 2cm)

Fig.5.11

A
Area of 1 face: 1cm x 1cm = 1cm²
Area of 6 faces: 6 x 1cm² = 6cm²
Volume of cube: 1cm x 1cm x 1cm = 1cm³

B
Area of 1 face: 2cm x 2cm = 4cm²
Area of 6 face: 6 x 4cm² = 24cm²
Volume of cube: 2cm x 2cm x 2cm = 8cm³

Surface area/volume = 6cm⁻¹ or 3cm⁻¹

We notice that the surface area/volume ratio of A, the smaller cube, is twice as large as that for B. We can thus make this statement: as an object increases in size the surface area/volume ratio gets smaller. However, respiratory surfaces in organisms have the feature of large surface area so that the reactants (of a chemical reaction) could be spread thinly and aid diffusion.

Tissue respiration

We have discussed how air is brought close to respiratory surfaces. There is usually more oxygen in the air than there is in the cell of the respiratory organs. The oxygen in solution, diffuses across the cell membranes and into the blood. Blood in man contains a red pigment, haemoglobin, which allows it to carry much oxygen. The haemoglobin combines with the oxygen, forming oxyhaemoglobin.

Oxygen + haemoglobin = oxyhaemoglobin

Oxyhaemoglobin is carried by the blood to every cell. The concentration of oxygen in the cells is very low. Oxygen passes out of the blood, by diffusion, into the cells, and haemoglobin is re-formed:-

Oxyhaemoglobin = oxygen + haemoglobin

Each cell uses the oxygen to oxidise (burn) the food in it. This is tissue respiration, also called cellular respiration and internal respiration. The energy stored in the food is released in a form that can be used for life processes. Activities can be done, using that potential energy.

Much carbon dioxide diffuses out of each cell into the blood. The blood returns to the respiratory surface. There, carbon dioxide is in greater concentration in the blood than in the cells of the
respiratory surfaces. Carbon dioxide diffuses out of the gill filaments into the water as it flows over them. In mammals, the carbon dioxide diffuses out of the cells of the alveoli, into the air sacs. The air is forced out of the lungs at exhalation.

**Respiratory reactants and products**

So far we have considered respiration as an energy-releasing process in cells. We have distinguished respiration, a cellular process, from breathing, a mechanical process for moving the gases, oxygen and carbon dioxide, between the respiratory surface and the surroundings.

In this section, we are going to study both the word equation and the chemical equation that represent the process of respiration. We will also learn how to test for the reactants and products of respiration.

Respiration is a biochemical process.
Q. What reactants take part in respiration?
A. Food and oxygen.
Q. In what form is the food?
A. Food has been ingested, digested and absorbed. The part respired is usually in the form of a simple substance viz. glucose.
Q. What products are formed when glucose and oxygen react?
A. The products are carbon dioxide, water, (usually in the form of water vapour) and energy.
Q. How is it that carbon dioxide and water are formed?
A. Glucose consists of carbon(C), hydrogen (H) and oxygen (O). Its formula is \( C_6H_{12}O_6 \). When the carbon is oxidised, carbon dioxide is formed. When the hydrogen is oxidised, water is formed.

Q. How much energy is released?
A. In aerobic respiration all the energy of the food is released, viz. 2900 kJ per molecule of glucose. In anaerobic respiration only 270kJ per molecule are released.
Q. Why is there less energy released in anaerobic respiration than in aerobic?
A. Although the reactant, glucose, is the same in both aerobic and anaerobic respiration, less energy is released in anaerobic respiration because the products still have stored energy.
Q. What are the products of anaerobic respiration?
A. That depends...! If it takes place in plants e.g. in yeast, the products are carbon dioxide, alcohol and energy. If it takes place in animals e.g. in our muscles, lactic acid is formed.
Q. What is the equation that represents aerobic respiration?
A. Let us work out a word equation.
   \[ \text{Glucose} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water} + \text{energy.} \]
   
Now for the chemical equation.
The chemical formula of glucose is \( C_6H_{12}O_6 \)

The balanced equation is:-
\[ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy.} \]
Q. What is the word equation that represents anaerobic respiration?
A. Oxygen is not used so(in muscles)
Glucose $\rightarrow$ Lactic acid + energy (0.83kJ/g) (In Yeast)

Glucose $\rightarrow$ Ethanol + carbon dioxide + energy (1.17kJ/g)

In yeast the reaction is called fermentation.

**Tests for the reactants and products**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Test</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactants</td>
<td>(a) Glucose</td>
<td>The blue colour of the reagent, changes to green if there is a little sugar; to orange if there is more. Cuprous oxide is formed.</td>
</tr>
<tr>
<td></td>
<td>(b) Oxygen</td>
<td>A glowing splint is re-kindled.</td>
</tr>
<tr>
<td>Products</td>
<td>(a) Carbon dioxide</td>
<td>Set up apparatus as shown in Fig. 5.12</td>
</tr>
</tbody>
</table>

![Diagram](image-url)

**Fig. 5.12 Test for carbon dioxide**

(a) Water vapour
(b) Blow on a mirror
(c) A mist forms on the cool surface of the mirror forming fine droplets of water.

Air is pulled in from A. It bubbles through the lime water. The lime water does not turn milky.

Exhaled air bubbles through the lime water. Quickly the lime water is rendered 'turbid' or milky.

Blow in air at B

Wave your hand to and fro
Blow on your hand
Refer to the activity which follows

You feel air at room temperature.
You feel air at body temperature.
The temperature in the flask with the seeds soaked for 24 hours is higher than that in the flask with the sterilised seeds.
Activity: Do plants produce heat when they respire?

Things you will need
- 50g of seeds e.g. channa, which have been soaked for 24 hrs (They may have begun to germinate.)
- 50g of the same seeds, untreated
- 2 vacuum flasks
- 2 thermometers, graduated to read tenths of degree
- cotton wool
- 10% formalin/household disinfectant or antiseptic
- source of heat

Refer to Fig.5.13
- Boil the set of untreated seeds for about 10 minutes.
- Let the seeds cool.
- Soak the boiled seeds, briefly, in 10% formalin or wash them in a household disinfectant or antiseptic.
- Place one set of seeds in each flask. Put the thermometers in the mouths of the flask. Plug the mouths of the flask with cotton wool. Label each flask appropriately.
- Take and record the temperature of each flask every day, at approximately the same time each day, for about a week.

Energy in respiration

Energy is needed for all types of work and for other activities as well. For instance, when you are resting, you are not doing work. Nevertheless your body needs energy for its basic metabolic activities.

Food is eaten, amongst other reasons, to supply the body with energy. The energy stored in food is potential energy, not available to the organism for doing work. It is tissue respiration that releases the stored energy in a usable form. Some of the released energy is dissipated, i.e. lost, as heat. This heat is taken around our body by the blood. It helps to maintain our body temperature at an even level.

Fig. 5.13
Exercises

1. Calculate the surface area/volume ratio of a:
   • 1 cm cube
   • 3 cm cube
   • Explain the implications of your results where the size of animals is concerned.

2. What do you think is the effect on the rate of respiration of:-
   • vigorous exercise
   • age
   • pain
   • cold water on the skin
   • holding your breath?

3. Try and make a model of the chest.
   Things you will need.
   • a bell jar
   • one-holed rubber bung
   • long delivery tube
   • a balloon
   • a rubber sheet

4. Give the composition of air inhaled and exhaled.

5. Define respiration.

6. Compare and contrast burning and respiration.

7. What type of substances control the rate of respiration?

8. What is 'breathing'?

9. What kind of organs does each of the following have for respiration?
   (i) insects
   (ii) spiders
   (iii) mammals
   (iv) fishes

10. Name four characteristics of respiratory surfaces.

11. What effect does increase in size of animals have on respiration?

12. What is the site of true respiration?

13. Name two respiratory pigments found in animals.

14. What is the role of a respiratory pigment?

15. Write a word equation representing the process of respiration.

16. What is the energy from respiration, used for?

Directions.
Each of the following ten questions consists of a statement in the left hand column followed by a second statement in the right hand column.

Decide whether the first statement is true or false. Decide whether the second statement is true or false.
Then answer:-

(A) - If both statements are true and the second statement is a **correct explanation** of the first statement.

(B) - If both statements are true and the second statement is **not a correct explanation** of the first statement.

(C) - If the first statement is true but the second statement is false.

(D) - If the first statement is false but the second statement is true.

(E) - If both statements are false.

---

**First statement**

17. Potential energy is stored in food

18. Only specific cells in organisms respire.

19. Energy in respiration is used to do work and other activities.

20. Respiration is always a burning process.

21. Oxygen is essential for cellular respiration

22. Respiration without oxygen is termed anaerobic respiration.

23. Water flows into a fish's mouth, over its gills and out again through its mouth.

24. Air flows into a man's nostrils, through the nasal passages, into his lungs and back along the same path.

25. No energy is needed for air to enter the lungs of mammals.

26. Energy is needed for air to be forced out of the lungs of mammals.

**Second statement**

Energy is released by respiration

Every cell in organisms has a food supply.

Without energy no work can be done.

When food is respired the energy stored in it is released all at once.

Energy can only be liberated by aerobic respiration.

If oxygen is supplied to anaerobes they would die.

As water flows over the gills, the blood flows near the surface of the gills and gases are exchanged.

Oxygen in the air that enters the lungs diffuses into the blood vessels in the lining of the lungs.

The elastic walls of the lungs expand and the pressure in the lungs decreases.

Inhaled and exhaled air have the same composition; only their temperatures differ.
WE HAVE LEARNT THAT

- food has stored or potential energy.
- respiration releases potential energy as kinetic energy, for work and other activities.
- when oxygen is involved in respiration it is aerobic; when not, it is anaerobic.
- respiration takes place in steps. Each step is controlled by a respiratory enzyme.
- respiration takes place in every cell.
- the term "breathing" refers to external respiration. It refers to the movements in animals, that get air close to the respiratory surfaces.
- small plants and animals have a large surface area/volume ratio. Enough gases can diffuse in and out, easily, through their surfaces to suffice the needs of their cells.
- larger animals have respiratory organs and blood, to help to take oxygen to each cell and take carbon dioxide from each cell. Larger plants have a system of stomata and lenticels. Those structures admit air. Oxygen diffuses in, carbon dioxide diffuses out.
- once oxygen gets to the site of the individual cell, tissue respiration takes place, and the energy stored in the food in the cell is released.
- the initial reactants of aerobic respiration are glucose and oxygen.
- the final products of aerobic respiration are carbon dioxide, water and energy.
- the word and chemical equations for aerobic respiration are:-
  Glucose + oxygen → carbon dioxide + water + energy.
  \[ C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 2900kJ. \]
- the energy released in aerobic respiration per molecule of glucose is 2900kJ.
- the energy released in anaerobic respiration per molecule of glucose is 270kJ.
Introduction

Energy is an important concept that influences all of Science, indeed, the world. Students of Biology, Chemistry, Engineering, Home Economics, Integrated Science and Physics, all debate it. We see and experience the effects of energy when something is happening, yet have difficulty in defining it. We are aware that persons, places, things and processes have energy, so we know that energy cannot be produced from nowhere, but must have a source.

Without heat from the sun, life could not exist. Light makes us see the size, and colour of things around us. With electricity we enjoy radios, television, electric light, electric washers, sewing machines and much more. Sound energy allows us to enjoy music such as calypso, soca and reggae. Chemical energy or energy from food enables us to grow and be active. We use large amounts of mechanical energy in the forms of potential and kinetic energy when we run a cross-country marathon. So energy is an essential part of our world and must exist in one form or another.

We observe our surroundings and learn from our engineers, the value of machines. Whether simple or complex, machines utilize, modify, transmit or apply energy in its various forms to make tasks, jobs and work easier and more convenient for us all.

In this unit, you will learn about:
- the nature, forms and types of energy
- energy conversion, interconversion, and the principle of energy conservation
- energy transfer and machines.

Nature, forms and types of energy

Do you have needs? Of course you do! This means that you need energy in its various forms. Fig. 6.1 shows some examples of the forms of energy.

We observe the following:-
- Mammals need a great deal of energy to keep their body temperature at the right level.
- Every aspect of staying alive has an energy need.
- Stored energy is carried in the blood stream to all the body cells, usually in the form of the simple sugar, glucose \((C_6H_{12}O_6)\).
- Plants need a constant supply of energy to stay alive.

We examine a number of energy situations and note that energy can be measured and quantified using the unit - Joules (J) and Kilojoules (kJ), as shown in the Table 6.1.
Fig. 6.1  Forms of energy
Table 6.1 Energy values for given situations.

<table>
<thead>
<tr>
<th>Situations where energy is present or needed</th>
<th>Comment</th>
<th>Type of energy</th>
<th>Energy value, measured in Joules, J</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>stretched rubber band</td>
<td>potential energy</td>
<td>1 J</td>
</tr>
<tr>
<td></td>
<td>you, on top of a step - ladder</td>
<td>potential energy</td>
<td>500 J</td>
</tr>
<tr>
<td></td>
<td>kicked football</td>
<td>kinetic energy</td>
<td>50 J</td>
</tr>
<tr>
<td></td>
<td>small car at 30 km/h</td>
<td>kinetic energy</td>
<td>500 000 J</td>
</tr>
<tr>
<td></td>
<td>hot cup of tea</td>
<td>heat energy</td>
<td>150 000 J</td>
</tr>
<tr>
<td></td>
<td>torch battery</td>
<td>chemical energy</td>
<td>10 000 J</td>
</tr>
<tr>
<td></td>
<td>chocolate biscuit</td>
<td>chemical energy</td>
<td>500 000 J</td>
</tr>
<tr>
<td></td>
<td>litre of petrol</td>
<td>chemical energy</td>
<td>35 000 000 J</td>
</tr>
</tbody>
</table>
Energy conversion, interconversion, and the principles of energy conservation

Energy conversion is the process by which energy in one form is converted to energy of one or more forms, while energy interconversion is the process by which energy of one form is converted to energy of one or more forms, and the process is reversible.

A system which changes energy from one form to another is called a transducer. An electric light bulb is a transducer since it changes electrical energy to light and heat energy.

![Energy conversion diagram](image)

**Activity**

Study the map on energy changes shown below. Copy it and complete the energy output column.

<table>
<thead>
<tr>
<th>Energy input</th>
<th>Energy changer</th>
<th>Energy output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td>Heating element</td>
<td></td>
</tr>
<tr>
<td>Sound</td>
<td>Microphone</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Loudspeaker</td>
<td></td>
</tr>
<tr>
<td>Kinetic</td>
<td>Brakes</td>
<td></td>
</tr>
</tbody>
</table>

![Energy changes map](image)

We now examine energy interconversion. You swing a pendulum to and fro. The swinging pendulum is an energy system. Study the stages in its movements in the Table 6.2.
<table>
<thead>
<tr>
<th>Diagram of pendulum</th>
<th>Comments</th>
<th>Types of energy</th>
<th>Energy changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The bob is at its highest point. Its kinetic energy is zero and it has maximum potential energy</td>
<td>Potential energy</td>
<td>$P.E. = 50J$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{total energy } = 50J$</td>
</tr>
<tr>
<td>2.</td>
<td>The bob is at a lower point. Its kinetic energy has increased and its potential energy has decreased.</td>
<td>Potential energy and kinetic energy</td>
<td>$P.E.$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{total energy } = 50J$</td>
</tr>
<tr>
<td>3.</td>
<td>The bob is at its lowest point. It is moving at its fastest. It has maximum kinetic energy.</td>
<td>Kinetic energy</td>
<td>$K.E.$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{total energy } = 50J$</td>
</tr>
<tr>
<td>4.</td>
<td>The bob is at a higher point. Its kinetic energy has decreased and its potential energy has increased.</td>
<td>Potential energy and kinetic energy</td>
<td>$P.E.$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{total energy } = 50J$</td>
</tr>
<tr>
<td>5.</td>
<td>The bob has reached its highest point. Its kinetic energy is zero and it has maximum potential energy</td>
<td>Potential energy</td>
<td>$P.E. = 50J$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{total energy } = 50J$</td>
</tr>
</tbody>
</table>

Key: Potential energy - P.E., Kinetic energy - K.E.
We observe that energy does not vanish, but just changes form. Scientists call this an energy chain. In every energy chain, the total amount of energy remains unchanged. This idea is called the law of conservation of energy. This means that energy can change into different forms, but it cannot be created nor be destroyed. So, energy interconversion and conservation go hand-in-hand.

**Energy transfer and machines**

When we speak of machines, most of us think of complex devices such as sewing machines, steam engines, motor cars, draglines and bulldozers.

You use some types of simple machines nearly every day. You use them to open a door, a can, a bottle, to raise a sail, a flag, a window shade, to catch a fish, hit a home run, split a log, to shovel seed, rake leaves and hammer nails. Without many machines, tasks would be more difficult and time-consuming.

Enabling machines to do what they do are the concepts of energy transfer, forces and energy conservation. We have seen that energy can be measured, we now look at measuring force using force measurer, or newton - meter.

**Activity: Making a force measurer**

You will need a wooden dowel rod, about 300 mm long and 10 mm in diameter; a piece of pvc pipe, 100 mm long and 20 mm in diameter; three cup hooks; two elastic bands as shown in Fig.6.4. Attach cup hooks as shown. Cut two notches on opposite sides at one end of the pipe. Assemble as shown.

![Fig. 6.4 Making a force measurer](image)

Observe that the force measurer can be used to measure forces in any direction as shown in Fig.6.5.

![Fig. 6.5 Measuring force](image)

You are aware that force is measured in newtons, hence the need for the scale shown. The procedure for establishing a scale is called calibration, which you will do in project 4.
THE INCLINED PLANE

Many persons appreciate that lifting up a resistance R vertically requires much more effort than sliding that resistance up an incline as shown in Fig. 6.6.

The inclined plane, or ramp, is the simplest of all machines. It increases the effort distance through which you move an object i.e. AB > CB, but decreases the effort necessary to move it i.e. 17 newtons instead of 25 newtons.

How is the stair or step, an example of the inclined plane? Consider a sequence of ramps, lined up end - on - end as shown. Now you see it!

Well, identify other examples of inclined planes.
Observe that each time the screw makes a full turn, it moves through a distance called the pitch. The wood screw, bolt and nut and a screw type jack are examples of screws. (Fig. 6.9(a), 6.9(b).

Someone once said, 'give me a rod that is long enough and I will move the earth.' We will examine how this could be achieved by studying the Fig. 6.10.

Observe that the energy (stored) in the hand is transferred to the crowbar. At the moment of transfer a force is made to act on the crowbar. In this situation:

$$E \times D \text{ (energy input)} = R \times d \text{ (energy output)}$$

Fig. 6.11 represents a device called a lever, which is essentially a bar acting about a pivot. There are three common ways to set up a lever.

---

**Fig. 6.9 (a) The screw   (b) The bolt**

**Fig. 6.10 Relationship between diagram and process for the lever**

69
Fig. 6.11  The three types of lever

Observe that type 1 lever has input effort and the output resistance on opposite sides of the pivot. Examples of type 1 lever are seesaws, pliers, scissors. With type 2 lever, the pivot is at one end of the lever and the resistance is closer to it than the effort. Try to identify some examples of this type of lever. In the type 3 arrangement, the pivot is at one end of the lever and the resistance is farther from it than the effort. Try to

identify some examples of this type of lever.

Note that with levers, a small effort moving through a longer distance overcomes a larger resistance moving through a shorter distance. This type of machine is called a force multiplier.

THE PULLEY

Grip your chalkboard duster in the midsection, press it to the chalkboard and rotate, then remove. What do you see? A kind of wheel! So you see, the pulley is basically a rotating lever.
Exercises

1. In the table below, put ticks in the boxes to show the main types of energy involved. Put a ring round the tick that shows the type of energy before the energy transfers. The first one has been done for you.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chemical</th>
<th>Mechanical</th>
<th>Gravitational</th>
<th>Heat</th>
<th>Light</th>
<th>Sound</th>
<th>Electrical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas oven</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car going uphill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growing plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parachute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Study the diagrams below. Use the law of conservation to find the missing data.

(a) energy in the battery 10 J  
useful energy __ __ J 
wasted energy 3 J

(b) a stove. 100 J of chemical energy in fuel
20 J light energy
60 J heat energy
__ __ J wasted energy

3. Complete the word equation
A torch \rightarrow \text{Light energy} + ____

4. List 10 machines within your environment. Explain how machines are a vital part of our every day life.

5. Put a tick (✓) in the appropriate box. The first one has been done for you in the table below.

6. Show by means of simple diagrams how you can classify levers. On your diagrams label the load, pivot or fulcrum, effort.

7. Draw diagrams to illustrate three machines that are adaptations of the inclined plane.

<table>
<thead>
<tr>
<th>Device</th>
<th>First class lever</th>
<th>Second class lever</th>
<th>Third class lever</th>
</tr>
</thead>
<tbody>
<tr>
<td>a broom</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a nutcracker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a knife</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a pair of pliers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a pair of scissors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a screw driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a wheel barrow</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

72
8 Match one item of column A to one item of column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Lift a car so you could change a wheel.</td>
<td>(i) a crowbar</td>
</tr>
<tr>
<td>b) Lift a bucket of cement to the top of a building under construction.</td>
<td>(ii) an auger</td>
</tr>
<tr>
<td>c) Remove a big rock from the ground.</td>
<td>(iii) a screw driver</td>
</tr>
<tr>
<td>d) Drill a hole through a board.</td>
<td>(iv) a screw</td>
</tr>
<tr>
<td></td>
<td>(v) a jack</td>
</tr>
<tr>
<td></td>
<td>(vi) a pulley</td>
</tr>
</tbody>
</table>

Projects

- It is the muscular system that gives shape to your body and is the machinery for moving the bones. Construct a model of the human arm or knee to demonstrate the functioning of the muscles and movement.

- You are the chairperson of your Nation's Energy Commission. You must make plans for your nation's energy future. Here are your vital energy needs in heating, entertainment, lighting, communication, cooking, food storage, transport, building, industry, agriculture.

    Here are your available energy sources: biomass, geothermal, wind, wave, solar cell, tidal, solar panel, hydro, solar furnace, nuclear.

    Match the energy sources to the energy needs. Use your skill and judgement to get the best match.

- Calibrating your force measurer

    (a) Hang the top hook of your force measurer on the lower hook of a spring balance.

    (b) Make a mark on the rod where the top of the PVC pipe meets it.

    (c) Make another mark.

    (d) Repeat step (c) then (d), for different forces.

    (e) Mark 10 equal sub-divisions for each newton for alignment.

    You can now use your force measurer to measure forces to the tenth of a newton.
Now study the energy chart below, copy it and complete the energy change columns. The electric battery is done as an example.

**ENERGY CHART**

<table>
<thead>
<tr>
<th>Year</th>
<th>Transducer</th>
<th>Energy change</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>Electric battery</td>
<td>Chemical</td>
<td></td>
<td>Electrical</td>
</tr>
<tr>
<td>1820</td>
<td>Camera</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1831</td>
<td>Electric generator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1840</td>
<td>Bicycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1859</td>
<td>Internal combustion engine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1876</td>
<td>Microphone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1878</td>
<td>Filament light bulb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1884</td>
<td>Steam turbine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1896</td>
<td>Radio set</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1902</td>
<td>Photo cell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1926</td>
<td>Television</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1945</td>
<td>Radio telescope</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>Compact disc player</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
WE HAVE LEARNT THAT

• energy cannot be created from nowhere, but must have a source.
• mechanical energy exists in the form of potential and kinetic energy.
• potential energy is stored energy.
• kinetic energy is energy due to motion.
• all forms of energy are measured in joules (J).
• energy conversion is the process by which energy in one form is converted to energy of one or more forms.
• energy interconversion is energy conversion that is reversible.
• a transducer changes energy from one form to another.
• energy does not vanish, but just changes form.
• the law of conservation of energy means that energy can change into different forms but cannot be created nor destroyed.
• there are three classes of levers.
  • with a second class lever the load and the effort are on the same side of the pivot with the load closer to the pivot.
  • with a third class lever the load and the effort are on the same side of the pivot with the effort closer to the pivot.
• levers are force multipliers.
• the screw is a form of the inclined plane.
• the pulley is a rotating lever.
• a machine is a device that helps you do work.
• all machines are made up of one or more simple machines.
• every job has an energy cost.
• some machines need fuel or chemical energy to do work.
• machines are a vital part of our everyday life.
Introduction

What holds a bridge up but also causes it to fall apart? What causes electric current to flow through conductors and water through pipes? **Forces** do! The action of forces explains many circumstances known to us.

We can examine a number of situations in Table 7.1 to appreciate forces at work.

In this unit, we will examine:

- the key features associated with the shape and form of things
- the effect of these features on stability and staying upright.
- how animals stay upright
- how plants stay upright
- the factors enabling/hindering movement
- methods for reducing friction.

Table 7.1  Forces at work

<table>
<thead>
<tr>
<th>Situation where force acts</th>
<th>Comment</th>
<th>Type of forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="" /></td>
<td>Two forces ($\rightarrow$) squash an object when they are in opposite directions along the same line.</td>
<td>mechanical squashing</td>
</tr>
<tr>
<td><img src="image2" alt="" /></td>
<td>The turning effect increases with the handle's length. A bigger force will have a bigger effect.</td>
<td>mechanical turning</td>
</tr>
</tbody>
</table>
A pair of equal and opposite parallel forces which do not act through a point and cause rotation only.

You need three forces to bend a ruler.

**Gravity** pulls you down - unless another force pulls you up. This is the force which makes planets circle the sun.

**Capillarity** is a force which causes liquids to rise up narrow tubes.

**Cohesion** is the force of attraction which exists between molecules of the same kind.

**Adhesion** is the force of attraction which exists between molecules of different kinds.

**Surface tension** is the force of attraction of molecules which cause the surface of a liquid to behave as if it were covered by an invisible elastic skin. Note however that there are forces other than mechanical.
Factors affecting staying upright

We examine in some detail the circumstance known to us as staying upright. Firstly, we observe that around us are non-living things, plants and animals. These all have shape and form, and may be made up of materials of varying densities.

Associated with shape and form of objects are a number of features such as regular; irregular; symmetrical, asymmetrical; centre of mass (CM) or centre of gravity (CG); positioning; height of CM/CG with respect to a surface. We will discuss how these features affect staying upright.

- Regular, irregular
- Symmetrical, asymmetrical

Using a basic shape, the unit square, we take five of these and fashion a number of forms as shown below.

![Various forms](image)

Recalling our knowledge of mathematics, we observe that:

- Fig. 7.1 (a) is regular, i.e. all sides have the same size, whereas Fig. 7.1 (b), (c), and (d) are irregular i.e. the sides have varying sizes. So we can appreciate that the things we observe can be regular or irregular.
- Fig. 7.1(a) has symmetry, whereas Fig. 7.1 (c) is asymmetrical.

We observe that:

- The four figures have the same mass, since each is made up of the same five units. However, each figure has a different centre of mass or centre of gravity, which is the point at which all of the mass or weight appears to act, i.e. the point of balance.

We note the following:

(a) for each object, there is only one CG
(b) for symmetrical bodies the position of the CG can be found by symmetry as in Fig. 7.1 (a), (b), (d). Thus, for a uniform rod, it is at the middle Fig. 7.2a; for a uniform sphere, at the centre, as in Fig. 7.2b.

![Uniform rod and sphere](image)

Fig. 7.2  (a) A uniform rod
(b) A uniform sphere (solid)
(c) When a body is pivoted freely, it comes to rest with the CG vertically below the point of support as in Fig. 7.3.

![Fig. 7.3 An object freely suspended](image)

(d) For a body which can be divided into two parts, for each of which the centres of gravity \( CG_1 \) and \( CG_2 \) can be found, the centre of gravity \( CG \) of the body lies along the line joining \( CG_1 \) and \( CG_2 \) as in Fig. 7.4.

![Fig. 7.4 Centre of Gravity, CG from two CGs, CG₁ and CG₂](image)

Now look back at Fig. 7.1 (a), (b), (c) and their CGs.

(e) Note, however, the CG of an object can exist at the geometric centre, but where no material is present as illustrated below.

![Fig. 7.5 A ring, a basket ball, an empty cup, a bow](image)

(f) Note also, objects with varying material throughout may have their CGs very different from the geometrical centre as shown in Fig. 7.6.

![Fig. 7.6 A toy](image)

We observe that an object of a specific shape can be positioned on a surface in many ways as shown in Fig. 7.7, with varying base areas supporting it.

![Fig. 7.7 A cone in various positions](image)

We also observe that the height of the centre of gravity changes with the position of the object.

The slightest air current will cause the cone in Fig. 7.7a to move, the CG is lowered in the process and extends beyond the supporting base, hence the cone soon topples. When the apex of the cone in Fig. 7.7b is pushed the CG is raised and extends beyond its new supporting base, so it topples. The cone in Fig. 7.7c, no matter how it rolls about has its CG at the same height, and there is no toppling.
Attach a plumbline to the centre of one face of a heavy wooden block and tilt the block until it topples over as in Fig. 7.8. Observe that when the plumb line extends beyond the supporting base of the block, the block topples.

Fig. 7.8 The block topples when the CG extends beyond its support base.

Now that we have an appreciation of the factors involved in maintaining an object in stable condition, we will examine how animals and plants stay upright.

**How animals stay upright**

Animals need to stay upright and at the same time, be able to move from place to place maintaining balance. You understand that CG is a very important idea. Consider yourself standing upright with your arms hanging at your side; your CG is within your body, 2 to 3 cm below your navel, and half way between your front and back, varying with gender and age.

Fig. 7.9 The human skeleton
If you raise your arms vertically overhead your CG raises 5 to 8 cm. Bend your body into a U or C shape and your CG may be located outside your body. It is this knowledge that a high jumper uses to clear the bar by ensuring his CG just passes beneath the bar.

But what exactly is this body? It is the ultimate coordination of a number of systems, not the least of which are the skeleton and muscles.

**The skeleton**

The skeleton is the hard framework of things or the bones of animals. Some vertebrates have skeletons within the body, i.e. an internal skeleton called an *endo* - skeleton (*endo*-means inside), whereas invertebrates have an outside skeleton called an *exo* - skeleton (*exo*-means outside).

The human skeleton is the white framework of the 206 bones of the body. These bones are more remarkable than any girders that hold up the tallest buildings. (see Fig. 7.9)

Note that bones are living substances made of minerals such as calcium phosphate and magnesium salts which causes progressive hardening with age. They also contain collagen fibres, a protein, which contributes to elasticity.

Look around you, and observe that animals can do many things from forming cart wheels and somersaults to climbing trees or curling up in a barrel. All this is made possible by a system of joints and muscles. Now examine table 7-2 for an appreciation of some types of joints.

<table>
<thead>
<tr>
<th>Type of Joint</th>
<th>Illustration</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ball and socket joint</td>
<td><img src="image" alt="Illustration" /></td>
<td>Shoulder joint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hip joint</td>
</tr>
<tr>
<td>• Hinge joints</td>
<td><img src="image" alt="Illustration" /></td>
<td>Elbow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knee</td>
</tr>
</tbody>
</table>

Observe, that no man-made machinery is as extraordinarily constructed for strong, smooth motion as our own joints.

However, it is the system of muscles, which come in any size, that gives shape to your body and is the machinery which moves the bones in a manner similar to strings on a puppet. This important role of muscles is demonstrated by the fact that they make up about 40% of your body weight.
Tendons, which do not stretch, are strong tissue which attach the muscles to the bones. The relationship among bones, joints, muscles and tendons can be understood by examining the arm in the two positions shown in Fig. 7.10.

Sense of balance

So far we have learnt that, shape, form, symmetry, distribution of densities, locations of centres of gravity, supporting base area, all contribute to stability. However, animals move using their skeletons, muscles, joints and tendons as well as their brains and ears.

As they move, changing forms in the process, the positions of their CGs and supporting base areas change, upsetting their stability. The brain and ear act together, automatically, to adjust the CGs to locations that ensure stability. How is this accomplished?

Each ear has three semi-circular canals each at right angles to the other. Near one end of each canal is a swelling called the ampulla which contains hairs embedded in a jelly called the cupula. The semi-circular canals are sensitive to movement of the head. When you move your head, the cupula pulls on the hairs causing the hair cells to send messages along nerves to the brain. By comparing the messages, your brain can tell exactly how your head is moving and make adjustments to ensure your balance. You will learn more about the ear in Unit 9.

How plants stay upright

Plants also have skeletons viz. hydrostatic and endo-skeletons. These serve mainly for support. Plants are anchored by various types of root systems which provide supporting base area. (see Fig. 7.11). Plants stems, root and leaves contain xylem.

Xylem is made of cells which have very strong walls containing lignin which forms wood.

The larger and taller the plant, the more it needs support. You would have observed that occasionally mango, bread-fruit, flamboyant and other trees are trimmed, but that trimming is done while maintaining the trees' symmetry. In parts of plants, where there is little xylem, support comes from cell turgor, i.e. when a plant has plenty of water, the cells become firm or turgid pressing out wards on the cell walls holding the plant firm and upright.
Movement

We have been studying our surroundings and are aware that living things move to meet their basic needs. Animals crawl, walk, run, jump, swim, or fly in moving from place to place, while plants exhibit sensitivity by bending, closing or opening as they respond to sunlight and touch. On the other hand, a motor car, for example, will accelerate when the chemical energy from the petrol causes combustion in the engine. The movements described so far can be linear or angular as illustrated in Fig. 7.12 and Fig. 7.13.

Fig. 7.12 Linear motion

Fig. 7.13 Angular motion

All aspects of these movements can be explained using what you have learnt about cells, tissues, nutrients, machines, forces, energy, skeletons, bones, joints, muscles, centre of gravity and the role of the brain in interpreting messages.

Factors enabling movement

In order to understand movement, we will study our own motion. We note, that scientists, like Sir Issac Newton, have demonstrated to us that human motion, in all its variety obeys the laws of all motion. We now study a number of circumstances in Fig. 7.14 below. Note, arrow →, represents force applied.

<table>
<thead>
<tr>
<th>Situation 1</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>at rest</td>
<td>at rest</td>
<td></td>
</tr>
<tr>
<td>Then</td>
<td>later</td>
<td>now</td>
</tr>
</tbody>
</table>

Everything in the universe is lazy

<table>
<thead>
<tr>
<th>Situation 2</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>at rest</td>
<td>10km/h</td>
<td></td>
</tr>
<tr>
<td>Then</td>
<td>later</td>
<td>now</td>
</tr>
</tbody>
</table>

Force jettison the move

Travels in straight line with constant speed

<table>
<thead>
<tr>
<th>Situation 3</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>10km/h</td>
<td>at rest</td>
<td></td>
</tr>
<tr>
<td>Then</td>
<td>Now</td>
<td></td>
</tr>
</tbody>
</table>

Force must be applied to stop it

<table>
<thead>
<tr>
<th>Situation 4</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>10km/h</td>
<td>10km/h</td>
<td></td>
</tr>
<tr>
<td>Then</td>
<td>now</td>
<td>later</td>
</tr>
</tbody>
</table>

Force must be applied to change direction

<table>
<thead>
<tr>
<th>Situation 5</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>10km/h</td>
<td>20km/h</td>
<td>30km/h</td>
</tr>
<tr>
<td>Now</td>
<td>later</td>
<td></td>
</tr>
</tbody>
</table>

Force must be applied to speed up

<table>
<thead>
<tr>
<th>Situation 6</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>30km/h</td>
<td>10km/h</td>
<td></td>
</tr>
<tr>
<td>Now</td>
<td>then</td>
<td></td>
</tr>
</tbody>
</table>

Reduced force slows it down

Fig. 7.14 Newton's first law of motion
This study informs us of the First Law of Motion, which states simply that everything in the universe is lazy, so lazy that force is necessary to get it on the move, when it then travels in a straight line with constant speed, so lazy that, once in motion, further force must be applied to slow it down, stop it, speed it up or change its direction. Observe however, that the effect of the force applied, also varies with the point of application, P, as shown in Fig. 7.15.

![Fig. 7.15 Effect of a force](image)

You sit, for example, on your bench, your weight will be the action force and the support from the bench will be the reaction force.

![Fig. 7.16 Action vs. reaction](image)

That is, for any situation or system, a single isolated force is an impossibility; since for every action there is a reaction, equal and opposite, but never cancelling each other out (see Fig. 7.16). This leads us to Newton's Third Law of Motion.

With Newton's laws in mind, we note that the athlete would move through space uniformly, and indefinitely on a straight path; but air resistance will slow him/her down, and gravity will pull him down resulting in his path curving downward.

Movement of any part of the body is produced by contraction and relaxation of muscle fibres, but no muscle can act unless a nerve message is brought to it from the brain or spinal cord. Movements such as running, walking require a great deal of organisation through a large number of muscles.

Initially, the athlete uses his foot as a second lever, in rising on his toes, see Fig. 7.17.

![Fig. 7.17 The foot as a lever](image)

Through a system of other levers in his body he is able to apply muscle forces which are provided by tensions of the muscle fibres throughout the muscular system, and coordinated by the brain.

**Factors hindering movement**

If you walk on a muddy dam, how do your feet feel? Can you run very fast on a muddy dam? On a gravel dam, you can get a better grip on the gravel when you walk or run. These circumstances can be explained by an idea called friction, which we will examine in the following activity.
General discussion

Our activity has demonstrated to us that friction exists between surfaces and makes things move slowly. Other activities around us such as:

(a) the rubbing of a brick against a concrete wall shows us that friction makes things get hot.

(b) the on-going movement of a metal part over another in a machine results in the wearing away of their surfaces.

(c) the movement of objects through fluids (i.e. gases and liquids) also shows resistance due to friction with the fluid molecules - known as drag.

The above effects of friction are not always desirable. So we ask ourselves the question: Can frictional forces be altered? Well!, we observe that if we put a few drops of water between a wooden block and the surface beneath it, the nature of the surfaces in contact is changed. Instead of wood being in contact with wood, water is in contact with wood. Similarly, if we use oil instead, the interacting surfaces are changed. Engineers use this knowledge to either reduce friction or increase it.

Reducing friction

Friction can be reduced by the following means, viz:

- lubrication - a means of gaining smoothness
- use of bearings
- streamlining.
Lubrication

We observe that all engines have lubricating systems which use lubricating oils to perform the following jobs:

- lubricate moving parts to minimize wear
- minimize power losses in the engine
- serve as a cooling agent
- form gastight seal between piston rings and cylinder walls
- act as a cleaning agent by picking up particles of metal and carbon and carrying them away.

However, since oils lose their effectiveness, as an engine lubricant, with time, oils must be changed regularly.

Use of bearings

Bearings are placed in the engine wherever there is rotary motion between engine parts. Bearings can, for example, be ball bearings, mimicking your marbles, or be roller bearings, mimicking your round pencils. The bearing material is tough enough to minimize its wear, yet soft enough to trap damaging particles. In this way, the bearing wears and can be easily replaced, and not the more expensive engine part.

Streamlining

Streamlining makes it easier for objects to move through fluids (liquids) or gases. As an object such as a submarine or acroplane moves faster, the resistance becomes greater, and so streamlining becomes more significant at higher speeds. It reduces the drag of the object as it flows through a fluid, by encouraging smoother flow over the surface (Fig. 7.19).

Streamlining also affects living things, and is particularly helpful to relatively slow moving fish. With respect to birds, the wing is streamlined in cross-section allowing air to slip over the wing creating lift with minimum drag.

Increasing friction

We have learnt that friction can be helpful. Hence, we consider how friction can be increased when needed. We observe that many accidents are caused by over-smooth road surfaces or because loose gravel chips on the road cause vehicles to skid very easily. And so, properly made and maintained roads have a few loose chips and good drainage to remove water.

We also note that friction enables us to walk without continually slipping and falling over, hence the use of 'rough' patterns on the soles of shoes. Similarly, friction enables drive belts in motors to work to transmit power and enable brakes to be used to slow down or altogether stop things.

Streamlining a car makes it more "slippery" so that it has less wind resistance. The black lines illustrate how the air moves up, over, and around the car.

Fig. 7.19 Streamlining a car
Exercises

The following questions are on movement.

1. Study the picture below carefully.

2. Copy and complete the table below.

<table>
<thead>
<tr>
<th>Name object</th>
<th>Living thing</th>
<th>Non-living thing</th>
<th>Moves by itself</th>
<th>Moves by applied force</th>
<th>Types of movement</th>
<th>Forces of opposition</th>
</tr>
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<td></td>
<td>(✓)</td>
</tr>
</tbody>
</table>

3. Answer the questions on lubrication.
   a. Get a can with a flat smooth bottom and put some water in it to make it heavy.
   b. Put it on a sheet of glass or a smooth sheet of metal and use your force measure to find the force needed to move it.
   c. Now put some oil on the glass. Do you require a bigger force now to move the can over the oily surface?

   If you give the can a push, does it move further over the oiled surface than it does over the unoiled surface for the same force.
WE HAVE LEARNT THAT:

• the action of forces explains many circumstances known to us.
• living and non-living things have shape and form and their materials have varying densities.
• features such as regular, irregular; symmetrical, asymmetrical determine cm/cg.
• centre of mass or centre of gravity; positioning of height of CM/CG affect uprightness.
• for any object there is only one CG.
• for symmetrical bodies the position of the CG can be found by symmetry.
• animals need to stay upright and at the same time be able to move from place to place while maintaining balance.
• your CG is within your body, 2 to 3 cm below your navel, and halfway between your front and back.
• the body is the coordination of a number of systems.
• the skeleton is the hard framework of things or the bones of animals.
• some vertebrates have an internal skeleton called an endo- skeleton.
• invertebrates have an outside skeleton called an exo-skeleton.
• the human skeleton has 206 bones.
• bones are living substances made of minerals.
• animals move by a system of joints and muscles.
• tendons attach muscles to bones.
• each ear has three semi-circular canals which are sensitive to movement.
• the brain compares messages and makes adjustments to ensure balance.
• plants also have skeletons.
• plant stems, roots and leaves contain lignin.
• cell turgor supports plants with little xylem.
• all motion can be described by Sir Isaac Newton's three laws of motion.
• a single isolated forces is an impossibility.
• friction is a force between two surfaces, which can be a help or hindrance.
• friction can be static, sliding, or rolling.
• friction can be reduced by lubrication, bearings and streamlining.
Making electricity

Introduction

Electricity, a basic form of energy, is the most versatile form because it can be converted to other forms of energy. Electricity plays a vital role in nearly all aspects of man's life. Life has been made much easier and better. Can you imagine what life would be like without electricity? Here is an activity for you to do with your friends. Make a list of things that are done by using electricity. This will help you to imagine what life would be like without it. Electricity existed in nature long before man discovered it and harnessed it for use. The electric ray uses electricity in its fins for stunning its prey. The snake-like fish, the electric eel, also produces large amounts of electricity that can kill a man. In animals the nervous system works by small electric currents.

In this unit we will learn about

- how electricity can be produced
- electric circuits; series and parallel
- conductors and insulators
- current, voltage and resistance
- the heating effect of electricity
- the danger of electricity
- the safety precautions which must be followed when handling wire, plugs, electrical appliances and when flying kites
- what to do in an emergency.

How electricity is produced

Electricity can be produced in a number of ways.

Friction

Use a plastic pen and rub it on your hair about ten times and then hold the pen close to small pieces of tissue paper or chalk dust. You will find that the bits of paper or chalk dust would cling on to the pen. What you have done there is to create a form of electricity called static electricity. This kind of electricity is produced by friction. The pen becomes electrically charged. Static electricity is also found in the atmosphere. During a thunderstorm, clouds may become charged as they rub against each other. The lightning which we often see during a storm is caused by a large flow of electrical charges between clouds or between charged clouds and the earth. You must have heard of lightning striking a tree.

Chemical action

Another way of producing electricity is by chemical action. The chemical action between chemicals causes particles to move and produce another type of electricity called current electricity. This type of electricity can be stored in what is called a dry cell. You may have used dry cells in transistor radios, tape recorders, or flash-
lights. This act of producing current by chemical action was first discovered by an Italian scientist named Volta. He used three chemicals, **zinc**, **copper** and **dilute sulphuric acid**. The following gives an illustration of how this was done.

![A simple voltaic cell](image)

**Fig. 8.1** A simple voltaic cell

![A dry cell from the outside and cut in half](image)

**Fig. 8.2 (a)** A dry cell, (b) Accumulators and batteries
Today the principle of the voltaic cell is used to produce car batteries or accumulators. These have plates made of lead and another chemical in the form of dilute sulphuric acid. The acid is called the electrolyte.

The current produced by a chemical cell flows only in one direction. This is called direct current.

**Electromagnetic induction**

We can also produce current by electromagnetic induction.

If a bar magnet is plunged into the coil and then taken out, the needle of the galvanometer moves to and fro, showing that a current is flowing in the wire. This happens only when the magnet is moving. We say that a current has been induced in the wire. You may be able to try this in your school laboratory.

When the magnet is moved in and out of the coil, the direction of the current changes constantly. Such a current is called an alternating current.

![Diagram demonstrating apparatus for electromagnetic induction](image)

Fig. 8.3. Diagram demonstrating apparatus for electromagnetic induction

Most of the electricity which we use today is produced by generators. These generators work on the principle of induction. Look at Fig. 8.4.

In this case the coil is moved between the poles of a magnet. A current flows in the wire causing the bulb to light. Mechanical energy is changed to electrical energy.

The generators used in power plants which produce electricity for use in our homes are much more complex than the one shown in Fig. 8.4. The coils are connected to a set of wheels called a turbine. (Fig. 8.5)

![Model of a generator](image)

Fig. 8.4. Model of a generator

Mechanical energy is used to turn the turbines. The mechanical energy can be supplied by steam, or by water as in the case of hydroelectricity.

![Model of a steam turbine and generator](image)

Fig. 8.5. Model of a steam turbine and generator

In a "wind charger" mechanical energy from the wind is converted to electrical energy.
Hydroelectric generators

Have you ever heard of the Moco-Moco Hydroelectric plant in the Rupununi area of Guyana?

In a typical hydroelectric plant (Fig. 8.6), a large dam is built across a river to hold back the water. The water is released through special control gates. The flowing water turns the turbine which then turns a generator to produce electricity.

Fig. 8.6. View through a hydro-electric plant.
Nuclear energy to electricity

The energy within the nucleus of an atom is called nuclear energy. By a suitable method this energy can be released.

In a nuclear power plant, some of the nuclear energy becomes heat energy which can boil water to produce steam. The steam drives a turbine which in turn is used to run a generator. Thus nuclear energy is converted to electrical energy.

The Orella Health Centre on the Corentyne River is powered entirely by a solar cell system consisting of a series of solar cell panels, batteries to store the electrical energy and an inverter to convert the direct current from the batteries to alternating current for household use.

![Energy conversion in a nuclear power plant](image)

Although there is no nuclear-powered electrical plant in Guyana, there are many in other parts of the world. As humans use up more and more of the other fuels, such as coal and natural gas, they will turn more to other alternative power to generate electricity.

Solar cells

Some calculators use solar energy. Have you ever seen a solar cell in a calculator? A solar cell converts light energy from the sun to electrical energy. Solar cells require no moving parts so they do not wear out quickly. Many artificial satellites orbiting the earth are powered by solar cells. (Fig. 8.8.)

The disadvantage of solar cells is that they produce electricity only when light is shining on them. The electrical energy is normally stored in special batteries.

![Satellite powered by solar cells.](image)

Can you identify the solar panels?
Simple circuits

How does electricity travel from a power station, where it is produced, to our homes where we need it? How does it travel from the battery (which is what a group of cells is called) of a torchlight to the bulb?

In order to answer the above questions, we need to investigate for ourselves. However, it is not safe for us to experiment with electricity from the mains, so we will be using cells or battery as our source of electricity.

Making a simple circuit

![Diagram of a simple circuit](image)

Fig. 8.9 Components used to make a simple circuit.

Activity

- Examine the apparatus shown above.
  Notice the following:
  (a) The bulb has two contacts, one at the bottom and one at the side.

(b) The cell has two terminals one is marked positive (+) and the other negative (-).

- Using the wire connect the bulb and cell in four different ways to make the bulbs light.
- Answer the following questions:
  (a) Which two places on the bulb must be connected to the cell to make it light?
  (b) Which two places on the cell must be connected to the bulb to make it light?

Now, put the bulb in a holder and connect it to the cell and a switch as shown below.

![Diagram of a completed simple circuit](image)

Fig. 8.10 A simple circuit.

Put the switch on. Does the bulb light? Now turn the switch off. Does the bulb light? Why does it not light when the switch is off?

When the bulb lights, we think of the electricity as a current passing through it. As soon as the switch is turned off, the bulb goes out because the current stops.

For electric current to flow there must be an unbroken path for it from the cell and back again. In other words, there must be a complete circuit through which the current can pass.
Materials which allow electric current to pass through them are called conductors. Those which will not allow electric current to pass are called insulators.

The power station sends electricity to our homes through electrical cables forming a circuit. The torchlight has an electrical circuit connecting the cells to the bulb. (Fig. 8.11). Often, in a torchlight with a metal casing, the metal acts as part of the circuit from the battery to the bulb. If the torchlight has a plastic casing, a metal strip or wire inside acts as part of the circuit.

![Switch Cells Lamp (bulb)](image)

**Fig. 8.11** The torchlight - a simple circuit.

Do you think air is a conductor or an insulator?

**Testing for conductors and insulators**

Connect up a circuit as shown in Fig. 8.12, leaving a gap between points A and B. We will use this circuit to find out whether materials are conductors or insulators. Find a good variety of materials for testing, for example, plastic, rubber, graphite (‘lead’ pencil), water, a salt solution, acid, wood, gold (ring), mercury, aluminium, glass, brass, copper and silver. When the gap between A and B is left open, what is there in it? Is this material a conductor or insulator?

Use each test material in turn to close the gap in the circuit between A and B. Note the brightness of the lamp for each material tested. Record your results in the table shown, putting the names of materials which are conductors in one column and the names of materials which are insulators in the other.

![Diagram](image)

**Fig. 8.12** Testing for conductors and insulators.

<table>
<thead>
<tr>
<th>Conductors</th>
<th>Insulators</th>
</tr>
</thead>
</table>

When the lamp is bright, the material is a good conductor and is passing a large current. When the lamp is dimmer the material is a poorer conductor and is passing a smaller current. When the lamp is off, very little or no current is flowing and this means the material being tested is probably an insulator.

Using a lamp as the indicator, we can only show which materials conduct well enough to light it. If we wanted to show much smaller currents in many other materials, we would need to use a more sensitive current detector, such as a milli- or micro-ammeter in place of the lamp.
From your experiment you must have noticed the following results:

(a) All metals are good conductors. Mercury is the only liquid which conducts electricity well.

(b) Some materials are poor conductors e.g graphite, salt solution, acid and water.

(c) Some materials do not conduct electricity at all. Among these the best insulators are plastics, glass, polythene, porcelain, p.v.c (used to insulate electric cables) and rubber.

Symbols for electrical apparatus

So far, we have been using diagrams or pictures of components in the circuits which we have drawn. To save ourselves the trouble of drawing diagrams or pictures of the lay-out of apparatus each time we want to describe an experiment, we use certain symbols for each component. Here is a list of some components with their symbols.

Table 8.1

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Component</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Connecting Wire" /></td>
<td>connecting wire</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
<tr>
<td><img src="#" alt="Joined Wires" /></td>
<td>joined wires</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
<tr>
<td><img src="#" alt="Wire Cross, Not Joined" /></td>
<td>wires cross, not joined</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
<tr>
<td><img src="#" alt="Cell" /></td>
<td>cell</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
<tr>
<td><img src="#" alt="Battery of 3 Cells" /></td>
<td>battery of 3 cells</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
<tr>
<td><img src="#" alt="Bulb or Lamp" /></td>
<td>bulb or lamp</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
<tr>
<td><img src="#" alt="Switch" /></td>
<td>switch</td>
<td><img src="#" alt="Symbol" /></td>
</tr>
</tbody>
</table>
We shall add more symbols to the list as we use them.

The diagram below (Fig. 8.13) shows the circuit diagram for Fig 8.10

![Circuit diagram](image)

Fig. 8.13 Circuit diagram - a simple circuit.

**Electric current, voltage and resistance**

**Electric current**

In Unit 3, we looked at the atoms of elements. Do you remember we described the atom as consisting of protons (positive) and neutrons (uncharged) in the nucleus and negative electrons moving around? Well, it is the free electrons which are responsible for the conduction of electricity in metals.

We can think of an electric current in a metal wire as a movement, or flow of the electrons. The electrons are present in the atoms all the time, but to get an electric current we have to make them move. One way of doing this is to use a cell or a battery (a group of cell).

In Fig.8.13, the electrons flow round the circuit through the wires, the switch and the bulb. The cell acts like a pump and forces the electrons around. They leave the negative end of the cell, travel through the circuit and come back to the positive end of the cell. It must be noted that the cell does not produce the electrons - they are within the metal wire.

When scientists first investigated electric current, they thought it was the flow of positive charges repelled from the positive plate, and this was referred to as "conventional current". When the electron was discovered in 1895, it was realized that the guess had been wrong. Due to this old idea, the "conventional current" on current is still marked today as flowing from the positive of the cell to the negative, but the electron flow is really negative charges flowing the opposite way (Fig.8.14)

![Conventional current flow and electron flow](image)

Fig. 8.14 Conventional current flow and electron flow.

In order for us to measure electric current we use an instrument called an ammeter (symbol - A). The unit in which we measure current is the ampere (A). It was named after a famous scientist, Ampere. Since an ammeter measures the current flowing through a circuit, it is always connected in series with the other components.

An ammeter has two terminals - one marked positive (+) and the other negative (-). The positive terminal of the ammeter must be connected to the positive terminal of the battery. (Fig.8.15)
Voltage or potential difference

We mentioned earlier that the cell acts like a pump in driving electrons round a circuit. This also is true for all other sources of electricity. However, some sources can do this better than others. They have more power or strength behind them. We referred to this power to move electrons as voltage and is measured in volts (V).

We can compare the movement of electrons through a wire with the flow of water through a pipe at the bottom of a water tank (Fig. 8.16).

The greater the height of water in the tank, the greater will be the pressure of the water through the pipe. Voltage is something like an "electric pressure difference", and it is referred to as "potential difference" (p.d). The electric current on the other hand can be compared to the rate of flow of water through the pipe. The voltage does not flow. It is just an electric potential difference.

The voltage of an ordinary cell is 1.5 volts, whereas the voltage of a car battery is usually 12 volts. In Guyana, the voltage of the mains is 110 volts and 220 volts.

You can see that the voltage of the mains is very much higher than that of a cell, so our mains electricity is much more powerful. If you touch wires that are connected to the mains electricity supply you may get a severe shock which may be enough to kill you!

The voltage of a cell, a battery, or any other source of electricity is measured by using an instrument called a voltmeter. The symbol for a voltmeter is -V-. To find the voltage of a source of electricity e.g. a cell, you simply connect the voltmeter across it or parallel, connecting the terminal of the voltmeter marked (+) to the positive end of the source, and that marked (-) to the negative end (Fig. 8.17).
Resistance

Fig. 8.18 Investigating the resistance of a nichrome wire

Set up the circuit as shown above. The wire AB is made of a special alloy (mixture of metals) called nichrome which you can obtain from your laboratory. This alloy contains nickel, chromium and copper.

Slide the clip C from A towards B along the wire. What happens to the brightness of the bulb and the reading of the ammeter as you do this?

Do you think the current flows as easily through the nichrome wire as it does through the copper wire used to connect up the circuit? You will probably have noticed that the bulb does not glow as brightly when there is nichrome wire in the circuit as when there is copper. We say that the nichrome wire is opposing the flow of current through it, or that it is resisting the circuit. The greater the resistance, the smaller will be the current. Therefore, resistance is the ability to oppose the flow of an electric current.

A resistor is a piece of apparatus put into a circuit for the purpose of opposing the flow of electrons. The nichrome wire is an example of a resistor and so is the bulb on the circuit.

The symbol for a resistor is \[\text{\includegraphics[width=0.5\textwidth]{resistor}}\] or \[\text{\includegraphics[width=0.5\textwidth]{resistor}}\].

Kinds of circuits

Series circuits

Fig. 8.19 Series circuit

Connect up circuit 1 as shown above. Note the reading of the current on the ammeter. Now take the ammeter out and put it between the bulbs x and y (Circuit 2), and then between the bulb y and the battery (Circuit 3). Note the reading of the current on the ammeter in each case.

What do you notice about the readings of the ammeter in the different positions? What happens to the reading as soon as the circuit is broken at any point?
This type of circuit is called a **series circuit**. A **series circuit** has only one path for the current. The same current flows through everything in the circuit. When the switch is closed both bulbs light. A break anywhere in the circuit will stop the current flowing. Take out one of the bulbs—the other goes out. If one of the bulbs breaks, both bulbs go out. This is why series connection of bulbs is not a good idea; one out, all out.

You may have a set of Christmas tree lights that are in series. If they go out it is not easy to find the faulty one.

In a **parallel circuit** there is more than one path for the current. Fig. 8.20(a) shows a simple parallel circuit. When the switch is closed both bulbs light. Each bulb has its own branch of the circuit. The current from the battery divides at point A. Each bulb has a share of the current. These shares join together again at B and flow back to the battery. If you take out one bulb, what do you think will happen to the other one? If one bulb breaks, the other is not affected. Most lighting circuits in the home are in parallel.

If you use two bulbs and three switches (Fig. 8.20 b), you can make a circuit in which each bulb is controlled by its own switch. $S_1$ controls bulbs $x$ and $S_2$ controls bulb $y$. The third switch $S$ is a master switch. It controls the whole circuit. Neither lamp can be switched on unless the master-switch is on. Try to trace the circuit path for yourself. This master-switch is similar to the main switch in your home. When the main switch is off no appliance in the home can work.

### Connecting cells together

Cells may be connected in series or in parallel.

![Battery of three cells](image)

**Fig. 8.21** A battery of three cells
When two or more cells are connected in series as shown in Fig 8.21, that is, with the positive terminal of one cell connected to the negative terminal of the next, they form a **battery**.

Connect up the circuit as shown in Fig 8.17 again. Close the switch and note the reading on the voltmeter. Now, use two cells and then three. In each case note the reading on the voltmeter.

You may have noticed that the voltages for one to three cells in series increased in the order 1.5 volts to 3 volts to 4.5 volts. When cells are connected in series, the greater the number of cells the greater is the voltage. What do you think will be the voltage of four cells in series?

Fig. 8.22 shows three cells connected in **parallel** with all the positive terminals connected together and all the negative terminals connected together. Connect up the circuit in Fig.8.17 again. Now use two and then three cells in parallel and note the reading of the voltmeter in each case. What do you notice? Is the voltage the same in all three cases?

Any amount of 1.5 V cells connected in parallel will give the same effect as one large 1.5 V cell.

**Electricity in the home**

Electricity is very useful. It is also quite easily moved from one place to another by means of cables such as those which bring electricity into our homes. The energy is then available to us at the press of a switch. It does not have to be stored like coal, oil or gas. It is clean and quiet and can be easily changed into other forms of energy such as light, heat, sound and mechanical energy. But, household electricity can be dangerous.

The electricity which is supplied to our homes and schools is at a much higher voltage than that of an ordinary cell or battery. If our bodies should come in contact with such a high voltage, we can receive a severe ‘shock’ and burn. The heating effect of electricity can also lead to fires. Many fires are caused by faulty electrical wiring and appliances. It is therefore necessary to follow all precautions when handling electricity. You must protect yourself, others and the surroundings. Remember, **electricity can kill**!

**Heating effect of electricity**

We have already mentioned that an electric current can produce a heating effect. This effect is very useful in, say, an electric iron. But it can also be a nuisance, for example, in heating the cables through which an electric current flows.

We can demonstrate in the laboratory how strands of steel wool can be burnt owing to the heating effect of electricity. Fit up a circuit as in Fig.8.23.
Electrical safety

Electricity is very useful and can also be dangerous. Since we need to use electricity safely we should know about the design of circuits and safety devices used in houses and how to fit fuses and plugs correctly.

Fig. 8.23  Demonstrating the heating effect of an electric current.

A ‘flying’ lead is connected across the bulbs and can be made to touch some strands of steel wool connected in the circuit. What happens to the steel wool, and to the bulbs?

Now replace the steel wool with a piece of thin wire called a ‘fuse wire’. Connect the battery directly across the fuse wire so that a heavy current passes through it. What happens to the wire?

For the fuse wire to melt it must have got hot. Therefore, the electric current passes through the wire to make it hot. The soft thin fuse wire is made up of tin and lead, two metals which melt easily.

Many appliances use the heating effect of electricity. An electric lamp glows because the current passing through the wire in the lamp makes it get hot. The same current flows through both the wires and the lamp, but why do you think only the filament in the lamp gets hot? The reason is that the filament in the lamp has a higher resistance than the connecting wires. The electric kettle and the electric cooker are some appliances which use the heating effect of an electric current. Can you list some others?

Wires

Wires (or cables as they are sometimes called) are conductors which bring electricity into our homes and which are used to take electricity to the lamps and other appliances. These wires must be thick enough not to get too hot when they are carrying the normal current. If something goes wrong with the wiring a very large current might pass through the wires which would make them get red hot and this may set your house on fire.

Wires carrying current in the house need to be well insulated. You may have noticed that the wires attached to appliances are covered with plastic material. Why is this so?

Examine a length of cable such as that used to connect an appliance to a plug. Strip off about two centimeters of the thick outer covering. You will notice that there are either two or three smaller sets of wire in the cable. These wires have insulation of different colours so that we can tell the difference between them.

All appliances need two wires to form a complete circuit from the source, through the appliance and back to the mains. These are the live (brown) and neutral (blue) wires. Some appliances have three wires attached to them. The third is known as the earth wire and is usually green and yellow or green only. The earth connection is a safety device to prevent electric shock in the case of a faulty appliance. It is connected to the metal case of the appliance.

The colour codes used to differentiate among the live, neutral and earth wires are shown in Table 8.2.
Table 8. 2

<table>
<thead>
<tr>
<th>Code</th>
<th>Old standard</th>
<th>New international standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live wire, L</td>
<td>Red</td>
<td>Brown</td>
</tr>
<tr>
<td>Neutral wire, N</td>
<td>Black</td>
<td>Blue</td>
</tr>
<tr>
<td>Earth wire, E</td>
<td>Green</td>
<td>Green or Green/Yellow stripe</td>
</tr>
</tbody>
</table>

**PLUGS**

Appliances are connected to the main supply by **plugs** placed into **sockets**. (also called points) There are two kinds of plugs: two-pin plugs and three-pin plugs. The two-pin plug has two wires - the live and neutral.

![A two-pin plug](image)

**Fig. 8.24  A two-pin plug**

The three-pin plug has a third wire, the earth, for safety as mentioned earlier. We shall now look at how we can connect an electric cable to a three-pin plug. (Fig. 8.25)

![Wiring a three-pin plug](image)

**Fig. 8.25  Wiring a three-pin plug**

(a) Remove the cover from the plug and estimate the length of wire needed to reach the screws. Remember that the outer sheath of the cable should be firmly held by the cable grip and care should be taken not to remove too much of the outer ‘sheath’.

(b) Cut away the outer sheath. Be careful not to cut into the coloured insulation on the inner wires.
(c) Remove one to two centimeters of the coloured insulation from each of the three inner wires. Be careful not to cut off any of the fine strands of wire and leave enough insulation on each wire to protect it right up to the connector.

(d) Twist the fine strands in each wire together so that no stray strands are left loose inside the plug.

(e) If the plug has wrap-round screw terminals, bend the end of each wire round in the direction of tightening of the screw, as shown.

(f) Fit the wire to the correct terminal (marked L,N,or E on the plug) according to the colour code. Can you remember?

(g) Tighten the cable grip and test to see that the cable will not pull out.

(h) Place the fuse in the fuse holder.

(i) Replace the cover of the plug.

Do not fit appliances requiring a three-pin plug with a two-pin plug.

**Fuses/short circuit**

Fuses are safety devices which use the heating effect of an electric current. Suppose the wires leading to the lamp in your room have become so warm that the insulation round the wires has broken and the wires touch each other. The electricity, instead of going through the lamp, will now take the much easier path through the wires which are touching each other. A large current will flow and the cables could get very hot and start a fire. When two wires which should not be connected touch each other like this and a large current flows we say we have a **short circuit**.

This danger is reduced by putting into the circuit a **fuse**, consisting of a piece of soft thin fuse wire which melts as soon as it gets hot and thus breaks the circuit.

Houses have sealed fuses where the cables enter the house. You cannot interfere with these as only electricians employed by the electricity company are able to replace these fuses if they ‘blow’ or melt. These fuses are very unlikely to blow because there are smaller fuses in the circuit, inside your house, which blow first. Between these sealed fuses, called the main fuses, and the appliances in your house, there is a **fuse box** which contains fuses for the different circuits of the house. If a fuse is blown it must be replaced.

Before you touch a fuse you must be certain that the electricity is turned off at the main switch.
so that no electricity can get into the house. Otherwise you might touch a live wire and be killed! Some fuse boxes will not open until the current is switched off.

The 3-pin plugs which we have looked at earlier are fitted with a cartridge fuse, so that if the appliance connected to the plug takes too much current the fuse inside the plug blows. If this occurs, you first have to find out what made the fuse blow, rectify the fault and then put in a new cartridge fuse.

It is very important that a fuse of the right size, or rating, is fitted in the particular circuit. Thus, suppose you have a television set which takes a current of 3 amperes, a fuse of rating 5 amperes will be suitable. If, however, you have a 13 ampere fuse in the plug, it could allow dangerously high currents to be supplied to the set without the fuse blowing.

Another kind of safety device which prevents too high currents flowing in a circuit is the **circuit breaker**. This is a kind of magnetic switch which turns off the current automatically if it gets too large.

**Overloads**

Overloading of a circuit occurs when too many appliances are plugged into the same socket by means of a multiway adaptor (Fig. 8.28). This is a very dangerous practice and should never be encouraged. Overheating which may result from overloads can cause burns and fires.

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**Wet areas or hands**

When we were looking at conductors and insulators, you would have noticed that water was a conductor, a poor one. However, under certain conditions, especially at high voltages water can become a deadly conductor. Therefore, the earth and your bodies, particularly if wet or damp, are conductors. Handling electricity with wet hands can be fatal. Electricians should use dry tools and wear dry clothing and boots.

Electricity is normally transmitted by cables running on wooden posts. These cables are mounted on porcelain insulators which keep the cables stretched between the points of contact with the wood. Can you think why? Is wood a conductor or insulator? Damp wood is a conductor, and if the live wire were to touch the damp post, anyone touching the post would get a severe shock.

![Electricity is transmitted by cables running on wooden posts. Can you identify the porcelain insulators?](image)

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**Fig. 8.28** Overloading is dangerous!
Do not operate any electrical appliance or switch if any part of your body or clothing is wet. The greatest precautions must be taken in a kitchen and bathroom where water may be present.

**Appliances**

Computer system

Fan

Microwave oven

Tape recorder

Fig. 8.30 Electrical appliances

In your home many jobs are done by electrical **appliances**. Each appliance changes electrical energy to some other form, for example heat, light and mechanical. List the appliances which you use at home and at school. You should switch off and disconnect from the socket all appliances when not in use, and always before starting any repair work. You must also never leave long cables from electrical appliances trailing across a room, as this may cause accidents.

Do not install television antennae close to any high or low voltage electricity line.

Electronic appliance - television set, video cassette recorder, stereo system and the computer should not be connected to the same electrical outlet that supplies power to rotary or heating appliances such as fans, irons, microwave ovens or washing machines.

**Kite flying**

Fig. 8.31 Always fly your kite in open places

Kite flying is usually done during the Easter season, but this practice can be very dangerous if it is done where the kite or twine can come into
contact with electrical wires. You must always fly your kites in open spaces, free from any electrical wires. As we have mentioned earlier, water is a conductor and a damp string or twine can be a deadly conductor! If your kite or twine becomes entangled in an electric wire, do not pull; let go of it. It is better to lose your kite rather than your life. It is also advisable never to fly your kite during a thunderstorm as a flash of lightning could give you a strong electrical shock.

What to do in an emergency

Here is a list of some of the safety precautions you must take in cases of emergency.

- **ARCS/SPARKS:** If you observe sparks or bright lights or you hear sizzles or buzzes anywhere in your electricity system, especially during a thunderstorm, switch off the main switch.

- **ODOURS/OVERHEATING:** If there is a distinctive odour or any great heat coming from an electrical appliance - other than irons, hotplates etc, - always switch it off immediately; something is wrong!

- **FIRE:** If an electrical appliance is on fire, or if there is a fire in your building or in an adjoining building, always switch off the electricity at the main switch and inform the power company.

- **DANGLING WIRES:** Maintain a safe distance of at least six (6) feet from a burst electricity wire that may be dangling or lying on the ground. Inform the power company immediately.

- **ELECTRIC SHOCK:** If someone is accidentally shocked from a live wire, do not touch the person! Turn off the main switch immediately and inform the power company.

- **OTHER EMERGENCIES:** In case of any other emergency the key words are "SWITCH OFF".

**Exercises**

1. (a) The electricity produced in a bicycle generator is produced by:-
   (a) induction
   (b) friction
   (c) chemical
   (d) solar power

2. (b) A car battery produces electricity by
   (a) friction
   (b) solar power
   (c) chemical reaction
   (d) nuclear power

3. (c) Electricity produced by friction is called ______ electricity.
   (a) hydro
   (b) static
   (c) nuclear
   (d) solar

4. Choose the answer A - E which best fits each statement.
   (a) ammeters
   (b) cells
   (d) series
   (e) current

   (i) The current in a ______ circuit is the same whenever it is measured.

   (ii) A car battery is made up of several ______ connected in ______.

   (iii) Most lighting circuits in the home are connected in ______.
(iv) _____ are used to measure currents.

3. What are the advantages of connecting bulbs in parallel rather than in series?

4. Classify the following substances as conductors and insulators in the form of a table: wood, air, brass, rubber, cotton, gold, plastic, glass, silver, paper, aluminium, china, cloth, sugar, copper, mercury, tin, corn, copper, clay.

5. Draw circuit diagrams to show:
   (a) a battery of three cells and a switch in series, connected to two bulbs in parallel.
   (b) a battery of two cells, a switch and four bulbs all connected in series.

6. Cells can be connected in series or in parallel. If each cell in the following arrangements has a voltage of 1.5 volts, what would be the voltage across the points X and Y in each case?

7. State two ways in which electricity can be dangerous and five precautions which you can take to avoid danger.

8. List appliances, in each case, which change electrical energy to:
   (a) heat energy
   (b) light energy
   (c) mechanical energy

9. (a) Why are fuses put into circuits?
    (b) There are different places in the home where you may find a fuse. Where are they?

10. Egbert, an eleven year old boy, is flying his kite from his back step with a thin coil wire which his father threw away. Is this a safe practice? Discuss it with your friends and teacher.

Activities/Projects.

1. Collect pictures of sources of electricity and make a scrap book entitled "Sources of Electrical Energy". The pictures can include batteries of various sizes and shapes, small lighting plants, steam boiler turbines, windchargers, hydro-electric power stations, nuclear power stations, solar cells, etc.

2. Using cardboard boxes, pastes, tapes, three cells, two bulbs, three switches and connecting wires, make a doll house as shown in the diagram.
Light the upstairs light only, then the downstairs light only and then both lights together. What happens when the main switch is off?

3. Three students Ali, Balgobin and Carl are given a battery of three cells, three identical bulbs and connecting wires. They are told that the three bulbs can be connected in series or in parallel as shown.

Ali predicts that the bulbs in circuit 1 will light brighter than in circuit 2.

Carl predicts that the bulbs in circuit 1 will light just as bright as in circuit 2. Who is correct?

Carry out the investigation to find out whose prediction is correct. Include a conclusion in your report.
WE HAVE LEARNT THAT:

- electricity is a form of energy which plays a vital role in man's life.
- electricity can be produced by friction, chemical reaction and electromagnetic induction.
- hydro electric generators, nuclear power plant and solar cells can be used to transfer energy from different forms to electricity.
- a circuit is a complete path through which current can pass.
- conductors allow electric current to pass through them whereas insulators do not allow the passage of electric current.
- electric circuits can be drawn using symbols.
- electricity is connected with electric current and voltage (potential difference).
- ammeters are used to measure current in amperes and voltmeters are used to measure voltage in volts.
- resistance is the ability to oppose an electric current.
- there are two types of circuits - series circuits and parallel circuits.
- cells may be connected in series or in parallel.
- household electricity is useful but can also be dangerous if all precautions are not taken when handling it.
- electricity can produce a heating effect and this can be very beneficial but can also be a nuisance. Try to recap how this is so.
- safety precautions must always be followed when handling wires, plugs and electrical appliances.
- fuses must be fitted in circuits as safety devices in case there is a short circuit.
- we should never overload an electric socket.
- we should never handle electrical appliances with wet hands.
- you must always fly your kite in clear open areas away from electric wires.
- in case of emergency always switch off the main switch.
Unit 9

Detecting the environment

Introduction

It is very important for us to find out about ourselves and our surroundings, that is, to detect our environment. All information comes to us through our senses. What are the senses? They are the faculties by which stimuli from outside or inside the body are received and responded to by parts of the body.

Each sense is detected by a sense organ - a special structure where sensory cells are concentrated and which functions as a receptor. The eyes, ears, nose, tongue and the skin are all sense organs.

In this unit we will discuss

• the structure of each sense organ in the human body
• the way the sense organs function to keep us in touch with the world around us and to protect us from harm
• the stimuli to which each sense organ responds
• comparison of the eye with the simple camera, and the ear with a microphone
• the importance of caring for our sense organs and how to care for them.

The eye

Our eyes are the windows through which we can look at the world outside of ourselves. They are the most sensitive instruments that the body has to find out about the environment and we must take the best care of our eyes to keep them working well for us.

Fig. 9.1 The eye ball.

4 of the 6 muscles which turn the eyeball, so that you can look in different directions

The nerve which takes messages to the brain
Structure and functions of parts of the eye

Fig. 9.2. represents what the eyeball looks like inside.

The eyeball is fluid - filled with a front cavity and a back cavity. The front cavity contains a transparent watery liquid (the aqueous humour) that supports the front of the eye. The back cavity is filled with a transparent jelly-like substance (vitreous humour) which supports the back part of the eye.

The aqueous humour and the vitreous humour prevent the eyeball from collapsing inwards. Other parts of the eye are:

The lens - this separates the front cavity from the back cavity and is suspended between the aqueous humour in the front and the vitreous humour in the back. The function of the lens is to help focus light rays on to the retina.

The cornea - this is a transparent layer at the front of the eyeball. As it is transparent, it allows light to pass through and bends these light rays towards the lens. The cornea therefore helps in focussing light while covering the iris and the pupil.

The iris - the iris is the coloured ring of muscle around the pupil. It adjusts the size of the pupil thus controlling the amount of light entering the eye.

The pupil - this is the central hole formed by the iris. It is the opening through which light enters the eye and looks like a black circle in the centre of the iris.

The retina - this is like a screen on which a clear image is formed. It is sensitive to light falling on it, and from it messages go through the optic nerve to the brain.

How do we see?

In order for an object to be seen, light from the object must enter the eye. As light enters the eyeball, it is refracted or bent. It is bent by the cornea and by the lens, so that it comes to a focus on the retina. The retina has special light-sensitive cells which respond to the light and cause messages to go through the optic nerve to the brain which is able to interpret images of whatever is being viewed. Note the four important things that must occur for us to see:

(1) Light must enter the eye.
(2) The lens in our eye must focus light on to the retina.
(3) The optic nerve must take messages to the brain.
(4) The brain has to interpret images.

FORMING REAL IMAGES WITH CONVEX LENSES

You may wonder what forming images has to do with seeing well. The lenses in our eyes help in the formation of images by focussing light. Let us see how it happens.
The type of lens in the eye is a convex lens which will bring a parallel beam of light to a focus. The types of lenses which you have in your laboratory are made of glass. In the laboratory, see if you can get a picture of a window on a piece of paper or cardboard by holding a convex (converging) lens between the window and the paper. You will have to move the lens to and fro until you get a sharp image.

![Diagram of convex lens formation](image)

Fig. 9.3 Formation of a real image by a convex lens.

This picture is called a **real image** of the window. (The window is the object.)

Is the image the right way up? Is it **inverted** (upside down)? Is it the same way round as the window? Is the image smaller or larger than the object?

Note how far away from the paper you have to hold the lens to get a clear image. Now, repeat the experiment using lenses of varying thickness. Do you have to hold the lenses the same distance to get a sharp image?

You will have noticed that the image formed by the lens is inverted and smaller than the object. Also, the fatter the lens, the nearer it has to be held to the paper to get a clear image. The thinner the lens the further you have to hold it away from the screen (the paper on which the image is formed) to get a sharp image.

The eye has a convex lens, so the image formed on the retina (screen) of the eye is also inverted and smaller. The brain does a very wonderful thing in interpreting the image the right way up. The eye has to focus objects at different distances on to the retina. The distance between the lens and the retina in the eye cannot be altered, so the only way in which the eye can focus things at different distances is by changing the shape (thickness) of the lens. It does this by making the lens thicker or thinner. There are muscles at the sides of the lens which do this. This changing of the shape of the lens is called **accommodation**.

![Diagram of eye with accommodation](image)

(a) The near point

(b) The far point

Fig. 9.4 Accommodation.
Controlling brightness.

![Diagram of eye showing change in pupil size from bright light to dull light.](image)

Fig. 9.5 Changing the size of the pupil.

Look at the two eyes above. Do you notice a difference in the size of the pupil? As we have mentioned earlier, the iris controls the amount of light entering the eye by varying the size of the pupil. When the light is very bright the iris expands and makes the pupil smaller, and less light enters the eyeball. When the light is dull, the iris contracts and the pupil gets larger, and more light enters the eyeball to enable you to see clearly.

You can observe this change in the size of the pupils in your own eyes. Close your eyes for a few minutes, and then open them in front of a mirror, with a good light shining into them. The pupils will be large after your eyes have been closed for a few minutes, but will become smaller very rapidly. You will have to look very quickly. You may find it easier to observe the change in a friend’s eyes.

A simple lens camera

The camera is a man-made copy of the eye. The camera consists of a lens (made of glass) and a sensitive film (retina) in a light-tight box (eyeball), with provision for adjusting the distance between the lens and film. A shutter of variable speed, and a diaphragm (iris) of variable aperture (pupil), regulate the amount of light entering the camera. (Fig. 9.6). A sharp image is focussed on the film by turning a screw which varies the distance between the lens and the film. The image, like that formed on the retina of the eye, is smaller than the object and is inverted.

Care of our eyes.

Since our eyes are very important to us we must take good care of them. Whenever we are doing work (at home, in the laboratory or at a workshop) where there is a danger of particles getting into our eyes, we must wear goggles for protection. Though our eyes wash themselves in their own salty liquid (tears), they do need washing with clean cold water sometimes. Soap, shampoos and cosmetics should be kept well away from the eyes. If something does get into the eye, it should be washed out, not rubbed out. If this fails, medical aid should be sought. Never press on the eyeballs in any way, for, as you have seen, there is only the liquid and jelly inside the eyeball to support it. Pressing on the eyeball pushes it out of shape and this may affect your focussing. When using your eyes for close work like reading, sewing, or writing, be sure that you work in good light, but not in dazzling light. It is best if the light shines over your shoulder on to your work. Doing close work for long periods, watching television screens and cinema screens, and watching moving objects from a car or watching machines are all tiring to the eyes.
The ear

We will now investigate another of our senses through which we learn much about our surroundings. It is the sense of hearing. Our sense of hearing responds to sounds and the organ through which we perceive these sounds is the ear.

The human ear is a remarkable organ that can detect a wide range of sounds. How does it do this? It can convert signals carried by sound waves into nerve impulses that it sends to the brain.

The ear's structure

How the ear works

- The fleshy lobe of the outer ear, called the pinna collects and funnels sound waves into the ear canal.
- The sound waves travel along the ear canal to the eardrum.
- The eardrum starts to vibrate when it is hit by sound waves.
- These vibrations are passed through the middle ear by three tiny bones called ear ossicles. They are the hammer, anvil and stirrup and these three bones pass on vibrations to the oval window.
- The vibrations of the oval window are transmitted through the fluid of the cochlea which is in the inner ear.
- Inside the cochlea are tiny hair cells which are sensitive to sound vibrations. Movement of the fluid sets these hair cells vibrating.
- The vibrating hair cells send off nerve impulses to the brain along the auditory nerve.
- The brain then interprets these impulses as sounds.

Hearing sounds

Let us first examine some of the sounds around us. Close your eyes and for about two minutes try to listen carefully to what is going on around you. Open your eyes and write down what you heard. You may use sound words like ‘bang’ of a car door; ‘thud’ of a falling book; ‘rustle’ of paper being turned over. You may describe the sound by naming the source like ‘sound of voices’, ‘sound of breathing’, ‘sound of a sneeze’.
Don't you agree that there are numerous sounds we hear daily that we do not stop to think about? Much of our information about the world comes to us through our ears. Hearing is especially important for communication and sounds tell us much more than we may realise. A sound can warn us of danger, e.g. a car horn. Think about different kinds of sounds. A whistle has a 'shrill' sound. Some birds have a shrill call. A hard cuff into a pillow makes a dull sound. Some sounds are high-pitched, e.g. a scream; some are low-pitched, e.g. a growl; some are soft, e.g. a whisper; while some may be harsh, e.g. a bell. Can you make such sounds with your voice?

What do you see?
5. You whistle. What do you feel?
6. Put your fingers lightly on your throat just above your 'Adam's Apple' and say 'Ah'. What do you feel?
7. Flatten the palms of your hands against your ears. What do you hear? Now cup your hands over your ears. Do you hear the same thing as before?

Read what you wrote as you observed each part. Did you always see or feel movement? Quick movements backwards and forwards are called vibrations. Did you see and feel vibrations each time there was a sound? Sounds are caused by vibrations. The vibrations set up sound waves which we cannot see.

Look at these sound producers, shown in Fig.9.8 Which part vibrates in order to produce sound?

You will need:
• Three rubber bands (broad, medium, narrow)
• an open chalk box
• a school bell
• a guitar
• a drum

1. Stretch the three rubber bands around the open chalk box at regular intervals. Pluck each one in turn. What do you see about the movement? What do you hear?
2. Ring the bell and lightly touch the metal with your finger. What do you feel?
3. Pluck the string of a guitar. What do you see?
4. Strike the drum and while it is still making a noise hold a strip of paper on the part you hit.

Fig.9.8 Sound producers
Sounds travels

How does the sound of your friend's voice reach you when he calls you from a distance? Remember that we just observed how objects vibrate to produce sounds. These vibrations produce sound waves which can travel through the air.

Can sound also travel through liquids and solids?

Activity: Sound through liquid

You will need
- a glass tank with water
- two bricks
- two persons to do the activity

Let your partner press her ear to the glass tank while you knock the two bricks together under water. Your partner should hear the knocking of the bricks where she is. The water is liquid, so we can safely say that sound travels through liquid.

Activity: Sound through solid

You will need:
- a pencil
- two persons to do the activity
- a wooden table top

Have your friend press his ear to the table top at one end (see Fig. 9.9). Tap the pencil at the other end as shown. The tapping can be heard through the wood. Since the wood is solid, we can conclude that the sound travels through solid.

Fig. 9.9. Sound travels through solid

Fig. 9.10. Sound travels through liquid

Sounds also travels through gases. Remember we mentioned how our friend's distant voice reaches us as sound waves through the air. Air is made up of gases, so we conclude that sound travels through gases.
A simple microphone

A man made instrument that can collect sounds like the ear is the microphone. The microphone is a device that collects sound waves on its diaphragm which vibrates. The vibrations are converted to electrical signals which eventually come through a speaker as sounds.

Fig. 9.11 (a) A simple microphone
(b) A speaker

Care of our ears

Our ear is a delicate organ that is an important link with our environment. We should take care not to damage it. We should keep the following points in mind:

• Never put anything in your ear. This includes pencils, pens, and Q-tips.

• Clean your ears - the pinna area - with mild soap and water and a soft washcloth.
• Do not remove wax with hairpins, safety pins or other small implements. Some cotton wrapped on the finger may be used. A build-up of wax should be removed by a doctor.
• Avoid loud noises. These include high-volume stereos and television sets.
• If you have to operate a loud music system use earplugs or ear muffs for protection.
• If you have an ear ache that persists, see a doctor. Do not try homemade remedies. They may do further damage.

Sense of balance and the ear

The ear is also associated with another sense that humans have - the sense of balance. The human ear has special structures that help us keep our balance. They are the semi-circular canals. They contain a fluid that is sensitive to movement. Body movement in any direction is detected by sensory cells and the information is passed on to the brain. The brain then makes you aware of the movement.

More on the senses

We will now examine the other three senses that help us to get information about the world around us. They are the sense of smell, the sense of taste and the sense of touch.

The nervous system through which our senses operate has receptors which receive stimuli. Our sense organs are receptors that are linked to the brain. Let us look at the receptor organ of smell.
The nose

The nose is our organ of smell. Fig. 9.12 gives us an idea of its internal structure.

![Diagram of the nose showing nerve endings and internal structures](image)

Fig. 9.12 Nerve endings in nose and tongue

When we breathe in, air enters the nose in two streams through the two nostrils. These open into the nasal passages which lie above the mouth cavity. In a patch of tissue high in each passage are special cells called olfactory cells. These cells are really smell receptors which have hairlike endings that come together in the olfactory nerve. This nerve carries the nerve impulses to the brain. How do these structures help us to smell?

Substances release molecules that diffuse (i.e. spread out or disperse) through the air. When you inhale air, you take in molecules of chemicals mixed with the air. The molecules of these chemical substances stimulate the nerve endings of the olfactory cells. The olfactory nerve picks up the impulses and takes the messages to the brain. The brain interprets the information and then you smell.

Was there ever a time when you could not smell? Was it while you had a cold or other illness? Speak with others and find out if they had similar experiences.

What sense do tracker-dogs use? Can they smell in water?

Describing smells

The sense of smell responds to chemicals in things. Some responses produce a pleasant sensation while others give very unpleasant ones. Some smells are pleasant and bring us pleasure.

The smell of a rose, of a marigold flower, of a fragrant perfume or of a favorite dish are all smells we may describe as pleasant or uplifting. Such smells give rise to good feelings in us.

On the other hand some smells are so unpleasant that they may make us ill. The fumes from rotten and decaying animal or vegetable matter may be so unpleasant that the feeling of nausea may result. Such smells may be described as putrid, stink or offensive. You may speak of the stench of rotting garbage. Can you think of other words to describe smells?

Have you ever sneezed? Are sneezes caused by odours or by particles in the air?

Care of our nose

As a respiratory organ and as the receptor organ of smell, the nose has a very important dual function. We would therefore do well to take good care of it. Some guidelines on caring the nose are:

- The nose should be cleaned regularly with damp cotton wrapped around the finger. This removes dirt that collects in the fine hairs that help to filter the air we breathe.
- Never push any small object like a button, seed or peanut into the nostrils. Such objects usually get stuck and block the air passages thus hampering breathing.
- Do not put any sharp or pointed implement in the nostrils because these may cut or punc-
ture the delicate lining of these structures.

- Never inhale chemicals.
- When there is a pain or other discomfort seek medical help. Do not use unprescribed medication in the nostrils. Use only a prescribed inhaler for any blockages during a cold.

Let us now look at the receptor organ of taste.

**The tongue**

If you stick your tongue out and look at it in a mirror you will see that it has little projections like bumps sticking up from the surface. These are called **papillae** and they contain receptors called **taste buds**. In each taste bud there are taste cells which are sensitive to certain chemicals. Each cell has a tiny hairlike part that comes out of an opening in the taste bud. At the bottom of the taste bud is a nerve thread that gathers together with others into a large nerve that leads to the brain.

**Areas of the tongue for tasting**

Because of the risk of infection, it is not wise to experiment in the laboratory with taste. However, you could taste some foods or medicines at home to see if you agree with the information given in Fig. 9.13. Why not discuss now with your friends and plan the investigation? You could use sugar and honey for sweet; cascara or corilla as bitter; lime juice and green mango as sour and a pinch of table salt as salt. You could call your investigation "**Parts of the tongue used in Tasting**". Write out step by step what you would do. Record your observations in a table like this.(Table 9.1)

Did you wash out your mouth and dry your tongue between tests? If you did not you could repeat the investigation, including washing out your mouth and drying your tongue between substances.

There are persons whose jobs are to taste. Wine tasters and tea tasters do not actually swallow what they have to taste. They hold it in their mouth and breathe normally. You too try this method of tasting. You would still have to swallow to feel the effect of the 'food'.

---

**Table 9.1 - Tasting**

<table>
<thead>
<tr>
<th>Substances used</th>
<th>Tip of tongue</th>
<th>Side of tongue towards the front</th>
<th>Side of tongue towards the back</th>
<th>Back of tongue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

120
The skin

The skin is a sense organ that responds to the stimulus of touch. It is also sensitive to heat, cold and pressure. The skin has five kinds of receptors which respond to stimuli of either touch, pressure, pain, heat or cold.

What our skins do

The skin is the largest sense organ because it covers the entire body. It plays an important role in protecting us from certain dangers. The sensation of pain is a protective device because it signals a threat of injury to the body.

The receptors that respond to heat and cold tell us when temperature changes are affecting us. If we feel uncomfortably hot or cold we can do something to remedy the situation. This helps us to maintain a constant body temperature.

Activity: Responding to the stimulus of touch

You will need:
- a hairpin or similar object
- a partner

1. Ask your friend to sit with his eyes closed and to put out his hand, palm downwards, on the table.

2. Lightly touch the back of his hand with the hairpin, using sometimes one point and sometimes two.

3. Ask him to tell you each time whether he feels one point or two points.

4. Touch other parts of his hand and arm. Is the whole surface of the skin equally sensitive to touch?

How sensitive is our tongue?

Experiments show that the tongue is sensitive to only four kinds of stimuli (tastes):- sweet, salt, sour and bitter. Each of these is detected by a different part of the tongue. How can we explain the wide variety of taste sensations which we experience when we eat and drink? The answer is that our sense of smell also plays an important part. Have you noticed that if you have a heavy cold and your nose is blocked, your sense of taste, as well as your sense of smell, is reduced? Is there any part of the tongue that is not sensitive to taste?

How we taste

When you eat something, the tiny hairlike parts coming out of the taste buds are stimulated by the chemicals in the food, chemicals which have been dissolved i.e. put into solution by the saliva. The nerve threads send impulses to the brain which interprets what you are tasting.

Care of our tongue

The tongue should be cleaned regularly with cotton wrapped around the finger and by rubbing it gently. A toothbrush with soft bristles may also be used. Never taste strong chemicals.
Activity: Responding to stimulus of temperature.

You will need

- three bowls
- the first with ice-cold water
- the second with hot water
- the third with water at room temperature

1. Place your left hand in the cold water, and your right hand in the hot water for one minute.

2. When the minute is up, place both hands in the water at room temperature.

What does each hand feel like?

What does this tell us about our sense of touch where temperature is concerned?

**Main receptors of the skin**

Fig. 9.14 shows the main sense receptors in the human skin and the sensations to which they respond. Look carefully at the diagram and you will see that there are two main sections in the skin. The outer section or epidermis, is made up of layers of cells. The inner section or dermis also has layers of cells, and contains most of the sense receptors.

The dermis also contains sweat glands and sebaceous or oil glands, blood vessels, and hair follicles. The sweat glands have sweat ducts that lead to the surface of the epidermis. Sweat pores open out on the outer surface. All of these structures help the skin to perform its many functions.

**Care of our skin**

Hints on the care of our skin

- Wash daily with soap and water.
- Use a wash-cloth to rub away dirt from exposed surfaces like the hands, arms and face.
- Medicated soaps should be prescribed by a doctor.
- Skin preparations for cosmetic use should be used with caution.
- Wounds, bruises and other damage to the skin should be treated by a doctor.
The skin as the body’s largest defence against disease and external injury to body tissues is very important to us. We should take great care to keep it healthy.

We have now learnt about each of our five senses.

Try and practise drawing the diagram of each one. When you have drawn them all, label the drawings.

Try and read more about these sense organs to understand better how they work.

**Exercises**

1. Make a drawing to show what the eyeball is like inside.

2. Obtain a cow’s eye from a butcher. Place the eyeball facing upwards and make two cuts at right angles and turn back the flaps. The aqueous humour will pour out. Cut out the lens. Put it on some newsprint and notice how it magnifies the letters. Empty out the vitreous humour and examine the retina. Notice where the optic nerve leaves the retina.

3. Make a list of some of the ways in which a camera is similar to the eye.

4. What are the things you should avoid doing in order to take care of your eyes?

Answer these by choosing (a), (b), or (c).

5. The outer ear
   (a) changes vibrations into nerve signals
   (b) gathers sound
   (c) vibrates to make sounds.

6. The eardrum
   (a) has three small bones
   (b) cannot vibrate
   (c) vibrates when sounds hit it.

7. Vibrations are changed into nerve signals by
   (a) the vocal cords
   (b) the eardrum
   (c) the cochlea.

8. The ear bones are
   (a) between the eardrum and the cochlea
   (b) outside the eardrum
   (c) between the cochlea and the brain.

9. Sound is carried from its source to our ears by
   (a) transmitters
   (b) sound waves
   (c) compressions.

Now try these:

10. What is the purpose of the auditory nerve?

11. What makes the eardrum vibrate?

12. Describe how sound waves travel from a source of sound to the human ear?

13. Draw a labelled diagram of the human ear. State how each part helps in hearing.

14. What is the name for the part(s) of the body described below?
   (a) nerve leading from the nose to the brain.
   (b) the two openings of the nose through which air enters?
   (c) the sense organ of taste
   (d) the largest sense organ
   (e) the organ that interprets the senses.

15. What kind of receptors are stimulated when you perform each of the following activities?
   (a) Move a pencil on your hand
   (b) Cut your finger with a knife
   (c) Place some food in your mouth.

16. Choose the correct letter and encircle it.

If you had no sense of smell
A. you would not be able to taste anything.
B. you would only be able to taste spicy food.
C. you would only be able to taste salt, bitter, sour and sweet
D. it would have no effect on your taste.

17. Explain briefly in your own words:
Why do you think it is difficult to taste things when you have a cold?

Answers to questions
15. (a) Touch receptors
(b) Pain receptors
(c) Taste receptors / Taste buds.

16. C. you would only be able to taste salt, bitter, sour and sweet.

17. A wide variety of tastes/ flavours is possible because our sense of smell plays an important part. The sense of smell and sense of taste are closely linked because they both respond to chemicals in substances. When you have a cold the air passages may be blocked. The sense of smell may therefore be affected. Hence the sense of taste may also be affected.

Summary

WE HAVE LEARNT THAT
- our eyes are the most important sense organs to help us to detect the environment.
- the image is formed on the retina at the back of the eye. It is real, inverted and smaller than the object.
- the iris controls the size of the pupil and regulates the amount of light entering the eye.
- the camera is a man-made copy of the eye and resembles the eye in many ways.
- we must always take good care of our eyes wherever we go and whatever we do.
- our sense of hearing teaches us much about our surroundings.
- the ear is the sense organ of hearing.
- the auditory nerve takes impulses from the ear to the brain.
- sounds are caused by vibrations.
- sounds travel through gases, liquids and solids.
- a microphone is a device that collects sounds from your voice.
- we need to take care of the ear since it enables us to respond to sounds that warn us of danger.
- the sense of smell and the sense of taste are closely linked.
- the skin may be considered the largest sense organ. It responds to several kinds of stimuli such as heat, cold, touch, pain, and pressure.
- it is important to take care of our sense organs since they inform about our environment and also help to protect us from harm.
Unit 10

Domestic materials

Introduction

Do you realise that we use an abundance of chemicals in and around our homes? Chemicals! Yes, if we were to examine substances used in the kitchen, bathroom, toilet, bedroom and even in our kitchen gardens, we will discover that we do indeed use an amazing variety of chemicals. Have you ever considered that water is an important chemical that is most widely used?

In this unit we will learn about

- chemical substances in and around the home.
- how to examine substances to find out their nature using indicators and the pH scale.
- acids, bases and neutral substances.
- active ingredients in common household substances.

Here is a drawing showing a number of household substances. You can add to the list.

Fig 10.1 Samples of household substances

125
Table 10.1

<table>
<thead>
<tr>
<th>Substances found in the Kitchen</th>
<th>Substances found in the Bathroom</th>
<th>Substances found in the Restroom</th>
<th>Substances found in the Dining Room</th>
<th>Substances found in the Toilet</th>
<th>Substances found in the Garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Soap</td>
<td>Perfume</td>
<td>Vinegar</td>
<td>Harpic</td>
<td>Insecticide</td>
</tr>
<tr>
<td>Tea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lime</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Activity

Here is a table showing sections in and around the home where chemicals are used. Fill in the blanks with chemicals for each respective section.

We can examine and investigate the above substances to identify their nature, that is whether they are acidic, basic or neutral. This can be done by using the pH scale and indicators.

The pH scale

Chemists use a scale of numbers called the pH scale to compare strengths of acids and bases. The numbers on this scale range from 0 - 14 and they relate to acidity 0 - 6 and basicity 8 - 14. A pH of 7 indicates that the substance is neutral; for example, pure water. Basic substances have a pH of more than 7 while acidic substances have a pH less than 7.

Here is an illustration of a pH scale that shows samples of substances with specific pH. Chemists not only use pH scales but also pH meters which give very accurate measurements of pH.

Fig. 10:2  The illustrated pH scale
Indicators

Indicators are compounds which have different colours in solution, depending on the nature of the solution whether acidic, neutral or basic. There are many kinds of indicators but we will only deal with three of them.

Litmus

Litmus paper is used to indicate whether substances are acidic or basic. In a solution of pH 1 to 6.9 litmus is pink; in pH 7, mauve and in pH 7.1 to 14 blue. It can be seen therefore that its use is limited because it only tells if substances are acidic or basic; the strengths of the substances are not revealed.

Universal indicator

If an indicator is to determine the strength of an acid or alkali it must be capable of showing a variety of colours--each of which corresponds to a certain pH. A special indicator which has such a variety of colours is ‘Universal Indicator’. It is really a mixture of several indicators and changes colour gradually from red through green to violet over a wide range of strengths.

Methyl orange

This indicator is red below pH 3, orange between pH 3 and 4 and yellow above pH 4.

The following illustration gives a graphic picture of the use and colours of the various indicators.

<table>
<thead>
<tr>
<th>Litmus</th>
<th>Acid - pH 1-6.9</th>
<th>Neutral - pH 7</th>
<th>Base - pH 7.1-14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universal Indicator</td>
<td>pH 1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Methyl orange</td>
<td>pH &lt;3</td>
<td>&gt;4</td>
<td></td>
</tr>
</tbody>
</table>

Red or pink
Mauve
Blue
Dark red
Red
Red orange
Orange
Yellow orange
Yellow
Light green
Deep green
Blue green
Blue
Blue violet
Violet purple
Violet
Deep violet
Red
Yellow

Fig 10.3 Range of colours of three indicators.

Activity: Indicators from flowers.

You will need: Flowers such as red roses, red Hibiscus and Bougainvillea.
- 25 cm³ distilled water
- 25 cm³ acetone (propanone). (Be careful, this is highly inflammable)
- mortar and pestle
- round-bottom flask
- Bunsen flame
- tripod stand
- wire gauze
- water bath

1. Weigh 4g of flower petals.
2. Place flowers in a mortar together with a mixture of water and propanone.
3. Grind up the mixture so that the solvent can penetrate through the tissues of the flower petals.
4. Your teacher will fit up the apparatus.

It consists of a flask attached to a condenser
such as the one used to distill water in Book 1.

5. Transfer the mixture to the flask and heat the contents over a water bath until the solvent is boiling gently. Boil for about twenty minutes and then allow the flask to cool.

6. Filter the cooled mixture into a suitable container. A clear coloured solution is obtained.

Your indicator may contain more than one coloured pigment. If this is so, you will be able to use it as a “Universal Indicator”. Check what colour your indicator has with lime juice, vinegar and Milk of Magnesia.

Activity: Compare the pH value of different substances.

You will need:
- vinegar
- lime juice
- orange juice
- baking soda solution
- antacid e.g. Alka-seltzer
- distilled water
- washing soda solution
- Universal Indicator
test tubes
- ammonia solution
- salt solution
- sour milk
- soap solution

Test each of the substances in turn with Universal Indicator and match with the colour chart.

Record your observation in a table like the one shown below. (Table 10.2)

### Table 10.2

<table>
<thead>
<tr>
<th>Substance</th>
<th>Colour of Universal indicator</th>
<th>Acid</th>
<th>Base/alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinegar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lime juice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange juice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baking soda solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antacid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distilled water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing soda solution</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Now that we can identify acid and basic substances, let us consider some of the characteristics of acids and bases.

**Acids**

Acids are corrosive substances, that is, they can damage tissues. They have a sour taste, turn blue litmus red or pink, and have a pH less than 7. Furthermore, acids also contain hydrogen which can be released when they react with metals. Can you name some fruit or substances that have sour tastes?

**Inorganic and organic acids**

Acids can be classified as inorganic and organic. Inorganic acids are manufactured and are widely used in industrial processes. Sulphuric, Hydrochloric, nitric and phosphoric acid are good examples of inorganic acids. Organic acids, however, are compounds found in vinegar, fruit, sour milk and other natural substances.

Organic acids contain carbon atoms and are not strong. Ascorbic acid or vitamin C which is found in limes, oranges, tomatoes and green vegetables prevent us from having a disease called scurvy. Carbonic acid also is another popular one. Can you tell what it is used for? Amino acids are another group of acids that contain nitrogen. They play an important part in the structure of protein, since they are the building blocks of proteins. Protein foods are digested to form amino acids.

<table>
<thead>
<tr>
<th>Acids</th>
<th>Where found</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetic acid</td>
<td>vinegar</td>
<td>softening meat</td>
</tr>
<tr>
<td>(Ethanoic acid)</td>
<td></td>
<td>pickling foods e.g. pepper</td>
</tr>
<tr>
<td>ascorbic acid</td>
<td>fruits e.g. cherries, citrus</td>
<td>nourishing the body;</td>
</tr>
<tr>
<td>(vitamin C)</td>
<td>fruits, vegetables e.g.</td>
<td>preventing disease e.g. scurvy</td>
</tr>
<tr>
<td></td>
<td>tomatoes</td>
<td></td>
</tr>
<tr>
<td>citric acid</td>
<td>citrus fruits e.g. limes</td>
<td>flavavouring foods and drinks</td>
</tr>
<tr>
<td></td>
<td>lemons, oranges</td>
<td></td>
</tr>
<tr>
<td>lactic acid</td>
<td>sour milk</td>
<td>removing ink spots from clothing</td>
</tr>
<tr>
<td>tartaric acid</td>
<td>fruits</td>
<td>making of baking powder, jams and jellies.</td>
</tr>
<tr>
<td>tannic acid</td>
<td>tea leaves</td>
<td>dyeing materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(making ink and paper)</td>
</tr>
</tbody>
</table>
Use of acids

Acids are found in many materials we use in our homes. Find out from the table below and note their names, sources and uses. Acids found in the laboratory are also used to produce various materials.

Hydrochloric acid (1% \( \text{HCl} \)). This is the acid found in the stomach (1%) and which helps in digestion. In industry it is used in making compounds that clean tarnished metals and remove rust.

Nitric acid (\( \text{HNO}_3 \)) is used to make fertilizers and explosives.

Sulphuric acid (\( \text{H}_2\text{SO}_4 \)) is used in the manufacturing of fertilizers, soapless detergents and car batteries.

Strong and weak acids are dependent on the percentage of hydrogen found in them. Strong acids are not made weak by addition of water. Addition of water to acids does not affect the strength but the concentration. Addition of water therefore makes an acid dilute. A typical example is glacial acetic acid which is concentrated while vinegar a dilute acid is formed by addition of water to glacial acetic acid. Orange drink is diluted orange juice.

Activity: The effects of different concentrations of acetic acids on beef.

You will need:
- 10 g raw beef
- 5 cm\(^3\) glacial acetic acid
- 5 cm\(^3\) vinegar
- 3 petri dishes
- 2 pairs tweezers
- 2 tiles
- dropper

2. Place each portion in a labelled petri dish.
3. With the dropper, pour 5 drops of glacial acetic acid on the beef in dish labelled ‘+ glacial’.
4. Pour 5 drops of vinegar on beef in dish labelled ‘+ vinegar’.
5. In the third dish, nothing is added to the meat.
6. Leave all three of the dishes to stand for 20 minutes.

Observe and record any changes.

Table 10.4

<table>
<thead>
<tr>
<th>Household substance</th>
<th>Base present</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>lysol</td>
<td>sodium hydroxide</td>
<td>disinfectant in hospitals</td>
</tr>
<tr>
<td>milk of magnesia</td>
<td>magnesium hydroxide</td>
<td>laxative; antacid to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>relieve upset stomachs</td>
</tr>
<tr>
<td>ammonia solution</td>
<td>ammonium hydroxide</td>
<td>household cleanser,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e.g. cleanser of brass, copper.</td>
</tr>
<tr>
<td>whitewash</td>
<td>calcium hydroxide</td>
<td>painting fences</td>
</tr>
<tr>
<td>soap</td>
<td>sodium hydroxide or</td>
<td>cleans the body;</td>
</tr>
<tr>
<td></td>
<td>potassium hydroxide</td>
<td>removes grease</td>
</tr>
</tbody>
</table>
7. Use tweezers to remove meat from dishes to tiles. DO NOT TOUCH THE ACID.

8. Pull each piece of meat apart using tweezers.

Record observations.

Were changes to the meat related to the concentrations of the acetic acid?

**Bases / alkalis**

Bases are the chemical opposite of acids. They taste bitter and turn pink litmus blue. The pH of bases is between the range of 8 - 14 on the pH scale. Like acids, they are corrosive, i.e. they can damage body tissues. If bases are touched by hands, they feel very slippery. Bases/alkalis contain hydroxyl ions. Bases which dissolve in water are called alkalis. Oxides and hydroxides of metals are bases.

Bases or alkalis form the main ingredient of many household substances. Table 10.4 gives us some examples.

Some of the bases found in the laboratory are used in the manufacture of commercial products. Four such bases are mentioned below.

- Sodium hydroxide which is also called **caustic soda** is a main ingredient in the manufacture of soap and also of other products for the removal of grease.

- Potassium hydroxide is called **caustic potash**. It is used for making soap and in removing grease.

- Calcium hydroxide, called **slaked lime**, is used to make plaster and mortar. A mixture of calcium hydroxide and water (limewater) is used in tanneries to remove hair from cow hides.

- Calcium oxide, which is known as **lime**, is used by farmers to reduce the acid content of soil.

**DON'T TOUCH ACIDS!**

**Case study 1**

Mr. Jones worked as a mechanic at a gas station. One day he was careless in handling a car battery. The solution in the battery fell on his hand. Shortly after, he felt the burning. He was taken to the hospital for emergency treatment. Long after the incident he still had an ugly scar.

Questions.

1. A car’s storage battery contains an acid. Which acid is it?

2. How would you describe such an acid?

3. What should Mr. Jones have done immediately after the accident to prevent his skin from burning so badly?

'**FIRE WATER**' IN **PHAGWAH CELEBRATIONS**

**Case study 2**

Everyone was having fun, throwing water on friends and passers-by. One passer-by who was drenched got angry, went home and came back with a cup-full of liquid. He threw the container with liquid towards the crowd and Johnny, who was standing closest to him at the time, got the full dose. Johnny ran towards his home, screaming in pain.

Johnny was taken immediately to hospital. He was hospitalised for weeks with serious burns on his face and upper body. His face was disfigured for life by this incident.

Questions.

1. ‘Fire-water’ is the common name of an acid. Which acid is it?

2. How was this acid used in the incident described above?

3. Why was Johnny’s face disfigured?
BE CAREFUL WITH ACIDS!

We have learnt that acids taste sour but remember never to taste any substance in the laboratory. Acids may be poisonous and they are corrosive. They burn and can dissolve tissues of plants and animals. Concentrated acids are very dangerous chemicals and must be handled with caution.

You would notice that when meat is marinated or soaked in vinegar before cooking, the texture of the meat is softened and it gets tender quickly. Why is this so? The ethanoic or acetic acid in vinegar acts on the tissues of the meat making them softer.

DON'T TOUCH BASES!

Case Study 3

DANGEROUS CHEMICAL! CAUTION!

This sign was painted in red.

At the alumina factory there was a large tank with a solution of sodium hydroxide (caustic soda). One Monday morning Mr. Thomas was checking the level of the chemical, when he suddenly slipped and fell in. He was pulled out in moments but he was so badly burnt that he was unconscious.

When he was rushed to the hospital his condition was considered critical. It took months of intensive care before he was healed, but he was left badly crippled. His whole body had been burnt.

Questions.
1. How would you describe a chemical that burns tissues?
2. What other precaution, besides a danger signal, could have been taken by the management of the factory?

Activity: The action on alkali on meat

You will need:
- 10 g raw beef (cut into slices)
- $10 \text{ cm}^3$ bench (2M) sodium hydroxide solution
- 1 dropper
- 2 petri dishes
- tweezers
- tile

1. Place one slice of beef in one petri dish.
2. With the dropper, place 5 drops of sodium hydroxide solution on the meat and leave the experiment to stand for about 20 minutes.
3. Place the other slice of meat in the other petri dish.
4. Compare the two pieces of meat and record any differences.
5. Use the tweezers to remove the treated meat from the petri dish and place it on the tile.
6. Prod the meat tissue with the tweezers and record your observations.
7. Repeat stages 5 and 6 with the untreated piece of meat and record any differences.

What is the effect of the sodium hydroxide on the beef?

You can repeat the experiment using other meats such as fish and chicken. Does sodium hydroxide affect them in the same way?
Reactions of acids

Acids are very reactive substances. For example they react with wood, paper, cloth, plant material, plastics and coins. Some reactions are vigorous while others are slow. However, many factors, including the strength of acids, determine the extent of a reaction.

Here are some reactions of common acids with substances such as metals, bases and carbonates. These reactions are important to us since most of the materials we use are made of or include these substances.

Acids and metals

What happens when an acid reacts with a metal? Have you ever noticed what happens when acid drops on a coin or a nail?

Activity

1. Pour dilute sulphuric acid into a test tube to depth of about 3cm³.
2. Add a piece of magnesium ribbon or a half spatula of magnesium powder.
3. Observe carefully and note what happens.
4. Collect some of the gas given off as shown in Fig 10.6.
5. Your teacher will test the gas with a lighted splint.

What is produced when an acid reacts with a metal?

You will need:
- a piece of magnesium ribbon
- 2 test tubes
- dilute sulphuric acid

![Diagram of test tube to collect gas, dilute sulphuric acid, and magnesium ribbon]

Fig.10.5. Collecting the gas produced when magnesium reacts with dilute sulphuric acid.

![Diagram of unknown gas being tested with a lighted splint]

Fig.10.6 Testing gas with a lighted splint.

WARNING. Be careful, hydrogen gas exposed to flame is explosive.

A ‘pop’ sound is heard as the flame goes out, showing that the gas is hydrogen.

The reaction that took place was:

Magnesium + Dil. sulphuric acid → Magnesium sulphate + Hydrogen.
Mg (s) + H₂SO₄ (aq) → MgSO₄ (aq) + H₂ (g)

Does this happen when any acid reacts with any metal?

Do the following activity and record what you observe in Table 10.5. In this activity we will use three different acids and several metals to find out whether the same observations would be seen in each case or if there are exceptions to a general pattern.

**Activity: The action of three acids on various metals**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Dilute Hydrochloric Acid</th>
<th>Dilute Sulphuric Acid</th>
<th>Dilute Acetic Acid (Vinegar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium ribbon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron filings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper turnings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium foil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 10.5  Record of the acid-metal reactions.**

1. Pour the dilute acid as indicated in Table 10.5 into a test tube to a depth of 3 cm³.
2. In each case add one or two pieces of the metal. If there is no reaction with the acid when cold, warm the test tube gently.
3. Observe carefully and record what you see and feel in Table 10.5.

In each case test for hydrogen gas. You would have noticed that some of the metals reacted vigorously with the dilute acids, while some did not. List the metals in order of their reactivity.

**Acids reacting with bases.**

We have discovered what happens when an acid reacts with a metal. Now we will be looking at reactions between acids and substances called bases. As you have learnt, bases are substances which turn red litmus blue. This tells us that bases are opposite to acids. We have also learnt that there are two types of bases, those which can dissolve in water and those which cannot. Can you remember what would be the pH range of an alkaline solution? What happens when acids and alkalis react?
1. Take 10 cm³ of sodium hydroxide solution in a 50 cm³ beaker and add 2 drops of Universal Indicator solution (or litmus solution).
2. Add dilute hydrochloric acid from a syringe, 1 cm³ at a time, shake and stir the liquid after each addition. Stop as soon as there is a permanent colour change.
3. Record your observations in Table 10.6.
4. Note the volume of hydrochloric acid used when the pH of seven (7) is reached.

When you use the Universal Indicator, read off the volume of acid from the table that corresponds to the green colour and a pH of 7.

However, if litmus is used, you may find it difficult to determine the pH at each step. You should take advantage of the sudden change in colour of the indicator.

What volume in cm³ of hydrochloric acid was added before the pH of 7 was reached? To answer this question correctly, you can repeat the activity, but this time when you have added one cm³ less than in the first case, you add drop by drop until the sudden change is seen. This is the volume of hydrochloric acid that is required to bring the pH of the solution to 7.

At this stage the amount of acid was just enough to react with the alkali present in solution:

Use measuring cylinder to measure 10 cm³ alkali
Add 2 or 3 drops of indicator solution
Use syringe to add acid to alkali

Fig.10.7 Reacting acid and alkali.

Table 10.6 Record of the acid-alkali reaction.

<table>
<thead>
<tr>
<th>Volume of hydrochloric acid added to 10 cm³ alkali</th>
<th>Indicator used</th>
<th>Colour of indicator</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 cm³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
that is, all the acid and alkali have been used up. What is therefore left or produced is a neutral solution, which has a pH of 7. The acid is said to have neutralised the base, that is, wiped out the effect of the base. The acid itself has become ineffective. This process which produces a neutral solution is known as neutralisation.

What are the products of neutralization?

**Activity**

1. Pour the neutral solution produced from neutralization into an evaporating dish.
2. Set up the apparatus with your teacher’s help as shown in the diagram below.

![Fig.10.8 Evaporating a solution.](image)

By now you must have realised what we are going to do. We are evaporating the solution obtained in neutralization. You have done this before in Book 1.

3. Heat the solution and stop just before the liquid dries up.
4. When cooled examine the dish. What does the substance in the dish look like?
5. Dissolve a little of the substance in water and test it with mauve litmus paper.

What effect does the solution have on the litmus?

![Glass rod](image)

**Fig.10.9. Testing neutralisation product with litmus**

You would have noticed that the solution has no effect on the litmus. This means that the solution is neutral. This solution is indeed different from the acid and base that we started with. This proves that a chemical change has taken place and a new substance is formed.

The substance formed is a white solid and it looks like salt. Indeed it is the common salt used in our kitchen. The other substance formed is water and this evaporated leaving the salt. This salt, sodium chloride, was produced from hydrochloric acid and sodium hydroxide.

\[
\text{Hydrochloric acid} + \text{Sodium Hydroxide} \rightarrow \text{Sodium chloride} + \text{Water}
\]

If other acids and bases are used, other salts would be formed.

Remember **"Do not taste the salts"**.

Some salts have an unpleasant taste.

The salts formed from hydrochloric acid are called chlorides, while those formed from sulphuric acid are sulphates and those from nitric acid are nitrates. The first part of the salt’s name
comes from the base that is used. For example, if magnesium hydroxide is used with hydrochloric acid the name of the salt is magnesium chloride.

\[ \text{Magnesium hydroxide} + \text{Hydrochloric acid} \rightarrow \text{Magnesium chloride} + \text{Water}. \]

However, if sodium hydroxide reacts with the hydrochloric acid the salt produced is called sodium chloride.

\[ \text{Sodium hydroxide} + \text{Hydrochloric acid} \rightarrow \text{Sodium chloride} + \text{Water}. \]

Whenever an acid reacts with a base, a salt and water only are formed.

\[ \text{ACID} + \text{BASE} \rightarrow \text{A SALT} + \text{WATER} \]

A salt and water are therefore the products of neutralization of an acid and a base.

All salts can be prepared or made by neutralizing a base by an acid. These chemicals called salts are very important. Can you recall some uses of salts?

In our homes, we use common salt to flavour our foods. Salt petre, which is potassium nitrate, is used to preserve meat. Epsom salts is used by us as a medicine.

In agriculture, the farmer uses salts such as ammonium sulphate, calcium sulphate and ammonium nitrate as fertilisers. In industries, chemicals such as ammonium chloride are used in the making of batteries.

### Acids reacting with carbonates

In the last section, we looked at how acids are neutralised by bases. Now we will be investigating the effect of acids on carbonates.

What happens when an acid reacts with a carbonate? Let us find out.

### Activity

1. Pour about 10 cm\(^3\) of dilute hydrochloric acid in a test tube.
2. Add a little sodium carbonate.

What happens? Does this reaction remind you of an activity you did in Book I?

![Reaction of acid with carbonate](image)

---

**Fig.10.10** Making of batteries.

**Fig.10.11** Reaction of acid with carbonate.
Yes, it reminds us of the activity with lime juice and 'bicarbonate of soda'. There was a lot of fizzing and bubbles were continually formed and burst until the reaction was completed. The bubbles tell us that a gas is produced.

Which gas is produced?

Repeat the activity but this time apply a lighted splint to the mouth of the test tube. What happens?

Now, add more carbonate to the test tube with the acid. As soon as the fizzing begins connect a delivery tube which leads to a test tube of lime water (calcium hydroxide solution). What happens?

What are the other products of the reaction between an acid and a carbonate? When the fizzing has ceased, test the pH of the liquid using indicator paper. What is the pH of the solution? What has happened to the acid?

Filter off the excess sodium carbonate and evaporate the solution. What did you get this time? Is it a salt? Yes it is a salt and the salt is sodium chloride. So the hydrochloric acid reacted with the sodium carbonate and produced carbon dioxide, the salt sodium chloride and water.

\[
\text{Hydrochloric acid} + \text{Sodium carbonate} \rightarrow \text{Carbon dioxide} + \text{a Salt} + \text{Water}
\]

\[
2\text{HCl(aq)} + \text{Na}_2\text{CO}_3(s) \rightarrow \text{CO}_2 + 2\text{NaCl} + \text{H}_2\text{O}
\]

\[
\text{Hydrochloric acid} + \text{Sodium carbonate} \rightarrow \text{Carbon dioxide} + \text{Sodium chloride} + \text{water}
\]

We can generalise and say:-

\[
\text{Acid} + \text{Carbonate} \rightarrow \text{Carbon dioxide} + \text{a Salt} + \text{Water}
\]

Instead of a carbonate you can try a bicarbonate. Your observations should be similar to those of the reaction with the carbonate.

\[
\text{Acid} + \text{Bicarbonate} \rightarrow \text{Carbon dioxide} + \text{a Salt} + \text{Water}
\]

Since a salt is formed we can say that the carbonate and bicarbonate can neutralize an acid. This neutralization of acid by carbonates and bicarbonates is used in the making of 'things' that are important to our everyday life. Here are some.

1. Baking powder contains a combination of baking soda (sodium bicarbonate) and a dry acid. When it is moist, they neutralise each other and the gas carbon dioxide is released in the process.
2. ‘Health salts’ contain sodium bicarbonate and tartaric acid, a dry acid. When this ‘health salt’ is added to water, the powdered acid dissolves and reacts with the bicarbonate producing the gas carbon dioxide. See Fig.10.13.

![Figure 10.13: Health salts.](image)

3. In fire extinguishers there is a container with sodium bicarbonate and water.

![Figure 10.14: Inside of a fire extinguisher.](image)

Table 10.7

<table>
<thead>
<tr>
<th>Reactions of acids</th>
<th>Gas produced</th>
<th>Salt formed</th>
<th>Other products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Acid + metal</td>
<td>Hydrogen</td>
<td>a Salt</td>
<td></td>
</tr>
<tr>
<td>e.g. ( \text{H}_2\text{SO}_4 \text{ (aq)} )+ Mg</td>
<td>( \text{H}_2 )</td>
<td>( \text{MgSO}_4 )</td>
<td></td>
</tr>
<tr>
<td>Sulphuric acid + Magnesium</td>
<td>Hydrogen</td>
<td>Magnesium sulphate</td>
<td></td>
</tr>
<tr>
<td>2. Acid + base</td>
<td>–</td>
<td>a Salt</td>
<td>Water</td>
</tr>
<tr>
<td>e.g. ( \text{HCl \text{ (aq)}} )+( \text{NaOH \text{ (aq)}} )</td>
<td>–</td>
<td>( \text{NaCl} )</td>
<td>( \text{H}_2\text{O} )</td>
</tr>
<tr>
<td>Hydrochloric acid + Sodium hydroxide</td>
<td>–</td>
<td>Sodium chloride</td>
<td>Water</td>
</tr>
<tr>
<td>3. Acid + Carbonate</td>
<td>Carbon dioxide</td>
<td>a salt</td>
<td>Water</td>
</tr>
<tr>
<td>e.g. ( \text{HCl \text{ (aq)}} )+( \text{Na}_2\text{CO}_3\text{(s)} )</td>
<td>( \text{CO}_2 )</td>
<td>2( \text{Na Cl} )</td>
<td>( \text{H}_2\text{O} )</td>
</tr>
<tr>
<td>Hydrochloric acid+ sodium carbonate</td>
<td>Carbon dioxide</td>
<td>sodium chloride</td>
<td>Water</td>
</tr>
</tbody>
</table>
**Identifying chemicals**

Many household substances contain a variety of chemicals. Many of these chemicals can be identified by gases given off during reactions. Would it not be exciting to find out many of these unknown substances? Reactions can be brought about by heating or by addition of another substance. In this process a gas is given off and by testing it, substances can be identified.

**Which gas is it?**

Gases can be identified by their colour and odour and also by their chemical properties, that is, the way they behave or react. For example, oxygen and carbon dioxide are colourless gases while chlorine is a greenish-yellow gas. Oxygen has no smell while hydrogen sulphide smells like rotten eggs.

In Book 1, we learnt that oxygen allows things to burn in it. We say that oxygen supports combustion. Earlier in this unit, we learnt that hydrogen puts out a flame with a ‘pop’ sound when the flame is placed in it. Even though hydrogen burns itself, it does not allow things to burn in it. The ‘pop’ sound is a result of an explosion between hydrogen and oxygen in the air forming water.

\[
2 \text{H}_2 (g) + \text{O}_2 (g) \rightarrow 2\text{H}_2\text{O} (g)
\]

Earlier we saw the lighted splint go out when placed in the mouth of the test tube of carbon dioxide. This tells us, that carbon dioxide also does not allow things to burn in it. The reaction that we used to test for carbon dioxide gas was the reaction with limewater.

<table>
<thead>
<tr>
<th>Name and Formula</th>
<th>Colour</th>
<th>Odour</th>
<th>Effect on litmus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen O₂</td>
<td>colourless</td>
<td>odourless</td>
<td>neutral</td>
</tr>
<tr>
<td>Carbon dioxide CO₂</td>
<td>colourless</td>
<td>odourless</td>
<td>turns red</td>
</tr>
<tr>
<td>Hydrogen H₂</td>
<td>colourless</td>
<td>odourless</td>
<td>neutral</td>
</tr>
<tr>
<td>Chlorine Cl₂</td>
<td>yellow green</td>
<td>choking smell</td>
<td>bleaches</td>
</tr>
<tr>
<td>Ammonia NH₃</td>
<td>colourless</td>
<td>choking smell</td>
<td>turns blue</td>
</tr>
</tbody>
</table>

Looking at Table 10.8 we have more than one colourless and odourless gas and as such it is sometimes difficult to identify gases by colour and odour only. Because of this, gases are best identified by their chemical properties, that is, the way they behave or react.

Carbon dioxide + Calcium hydroxide → Calcium carbonate + Water

\[
\text{CO}_2 (g) + \text{Ca} (\text{OH}_2) \rightarrow \text{Ca CO}_3 (s) + \text{H}_2 \text{O}
\]

Carbon dioxide is the only gas that turns limewater milky.
Identifying by hydrogen

METALS AND WATER

Activity

1. Pour some water into a large beaker or trough.
2. Drop a small piece of calcium metal into the water.
3. Invert a funnel over the piece in the water. The stem of the funnel should be under the water.

Fig. 10.15. Reaction of calcium with water.

4. As seen in Fig. 10.15, invert a test tube full of water over the stem of the funnel.
5. Observe carefully and record in your notebook.
6. Now, test the liquid in the beaker by placing two drops on the litmus paper.
7. Remove the test tube and test the gas by use of a lighted splint as you did in Fig. 10.7
8. Record your observations.

What happened? What is the name of the gas produced? If it is possible, your teacher can do a demonstration using sodium and another metal, lithium. A large trough should be used.

WARNING: The reactions of both sodium and lithium with water are dangerous. So, teachers, students should not be allowed to stand close by.

You would have observed that the remaining solutions turned red litmus blue. Therefore they are both alkaline. Also the lighted splint went out with a ‘pop’. Can you remember the name of the gas that does this? Yes, it is hydrogen. The reaction between calcium and water is:

\[
\text{Calcium + water} \rightarrow \text{Calcium hydroxide} + \text{Hydrogen}
\]

\[
\text{Ca(s)} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 (\text{aq}) + \text{H}_2(\text{g})
\]

The other metals like sodium and lithium are too reactive to be done in a similar way. However, if you test the solutions remaining in the troughs, they too are alkaline and the gas is hydrogen. So we see that:

\[
\text{Metal + Water} \rightarrow \text{Metallic oxide} + \text{Hydrogen}
\]

The less reactive metals, for example, zinc and magnesium, react with steam and produce hydrogen. This means that any substance that reacts with water and produces hydrogen gas is a metal.

METAL AND ACID.

Do you remember the reaction between an acid and a metal? What gas was produced? When metals react with dilute acids hydrogen is produced. Therefore hydrogen is produced when an acid reacts with a metal and also when water reacts with a metal. In both cases the metal replaces the hydrogen in the other reactant.

\[
\text{e.g. Metal + Acid} \rightarrow \text{Salt} + \text{Hydrogen}
\]
e.g.  
Metal + Water $\rightarrow$ Metallic oxide + Hydrogen

When hydrogen is produced as a result of reaction, if water is one reactant, then the other reactant must be a reactive metal. If one reactant was a dilute acid then the other would be a reactive metal.

**Identifying substances by carbon dioxide**

Is it possible to identify a substance by the evolution of carbon dioxide? Let us find out.

**Activity**

1. Pour about 2 cm$^3$ of dilute acid in each of three test tubes.
2. To the test tube no. 1 add half a spatula of calcium carbonate.
3. Shake the test tube and connect it to a delivery tube which leads to a test tube of limewater. See Fig. 10.16.

Record observations in a table like that below.

**Table 10.9**

<table>
<thead>
<tr>
<th>Carbonate</th>
<th>Was a gas produced on adding the carbonate? Yes or No</th>
<th>Did the limewater turn milky? Yes or No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What can you really say about carbonates?

In each case a gas was produced which turned limewater milky. This indicates that carbon dioxide was produced.

Now let us look at another activity. Your teacher could do it as a demonstration activity.

**Activity: Heating carbonates**

Your teacher could put half a spatula of magnesium carbonate, zinc carbonate and copper carbonate in separate test tubes. Then attach the delivery tube to test tube no. 1 and heat as shown in Fig. 10.16 below. Remember to move the tube about while it is in the flame.

![Fig. 10.16 The heating of magnesium carbonate.](image)

You can observe and record the results in a table like Table 10.10.
Table 10.10 Heating carbonates.

<table>
<thead>
<tr>
<th>Substances heated</th>
<th>Action of heat</th>
<th>Effect on limewater. Limewater turns milky? Yes or No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc carbonate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper carbonate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Your teacher could repeat by heating zinc, and then copper carbonate. Rinse the delivery tube after heating each metal carbonate.

You would have observed that in each case the limewater turned milky, which indicates that carbon dioxide was produced. The reaction for magnesium carbonate:

\[
\text{Magnesium carbonate} \rightarrow \text{Magnesium oxide} + \text{Carbon dioxide}
\]

\[
\text{Mg CO}_3(s) \rightarrow \text{Mg O(s)} + \text{CO}_2(g) \quad \text{heat}
\]

We can see from this activity that:

Metal carbonate \(\rightarrow\) Metal oxide + Carbon dioxide

On heating, metal carbonates produce the oxide and carbon dioxide.

From the two activities we see that carbon dioxide is produced when a carbonate reacts with dilute acid and also when it is heated. Thus the production of carbon dioxide indicates that a carbonate is one of the reactants of the reaction.
Exercises

1. Use the following words to complete the statement below.
   Words: - blue, litmus, sour, hydrogen.
   Acids taste _______ turn _______ _______ pink.
2. An acid used in the home is _______
3. Alkalis turn pink litmus _______.
4. Acids have pH numbers _______ _______ 7
5. Alkalis have pH number _______ _______ 7
6. The _______ the pH the stronger the alka-
   lis.
7. The _______ the pH the stronger the acid.
8. A can of frozen lemon juice is opened and mixed with water. Does the lemon juice become more dilute or more concentrated?
9. Zinc was added to some dilute hydrochloric acid. What products were formed?
10. Potassium hydroxide and hydrochloric acid reacted. Write a word equation for this reaction.

Summary

WE HAVE LEARNT THAT:

- acids and alkalis could be identified using certain materials called indicators.
- acidity and alkalinity are also measured by the pH scale.
- acids are sour in taste, contain hydrogen ions and turn blue litmus red.
- bases have a bitter taste and turn pink litmus blue.
- bases which are soluble in water are called alkalis.
- when acids react with bases, salts and water are produced. This process is called neutralization.
- when acids react with metal, hydrogen is given off and a salt is formed.
- when acids react with carbonates, carbon dioxide, water and salt are produced.
- salts are important to our everyday lives. They are used as fertilizers, food preservatives and as electrolytes in making batteries.
- acids and alkalis are widely used in industries in the manufacturing process.
- oxygen can be recognised by relighting a glowing splint.
- hydrogen goes out with a pop when a lighted splint is placed in it.
- carbon dioxide gives bubbles in some water and causes it to turn milky due to precipitation of calcium carbonate.
- the liberation of hydrogen from a substance tells that one of the reactants is water or acid and the other is a metal. The presence of carbon dioxide tells that the substance is a carbonate.
Unit 11

Soil-the basis of Agriculture

Introduction

Soil is that part of the earth's crust which supports plant life. How is soil formed? It is formed by the breaking down of rocks, by a very slow process called weathering. The crumbling of rocks to very fine particles is brought about mainly by extreme heat, wind and rain. It is important for the farmer to know the kind of soil his land is made of because the farmer has to know if the soil is good for agriculture before he invests in planting crops.

In this unit we will learn about:

- the organic and inorganic components of soil
- organisms that live in soil
- the properties of different types of soil
- the composition of loam and its suitability for agriculture
- the importance of soil pH to the farmer
- methods of improving soil fertility.

What is soil made of?

We have seen the white sand of the Soesdyke/Linden Highway area, the reddish soil in Linden; the cement-like soil from some parts of the Rupununi and the dark brownish grey muds from some parts of West Demerara. As you dig a deep hole in the ground, is the soil the same from the surface to the underlying rock? Have you ever seen a freshly-dug pond, grave or sand pit for charcoal burning? If you have travelled through the interior and have looked at a cliff you would see several layers. These layers are called the soil profile. The top dark layer is usually thin and is called top soil. Under the top soil is the subsoil consisting of gravel, stones, sand and clay.

The deep tap roots of larger plants grow down into the subsoil. Further down is rock.

A careful examination of soil will reveal that soil is made up of many parts. Here is an activity that will enlighten you.

Activity

You will need:

- samples of soil from five different places.
- five glass jars or wide-mouth bottles.
- stirrer.

1. Place equal volumes of each sample of soil in separate jars or bottles.
2. Pour in some water to cover the soil.

Note carefully if any bubbles appear. Mix the soil and water thoroughly and leave the mixture to settle for one day.

3. For each sample of soil note the number of layers formed.
Look at the diagrams in Fig. 11.1 and compare them with what you have observed with your samples.

Fig 11.1 Components of a sample of soil.

From this activity, we see that the soil may have gravel, coarse sand, fine sand, silt, clay and floating humus. Let us have a closer look at the components of soil.

**Minerals**

The minerals of soils are derived from the rocks from which soil is formed. Minerals are **inorganic** substances found in the sand, silt and clay. These minerals are required for healthy growth of plants.

**Humus**

The ‘floating’ particles found in the activity you did are particles of humus. **Humus** is the **organic** part of soil and is usually responsible for the dark colour of soils. Humus is formed by the action of micro-organisms. Humus is very important because it helps the soil to absorb water easily and it also loosens up soils. Can you think of any other function of humus?

Read the following case study and try to answer the question at the end.

**Case study**

A woman planted some gooseberry trees in her garden, about two metres apart. When both trees were about 120 cm high and just after a rainy season she weeded around the trees and decided to put some animal manure. The only kind she could get from the nearby open pasture was horse dung. She had applied two buckets of horse dung to one tree before a neighbour stopped her, explaining that horse dung was harmful to plants. (She did not remove the dung, and she did not put any on the other tree.) About ten days later she noted that the tree which had the horse dung was bigger than the tree which had none.

**Question:**

Was the horse dung harmful to that gooseberry plant? Give reasons for your answer.

**Soil water**

Soil water is found around the inorganic particles of soil. Soil water helps to dissolve the minerals so that plants can absorb them. (Remember that solids must be dissolved before they can diffuse across cell walls.) Here is another activity. It illustrates that water is present in soil.

**Activity: Investigating the presence of water in soil.**

You will need:

- a beaker/evaporating dish
- a watch glass
• tripod stand with wire gauze
• a heat source
• a container in which to heat soil e.g. a tin can
• two samples of soil
• a balance

Procedure:
1. Set up the experiment as shown in Fig. 11.2.

![Diagram showing how to investigate the water content of the soil](image)

Fig. 11.2. Diagram showing how to investigate the water content of the soil

2. Heat one of the samples of soil gently, and observe under the watch glass. Note what you see.
3. Put the second sample of soil into the open container. Weigh and record the mass.
4. Heat the open container gently, for a few minutes. Allow it to cool, and weigh it again.

Record the mass. What do you notice about the mass?
5. Explain how these activities show that soil contains water.

Organisms

Can you name the organisms you have found in the samples of soil you have used? Some of these organisms are large while others are small. Some are so small that they cannot be seen without a microscope. These are called micro-organisms. While some organisms help to improve the soil, some are detrimental. Draw the organisms you have found in the soil samples. You may need to use a magnifying glass or hand lens. Did your samples have any of these organisms shown in Fig. 11.3?

![Some organisms present in the soil](image)

Fig. 11.3 Some organisms present in the soil
Did your friend's soil samples have the same organisms as yours? How can you tell if your soil sample contains micro-organisms? Examine the diagram Fig.11.4 carefully and remember what you learnt about respiration and about acids and bases.

If there are micro-organisms present in the soil, what would you expect as the product of their respiration? Would you expect the gaseous product of respiration to react with the potassium hydroxide solution? If you were to use calcium hydroxide solution i.e. limewater instead of potassium hydroxide solution, what would you expect to observe?

Now try setting up apparatus as in Fig. 11.4. Gauze or mosquito net, doubled, should work if you do not have muslin. Use a sample of the soil you heated earlier; use also soil samples from a garden, near the sea-shore or river bed, and under a tree. Record your results in a table like Table 11.1

**Investigation:**- Do soils contain micro-organisms?

---

**Fig. 11.4 Investigating the presence of micro-organisms in the soil**

**Atmosphere**

In the first activity of this chapter, did you see many air bubbles when you poured water on the soil? The air bubbles show that air is present in the soil. You have already learnt about respiration and you found animals in soil. Would you expect the composition of the air in the soil to be the same as that of the air above the soil? Try and find reasons for your answers.

---

**Table 11.1. Investigating micro-organisms in soil observations**

<table>
<thead>
<tr>
<th>Soil Sample</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st day</td>
</tr>
<tr>
<td>(1) Heated soil</td>
<td></td>
</tr>
<tr>
<td>(2) Garden soil</td>
<td></td>
</tr>
<tr>
<td>(3) Near sea-shore/river bed</td>
<td></td>
</tr>
<tr>
<td>(4) Under a tree</td>
<td></td>
</tr>
</tbody>
</table>

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Here is an experiment to investigate if soil contains air. You will need two measuring cylinders.

(a) Measure 50 cm$^3$ top soil in one cylinder.
(b) Measure 50 cm$^3$ of water in the other cylinder.
(c) Add the water to the soil. Observe, stir, observe again.
(d) What do you notice as you stir the soil?
(e) How can you explain your observations?
(f) What is the total volume?
(g) How can you explain your results?
(h) Do this activity for at least three samples of soil, from different places e.g. an empty lot, side of a path, under a tree or under rotting grass, beside a pond, in a swamp.
(i) Explain your results.

Comparing soils

Soils can be compared using the following properties:- particle size, capillarity or ability to draw up water, humus content, texture, air content, or permeability or ability to drain.

Capillarity is what you observe when you put tubes of different bores or diameters in liquid.

Here are some activities that will help in comparing soils.

![Diagram showing air in soil](image)

**Fig. 11.5** Diagram showing that air is present in soil.

**Types of soil**

Basically there are three types of soil: sand, silt and clay. These are so classified because of their particle size or texture. The texture of the soil can be felt by rubbing some particles between your fingers. Sand has the largest particles while clay has the smallest. Silt particles are smaller than sand, but larger than clay. A mixture of particles of different sizes form what is called loam soil.

You will need:
- a jam jar or beaker with coloured solution.
- a transparent plastic straw.
- a length of the outer case of a transparent ball point pen (same diameter throughout).
- a transparent inner case of a ball point pen (the tube which contains the ink).
Place the tubes in vertically. Note the height to which the solution rises. Is the height of solution in any of the three tubes lower than the height of the jam jar or beaker?

Activity: Permeability in soil

Permeability can be checked by setting up an activity like that shown in Fig. 11.7.

Method:

(a) Collect, dry and crush samples of sand, loam and clay. Note that the drying should be done by air and sunlight, and not by any heat other than the sun.

(b) Lightly plug the necks of the funnels with cotton wool.

(c) Put a known mass of sand into a funnel; the same mass of loam into another funnel and the same mass of clay into the third funnel.

(d) Place the funnels in conical flasks.

(e) Record the time and then pour 75 cm³ of water on to each type of soil and allow to drain.

(f) Record observations as in Table 11.2.

Activity: Capillarity of sand, loam and clay

Examine the diagram below.

![Diagram comparing capillarity in soils](image)

Fig. 11.6. Diagram comparing capillarity in soils.

Set up an investigation as shown in Fig. 11.6 to compare capillarity of sand, loam and clay.

Note that you must start with dry samples of soil.

![Diagram comparing permeability in soils](image)

Fig. 11.7 Diagram comparing permeability in soils
Table 11.2  Results obtained in investigation: Comparing permeability in soils.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sand</th>
<th>Loam</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time taken for the first drop of water to drip from funnel. (sec)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The quantity of water drained after 3hr.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The quantity of water drained after 24hr.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11.3  Comparison of soil types

<table>
<thead>
<tr>
<th>Property</th>
<th>Sand</th>
<th>Loam</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle size</td>
<td>large</td>
<td>mixed</td>
<td>very small</td>
</tr>
<tr>
<td>Capillarity</td>
<td>low</td>
<td>fair</td>
<td>high</td>
</tr>
<tr>
<td>Humus</td>
<td>none/little</td>
<td>fair amount</td>
<td>high/heavy</td>
</tr>
<tr>
<td>Texture</td>
<td>light</td>
<td>medium</td>
<td>heavy</td>
</tr>
<tr>
<td>Air</td>
<td>high</td>
<td>fair</td>
<td>low</td>
</tr>
<tr>
<td>Permeability</td>
<td>high</td>
<td>fair</td>
<td>low</td>
</tr>
</tbody>
</table>

**Soil and the farmer**

We have learnt that the difference in particle size means that different soils have different properties. Most soils are a mixture of sand and clay particles and therefore combine the properties of both. Such a mixture is called loam and it often contains a sufficient amount of organic matter - humus - to make it the best type of soil for plant growth.

Loam which is warm, easy to be worked and has adequate air, water and plenty of mineral plant foods is good for Agriculture. The farmer, however, can improve sandy and clayey soils and make them suitable for Agriculture.
Improving sandy soils

In order to improve any type of soil, we must know its properties. We must also know of the needs of the crop that we would like to plant. Sandy soils with large particles and little plant food can be improved in the following ways.

- By adding clay. Do you think this is practical or feasible on a large scale?
- By adding organic plant food such as animal dung, leaf litter, dried grass and compost material. Each example must be rotted properly before use. All these materials form humus which is good for plants.
- By adding fertilisers

You will need:
- sand dried by air and sun
- funnel
- measuring cylinders

Activity

1. Collect and dry about two five-pound milk tins of sand.
2. Mix about a one-pound tube of sand thoroughly with the same quantity of well-rotted dung - Sample P.
3. Repeat 2, using well-rotted filter mud - Sample Q.
4. Repeat 2 using ash from paddy shell - Sample R.
5. Repeat 2 using well-rotted leaf litter or dried grass - Sample S.

Do you remember how to check for texture, presence of air, capillarity and permeability? Compare capillarity of sand and of the four samples P, Q, R and S.

Then compare permeability of sand and of the four samples P, Q, R and S.

Present your results in a table like table 11.4.

Table 11.4 Comparison of texture, capillarity and permeability of sand and four soil samples.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sand</th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time taken for sample to become wet at top</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time taken for the first drop from funnel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of water drained in half an hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of water drained in one hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of water drained in one and a half hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of water drained in two hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From which sample did water drain faster? Soil which allows water to drain away so quickly is easily leached - that is the soil loses its nutrient value by the water washing it away. Thus the plant nutrients must be replaced regularly for the plants to survive.

Now try planting some seeds in the sand and in samples P, Q, R and S. Tin cans could work well as long as you put holes in the bottom to allow water to drain out. Place a few stones at the bottom of each tin can to prevent the soil from falling through the holes. Label the cans - sand, P, Q, R and S. Fill the cans with the samples and place all in a fairly sheltered position. Water lightly and place about six black-eye seeds in each tin can. Just cover the seeds with some of the matching sample of sand and soil and water lightly each day, even after the first foliage leaves appear. Monitor and record progress in a table like Table 11.5.

**Improving clay soils**

It is difficult to work clay soils for planting crops because the particles stick together, the soil drains slowly (becomes water logged easily) and it has little soil atmosphere.

Improving clay soils can be done in four ways.

1. Add sand to increase the average size of particles. Is this feasible on a large scale?
2. You may investigate whether organic manures and paddy shell ash would improve clay soils. You may follow the same method as with sand, but substitute clay instead.
3. Add lime. The effect of lime on clay is to cause the fine particles of clay to stick together in groups thereby increasing the average particle size and reducing its stickiness.

What would you recommend to the farmer who lives in an area of heavy clay soil?

<table>
<thead>
<tr>
<th>Time for germination Growth - days</th>
<th>Sand</th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After completing this investigation, what would you recommend to the farmer who lives in an area with much sand?

Liming is a relatively cheap way of treating soil since machinery can easily spread it as required.
Here is an activity that will demonstrate to you the effect of lime (calcium oxide - a solid white compound) on clay soils.

1. Collect two samples of clay soils and make clay suspensions in two beakers or jam jars using distilled or rain water.
2. Cover one jar/beaker with a greased covering. This would act as a control.
3. Add a few cm³ of lime water to the second jar/beaker and stir well. Cover it and set it beside the first jar/beaker.
   Record your observations.

How would you explain the differences observed?

4. Clayey soil could also be improved by the addition of chemical fertilisers. Remember though that we would have to ensure that our clay soil is well drained so that the fertilisers do not become too concentrated after repeated use.

Farmers have a choice. They can measure the pH of their soil and then choose a crop which will grow well on it. Alternatively, they can alter the pH of the soil to suit the crop which they want to grow.

When soils are acidic, farmers add lime to neutralise the excess acid. Sometimes the soil is too alkaline (11) and iron sulphate is added because it is acidic in solution and neutralises the excess alkali in the soil.

Here is an activity that will help you to find the pH of a sample of soil.

**Activity**

1. Select a sample of soil. Take about 1 cm³ of the soil and mix it with some distilled water and allow to settle.
2. Add a piece of Universal Indicator paper and note the colour change; compare this with the pH value.

Now you can check pH of soils from many areas. Record your observations in a table like Table 11.6.

---

**Improving soil pH**

A soil may be acidic or alkaline or neutral. For each type of plant, there is a range of soil pH over which the plant can be grown successfully.

---

Table 11.6 Record of the colour of Universal Indicator paper and of pH of different samples of soil.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Colour of Universal Indicator paper</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Conserving and renewing soil fertility

Fertile soil has an adequate supply of air, moisture and plant nutrients and has the correct pH for the crops.

Since soil is so important to the cultivation of crops, we should protect it and follow practices that would renew fertility.

METHODS OF RENEWING SOIL FERTILITY

The bush fallow method

This allows land to be abandoned for several years. Animals may use it as pasture and the plants which come up by themselves provide litter. Thus the land is re-fertilised by decay of organic matter.

Rotation of crops

This is another system that could be used. This would prevent taking one type of nutrient from the soil. Different plants make different demands on the soil. Some plants are shallow-rooted while others are deep-rooted. Rotating crops of different types would enable soil to retain and conserve fertility.

Selection of crops in this system is of great importance.
Can you give reasons why?

One chief way in which soil loses its fertility is by erosion, either by wind or by water. Erosion can be prevented by terracing slopes or by planting trees to break the force of wind.

Soil fertility can also be maintained by the use of natural and artificial fertilisers. A good source of natural fertiliser is manure from a compost.

Preparing a compost

Farmers could get valuable manure from garden compost. Materials like vegetable skins, dry leaves and animal dung could be put together in a compost heap.

![Diagram of compost process]

1. Kitchen wastes or garbage
2. Plant remains (a) Weeds (b) Unwanted remains of cultivated crops
3. Litter and droppings from animal sheds

Farmer applies composted manure to his garden

Not desirable: bottles, stones, hard wooden materials, seedy weeds

Fig. 11.8 Materials for compost.
Decay bacteria, decay fungi and other organisms break down the plant and animal remains into organic salts, e.g. nitrates which could be absorbed by plants. Much heat is given off while the decomposition occurs.

![Diagram showing decomposition process](image)

**Fig. 11.9 How compost is decomposed to form manure**

Materials like plastics, bottles, tin cans, weedy weeds, wood and stones are unsuitable for composting. They are either not degradable or if they are, they take a long time to decompose. Compost heaps should not be exposed to rain, which would leach out plant nutrients or to direct sunlight which would evaporate the moisture.

Manure or cured compost is mixed with the composting material, to supply micro-organisms to start the decomposition. Sulphate of ammonia and ground limestone should be added to give favourable conditions for the microbes to break down the waste materials efficiently. The fresh composting materials are stacked loosely so that the compost heap should be turned over twice. For a heap two metres high the first turn could be done after four weeks and the second air could be after another four weeks. After yet another two weeks the heap should be ready to be used.

When compost is decomposed to form manure for plants through fermentation, carbohydrates and fats are broken down to carbon dioxide. Green plants can use the carbon dioxide for photosynthesis. From the proteins in compost, the soluble salts, nitrites and nitrates are formed. These are absorbed by the roots of plants and used to build plant proteins. Compost helps plants to grow vigorously.

Yet another way of conserving soil fertility is by **keeping garden beds weeded**. Weeds use up some of the plant food. They rob plants also of light and water. Should they be pulled up, more light, water and food would be available to crops. The weeds could be cut up and added to compost heaps.
Exercises

1. Explain how you could find out which type of soil drains quicker; sandy or clayey.

2. You notice that your new neighbour always weeds the grass parapet until there is not a trace of grass and then, when the grass weeded has dried, he burns it.

Is this a good practice? Write a letter to your neighbour explaining your view of the matter.

3. List three reasons why it is important that we conserve the fertility of soil.

4. List three ways in which soil fertility could be conserved and renewed.

5. (a) Select a sample of soil in your school yard/garden.

   Carry out an experiment to find the pH.

   (b) State whether the soil is acidic, neutral or alkaline.

   (c) If your soil is easily waterlogged what could you do to improve the situation?

---

WHAT WE HAVE LEARNT

- soil is made up of mineral inorganic matter, water, air, organisms and humus.
- soil may be classified by particle size.
- how to improve sandy and clayey soils.
- how to improve the pH of soils.
- how to conserve and renew soil fertility.
- some organisms help to improve the soil they live in.
- how a compost heap is useful to the farmer.
Projects and revision exercises

Introduction

In order to enjoy science you should use your knowledge of it to figure out how various devices operate and how you can make devices yourself. You have already encountered some interesting projects in this book. We shall now look at some additional projects which you can undertake at home or at school.

Projects on our sense organs

Making a model eye

Fig. 12.1 A model eye

You can make a model of an eye like the one shown above, if you have a lens. The lens is attached to two screws which can control its thickness. A white screen is placed at the back to act as the retina. You can use a small circular cardboard with a hole at the centre to act as the iris. Place lighted candles or bulb in front of the model eye and adjust the screw until the image is focussed on the retina (screen).

Making a model ear

Fig. 12.2 Making a model ear.

You will need:
- cardboard tube
- paper plate
- plastic cup (with water)
- tracing/grease-proof paper
Projects on soils

Clay model to show terracing

A clay model to show how a hill could be made. A piece of thick cardboard, plywood or tентест could be used as the base. The slope of the hill could be made into terraces as shown in Fig. 12.4. Pieces of rocks could be affixed to the steep side of the steps.

Fig. 12.4 A hill showing terraces.

Clay model to show contour ploughing

In this model, mounds and troughs or drains are arranged in contours to prevent erosion. See Fig. 12.5 which demonstrates how this could be done.

Fig. 12.5 Contour ploughing.
Clay model to show belt of sheltering trees.

In this model, a flat surface of clay is prepared and twigs with green-coloured plasticine as leaves could be stuck in the clay foundation. Here is a diagram to illustrate this. See Fig. 12.6

Fig. 12.6 A hill showing a belt of sheltering trees.

Some other models, some other projects.

There are other models you could make, for instance 'contour strip cropping'. You could ask your teacher to tell you about it. It would be good for you to read about it in science books in your library.

You could make a drawing in your exercise book of a slope, and mark three strips, at right angles to the slope. You could label the types of plants you would grow on the strips, and the types you would grow in between the strips. You could then write a short note, stating what plants you would grow on the strips the next time you plant, and what plants in between.

Then you could try to make a model, in clay, with strips completely covered with grass and with pieces of other plants to represent the crops being grown in between the strips of grass.

Why not try making compost manure? You could work in groups. You could bring kitchen waste from home, and manure also, with which to 'seed' the waste material. You could weed a patch of the school yard. You could rake up the leaves. Some of you could use the compost material as it is. Others could chip the green material and pound the dry leaves and use that material for their compost heap. Follow the instructions carefully, adding the necessary chemicals. Take and record the temperature of the heap at regular intervals and at about the same time of day, measure the temperature. Remember to turn over your stack of compost twice. Then make good use of the finished product.

Yet another project you could do is to visit places where soil erosion has taken place; by wind e.g. on the seashore and you could then make models showing the effect of wind and water e.g. on bare slopes. You could carry out an experiment, with seed boxes, to investigate ways by which the amount of erosion by water could be reduced.

Think of ways in which you could go about such an investigation. Discuss your thoughts with your class mates. Check them out with your teacher. Carry out the investigation. Write up your work.

Happy experimenting!
Other ideas for projects

If electric bells are not available for this project, you can make a 'buzzer' with a small electric motor from a toy car. If a short piece of string is attached to the axle of the motor and it is placed in a small box so that it can open freely, the string hitting the sides of the box will make a 'buzzing' sound.

![Diagram of buzzer circuit](image)

Fig.12.7  Communication by buzzers.

Look at Fig. 12.7 above. It shows how you can communicate between two rooms, A and B, by means of buzzers, A and B. Switch A in room A controls buzzer B in room B and switch B in room B controls buzzer A in room A. Switch A is in series with buzzer B and switch B is in series with buzzer A. Both circuits are connected in parallel to the mains which is 3V d.c obtained from 2 cells in series. You can set up the system above at home in two rooms or upstairs and downstairs.

Making an optical audible alarm to do a specific job.

Fig.12.8 shows how an alarm system can be set up to give a sound or light when a door is opened. The circuit consists of a battery connected to a buzzer and/or a bulb. When the door is closed the switch is opened. However, when the door is opened contact is made at the points A and B. The circuit is now closed and the buzzer will make a sound and/or the bulb will light (a red light). This alarm system can be set up on your bed-room door at home.

![Diagram of door alarm circuit](image)

Fig.12.8  Door alarm.

Making a xylophone spanning an octave

A xylophone is a musical instrument made of a series of graduated flat metal bars played by striking with a small wooden hammer (mallet).

![Diagram of xylophone](image)

Fig.12.9  Making a xylophone.

You can make a xylophone by riveting eight metal bars (of varying lengths) to a wooden sound box as shown above. Suitable lengths of the bars are 30 cm, 28 cm, 25 cm, 23 cm, 20 cm,
19 cm, 17 cm, and 15 cm. When the bars are struck with the mallet, each one of them will be vibrating and producing sound at different frequencies. The longer the bar the smaller is the frequency, or the lower the note (pitch).

**Copper plating**

By the process of electrolysis if an electric current is passed through an aqueous solution of copper sulphate (CuSO₄), a film of copper will be deposited on the cathode (negative electrode), when the anode (positive electrode) is made of copper.

![Figure 12.10 Copper plating.](image)

A nail can be copper plated if it is made the anode as shown in Fig.12.10 above. The nail must first be cleaned thoroughly with sand paper so as to remove the rust and dirt. During electrolysis the copper ions (Cu²⁺) will move to the cathode (nail) where it is deposited as copper.

![Figure 12.11 Float-operated switch.](image)

If you have an overhead water tank at home, you can make a switch operated by a float as shown above. When the tank is full, the float moves upwards and the lever arm on the other side of the pivot moves downwards, depressing a brass strip (spring) which makes contact between two points or contacts. This acts as a switch which can be used to operate a light or a sound alarm system. When the alarm is sounded, it gives a warning that the tank is full and the pump taking water to it can be stopped. This can be very useful in preventing the tank from overflowing and wasting the water.

**Let's pretend**

You have learnt about the senses. Pretend that each of you in the class is a specialist. One a dermatologist or skin specialist, another a nose and throat specialist, another an optician. Another an attractive potter which you could use to encourage pupils to want to do your career.

Musical bands are very popular. Imagine you are at a function where a string band is playing. Name each instrument. Draw five of them, labelling on each the part which produces the sound by vibration.
Areas of revision

At the end of each unit you would have had some revision; but here we are going to look back, yet again, at eight areas.

THE FLOWER

The flower is the reproductive organ of the flowering plant. The flower is used by the plant for sexual reproduction. Each flower has the male part— the stamen—which produces the pollen grains; the female part— the carpel—which is made up of the stigma, style and ovary. The ovary contains the ovules with the female sex cell. The ovary develops into a fruit after the processes of pollination and fertilization have taken place. Inside the fruits are seeds. Each seed has a young plant and, given the right conditions, it will germinate and produce a new plant. New plants can also be gotten from other parts of the plant.

WHO FEEDS ON WHOM?

Organisms usually feed on specific types of food. These organisms are classified as herbivores, carnivores and omnivores. In a food chain or food web, the energy from the sun is transferred from one organism to another. All food chains and food webs have the plant as the producer. A food web is a combination of many food chains because most organisms have more than one source of food. There are also decomposers in a food chain and a food web.

MACHINES

Machines make work easier. They reduce the force and are more convenient. Man uses machines to help save the energy from his muscles. There are complex machines and simple machines. The levers are simple machines. There are three classes of levers:- first class, second class and third class.

STAYING UPRIGHT

Both animals and plants need to stay upright. The roots hold plants firmly in the soil, but the xylem vessels ensure that fluid (water) is supplied to all parts of the plant. The cells are firm and stiff (turgid) or to say it another way, they are in a state of turgor. Animals stay upright by the presence of a skeleton. The skeleton is either within the animal’s body or outside. Muscles are attached to the skeleton.

MOVEMENT

Movement in living things happens as a result of energy being produced during respiration. Movement in non-living things like engines is produced when energy is released by the burning of fuel. Movement is affected by friction. Friction can be overcome by smoothness, lubrication and streamlining.

ATOMS, ELEMENTS AND COMPOUNDS

Atoms are the particles of matter. Atoms join together in clusters to form a molecule. An element is made up of two or more atoms of the same kind. Elements combine to form compounds. Elements are represented by symbols and compounds by formulae. The making and breaking of compounds are very important processes in industries. Electrolysis is one of the methods used in breaking compounds.
ACIDS AND BASES

Acids and bases are useful in our everyday life. Acids are used in the home as cleaning agents and to preserve food, like fruits, vegetables and even meat. An acid is used in batteries of vehicles. Bases are used as antacids to relieve upset stomachs. They are also used to reduce the acidity of soils. But some acids and bases could also be dangerous. We must be very cautious when using those types of acids and bases, in the laboratory and elsewhere. The pH scale and indicators are used to determine the acidity of substances. Acids react with many substances, such as metals and bases.

SOIL

Soil is one of the most important natural resources. Soil consists of organic and inorganic materials that are necessary for plant growth. It is important for farmers to be aware of the different types of soil and the methods of improving each type. A fertile soil produces best quality crops.

Exercises

WRITTEN QUIZ.

In this activity you will be given about ten to twenty questions for which you will write the responses. These questions will be given by your teacher. The responses are usually short. For example

(i) What atoms are present in sodium chloride? (sodium, chlorine)

(ii) What are the negatively charged particles of an atom called? (electrons)

TAKE THEM DOWN

This activity was explained in Bk 1. Read the explanation again. That exercise could be used here also, as an activity for revision. All you need are questions based on the concepts you have learned in this book. Follow the instructions given in Bk 1.

GROUP QUIZZ TOURNAMENT.

For this activity you may need four to six groups, depending on the size of your class. You may give names to each group. Here is where you all have an opportunity to make and to submit to your teachers your own questions to make a pool of questions. The same rules for ‘Team versus Team’ explained in Bk 1 are used here. In the final round, the group with the highest score emerges the winner.

STUMP THE PANEL

Here again you have an opportunity to make and to submit questions that will be used along with those prepared by your teachers. Follow the rules of the game given in Book 1.

Some examples of questions.

Here are a few examples of questions that you can use in your revision exercises.

1. Draw and label the parts of a named flower.

2. Name two flowers that have only female or only male parts.

3. (a) Define electrolysis.
   (b) What is an electrolyte?

4. List two inorganic substances that green plants need to manufacture their food.
5. What class of food do you expect to be present in each of the following?
   (a) peanuts  (b) cassava  (c) callaloo

6. List at least two reasons why soil is important to the farmer.

7. List at least two ways in which organisms present in the soil are important.

8. Which type of soil has the smallest particles?
   (a) clay  (b) loam  (c) sand  (d) silt.

9. Which type of soil will show high capillarity?
   (a) clay  (b) loam  (c) sand  (d) silt.

10. The part of the microscope that makes the object seem to look bigger is the
    (a) adjusting knob  (b) lens  
    (c) mirror  (d) stage.

11. The part of the cell that controls its activities is called the
    (a) cell wall  (b) cytoplasm  
    (c) nucleus  (d) vacuole.

12. List two ways in which sandy soil can be improved.

13. Explain what is meant by this statement. “Sandy soil can be easily leached or washed out.”

14. What is the point, or the range on the pH scale for the following?
    (a) acid soil  (b) neutral soil  
    (c) alkaline soil.

15. Suppose your grandmother has some old copper coins. Suggest which of the following she may use to make them shine bright again.
    (a) lime juice  (b) magnesium hydroxide

16. Describe how one can extract the colour from a red flower.

17. What is the reaction of acid on (a) blue litmus and on (b) baking soda?

18. What substances are produced when sulphuric acid reacts with magnesium?

19. Describe how one can test for the gas produced when an acid reacts with a metal.

20. Define the term ‘circuit.’

21. List two ways in which electricity is produced.

22. List two types of circuits.

23. What is likely to happen to the lamps in a series circuit if one of them is blown?

24. What is the voltage of each of five similar cells arranged in series if the total voltage is 7.5 V?

25. How does ‘resistance’ affect the flow of current?

26. Why do you think it is important to detect your environment?

27. Explain how one is able to see an object.

28. What are four similarities between the eye and the camera? Name any differences you may have noticed.

29. ‘A good speaker is heard by everyone in his audience, even by those behind him.’ Explain this statement.

30. What is the purpose of the arrows in food chains and food webs?

31. What is the role of the decomposers in food chains and food webs?

32. Explain what you think would happen if the producer in the food chain is destroyed.

33. What is meant by the statement “machines save energy”?
34. Name two parts of the body that are levers and state to which class of levers they belong.

35. Explain the main difference(s) between simple machines and complex machines.

36. Explain why most plants and animals need to stay upright.

37. How does water get into the xylem vessels in roots?

38. What is the purpose of the muscles that are attached to a skeleton?

39. Explain how energy is produced in living things.

40. Do all non-living things need energy to move? Give reasons for your answer.

41. Name one living thing that uses streamlining to overcome friction during movement; and one non-living thing in which streamlining is used to overcome friction during movement.

42. Punch a hole in the bottom of each of two tin cans, and connect them with wire about 15 feet long. Tie the end of the wire inside each can to a nail to keep it from slipping out. Using this device, and keeping the wire taut from one can to the other, communicate with another student across the room. Vary the length and tautness of the wire. (You could use string instead of wire.) Explain how the device works whether you have string or wire. Compare and contrast their effects as a means of transmitting sound waves.
Glossary

Accommodation - the automatic adjustment of the lens of the eye to see objects at different distances.

Acetic acid - a colourless organic acid with a sharp sour odour. Its clear pure form is called glacial acetic acid.

Acid - any group of chemical compounds that tastes sour, turns blue litmus red and can neutralize bases.

Aerobes - Organisms which can live only in the presence of oxygen.

Alternating current - electric current that reverses direction periodically.

Alkali - a base that dissolves in water.

Ammonia - a colourless flammable gas with a strong irritating odour; forms alkaline solution.

Ammeter - an instrument for measuring electrical current in amperes; usually indicated by a movement of a needle across a dial.

Anaerobic respiration - decomposition of food substances without the presence of oxygen.

Antiseptic - (adj) preventing infection; (n) a substance that kills or prevents the growth of germs and thus prevents infection.

Ascorbic acid - vitamin C - a white crystalline solid occurring naturally in many plants. Its deficiency in diet produces scurvy.

Asexual reproduction - the producing of new offspring with the use of one mature parent.

Aquatic - living or growing in water.

Aqueous humour - the watery liquid which fills the space in the eye between the cornea and lens.

Auditory - having to do with hearing, the sense of hearing, or the organs of hearing.

Baking soda - a common term used for sodium bicarbonate.
<table>
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<tr>
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<tbody>
<tr>
<td>Base</td>
<td>a chemical compound that feels slippery; turns red litmus blue and reacts with an acid to form salts.</td>
</tr>
<tr>
<td>Battery</td>
<td>a device of two or more electric cells that changes chemical energy to electrical energy.</td>
</tr>
<tr>
<td>Brain</td>
<td>a nerve tissue enlargement enclosed in the skull or head of vertebrates and which occurs at the upper end of the spinal cord, and which serves as the body's control mechanism.</td>
</tr>
<tr>
<td>Brownian motion</td>
<td>the aimless movement of tiny particles suspended in a fluid.</td>
</tr>
<tr>
<td>Bulb</td>
<td>an electric lamp.</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>an inorganic compound; occurs in nature as calcite and limestone; used to make lime and cement.</td>
</tr>
<tr>
<td>Calcium hydroxide</td>
<td>an inorganic base used in making cement and medicine - also called slaked lime.</td>
</tr>
<tr>
<td>Camera</td>
<td>a device for copying an optical image onto a light sensitive emulsion.</td>
</tr>
<tr>
<td>Capillarity</td>
<td>the tendency of liquids in very thin tubes to curve upward or downward at the point of contact with the tube wall; also the tendency to rise higher than, or sink lower than the level of liquid outside the tube.</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>CO₂, a colourless odourless gas used by plants to make food; given off by plant and animals during respiration; used to make carbonated beverages; also called Dry Ice when in solid form.</td>
</tr>
<tr>
<td>Carnivore</td>
<td>an organism that feeds chiefly on flesh.</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>a device in which objects can be placed and rotated at high speed.</td>
</tr>
<tr>
<td>Characteristic</td>
<td>a special quality or feature.</td>
</tr>
<tr>
<td>Charge</td>
<td>the electrical characteristic of an atomic particle either positive or negative.</td>
</tr>
<tr>
<td>Cell</td>
<td>is the basic unit of living matter that can survive independently.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>Chemical equation</td>
<td>a symbolic form for expressing a chemical reaction.</td>
</tr>
<tr>
<td>Chlorine</td>
<td>a poisonous yellowish gas that attacks the respiratory system; used in making bleaches and disinfectants.</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>a complex substance responsible for the green colouring in plants.</td>
</tr>
<tr>
<td>Circuit</td>
<td>an electrical system for the passage of current.</td>
</tr>
<tr>
<td>Community</td>
<td>all of the organisms of a given area.</td>
</tr>
<tr>
<td>Compost</td>
<td>a mixture of decaying leaves, manure, and other nutritive material for improving and fertilizing soil.</td>
</tr>
<tr>
<td>Compound</td>
<td>a substance consisting of two or more elements.</td>
</tr>
<tr>
<td>Concentrated</td>
<td>containing a very high proportion of solute in a solution.</td>
</tr>
<tr>
<td>Conductors</td>
<td>a substance, usually a metal that will carry an electric current.</td>
</tr>
<tr>
<td>Concave</td>
<td>hollow and curved inward like the inside of a circle or sphere.</td>
</tr>
<tr>
<td>Corm</td>
<td>a fleshy, bulblike, underground stem of certain plants, that produces leaves and buds on the upper surface and roots on the lower.</td>
</tr>
<tr>
<td>Convex</td>
<td>curved out like the outside of a circle or sphere.</td>
</tr>
<tr>
<td>Consumer</td>
<td>animals that use food made by producers.</td>
</tr>
<tr>
<td>Cornea</td>
<td>a transparent layer of tissue at the surface in front of the eye ball.</td>
</tr>
<tr>
<td>Cytoplasm</td>
<td>all protoplasm outside the nucleus of a cell.</td>
</tr>
<tr>
<td>Decomposers</td>
<td>organisms that cause material to decay or become rotten; decomposing agents.</td>
</tr>
<tr>
<td>Diaphragm</td>
<td>a thin disc or membrane especially one that controls the amount of light as a camera.</td>
</tr>
<tr>
<td>Diffuse</td>
<td>scatter widely.</td>
</tr>
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Dilute - reduce in concentration.

Distillation - evaporation of a liquid and condensation of the vapour back to a liquid state.

Dry cell - an electric battery in which the electrolyte is present as a deposit in a porous medium rather than as a free flowing liquid.

Electricity - a form of energy in which electric charges are in motion.

Electrode - any conductor through which an electrical current enters or leaves any medium.

Electrolysis - the process of decomposing a chemical substance into ions using electricity.

Electrolyte - a chemical substance that dissociates into ions when fused or in solution and conducts an electric current.

Electromagnet - a device consisting of a soft iron core with a coil of fine wire around it; a magnet only when current flows through the coil.

Electrons - negatively charged particles.

Element - a pure substance, which cannot be broken down into a simpler substance.

Energy - is the ability to do work.

Eye - the sense organ that transmits light waves to the nervous system for interpretation as sight.

Fermentation - a process in which sugar is gradually decomposed by agents such as bacteria and yeast to produce alcohol and carbon dioxide.

Fertilization - the union of sex cells to form an embryo.

Focus - the point at which light rays converge or a point from which they diverge.

Food chain - a group of organisms so interrelated that each member of the group feeds upon the one below it and is in turn eaten by the organism above it.
Food web - a system of overlapping food chains. (See food chains)

Friction - the force of resistance a body offers to motion, produced by its contact with another body.

Fuse - a strip of wire of low melting point; metal that breaks an electrical circuit when overheated by excessive current.

Generator - a device for converting mechanical energy or material energy to electrical energy.

Germination - the process through which a seedling (new individual) is formed from a seed.

Habitat - the place where an animal or plant naturally lives or grows.

Hearing - the sensory response to sound waves.

Herbivore - an organism that feeds on grass or other plants.

Humus - the dark-brown or black part of soil formed from decayed leaves and other vegetable matter.

Hydrogen - the lightest and simplest element.

Image - the optical equivalent of a real object produced by light in an optical system such as a lens or mirror.

Indicator - a substance used to show the state of a reaction usually by colour change.

Induction - the process by which an object having electrical or magnetic properties creates a similar property in a nearby object.

Insulators - a non-conducting material surrounding a substance used to prevent the loss or gain of electricity, heat or sound.

Ions - an electrically charged atom or group of atoms.

Iris - the opaque diaphragm in front of eye which controls the amount of light passing through the pupils.

Lens - any object - glass or transparent objects - that light can pass through;
one or both sides can be curved.

**Lime** - a white powdery alkali obtained by roasting limestone.

**Litmus** - a substance obtained from certain lichens which is used as an acid-base indicator.

**Magnesium** - a greyish white metal that is very reactive.

**Manure** - a substance that is put in or on soil as fertilizer.

**Mechanics** - machines or their working parts.

**Microphone** - a device for converting sound waves into electrical current.

**Microscope** - is an instrument used to enlarge the image of very small objects, such as cells of an organism.

**Mitochondrion** - minute sausage-shaped organelles found in the cytoplasm of cells, containing many enzymes for aerobic respiration; the power-house of the cell; plural - mitochondria.

**Molecule** - the smallest part of any substance that retains all the properties of the substance.

**Natural elements** - elements found in the earth's crust as pure elements.

**Nose** - part of the face that contains the nostril.

**Nucleus** - the central mass of protoplasm in animal and plant cells which governs cellular activity.

**Nutrients** - nourishing substances.

**Olfactory** - having to do with smelling. The nose is an olfactory organ.

**Omnivore** - animals that eat both plants and animals.

**Orbit** - the part surrounding the nucleus of an atom, and which consists of electrons.

**Organism** - an individual living plant or animal.

**Organic** - having to do with compounds containing carbon; produced
by plant and animal activities.

**Oxygen** - colourless, odourless, flammable gas.

**Papillae** - a small projection from the surface of tissue; shaped somewhat like a nipple; occurs on the tongue of man.

**Periodic Table** - the orderly arrangement of chemical elements according to the atomic number.

**Permeable** - that which allows the passage or diffusion of liquids or gases through it.

**Photosynthesis** - the process by which plant cells make carbohydrates from carbon dioxide and water in the presence of chlorophyll and light and release oxygen as a by-product.

**Pollination** - the transfer of pollen grains from the stamen of one flower to the stigma of the same or another flower.

**Producers** - plants that make their own food by means of photosynthesis.

**Protoplasm** - a greyish translucent living substance of which all plant and animal cells and tissues are composed.

**Predator** - an animal that hunts and kills another animal for food.

**Prey** - the animal that is hunted and killed by another animal.

**Pupil** - a circular expanding and contracting opening in the centre of the iris of the eye through which light passes to the retina.

**Receptor** - A cell or group of cells sensitive to stimuli, such as a sense organ or the terminal portion of a sensory neuron.

**Reproduction** - the production of a new living organism by an ancestor or by ancestors of the same species.

**Reproductive organ** - this is a specific structure of the plant and animal that is responsible for reproduction.

**Resistance** - the property of any substance opposing the flow of electric current, is usually measured in ohms.
<table>
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</thead>
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<tr>
<td>Receptor</td>
<td>an instrument/object which resists the flow of electricity.</td>
</tr>
<tr>
<td>Respiration</td>
<td>the gradual release of energy from food substances in body cells.</td>
</tr>
<tr>
<td>Retina</td>
<td>the innermost structure of the eyeball consisting of distinct layers.</td>
</tr>
<tr>
<td>Satellite</td>
<td>a man-launched object that revolves around the earth, another planet or the sun used for scientific or military purposes; satellites can also occur naturally, e.g. the moon is a satellite of the earth.</td>
</tr>
<tr>
<td>Scavenger</td>
<td>any animal that feeds on dead organic matter.</td>
</tr>
<tr>
<td>Seedlings</td>
<td>these are new/young plants.</td>
</tr>
<tr>
<td>Sex cells</td>
<td>these are male and female reproductive cells which when combined together will produce a zygote.</td>
</tr>
<tr>
<td>Sexual reproduction</td>
<td>the producing of new offspring, with the involvement of cell fusion from one or two parents.</td>
</tr>
<tr>
<td>Slide</td>
<td>is a rectangular piece of glass (sometimes plastic) upon which specially prepared sections of tissue or whole animals or plants are mounted for study on a microscope.</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>a corrosive white lumpy inorganic base that absorbs water and carbon dioxide from the air, also called caustic soda.</td>
</tr>
<tr>
<td>Solar cells</td>
<td>a photo-electric device that changes solar light energy into electricity.</td>
</tr>
<tr>
<td>Species</td>
<td>the basic unit of plant and animal classification.</td>
</tr>
<tr>
<td>Static electricity</td>
<td>an accumulation of postive or negative charges on a base caused by friction.</td>
</tr>
<tr>
<td>Sterilise</td>
<td>make free from living germs and micro-organisms.</td>
</tr>
<tr>
<td>Stimulus</td>
<td>something that excites the body or some part of the body to a specific activity or function; something that produces a response.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>Stoma</td>
<td>a tiny opening on the surface of a leaf; plural - stomata.</td>
</tr>
<tr>
<td>Storage organs</td>
<td>these are structures which can store energy (food substance) for the plant.</td>
</tr>
<tr>
<td>Sub-atomic particles</td>
<td>a particle having mass and occupying space that is smaller than the composite atom. e.g proton, neutron, electron.</td>
</tr>
<tr>
<td>Subsoil</td>
<td>the layer of earth that lies just under the surface soil.</td>
</tr>
<tr>
<td>Texture</td>
<td>the structure, constitution or make up of a material. e.g the granular texture of sandy soil.</td>
</tr>
<tr>
<td>Switch</td>
<td>a device to open and close an electrical circuit.</td>
</tr>
<tr>
<td>Tissue</td>
<td>a group of cells all having the same structure and performing the same function; different tissues may function together to form an organ.</td>
</tr>
<tr>
<td>Vacuoles</td>
<td>any small cavity found in the protoplasm of a cell, often filled with fluid; in unicellular organisms a vacuole discharges wastes and excess water.</td>
</tr>
<tr>
<td>Vascular</td>
<td>having the form of or consisting of tubes.</td>
</tr>
<tr>
<td>Vegetative propagation</td>
<td>plant reproduction by means other than seeds.</td>
</tr>
<tr>
<td>Vibratory motion</td>
<td>movement due to vibration.</td>
</tr>
<tr>
<td>Vitreous humour</td>
<td>the transparent, jellylike substance that fills the eyeball behind the lens. The vitreous humour helps hold the retina or visual sense cells in place.</td>
</tr>
<tr>
<td>Volt</td>
<td>a quantity of electrical potential difference.</td>
</tr>
<tr>
<td>Voltmeter</td>
<td>an instrument for measuring potential difference between any two points in an electrical circuit.</td>
</tr>
<tr>
<td>Volume</td>
<td>the space bounded by a closed surface.</td>
</tr>
<tr>
<td>Zygote</td>
<td>a fertilized egg cell formed by fusion of gametes (sex cells).</td>
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‘Science in Daily Life’
offers an integrated approach to the studying
of Science in Levels 7, 8 and 9 (Forms 1, 2 and 3)
of Secondary Schools.

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level. These revised editions not only provide basic scientific
knowledge and skills for junior secondary school students, but also
present the content in an appealing and user-friendly format.

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for Secondary Students who will later prepare for CXC Biology,
Chemistry, Integrated Science and Physics examinations.

The key features of Book 2 are:

• the integration of content areas into 12 concise units which illustrate the
  basic themes; Life, Matter and Energy.
• additional material on reproduction in animals and a completely new
  approach to the study of energy, machines, and forces.
• the inclusion of domestic materials used in everyday life
  and the linking of their properties and their uses.
• the inclusion of practical experiments and projects which develop
  skills in using the senses and scientific instruments, enhance mathematical
  skills, and develop the skills of learning by enquiry.
• activities for developing care and concern for the environment.
  • exercises for evaluation and reinforcement
    of knowledge and skills.
• text supplemented illustrations, tables, games, and
  information from local industries and other
  places in the community which demonstrate
  applications of Science.