Science in Daily Life

Book 3

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Our country, and more specifically the Ministry of Education, has a rich and proud tradition of producing educational resources for our schools. These efforts are such that commercial publishers have purchased the copyrights of some of our textbooks and others have offered to work in partnership with the Ministry of Education.

This revised text is testimony to the disciplined and dedicated work of our teachers and education officials. It is firmly grounded in practice and I wish to commend all who worked over the last two years on this book.

Our students now have access to a quality textbook produced by some of our top professionals and I wish to urge them to make full use of it. The Ministry of Education will continue to attempt to provide quality material for our school system.

Dr Henry Jeffrey
Minister of Education
Preface

This series of textbooks has evolved from the first set of secondary school textbooks which was planned for students in General Secondary Schools. An important modification is that the new 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

Understanding matter and its interactions

Introduction

In Book 2, Unit 1, we saw what happened to the crystal of potassium permanganate in water. Its tiny particles spread throughout the water particles causing the water to look purple. Similarly, you can get the fragrance of your teacher’s perfume because of the spreading out of its vapour through the particles in the air to your nose.

In the Caribbean, if we should rise early on a cold, chilly morning, we may see a cloud appearing to rest very low, like a blanket, near the ground or over the surface of a large body of water e.g. the sea. This cloud is thin and one can see through it. It is called a mist. Similarly countries with a colder climate, like Britain, experience a thicker, low-lying cloud that is called fog. The fog may be so thick that one can hardly see through it, even for short distances.

In fact, a cloud is a large number of condensed water vapour particles. When the air can no longer hold water, the vapour condenses and forms tiny droplets, which may remain suspended as a mist, a fog or a cloud. All these situations can help to explain that there are numerous, tiny particles present in substances around us. Can you think of other situations like these?

Depending upon the amount and similarities of these tiny particles present in any substance, they can be classified as elements or compounds. All the known elements are arranged in a table called the Periodic Table.

These elements - metal, non-metal and semi-metal can react with other elements electrovalently or covalently to form compounds. We are going to observe the chemical reaction of some of these metals with oxygen, water and acids. We will then arrange the metals according to their reactivity. Some metals will react vigorously, while others will react very slowly or not at all. As we work, especially with acids, we must remember to be very careful. If any acid should ‘spill’ on your hands, wash them thoroughly with water. Your teacher will remind you of the safety rules when using acids.

In this unit, we will learn about:
- atoms and sub-atomic particles.
- atomic number and mass number.
- how elements combine.
- the Periodic Table.
- the reactivity of some elements and the reactivity series.

What are substances made of?

We have already learnt that substances are made up of numerous, tiny particles called atoms. We learnt too that when atoms of the same kind are bonded, elements are formed. When these elements are bonded, compounds are formed.

The physical arrangement of these atoms will determine the state (solid, liquid or gas) of the substances.
These atoms are constantly in motion.

What are atoms made of?

Let us look at atoms once again. We learned earlier that atoms are made up of smaller particles, namely, electrons, protons and neutrons. These particles are known as sub-atomic particles.

![Diagram of an atom]

**Fig. 1.1** A generalised model of an atom

We also learned that the positively charged particles are protons and the particles with no charge are neutrons. These are found in the nucleus of an atom. The negatively charged particles, electrons, move around the nucleus in fixed energy levels or shells. In fact, an atom is like the solar system. The nucleus is like the sun in the centre and the electrons revolving around the nucleus, are like the planets revolving around the sun. Fig. 1.1 is a generalised model of an atom. The electrons and the nucleus, shown in model form, are very large compared to the actual atom.

An atom is electrically neutral, since the number of positive charges equals the number of negative charges. All the mass of an atom is contained in its nucleus. The number of protons plus the number of neutrons equals the mass number of the atom. The number of protons or electrons determines the atomic number of the atom.

Earlier when you looked at the Periodic Table, you would have seen numbers written above and below the symbols. These are actually the mass numbers and the atomic numbers. A general representation of these numbers is shown in Fig 1.2, where A represents mass number and Z represents atomic number.

![Diagram of element representation]

**Fig. 1.2** General representation of an element in the Periodic Table.

Therefore, the element aluminium will be represented as shown in Fig 1.3.

![Representation of aluminium]

**Fig. 1.3** Representation of the element aluminium

The atom of aluminium has 13 protons, 13 electrons and 14 neutrons. To find the number of neutrons,
subtract the atomic number (Z) from the mass number (A) i.e 27-13 = 14 (A - Z = Number of neutrons).

Table 1.1 Number of subatomic particles, atomic and mass numbers of atoms of some elements.

<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic Number</th>
<th>Protons</th>
<th>Electrons</th>
<th>Mass Number</th>
<th>Neutrons</th>
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<tr>
<td>H</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>C</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>14</td>
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</tr>
<tr>
<td>O</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>16</td>
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</tr>
<tr>
<td>Na</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>23</td>
<td>12</td>
</tr>
</tbody>
</table>

For this activity you will need an inflated balloon and a piece of woollen cloth.

1. Turn on the tap and allow the water to flow slowly. Ensure that there is a fine continuous stream of water flowing. Now rub the balloon with the piece of wool as in Fig. 1.4(a). Bring the balloon near the fine stream of water as in Fig. 1.4(b). What has happened to the balloon? What do you observe? Explain your observations.

*Turn on the tap and allow the water to flow slowly. Ensure that there is a fine continuous stream of water flowing. Now rub the balloon with the piece of wool as in Fig. 1.4(a). Bring the balloon near the fine stream of water as in Fig. 1.4 (b). What has happened to the balloon? What do you observe? Explain your observations.*

Rub a plastic pen or a ball point pen with a piece of nylon cloth. Now place the pen near very tiny pieces of paper or fine sand or even chalk dust. Observe all that happens. Were you able to pick up the bits of substances on any part of the pen? What has happened to the pen?

Good! Here is another activity you can try. This time we will bend water.

**Fig. 1.4 Electrostatic activity - bending water**
As we rubbed the plastic pen with nylon and the balloon with wool, the pen and balloon became electrically charged. Hence, there was attraction between the pen and bits of paper and between the balloon and the water. The nylon and wool lost electrons and became positively charged, while the balloon and plastic pen gained electrons and became negatively charged. All these are evidences of electrostatic activities.

One thing we must bear in mind is that rubbing does not produce electricity. Rubbing causes electrons to be transferred from one substance to another.

How do elements combine?

When elements combine, they either lose, gain or share electrons. But before we look at the combining of elements, let us look at the arrangements of the electrons of an aluminium atom. This arrangement is known as the electronic configuration of the element.

Earlier we learned that electrons revolve in shells around the nucleus of the atom. Each of these shells can accommodate a maximum number of electrons. The first shell can have a maximum of two electrons, the second shell can have a maximum of eight electrons, the third shell can have a maximum of eighteen electrons.

For example, an atom of aluminium, \( \frac{27}{13} \) Al, has thirteen electrons revolving around its nucleus like this. See Fig. 1.5.

Therefore the electronic configuration of aluminium is 2.8.3.

Write the electronic configuration of the following:-

\[
\begin{align*}
16 & \quad 12 & \quad 23 \\
\text{O} & \quad \text{C} & \quad \text{Na} \\
8 & \quad 6 & \quad 11 \\
14 & \quad 35 & \quad 24 \\
\text{N} & \quad \text{Cl} & \quad \text{Mg} \\
7 & \quad 17 & \quad 12
\end{align*}
\]
<table>
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<th>Atomic number</th>
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<tr>
<td>20</td>
<td>Ca</td>
<td>2.8.8.2</td>
</tr>
</tbody>
</table>

Now let us consider how elements combine. The last shell of electrons of an atom is called the **valence shell or outer shell**. The electrons in the outer shell are the ones that take part in chemical bonding.

When atoms lose electron(s), they become positively charged ions. **Positively** charged ions are called **cations**. When atoms gain electron(s), they become negatively charged ions. **Negatively** charged ions are called **anions**. The bonding of cations and anions involves **ionic** or electrovalent type of bonding.

Ionic bonding occurs between metals and non-
metals. In this type of bonding, the electrons move from the metal atom to the non-metal atom.

Let us consider the two elements, chlorine (Cl) and sodium (Na). When they combine, the sodium atom loses its one outer shell electron and chlorine takes it in. They have now become sodium and chloride ions, written as Na⁺ and Cl⁻. What would be the electronic configuration of each ion now?

The electronic configuration of the sodium ion is 2.8. The electronic configuration of the chloride ion is 2.8.8. Each ion now has the maximum number of electrons in each shell. Each ion has now become stable. (See Fig. 1.6.)

The combining of these two elements gives rise to the compound, sodium chloride. Do you think there would be a change in the properties of the new substance formed?

Elements also combine by sharing electrons. This type of bonding is known as covalent bond. Covalent bonds involve the sharing of electrons between atoms of nonmetals to form molecules. Therefore, we can now describe a molecule as two or more atoms joined by covalent bonds. (See Fig. 1.7.)

![Fig. 1.6 Ions formed by the loss or gain of electrons in making sodium chloride](image)

![Fig. 1.7 Covalent bond consisting of a pair of electrons](image)
Fig. 1.8 The bonding of hydrogen atom and chlorine atom covalently to form hydrogen chloride molecule

Can you explain simply what happened in Fig. 1.8?

More on the Periodic Table

We are now going to have a closer look at the Periodic Table

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Ce  Pr  Nd  Pm  Sm  Eu  Gd  Tb  Dy  Ho  Er  Tm  Yb  Lu
Th  Pa  U  Np  Pu  Am  Cm  Bk  Cf  Es  Fm  Md  No  Lw

- Gp. Means Group
- Pd. Means Period

Fig. 1.9 The Periodic Table
The columns are called groups. The rows are called periods. Elements are placed in groups because they have similar properties.

All elements in Group I have one electron in their outer shells. Those in Group II have two electrons in their outer shells. Similarly, in Group VII, the elements have seven electrons in their outer shells. The elements helium, argon, krypton and xenon, in Group 0, have full outer shells, and this makes them very unreactive. Hence, they are called inert or noble gases.

By looking at the Periodic Table, chemists can tell a great deal about each element. For example, metals lower down in Group I are more reactive than those above e.g. Potassium is more reactive than sodium.

Period 4 has more elements than Period 3.
Compiling a reactivity series

The reactivity of metals with oxygen

We have burnt magnesium in air and observed that it burnt with a dazzling flame. Now let us look at the reaction of three other metals.

You will need a very small piece of calcium in a deflagrating spoon. Heat the spoon gently until the calcium ignites. Quickly put the spoon into a jar of oxygen. Observe what happens. Repeat the experiment using iron, zinc and magnesium. Make careful observations and record in a table. Now arrange the metals in the order in which they react, starting with the one that reacted most vigorously.

We can write a word equation to represent the reactions of some metals with oxygen.

e.g. magnesium + oxygen = magnesium oxide
     calcium + oxygen = calcium oxide

The reactivity of metals with water

Put a small piece of calcium in a large test tube half full of water. Observe what happens. Does the temperature of the tube change during the reaction? Is a gas given off? Record your results in a table. The reaction can be represented as follows:

calcium + water = calcium hydroxide + hydrogen.

Now repeat the experiment using magnesium. Your teacher may show you the reaction of sodium with water. Does he/she use a large container of water? Record all observations.

Write the word equations for the reactions of sodium and magnesium with water. Arrange the elements according to how active they were, beginning with the most active one.

What happens to the metal when it reacts with water? Sodium reacts vigorously. Calcium reacts steadily while magnesium reacts very slowly. The hydroxides of the elements are formed e.g. calcium hydroxide. The gas hydrogen is liberated. Let us now see what happens with metals and acids.

The reactivity of metals with acids

You will need dilute hydrochloric acid and dilute sulphuric acid; small pieces of iron, aluminium, tin, zinc, lead and copper.

Pour about 5 cm³ of dilute sulphuric acid in a test tube. Add a small piece of aluminium. Observe and record your observations. Repeat using the other metals. Do you think metals will react the same way with hydrochloric acid? Let us find out.

Repeat the whole sequence, using dilute hydrochloric acid instead of sulphuric acid. Observe what happens and record your observations in a table, as shown below.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Dilute hydrochloric acid</th>
<th>Dilute sulphuric acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aluminium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Iron</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Did the test tubes get warm? Was any gas given off? Test the gas with a lighted splint. Which metal is most reactive?

Pour a little of the solution from the test tube, after a reaction has taken place, into an evaporating dish. Place it over a Bunsen flame and heat gently until it boils. Remove the flame just before all the substance dries out. What is left in the evaporating dish? It surely looks like salt, doesn’t it? It is a salt! When a metal reacts with an acid, a salt of the metal is formed. The salts formed using hydrochloric acid are called chlorides.

Those formed using sulphuric acid are called sulphates.

What salt is formed when aluminium reacts with dilute sulphuric acid?

The word equation for the above reaction is: aluminium + sulphuric acid = aluminium sulphate + hydrogen.

Now did all the metals react with the acids?

Write a word equation for each reaction that took place.

Arrange the metals according to how they react with oxygen, water and acids, beginning with the most reactive one.

Does your arrangement look like this?

<table>
<thead>
<tr>
<th>Oxygen</th>
<th>Water</th>
<th>Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Sodium</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Calcium</td>
<td>Zinc</td>
</tr>
<tr>
<td>Zinc</td>
<td>Magnesium</td>
<td>Iron</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper</td>
</tr>
</tbody>
</table>

N.B. The metals - tin, lead and copper do not react with dilute hydrochloric acid.

What have you noticed about your arrangement?

Notice that calcium is more reactive than magnesium in its reaction with oxygen and water. Sodium is more reactive than calcium in water. Sodium reacts vigorously with water. How do you think it will react with oxygen or acid.

N.B. Do not try this out! Do you think that sodium will react just as vigorously with oxygen or acid as it did with water?

From similar experiments like the ones you have just completed, scientists were able to arrange metals in order of their reactivity with oxygen, water and acid. The arrangement is called the reactivity series.

What we have done so far is to look at the reactivity of a few metals with water, oxygen and acids and to compile a reactivity series for these metals.

But there are other metals that can be added to the series. Here is a full series of the names of metals according to their reactivity with water.

1. Potassium 7. Iron
2. Sodium 8. Lead
3. Calcium 9. Hydrogen
4. Magnesium 10. Copper
5. Aluminium 11. Mercury

Where in the reactivity series do you think we can place metals such as tin, lithium and gold?

Here is something you can try.

You will need filings of the metals: zinc, iron and magnesium.
Heat each metal separately in a bunsen flame and observe the reactions.

Place small amounts of each metal in a test tube with 3 cm³ water. Observe and record your observations.

Repeat using acid instead.

Are the reactions faster when ‘filings’ or when ‘pieces’ of metals are used?

Can you explain your observations?

Actually with the filings, a larger surface area is exposed, hence a faster reaction.

5. An element has an atomic number of 20, and a mass number of 40. State how many of each type of sub-atomic particles are present in an atom of this element.

6. ‘The Periodic Table is very important.’ Give THREE reasons to support this statement.

7. What compounds are formed when magnesium reacts with:
   (a) oxygen (b) water (c) hydrochloric acid (d) sulphuric acid?

8. Name the gas liberated when metals react with water.

9. Which is the most reactive metal and the least reactive metal in the reactivity series?

10. To which group on the Periodic Table does the most reactive metal belong?

11. Explain why copper, silver and gold are used for coinage and to make jewellery.

Exercises

1. What are the sub-atomic particles of an atom?

2. What are (a) the atomic number and (b) the atomic mass of an atom?

3. What is the electronic configuration of an atom?

4. (a) Which electrons take part in chemical bonding?

   (b) Name the various types of chemical bonds and describe simply how each is formed.
WE HAVE LEARNT THAT

- substances are made up of numerous tiny particles called atoms.
- atoms are made up of smaller particles - electrons, protons and neutrons. These are called sub-atomic particles.
- atomic number is the number of protons or electrons present in an atom of an element.
- atomic mass is the sum of the number of protons and the number of neutrons in an atom of an element.
- the electrons revolve in shells around the nucleus of an atom. The arrangement of these electrons is called the electronic configuration of the atom.
- elements combine by either forming ionic bonds or covalent bonds.
- the Periodic Table groups elements according to their properties.
- some metals react more vigorously with oxygen, water and acid than others.
- metals may react with oxygen to form oxides.
- metals may react with water to form their hydroxides and hydrogen gas.
- salts are formed when metals react with acids.
- salts formed when metals react with dilute hydrochloric acid are called chlorides. Salts formed when metals react with dilute sulphuric acid are called sulphates.
- hydrogen also may be liberated when metals react with dilute acids.
- the arrangement of metals in order of their reactivity with oxygen, water or acid, beginning with the most reactive, is called the reactivity series.
Unit 2

Our environment

Introduction

A study of the environment and how living things interact with each other helps us to learn more about the balance of nature. When we study a specific area in the larger environment we come to understand how certain conditions favour the existence of organisms found there.

Soil is an important part of the environment because, apart from its role in allowing plants to grow, it is the home of countless small organisms which carry out their entire life cycle within it. One definition of ‘soil’ is “the layer of earth that harbours life”. This is true because humans and many other animals also depend on soil as it provides support, water, and nutrients for plants which in turn provide food for humans and animals.

In this unit we will consider

• soil organisms.

• activities of soil organisms that contribute to soil fertility.

• activities of soil organisms that are harmful to plant life.

• components of soil and other environmental factors that make it ideal as a habitat.

• an ecological study.

• relationships in an ecosystem.

Organisms in soil

We know that plants grow in soil, but there are numerous other organisms that live in the soil, some of which we cannot see with the naked eye. Soil contains large numbers of small animals and microorganisms such as bacteria, protozoa, fungi and algae.

Let’s take a closer look at some of these soil organisms and their activities.
<table>
<thead>
<tr>
<th>Organisms</th>
<th>Where found</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthworms</td>
<td>in soil</td>
<td>active burrowers in soil; eat decaying plant matter; fertilise the soil; aerate the soil.</td>
</tr>
<tr>
<td>Termites</td>
<td>in soil</td>
<td>active burrowers in soil; eat dead and decaying wood.</td>
</tr>
<tr>
<td>Cockroaches</td>
<td>under leaf litter and stones</td>
<td>eat decaying material.</td>
</tr>
<tr>
<td>Ants</td>
<td>in soil</td>
<td>burrow in leaf litter and soil; feed on small plants and animals.</td>
</tr>
<tr>
<td>Spider</td>
<td>leaf litter, soil spaces, under stones</td>
<td>feed on other soil organisms.</td>
</tr>
<tr>
<td>Nematodes</td>
<td>in soil water</td>
<td>invade plant roots, eat animals or decaying plants.</td>
</tr>
<tr>
<td>Centipedes</td>
<td>in and under leaf litter</td>
<td>eat small animals e.g. insects, spiders and worms.</td>
</tr>
<tr>
<td>Millipedes</td>
<td>in leaf litter or in soil</td>
<td>eat plants and aerate the soil.</td>
</tr>
<tr>
<td>Snails</td>
<td>on leaf litter or under stones</td>
<td>feed on living or dead plants.</td>
</tr>
<tr>
<td>Slugs</td>
<td>on leaf litter or under stones</td>
<td>feed on living or dead plants.</td>
</tr>
<tr>
<td>Wood lice</td>
<td>Under leaf litter, stones, and soil spaces</td>
<td>eat decaying material.</td>
</tr>
<tr>
<td>Beetle larvae</td>
<td>in soil</td>
<td>active burrowers; feed on plants and decaying material.</td>
</tr>
<tr>
<td>Insect pupae</td>
<td>in soil spaces</td>
<td>non-feeding, resting.</td>
</tr>
<tr>
<td>Mites</td>
<td>in soil spaces</td>
<td>attack earthworms and nematodes.</td>
</tr>
</tbody>
</table>
In the chart we see a variety of insects and other small animals that live in the soil. They may be put into three large groups; namely true worms, arthropods and molluscs. Fungi and bacteria are decomposers. They are the main agents of the decay of animal and plant material in the soil.

The presence of all of these soil organisms may or may not contribute to soil fertility. A look at the advantages and disadvantages of organisms in soil could help us to see how this is so.

Advantages of organisms in soil

Certain activities of organisms in soil help to increase soil fertility. The following are examples of such activities:

1. Decomposition or breakdown of organic matter. Soil organic matter consists of living organisms. Most of the decomposers in soil obtain their energy from feeding on such decaying material, thereby aiding its decomposition. When some bacteria feed, they digest their food outside the bacterial cell. Enzymes secreted by the bacteria pass out of the bacterial cell membrane and break down the food molecules. Digested food passes into the bacterial cell. The decomposed residues are rich in plant nutrients.

2. Release of mineral salts and carbon dioxide. During decay, bacteria break down complex molecules in dead plant and animal matter and form simpler chemical compounds. These compounds are used as plant nutrients.

3. Special chemical changes. Bacteria also contribute to certain chemical changes. One example is that ammonium compounds are oxidised to nitrates. Plants can absorb nitrates.

4. Nitrogen fixation. Nitrogen from the air is turned into nitrogenous compounds in the soil by the action of two kinds of bacteria. There are the bacteria that live in the root nodules of legumes such as peas and beans; and those that live freely in the soil.

5. Formation of a soil structure. This is good for plant growth. Bacterial gums, fungal threads and termite saliva all help to bind soil particles together to make good soil structure.

6. Increased aeration and drainage. The constant burrowing and tunnelling of some soil organisms cause air to circulate more freely and water to drain more easily, thus improving aeration and drainage.

The earthworm

One soil organism that helps the farmer significantly is the earthworm. Its activities are exactly what a farmer aims to do to make a soil fertile. The earthworm makes its burrow by taking in soil through its mouth. The soil is finely ground up in the intestine where any nutrients are extracted for food. The remains are passed out through the anus to form a cast above ground. The following activities of the earthworm all aid in increasing soil fertility:

1. Tunnelling and burrowing. These activities aerate and drain the soil.

2. Pulling leaf litter down into the tunnels. Once there, bacteria and fungi decompose the leaves, setting free plant nutrients.


4. Bringing up mineral salts from lower layers of soil. The earthworms may eat their way through tightly-packed soil. They excrete worm casts
on the surface of the soil. In this way they till the soil.

5. **Secreting calcium carbonate (lime)** from their gut in the worm casts. The lime helps to neutralise acid soils.

When the earthworm dies, its body decomposes and contributes to soil fertility.

![Earthworm diagram](image)

**Fig. 2.1 Earthworm in the soil**

3. **The organisms in soil compete with crop plants for nutrients (mineral salts).** If the organisms take too much of the nutrients the plants may be stunted in growth, suffering from a deficiency of mineral salts.

4. **Some bacteria produce toxins (poisons)** in soils that are deficient in oxygen. These toxins inhibit root growth.

   Damage to crops by soil organisms causes a reduction in the productivity of crops i.e. stunted or diseased plants do not grow well enough to produce a good crop. Spores of parasitic fungi and some bacteria are pathogens which cause crop disease.

   You will have seen that there are more advantages than disadvantages.

Let us now do two investigations of soil life.

---

**Disadvantages of organisms in soil**

Soil organisms could have activities which are detrimental to soil fertility. Such activities are as follows:

1. **Certain bacteria change nitrates in the soil into nitrogen.** The nitrogen is released into the atmosphere. This process is termed denitrification. This action causes a reduction of the available nitrates needed by plants.

2. **Various animals and plants damage crops.** Millipedes and nematodes attack plant roots, especially of vegetable crops. Some insect larvae also eat the roots of plants. Termites too can do a lot of damage to crops.

1. Choose a place under a tree where there are lots of decayed leaves (leaf-litter).

2. Dig up a spadeful of leaf-litter, put it in a plastic bag and carry it inside to your classroom or laboratory.

3. Spread your sample on a sheet of white paper or cloth, taking care to catch anything that moves. Use a large spoon or a pair of forceps, as some animals bite or sting.

4. Put each type of animal into a separate specimen bottle and cover it.
1. Make small holes, of 2 mm diameter, in the bottom of a 2 litre plastic container.

2. Remove leaf litter from an area of ground, and dig up a spadeful of the soil underneath. Two thirds fill the container with soil.

3. Support the container above a beaker of water.

4. Arrange a light above the container. The light and heat will drive soil animals downwards and so out of the soil and into the water below.

5. Identify any animal, using the chart.

Fig. 2.3 Collecting soil animals

Soil as a habitat

We have just learnt that soil contains thousands of plants and animals, most of which are microscopic. In order for these organisms to survive they have to obtain food. Some digest decaying organic matter found on top of or in the soil. Others exist on roots and underground stems in the soil. Still others are predators that search for and attack other soil organisms.

The number of organisms in a sample of soil, however, depends on other environmental factors such as light or lack of it, water, air and temperature. In this section we will look at how some of these factors affect the activities of soil life.
The components of soil

Let us do an activity to find out the various parts of a soil.

**Activity** To separate the components of soil

The following method of separating the different parts of soil is called the **Sedimentation method**.

You will need:

- a sample of soil
- measuring cylinder

1. Put 50 cm³ of your soil sample in a 100 cm³ measuring cylinder and add 50 cm³ of water.

2. Use a glass rod and stir.

3. Leave the cylinder and its contents to settle for at least three hours, but preferably for about two days.

4. The different components of the soil will settle out into different layers depending upon the size and weight of the particles.

5. Look at the diagram in Fig. 2.4 and identify the different parts of the soil profile you have.

If we could look at a giant slice of the earth's crust, we would most probably see a similar arrangement to that in Fig. 2.4 (except for the water which we added.)

The upper layer of the “slice” is called top soil and on top of that is leaf litter or humus. This arrangement is ideal as a habitat for plants. Plant roots can grow deep and/or wide in the top-soil; and can absorb water with dissolved mineral salts for nutrients. Air, with its carbon dioxide, supplies plants with the element carbon.

Every other element that plants need could be supplied by soil.

![Diagram of soil layers](image)

**Fig. 2.4** A soil profile obtained by the sedimentation method

### Water in soil

Water is very important to organisms. It is a good solvent. Soil-water dissolves mineral salts present in soil. Plant roots can then absorb the mineral salts and be nourished. The main source of soil water is rain.

When rain falls to the ground it may :-

- evaporate.
- run off into streams and rivers.
- percolate through the soil pore spaces.
- be absorbed by the soil and be retained in its pore spaces.
- flood the soil completely.
The water that is retained in soil becomes part of the soil and is regarded as its **water content**. This water is used up gradually by soil life. Even if a soil appears to be completely dry it may still contain some moisture clinging to the soil particles.

Moisture will cling to soil particles because soil components such as clay and humus have a strong attraction for water molecules. They **imbibe** water.

![Soil particles with film of soil water](image)

**Fig. 2.5 Soil particles with film of soil water**

There are several ways in which the soil gets its water-content. The main ones are **percolation** of rain water and **capillary action**. Capillarity is the movement of water upward through the soil from a more saturated to a less saturated region. You could investigate **capillarity**.

**Things you will need**:

- glass tubing of three widths - wide bore, medium bore and very narrow bore.
- glass trough
- three retort stands and clamps
- water

1. Pour water into the trough.
2. Stand the glass tubes in the water. Support each one with a clamp. (See Fig. 2.6)
3. Note the water level in each tube.
4. Record your observations.

**Fig. 2.6 Apparatus with which to investigate capillarity**
Capillarity

The atmosphere is pressing down on the water in the trough. This atmospheric pressure pushes water up each tube. The volume of water in each tube, above the general water level, is the same. But because the bores are different the heights differ.

In sandy soil, the pore spaces are wide. Capillarity is therefore poor/low. In other words, water does not move upwards much. But in clayey soil, the pore spaces are extremely narrow. Water rises well.

Table 2.2 Comparison of properties of two types of soil

<table>
<thead>
<tr>
<th>Property of soil</th>
<th>Sandy soil</th>
<th>Clayey soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of soil particles</td>
<td>large</td>
<td>small</td>
</tr>
<tr>
<td>Size of pore spaces</td>
<td>large</td>
<td>small</td>
</tr>
<tr>
<td>Water-movement</td>
<td>very rapid</td>
<td>very slow</td>
</tr>
<tr>
<td>Water-retention</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Capillarity</td>
<td>poor/low</td>
<td>good/high</td>
</tr>
</tbody>
</table>

The two types of soil in Table 2.2 are not the most suitable for soil organisms.

Sandy soils are very porous and do not hold much water and nutrients.

Clay soils are far less porous, but they become waterlogged easily and inhibit free movement of air.

Loams, however, are ideal for soil organisms because their properties are just right for sustaining life. The particles are of mixed size - there are therefore some large pore spaces and some small ones.

Excess water can drain away easily. At the same time, clay particles imbibe water, so water is available to soil organisms. The water also rises up between the clay particles by capillarity.

Air in soil

Air lies trapped between the solid soil particles, in the pore spaces that are not occupied by water. The volume of air that is present in the soil is therefore dependent on the texture of the soil i.e. its particle size in relation to pore spaces.

Most of soil life is found in the air spaces. This is so because soil air provides oxygen for respiration. Every living cell respires; plant roots and soil organismsrespire. As a result of respiration, soil air is higher in moisture and carbon dioxide and lower in oxygen than the atmosphere.

Air is a valuable part of soil because it:
- makes respiration possible.
- provides nitrogen for the nitrogen-fixing bacteria to form nitrogen compounds.
- is essential for germination and root-growth.

Soil aeration is necessary in maintaining soil fertility. It is achieved by regular digging, hoeing and ploughing. Earthworms also are very useful in aerating the soil. Their tunnelling and burrowing loosen and turn over soil thereby making possible the circulation of air. Whenever soil becomes water logged, the air is pushed out. No longer is aerobic respiration possible.
Some plants e.g. mangroves, have overcome the difficulty of living in swamps. Their roots grow up out of the mud into the air.

1. Put 50 cm³ of a sample of soil into a 100 cm³ measuring cylinder.

2. Add 50 cm³ of water.

3. Stir soil and water. Observe the bubbles of air escaping from the air spaces between the soil particles.

4. The original volume of soil plus water in the measuring cylinder was 100 cm³. Find the final volume. How much air has escaped?
   i.e. (Original volume—Final volume)

5. The percentage of air by volume is then:

\[
\frac{\text{Volume of air which has escaped}}{\text{Original volume of soil (50 cm³)}} \times 100
\]

Temperature of soil

Warmth is one of the needs of most plants. Temperature is a measure of warmth and is a physical property of soil that affects agricultural productivity.

All changes in nature are controlled by energy and heat is a form of energy. The main source of heat in soil is radiation from the sun. This radiation provides warmth for plant growth. The extreme temperatures of frozen regions and of very hot areas are unsuitable for the majority of soil organisms.

In cold climates the activities of soil organisms are slowed down when the soil is cold. When the soil is very hot the heat could destroy most of the organisms. Their protein could be **denatured**, that is, they lose their ability to function.

pH of soil

‘pH’ is the term used to express the degree of acidity or alkalinity of a substance. pH is measured on the pH scale ranging from 0-14. On the scale, 7 is neutral. This means that there are just as many hydrogen ions as hydroxide ions. A pH that is less than 7 means that there are more hydrogen ions than hydroxide ions. Such solutions are **acidic**. A pH that is greater than 7 means that there are more hydroxide ions than hydrogen ions, and so those solutions are **alkaline**.
Fig 2.8 pH scale showing limits for plant growth

It is more common to find soils that are acidic. Factors contributing to this condition are: leaching i.e. washing away of plant nutrients; uptake of nutrients by plants; application of fertilisers and the presence of sulphur compounds.

Soils that are highly acidic can cause damage to plants because elements such as iron, copper and manganese dissolve in acid soil water. These dissolved substances may become poisonous to plants.

Plants usually thrive better in neutral soils or ones which are slightly acidic, than in soils of greater acidity. A pH of between 6 and 7 is suitable for most garden plants.

In order to adjust the pH of a soil that is too acidic, the farmer needs to add lime to the soil. If it is too alkaline he should add ammonium sulphate. These chemicals will neutralise the soil and make it more suitable for soil life.

Let us do another activity, this time about pH.

You will need:

- a sample of soil
- test tube
- barium sulphate powder
- Universal Indicator solution
- distilled water

1. Put about 1 cm$^3$ of the soil in a test tube and mix it with barium sulphate powder and distilled water.

2. Cork the test tube and shake the contents vigorously. Allow to settle. (Barium sulphate is added to ‘clump’ the clay particles so that they become larger and sink. This leaves a clear solution to test for pH.)

3. Add a few drops of Universal Indicator solution. Compare the colour of the solution with the colour chart provided with the indicator.

4. Is the soil acidic, alkaline or neutral? Record your observations.

5. Test other soil samples from other areas and record your observations.
An ecological study

Ecology is the study of the relationships of living things to their surroundings and to one another i.e. how living things and non-living things in the environment affect each other. The non-living parts or physical factors in the environment including temperature, light, water, weather conditions, altitude and essential elements like oxygen, carbon and nitrogen are referred to as the abiotic factors.

The relationships amongst organisms are the biotic factors. Everything that happens among organisms in relation to their surroundings is taken into account when studying an ecosystem i.e. a section of the biosphere in which living and non-living things interact and inter-relate.

Terms used in ecology

The organisms, places, relationships, interactions and conditions in an ecological study all have specific terminology.

Energy is essential for life’s activities, thus all organisms need energy. The sun is the source of all the energy in the biosphere, that is, the thin layer on and above the earth where life exists. Plants use this energy from the sun to produce food, therefore, plants are called producers.

The food that plants produce stores energy and this is passed on to all organisms when they take in food. A food chain is a sequence of organisms showing their feeding relationships. Energy is transferred from one organism to another during this relationship. A food web is a combination of overlapping food chains in an ecosystem.

In a food chain there are animals that depend on plants and on animals for food. All of them are called consumers. The consumers that feed on plants only are called herbivores, and those that feed on animals only are called carnivores. The consumers that feed on both plants and animals are called omnivores. Some organisms bring about the decomposition or decay of living organisms that have died. They are called decomposers.

Habitat

Different organisms live in different kinds of places. The place where an organism lives i.e. where it is most frequently found, is called its habitat. All organisms depend on their surroundings for support for the activities of life, so nature ensures that organisms develop features which help them to adapt to and survive in the prevailing conditions of their habitats. One such feature is a change of colour to that which blends in with the colour scheme of the habitat.
This feature is called camouflage, for example, a stick insect among twigs or a green iguana in a tree.

How do we differentiate between an ecosystem and a habitat? An ecosystem is a section of the environment. It consists of the organisms and non-living things. Scientists who study ecosystems are called ecologists. A habitat is a particular place in an ecosystem, therefore, each ecosystem would have a number of habitats. There are aquatic habitats like fresh-water lakes, ponds and streams, salt-water seas or oceans, and terrestrial habitats which are on land.

Let us do a practical exercise!

You will need

- a large shady tree, notebook and pen
- a small shovel/hand fork
- hand lens

1. Choose one of the following habitats using the large tree as your ecosystem:
   - the branches and trunk of the tree
   - beneath its bark
   - on the roots
   - under the leaf litter below the tree
   - under stones or attached to trees nearby
   - in the nearby soil

2. Select a good position for observing the living organisms that are visible - plants and animals. Use a hand lens for close-ups.

3. Use the shovel or other similar tool for getting to the organisms e.g. lifting bark, removing leaf litter, stones and sample of soil.

4. Draw up a table as in Table 2.3 and record your observation.

N.B. ‘Behaviour’ includes: eating habits, whether or not the organisms move about — hunting or being hunted.

Table 2.3  Information about the organisms found in a named habitat.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Colour</th>
<th>Where found</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Population

The number of pupils in your school could be called your school population. The grasshoppers in the vacant field close to your school; the earthworms found in the sample of soil; the daisies growing in your school plot; the ‘millions’ fish found in the drain are all populations.

A population is a group of organisms of the same kind or species in a particular place. One of the factors influencing an ecosystem is the number of each species of organism present. Food chains and food webs tend to keep the numbers of organisms constant and distribution often depends on such relationships as predator prey and parasite-host relationships.

![Image](image.png)

Fig. 2.10 An example of a ‘predator-prey’ relationship

Predator: the animal that catches and eats another e.g. when the frog catches and eats a cockroach, the frog is a predator.

Prey: the animal that is caught and eaten e.g. the cockroach that is eaten by the frog is the prey.

Parasite: an organism that feeds and lives on or in another living organism e.g. hookworm found in intestines of humans.

Host: the organism on which or in which a parasite lives and feeds is the host e.g. a child with hookworms in its body.

Such relationships always affect the size of populations. Let us consider a predator-prey situation. A large spider population eats a lot of insects. The number of insects may decrease as they are eaten by spiders. Then the spiders would have less food and competition amongst the spiders for food could result in a smaller spider population. With fewer spiders, the insect population might increase again.

Likewise, in the parasite-host relationship, the parasite population is limited by the size of the host population, e.g. there could only be as many full-grown tapeworms as there are hosts. Note that competition occurs when there are limited materials and every organism has to work ‘against’ other organisms to meet its needs.

You will need:

- ten square-metre quadrats (a quadrat or a one-metre square wooden frame is used to help us in estimating the size of a population).
- four stakes
- tape measure

1. Measure a grassy plot 10 metres by 10 metres, as shown in Fig. 2.11. Put a stake at each corner.
1. **Mutualism.** The characteristics and functions of one organism help to meet the needs of another. For example, bacteria live in the intestines of herbivores. They help to digest cellulose and to decompose waste.

2. **Commensalism.** This is a relationship of cooperation in which one organism is helped and the other is in no way harmed. For example, the egret and the cow benefit from each other in that the egret feeds on ticks and other insects that live on the cow. Can you name any other examples of mutualism and of commensalism?

**Other environmental factors**

The physical factors in any environment play a vital role in the interactions that take place in an ecosystem. The physical factors such as light, temperature, rain (water) and wind form part of the climatic conditions in a region. The climatic factors in these regions affect organisms in many ways.

**Light:** Plants must have light to make food. Some, such as the sunflower need more light than others. Some organisms avoid light and seek dark habitats. Some animals are active during the day and rest at night. These are **diurnal** animals. Those that are active only in the night are called **nocturnal** animals.

**Temperature:** Heat and cold affect the growth and behaviour of plants and animals. Humans and some other animals, for example, **birds are homoiothermic**, that is, they can keep their body temperature fairly constant, despite temperature...
changes in the environment. Some animals, such as lizards are **poikilothermic**, that is, they cannot control their body temperature, which varies with the temperature of the environment. In extremes of heat or cold such animals are very inactive.

**Water** : Water is essential for life. Adequate supplies of fresh water in the environment are maintained by the water cycle.

![Diagram of the water cycle](image)

*Fig. 2.12 The water cycle*

Water occurs in the atmosphere as water-vapour, the presence of which is called **humidity**. Too much water or too little can be harmful because the concentration of cell fluid should be constant. In tropical rain forests, the vegetation is lush while in the desert there is scant growth of plants because there is more water in the rain forest than in the desert.

**Wind** : The movement of air caused by differences in atmospheric **temperature** is known as wind. The wind plays its part in causing rain. It has a cooling and drying effect on plants and on animals. It also helps in the dispersal of seeds, fruits, pollen and spores. Strong winds, however, can damage plants and blow away topsoil from the land. This removal of top soil is **erosion**.

**Ecology of a tree as an ecosystem**

The tree in this study must be alive. From your previous work you will now know that the ecology of a tree entails the examination of the many organisms associated with the tree. Any type of tree which is easily accessible forms a good subject for study.

Follow the two procedures given.

**Procedure A** — A botanical study of the tree.

1. Select a tree with low sturdy branches. Do not damage the tree during the investigation.

2. Record in drawings (a) the overall shape of the tree (b) the way the branches emerge (at right angles or otherwise) (c) the twigs (d) the bark (e) the leaves (f) the flowers (g) the fruit.

3. Note the tree’s exposure to sun, prevailing winds and rain, and its nearness to buildings.

4. Search the ground around the tree for germinating seedlings. Measure the distances between the seeds and seedlings and the parent tree.

Fill in the table (as in Table 2.4) as you go along.
Table 2.4. Record of observations during study of tree as an ecosystem.

<table>
<thead>
<tr>
<th>Name of organism</th>
<th>Where found</th>
<th>Number found</th>
<th>Branches searched</th>
<th>Total branches on tree</th>
<th>Estimate of population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bugs</td>
<td>on leaves</td>
<td>10</td>
<td>4</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Caterpillars</td>
<td>on stems</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Spiders</td>
<td>on stems</td>
<td>2</td>
<td>1</td>
<td>12</td>
<td>24</td>
</tr>
</tbody>
</table>

**Procedure B**— Study of the tree community.

1. Collect any animals from the following sites:
   (a) the litter at the base of the tree
   (b) the holes and hollows on the trunk
   (c) under loose bark
   (d) in the forks of branches

2. Draw a distribution map for the types of organisms found at the different areas listed in Fig. 2.13.

- Collecting areas:
  - 1 and 2 - litter at base of tree
  - 3, 4, 5 and 6 - holes and hollows
  - 7 and 8 - on and under bark

3. Investigate other areas. Examine leaves carefully on both surfaces; flowers, twigs, fruits and seeds for any organisms. Look carefully for animals hiding, feeding, attached to or inside flowers or fruits. Note insect visitors to flowers. Record all of your observations.

4. Collect samples of plants growing on the tree. These may be algae, lichens and mosses growing on the bark. There may also be epiphytes like wild pine, or parasites like bird vine on branches. Record your observations.

5. Estimate the population of each type of organism present on the tree. Make a table (as in Table 2.4) and use the format for your estimates.

This study could be done during the two seasons we have here in Guyana - wet and dry. A comparison of the biotic factors may be made.
Table 2.5 Record of observations during field study.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Observation</th>
<th>Wet season</th>
<th>Dry season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>No leaves present</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many young leaves</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leaves change colour</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leaves fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoots</td>
<td>Many new shoots</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Few new shoots</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No new shoots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flowers</td>
<td>No flowers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flower buds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Few open flowers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Many open flowers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits and seeds</td>
<td>No fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Young fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ripe fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Old fruits fallen</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seed dispersal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climatic conditions</td>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rainfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Humidity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exercises

1. Answer the following:

   (a) List **FIVE** different activities of soil organisms that affect or benefit the soil.
   (b) In what ways is the amount of nitrates (i) increased (ii) decreased in the soil?
   (c) What organisms are responsible for (i) an increase (ii) a decrease in the amount of nitrates in the soil?
   (d) How would you group the animals listed in Table 2.1? Use the format overleaf. (Tick the appropriate column in each case.)
   (e) How can the eating of dead matter help the dead matter to decompose?
<table>
<thead>
<tr>
<th>Name of organism</th>
<th>Worms</th>
<th>Arthropods</th>
<th>Molluscs</th>
</tr>
</thead>
</table>

Answer the following:

2. (a) Which type of soil drains best?
   (b) What effect will this have on the soil, and on organisms living in it?

3. (a) In which type of soil is water retention the greatest?
   (b) What effect will this have on the soil, and on plants living in the soil?

4. Plants need water and air from the soil. Which of these is likely to be in short supply in (a) sandy soil (b) clay soil?
   Explain your answers.

5. (a) How could a farmer improve a soil that is too acidic?
   (b) If a soil is too alkaline, what should the farmer do?

6. The farmer ploughs soil to turn it over and aerate it. What does it mean to ‘aerate’ the soil?

7. (a) List three characteristics of clay soil that could make it unsuitable for soil life.
   (b) What would you do to improve a clay soil?

8. List the statements/phrases, a - e, in your book and cross out those that are not true of ecosystems.
   (a) sections of the environment
   (b) methods ecologists use to classify organisms
   (c) diagrams that show energy transfer
   (d) can be large or small
   (e) what ecologists study

N.B. Do not write in the text book.

   (a) Animals that control their body temperature are called ________ animals.
   (b) A group of the same kind of organism living together is called a ________
   (c) Plants make food and are called ________

10. Answer the following:
    (a) Why isn’t all the water in the environment available to organisms?
    (b) Why is the removal of all the predators from an area not wise?
    (c) Why do you think so few large animals live in the desert region?
    (d) Explain how people get their supply of energy.
WE HAVE LEARNT THAT

- there are numerous organisms (including microbes like bacteria and fungi) living in the soil.
- small soil animals can be put into three groups: true worms, arthropods and molluscs.
- many of the activities of soil organisms contribute greatly to soil fertility.
- the earthworm is very useful to the farmer.
- there are some activities of soil organisms that are harmful to plant life.
- soil could be a mixture of sand, silt, clay, and humus along with water, air and minerals.
- soil environmental factors include illumination and temperature.
- the pH of soil is another property that is important to plant growth. Plants grow better in a slightly acidic soil.
- scientists, called ecologists, study relationships amongst living and non-living parts of eco-systems.
- the place in which an organism lives is called its habitat.
- the number of plants or animals of a particular species in a given habitat is the population of that species.
- physical factors such as light, water, temperature and wind are part of the climatic conditions.
Unit 3

Materials from the earth

Introduction

The earth is believed to be a sphere with three layers, the crust, the mantle, and the core. The top layer of the crust is the part on which we live, grow our crops and get raw materials to manufacture other things.

The earth’s crust

As we travel around Guyana and some islands in the Caribbean, we observe that there are large areas and beautiful beaches both covered with sand and rocks, but the sand and rocks on all these areas and beaches do not necessarily look alike. Have you ever wondered why? Well we will attempt to answer this question.

Is rock just rock?

It is believed that the earth was once molten (i.e. hot liquid) and that when it cooled, different minerals separated out as crystals.

Collect as many rocks as possible from around your home and school compound. Try to get many different kinds. Maybe the road near your home is being repaired. Try to find other kinds of rocks there too.

Examine these rocks carefully. Are they all hard? Do they have crystals in them?

You may have noticed that some have bits of shiny materials/crystals of one kind or of different kinds. Rocks are minerals. For us to have a better understanding of rocks, let us see how they are formed. There are three types of rocks.
Igneous rocks

These rocks are formed inside the earth under great pressure and heat. Most of these rocks are crystalline. Some of them cool slowly and contain large crystals while others cool quickly and form small crystals. These rocks are not formed in layers and do not have fossils.

Rocks of these kinds are either poured out as lava on to the earth’s surface, during a volcanic eruption, (See Fig. 3.2.) or exposed by the gradual wearing away of surface layers which we call erosion.

Sedimentary rocks

The most common sedimentary rocks are composed of particles of rocks which have been deposited, usually in layers, by water, wind or moving ice. All sedimentary rocks are non-crystalline and contain fossils. Examples of sedimentary rocks are gravel and coral. Corals are small organisms that live in the sea. Their calcium carbonate covering accumulates over years to form rocks. See Fig. 3.3.

Metamorphic rocks

The structure and appearance of these rocks have been changed by great heat, pressure or both. Any rock can be changed into a metamorphic rock. Examples of metamorphic rocks are marble, graphite and slate.

Find out and make a list of other minerals found in the earth’s crust.
Is sand just sand?

How is sand formed? Let us first define sand. Sand is loose material consisting of small rock fragments. The grains are like granulated sugar. Sand is easily seen without a magnifying glass. Where did the rock fragments come from? The rocks, of course.

Actually sand is derived from the weathering of rocks by exposure to different temperatures, wind, rain, snow and frost. Then sand must contain the minerals of which these rocks consist. Some types of sand contain quartz, a crystal identified by its hardness and resistance to decay.

In the Caribbean, a common rock is coral. Some islands, like Barbados are made up almost entirely of coral. What kind of sand would one find there? Surely, sand containing fragments of the rock coral i.e. coral sand. Places, where there is a lot of volcanic activity would have sand derived from the lava. In Brazil, our territorial neighbour, we find in some areas black sand.

Precious materials from the earth

There are precious materials found in the earth. This is due to the presence of magnetite, an iron ore. Here, in Guyana, we too have sand of different colours. Find out the origin of these types of sand. Most light coloured types of sand contain quartz which are used as raw material to manufacture beautiful ornaments and jewellery.

Precious minerals

Precious and semi-precious minerals are called gems. Among them are diamonds, rubies, emeralds and sapphires. Gold and silver are other precious minerals.

Here in Guyana, we mine gold and diamonds. These two minerals are highly priced because they are comparatively rare. Gold is mined both on land and in water.

The Highland Region in Guyana - is our main gold-producing area. Some of the methods used in mining gold are dredging and hydraulics. See Fig. 3.5

Fig 3.4 Pork-knockers at work
Diamond is the hardest natural substance known. Diamonds can be obtained by diving. (See Fig. 3.5) Diamond diving is very dangerous. Diamonds are found mainly in sand and in the gravel of creeks and rivers. The gravel which contains diamonds is said to be "diamondiferous".

**Jewellery**

The precious materials of which we have just spoken are used for jewellery. Jewellery is used widely by people to enhance their appearance. Most of the jewellery used here in Guyana is made from gold. A few of them have diamonds fitted into them, for example, diamond engagement rings.
The structure and uses of clay

Have you seen the vases and goblets at the craft shops? They look beautiful. Look at those with the curved handles. There are some beautiful ornaments of uncommon shapes. See Fig. 3.7.

Fig. 3.7 Articles made of clay

In antique shops there are some lovely ‘pieces’ but they are expensive. There is a strange looking pot that stands on three legs, Fig. 3.8. It resembles a medieval cooking pot. The three legs enable the pot to stand securely in hot ashes.

Fig. 3.8 Old medieval pot.

Why is it that grandma makes such a fuss about her goblet in the kitchen? Why does grandpa insist that he drinks water from the goblet? In this unit we are going to investigate the material of which some ornaments, goblets and vases are made. That material is clay.

Is clay just clay?

Clean clay

What is clay? This term commonly refers to a variety of soils or rocks which are made up of extremely fine particles of clay minerals, quartz, calcite, iron oxide and organic matter. The clay minerals are hydrated aluminium silicates with metals such as iron and manganese in the molecules.

Clays range in colour from black to white. The deep sea clays are red and blue in colour. Garden clay may be yellow or slate grey. The deeper the colour of the clay, the more impure the clay is.

The purest clay known is kaolin, also called china clay or porcelain clay. The clay mineral is kaolinite. It is made up of approximately 46% silica, 40% of aluminium oxide and 14% water. In the raw state it is white or creamy. It has little or no mineral impurity. Earthenware clay contains iron and other mineral impurities and may be red, brown or greenish in colour.

Pure clay is sometimes referred to as ‘clean’ clay. However when a potter refers to ‘clean’ clay, he is referring to clay that comes from the ground and is free of physical impurities such as sticks, roots, humus, sand pebbles and rocks. In cases where the potter’s clay needs to be refined, it is done by removing the physical impurities. Figure 3.9. shows a sample of clay with physical impurities.
Fig. 3.9  A picture of ploughed clay

**Water makes a difference**

Do you remember playing with clay and water when you were much younger? When you added the water to the clay and mixed it you got ‘mud’. Water is added to make it easy for you to work the clay into the desired shape.

The structure of clay consists of sheets or layers of silicates which form fine flaky crystals. These layers are arranged one above the other. When water is added, it is absorbed by the flaky crystals causing the clay to become ‘plastic’. The water gets between the layers and forces them apart resulting in the characteristic ‘swelling’ effect. This enables the clay to be stretched and shaped.

This property of **plasticity** is very important to the potter since he is able to better knead the clay and remove the air spaces. (See Fig. 3.10.) The result is a uniform mixture for making vases, goblets and various ornaments.
**Heating makes a difference**

An important step in the craft of pottery is the firing process. After a pot or vase is made, the next step is to let it dry completely, getting rid of all moisture. This is done in a firing kiln. See Fig. 3.11 where the temperature may be as high as 2340 °C.

The removal of water causes shrinkage or contraction of the clay material. The shrinkage continues until the particles are in contact with each other. The clay becomes hard.

In addition to removal of water, the heat ‘burns out’ all organic matter and eliminates gases. If these unwanted substances, i.e. organic substances and gases are not gotten rid of, they would prevent the clay particles from coming as close together as possible. Instead of obtaining a strong end product, cracking would result.

![Kiln fired by gas](image)

![The inside of the kiln](image)

![A brick kiln](image)

Fig. 3.11 Kilns

**Uses of clay**

Clay has been used for centuries in the making of pottery and in construction. Even before the birth of Christ, the Egyptians used clay in the making of bricks for large buildings such as the pyramids. Fig 3.12 shows how clay bricks are made at a modern Clay Brick Factory in Guyana.

**How bricks are made in a modern factory**

How are bricks made? Clay from a hopper passes through rollers and into a trough mixer. In the pug mill the clay goes through a shredder and vacuum chamber, where any air bubbles are removed. It is then squeezed out and cut into brick-sized pieces before going into the kiln to be fired.
Fig. 3.12 Manufacturing clay bricks in Guyana
After the opening of the Bel-Lu Clay Brick factory in Guyana in 1976, several buildings were constructed using clay bricks, for example, the NIS buildings (see Figure 3.14). The bricks are much cheaper than concrete bricks. Also, the buildings made of clay bricks are cooler. In addition to these fire proof-bricks, clay is used to make tiles, sewer pipes and other hardware.

In the area of ceramics, clay is used in the making of pots, jugs, goblets, table ware, candle holders and jewellery. See Fig. 3.15

Ceramics is important in the tourism industry of the Caribbean.

White clay, kaolin, is used in the manufacture of refractories and fillers. Fillers are used in the manufacture of emulsified products, paper, rubbers, paints, medicines and cosmetics.

Grandma would indeed be furious if her goblet breaks because it would be expensive to replace. Also the type made now may be different in quality. Any water or liquid in a goblet remains cool. Can you tell why?

Cement

A look around the city will reveal many beautiful buildings and more are being constructed everyday. Each new design is taller than the previous one. Apart from the size, what is the main difference between these buildings and the older ones? The noticeable difference is that the old buildings were made mainly of wood while nowadays they are usually made of concrete. See Fig. 3.16
In the manufacture of cement the ingredients are crushed and ground to fine powder, then blended in the desired proportions and heated in a kiln at high temperatures. (See Fig. 3.17)

This last process forms lumps called 'clinkers' which are then mixed with gypsum. Gypsum is a white mineral -- calcium sulphate. Gypsum retards the setting of cement.

Special ingredients may be added at this point in the process to produce cement with special properties. For example, cement used in the making of oil wells or deep wells has added material which is designed to resist high temperatures and pressures. The mixture is then pulverized into a fine even powder.

Some Caribbean Countries that manufacture cement are Trinidad and Tobago and Jamaica. The manufacture of cement requires large amounts of fuel and heat.
Uses of cement

Cement is rarely used by itself. It is generally mixed with a filler material, an aggregate. The aggregate is usually a mixture of sand and stone. The addition of water to cement produces a soft manageable substance which sets hard through the formation of hydrated silicates. This property makes it useful in various ways. Concrete is sturdy, adaptable and inexpensive and is the world’s most widely used building material. Cement made from gypsum is used for plastering walls and partitions between rooms.

The discovery of the metal has completely revolutionised industries. Knowledge of the strength, nature and ability of this metal to mix with other metals to form alloys has widened the scope of its uses. Today, the variety of implements and equipment manufactured from this metal would include the following: ships, tractors, motorcars and smaller items such as knives, tools, springs, surgical instruments and countless other articles. Can you name some more?

From iron ore to steel

The discovery and use of metals by man brought great changes and development in society. The discovery and use of iron is no exception. An entire era, the Iron Age, was named after this metal.

Where is this iron ore found?

Iron ore is found in large deposits in the United States, Great Britain, Sweden and many other countries. It is found as a dark red shiny lump of rock called haematite. It is also available in the form of ores such as magnetite and siderite.
Getting iron from the ore

Iron is obtained from the ore by heating it to a high temperature with carbon, in the form of coke, and limestone (calcium carbonate) in a blast furnace. Coke is obtained from coal by heating it in the absence of air.

The blast furnace is about 30 metres high and is made of steel with a lining of fire-proof bricks. See Fig. 3.18.

For the process to start, quantities of iron ore, limestone, and coke are placed at the top of the furnace (hopper). This raw product is called the charge. The purpose of the coke is two-fold. Firstly, it provides heat energy while it burns and forms carbon dioxide. Secondly, it reacts with carbon dioxide to form carbon monoxide. Carbon monoxide reacts with the iron ore. The limestone decomposes to form calcium oxide and carbon dioxide. This reacts with silica sand to produce slag or molten calcium silicate and floats at the top of the molten iron and is removed from time to time. The dense molten layer of iron at the bottom of the furnace is also removed at the appropriate time.

This iron is very impure and is called pig iron. It can be converted to various forms which can be used in many ways. Fig. 3.19 summarises the steps in the conversion of iron ore to useful products.

For many centuries people have been using iron ore from which they extracted iron. Iron had been the main metal used in construction. This was because of the difficulty in extracting aluminium from its ore. It was not until 1856 when man discovered a practical industrial process for extracting aluminium from bauxite, that aluminium extraction became important. Many new uses are being discovered yearly, hence the continued demand for aluminium. More about aluminium would be discussed later in this unit.

Fig. 3.18 The blast furnace

Fig. 3.19 Flow diagram of an integrated steel works based on a blast furnace
Using iron

Iron can be processed with various substances to produce various types of steel. These types of steel may demonstrate various properties. Soft **cast iron** is a form of steel which contains up to about 4% carbon. **Wrought iron** is another form which contains less than 0.1% carbon. It is soft, but tough, **ductile** (i.e. it can be pulled into wire) and **malleable** (i.e. it can be beaten into sheets). It does not corrode easily and wears well. **Carbon steel** contains less than 1.5% of carbon. The carbon content of steel determines its hardness. Carbon and other impurities e.g. sulphur and phosphorus are removed by oxidation.

**Alloy steel** is the name given to steels which have iron mixed with elements other than carbon. The table below gives some alloys of iron, their properties and uses.

From bauxite to aluminium

To many of us who have either lived in or visited bauxite mining towns such as Linden in Guyana and Mandeville or Ewarton in Jamaica, bauxite is considered as a ‘dusty’ subject. Bauxite, the main ore of aluminium, was named in 1832 by Pierre Berthier of the French Royal Corps of Mines.

One afternoon he strolled along the hills around the village Les Baux in France with his companion, a beautiful girl. She sat upon a convenient rock. Her dress was stained badly and the stain couldn’t be removed. Pierre collected samples and analysed them. They were found to contain 52% alumina, 27.6% iron (III) oxide and 20.4% water. This was the first official recognition given to this deposit of ore which became known as **bauxite** associated with Les Baux in France.

Table 3.1 Alloys of iron

<table>
<thead>
<tr>
<th>Name</th>
<th>Properties</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low carbon steel</td>
<td>tough, malleable, ductile</td>
<td>boiler plates, rivets</td>
</tr>
<tr>
<td>High carbon steel</td>
<td>tough, ductile</td>
<td>cutting tools, e.g. files</td>
</tr>
<tr>
<td>Manganese steel</td>
<td>tough</td>
<td>railway points, safes</td>
</tr>
<tr>
<td>Tungsten steel</td>
<td>high melting point, tough</td>
<td>tools</td>
</tr>
<tr>
<td>Chromium steel</td>
<td>hard, high tensile strength</td>
<td>ball bearings</td>
</tr>
<tr>
<td>Stainless steel (chromium and molybdenum)</td>
<td>non-rusting at high temperatures</td>
<td>car accessories, cutlery</td>
</tr>
<tr>
<td>Cobalt steel</td>
<td>highly magnetic</td>
<td>magnets</td>
</tr>
</tbody>
</table>
Where is bauxite found?

The world's bauxite deposits lie in the tropical and subtropical regions. In South America bauxite is found in Guyana, Suriname and Brazil. It is also found in Africa, Guinea and in Jamaica in the West Indies. France, United States and Australia also have deposits of bauxite.

In Guyana and Jamaica the reserves of bauxite are a little less than 2000 million tonnes. However, in Guinea, Australia and Brazil the resources range from 8000 to 4000 million tonnes each. There is enough bauxite in the world to last for at least 400 years and Guyana can continue to mine at her present rate for the next 20 to 30 years.

The bauxite deposits in Guyana are found in areas where there are White Sands. This includes the upper Demerara areas of Linden and Ituni and in the Berbice River region, Kwakwani. (See Figure 3.20.)

The deposits occur as a lens-shaped formation, which vary laterally from distances ranging from a few hundred to several thousands of feet. (See Fig 3.20.) The layer of bauxite is usually well defined and at the bottom passes fairly abruptly into residual clay.

Fig. 3.20  Map showing bauxite areas in Guyana
The bauxite varies greatly in hardness, texture and colour making it difficult to gauge its quality by usual excavation. The colour ranges from light grey to cream or buff, or from pink to a dark reddish brown when the iron content is high.

**What is bauxite?**

You may ask “What is bauxite?” It is impure hydrated aluminium oxide, Al₂O₃·3H₂O. It is the main ore of aluminium. The ore may contain impurities as much as 50% by mass. The main impurities are iron (III) oxide, Fe₂O₃ and silica (silicon dioxide). Other impurities are oxides of titanium and gallium. The reddish colour of bauxite indicates the presence of much iron in the ore.

The type of bauxite is based on the percentage of aluminium oxide, better known as alumina. In Guyana there are four main types of bauxite. The main type is the calcine bauxite which is used to produce the main product calcined bauxite (RASC). The other types are metal grade bauxite (MAZ), chemical grade bauxite (CGB) and aluminium ores cement grade bauxite (ACGB). See Table 3.2. with the types of bauxite and their products.

---

**Table 3.2 Products of Linmine and Bermine Bauxite Plants of Guyana**

<table>
<thead>
<tr>
<th>Product</th>
<th>Composition</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Refractory 'A' grade super calcined bauxite</td>
<td>≥87% alumina, Al₂O₃</td>
<td>Refractory bricks</td>
</tr>
<tr>
<td></td>
<td>≤2% iron (III) oxide Fe₂O₃</td>
<td>Anti-skid surfaces</td>
</tr>
<tr>
<td>2. Abrasive 'A' grade calcined bauxite (AAC)</td>
<td>83% alumina, Al₂O₃</td>
<td>Electrical porcelain</td>
</tr>
<tr>
<td>3. Chemical grade bauxite (CGB)</td>
<td>4.5-5.6% Silica, SiO₂</td>
<td>Welding electrodes</td>
</tr>
<tr>
<td></td>
<td>Low iron content</td>
<td>Manufacture of abrasives</td>
</tr>
<tr>
<td></td>
<td>&gt;50% available alumina Al₂O₃</td>
<td>Manufacture of aluminium sulphate and</td>
</tr>
<tr>
<td></td>
<td>≤5% reactive silica, SiO₂</td>
<td>other chemicals</td>
</tr>
<tr>
<td>4. Aluminous cement grade bauxite (ACGB)</td>
<td>≥50% available alumina Al₂O₃</td>
<td>Manufacture of cement high in alumina</td>
</tr>
<tr>
<td></td>
<td>≤5% reactive silica, SiO₂</td>
<td>and in iron (III) oxide</td>
</tr>
<tr>
<td>5. Metal 'A' grade bauxite (MAZ)</td>
<td>52% available alumina, Al₂O₃</td>
<td>Manufacture of alumina for the production of aluminium</td>
</tr>
</tbody>
</table>
Getting bauxite from the ground

There are four separate stages in the mining of bauxite in Guyana. These are:

1. drilling and clearing of land
2. removal of sand and sandy clay
3. removal of hard clay
4. cleaning of ore

The ground is drilled using a diamond drill to determine the depth of the bauxite. See Fig. 3.21.

Fig. 3:21 A diamond drill to drill the ground to determine depth of bauxite

The land is debushed and cleared by bulldozer.

Huge machines with revolving wheels, and with buckets fixed to the wheels, are used to remove the sand and sandy clay. These machines are called bucket wheel excavators. (See Fig. 3.22.)

Fig. 3:22 Bucket-wheel excavator

Walking draglines are then used to scoop up the hard clay overburden. (See Fig. 3.23.) The bauxite is then dug out by the draglines and stock-piled.

Fig. 3:23 Draglines

Trucks and ore cars then transport the ore to the bauxite plant. (See Fig. 3.24.) In Berbice, barges are used to transport the ore to the plant.
Unlike Guyana, the bauxite in Jamaica is just below the ground so there is no need to strip the ground of sand and clay. Bauxite is obtained much easier from the ground.

The bauxite is crushed on arrival at the plant, then washed and dried in kilns. (See Fig. 3.25.)

**Getting alumina from bauxite**

As was mentioned earlier, bauxite is impure aluminium oxide. The process of obtaining alumina (aluminium oxide) from bauxite is really the purification of the oxide. During this process the three main impurities of the ore, namely, silica (sand), iron (III) oxide and titanium oxide are removed.

The impurities are removed by mixing the bauxite with hot **caustic soda**, that is, sodium hydroxide solution. The caustic soda dissolves the alumina leaving the impurities behind. The concentrated solution of the sodium hydroxide and alumina is filtered and allowed to cool. The alumina precipitates out. The reddish brown bauxite is converted to pure aluminium oxide, alumina, a white powder. (See Fig. 3.26)

**Grinding:** to ensure standard size of particles
Digestion: Reaction between caustic soda and the bauxite takes place.

Settling: Red mud is washed, filtered, settled and pumped away.

Filtration: Caustic soda solution filtered to remove 'red mud'.

Precipitation: Alumina seed crystals are added to aid the formation of large crystals.

Calcination: The crystals are washed free of caustic, then calcined.

Shipping: The calcined alumina is stored and then shipped.

Fig. 3:26 Diagrams showing stages in alumina production
This principle is based on the **Bayer process** and was used in Guyana from 1961 until the closure of the alumina plant in Linden. Even though the principle is straightforward, the operation is a highly complex one.

Let us look at the process more closely. There are seven main operations, namely:

1. **grinding**
2. **digesting**
3. **settling**
4. **filtering**
5. **precipitating**
6. **calcining**
7. **storing and shipping**

**Grinding**: The ore is ground up to form a powder.

**Digesting**: In large pressure vessels called digestors (like the pressure cooker at home) the powdered bauxite and caustic soda solution are mixed at a temperature of about 200°C. Resulting from this mixture is the dissolved alumina called sodium aluminate and the undissolved "red mud" of the impurities.

**Settling**: The liquid is passed into large settling tanks where the impurities settle out as red mud as the temperature is reduced. The red mud is washed, filtered and pumped away to a large area which in Guyana is called the 'wash pond'. See Fig. 3.26 for the stages in the entire process.

\[
\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} \xrightarrow{\text{heat}} \text{Al}_2\text{O}_3 (s) + 3\text{H}_2\text{O}
\]

**Filtering**: The partially clear liquid containing alumina is cleared up by filtering under pressure to remove any trace of red mud.

**Precipitating**: The now clear strong ‘tea-coloured’ solution is pumped into precipitation tanks. Compressed air is added to agitate the contents. Fine ‘seed’ alumina crystals are added to encourage precipitation. After a day or two, the precipitated hydrated alumina is drawn off.

**Calcining**: The large crystals are washed free of caustic, filtered and then calcined. This operation involves the drying of alumina in large high-temperature kilns. The hydrated alumina is converted to anhydrous alumina and this results in a change of the alumina structure.

**Storing and shipping**: In countries like Jamaica where alumina is produced, it is stored in large silos and then shipped to be used for making aluminium, the metal.
Effect on our environment

The mining of bauxite and the making of alumina have seriously affected our environment. Therefore, a country has to weigh the effects before allowing mining to be done. There is air and water pollution as a result of these processes. Let us discuss these effects.

1. The dust particles of the bauxite rise into the air through large stocks and cause increased reflection of incoming radiation which can lead to the 'green house effect'. You can find out more about the 'greenhouse effect' and its consequences.

2. Dust particles get into homes, offices and business enterprises and this adds to the cost of cleaning.

3. Lung cancer and bronchitis have been identified as contributors to the mortality rate.

4. Bunker C. fuel that is used to heat the kilns would sometimes spill into the river which is used by some persons for washing and for drinking.

5. The waste, ‘red mud’, is dumped into an area called the ‘wash pond’. This results in death of plants and animals in that area. The caustic soda is mainly responsible for this. The land lies waste.

6. Further environmental effects are the changing of the landscape, destruction of natural vegetation due to clearing of the land and stripping off of the sand and clay before mining begins. This destroys the ecosystem and there is a general reduction in oxygen content and an increase in carbon dioxide in the atmosphere. How does the removal of vegetation bring about these changes in the atmosphere?

Getting aluminium from alumina

Aluminium is obtained from alumina by an electrolytic process. It is sometimes referred to as the Hall-Heroult process because of the two men who simultaneously, but independently, discovered the process in 1886.

This process makes use of electricity to break down very reactive compounds into their elements. Alumina is a compound with strong chemical bonds and it cannot be broken down by reduction using carbon as is done in the manufacture of iron. Lack of cheap electricity in Guyana is one reason why the process is not used in Guyana.

The electrolysis takes place in a smelter. (See Fig. 3.27)
The alumina is dissolved in molten cryolite at a temperature of about 900 °C in iron tanks lined with graphite. The graphite lining is used as the cathode. See Fig. 3.28. Carbon electrodes, the anode, are suspended in the electrolyte. A very high current (10,000 kv) is passed through the electrolyte. The aluminium ions are attracted to the negative carbon lining and discharged as aluminium. The molten aluminium is collected in the bottom of the tank and is run off from time to time, through a tapping hole and moulded into bars. Oxygen produced at the anode causes it to burn away. A new set of anodes is replaced frequently.

$$\text{Al}_2\text{O}_3 \rightarrow 2\text{Al}^{3+} + 3\text{O}^2-$$

$$2\text{Al}^{3+} + 6 \text{electrons} \rightarrow 2\text{Al} \text{ (metal)}$$

**Uses of aluminium**

Aluminium reacts readily with oxygen in the air to form aluminium oxide. However, only a thin transparent film of the oxide is formed on the surface. This film of oxide prevents further corrosion. This property enables aluminium to be used to make sheets for roofing, food and drink cans (often called ‘tins’). It is a good conductor of electricity and heat and is used to make cook-

**Exercises**

1. What is rock?
2. (a) Explain how sand is formed.
   (b) Of what does sand consist?
3. On what does the size of ‘crystals’ depend?
4. List some of the minerals that can be found in the earth’s crust.
5. What are the main differences between sedimentary and igneous rocks?
6. Find out more about how gold and diamond are mined in Guyana. Write up your findings.
7. Which of the following gives clay the dark colour?
   A. alumina
   B. iron oxide
   C. clay minerals
   D. quartz
8. Clean clay refers to
   A. pure clay
   B. clay with a small percentage iron oxide
   C. clay free of sand
   D. kaolin or white clay.
9. Cement is made of
   A. calcium carbonate, sand and iron oxide
   B. clay, silica and limestone
   C. silica, alumina and iron oxide
   D. limestone, clay and alumina.
10. What is clay?
11. What happens when water is added to clay?
12. Explain the changes that take place when a vase is ‘fired’.
13. List some uses of clay.
14. What is the difference between cement and concrete?
15. What property of concrete makes it the world’s leading building material?
16. **Activity to determine the plasticity of clay.**
   Take a piece of the clay and form a ball. Roll the ball into a thin rope. Coil the rope around your fingers.
   If it shows no sign of cracking then the clay is plastic.
   Clay could only be 'worked' when wet.
17. Explain what is meant by the following terms:
   (i) cast iron
   (ii) carbon steel
   (iii) wrought iron
   (iv) alloy steel
   (v) slag
18. Explain the functions of the following in the blast furnace:-
   a. hot air
   b. coke
   c. limestone
19. (a) List **TEN** household articles manufactured from steel and other alloys of iron.
   (b) Find out what other metals were used to make the alloys mentioned in (a) above.
20. Where is bauxite found in Guyana?
21. Why is bauxite considered the main ore from which to extract aluminium?
22. What are the impurities found in bauxite?
23. What is the difference between reddish brown bauxite and grey bauxite?
24. Name the type of bauxite from which aluminium is extracted.
25. Why is the extraction of bauxite more costly in Guyana than in Jamaica?
26. Outline the process used to obtain pure aluminium oxide (alumina).
27. Describe briefly the extraction of aluminium from alumina. **Write two** equations to represent the reaction during the extraction.
28. Discuss the environmental effects of the bauxite industry in Linden.
29. (a) State **two** uses of aluminium.
   (b) State the property associated with each use.
WE HAVE LEARNT THAT

- the earth is made up of three layers: crust, mantle and core.
- the earth is made up of sand and rocks.
- sand and rocks are really minerals of varying kinds.
- some minerals are precious and used to manufacture jewellery.
- clay is basically minerals, quartz calcite, iron oxide and organic matter.
- clay minerals vary in colour, according to the iron and other mineral content.
- clay is used to make bricks, utensils, and ceramics; and in the manufacture of cement.
- cement contains calcium carbonate, silica, alumina and iron oxide.
- iron is produced from ores called haematite, magnetite and siderite.
- limestone, iron and coke are used to produce pig-iron.
- steel type varies with the carbon content.
- bauxite is the main ore of aluminium.
- bauxite is found in the tropical and subtropical regions of the world.
- the purification of aluminium oxide entails the following processes: grinding, digesting, settling, filtering, precipitating and calcining.
- aluminium is a very reactive metal which is light, strong and resistant to corrosion.
Unit 4

Photosynthesis and foods

Introduction

What does photosynthesis mean? You may have guessed by now that it has something to do with 'light'. And you are correct, photo means 'light' and synthesis means ‘building up’. Where does the light come from? The sun, of course. Photosynthesis is a chemical process by which green plants use the light energy to build up their own food. This process occurs in the green parts of the plants mainly the leaves.

Plants use some of the food for their own growth and repair and store the rest. Where is this food stored? It is transported to different parts of the plant to be stored. These parts of the plant that store food are called storage organs. We and other animals use these storage organs as food, directly or indirectly. For example, we eat parts of plants such as cassava, carrot, potato, mango, calaloo. We also eat the meat of animals that eat plants as food - pork, beef, chicken. Why do we eat food? Of course, the food nourishes our bodies and supply energy for our daily activities.

Can you imagine life on earth without plants? It is therefore, very important for us not to take plants for granted as we sometimes do. Do not destroy plants. They are very important organisms.

Here in this unit we will learn:

- how green plants make food.
- how the leaf is adapted for photosynthesis.
- the conditions necessary for photosynthesis.
- the products of photosynthesis.
- where plants store food.
- the types of food and their sources.
- the function of each type of food.
- the effects of nutritional deficiencies.
- how to do food tests.

How is food made in green plants?

To make food or anything else we must have the raw materials. In order to build up food, plants too need raw materials. What do you think are the raw materials and from where do they get them? In fact, the raw materials are carbon dioxide and water. The water is obtained from the soil surrounding the plant and carbon dioxide from the air. For aquatic plants, the carbon dioxide can be found dissolved in the water surrounding them.

Plants use the light to combine carbon dioxide with water to make glucose, (a simple carbohydrate), which is quickly converted into starch (a complex carbohydrate). Chlorophyll in the leaf is used to effect the reaction and oxygen is given off as the by-product. During this process plants convert light energy into chemical energy which is stored in the food. See Fig. 4.1.
Fig. 4.1 Process of photosynthesis

\[ \text{Carbon dioxide} + \text{water} \xrightarrow{\text{light energy}} \text{chlorophyll} \xrightarrow{\text{sugar+oxygen}} \]

The leaf then, has to be adapted to allow photosynthesis to take place quickly and efficiently.

**How is the leaf adapted for photosynthesis?**

**Activity:** Examining a dicotyledonous leaf

You need a simple leaf and a hand lens.

Use the hand lens to examine the external features of the leaf. Record your observations. Draw and label the leaf showing its external structure. (See Fig. 4.2)

Fig. 4.2 Drawing of a dicotyledonous leaf to show external features

\[ \text{The petiole (leaf stalk) holds the leaf in a position for maximum exposure to light. (If the water supply is poor, this position may not obtain.)} \]

The broad, flat and thin part of the leaf is the lamina, which provides a large surface area so that light can penetrate easily. The lamina also has pores (stomata) which allow the gases - carbon dioxide and oxygen to pass in and out of the leaf. Carbon dioxide can diffuse easily into the cells.

The veins also have a very important part to play. They contain two types of vessels: the xylem which transports water to all parts of the leaf and the phloem sieve tubes which transport manufactured food away from the leaf. Apart from these two roles, the veins help to support the leaf and hold the lamina open so that the whole surface is exposed to light. \]
Fig. 4.3 Diagram showing transverse section of a dicotyledonous leaf

Although a leaf may look thin, it consists of several layers of cells. Let us now look at a transverse section through a part of the leaf.

There are two layers of cells closely fitted at the top and bottom of the leaf. These layers are called the epidermis. The upper epidermis has a waxy layer, called the cuticle on its outside. It helps to stop evaporation from the leaf. It also protects the cells from mechanical damage and from invasion by fungi and other disease causing organisms. The lower epidermis usually contains more stomata than the upper epidermis. These stomata allow gases to diffuse in and out of the leaf. Surrounding each stoma are two crescent-shaped guard cells which control the opening and closing of the stomata.

Between the upper and lower epidermis are photosynthetic cells called the mesophyll. The term means "middle leaf."

These cells contain chloroplasts in which the chlorophyll is found. There are also several air spaces which allow gases to pass easily through the leaf. The network of veins runs through the mesophyll. These veins, as we learned earlier, transport water and manufactured products.

**Conditions necessary for photosynthesis**

We have already learnt that green plants use light to combine carbon dioxide with water to produce food with its stored chemical energy. The food is usually in the form of starch and often it is stored in the leaf.

Let us test for the product starch.

Take a leaf from a healthy plant. Boil the leaf in water for about one minute to kill the cells.
Remove the leaf and place it in a test tube half-full of alcohol. Place the test tube in the hot water bath for 5 minutes. (Remove the flame from under the water bath.) Leave the test tube in the water bath until the colour is extracted from the leaf. (See Fig. 4.4).

Remove the leaf from the alcohol. Note its texture. Rinse the leaf in the hot water, to soften it.

Spread out the leaf on a white tile or in a watch glass and add a few drops of iodine solution. A blue-black colour indicates starch is present.

![Diagram showing extraction of chlorophyll from the leaf.](image)

Record all observations, including:
1. the texture of the leaf before and after placing it in alcohol;
2. the colour of the alcohol when the leaf was removed;
3. the colour of the leaf when it was removed from the alcohol
4. the colour of the leaf after the addition of the iodine solution.

Having learnt how to test for starch, let us now investigate the role of the various factors needed for photosynthesis. What would you expect if any one of those factors such as light, chlorophyll or carbon dioxide was removed from the plant? Let us find out. N.B. Water is so vital to all processes that we would not remove it from the plant.

Take a healthy potted plant. Leave it in a dark cupboard for about 48 hours to destarch it.

Test one leaf for the presence of starch to ensure that it does not contain any starch.

Use a folded piece of black paper or aluminium foil, a little larger than the leaf. Cut out a shape. Fasten the paper or foil over both sides of the leaf on your plant making sure that the edges are held firmly together.

N.B. Do not take the leaf off the plant.

![Diagram showing leaf covered with foil](image)

Leave the plant in bright light for at least two hours.

Remove the cover from your leaf. Detach the leaf from the plant and test for starch. Record your
Destarch a potted plant.

Place a plastic bag over each of two leaves. Label the leaves A and B respectively. In the plastic bag, containing leaf A, put some sodium or potassium hydroxide pellets in a container to absorb the carbon dioxide from the air. Place the same plant in light.

Destarch a plant with variegated leaves, example, green and white.

Leave the plant in a well lit spot for a few days. Remove a leaf and make a sketch. Label the green and white parts. Test the leaf for starch. Which part of the leaf tested positively for starch? Was it the green or the white part of the leaf? Do your results tell you anything about chlorophyll and photosynthesis? Record all your results.

The role of chlorophyll

During photosynthesis, energy is needed and we know that light is a type of energy. How does light enter the leaves? The light energy is absorbed by the chlorophyll. When light 'falls' on the leaf the chlorophyll molecule absorbs the energy, converts it from light energy to chemical energy then releases the chemical energy causing carbon dioxide to combine with hydrogen.

The role of light

The light absorbed by the chlorophyll splits water into its components, hydrogen and oxygen. The hydrogen combines with the carbon dioxide and the oxygen is released.

The products of photosynthesis

Photosynthesis is a chemical process. It can be summarised by a chemical equation. The word equation which follows shows the raw materials, the energy used and the products of photosynthesis.
Raw materials → Products
Carbon dioxide + water + light + glucose + oxygen + chlorophyll

We have previously tested a leaf for starch. Now we are going to test for oxygen.

Set up the apparatus as shown below. Make sure that the test tube is completely full of water. Use a deep container, full of water, for setting up this experiment. See Fig 4.7.

Place a glowing splint in the inverted test tube. Record your observations. The glowing splint should have rekindled since oxygen is present.

**Storing the products of photosynthesis**

The food produced during photosynthesis is used in the cells during respiration and is taken to different parts of the plant to be stored for further use. This process is called **translocation**.

Storage organs may be in the leaves, the stem or the roots of the plant. Table 4.1 shows the parts of the plant that store food and the types of food that they store.

**Table 4.1 Food stored in flowering plants**

<table>
<thead>
<tr>
<th>Plant</th>
<th>Plant Part</th>
<th>Type of food stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>ginger</td>
<td>rhizome</td>
<td>oil, starch</td>
</tr>
<tr>
<td>sweet potato</td>
<td>root tuber</td>
<td>starch, sugar</td>
</tr>
<tr>
<td>peas, beans</td>
<td>seed</td>
<td>starch, protein</td>
</tr>
<tr>
<td>rice</td>
<td>endosperm</td>
<td>starch</td>
</tr>
<tr>
<td>ground nut</td>
<td>seed</td>
<td>oil, protein, starch</td>
</tr>
<tr>
<td>sugar cane</td>
<td>stem</td>
<td>sucrose</td>
</tr>
<tr>
<td>carrot</td>
<td>tap root</td>
<td>glucose</td>
</tr>
<tr>
<td>onion</td>
<td>bulb</td>
<td>glucose</td>
</tr>
<tr>
<td>yam</td>
<td>stem tuber</td>
<td>starch</td>
</tr>
</tbody>
</table>
Importance of photosynthesis

Photosynthesis is thought to be the most important chemical reaction in the world. What do you think would happen if photosynthesis ceased?

Plants produce other foods besides carbohydrates. They can also produce proteins, oils, vitamins and minerals.

Oxygen is produced, and released into the atmosphere. Hence, although oxygen is used up in respiration, the level of oxygen in the air is constant. The carbon dioxide, produced during respiration in living things, is used up during photosynthesis. Can you imagine what life would be like with more carbon dioxide than oxygen in the air or with more oxygen than carbon dioxide? Make a list of all of the things that you think may happen.

Types of food nutrients and their sources

Our daily diet consists of one type or a combination of types of food. The three main types are:

- proteins
- carbohydrates
- fats

We also need vitamins, minerals and water. Table 4.2 shows a list of the different types of food and some sources of each type.

Fig. 4.8 Sources of food nutrients
<table>
<thead>
<tr>
<th><strong>Food nutrients</strong></th>
<th><strong>Sources of food nutrients</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>fish, beef, liver, lamb, eggs, peas and beans, poultry, milk and milk products.</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>yam, rice, sugar, plantain, cereals, bread.</td>
</tr>
<tr>
<td>Fat</td>
<td>cheese, butter, milk, oil, lard, avocado pear, margarine.</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>liver, cod-liver oil, fish, spinach, carrot, dark green vegetables, milk.</td>
</tr>
<tr>
<td>Vitamins B&lt;sub&gt;1&lt;/sub&gt;</td>
<td>liver, egg yolk, brown rice, cereal, whole wheat bread.</td>
</tr>
<tr>
<td>(Thiamin)</td>
<td></td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;2&lt;/sub&gt;</td>
<td>milk, meat, cheese, green vegetables.</td>
</tr>
<tr>
<td>(Riboflavin)</td>
<td></td>
</tr>
<tr>
<td>Niacin</td>
<td>poultry, peanuts.</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td>food from animals</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>citrus fruits, potatoes, tomatoes, green vegetables.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D</td>
<td>milk, fish, action of sunlight on the body</td>
</tr>
<tr>
<td>Calcium</td>
<td>milk, cheese, green vegetables, dried peas and beans.</td>
</tr>
<tr>
<td>Iron</td>
<td>liver, meat, dark green leafy vegetables, pumpkin, sunflower seeds, nuts.</td>
</tr>
</tbody>
</table>
Here is something for you to do on your own. Find out sources of Vitamins E and K and of the minerals phosphorus and iodine.

The function of each type of food nutrient

The foods we eat all have a very important role to play in the proper functioning of our body.

Protein foods are energy-giving foods. However, their main functions are to build and repair body tissues, to replace worn-out body tissues and to build antibodies – the blood component which fights infections.

Table 4.3 Some minerals and their functions

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>- combines with protein to form haemoglobin.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>- aids in the formation and maintenance of strong bones and teeth.</td>
</tr>
<tr>
<td>Calcium</td>
<td>- promotes healthy nerve function and normal blood clotting.</td>
</tr>
<tr>
<td>Iodine</td>
<td>- aids in the formation of healthy bones and teeth.</td>
</tr>
<tr>
<td></td>
<td>- aids in function of the thyroid gland</td>
</tr>
</tbody>
</table>

Carbohydrates and fats are the main sources of energy which we need for our every day activities. Apart from supplying energy, carbohydrate foods assist the body in using up fats, while fats aid in the absorption of fat-soluble vitamins.

Vitamins aid normal growth and appetite, maintain healthy skin, teeth, gum and eyes. Vitamins also maintain a normal nervous system and aid the formation of red blood cells. These are but a few functions of vitamins. Find out other functions and make a list of them. Minerals are essential too. Their functions, like vitamins, are many. In Table 4.3 are a few of the functions of some minerals.
## Nutritional deficiencies

Lack of the types of food nutrients discussed earlier leads to poor functioning of body systems. This lack of a sufficient quantity of these foods in the diet results in **deficiency** diseases. For example, a lack of enough protein in the diet of growing children results in the disease **kwashiorkor**. Children with kwashiorkor have soft, flabby muscles, and are usually listless, miserable and weak.

Table 4.4 shows some deficiency diseases associated with food nutrients.

<table>
<thead>
<tr>
<th>Food nutrients</th>
<th>Deficiency diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>skin becomes dry and scaly. night blindness.</td>
</tr>
<tr>
<td>Vitamin B</td>
<td>beri-beri i.e. loss of weight and appetite; swelling of feet and legs; mental disorder; anaemia, tiredness and lack of energy</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>scurvy, bleeding gums</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>rickets i.e. bones remain soft and become deformed.</td>
</tr>
<tr>
<td>Calcium</td>
<td>same as Vitamin D</td>
</tr>
<tr>
<td>Iron</td>
<td>anaemia - tiredness and lack of energy</td>
</tr>
<tr>
<td>Iodine</td>
<td>goitre - a swelling of the thyroid gland in the neck.</td>
</tr>
</tbody>
</table>
We will now learn more about these food nutrients so that we can try and avoid getting the deficiency diseases.

**Food tests**

We will now test a few samples of food for the presence of starch, protein, reducing sugar and fat. You need samples of different kinds of food.

**Starch test**

**Aim**: To test food samples for the presence of starch.

**Materials**:
- cooked rice
- iodine solution
- a small piece of meat
- peanut
- egg white
- milk
- test tubes or watch glasses or white tiles

**Method**:
- Place a small quantity of cooked rice on watch glass.
- Put about 2 or 3 drops of iodine solution on the rice.
- Observe the colour change.
Repeat using the other food samples provided. Record all observations in a table like the one below.

<table>
<thead>
<tr>
<th>Food Samples</th>
<th>Observation</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>rice</td>
<td>blue-black</td>
<td>starch is present</td>
</tr>
</tbody>
</table>

**Observations**

**Protein test**

You may use the same food samples you had for the previous section.

**Method**:
To a sample of egg white add about 2 cm³ (moldm⁻³) sodium hydroxide solution followed by 1 or 2 drops of 1% copper sulphate solution.
- Record all observations.
- Purple coloration indicates the presence of protein.
- Repeat using the other food samples provided.

**Reducing sugar test**

**Method**:
- Using the same samples of food, add 1 dropper full of Benedict’s solution to a small sample of each food.
- Place in a hot water bath for five minutes.

N.B. A colour change ranging from green to yellow to orange to rust brown will indicate the presence of reducing sugar.

**Fat test**

**Method**:
Be sure to crush small bits of each solid food in a little alcohol (ethanol) in a dish.
- Label the required test tubes and pour a small amount of the liquid from each food into its respective test tube.
- Add about 2 cm³ alcohol to each test tube.
- Shake test tube, add a portion of the mixture to another test tube containing water.
- Record all observations.
N.B. A cloudy mixture indicates the presence of fats.

**Exercises**

1. Define the process of photosynthesis.
2. (a) What are the raw materials needed for photosynthesis?
   (b) What are the products of photosynthesis?
3. Write a word equation to summarise the process of photosynthesis.
4. (a) Name the light-trapping substance in the leaf.
   (b) State in which part of the leaf the light-trapping substance is found.
5. Explain how a leaf could be tested for starch.
6. (a) Name the **three** main types of food nutrients.
   (b) Give **two** sources of each type of nutrient.
7. State the function(s) of: (a) iron
   (b) Vitamin A in our body.
8. Tom’s daily diet lacks Vitamin B. What could eventually happen to him?
9. Explain what is likely to happen if you do not get enough Vitamin C in your daily diet.
10. Describe how to test food samples for the presence of (a) protein (b) reducing sugar.

**Summary**

**WE HAVE LEARNT THAT:**
- photosynthesis is the most important chemical reaction in the world.
- photosynthesis takes place mainly in the leaves of green plants.
- chlorophyll absorbs light energy from the sun.
- light splits up water into hydrogen and oxygen.
- plants convert part of the sun's energy that falls on them into chemical energy.
- the factors necessary for photosynthesis are carbon dioxide, water, chlorophyll and light.
- the leaf is specially adapted for the process of photosynthesis.
- the products of photosynthesis are carbohydrates and oxygen.
- plants store food in their leaves, stems and/or roots.
- food nutrients can be divided into different types. The main types are proteins, fats and carbohydrates.
- carbohydrates and fats provide energy while proteins are used for growth and for the replacement of worn-out and dead cells.
- the lack of the right types of nutrients in the daily diet may result in deficiency diseases.
- foods containing starch turn blue-black when iodine solution is added.
- protein gives a purple coloration with sodium hydroxide and weak copper sulphate solution. An orange/red/rust brown precipitate indicates the presence of reducing sugar in substances when Benedict’s solution is added and they are heated.
Unit 5

Balanced diet

Introduction

Diet is the variety of foods that a person consumes each day. When the diet contains foods with adequate amounts of the five nutrients and water and the quantities are sufficient to supply our energy needs, we say that it is a balanced diet. Thus a balanced diet has the right kind of foods provided in the right amounts.

The food we eat is complex and insoluble. It has to be made simple and soluble, then it can be absorbed and assimilated by our bodies. Digestion makes complex and insoluble food simple and soluble.

When animals take in food the processes which must occur before the food could nourish them are as follow:

1. ingestion, which is the act of eating, feeding or drinking food.
2. digestion, which is the changing of food nutrients to a soluble state. Digestion occurs in two phases:
   (i) mechanical digestion, which brings about a physical change e.g. chewing in the mouth breaks up food and changes the size of the food particles. Mechanical actions have no effect on the chemical make up of the food. These merely break it up physically.
   (ii) chemical digestion effects chemical changes that cause food nutrients to become soluble and able to diffuse through cell membranes. Enzymes are essential for this chemical action.
3. absorption, in which soluble nutrients diffuse into the blood stream.
4. egestion, in which insoluble, undigested food parts are expelled from the body.

These processes are carried out in the digestive system. In humans the digestive system consist of the alimentary canal and associated organs. The alimentary canal is a pathway or tract in animals through which food moves. It has two openings - one where the food enters and the other for expelling undigested food.

We will discuss this in detail later.

Here in this unit we will learn about:
- what constitutes a balanced diet.
- the need for a balanced diet.
- the energy requirements for individuals.
- the amount of energy expended by various activities.
- the effects of an unbalanced diet.
- the types of teeth of mammals.
- the digestive system and associated organs.
- what happens to undigested food.
- the properties of enzymes and their role in digestion.
Balanced diet

A balanced diet has the right kind of foods provided in the right amounts. The right kind of food may be chosen from the six food groups.

In the Caribbean one such listing is:-
- staples
- food from animals
- legumes
- vegetables - dark green leafy and yellow
- fruits
- fats and substitutes

Fig. 5.1 Food groups

Table 5.1 Sample menu (for one person)

<table>
<thead>
<tr>
<th>MENU</th>
<th>FOOD GROUP</th>
<th>NUTRIENT</th>
<th>SERVINGS</th>
<th>AMOUNT IN GRAMS</th>
<th>ENERGY IN CAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cup cooked rice</td>
<td>Staple</td>
<td>Carbohydrate</td>
<td>2</td>
<td>50</td>
<td>185</td>
</tr>
<tr>
<td>1 plantain</td>
<td>Staple</td>
<td>Carbohydrate</td>
<td>2</td>
<td>120</td>
<td>146</td>
</tr>
<tr>
<td>1/2 cup cooked green peas</td>
<td>Legume</td>
<td>Protein</td>
<td>2</td>
<td>45</td>
<td>151</td>
</tr>
<tr>
<td>stewed chicken (3 oz)</td>
<td>Food from animals</td>
<td>Protein</td>
<td>1</td>
<td>124</td>
<td>151</td>
</tr>
<tr>
<td>1/2 cup callaloo</td>
<td>Dark green leafy veg.</td>
<td>Vitamins and Minerals</td>
<td>1</td>
<td>90</td>
<td>35</td>
</tr>
<tr>
<td>1 glass fresh orange juice</td>
<td>Fruit</td>
<td>Vitamin</td>
<td>2</td>
<td>250</td>
<td>113</td>
</tr>
<tr>
<td>Oil for cooking</td>
<td>Fat and substitutes</td>
<td>Fat</td>
<td>2</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>
The amount of food eaten is important because an individual should consume sufficient food to supply the energy required by the body.

Some persons are on special diets for various reasons. Diabetics must carefully follow a special diet to avoid illness. Vegetarians who eat no animal products may decide to follow a strict diet for religious or moral reasons.

Whatever the reason, an individual should eat a variety of foods in moderate amounts to provide all the energy and nutrients the body needs.

**The need for a balanced diet**

To be healthy you must eat foods with enough carbohydrates, proteins, fats, vitamins, mineral salts and water. Each nutrient is valuable to the body in several ways. Study Table 5.2 and you will see how important each nutrient is to effective functioning of the body.

<table>
<thead>
<tr>
<th>Nutrient class</th>
<th>Why needed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The organic nutrients (i.e. with carbon)</strong></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td></td>
</tr>
<tr>
<td>- sugar</td>
<td>- supplies energy.</td>
</tr>
<tr>
<td>- starch</td>
<td>- provides energy.</td>
</tr>
<tr>
<td>- cellulose</td>
<td>- cellulose helps normal intestinal functioning.</td>
</tr>
<tr>
<td>Fats</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- provide a concentrated energy source.</td>
</tr>
<tr>
<td></td>
<td>- help to keep skin smooth and healthy by supplying essential fatty acids.</td>
</tr>
<tr>
<td></td>
<td>- help the body to use the fat-soluble vitamins i.e. A, D, E and K.</td>
</tr>
<tr>
<td></td>
<td>- provide insulation and warming effect in the body.</td>
</tr>
<tr>
<td></td>
<td>- cholesterol is an important part of useful substances e.g. bile salts.</td>
</tr>
<tr>
<td>Proteins</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- build and maintain all body tissues. N.B. If sufficient carbohydrate isn't</td>
</tr>
<tr>
<td></td>
<td>taken in, protein is used to supply energy, and not to build the body.</td>
</tr>
<tr>
<td>Nutrient class</td>
<td>Why needed</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Proteins (continued)</td>
<td>- important component of enzymes, hormones, antibodies, body fluids</td>
</tr>
<tr>
<td></td>
<td>- supply energy.</td>
</tr>
<tr>
<td></td>
<td>- help to maintain constant internal environment i.e. water balance.</td>
</tr>
<tr>
<td>The inorganic nutrients</td>
<td></td>
</tr>
<tr>
<td>Minerals</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>- combines with protein to make haemoglobin.</td>
</tr>
<tr>
<td></td>
<td>- helps cells to use oxygen.</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- builds bones and teeth.</td>
</tr>
<tr>
<td></td>
<td>- helps blood to clot.</td>
</tr>
<tr>
<td></td>
<td>- helps nerves, muscles and the heart to function properly.</td>
</tr>
<tr>
<td>Sodium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- maintains blood and cell activities.</td>
</tr>
<tr>
<td></td>
<td>- helps growth.</td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- maintains muscle and nerve action.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- helps formation of ATP and nucleic acids.</td>
</tr>
<tr>
<td>Iodine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- helps thyroid gland to function.</td>
</tr>
<tr>
<td></td>
<td>- growth</td>
</tr>
<tr>
<td>Vitamins</td>
<td></td>
</tr>
<tr>
<td>(fat soluble) A</td>
<td>- maintains health of eyes, permitting good night vision and preventing night blindness</td>
</tr>
<tr>
<td></td>
<td>- maintains structure and function of skin cells and mucous membranes.</td>
</tr>
<tr>
<td></td>
<td>- helps normal bone and teeth development.</td>
</tr>
<tr>
<td>Nutrient class</td>
<td>Why needed</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Vitamins (continued)</strong></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>growth.</td>
</tr>
<tr>
<td></td>
<td>regulates calcium and phosphorus absorption and use by the body.</td>
</tr>
<tr>
<td>E</td>
<td>aids normal reproduction.</td>
</tr>
<tr>
<td>K</td>
<td>aids clotting of blood and liver functions.</td>
</tr>
<tr>
<td>(water soluble)</td>
<td></td>
</tr>
<tr>
<td>B₁ (Thiamine)</td>
<td>growth.</td>
</tr>
<tr>
<td></td>
<td>aids carbohydrate metabolism.</td>
</tr>
<tr>
<td></td>
<td>helps functioning of the heart, nerves and muscles.</td>
</tr>
<tr>
<td>B₂ (Riboflavin)</td>
<td>growth/functioning of eyes.</td>
</tr>
<tr>
<td></td>
<td>maintains health of skin and mouth.</td>
</tr>
<tr>
<td></td>
<td>aids carbohydrate metabolism.</td>
</tr>
<tr>
<td>Niacin</td>
<td>growth.</td>
</tr>
<tr>
<td></td>
<td>aids functioning of the stomach and intestines.</td>
</tr>
<tr>
<td></td>
<td>aids carbohydrate metabolism.</td>
</tr>
<tr>
<td>Folic acid</td>
<td>aids red blood cell formation.</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>helps hold body cells together and (Ascorbic acid) maintains strength of blood vessels.</td>
</tr>
<tr>
<td>Water</td>
<td>forms an important part of all cells and fluids in the body.</td>
</tr>
<tr>
<td></td>
<td>carries nutrients and wastes to and from body cells.</td>
</tr>
<tr>
<td></td>
<td>aids digestion and absorption of food.</td>
</tr>
</tbody>
</table>
Another important diet input is energy. Every function and process in the body requires energy. Energy of various types is used in the body. The types are:

- mechanical energy for the movement of muscles for external activities such as sitting, walking, running and internal body processes like heart beat, circulation and breathing.
- chemical energy for all chemical and metabolic reactions.
- heat energy to maintain the body temperature.
- electrical energy for the transmission of nervous impulses.

**Energy requirement of people**

How is the energy value of food measured?

Well, under the SI system of measurement, the unit for energy is the joule (J). In nutrition, the ‘joule’ is replaced by the term ‘calorie’. Both joule and calorie are very small measurements, so kilojoules (1000 joules) (kJ) and kilocalories (kcal) (1000 calories) are more often used. 1 kilocalorie is the amount of heat energy that is required to raise the temperature of 1 kilogram of water by 1°C. The kcal is equivalent to 4.2 kJ.

The instrument that is used to measure the energy value of food is the calorimeter. (See Fig. 5.2) This measures the amount of heat released when a sample of food is burned. A carefully weighed sample of food and an amount of oxygen are placed in a small chamber.

The calorimeter contains a known quantity of water. An electric spark ignites the food and it is burnt. The rise in temperature of the water can be used to calculate how much heat the burning food has released. Carbohydrate, protein and fatty foods as measured by the calorimeter have approximate energy values as follow:

- 1 gram of carbohydrate produces 16 kJ/3.75 kcal
- 1 gram of protein produces 17 kJ/4 Kcal
- 1 gram of fat produces 38 kJ/9 Kcal

Note that fats supply more than double the energy value per gram of proteins and carbohydrates.

![Calorimeter diagram](image)

**Fig. 5.2** Apparatus used for measuring energy value of food - the Calorimeter

The energy that is provided by food is released by respiration for use in the body. Respiration is summarised by the following equation:

food + oxygen \(\rightarrow\) energy + water + carbon dioxide

Respiration in cells involves a complex chain of chemical reactions known as metabolism. During metabolic reactions energy is released. In humans, the metabolic rate that will release energy to keep the body’s internal processes at work is called basal metabolic rate.
This will vary from individual to individual because of factors such as age, sex, body size, occupation and health status.

Our average daily intake of food therefore should equal our daily energy requirements. The requirements are determined by:

**Age:** Young children require more energy for their size than elderly adults because they are growing rapidly.

**Sex:** Men tend to be larger overall in body size than women and a woman’s energy output is usually less than a man’s.

**Occupation/Physical activity:** The amount of energy people use in physical activity varies according to their occupation and their recreational activities. Occupation may be classified as:
- sedentary - Office workers, clerks, teachers, doctors, lawyers.
- moderately active - Railway workers, postmen, farm workers.
- very active - Dock workers, army recruits, weeders, cane-cutters.

Experts have worked out several methods for determining the minimum daily requirements of energy. The charts that follow could help you. Use one of these methods for calculating your own energy needs.

### Table 5.3  Basal metabolic requirements

<table>
<thead>
<tr>
<th>Category by Age</th>
<th>Mass</th>
<th>Resting energy requirement (kJ per kg per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant 1 year old</td>
<td>10kg</td>
<td>210 (50 kcal)</td>
</tr>
<tr>
<td>Child 8 years old</td>
<td>25kg</td>
<td>168 (40 kcal)</td>
</tr>
<tr>
<td>Adult woman</td>
<td>55kg</td>
<td>105 (25 kcal)</td>
</tr>
<tr>
<td>Adult man</td>
<td>65kg</td>
<td>105 (25 kcal)</td>
</tr>
</tbody>
</table>

### Table 5.4  Energy expenditure for various types of activities

<table>
<thead>
<tr>
<th>Type of activity</th>
<th>Estimated energy expenditure (kJ per kg per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) At rest most of the day (sitting, reading, very little walking or standing)</td>
<td>51.2 (12.17 kcal)</td>
</tr>
<tr>
<td>(b) Very light exercise (sitting, standing, walking)</td>
<td>59.76 (14.23 kcal)</td>
</tr>
<tr>
<td>(c) Light exercise (standing, typing, laboratory work)</td>
<td>79.92 (19.03 kcal)</td>
</tr>
<tr>
<td>Type of activity</td>
<td>Estimated energy expenditure (kJ per kg per day)</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>(d) Moderate exercise (walking, housework, moving about constantly, gardening)</td>
<td>110.88 (26.4 kcal)</td>
</tr>
<tr>
<td>(e) Severe exercise (outdoor games, dancing, on the move all the time)</td>
<td>172.08 (40.97 kcal)</td>
</tr>
<tr>
<td>(f) Very severe exercise (sports, tennis, swimming, heavy manual work)</td>
<td>241.68 (57.54 kcal)</td>
</tr>
</tbody>
</table>

Sample calculation
1. Assume sex, age and weight along with activity.
2. Energy expenditure for basal metabolism = kJ
3. Add energy expenditure for activity = kJ
4. Add kJ for the influence of food = kJ
   (10% of total of 2 and 3)
5. Total estimated kJ required daily = kJ

The effects of an unbalanced diet

An unbalanced diet will be clearly one that does not contain one or more of the essential nutrients in enough quantities to supply daily energy needs. A diet such as this results in malnutrition. Malnutrition may be defined simply as "bad" nutrition. This may be due to under-nutrition, meaning inadequate intake of correct foods or to under-nourishment which is the inability of the body to digest, absorb or make use of the nutrients.

Malnutrition may also mean bad nutrition in the sense of over-eating. This results in obesity or gross overweight. Obesity is often associated with varicose veins, diabetes, heart disease and kidney disease.

Severe malnutrition due to undernutrition manifests itself in various forms. One of these forms (kwashiorkor) you learnt about earlier. Another form is:-

- marasmus, which is a condition of general starvation. It is prevalent in infants who are fed very poorly after weaning. Symptoms include underweight, skinyness, loss of appetite and diarrhoea.

Generally, persons who are malnourished suffer from lack of energy, they tire easily, get headaches, lose weight, are irritable and are easy prey to infection especially of the gastro-intestinal tract. Some may even experience brain damage and may respond poorly to learning.

Most of the above mentioned nutrition-related problems may be corrected by a proper balanced diet or special adjustments to the regular daily diet.
Digestion in animals

Teeth

The teeth of animals are used for biting and for chewing food into small pieces. There is much difference in the number and shape of teeth in various animals. This fact is related to the type of food that is eaten by the particular animal.

Herbivores, like rabbits and sheep, have teeth with sharp edges and ridges for cutting and grinding grass or other plant material. The teeth of herbivores grow as fast as they are worn away.

Carnivores like dogs and cats, on the other hand, have teeth that are sharply pointed for tearing flesh. Their teeth do not wear away as do the teeth of herbivores. So their teeth stop growing when they have reached a certain size.

Humans are omnivorous. Our teeth have features of both herbivores and carnivores. We have four types of teeth, some for biting and tearing, and some for chewing and grinding.

Each mammal has its own dental formula i.e. a formula describing the number and kinds of teeth. For an adult human the dental formula is:

\[
\begin{align*}
i & : 2 \\
c & : 1 \\
\text{pm} & : 2 \\
m & : 3
\end{align*}
\]

What does this formula mean? The figures above and below the lines represent the number of pairs of each type of tooth in the upper and lower jaw on one side of the body. The ‘i’ represent incisors, ‘c’ canines, ‘pm’ pre-molars and ‘m’ molars. Let us look at these types of teeth more closely.

Types of teeth and their functions

Look carefully at the drawings in Fig. 5.3. Each drawing shows the shape of that type of tooth.

Each type is designed to perform a special function. Table 5.5 gives us information about the types of teeth in human and their functions.

Mammals have in their lifetime two sets of teeth.

- Temporary (or milk) teeth which are the first set of teeth and last only a short time—from about three months to about ten years old. See Fig. 5.4 (a).

- Permanent teeth which are the second set of teeth. They could last for the rest of a lifetime. See Fig. 5.4 (b).
Table 5.5  Types of teeth in humans and their functions

<table>
<thead>
<tr>
<th>Type of tooth</th>
<th>Number</th>
<th>Function</th>
<th>Special features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incisors</td>
<td>eight</td>
<td>to bite or cut food</td>
<td>- at front of mouth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- have sharp edges.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- chisel-shaped.</td>
</tr>
<tr>
<td>Canines</td>
<td>four</td>
<td>to tear food, especially flesh</td>
<td>- pointed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- long crowns.</td>
</tr>
<tr>
<td>Pre-molars</td>
<td>eight</td>
<td>to crush food and further tear it if necessary</td>
<td>- also called &quot;cheek&quot; teeth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- usually have two ridges or &quot;cusps&quot; hence the name bi-cuspid.</td>
</tr>
<tr>
<td>Molars</td>
<td>twelve</td>
<td>to crush and grind food to fine pieces.</td>
<td>- have sharp ridges and grooves.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- have broad surfaces.</td>
</tr>
</tbody>
</table>

![Fig. 5.4 (a) Milk dentition of a six year old](image)

You will need:
- a fellow student.
- a child between six and ten years of age.
- a mirror.

**Procedure A**

1. Examine a fellow student’s teeth. How many of each kind of tooth can you see? How many are there in all?
2. Examine the teeth of a child between six and ten years of age. How many teeth are there in all?
3. Open your mouth, and use a mirror to look at the teeth in your bottom jaw.

![Fig. 5.4 (b) Permanent dentition of an adult](image)
Table 5.6  Types and numbers of teeth in different persons.

<table>
<thead>
<tr>
<th>Person being examined</th>
<th>Type of tooth</th>
<th>Number in upper jaw</th>
<th>Number in lower jaw</th>
<th>Teeth lost or extracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>incisor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>canine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>premolar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>molar</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do you have any decayed or broken teeth?

Procedure B

1. Draw up a table like the one above and complete it for each person.

Look at Fig.5.4(b) and compare your information with the number of teeth shown in that figure.

The structure of a tooth

Our teeth are made to last a lifetime and thus they are made up of very strong, long-lasting materials. The part of each tooth that we see above the gum and use to chew our food is the crown. The part that is hidden from sight is the root, while the section at the gumline is called the neck.

The crown is covered with a creamy-white substance called enamel. Enamel is said to be the hardest substance in the body. Under the enamel is dentine, a bone-like substance that makes up the greater part of the internal structure of the tooth. The innermost part is the pulp cavity which consists of soft tissue and contains the nerves and blood vessels that keep the tooth alive.

The tooth is embedded in a socket in the jaw bone and is held in place by a layer of cement and by small elastic fibres. Fig. 5.5 shows the structure of a tooth.
The alimentary canal

As we learnt earlier, the alimentary canal is the digestive tract in animals. This tract is only part of the digestive system. The other part is made up of associated digestive organs such as the salivary glands, the liver and the pancreas, which are all connected to the alimentary canal.

The alimentary canal begins at the mouth where food is ingested. As we also learnt earlier, the food is well chewed in the mouth of humans. The food is swallowed and it passes through the gullet (or oesophagus) which is a straight tube that passes through the chest cavity and the diaphragm and opens into the stomach. The stomach lies in the abdominal cavity. From the stomach, food moves into the small intestine where absorption takes place. The undigested food material is then passed into the large intestine where water is extracted. The unwanted material is finally expelled from the rectum by way of the anus.

Structure of the alimentary canal

Study the drawing below. Fig 5.6 gives us the structure of the alimentary canal in humans, Fig. 5.7 of the alimentary canal in the rabbit, and Fig. 5.8 of that in a shark.
Functions of the main parts of the alimentary canal

The mouth is the cavity where digestion begins. It is here that the mechanical breakdown of food, by teeth, takes place. While the food is being chewed, it is mixed with saliva and worked into a ball by the tongue. At the back of the mouth is the pharynx where food is swallowed and passed into the oesophagus. The oesophagus is a straight tube with muscles that contract and relax to force food downward. This movement of the oesophagus is called peristalsis.

The stomach has muscles in its walls. The muscles contract and relax when food is present. This is the other phase of the mechanical breakdown of food in man. (The first was by the teeth, in the mouth.) The movements churn the contents of the stomach to a soup-like mixture called chyme. In the stomach the food is mixed with gastric juice. This contains hydrochloric acid which kills bacteria in the food and creates an acidic medium for the enzymes. The gastric juice also contains enzymes. The enzymes act only on proteins. Food normally remains in the stomach for about four hours but substances like alcohol diffuse directly into the blood stream through the stomach walls.

The small intestine is the longest part of the digestive tract. It is divided into two main sections — duodenum and ileum. Most of the chemical breakdown of food occurs in the duodenum where pancreatic juice and bile act on food. Digestion is completed in the ileum and absorption of nutrients takes place right there. The inner wall of the small intestine has many finger-like projections called villi (singular ‘villus’). The villi absorb the food nutrients. The villi greatly increase the surface area through which absorption can occur. The wall of a villus is only one cell thick so that soluble food nutrients can easily diffuse across it.
2. Use a piece of string to measure the length of the (a) oesophagus, (b) stomach, (c) small intestine and (d) large intestine.

What is the total length of your specimen’s alimentary canal? Record your measurements and comment on them.

**Properties of enzymes**

Enzymes are organic chemicals that change the rate of chemical reactions. They are secreted in solution in the living cells of plants, humans and other animals. They enable the bodies of organisms to carry out the many chemical reactions necessary to life. They belong to the group of chemicals called *catalysts* and as such they speed up the rate of chemical reactions. Generally enzymes have the following properties:

- **They are proteins.**
- **They are affected by temperature.** They work best at 37 °C to 40 °C which is about body temperature. They could be destroyed by heat above 40 °C.
- **Each does a particular job.** Each enzyme is important for one specific reaction; each always acts on one particular substance, thereby producing the same end-product.
- **Enzymes could be used again.** Each enzyme catalyses the reaction but is not changed by it.
- **They are sensitive to pH.** Each enzyme works most effectively at its own specific pH. (See Table 5.7)
- **They are required in small quantities only.**

Digestive enzymes have the special job of catalysing the reactions in the breakdown of food nutrients.

---

**Activity:** The digestive system of a mammal.

You will need a dissection of a small mammal e.g. a guinea pig. N.B. A laboratory rat should be used to avoid contracting diseases.

**Procedure:**

1. Find all the parts of the digestive system you have learnt about and write a brief description of each in your practical book.
The roles of enzymes in digestion

Digestive enzymes are hydrolytic i.e. they cause a chemical change in which water molecules interact with and are added to food molecules. During digestion large molecules of starch are hydrolysed to become single molecules of glucose.

![Diagram showing hydrolysis of starch](image)

Enzymes that are present in the digestive juices

The chemical reactions in digestion require a lot of energy but, in the body, enzymes lower the amount of energy needed to start the reactions. This is so because digestive enzymes act as catalysts that accelerate the rate of food breakdown.

In the chemical reaction that each enzyme promotes, only the substrate is changed.

There are at least nine digestive enzymes in the body. They are secreted by special organs in different parts of the digestive system. Each enzyme acts on a specific substrate during digestion. The table below gives us a summary of enzyme activity during digestion of food in humans.

The action of enzymes on food

Let us investigate enzyme action on food to see how enzymes help in the chemical breakdown of food.

Activity: Action of amylase on starch

Caution! Because of possible infections, experiments involving saliva are not recommended!

You will need:
- a piece of cracker biscuit or bread,
- 1% amylase solution (prepared by your teacher)
- mortar and pestle
- 3 test-tubes
- dropping pipettes
- beakers
- bunsen burner
- Benedict’s solution
- iodine
- distilled water
- tap water
- white tile
- glass rod

Procedure

Read through all the instructions before you begin the exercise.

1. Heat a beaker of tap water to 37 °C. (Use it as a water-bath)
2. Measure accurately 3 cm$^3$ of amylase solution into a test-tube and place the test-tube in the water bath.
3. Break up the cracker biscuit or crumble the bread and mix with 2 cm$^3$ water. (This is your sample of cooked starch.)
4. Take three test-tubes and label them A, B and C. Divide the sample of cooked starch equally between test-tubes A and B (about 1 cm³ in each test-tube). Add 1 cm³ of distilled water to tubes A, B and C.

(N.B. Measure the quantities accurately.)

5. Prepare a white tile, as in Fig. 5.11, with three rows of drops of iodine solution (four or five drops in each row).

<table>
<thead>
<tr>
<th>Table 5.7 Enzyme activity in digestion in man</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part of digestive system with pH</strong></td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Mouth cavity, pH &gt; 7</td>
</tr>
<tr>
<td>Stomach, pH &lt; 7</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Small Intestine, duodenum (a)</td>
</tr>
<tr>
<td>Intestine, duodenum</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Liver</td>
</tr>
<tr>
<td>Ileum</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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6. Prepare a Table as in Table 5.8 (A), then work quickly!

7. Record the time, then add 1cm$^3$ of warmed amylase to tube A. Stir the contents with a glass rod. Immediately remove one drop of the mixture with a dropping pipette and add it to the first drop of iodine solution. Note and record quickly the colour of the iodine solution.

8. After 30 seconds, stir and remove a second drop and put it into the second drop of iodine solution. Record the colour and repeat the test every 30 seconds until the colour of the iodine solution no longer changes. Record your results.

9. Take tube B. **Do not add amylase.** Repeat the process as with tube A over the same length of time. Record your results.

10. Add 1cm$^3$ of amylase to tube C and repeat the process. Record your results.

11. Finally, test the contents of tubes A, B and C for the presence of sugar using Benedict’s solution. (You will recall that you did these tests earlier in this unit). Record your results.

![Diagram showing spotting tile for starch test](image)

**Table 5.8 Saliva and Cooked starch**

<table>
<thead>
<tr>
<th>Time/sec</th>
<th>Tube a</th>
<th>Tube b</th>
<th>Tube c</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>120</td>
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<td>...</td>
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<td></td>
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<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.8 (B) Benedict’s test**

<table>
<thead>
<tr>
<th>Time/sec</th>
<th>Tube a</th>
<th>Tube b</th>
<th>Tube c</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>30</td>
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<td>60</td>
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<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions:
What do you conclude from your observation when the iodine no longer changed colour after a while?

Activity: The action of pepsin on egg albumen

You will need:
- egg albumen suspension i.e. 1% dried albumen
- in water heated to 90 °C.
- 10% HCl solution
- 1% pepsin
- 4 test-tubes
- beaker
- Bunsen burner
- tap water

Procedure
1. Take a beaker of tap water and warm to about 37 °C.
2. Take four test-tubes and into each place about 5 cm³ of egg albumen suspension. Label the tubes A, B, C and D.
3. To each of the tubes B, C and D add three drops of 10% hydrochloric acid.
4. Place 1cm³ of 1% pepsin in a test-tube and heat until it boils, then add it to tube D. Place 1cm³ of 1% pepsin (unboiled) in tubes A and C only.

Now see Table 5.9 to ensure that each tube has the correct contents.

5. Place all four tubes in the water bath.
6. Examine the tubes at 2 minute intervals, and after 6-8 minutes remove the four test-tubes from the water bath and place them in a test-tube rack. Examine the contents of each tube and record your observations in the form of a table as shown in Table 5.9.

Table 5.9 Pepsin and egg albumen

<table>
<thead>
<tr>
<th>Tube contents</th>
<th>Appearance at the beginning of experiment</th>
<th>Appearance at the end of experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Albumen + pepsin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B Albumen + HCl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Albumen + HCl + pepsin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D Albumen + boiled pepsin+ HCl</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions

1. In which tube have the contents a different appearance after six minutes or more? What has happened to the egg albumen?
2. What is the best pH medium in which the enzyme pepsin can act?
3. How do you account for any differences between tubes C and D?

What happens to undigested food?

Most of the food we eat has a lot of undigestible material. This material is called roughage or dietary fibre, and it is undigested because its materials cannot be easily broken down into soluble molecules in the body. One example of roughage in food is cellulose which is a carbohydrate that makes up a large part of vegetables, grains and fruits. Its bulkiness is useful to the digestive system because it causes the intestines to expand as it moves through them. It also stimulates muscle contractions in the intestines, causing movement of undigested food.

The undigested food passes through the small intestines until it reaches the large intestine as a watery mass of food bulk. As this mass moves through the large intestine, much of the water is absorbed into the tissues. The undigested food becomes more solid as the water is absorbed. This solid intestinal content is now called faeces and it is passed into the rectum where it accumulates until it is eventually eliminated through the anus.

![Diagram showing breakdown of complex insoluble food to simple soluble ones.](image)

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*Fig. 5.12  Diagram showing breakdown of complex insoluble food to simple soluble ones.*
Exercises

Answer the following in your own words.

1. What are the SIX broad food groups found in a balanced diet? Give examples of foods in each broad food group.

2. Why does the body require energy?

3. What types of energy does the body use?

4. What is oxidation? Where does oxidation usually occur in the body?

5. Define basal metabolism.

6. Why do different people have different requirements for energy?

7. (a) What is the function of haemoglobin?
   (b) Which mineral element is connected with haemoglobin?

8. Define obesity. How does eating more carbohydrates and fat than you require contribute to obesity?

9. **Activity:** Investigating energy values of some common foods.

   Find the energy value of the foods listed: milk, rice, bread, beef, eggs, ripe banana, corn, butter, mango, sugar.

10. Make your own drawing of the digestive system. Refer to the drawing, Fig. 5.13, on this very page. On your drawing name the parts labelled A - G (Do not write in the text book).

11. In which part of the digestive system is the digestion of food completed? What are the end products at this stage?

12. Identify the parts of the digestive system in which the changes listed below occur. Transcribe each sentence and write the name of the part beside the sentence.

   (a) Food nutrients move into blood by diffusion.

   (b) Food is first mixed with an enzyme.

   (c) Muscles move food downwards after it is swallowed.

   (d) Undigested food is moved out of the body.

   (e) Food is mixed with hydrochloric acid and enzymes.

13. What is the role of enzymes in the digestive system?

14. (i) Name **THREE** enzymes found in the digestive system.

   (ii) Name the organs which secrete these enzymes, the food (or the substrate) each of the enzymes breaks down and the end products of that breakdown.
WE HAVE LEARNT THAT:

• a balanced diet contains the five food nutrients, viz. carbohydrates, proteins, fats, minerals and vitamins, and water; and supplies our daily energy needs.
• choosing foods in correct quantities from the six food groups, viz. staples, fats and substitutes, fruits, vegetables, legumes and food from animals ensures that we have a balanced diet.
• for proper health and growth it is necessary to have a balanced diet containing the correct proportions of the food nutrients.
• energy is obtained mainly from fats and carbohydrates. Energy is released in the body in the process known as respiration.
• energy is needed for every activity we perform as well as for internal body processes. Energy in the body can be measured in kilojoules (kJ) or kilocalories (Kcal).
• unbalanced diets result in malnutrition.
• there are four types of teeth in mammals, each type having a different shape and function.
• the main parts of the teeth are enamel, dentine, and pulp cavity.
• the digestive system is made up of the alimentary canal and associated digestive organs.
• in mammals, the mechanical breakdown of food is carried out by the teeth and also by the contraction and relaxation of the muscles of the alimentary canal.
• the digestive system in animals has four functions: (1) passing food along (2) adding digestive juices to food (3) absorbing the digested nutrients (4) getting rid of undigested food materials.
• enzymes are specific and act on specific substrates.
• digestive enzymes are hydrolytic i.e. they cause a chemical change in which water molecules interact with and are added to food molecules.
• there are at least nine digestive enzymes in our body.
• enzymes are secreted by special organs in different parts of the digestive system.
• enzymes act as catalysts that accelerate the rate of food break-down.
Unit 6

Electricity and magnetism

Introduction

In this unit we will learn about:

- the importance of electrical measurements.
- how to connect and use voltmeters and ammeters.
- investigating current and voltage in series and parallel circuits.
- the relationships among voltage, current and resistance.
- the power of electrical appliances in the home.
- calculating and paying for electricity.
- what happens when electricity passes through some liquids.
- the process of electrolysis and electroplating.
- magnets and magnetic fields.
- the methods of making magnets and uses of magnets.

Importance of electrical measurements

Electrical measurements are very important. The voltage and electric current must not be too large or too small for a particular conductor or machine to work correctly. For example, too little current may fail to light a lamp or turn a motor, but too much current could burn out the filament of the lamp or burn a motor.

Meters are devices that indicate the exact voltage or current for a particular circuit or appliance.

Meters can also be used to find faults in electrical or electronic circuits. The instrument panel of a car has a meter to show when the battery is being charged. Electricity boards use meters to measure how much electrical energy has been supplied. Can you think of some other cases or situations where electricity meters are used?

Using the voltmeter

The voltmeter is an electrical instrument used to measure the potential difference (p.d) or voltage between two points in an electric circuit. The unit of potential difference or voltage is the volt (symbol V). Since a voltmeter measures the potential difference across an appliance in a circuit, it is always connected in parallel. Therefore, to find the voltage across a component such as a lamp (Fig. 6.1) the positive of the voltmeter is connected to the positive end (X) of the source and the negative of the voltmeter to the negative end (Y).
N.B. Voltmeters must always be connected in parallel and ammeters in series. Both ammeters and voltmeters must be connected according to the correct polarity marked on them (i.e. + and - poles). Wrong connection may damage the instruments. It is also important to use meters of the correct rating for a particular circuit.

**Using the voltmeter with the ammeter**

**Using the ammeter**

The ammeter is an instrument used to measure electric current in a circuit. The unit in which electric current is measured is called the ampere (symbol A). The ammeter is always connected in series. Fig. 6.2 shows an ammeter connected in a circuit consisting of two cells, a switch and a lamp. Set up the circuit in the laboratory. State the reading on the ammeter.

![Fig. 6.2 Diagram showing an ammeter connected in series](image)

Fig. 6.2 Diagram showing an ammeter connected in series.

How can you find the current and voltage?

Fig. 6.3 shows a simple circuit consisting of three cells, a switch and a lamp. Current is flowing through the circuit and also there is a potential difference across the lamp. How can we find the current through the lamp and potential difference across it? Of course we have to use two meters — the ammeter to measure the current and voltmeter to measure the potential difference (See Fig. 6.4).
Series circuit

As mentioned in Book Two, a series circuit has only one path for the current to flow. In the simple series circuit in Fig. 6.5, when the switch is closed, both lamps light. A break anywhere in the circuit will stop the current flowing. If you take out one lamp, the other goes out. If one of the lamps breaks, both lamps go out. This is what happens with some fairy lights. Can you suggest why electric lights in homes are not connected in series?

Investigating simple circuits

By now you should be able to connect ammeters and voltmeters correctly in electric circuits.

We shall now investigate the currents and voltages in series and parallel circuits. For this you will need the following: two cells; two different lamps; three ammeters; three voltmeters; connecting wires and a switch.

Current in a series circuit
Set up the series circuit shown in Fig. 6.6 (a) consisting of 2 cells, 3 ammeters and 2 lamps in series. All the ammeters show the same reading. The current is therefore the same in all parts of the series circuit. The same current flows through each cell. Therefore, you can put an ammeter anywhere in such a series circuit to measure the current. Change the positions of the ammeters as shown in Fig 6.6(b). Note the current which flows through each ammeter.

![Diagram showing the rearrangement of ammeters](image)

Set up the circuit as shown in Fig 6.7 consisting of 2 cells, 2 lamps, a switch and 3 voltmeters. The voltmeters are measuring the voltages or potential difference in a series circuit. Note that the voltmeters are connected in parallel with the lamps. Voltmeter $V_0$ shows the voltage across the lamps, voltmeter $V_1$ shows the voltage across the lamp $L_1$, and voltmeter $V_2$ shows the voltage across lamp $L_2$.

What do you notice about the voltage shown on the three voltmeters? The voltage on voltmeter $V_0$ is equal to the voltage on voltmeter $V_1$ plus the voltage on voltmeter $V_2$. Therefore, in symbols,

$$V_0 = V_1 + V_2$$

The voltage supplied by the battery is shared between the two lamps.

For any series circuit the total voltage across is equal to the sum of the individual voltages.

**Parallel circuit**

In a parallel circuit there is more than one path for the current. Fig. 6.8 shows a simple branched or parallel circuit with two lamps, $L_1$, and $L_2$. When the switch is closed both lamps come on. Current flows from X to A. It then splits up; some of it flows through lamp $L_1$ and the remainder flows through lamp $L_2$. If you take out one of the lamps the other stays on. This is possible because if $L_2$ is removed, the current still has a closed path X AL1 BY in which to flow. If one lamp breaks, the other is not affected. Therefore, most lighting circuits are connected in parallel and not in series.
The current from the battery is shared between lamps $L_1$ and $L_2$. When the current splits into two parts no current is lost. For any parallel connection the total current is equal to the sum of the individual currents in each branch of the circuit.

Voltage in a parallel circuit

Set up the parallel circuit as shown in Fig. 6.10. Note the readings on the voltmeters. Do you notice that the readings on all the voltmeters are the same? Electrical components joined in parallel always have the same voltage across them. Therefore,

$$V_0 = V_1 = V_2$$

This voltage is also the same as the voltage across the battery. Therefore, for any parallel circuit the voltages across individual components are always the same.
The equation $V = IR$

Fig. 6.11  Diagrams showing how resistance is measured.

Set up the circuit as shown in Fig. 6.11(a) consisting of two cells, one lamp and an ammeter in series. Observe the brightness of the lamp and note the ammeter reading. Then add another lamp in series as shown in Fig. 6.11(b). Is there any difference in the brightness of the first lamp? Note the new reading on the ammeter. What do you think causes this difference in the current? You must have noticed that current is less when two lamps are connected. We say that the lamps have a certain resistance - that is, they resist the flow of the current. All electrical appliances have a certain resistance. Two lamps have more electrical resistance than one lamp. Can you say why? The greater the number of lamps, the greater will be the resistance.

Set up the circuit again as shown in Fig. 6.11(a). Then add another cell in series (See Fig 6.11 (c)) so as to increase the voltage across the lamp. What happens to the brightness of the lamp and the reading on the ammeter? You must have noticed that the current increases when the voltage increases. Therefore, the current also depends on the voltage across the lamp.

You can control the current in a circuit by using a variable resistor or rheostat. Fig. 6.12 shows one type of rheostat in which a length of the resistance wire is wound on a tube. The length of wire connected in the circuit may be changed by adjusting the position of the sliding contact, C.

Fig. 6.12  Drawing of a rheostat

The current flowing in a circuit depends on the resistance of the circuit and also on the voltage across it. It is often important to measure the resistance of a circuit or part of a circuit. This can be done by measuring the current and the voltage. The resistance can be found by using the formula.

$$ \text{resistance} = \frac{\text{voltage}}{\text{current}} $$

i.e.

$$ R = \frac{V}{I} $$

where $R$ is the resistance, $V$ is the voltage and $I$ is the current. Voltage is measured in volts (V),
current in amperes (A) and resistance in ohms (Ω).

If the current and resistance are known, then the voltage can also be found by using another form of the formula which is

\[ V = IR \]

To find the current when the voltage and resistance are known we use:

\[ I = \frac{V}{R} \]

The following examples show how the formulae can be applied.

**Example 1.** Calculate the resistance of a hot plate if the current is 6 A and the voltage is 240 V.

\[
\begin{align*}
\text{We have} & \\
V &= 240 \text{ V} \\
I &= 6 \text{ A} \\
R &= \frac{V}{I} \\
&= \frac{240 \text{ V}}{6 \text{ A}} \\
&= 40 \Omega \\
\text{So the resistance is 40 Ω}
\end{align*}
\]

**Example 2.** How much current would flow through a lamp of resistance 22.5 Ω, connected to a 4.5 V supply?

\[
\begin{align*}
\text{We have} & \\
R &= 22.5 \Omega \\
V &= 4.5 \text{ V} \\
\text{Using} & \\
I &= \frac{V}{R} \text{ gives} \\
I &= \frac{4.5 \text{ V}}{22.5 \Omega} \\
&= 0.2 \text{ A} \\
\text{So the current is 0.2 A.}
\end{align*}
\]

**Example 3.** A lamp has a resistance of 480 Ω. If the current flowing is 0.25 A, what is the voltage across the lamp?

\[
\begin{align*}
\text{We have} & \\
I &= 0.25 \text{ A} \\
R &= 480 \Omega \\
\text{Using} & \\
V &= IR \\
V &= 0.25 \text{ A} \times 480 \Omega \\
&= 120 \text{ V} \\
\text{So the voltage} &= 120 \text{ V}
\end{align*}
\]
Paying for electricity

Most of us in Guyana obtain our electricity from the Power Company and we must pay for the electrical energy we use each month. But how does the company know how much electrical energy we use each month so as to send us the correct bill? Of course, there is in our homes an electricity meter that measures the amount of electrical energy used.

Gasoline is a fuel or a source of chemical energy used to run our cars. When we buy 'gas' from a 'gas' station, it is normally measured in litres by a special pump with a meter. The pump measures the volume of fuel taken and we pay according to this volume. But how is the electrical energy really measured and in what unit is it measured?

The wattage of appliances

Electrical appliances used in the home change the electrical energy supplied to them into other types of energy such as light, heat, sound or mechanical energy. For example, a fluorescent lamp changes electrical energy to light energy. Also, an electric iron changes electrical energy to heat energy. List some other household appliances and state the type of energy into which the electrical energy is converted.

-In these electrical appliances, what is important is not only the amount of energy transformed but the rate at which the energy is transformed. This is called the power of the appliances.

The power of an electrical appliance is the rate at which it transforms electrical energy to other types.

Therefore, Power = \( \frac{\text{Energy transformed}}{\text{Time taken}} \)

The unit of energy is the joule (J) and the unit of time is the second (s). Therefore the unit of power is J/s (Joule per second) or watt (one watt is one Joule per second). In electrical circuits the power of a bulb, for example, is the number of joules of energy transformed in one second. The power is sometimes referred to as the wattage. The power or wattage of a bulb can be found by measuring the current through it and the voltage across it. (See Fig. 6.13).

Then,

Power (P) in watts = Current (I) in amperes x voltage (V) in volts

\[ P = IV \]

Wattage (W) = Ampere (A) x volt (V)

\[ W = AV \]

Fig. 6.13 Diagram of apparatus used to measure the power or wattage of a bulb
If you examine any electrical appliance, you will notice that there is a plate with some markings on it. The information on the plate tells us the voltage at which the appliance should be operated and the **power rating** of the appliance. The following information was copied from an electric sewing machine, **120 V, 0.75 A, 60 Hz**. The power rating is obtained by multiplying V x A i.e. **120 V x 0.75 A = 90 W**. On some appliances, the power rating is given in watts. Look at a light bulb and you will see this.

Examine several household appliances and record the power rating of each in a table such as the one shown below.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Power rating/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light bulb</td>
<td>40</td>
</tr>
<tr>
<td>Light bulb</td>
<td>60</td>
</tr>
<tr>
<td>Light bulb</td>
<td>100</td>
</tr>
<tr>
<td>Electric iron</td>
<td>750</td>
</tr>
<tr>
<td>Hair dryer</td>
<td>1250</td>
</tr>
<tr>
<td>Hot plate</td>
<td>2000</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>1000</td>
</tr>
<tr>
<td>Television set</td>
<td>150</td>
</tr>
<tr>
<td>Toaster</td>
<td>1140</td>
</tr>
<tr>
<td>Radio</td>
<td>50</td>
</tr>
<tr>
<td>Fan</td>
<td>100</td>
</tr>
</tbody>
</table>

### Comparing energy at different wattages

An electric bulb converts electrical energy to light energy and also heat energy. Place your hand around a lighted bulb. Can you feel the heat? The greater the wattage of the bulb, the brighter it will light and also the hotter it will become. This is because more energy will be converted in a given time.

We shall now perform an experiment to compare the energies converted by two bulbs of different wattage, but at the same voltage.

### Materials:

Two 12 V bulbs - A, of wattage 6W and B, of wattage 24 W, a 12 V battery; two similar styrofoam cups filled with water enough to cover the bulbs; two thermometers; connecting wires.

### Method:

Connect the two bulbs A and B in parallel and immerse each in a cup of water. (See Fig 6.14) The cups should contain equal masses of water. Place a thermometer in each container and note the initial temperatures (which must be the same for both containers). Switch on the circuit for about two minutes and note the maximum reading on each thermometer.

The electrical energy of both bulbs is converted to heat energy which is used to heat the water and increase the temperature. Compare the increase in temperature of the water in each container. What do you notice? The bulb with the larger power rating converted a larger amount of energy to the water in two minutes than the bulb with the lower rating.
Fig. 5.14 Diagram showing the comparison of energies converted by two bulbs.

The equation: energy = power x time

From the definition of power as the rate of transfer of energy we have:

\[
\text{Power} = \frac{\text{Energy}}{\text{Time}}
\]

Rearranging this formula we have:

\[
\text{Energy (in Joules)} = \text{Power (in Watts)} \times \text{Time (in seconds)}
\]

Therefore the amount of electrical energy used by a particular appliance depends upon its power and the length of time for which it is used.

Example: What is the amount of energy in Joules used by a 60 W bulb in 8 hours?

\[
\begin{align*}
\text{Power} & = 60 \text{ W} \\
\text{Time} & = 8 \text{ hours} \\
& = 8 \times 60 \times 60 \text{ seconds} \\
& = 28800 \text{ seconds}
\end{align*}
\]

Energy (in Joules) = Power (in Watts) x Time (in seconds)

\[
\begin{align*}
\text{Energy} & = 60 \times 28800 \\
& = 1728000 \text{ J} \\
& = 1728 \text{ kJ} \quad (1 \text{ kJ} = 1000 \text{ J}) \\
& = 1.728 \text{ MJ} \quad (1 \text{ MJ} = 1,000,000 \text{ J}) \\
& = 1.7 \text{ MJ}
\end{align*}
\]

Commercial unit of energy

The unit in which we pay for the electrical energy we use is not the joule or kilojoule but it is the kilowatt-hour (kWh). One kilowatt-hour is the amount of electrical energy used when an appliance of power rating 1 kW is used for 1 hour. To get the number of kilowatt-hours we use over a period, we simply multiply the power (in kW) by the time (in hours).

Energy (in kWh) = Power (in kW) x Time (in hours)

Example: What is the amount of energy in kWh used by a 500 W electric iron for 30 minutes?

We have, 500 W = 0.5 kW and 30 minutes = 30/60 hours = 0.5 hour

Energy in kWh = Power (in kW) x Time (in hours)

\[
\begin{align*}
& = 0.5 \times 0.5 \\
& = 0.25 \text{ kWh}
\end{align*}
\]

Find out the amount of energy in kWh used by:

(a) Six 100 W bulbs for 5 hours
(b) One 2 kW hotplate used for 15 minutes
(c) One 150 W television set used for 8 hours
(d) One 1200 W toaster used for 5 hours.
The kWh meter

As we mentioned earlier, there is a special meter used to measure the amount of electrical energy we use in the home. This meter is called the kilowatt-hour meter. Can you say why?

Take a look at your electricity meter (Don’t touch it!)

There are two types—one with dials and the other is the digital type.

Look at the dials in Fig. 6.16. Starting from the left the first dial gives “thousands” of units, the second ‘hundreds’, the third ‘tens’ the fourth ‘single’ and the fifth ‘one-tenth’ of a unit. The ‘one-tenth’ unit is normally ignored when we read the meter. The direction in which the dials spin is shown in the meters by arrows. When we read the meter, we read the number that the pointer has just gone past. Try to figure out why the reading of the meter in Fig. 6.16 is 6825 kWh. Try reading the dials shown in Fig. 6.17.

Fig. 6.15 Picture of dial / analogue meter

The dial type meter (Fig. 6.15) has many small dials. Each dial has a pointer and numbers 0 to 9 marked on it.

Fig. 6.16 Diagram showing the reading is 6825 kWh

Fig. 6.17 Diagram of dials of a meter

Fig. 6.18 Picture of a digital type meter

The digital meter, shown in Fig. 6.18, is easier to read than the one with dials.
The reading from the meter, in Fig 6.18, is 9,374 kWh. **Note:** The last digit, which is showing tenths of a unit, is ignored.

Your meter is read at intervals by an employee of the electricity company, and in this way, the amount of electrical energy used during that period can be calculated.

**Calculating energy used light-bills**

Fig. 6.19 shows an edited Guyana Power and Light (GPL) electricity bill.

---

40 Main Street, Georgetown  
Tel #: 226-2601-8

JOHN JACK  
1789 NORTH LANE  
GEM HOUSING SCHEME

<table>
<thead>
<tr>
<th>BILLING PERIOD</th>
<th>READING DATE</th>
<th>METER</th>
<th>METER NUMBER</th>
<th>TARIFF</th>
<th>PAYMENT DUE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAN 2001</td>
<td>JAN 20 2001</td>
<td>79823</td>
<td>1</td>
<td>RESIDENTIAL</td>
<td>JUN 12 2002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRESENT READING</th>
<th>PREVIOUS READING</th>
<th>UNITS USED</th>
<th>DEMAND KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>7578</td>
<td>7540</td>
<td>38</td>
<td>0</td>
</tr>
</tbody>
</table>

FIXED CHARGE 194.00
ENERGY CHARGE 882.00
DEMAND CHARGE 0.00
MISCELLANEOUS CHARGE 0.00
TOTAL CHARGES 1,076.00
PREVIOUS BALANCE 1,099.00
PAYMENT SINCE LAST BILL 1,099.00

TOTAL BALANCE 1,076.00

RATE PER KWH. $23.21

---

Fig. 6.19 Representation of an electricity bill
The chemical effects of electricity

In Book Two we learnt that electricity could produce heat and light. It can also cause shocks and burns. Electricity can also produce chemical change.

Some liquids conduct electricity

Let us find out by way of experiment which liquids conduct electricity.

![Diagram showing apparatus for investigating conduction](image)

**Procedure**

1. Pour a liquid from among those listed in the table.
2. Record your observations in a table as shown below, placing a tick (✓) in the appropriate column for each liquid.
3. Repeat steps 1 and 2 using a clean container for each liquid.
4. Remember to clean the carbon rods every time you try a new liquid.

<table>
<thead>
<tr>
<th>Liquids</th>
<th>Conductor</th>
<th>Non-conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ethanol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sodium chloride solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Petrol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Dilute sulphuric acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Vinegar</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Molten substances or solutions which allow electricity to pass through them, causing them to decompose, are called electrolytes. Those that do not conduct electricity are called non-electrolytes. Sometimes, some solids do not conduct electricity when dry, but do so when in solution. Use the same apparatus as Fig 6.20 and test the following solids: sulphur, sugar, iron, lead bromide, lead iodide, potassium iodide. Do they conduct electricity?

Repeat the activity with molten forms of lead bromide, lead iodide and potassium iodide and with molten sulphur. What do you notice with the molten substances? Do they conduct electricity? Electrolytes would include most salts, molten or in solution, acids and alkalis.
What happens when electricity passes through some liquids

Can electricity cause chemical reactions? Here is another activity for you to do.

Set up the apparatus as shown in Fig. 6.21

![Diagram showing electrolysis](image)

Bubbles of oxygen gas are formed at the anode. The electrons flow into the circuit. The negative cathode would attract the positively charged ions (H⁺) called cations and they take in the electrons to form hydrogen molecules.

\[ 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2 \]

This process is called electrolysis. Electrolysis is the decomposition of an electrolyte by the passage of an electric current through it.

Applications of the chemical effect of electricity

We have seen from the previous activities, that electricity may produce chemical reactions. These reactions are used in industries to produce many chemicals.

Here is another activity for you to do. Set up the apparatus as in Fig. 6.20 using copper electrodes instead of carbon. Use copper (II) sulphate solution as the electrolyte.

![Diagram showing electrolysis with active electrodes](image)
Follow the directions below:

1. clean the electrodes, observe and record their appearance.
2. weigh each electrode to be used and record its mass.
3. set up the circuit, close the switch and observe what happens.
   Is any gas produced at the anode or cathode?
   What do you notice about the appearance of the anode and cathode?
4. re-weigh the anode and cathode, after five minutes, then after ten minutes.
5. what do you notice about the mass of the anode and that of the cathode after electrolysis for (a) five minutes (b) ten minutes?

In the above experiment, you would have noticed that the loss in mass of the anode was equal to the gain in mass of the cathode. Electrolysis is used to produce pure copper. To do this, impure copper is placed at the anode and pure copper at the cathode and the electrolyte is a copper salt. Copper from the anode would move to the cathode thus building up pure copper. The impurities at the anode would be deposited in the solution.

At the anode, copper dissolves and forms copper ions and electrons, which flow to the cathode.

\[ \text{Cu} \rightarrow \text{Cu}^{2+} + 2e^- \]

At the cathode, copper ions turn into copper metal, coating it.

\[ \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} \]

**Electroplating** is the process by which an object placed at the cathode, is coated with a thin layer of metal during electrolysis.

Electroplating is widely done and a variety of materials is used. Iron, which rusts easily can be covered with nickel, silver, chromium, tin or even zinc. These kinds of plating not only prevent rusting and corrosion but also improve the appearance of the article thus treated.

Just as electricity can cause a chemical reaction to take place during electrolysis, **electrochemical reaction** can make an electric current flow round a circuit. If lead is used at the negative plate and lead dioxide is used as the positive plate in dilute sulphuric acid, reactions take place and electricity is the result. This principle is used to manufacture accumulators such as car batteries. If you could get a worn out car battery examine it carefully.

**Magnetism**

**Natural magnet**

The first observation on magnetism was made over 2 500 years ago in a place called Magnesia. The early Greek and Roman records tell of the discovery of a kind of rock called lodestone, which has the strange property of attracting bits of iron particles. This rock, also called magnetite, is now known to be a special form of iron oxide(Fe₃O₄). This rock can be considered as a natural magnet (See Fig 6.23).
If a piece of lodestone is dipped into iron filings it is noticed that filings cling usually to two particular places. You can show this in your laboratory using a bar magnet. The filings are seen to cling near the two ends. Few, if any, filings are attracted to the middle of the bar. (See Fig. 6.24) The ends of the magnet, where the attracting power is greatest, are called its poles.

The magnetic compass

When a magnet is freely suspended in a paper sling by a thread (Fig. 6.25), it will come to rest with one pole pointing towards the north and the other towards the south. The pole which points to the north is called the “North seeking” or North (N) pole of the magnet; the other is called the South (S) pole. Try to identify the poles of a bar magnet by suspending it.

A magnetic compass is an instrument which is used to indicate direction with respect to the north pole of the earth. A magnetic compass normally consists of a magnetic needle which is pivoted at the centre and which is free to swing. (See Fig. 6.26) The tip of the north pole of a magnet is normally coloured in red. Some magnetic compasses also consist of the magnet, which is floating in a liquid by a floater to which a chart with the cardinal points (N,S,E,W) is attached. (See Fig. 6.27).
Plotting magnetic fields

You can detect a magnetic effect in the space around a magnet. The region around a magnet where a magnetic force is felt is its magnetic field.

You can use iron filings to show the pattern of the magnetic field lines. Put a sheet of white card, a sheet of stiff plastic or glass on top of a magnet. Sprinkle the filings on the sheet. When you tap the sheet gently the filings move. The filings settle in lines round the magnet. These lines are called lines of magnetic force.

It is important to note that the magnetic field is not just flat, in the plane of the card. The field fills the space around the magnet — it is three-dimensional. You can map the field with a compass. This is a small magnet that can swing freely on a pivot inside a case. The compass needle shows the direction of the magnetic field. By moving the compass from place to place and marking its position, as shown in Fig. 6.28, you could make the map (See Fig. 6.29).

Place the compass near the North pole of the magnet. Make a pencil mark where the North pole of the magnet points. Carefully remove the compass and place it so that its south end points exactly on your pencil point.

Repeat many times. You should end up with a diagram like Fig. 6.29.
Table 6.2 Investigating the action of magnets, one on another.

<table>
<thead>
<tr>
<th>Pole of magnet X</th>
<th>Pole of magnet Y</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>N</td>
<td>Repulsion</td>
</tr>
<tr>
<td>N</td>
<td>S</td>
<td>Attraction</td>
</tr>
<tr>
<td>S</td>
<td>S</td>
<td>................</td>
</tr>
<tr>
<td>S</td>
<td>N</td>
<td>................</td>
</tr>
</tbody>
</table>

From the table the results may be summed up in the law:

Like poles repel, unlike poles attract.

Fig. 6.30 Drawings of magnets showing attraction and repulsion.

Arrows on the lines show which way the north and south poles of the compass point. The field is stronger where the lines are closer together. The further you go from the poles the weaker the field becomes.

Attraction and repulsion

Obtain two bar magnets, X and Y, of known polarity. Suspend X by a string and hold the other Y in your hand. Now move the north pole of Y towards the north pole of X. (See Fig. 6.30). What do you observe? Continue moving pole to pole for a while. Make a copy of Table 6.2 and record your observations.

Testing polarity

The polarity of a magnet may be tested by bringing its poles, in turn, near to the known poles of another magnet. Repulsion will indicate similar polarity. If attraction occurs, no firm conclusion can be drawn, since attraction would occur between either two unlike poles, or a pole and unmagnetised magnetic material. Therefore, only when repulsion occurs are we sure of the polarity. A north pole can only repel a north pole and a south pole can only repel a south pole.

The earth as a magnet

A powerful magnetic field surrounds the earth, as if the planet has an enormous bar magnet embedded within its interior (Fig 6.31). The S and N on the magnet indicate the orientation of the earth's magnetic field. Because the opposite ends of magnets attract, the northern end of a suspended magnet is attracted to the southern end of the earth's magnetic field.
The southern end of the suspended magnet points to the earth's magnetic north. Scientists believe that convection currents of charged, molten metal, circulating in the earth's core, are the source of the planet's magnetic field.

Fig. 6.31 Illustration of the earth's magnet field.

Making magnets

Magnets can be made from materials such as iron or steel. If you bring a magnet close to a piece of iron, the iron becomes magnetised. If you take the magnet away the iron loses its magnetism. Iron is therefore used to make temporary magnets. Making a temporary magnet this way is an example of magnetic induction. The magnetism from the magnet is induced in the iron. A material like iron, which is easy to magnetise, but which loses its magnetism easily, is called a magnetically soft material. The word 'soft' refers to its magnetism and has nothing to do with the sense of feeling. The magnets we use in the laboratory are permanent magnets, which do not lose their magnetism easily. Permanent magnets are made of magnetically hard materials such as steel (iron mixed with carbon).

In Fig. 6.32 the poles of the induced magnets are labelled n and s. N and S are the poles of the permanent magnet. The attraction between the poles of the permanent magnet and the induced pole n is the force that pulls the iron towards the magnet.

Fig. 6.32 Diagram showing how a magnet is made by induction.

If you stroke one pole of a magnet many times in one direction, along a piece of steel, the steel becomes magnetised (See Fig 6.33). It becomes a stronger magnet than one made by just touching the steel with the magnet.
Magnetise a piece of iron wire using this method.

The best way of making magnets is by an electrical method. Put the piece of magnetic material (iron or steel) which is to be magnetised inside a long coil of wire called a solenoid (Fig 6.34). Pass a large, direct (one-way) current through the coil for a short time. If the material is of steel it becomes a permanent magnet. If, however, the material is made of soft iron, the magnetism is lost as soon as the current is switched off. Such a magnet which is operated by electricity is called an electromagnet. You can make a small electromagnet in the laboratory by winding a coil of wire around an iron nail and passing a current from a battery through the wire.

Fig. 6.34 Diagram showing how to make a magnet using the electrical method

Use of magnets

There are many uses of magnets and magnetic materials. Some are as follows.

1. **Magnets show direction.** For hundreds of years magnetic compasses have helped travelers find their way by showing direction with respect to the geographic poles (Fig. 6.25).

2. **Magnets pick up things.** Electromagnets, particularly, are used for picking up things made of magnetic materials. All electromagnets have the advantage that the magnetism is lost when the current is switched off. Some large ones are used to lift scrap metal.

3. **Magnetic inks** contain iron oxide suspended in substances of high viscosity, that enable machines to pick up signal patterns, used for such
purposes as the sorting of bank cheques.

4. **Permanent magnets** are used in speakers, ammeters, voltmeters, bicycle dynamos and small electric motors. Moving magnets are used to generate electricity. Changing magnetic fields are used when sounds and pictures are recorded using tape and video recorders. The computer floppy disk, which is used to store data, is made of thin plastic material coated with particles that are magnetised.

### Exercises

Questions 1 - 4

Choose one word from (a) - (e) which best fits each statement 1 - 4.

(a) Parallel  
(b) Ammeters  
(c) Series  
(d) Voltmeter  
(e) Polarity

1. _______ are used to measure current.
2. Ammeters are connected in circuits in _______; voltmeters in _______.
3. _______ are used to measure potential difference between two points in a circuit.
4. Ammeters and voltmeters should always be connected according to their _______.
5. A student connected up a circuit to test a motorcar headlamp bulb, using a 12 V battery, a headlamp bulb, an ammeter, a voltmeter and a switch. Draw the correct circuit.
6. The current in a resistor is 4 A and the voltage between its terminals is 6 V. Calculate the resistance.

7. An iron wire has a resistance of 12 Ω. If the voltage across its ends is 20 V, calculate the current in the wire.

8. What is the voltage required to produce a current of 2.5 A through a conductor of resistance 12.5 Ω?

9. (a) Why is it important to measure the amount of electrical energy used in our home?
   
   (b) A bulb is connected to a 12 V battery. An ammeter connected in series with the bulb reads 2 A. What is the power of the bulb?

Fig. 6.35

10. Read the two sets of meters in Fig. 6.35 and calculate the cost of electricity for the month if each kWh costs $20.90.
11. Read the two sets of meters in Fig. 6.35 and calculate the cost of electricity for the month if each kWh costs $20.90.

12. What is meant by the following terms?
   (a) Electrode
   (b) Electrolysis
   (c) Anode
   (d) Cathode

13. List TWO uses of electrolysis in industry.

14. Explain what is electroplating and give illustrative examples.

15. (a) What is the difference between a magnetic material and a magnet?
    (b) One end of a piece of metal attracts the N-pole of a compass needle. What is (i) certain?
        (ii) possible with respect to the polarity of the metal?

16. (a) What is a magnetic field?
    (b) Sketch the pattern of the magnetic field around a bar magnet showing the polarity and the direction of the lines of force.
    (c) Describe how you would determine whether a particular piece of steel is a magnet.

17. Draw a circuit diagram to show how you may set up an electromagnet using an iron nail.

18. There are many uses of magnets. Discuss the various uses of magnets and show how these are important in your everyday life.

19. Complete the crossword using the following clues.

Fig. 6.36 Crossword

ACROSS
1. Commercial unit of energy.
3. Unit of an electrical quantity.
4. Current is measured in ....................
7. The rate of converting energy.
9. Some meters are of this type.

DOWN
2. The same as power.
5. Exists as many types.
6. Unit of Time.
8. Some meters have several of these.
WE HAVE LEARNT THAT:

- measuring electricity is very important as it promotes efficiency and safety in electrical circuits.
- voltimeters, connected in parallel, are used to measure potential difference or voltages in volts.
- ammeters, connected in series, are used to measure current in amperes.
- both ammeters and voltimeters may be connected in the same circuit.
- in a series circuit the current is always the same in all sections.

\[ I_0 = I_1 = I_2 \]

- in a series circuit the total voltage is equal to the sum of the individual voltages across the components.

\[ V_0 = V_1 + V_2 \]

- in a parallel circuit the total current is equal to the sum of the currents in the different branches.

\[ I_0 = I_1 + I_2 \]

- in a parallel circuit the voltage across all the components in parallel is the same.

\[ V_0 = V_1 = V_2 \]

- a rheostat can vary the resistance, current and voltage of a circuit.
- \[ V = IR, \ R = V/I \] and \[ I = V/R \]. where \( V \) is the voltage in volts (V), \( I \) is the current in amperes (A) and \( R \) the resistance in ohms (Ω).
- measuring electricity is important in order for us to know how much we have to pay.

\[
\begin{align*}
\text{Power} & = \frac{\text{Energy transferred}}{\text{Time in seconds}} \\
\text{Power} & = \text{Voltage \times Current} \\
\text{Watt} & = \text{Volt \times Ampere}
\end{align*}
\]
the greater the wattage of an appliance the more energy it will use in a given time.

- energy (in kWh) = Power (in kWh) \times \text{Time (in hour)}.
- the kWh meter used to measure electrical energy may be of the dial or digital type.
- electricity bills are calculated according to the number of kWh used and the cost per kWh.
- liquids which conduct electricity during electrolysis are called electrolytes.
- salt, in molten form, also conducts electricity.
- some liquids are decomposed when electricity is passed through them.
- the terminals that are used to conduct electricity in liquids are called **electrodes**.
- the positive electrode is called the **anode**, while the negative electrode is called the **cathode**.
- decomposition or **electrolysis** can be used to produce pure metals.
- electrolysis can be used to do **electroplating**.
- a magnet has two poles, a N-pole and a S-pole, where the forces are concentrated.
- a magnetic compass is used to show direction.
- the magnetic field is the region around a magnet where a magnetic force is experienced. This may be shown using plotting compasses or iron filings.
- like poles repel; unlike poles attract.
- repulsion is the only sure test for the polarity of a magnet.
- the earth can be considered as a large powerful magnet.
- temporary magnets made of iron do not retain their magnetism.
- permanent magnets made of steel retain their magnetism for a long time.
- magnets are usually made by putting a magnetic material in a coil carrying a direct current.
- there are many uses of magnets and magnetic materials. Magnets can be used to show direction, to pick up things and in the form of magnetic ink.
- many electrical devices contain magnets.
Unit 7

Transfer of heat

Introduction

From our own experience we have come to realise that some substances around us become hot, for example, a kettle on a lighted stove becomes hot after sometime, also a lighted oven, and even the earth becomes hot on a sunny day. Have you ever thought about how this happens?

In this unit we are going to find out:

• how heat travels through solids.
• how heat travels through liquids and gases.
• how heat travels through empty space.
• what happens to solids, liquids and gases when they are heated.
• what uses can be made of the knowledge of how substances behave when heated.

Heat travels through solids

Let us do a few activities which will help us to understand how heat travels through solids.

Activity: Heating a metal wire

Hold a metal strip or rod in a Bunsen flame for a few minutes.

As soon as you feel the rod getting warm, remove the rod from the flame. Remember to turn off the burner too. How did the heat get from the flame to your hand?

Here is another activity.

Activity: Heating a copper wire

Take a piece of stiff copper wire or a thin copper rod (or other metal if copper is not available), and make markings about 2 cm apart. Drop molten wax on the marked points along the wire. Allow to cool. Stick pins in the candle wax.

Fig.7.1 Diagram to show how heat travels through solids
Now heat the rod at one end. What happens to the pins? Why does this happen? Did you notice any movement of the material that makes up the rod?

By now you may have guessed that the heat travelled or moved through the metal rods; and if so you are correct!

We learnt earlier in Unit 1 that solids, liquids and gases are made up of tiny particles, called atoms, which are always in motion. These particles have energy. So when one end of the metal rod is placed in the flame, the particles at that end, are heated and move faster. They have gained more energy in the form of heat. As the particles move faster they bump into or hit the next particles harder, passing on this energy. These particles in turn also move faster, bumping into each other transferring the energy as they go along. Hence, there is the transfer of heat energy from one end of the rod to the other, causing the entire rod to be heated. This method of transfer of heat is called conduction.

When heat is transferred by conduction, heat passes from particle to particle within the material by collision but the material itself as a whole does not move. The materials that transfer heat, by conduction, are called conductors.

Heat always moves from places of higher temperature to places of lower temperature.

It is interesting to note that conduction can take place in all three states of matter. Gases and liquids are poor conductors of heat. Later in this unit we will look at the methods by which heat is transferred effectively in gases and liquids.

Does heat travel easily in all solids?

Activity: Comparing the rate of heat conduction of different materials.

Collect three or four rods of different materials; for example, copper, brass, glass and carbon. Each must be of the same length and thickness.

Stick a drawing-pin with molten candle wax or vaseline near the end of each rod. Mount each on the stand, so that the ends of the rods that do not have the pins, all touch. Place a flame exactly at that junction of the rod as in Fig.7.3. Observe carefully and note from which rod the pin falls off first. Which is the best conductor and which is the worst?

Record your answers.

Fig. 7.2 Diagram showing transfer of heat by conduction
Uses of good and poor conductors of heat

Metals are good conductors of heat; so they are commonly used for making cooking utensils—such as pots, kettles, saucepans. The most common metals used are aluminium, copper and in the Caribbean, cast iron. The heat is quickly passed from the burner to the food inside the utensil. The metals used for cooking utensils must have three very important properties. They must be able to conduct heat well, i.e., they must have high heat conductivity. They must not react with water, dilute acid and alkali—i.e. they must lack reactivity. These metals must not be poisonous i.e they must lack toxicity.

Some materials, such as wood, cork, plastic, wool and glass are poor conductors. Poor conductors of heat are called insulators. Insulators are used in many ways. The handles of some cooking utensils are made of wood or very hard plastic; while other pots and pans have metal handles; in this case, gloves or pads, lined with cotton or wool are used when handling the hot pots. Are these gloves or pads good or bad conductors of heat? Why are the insulators used for handles of cooking utensils? Look around the home or the laboratory and make a list of the types of materials used as heat insulators.
Air, like all other gases, is a very good insulator, since it conducts heat very, very slowly. Some materials, such as wool, have pockets of air trapped between the fibres. The pockets of air prevent the loss of heat by conduction. Ovens are lined with materials like fibre glass to reduce the loss of heat by conduction.

Birds, in cold areas, fluff their feathers more and appear fatter. In so doing, more air is trapped between the feathers; the air helps to keep the birds warm.

Can you think of other ways in which conductors and insulators of heat are used? Record your thoughts.

Transfer of heat

In the previous section the transfer of heat by conduction was discussed. You learnt that conduction was the method by which heat energy travelled in solids. Well this is not the only method of heat transfer. Two other ways are convection and radiation.

Heat travels through liquids and gases

You may wonder how heat energy travels through liquids and gases.

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1. Potassium permanganate

2. Straw

3. Water
   Beaker
   Convection current

   Potassium permanganate crystals

   Heat source
   Tripod stand

Fig. 7.5 Diagrams of apparatus to show convection current

A metal pot would get hot very quickly while it is over a flame, but water in the pot would take much longer to heat up and gain the same temperature as the pot. You may remember that water is a poor conductor of heat.

How then is the heat passed on in the water?

Convection

You will need

- a 250 cm³ beaker of water (three-quarter full)
- crystals of potassium permanganate
- Bunsen burner (or other flame)
- wire gauze
- tripod
- straw (drinking)
- matches

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**Procedure**

1. Light the burner and place it under the tripod and gauze.

2. Dip one end of the straw into the crystals so that a few stick to the inside. Wipe the outside of the straw with a tissue.

3. Place the straw into the water so that some of the crystals stay at the bottom of the beaker. Put the straw near the edge of the beaker as shown in the diagram.

4. Put the beaker onto the tripod so that the flame (a low one) is just underneath where the crystals are. Fig. 7.5 will show you how this is done.

5. Observe what happens as the flame heats the glass and then the water and write down what you see in your note book.

In the experiment you would observe coloured streaks (from the potassium per manganate) beginning to rise slowly upwards as the beaker is heated. This upward movement of the streaks shows what is happening to the water as the beaker is heated. There is movement of water in the beaker and the coloured streaks indicate to us how the water moves. Why is there movement of water? The particles of water, which is fluid, are free to move. Heated particles at the bottom move apart; thus that portion of water becomes less dense or lighter and rises to the top. Colder, denser fluid sinks to replace it at the bottom. This upward and downward movement of water in a continuous stream is called a **convection current**. Eventually, all the water is heated up to boiling point.

Note that water is fluid; so is air. This fact tells us that both liquids and gases have particles that are free to move. Air gets heated up in much the same manner as water — by means of convection currents. We can safely conclude therefore, that the transfer of heat in liquids and gases is mostly by convection. Convection may be defined as a means of transferring heat in fluids.

**Activity: What happens in water?**

You will need:
- ice cubes made with coloured water
- plastic spoon
- a kettle of warm water
- a large beaker

**Procedure**

1. Two-thirds fill the beaker with warm water.

2. Float some ice cubes in the warm water.

**Questions**

1. What do you see happening?

2. Explain your observations.

3. All of the liquid was cooled by the ice cubes. How do you account for this?

We have observed how convection currents are responsible for transfer of heat energy in a liquid.

Let us examine what happens with air.

**Activity: Studying convection currents in air**

You will need
- a candle
- a chimney (lamp shade)
- 2 small blocks of wood (5 cm cubes)
- matches
Procedure

1. Place the candle on a smooth flat surface and light it.

2. Put a lamp shade which is open at the top around it as shown in the diagram. (See Fig. 7.6)

3. When the flame eventually goes out, set the candle in position between the two blocks of wood and place the chimney on the blocks around the candle so that air can get in at the bottom. See Fig. 7.6.

4. Record your observations. Can you explain why the candle now burns steadily? In the first position the candle soon began to splutter and the flame went out. Why did the flame go out? There was no flow of air in the chimney so the oxygen in the chimney was used up. In the second position there is a steady flame because the supply of oxygen is continuous. By raising the chimney you have made it possible for the hot air to go out at the top and be replaced by cool air coming in at the bottom. You have set up convection currents in the air.

Further demonstrations of convection current can be shown by use of a convection box as seen in Fig 7.7.

Fig. 7.7 Diagram of the convection box

How is convection useful to us?

Convection current occurs because liquids and gases expand when they are heated. This expansion makes them less dense so that they rise up and are replaced by cooler material.
The following phenomena are all based on this principle.

**Land and sea breezes**

The land gets hot faster than the sea. On a hot day the warm air on the land rises and cooler sea breezes come in to replace the rising warm air. At night the process is reversed; the sea cools more slowly than the land. Thus warm air on the sea rises and cooler land breezes replace it. See Fig 7.9.

**Heating homes during winter**

The rooms are usually fitted with heaters. The rooms become warm to a comfortable level by the heater creating a convection current in the room. Can you suggest how this occurs?

**Ventilation of houses**

The air in a room is warmer than the air outside. The warmer air in the room rises and escapes through “air vents” and cooler, fresher air comes in through windows or doors (Fig 7.10)

**An electric hair dryer**

This appliance has a fan which blows air over a heating element. The air that passes over the element comes out as hot air. See Fig. 7.11.

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Fig. 7.9 Diagram showing land and sea breezes

Fig. 7.10 Diagram showing ventilation.

Fig. 7.11 Diagram showing how the electric hair dryer works
Hot water systems

A hot water system contains a hot water tank in which water is heated. Cold water is let in at the bottom of the tank, heated by the heating element and is taken through pipes for household use.

![Diagram showing hot water systems](image)

Fig. 7.12 Diagram showing hot water systems

Radiation

If you stand in the sunshine for a period of time you feel very hot. How does the heat reach you from the sun which is nearly 150 million km away? The heat from the sun comes to us by radiation.

Radiation is the way in which energy travels across space. Heat radiation does not need a medium (solid, liquid or gas) for its transfer. Radiation is the transfer of energy by waves and the heat energy that is transferred by radiation is called radiant heat. The earth's surface is heated by radiation.

Activity: Heating from a candle

You will need
- a candle in a dish
- matches

Procedure

1. Light the candle.
2. Hold your hand some distance above the flame. You will feel the heat that has risen by convection as the air became lighter and rose.
3. Hold your hand by the side of the flame. You will still feel some heat. How is it possible for the heat to travel sideways in this way?

Convection currents allow hot air to rise upwards and sideways. Air is a poor conductor of heat. Radiation is the way in which heat travelled through the space between the candle to your hand.

The following diagram illustrates what happens to the particles which travel by radiation.

![Diagram showing how heat travels through radiation](image)

Fig. 7.13 Diagram showing how heat travels through radiation
The activity reveals that it is not only the sun that radiates heat. Every hot object does. The hotter the object the more heat is radiated. Radiated heat energy is reflected by smooth shiny surfaces such as aluminium foil. On the other hand, dark, dull surfaces absorb radiated heat.

Because shiny surfaces reflect radiated heat the “thermos” flask keeps hot things hot and cold things cold. How is this so? Look at the diagram in Fig. 7.14 and think about how the silvered walls function. You should now be able to explain fully how the flask reduces heat loss or gain.

![Diagram of a thermos flask](image)

**Fig. 7.14 Diagram showing how the thermos flask works**

Even our bodies lose heat by radiation. When our bodies become overheated more blood flows to the surface of the skin which in turn loses heat by radiation. This enables the body to maintain its normal temperature (37°C) in hot conditions.

**Heat and expansion**

In the last two sections we looked at the transfer of heat through solids, liquids and gases. We saw that the solid as a whole, does not move during the transfer of heat, but a liquid and a gas actually move as heat travels through each of them.

In this section we will look at another effect heat has on these materials— solids, liquids and gases.

**Expansion of solids, liquids and gases**

Can you remember what happened to some of the substances we heated in year one? See Book 1 Unit 5 pages 100-101.

We heated air and a liquid; we also did the ball and ring experiment. In all these activities we observed that the substances expanded. We learnt that on heating, the molecules of each type of substance gained more energy, vibrated more and moved further apart, thus causing each substance to expand.

In Book One, Unit 2 we also studied the thermometer. We found that when the bulb of the thermometer is heated, the liquid expands and rises up the bore indicating an increase of temperature; on cooling, the liquid contracts and moves down the bore.

Having learnt that substances expand on heating let us now have a look at how man makes use of expansion.

**Expansion can be useful**

The expansion of solids, liquids and gases can be very useful. As you have seen, the thermometer is based on the principle of expansion and contraction. The liquid in the bore of the thermometer has the ability to expand when heated, thus
indicating the rise of temperature. There are different types of thermometers, which are used for various purposes.

Apart from the thermometer, there are other useful pieces of equipment, which operate on the principle of expansion. Let us now take a look at an electrical appliance - the electric iron.

Do you know how it works?

It is “automatic” in that it switches itself off when the required temperature is reached, and switches on again when the temperature drops. Think of this as we look at a bimetallic strip. It is made of two metals bolted together strongly.

![Bimetallic strip diagram](https://via.placeholder.com/524x701)

Fig. 7.15 Drawing to illustrate how the bimetallic strip works in an electric iron

Heat the strip in a Bunsen flame. What do you observe? Allow the strip to cool. What do you observe now? Turn it over so that the other metal is in the flame and heat again. Have you observed anything different?

On heating, the brass side of the strip expands more, causing the strip to bend. It becomes curved.

The electric iron has a thermostat. A thermostat contains a bimetallic strip. The purpose of a thermostat on any electrical appliance is to control its temperature.

Can you now tell how the thermostat works?

As the current flows through the appliance the bimetallic strip is warmed, along with the appliance. The strip bends away breaking the circuit and stops the flow of current; thus preventing the temperature of the appliance from increasing further. After a while the appliance begins to cool down, and at the same time the bimetallic strip cools and straightens out again to complete the circuit. The current will now flow again. The control knob changes the distance through which the bimetallic strip has to bend so as to break the circuit.

Having studied the thermostat, look at the diagram of an electric iron in Fig. 7.16. Can you explain how the iron works?
Many heating and cooling devices are controlled automatically by thermostats. Two examples of these are the refrigerator and the electric oven. Can you name others?

Have you ever tried taking the stopper off a glass bottle and realised that it was stuck in the neck of the bottle? What did you do?

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You need two metre rules, a length of fine copper wire and a Bunsen flame.

Attach the wire to the rules firmly. Hold the rules as far apart as possible. Heat the wire by moving a Bunsen flame back and forth along the wire for a few minutes. What happens to the wire?

Look at Fig 7.17.

You need a glass bottle with a stuck stopper. Try rubbing your hand vigorously around the neck of the bottle for a few minutes. Try removing the stopper now.

What do you observe? What was the purpose of rubbing the bottle neck vigorously?

What do you think would happen if a warm rag is wrapped around the neck of the bottle? Try it.

Can you think of any other equipment that operates on the principle of expansion?
Explain what you observe about the cables between the poles in each picture.

What do you think would happen if the cables were stretched tightly between the poles in the summer?

Here in Guyana, we do not experience extreme temperature changes in our climate, like countries in North America and Europe. It is difficult for us to notice the effect of expansion on the environment easily.

Engineers use their knowledge of expansion when they build metal structures such as bridges, railway tracks and ocean going vessels, making provision for expansion and contraction.

Fig. 7.18 Drawing to illustrate the arrangement of joints to allow for expansion

The joints in this bridge (Fig. 7.18) allow for expansion and contraction. What will happen when the weather gets hotter?

Why are such joints needed in long bridges?

Fig. 7.19. Diagram of a vacuum flask

Exercises

1. By what method is heat transferred in solids?

2. Explain what happens when heat is conducted through a material.

3. List some ways in which conductors and insulators are used in the home.

4. Describe an experiment which proves that heat does not pass easily through all solids. Hint - use different types of metals and a heat source.

5. Look at the diagram 7.19. and explain how loss of heat is reduced.

6-10

Questions 6-10

Determine whether each of the following statements is true or false.

6. Heat is a type of energy.

7. Heat is transferred through water by conduction.
8. Heat travels from the sun to the earth by radiation.
9. Liquids and gases are called fluids.
10. Cool air is less dense than hot air.

**Answer the following questions**

11. What effect does density have on convection?
12. How is convection different from radiation?
13. You are lying on the beach on a hot sunny day. How is the heat of the sun getting to you? How is heat taken away from your body while you are lying on the beach?
14. Explain why:
   (a) cricketers wear white loose clothing during a game in the Caribbean.
   (b) women wear dark stockings in winter and light-coloured stockings in summer.
15. Explain what happens when substances such as metals, liquids and gases are heated.
16. Explain how the electric iron works.
17. Name three other appliances that are controlled by a thermostat.

**Answers to Questions 6-10**

**True or False**

True
False
True
False

**Answer to Questions 11-14.**

11. Density is involved in convection. When a liquid or gas is heated it expands and becomes less dense than cooler material. Cooler, denser material sinks while warmer material rises.
12. Convection differs from radiation in the fact that there must be particles or a medium for convection to occur. Radiation, on the other hand, needs no medium.
13. The heat of the sun is transferred by radiation. The body loses heat through the skin by radiation. The capillaries in the skin dilate and bring extra blood to the skin. The heat brought by the extra blood leaves the skin by radiation.
14. (a) White reflects radiated heat while loose clothing allows circulation of air. Cricketers thus keep cooler.
   (b) Dark stockings absorb heat and keep legs/feet warm in winter, light-coloured stockings reflect heat and keep legs/feet cooler in summer.
WE HAVE LEARNT THAT:

heat travels through solids by conduction. 
as solids are heated the particles bump into each other and transfer the heat along the solid. 
the materials which conduct heat do not move; only the particles of which the material is made. 
materials which conduct heat well are called good conductors. 
poor conductors are called insulators. 
heat can also be transferred by convection and radiation. 
convection takes place in liquids and gases. 
in convection the particles move upward and downward in a continuous stream which is called convection current. 
as liquids and gases are heated they usually expand and become less dense. 
land and sea breezes are the result of convection currents. 
radiation is the transfer of energy in waves. It occurs where there are no particles or what is called a vacuum. 
white and shiny surfaces reflect radiated heat while dark dull surfaces absorb radiated heat. 
expansion of materials can be useful e.g. in the bi-metallic strip in a thermostat which regulates temperature automatically e.g. in an electric iron. 
expansion can also be a nuisance e.g. sagging of cables between poles during warmer months.
Unit 8

Waves

Introduction

In this unit we will learn about:

- waves and how they transmit energy.
- waves generated on a slinky spring.
- the difference between transverse and longitudinal waves.
- water waves and the waves generated on a piece of rope.
- the difference between circular waves and parallel waves.
- the crest, trough, amplitude, frequency, wavelength, waveform and velocity of waves.
- reflection, refraction and diffraction of waves.
- sound waves and their production.
- the loudness, pitch and quality of sound.
- musical instruments - wind, stringed and percussion.
- computer-generated sound.
- the vocal cords of man.

Waves transmit energy

Have you ever thrown a stone into a pond or any other still water? If so, what did you notice? You would have noticed that there are ripples in the water, which spread from the point where the stone hit the water. These rhythmic motions or vibrations are called waves, which transmit energy from one point to another. The point where the waves originate is called the source. There are also other forms of waves that we cannot see, but the energy which they transmit is noticeable e.g. sound waves, light waves and radio waves. Water waves travel in water, while sound waves travel in air, water and solids. Water and air are examples of the media in which the waves travel. Radio and light waves do not require a material medium in which to travel and can therefore pass through a vacuum.

Waves on a slinky spring

Let us now look at the motion of waves along a length of 'slinky' spring. Hold one end of a long slinky spring firmly on a smooth floor and ask your friend to stretch the spring out a bit across the floor. If you then move one end from side to side you will see a wave travelling along. (See Fig. 8.1). The vibration of the coil can be considered as vertical, whereas the wave itself travels in a horizontal direction. Waves such as this which travel perpendicular to the direction of the vibrations are called transverse waves. Water wave also is an example of a transverse wave. (See Fig. 8.3.).
Water waves

We have mentioned before that when a stone is thrown into a pool of water, waves spread out in all directions from the point at which the stone enters the water (Fig. 8.3). Though at first glance the water may seem to be transferred by the wave motion, this is not what actually happens. Pieces of cork floating on the surface of the water do not move any large distance horizontally. Instead, they bob up and down. The stone causes the water which it strikes to vibrate. This vibration, and the energy which causes it, travel along the surface. Water is the material or 'medium' in which the energy travels.

Since the up and down movement of the water is perpendicular to the movement of the wave, water waves are called transverse waves.

Waves on a rope

We can demonstrate transverse waves another way with a piece of rope tied at one end to a wall (Fig. 8.4). Tie a number of ribbons to the rope at intervals. Hold the free end and move the rope rapidly up and down.

How does the entire rope move?

In what direction do the ribbons move?
A wave travels along the rope from one end to the other. The ribbons, however, move up and down without moving along the rope. The hand moving up and down provides the energy to form the wave. This energy is then carried by the wave travelling along the rope (medium).

**Observing and measuring waves**

In order to understand waves better we shall now look at ways of observing, describing and measuring them.

We can observe the properties of water waves by using a ripple tank—a shallow rectangular glass dish as in Fig. 8.5. A lamp placed above the tank can cast shadows of the waves on a sheet of white paper below. The tank can also be placed in sunlight, if a lamp is not available. Put water into the dish to a depth of about 1 cm, making sure that it is level. Touch the surface of the wave with a finger and notice the pattern of the waves obtained. (See Fig. 8.6). This type of wave is called **circular wave** and the source of the wave (i.e. the tip of the finger) is called a **point source**.

Now, move the straight edge of a ruler up and down at one end of the water in the dish and notice the pattern of the waves obtained. (See Fig. 8.7). This type of wave is called **straight or parallel wave** and the source of the wave (i.e. the straight edge of the ruler) is called a **linear source**.
Fig. 8.8 shows the cross section of a water wave. The top of a wave is called the crest or peak and the bottom is the trough. The height of the crest above or the depth of the trough below the middle position is the amplitude of the wave. The amplitude indicates the amount of energy carried by the wave. Waves of larger amplitude carry more energy.

When studying water waves in the ripple tank, if the up and down movement (vibration) of the ruler is speeded up, the straight waves in the water are now produced at a faster rate, and more are seen travelling across the water in the dish. We say that the frequency of the wave has been increased. The frequency of a wave is defined as the number of waves passing a given point in one second. This is the same as the number of vibrations per second of the ruler, which produces the waves. Frequency is measured in hertz (Hz). 1 Hz is one complete vibration per second.

The distance between successive troughs is called the wavelength. It is usually measured in metres. The waveform is the shape of one wavelength. It is a snapshot of the wave shape. It should be carefully observed that at a higher frequency the wavelength becomes shorter. (See Fig. 8.9).

The speed of the wave is the speed of any single point on the wave in the direction of travel. It is also called the wave velocity and is measured in metres per second. The velocity of a wave, i.e. its ms⁻¹, wavelength and frequency are related to one another by the formula:

\[ \text{Wave speed} \ (c) = \text{frequency} \ (f) \times \text{wavelength} \ (\lambda) \]

The speed of light wave is 299,792,458 metres per second and the speed of sound wave is 331.6 metres per second in dry air at a temperature of 0 °C. If the temperature is increased, the speed of sound increases; thus, at 20 °C the velocity of sound is 344 metres per second.

**Reflection of waves**

If you throw a ball at a wall it will bounce away. In a similar way, waves can bounce or be reflected after striking barriers. Fig. 8.10 shows how a straight barrier reflects plane waves in a ripple tank. The plane waves are shown by lines drawn along each wave crest. These lines, like the waves, are parallel to the vibrating rod or source. The waves travel towards the barrier as the incident waves and the waves leave the barrier as the reflected waves. As with rays of light falling on a plane mirror, the angle of reflection equals the angle of incidence. It should be noted that the wavelength and frequency of the incident wave are equal to those of the reflected wave.
Reflection is obtained with all types of waves. Have you ever stood at a distance in front of a large wall and shouted or clapped your hands? If so you would have experienced the reflection of sound waves, called an echo or reverberation. Bats are able to navigate their way in flight by a process called echolocation. In echolocation, bats emit short pulses of high-frequency sounds that are usually well above the threshold of human hearing. The sound waves spread out in front of an echo. By interpreting the echoes, bats are able to discern the direction, distance, speed, and in some instances, the size of the objects around them. Such information is instrumental in avoiding midair collisions and in tracking winged insects and other live prey in the dark.

**Refraction of waves**

Waves travel at different speeds through different materials. You can make the waves in the ripple tank move slower by making the water shallower (Fig. 8.11). You can do this by placing an extra piece of glass on the bottom of the tank.

The vibrations of the bar are still at the same rate; so the frequency does not change. As the wave is travelling slower over the shallower water it will not get as far in the time of one vibration as it does over deeper water. The wavelength becomes shorter in the shallower water. Fig. 8.11 shows the faster waves striking the boundary at a right angle. They keep going in the same straight line, but more slowly and closer together.

If the waves strike at an angle, their direction changes as they cross the boundary (Fig. 8.12). This change in direction or bending of the waves is called **refraction**.

Sound moves in a straight line when travelling through a medium having uniform density. Sound is subject to refraction, which bends sound waves from their original path. In
polar regions, air close to the ground is colder than air higher up. A rising sound wave entering the warmer region, in which sound moves with greater speed, is bent downward by refraction.

The excellent reception of sound downwind and the poor reception upwind are also due to refraction. The velocity of wind is generally greater at an altitude of many metres than near the ground. A rising sound wave moving downwind is bent back toward the ground, whereas a similar sound wave moving upwind is bent upward over the head of the hearer. A straight piece of stick, when partly immersed in water, appears to be bent. This optical phenomenon is due to the refraction of light waves travelling from the stick in the water to the air outside. These are all interesting examples of refraction.

Diffraction of waves

It is interesting to observe what happens to straight waves when they pass through a hole in a barrier. Fig. 8.13 shows what happens with a hole several wavelengths wide. The plain waves go through with only a slight bending round at the edges. When the hole is reduced to about three wavelengths wide (Fig. 8.14) the waves spread round the corners to about 45°. When the hole is narrow, about the width of one wavelength, circular waves now spread out in all directions from the hole (Fig. 8.15). This effect, in which waves spread, is called **diffraction**.

Using your ripple tank, perform the experiment using your ruler as the source and blocks of wood as the barriers.

Diffraction, like reflection and refraction, is obtained with all waves. If a radio is turned on in one room, the sound from the radio can be heard in an adjacent room even from around a doorway. **Sound waves** are therefore diffracted when passing through openings such as doors and windows.

Light waves can also be diffracted or spread out, but this is unnoticeable. This is because the wavelength of light is extremely small, therefore the effect is only observed through very narrow openings. You can observe the diffraction of light if you look at a distant bright street lamp with your eyes half-closed or through the tiny holes of a handkerchief.
Sound waves

We live in a world filled with a great variety of sounds which affect us in many ways. Anything you hear is a sound. List some of the different sounds you can hear in your surroundings. Since sound is a wave, in order for it to be produced there must be a source producing the vibrations. Sound therefore, is a type of energy. Sound can travel through solids, liquids and gases, but not through space or a vacuum as light waves can. Sounds from distant sources reach our ears through the air and sounds can also be heard through solid walls. Whales are known to communicate with each other over great distances in the sea by sending and receiving sound waves.

Production of sound

Musical sounds may be produced by tuning forks. A tuning fork (Fig. 8.16) has two hard steel prongs. When struck on a hard rubber the prongs vibrate and a sound is produced. The vibration can be demonstrated by suspending a tennis ball with a piece of thread through it and allowing the ball to touch one of the prongs. The ball will be 'kicked' away by the prong. A vibrating tuning fork generates ripples when dipped into a container of water.

The way by which sound travels from a source may be explained as follows. Consider one prong of a tuning fork vibrating in air (Fig. 8.17). When it moves outwards from its resting position it pushes the molecules of air in the layer next to it closer together. This causes an area of high pressure known as compression (c). When the prong moves back through its resting position to a maximum in the opposite direction, the molecules of air have more space in which to spread out and as a consequence there is an area of low pressure or a rarefaction (r). A series of compressions and rarefactions are passed from one section of the air to the next and travel outward from the source in all directions. In this instance, unlike the case of water waves, the direction of vibrations of the air particles is parallel to the direction of travel of the wave. Sound waves are therefore, examples of longitudinal waves as shown in Fig. 8.17.

Since sound waves travel due to a series of compressions and rarefactions of air particles, sound cannot pass through a vacuum. This can be demonstrated by using a small electric bell hung from rubber bands inside a bell jar (Fig. 8.18). When the current is switched on the bell rings, the clapper is seen vibrating and the sound is heard. However, when the air is removed from the bell jar using a vacuum pump, although the clapper can be seen hitting the gong, no sound is heard. This shows that sound cannot pass through a vacuum. It requires a medium, such as air, for its transmission.
Kinds of sounds

There are many kinds of sounds. Some may be pleasant and some may be just 'noise'. Sounds can also be classified according to their loudness (or intensity), pitch and quality (or timbre).

Loudness

If you are asked to speak louder it means you have to expend more energy when you are talking. We say that the intensity of the sound is increased. "Loudness" increases as the sound intensity increases, or when the amplitude of the wave increases. Sounds of the same frequency can have different intensities if their amplitudes are different (Fig. 8.19).

Pitch

The pitch of a sound depends on its frequency. Girls normally have voices of higher pitch than boys. Fig. 8.20 shows sound of the same loudness (amplitude) but different pitch (frequency).
We can investigate the factors that affect the pitch of a stringed instrument by using a rubber band (or string) stretched across two bridges (See Fig. 8.21). When the string is plucked a sound of a certain pitch (frequency) is produced. By keeping the tension of the string constant and varying the **length**, it is observed that a shorter string gives a higher pitched sound and a longer string produces a note of a lower pitch.

If the length of the string is kept constant and the **tension** is varied, it is observed that the greater the tension the higher is the frequency or pitch and a lesser tension produces a note of lower pitch. The **thickness** of the string also affects the pitch of the sound produced. If the length and tension remain constant, a thicker string gives notes of lower pitch than a thinner one.

The lengths of air columns in wind instruments affect the pitch of the sound produced. Collect 8 glass bottles of the same size and kind. Fill them with water to varying levels (increasing/decreasing) so that the air columns inside have different lengths. Blow gently across the top of the tubes in turn, starting with A and finishing with H. Observe the pitch of the notes produced.

You will notice that the pitch is higher for a short column of air, so that the frequency increases as the length of the air column decreases.

The human ear cannot hear sounds of all
frequencies. The frequencies to which the human ear is sensitive are in the range of approximately 20 - 20,000 Hz. Sounds with frequencies above the upper limit are called ultra sound and sounds with frequencies below the lower limit are called infra sound. Dogs, cats, bats and certain other animals are sensitive to ultra sound. Some dog whistles emit sounds which are heard by dogs, but not man. Ultra sound waves are also used in medicine, for example, to check the growth and development of foetuses and to detect brain damage and certain types of cancer. In industry, ultra sound waves are used to drill holes in metals and glass.

Both ultra and infra sounds can have adverse effects on people - making them become confused and/or depressed, especially if the intensity is high.

**Quality**

A well-made tuning fork can provide a 'pure' or distinct note, one with a single frequency. A musical instrument such as a violin or clarinet never produces a note with a single frequency. Overtones of higher frequencies are always present. These overtones and their relative strengths determine the quality or timbre of the note played. The overtones are quieter than the main tone, but they provide a background which enables us to distinguish the same note played on different musical instruments. The overtones also enable a well-made violin to be distinguished from one which is poorly made. The overtones are linked with the waveform of the note (Fig. 8.22).

**Musical instruments**

Most musical instruments produce sounds by the vibration of air in pipes, the vibration of stretched strings or the vibration of pans and rods. These vibrations cause the surrounding air to vibrate.

**Wind instruments**

Blow across the top of a large bottle or the top of a pen cover and note the sound produced. You can also produce a sound due to vibration of air by blowing a whistle. In each case a sound of different pitch is produced.

In a wind instrument an open or closed air column acts as the source of the emitted sound. The pitch of the note depends on the length of the air column.

There are many different kinds of wind
instruments of varying shapes and sizes. Examples of some of them are the horn, tuba, cornet, trombone, trumpet, piccolo, oboe, clarinet, bassoon and saxophone Fig. 8.23

**Stringed instruments**

There are many musical instruments which use vibrating strings as the source of sound. Some of the best known stringed instruments are the violin, the viola, the cello, the guitar (Fig. 8.24), the mandolin, the banjo, and the piano.

Fig. 8.24 Diagram of a guitar

In the guitar, the mandolin and the banjo, the strings are set in vibration by plucking. Take a close look at a guitar. Are the strings of even thickness? The tension of each string can be varied by turning the individual knob at the end of the fret board. When the guitar is played the effective length of each string can also be varied by pressing the string at the different frets.

**Percussion instruments**

Percussion instruments produce sound by vibration of a surface. The note of the sound produced depends on the shape, size, density, elasticity and tension of the surface. Some examples of percussion instruments are the drum (Fig. 8.25), steel pans, the triangle, the castanets, the xylophone and orchestra bells.

Fig. 8.25 Diagram of a drum

The note produced by a drum can be changed by depressing the edge of the drum membrane with the hand and by striking it at different places. This change is due to a change in the elasticity and tension of the drum membrane. Steel pans of different shapes and sizes are also tuned to produce the desired notes. The triangle and castanet are percussion instruments used to keep time. The pitch of the sound produced by the xylophone and orchestra bells is determined by the size of the component parts.
The xylophone consists of metal bars of differing lengths.

**Activity: Balloon and cup**

Stretch a balloon over a cup and hit it with a spoon. Is a sound produced? Increase the stiffness of the balloon and note the change in the pitch of the sound produced.

**Electronics**

Nowadays, owing to the advancement of science, there are many sounds which are produced by electronic circuits and instruments such as the computer. You may have heard sounds from musical greeting cards, watches, clocks and electronic buzzers. The origin of the sound from these devices is from the electrical variation produced by the circuit, which is converted to sound via vibrating crystals or speakers. There is also the electronic synthesizer (Fig. 8.26) that can artificially combine frequencies to produce the sounds of almost all the different types of musical instruments by just touching the appropriate keys. The electronic synthesizer can also be used to combine sounds from different musical instruments and to create new sounds.

**Vocal cords**

The human voice is one of the most wonderful of all musical instruments. The human vocal apparatus is essentially a wind instrument in which an air column is set in vibration by the vocal cords. Air from the lungs is forced between the vocal cords that vibrate. Muscles connected to the vocal cords control the pitch of the sound. The vibrations of the vocal cords set up vibrations of the air in the throat, mouth and nose. The shape and size of this air column can be altered at will by moving the tongue, jaw, or lips (Fig. 8.27). Thus a great range of pitch and loudness of sound is possible.

Fig. 8.27 Diagram showing the vocal cords in man

Fig. 8.26 Photograph of an electronic synthesizer
Exercises

1 - 5
Match each of the letters A - F, with one of the numbers 1 - 5, which label the points or distances in the diagram of a transverse water wave.

(A) amplitude  (B) trough  
(C) crest  (D) wavelength  
(E) average (middle) position of water surface

Fig. 8.28 Diagram of a transverse wave

6. (a) What are longitudinal waves? Give two examples of longitudinal waves.
   (b) What are transverse waves? Give two examples of transverse waves.

7-10. Copy the following sentences and fill in the missing words.

7. Waves are repeated vibrations carrying ____________________.

8. The frequency of a wave is the number of _______________ per ____________________.

9. The reflection of sound waves is called ____________________.

10. The spreading of waves round corners is called ____________________.

11. Which one of the following cannot transmit sound?
   (a) Alcohol
   (b) Iron
   (c) A vacuum
   (d) Wood

12. A siren is located due west of your position. The sound is transmitted to your ear by:
   (a) air vibrating in a north-south direction only.
   (b) air vibrating in a west-east direction only.
   (c) air vibrating in a vertical direction only.
   (d) air moving continuously westward only.

13. The pitch of a pure note emitted by a tuning fork depends on:
   (a) the amplitude of the prongs
   (b) the frequency of the prongs
   (c) the intensity of the sound
   (d) the loudness of the sound.

14. Name as many musical instruments as you can and classify them according to the source of vibration to produce the sound - wind, strings, percussion or electronics.

15. (a) Explain with the aid of a diagram how sound waves travel from the prong of a tuning fork.
   (b) Describe an experiment to show that sound waves cannot pass through a vacuum.

16. (a) State the factors which affect the frequency of a vibrating string.
   (b) State the factors which affect the frequency of a note played by blowing the top of a bottle when water is poured into it.

17. State three characteristics of sounds, and state the factors upon which each characteristic depends.

18. Find the velocity of a wave of frequency 660 Hz and wavelength 0.5 m.
Summary

WE HAVE LEARNT THAT:

- Sound waves are rhythmic motions or vibrations by which energy is transmitted through matter.
- the particles do not move bodily along with the wave. They may vibrate perpendicular to the wave, as in transverse waves; or parallel to the direction of the wave, as in longitudinal waves.
- all waves carry energy.
- the top of a wave is called the crest or peak and the bottom is the trough.
- the amplitude is the maximum movement from the central position of a wave to a crest or a trough.
- the frequency of a wave is the number of waves passing a given point per second.
- the wavelength is the distance between successive crests and troughs of a wave.
- the speed of a wave, its wavelength and frequency are related to one another by the formula:
  \[ \text{Wave speed} (c) = \text{frequency} (f) \times \text{wavelength} (\lambda) \]
- all types of waves can be reflected or bent due to a change of speed after travelling from one medium to another.
- all types of waves can spread out or be diffracted after passing through openings the size of their respective wavelengths.
- sound is a type of energy that causes the sensation of hearing.
- to produce sound, energy is required to cause vibrations of the source.
- sound travels as a longitudinal pressure wave.
- in a sound wave, compressions and rarefactions follow each other alternately.
- sound can travel in solids, in liquids and in gases, but not through a vacuum.
- the loudness or intensity of a sound increases when the amplitude of the sound wave increases.
• in a vibrating string, higher pitches (frequencies) come from shorter, tighter, thinner, less dense strings.
• when the length of the air column of a wind instrument is decreased, the pitch (frequency) of the note produced is increased.
• different musical instruments produce notes of different quality or timbre.
• a pure or distinct note is one of a single frequency.
• musical sounds can be produced by strings, wind and percussion instruments, electronics and vocal cords.
Unit 9

Energy- sources and conservation

Introduction

Consider cars, trains, aeroplanes and ships. What do they all need in order to move? They need fuel. What is fuel? Fuel is any material which when burnt supplies energy for any purpose.

Fuel $\rightarrow$ Energy + Carbon dioxide + Water

The fuels used today are wood, coal, charcoal, petroleum and its by-products. Some of these fuels are referred to as fossil fuels. These are fuels which were formed from organisms which lived millions of years ago. These substances cannot be replenished within the life time of man, so they are said to be non-renewable. Once they are used up, they can be no more.

Fuels can be divided into three classes, namely, solid fuels, liquid fuels and gaseous fuels. Solid fuels are wood, peat, charcoal and coal. Liquid fuels are crude oil, petrol and other products of crude oil. Gaseous fuels are natural gas, gas oil, coal gas, water gas and bio gas.

The oldest fuel known to man is wood and it is the most widely distributed fuel in the world. It does not have a high heat value compared to other fuels. However, it is used where wood is plentiful and there is no suitable alternative.

Oil is the main source of our liquid fuels. When refined, a number of products is produced, each of which serve many useful purposes in our everyday lives. Oil is therefore the most important fuel in our world today. Oil fields can be found in every continent of the world. These sources of energy will be looked at, along with alternative sources of energy, since the demand for energy has increased considerably. This is mainly due to the massive manufacturing of several appliances that would make life easier and more comfortable for man. Most of these appliances are electrically operated, for example the cooker, washing machine, fan, sewing machine, vacuum cleaner, microwave oven, iron and air-conditioner.

Fig. 9.1 Diagram showing types of fuels
There are other instruments and devices which make use of less mechanical energy and more electrical energy, for example, musical instruments such as the electric guitar and the synthesizer. Then there are electrical typewriters, computers, stereo recorder players and the cassette recorders. See Fig. 9.2.

Fig 9.2  Diagram showing appliances in the home that require electrical energy

The main source of all this electricity has been fossil fuel, that is, crude oil, natural gas and, to a lesser extent, coal. This is true since most of the electricity used today is generated by burning fossil fuel to heat water, and create steam. This steam is used to drive turbines to make electricity. With the depletion of fossil fuel in the near future, alternative sources need to be found in order to generate electricity. We shall briefly outline some alternative sources. However, with the absolute need for the use of energy and the necessity for alternative sources of energy, the conservation of energy is just as or even more important, since wood is the most widely distributed and the oldest form of fuel used in the world today. The conservation of the forest is absolutely necessary. The forest provides man with a large supply of energy and a host of other useful products. It is an active part of the environment which must be conserved.

In this unit we will learn about:
• fuels.
• types of fuels.
• the origin, extraction and refining of crude oil.
• cracking of petroleum.
• manufacturing and distillation of coal.
• charcoal production.
• advantages and disadvantages of the use of oil/coal.
• types of alternative sources of energy and how they are being utilized.
  e.g - hydro power
  - solar power
  - wind power
• the forest.
• its use, destruction and conservation.

Crude oil

Origin of crude oil

The origin of crude oil is not known for sure. However one of the most popular theories says that millions of years ago most plants and animals lived in the sea. When these organisms died their remains, which included lots of shells, slowly decomposed owing to the action of bacteria, pressure and heat. As time progressed, the extreme heat pressure and the absence of air caused the partly decayed organic matter to be converted into crude oil.

Movement of the earth’s crust causes changes in the structure of the earth. These changes help to trap the oil in hollows formed in impervi-
ous rocks. The oil is therefore trapped between non-porous rocks. A layer of natural gas is usually found above crude oil. This theory stems from the fact that crude oil is always found below salt water.

**The extraction of oil**

Before the oil can be extracted the area is surveyed. This type of survey is known as a *seismic* survey. It involves the 'firing' of small explosives under ground. These explosives produce tremors. The echoes that rebound from the different layers of rock are recorded on a special instrument, which produces a *seismograph*. From this, geologists could determine if oil is present.

At some locations, geologists can know by just using aerial photographs. Sometimes temporary drilling is done to collect samples of the core rocks. The rocks indicate the type of fossil plants and animals. If the fossils are associated with the formation of oil then oil may be in the location. Drilling may be done on land or at sea as shown in Fig. 9.3.

![Fig. 9.3 Diagram showing drilling for oil](image)

Several holes may have to be drilled before oil is found. However, when the drill strikes oil, the underground pressure forces the oil up the hole, that is, the well. In cases where the pressure is not enough, sea water is pumped into the rock to force the oil out.

**Refining oil**

Crude oil as it comes out of the well is a very thick, black, viscous liquid. This complex mixture of substances is of no use in its crude form, hence the need to be refined. This is done at a refinery. See Fig. 9.4

![Fig. 9.4 Picture of an oil refinery](image)

The refining process involves the separating of the various fractions. These fractions are separated by making use of their difference in boiling points. The process is called *fractional distillation* and it takes place in a fractioning tower similar to the one in Fig. 9.5.
The crude oil or petroleum is preheated. Upon entering the lower compartment, the temperature increases changing the oil into vapour. As the vapour rises, it cools and condenses. The fraction with the lowest boiling point will be collected at the top of the tower. The fraction with the highest boiling point is collected at the bottom. Fig. 9.5 shows the fractions and some of their uses.

**Cracking**

A large percentage of the distillation products consists of large hydrocarbon molecules. Since the world’s demand is greater for smaller molecules such as gasoline and kerosene, these large molecules are broken down by cracking. Cracking can be done using heat or catalysts and is a very important process in the oil industry.

One of the small hydrocarbons produced is ethene, a colourless gas. It is useful in the making of polythene, which is a plastic from which many household articles are made. Look at the picture below and see how many items you can recognise.

Fig.9.6 Diagrams of some household substances produced as a result of cracking

Find out and compile a list of other products apart from plastics that are obtained from oil. Ethene is also used to make alcohol, which is used in the manufacture of medicines, varnishes and paints.

**Coal**

**Formation of coal**

Coal is a solid fossil fuel. It has been useful to man for thousands of years. This natural rock-like, brown to black substance has been formed from forest-type plant material which died millions of years and so it is considered as ‘modified wood’.

Coal is the end product of a long gradual change of plant material. One theory is that in the **carboniferous period**, the warm, wet climate caused the vegetation to flourish. When this
vegetation died it decayed and formed thick deposits called peat. These deposits became covered with alternate layers of sand and mud. The increased pressure and temperature on the peat led to the formation of lignite (i.e. soft coal) then to bituminous (black coal) and finally anthracite. All the stages of coal formation can be found in the earth's crust. Fig.9.7.

The substances produced are valuable fuel. See Fig. 9.8 for the products from destructive distillation of coal.

![Diagram showing distillation of coal](image)

**Charcoal**

Charcoal is a black porous solid containing about 85 to 98% carbon. It is produced by heating wood, peat or bituminous coal at 500-600 °C in the absence of air. Farmers in the Caribbean usually dig pits and pack them with wood. The wood is then covered with soil, ignited and allowed to burn for many days.

![Diagram showing manufacturing of charcoal](image)
Charcoal known as ‘coals’ in Guyana and the rest of the Caribbean is used as fuel for cooking both indoors and outdoors. It is used mainly in the rural area and in camps and picnics. Its by-product, wood ash, can be used as a fertilizer to supply potassium and calcium. Wood ash is also used as an abrasive to clean pots, as tooth paste and as a disinfectant. It is put on yams before planting.

Advantages and disadvantages of oil/coal

In our world today, oil is our major source of energy. Just look around at our vehicles, oil has determined the design of our cars, buses etc. Consider the size of our engines where the fuel is converted to other types of energy. If our cars were to be powered by steam from wood instead of petrol, think of the design and size of the cars.

The discovery of oil has a great impact on our society and general life style. One of the advantages is that it can be used to produce electricity. This type of energy is used to operate thousands of appliances in the home, office, school and industry and this has made life much easier. Even though oil and coal are used to provide a lot of heat, the majority is used to produce electricity.

Many nations and countries have become rich due to the discovery of oil. However, there are several disadvantages which need urgent attention if we hope to save ourselves and our environment.

Here are some of the disadvantages.
1. The earth’s resources are rapidly consumed.
2. Oil and coal are non-renewable.
3. They are not readily available.
4. They are bulky and thus difficult to transport.
5. The mining of coal is dangerous.
6. Men usually lose their lives in case of the caving in of the roof of the mine.

The greatest disadvantage is the pollution. Both coal and oil, when burnt, produce smoke. This pollutes the atmosphere and has become a health hazard. Another cause of pollution is the spilling of crude oil over land and in the waterways. This affects many aquatic, land and air animals. Millions of litres of oil usually cover the water and/or the land and millions of dollars are spent to clean up the mess. Oil spills have been the concern of the environmentalists for many years and they are fighting for legislation to protect our animal life and the rest of our environment.

Some alternative sources of energy

Even though electricity is a wonderful versatile type of energy, being able to produce power, light and heat, it has not been a suitable transport fuel. Much work is being done to replace the petrol now used by light and high-capacity batteries.

Countries like Guyana and Brazil which have large agricultural lands can grow sugar cane to supplement their fuel needs. The alcohol produced from the fermentation of the sugar is mixed with petrol to produce gasohol (a petrol-alcohol mixture).

Apart from gasohol other alternative sources of energy are solar energy, nuclear, wave, wind and geothermal energy, hydroelectricity and biogas. In the rest of this section we will look briefly at three of these alternative sources of energy.
Use of hydro power

Falling water from a tap is sufficient to turn the wheel of a toy car or truck. The same principle is used in hydroelectricity. Water falling from a height, e.g. the top of a waterfall or a high reservoir see Fig. 9.10 (b) has a lot of potential energy which can be used to do work.

Fast moving water falls on to blade of a turbine (i.e. vanes of the turbine) and the force of the water turns the turbine. This mechanical energy is converted by a generator or dynamo into electrical energy. See Fig. 9.11. Therefore, there is a change from potential energy to electrical energy.

Hydroelectricity is useful especially in cities where there is need for a large supply of cheap electricity. Towns, which have industries such as aluminium industries, consume a lot of electricity and hydropower has proven to be a good source.

The advantages of hydropower are:

- it is clean
- dependable
- pollution-free.

Fig. 9.11 Diagram of a generator showing the conversion of mechanical energy to electrical energy.

Fig. 9.10 (a) Diagram of a model hydroelectric station.

Fig. 9.10 (b) Diagram of hydroelectric station.
The disadvantages are:

It is not available everywhere and reservoirs may cause a change in ecological balance.
Countries in which hydropower exists are Canada, Belize, Venezuela, Jamaica and Dominica.

Guyana has the potential for several hydro-power stations because of its many waterways and waterfalls. However, the resources need to be harnessed since the location of the falls and the populated areas are thousands of miles apart and are spanned by huge rain forests. At present in the Rupununi area, there is a hydropower station and it supplies electricity to the residents there.

Use of solar power

Do you know that the sun is the original source of all energy? Plants utilise the sunlight as a source of energy to make food. Fossil fuel is formed from the remains of dead plants and animals. The amount of energy given out by the sun is thousands of times greater than the amount of energy consumed.

Man has been making use of the sun’s energy for centuries in the drying of fish, shrimps, rice, cocoa, beans, corn etc. However the problem was the storage of the energy for use when necessary even in the absence of the sunlight. Over the years man has been successful in acquiring techniques for exploiting solar energy. Some of the devices made are the solar dryers, solar cookers, solar stills, solar panels and solar cells.

Solar dryer

A solar dryer is a box (usually made of wood) fitted with a tray into which crops are placed. The box has a transparent top that is made of glass or plastic material. Look at Fig. 9.12

Fig. 0.12 Diagram of a solar dryer

You will observe holes in the walls of the box. These allow the passage of warm air over the crop and aids the drying process, at the same time preventing the temperature from getting too high. What advantages does the solar dryer have over drying in open sunlight? Write them down.

Solar cookers

Solar cookers are devices which use parabolic reflecting surfaces to reflect the sun’s rays and concentrate them to the point of cooking. The principle used is based on that of the ‘burning glass’. See Fig.9.13.

Fig. 9.13 Diagram showing solar cooking
Solar stills

The principle on which solar stills work is the physical method of separation, simple distillation. The sun’s energy is used to heat up the contaminated water, which eventually evaporates and then condenses and collects as pure water. This operation takes place in a shallow box-like structure, which is insulated and painted black on the inside. The top is covered with a transparent glass or plastic material (Fig. 9.14).

![Diagram of a solar still](image)

Fig. 9.14 Diagram of a solar still

A still may be made entirely of plastic. However, even though it will be cheaper and lighter, it is less efficient and will last for a shorter time.

In the Caribbean the main source of water is the sea water which is salty. The use of solar stills is a cheap way of obtaining pure water since there is bountiful sunshine all year round. Solar stills can be found in Barbados and St. Vincent.

Fig. 9.15 Diagram of a water heater that uses solar panels

Cold water is pumped through the tubes of the water heater. As the water heats up it passes out into the storage tank ready for use. If the water gives up its energy before use, it returns to the panels.

Solar cells

A solar cell is a photoelectric cell. It converts solar energy directly into electricity. Solar cells are found in calculators, watches, satellites, ship’s signal lights, etc. (See Fig. 9.16)

When the sun’s rays hit the solar cells the light energy is converted to electricity. The direct current (D.C) is stored in batteries. If alternating current (A.C) is required a power converter is used.

![Diagrams of devices that contain solar cells.](image)

Fig. 9.16 Diagrams of devices that contain solar cells.
The electricity obtained could be used by refrigerators, air-condition units, at pumping stations to pump water into pipe lines and to power satellites and spacecraft.

Research is being done on the possibility of establishing orbiting stations with satellites having huge solar panels of cells, which could capture the solar energy for twenty four (24) hours, thus making maximum use of the sun's energy.

Solar energy has some disadvantages such as:

- its intensity is irregular.
- it is difficult to store.
- initial costs are high.

However, the advantages outweigh the disadvantages. Advantages include:

- it is clean.
- it is pollution-free.
- it does not consume any of the earth's resources.
- it is plentiful.

The use of wind power

For many centuries, man has been making use of winds to provide mechanical energy. In the time of Christopher Columbus the power of wind was used to drive the sailing ships across the oceans. In Holland and other European countries wind was used to churn the butter and grind the wheat to make flour. During the early days of the sugar estates in the Caribbean, windmills were built to turn the cane crushers. With the wide use of oil less use was made of wind power. Now that there is need to find alternative sources of energy, wind power is being used not only to supply mechanical energy but also to generate electricity.

In the generation of electricity, giant propellers of wind turbines are turned by the winds. Each turbine is connected to a.c./d.c. generator. See Fig. 9.17.

![Diagram of a wind turbine.](image)

The d.c. current is later converted to a.c current. See Fig. 9.18

![Diagram of a windmill used to generate electricity.](image)

The amount of electricity depends largely on the size of the propellors and the amount of wind blowing.

Most Caribbean countries are windswept. This means that there is plenty of wind all year round. The use of wind power is an asset to these countries since it can reduce the amount of fuel imported and the outflow of foreign exchange.
Some countries have already taken advantage of the free wind power. The British Virgin Islands are using wind power to generate electricity. Barbados, Antigua and Barbuda are using wind power to irrigate dry lands. In Anguilla and the Turks and Caicos, wind power is used to flood salt ponds. At one time wind power was harnessed extensively in Guyana to generate electricity. However because of problems with the windmill blades and generator, and frustration caused by the low efficiency of the storage batteries, the project was abandoned. With improved technology in this area and increased foreign investment, Guyana should be able to re-establish their use of wind power for electricity in the near future.

Wind power can also be used in refrigeration, to circulate air for cooling purposes and to dry crops. There are several advantages in using wind power. These are:

- it is clean and pollution-free
- it is attractive
- it is readily available when needed
- it does not use up the earth’s resources and once established recurrent expenses are low.

The disadvantages are:

- the speed of wind varies
- difficulties in maintaining equipment high above the ground and
- lightning may damage cumbersome equipment.

The advantages clearly outweigh the disadvantages and as technology continues to improve wind power would be used in diverse ways.

### Conservation of energy resources

#### Forest

The forest may appear to be just a set of plants. A closer look however reveals that a forest is a complex structure.

#### How our forests serve us

Our forests form an active part of the environment. They do affect and are affected by the environment playing several roles at the same time.

1. Our forests produce a more regular uniform flow of water in streams and rivers. The fact that Guyana is a land of many waters is directly related to the extensive forested area.

   When the rain falls, it lands on the leaves and trunks and trickles down to the soil, where the humus and other materials trap the water and allow it to soak gradually into the soil. This slow movement of water from the leaves and branches on to the soil surface contributes to a regular flow of water to the water table. This explains why there is a strong link between the activities of the Soesdyke/Linden Highway and the water stored in the MMA reservoir basin.

2. The forests help to maintain stable temperatures of the surrounding areas. This is due to their normal biological function of transpiration.

3. Forests yield a wide variety of products such as woods, resins, balata, medicinal substances and fruits.
Wood is the most important product actually obtained from forests. One of the main uses of the wood is for energy. The wood may be used in its crude form as fuel-wood or firewood. Wood may also be distilled in a pit to produce charcoal, more commonly called 'coals'. See Fig. 9.19.

![Diagram showing charcoal production](image)

Charcoal is proportionally richer in carbon than wood and produces more energy. Charcoal is also much purer than wood and produces less smoke. It is therefore used in many homes for cooking.

Another use of wood is timber. It is used in the construction of homes and other buildings, wharfs and stellings, furniture and ornaments.

In Guyana, there are many valuable timber-yielding species such as greenheart (rare species of hard wood found only in Guyana), wallaba, mora, crabwood, cedar, silverballi etc. These woods are exported by Guyana and other countries to places such as the United Kingdom, Japan, United States of America and other parts of the Caribbean for foreign exchange.

Forests also offer a wide range of recreational opportunities. The variety of trees, the terrain, animals, rivers, rapids and waterfalls offer a refreshing contrast to the busy cities and other urban communities. Sports such as hunting, shooting and fishing are a few of the activities done by people.

The forests also provide food mainly in the form of protein. The Amerindians hunt deer, wild cow, wild pig, labba for protein. They would catch 'bush fish' such as houri, patwa, sunfish, tilapia and hassar in the rivers for food. The wild meat from the forests provides special dishes in restaurants in many countries. In Guyana, the wild animal, labba, makes a special dish. Visitors are encouraged to eat labba and to drink creek water when they come to Guyana.

**Destruction of our forests**

Tropical rain forests, which once covered about 10 percent of the earth’s land now cover only half of that area. This is because the world’s forests are being destroyed at an alarming rate. Every year enough acres are destroyed to cause a complete disappearance of rain forests within 30 years. These rain forests are constantly being destroyed either by design or by accident.

Most of the world’s tropical rain forests are found in the developing countries near the equator, in Central, South America, Africa and Asia. These countries destroy the forests by design in order to get desperately needed cash. The forests are mainly destroyed for:

- mineral extraction
- logging
- establishment of irrigation schemes and
- extension of urban areas.

Sections of the forests are leased to foreign companies which mine minerals such as gold and diamonds. In Guyana, companies such as Omai and Golden Star Resources Limited (G.S.R.L)
have signed contracts with the Guyana Government to use sections of the forest to extract gold and diamond for some years. See Fig. 9.20.

Fig. 9.20  Map showing Gold and Diamond Mining Companies in Guyana.
While the governments are receiving revenue for the use of the land, the forest is being destroyed. When trees are removed, tons of soil are also removed and in the cases of sloping land much of the soil is washed down into water bodies 'choking' streams, creeks and reservoirs and changing the water level. This sedimentation causes destruction of the forests. Habitats of animals, including birds, and other valuable plant life are destroyed.

The use of chemicals such as cyanide and mercury which are used by the miners add to the destruction of the forest. When these chemicals seep into the ground, they eventually enter the streams and rivers. Then the fishes and other aquatic life would be greatly reduced. Plants absorbing water containing the harmful chemicals may die. Persons that use the water for drinking and other domestic uses can be poisoned.

Relogging is another way by which our forests are destroyed. Some companies cut timber for export at a rate much faster than the trees can reproduce and replace themselves. In the removal of timber from one point to another many other plants are destroyed. (See Fig. 9.21).

The overcutting of trees for fuel and charcoal also causes problems. Some wood-cutters cut young trees, a practice which affects the replacement of certain species and poses possible disappearance in certain areas. In most cases the area is left bare. This results in loss of tree-cover in a localised area and a change in the topography usually results in serious environmental problems, e.g. increased soil erosion.

Fires also destroy our forests. In places such as North America, fire is the cause of destruction of thousands of acres. However, fires are not a serious threat in rainforests since the dry seasons are short and most of the year the forests are wet. The fires that are experienced in places like Guyana's forests, are often due to the careless use of coal pits. Fires of this type can be seen along the Linden - Soesdyke Highway during the short dry season. Sometimes the fires may burn for three to four days before they can be put out. (See Fig. 9.22).
The establishment of irrigation schemes requires the building of canals and dams from the forest area into the farm lands. This operation involves the joining of large bodies of water by cutting across forest lands and the destruction of the natural terrain.

The clearing of forest lands to do agriculture results in the destruction of the forests. The Amerindians, for example, would clear a piece of ground to farm. When the soil is depleted of its nutrients, they move to another piece of ground. In this way the forest is destroyed because of nonreplacement of nutrients to the soil and irresponsible use of land. (See Fig. 9.23.)

Extension of urban areas because of overpopulation of towns and cities is sometimes done at the expense of forests. However, in most cases the needs of the people would seem greater since people need to be properly housed.

The consequences of the loss or destruction of the forests can be summarised as follow:

1. acceleration of soil erosion, compacted top soil and reduced infiltration rates; also increase in flash-floods after rainfall
2. irregular stream flow due to reduced water volume reaching the water table
3. less biological activity in the soil which leads to reduced soil fertility
4. poor soil structure
5. loss of an enormous variety of animals due to destruction of their habitat
6. loss of employment
7. environmental and climatic changes.

Taking care of our forests

Our forest is the home of unique plants and animals. It can be considered a treasure chest flowing over with precious stones. If we do not take care of our plants and animals, and the treasures which cannot renew themselves, after a time the gems will disappear and the plants and animals will become extinct.

About half of the world’s plants and animals can be found in the tropical rain forest. Less than a million of these tropical species have been found and named. There are 80 million kinds of insects living in the rain forests. The forest is also very rich in other animal life. See Fig. 9.24 (a) and (b). Therefore it cannot be overemphasized that we need to care our forest.

In taking care of our forests there must be legislation governing the use of the forest. There should be hunting laws, logging laws and mining laws. Persons involved should be aware of the laws. All effort should be made to ensure that these persons comply with the law. Rangers should be stationed at different points in the forests to enforce these laws.

In countries such as Guyana, which is 4/5 (four-fifths) forest, (see Fig. 9.25), the nation should be educated in the care of the forest. People should know about the importance of wildlife which refers to both plants and animals, which are not domesticated. Some basic facts on how wildlife resources are managed and what is being done to conserve them should also be known.

![A parrot](image1.png)

(a) A parrot

![A sloth](image2.png)

(b) A sloth

Fig. 9.24 (a) and (b) Picture of rare animals found in the forest

There should be a reforestation programme to replace trees that are logged. Reforestation allows uniformity and more control over the quality of wood being produced. Plants are grown in the nurseries. (See Fig. 9.26).

They are then transferred to the reforestation site.
Fig. 9.25  Vegetation map of Guyana showing forested areas
A plantation established for the sole purpose of producing charcoal or fuel wood is known as an ‘energy farm’. Energy farms help ensure sufficient fuelwood is available without total depletion of forest reserves. Care of both our seasonal forests, which supply mainly fuelwood, and our rain forests, which supply industrial wood (timber, fibres), must be taken so as to utilise our forests without destroying them.

National conservation groups in rain forest countries have already begun to force aid agencies to adopt a broader vision and to view forests as a source of many goods and services and not just as timber quarries.

**Exercises**

1. Which of the following is **not** fossil fuel?
   - (a) Charcoal
   - (b) Coal gas
   - (c) Propane
   - (d) Kerosene

2. Which of the energy sources does not come from petroleum?
   - (a) Peat
   - (b) Vaseline
   - (c) Oil gas
   - (d) Waste

3. Which of the elements is found in gasoline?
   - (a) Sulphur
   - (b) Nitrogen
   - (c) Oxygen
   - (d) Carbon

4. Name the principle on which the fractions of petroleum are separated.

5. Why is the sign “No Smoking” seen at petrol (gas) stations?

6. Recently there have been large oil spills. Describe how an oil spill would affect your environment.
7. Kerosene, charcoal and coal are all fuels. This means that they would produce energy when burnt. Using the experiment with the burning of the peanut in Book 2, design an experiment to find out which fuel would produce the most energy.

8. Solar energy is regarded as an alternative source of energy because it:
   (A) does not pollute the atmosphere.
   (B) is not available at nights.
   (C) is used instead of oil.
   (D) was never used as a major source.

9. Which of the following is not regarded as an alternative source of energy?
   (A) Biogas
   (B) Kerosene
   (C) Gasohol
   (D) Wind

10. An advantage of hydroelectricity is that it:
    (A) is available everywhere.
    (B) produces valuable by-products.
    (C) is clean and dependable.
    (D) needs no expensive equipment.

11. Which of the following is a disadvantage of solar energy?
    (A) Produces a lot of pollution
    (B) Unavailable when needed most
    (C) Consumes a valuable earth resource
    (D) Very expensive to maintain.

12. An advantage of wind power is that it:
    (A) can be produced everywhere.
    (B) is an expensive source of energy.
    (C) is a constant source of energy.
    (D) uses none of the resources of the earth.

13. Name three alternative energy sources being used in your country. Do you think your country’s energy bill is less than it was five years ago? Why?

14. If you do not know, find out what is the source of energy being used at your school, both in the laboratory and Home Economics department. Discuss with your teacher the possibility of introducing or increasing the use of alternative sources of power.

15. Find out about the burning of paddy shells to produce electricity (Kayman Sankar Ltd.)

16. Name six hardwoods produced in rain forests.
    Find out what each can be used for.

17. What is wildlife? Give two reasons why wildlife is important.

18. Think of three ways in which you, as a student, can care for our forest.

19. What advice would you give to someone who would be starting a logging business?
WE HAVE LEARNT THAT:

- a fuel is any substance which burns and supplies energy.
- all fuels originate from plant and animal life.
- fossil fuels are those made from the remains of plants and animals that lived millions of years ago.
- fuel can be a solid, liquid or gas. Wood is the most widely distributed fuel. Oil is a main source of energy and the most important fuel.
- the fractions of crude oil are gases, petrol, kerosene, diesel oil, lubricating oil and bitumen (tar).
- large hydrocarbon molecules can be broken to produce smaller molecules by a process called cracking.
- coal can be distilled to produce the following substances: coal, tar, coke, coal gas, sulphur, ammonia and benzene.
- charcoal (‘coals’) is produced when wood is burnt in the absence of air.
- there are several alternative sources of energy available. They are: Solar power, Wind power, Hydro power, Nuclear power, Geothermal power, Biogas and Gasohol.

<table>
<thead>
<tr>
<th>Solar power</th>
<th>Wind power</th>
<th>Hydropower</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic heater</td>
<td>Fuel to make</td>
<td>Full supply of</td>
</tr>
<tr>
<td>Cooker, crop driers, driers, watches, calculator, d.c. and a.c. electricity</td>
<td>electricity</td>
<td>electricity</td>
</tr>
<tr>
<td></td>
<td>Irrigate flat lands. Pumps water from underground.</td>
<td></td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean and pollution free</td>
<td>Clean and pollution free</td>
<td>Clean and pollution free</td>
</tr>
<tr>
<td>Low running cost</td>
<td>Recurrent expense low</td>
<td></td>
</tr>
<tr>
<td>Plentiful</td>
<td>Uses none of earth’s resources</td>
<td>Uses none of earth’s resources</td>
</tr>
<tr>
<td>Uses none of earth’s resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial cost high</td>
<td>Not constant, Winds may vary</td>
<td>Not available everywhere</td>
</tr>
<tr>
<td>Difficult to store</td>
<td>Equipment may be damaged by lightning</td>
<td>May cause ecological unbalance</td>
</tr>
</tbody>
</table>
• our forests are very useful. We can obtain timber to build our homes; fruits; food in the form of wild meat; medicines; fuel; gold and other precious minerals and employment. The forest at the same time is the home of millions of animal and plant species.

• in the quest to obtain what forests have to offer they are destroyed, for example, by mining of minerals, logging, establishment of irrigation schemes, extension of urban areas. Remember that much land of the forest is lost to agriculture.

• essentially the consequences of loss of forest are:
  (i) loss of a variety of animals and plants
  (ii) accelerated soil erosion
  (iii) less biological activity, reduced soil fertility
  (iv) poorer soil structure and
  (v) environmental and climatic changes.

• there is therefore need to care for our forests since they cannot do it all by themselves. Management is the important tool for their conservation. This will ensure the production of timber and minor forest products and that the forests continue as animal habitats with the full complement of plant species.

• the principal fact however, is that no one has been able to quantify the true value of forests, especially tropical forests. We should endeavour to treat our forests with caution and respect, conserving them as much as possible and at the same time attaining reasonable goals of development.
Unit 10

Projects

Introduction

As we have mentioned earlier in Books I and II, projects are activities that we do on our own. Projects give you opportunities to use your knowledge of principles which you have learned. In order to carry out a project successfully one needs to do some research, gather the necessary materials and data, and write a report on completion of the project. The report will provide information from which others can learn. Projects can also be very interesting and entertaining when they are actually carried out.

Revision is also very important in order for you to remember what you have learned and to prepare you for further studies. A good athlete needs to exercise a lot to perform well. Similarly, a good student needs to revise his/her work continuously in order to do well in his/her examinations.

Some ideas for projects

The following projects can be done at home or at school and reports should be presented to your teacher at school.

Checking power ratings of appliances

The power rating of an electrical appliance tells you the rate at which the appliance converts electrical energy to other types. The power rating is the same as the “wattage” of the appliance. To find the power of an appliance we multiply the voltage across it by the current passing through it. (Refer to Unit 6).

Most electrical appliances normally have the maximum rating marked or engraved on them. However, appliances do not always work at their maximum power. We shall now look at a way by which we can check the power ratings of appliances.

![Diagram showing equipment for checking the power ratings of appliances](image)

Fig. 10.1 Diagram showing equipment for checking the power ratings of appliances
Table 10.1 The power ratings of various electrical appliances.

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Current (I)/A</th>
<th>Voltage(V)/V</th>
<th>Power (P)/W (=I xV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car head lamp</td>
<td>3</td>
<td>12</td>
<td>36</td>
</tr>
<tr>
<td>Toy motor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immersion heater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torchlight bulb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric bell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buzzer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.B  It may be dangerous to use high voltage from the main so you can use a low d.c. voltage from a battery. Remember P = IV.

**Monitoring electricity used in the home**

As you have learned in Unit 6, the total amount of electrical energy consumed in your home, over a period of time, is measured by the kilowatt-hour (kWh) meter. There are many different appliances in the home and they may vary in their power ratings and energy consumption. We can check the meter reading at the beginning and end of a time period. If we add up the energy consumed, in kWh, by all the appliances over a week, this amount of energy should correspond with the difference between the initial and final reading shown on the kWh meter. If the meter indicates that more energy is being used, it therefore means that energy is lost in the form of heat due to the resistance of the house wiring etc. If, however, the readings on the meter indicate that less energy is being used, it may be due to the appliances not functioning at their marked power ratings.

You can monitor the use of electricity in your home for a period of let’s say a week. You will record the initial reading on the kWh meter and then the final reading after the fixed period. You will also have to note the power in kW of all the appliances used and the time (in hours) during which each appliance is used. You can record your results in a table (See Table 10.2). The energy in kWh used by each appliance is found by multiplying the power marked on the appliance (in kW) by the time (in hours). (See Unit 6.)

\[
\text{Energy (kWh) = Power (kW) x time (h)}
\]

Total energy value calculated for appliance should approximately correspond to that from the meter readings.

Note that from the table, the quantity and nature of appliances will vary from home to home.

The period of monitoring can also be extended to months or a year.
Table 10.2 A typical house appliances system

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Power (kW)</th>
<th>Time used (h)</th>
<th>(kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filament lamp (each)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorescent lamp (each)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric iron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric fan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric kettle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hair dryer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food-mixer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio/stereo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Television set</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water pump</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total energy consumed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Making a two-way switching circuit

You can make a two-way switching circuit as shown in the circuit diagram (See Fig. 10.2)

![Diagram of a two-way switching circuit](image)

Fig. 10.2 Diagram showing a two-way switching circuit

The circuit consists of two cells, a lamp and two switches $S_1$ and $S_2$. Switch $S_1$ joins $X$ to either $A$ or $C$. Switch $S_2$ joins $Y$ to either $B$ or $D$. The circuit can be completed through wire $AB$ or through $CD$. The diagram shows the circuit with the lamp on. If $S_1$ is moved so that $X$ is joined to $C$, the lamp is turned off. The lamp could also have been turned off by changing $S_2$ instead of $S_1$, so that $Y$ is joined to $D$. Then by moving either of the switches the lamp can be put on again.

<table>
<thead>
<tr>
<th>Position of $S_1$</th>
<th>Position of $S_2$</th>
<th>State of Lamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X$ to $A$</td>
<td>$Y$ to $B$</td>
<td>ON</td>
</tr>
<tr>
<td>$X$ to $A$</td>
<td>$Y$ to $D$</td>
<td>OFF</td>
</tr>
<tr>
<td>$X$ to $C$</td>
<td>$Y$ to $B$</td>
<td>OFF</td>
</tr>
<tr>
<td>$X$ to $C$</td>
<td>$Y$ to $D$</td>
<td>ON</td>
</tr>
</tbody>
</table>
The two-way switching circuit is useful for a light on the stairs. You can switch the light on or off from either switch, one at the bottom and one at the top of the stairs.

Making a question and answer game

Fig. 10.3 shows how you can make a simple question and answer game. It consists of a piece of plywood with a lamp and cell connected in series at the top. Two sets of holes are drilled along the two vertical sides of the board. Metal washers are placed in the holes and these act as sockets. The set of holes on the left correspond to the questions and those on the right to the answers. Each question matches the correct answer by attaching an insulated piece of wire at the back of the board from the question socket to the correct answer socket. The connecting wires can then be covered by pasting a cardboard at the back of the board.

How the game is played. If Question 4, for example, is to be answered, connect the plug X to the socket 4. When the plug Y is placed in the correct socket (which is F), only then will the lamp light.

In the above game described, only six questions and answers are used. You can however make your game with more questions and answers. Exchange your game with other students of the class and you will find it more challenging to match the questions and answers designed by other persons.

**Questions**

What is the unit of:

1. Potential difference
2. Energy
3. Current
4. Power
5. Charge
6. Resistance

**Answers**

A. Joule
B. Coulomb
C. Ampere
D. Volt
E. Ohm
F. Watt
Revision exercises

1. Explain, as clearly as possible, differences between the following:
   (a) Scavengers and decomposers
   (b) Ecosystem and habitat
   (c) Population and community
   (d) Competitors and predators
   (e) Food chain and food web

2. Crossword

   Clues Across:
   1. Our surroundings
   3. Gas given off during photosynthesis
   5. Path through which electric current flows
   6. Atoms having negative or positive charge
   8. Periodic Table gives us information about this
   11. Water conducting tissue in stems

   Clues Down:
   1. A section of the environment
   2. Flows through a conductor as current
   4. Speed up chemical reactions in cells
   7. Carbohydrate found in plant parts
   9. Attracts iron or steel
   10. Poisons formed by living organisms

3. The word Search Puzzle below has 10 words that are found in this book. They are found on the following pages:

   Use the page clues to help you. The pages are: 23, 41, 63, 64, 88, 109, 110, 150, 187, 189.

   W A B C Z T R A U Q
   A Z Y W T U S B C D
   V O L T M E T E R Y
   E Y H C N S H W S R
   L I M Z G O N P Q E
   E S A E R C N A P T
   N O S P H U M U S E
   G I T Y N L A T E M
   T L A S T G D C B M
   H M D E N T I N E A
4. **Activity: Investigating water in food**

In this experiment you will investigate the percentage of water in a variety of foods. One way of doing this is to rehydrate some commercial dehydrated foods. Examples of such foods are dried peas, dried fish, dried fruit.

You will need

- Beaker  
- Balance  
- Heat source  
- Selection of dehydrated foods

**Procedure:**

1. Set up a beaker containing 100 cm$^3$ of water over a Bunsen burner.

2. When the water starts to boil, measure out about 10 g of one of the dehydrated foods. Write down the exact mass of this sample.

3. Add the sample to the water and simmer it gently until the food seems to be fully rehydrated.

4. Drain and remove excess water from the food.

5. Measure the new mass of the food.

6. Copy and fill in the table below.

7. Repeat the experiment with the other foods

**Answers to crossword.**

**Across:**

1. Environment  
3. Oxygen  
5. Circuit  
6. Ions  
8. Element  
11. Xylem

**Down**

1. Ecosystem  
2. Electricity  
4. Enzyme  
7. Starch  
9. Magnet  
10. Toxins

**Results**

<table>
<thead>
<tr>
<th>Food</th>
<th>Original Mass $M_1$</th>
<th>Mass after rehydration $M_2$</th>
<th>Percentage of water in food $\frac{M_1 - M_1}{M_2} \times 100%$</th>
</tr>
</thead>
</table>
Glossary

Aggregate - any rock made up of small particles bonded together.

Alloy - a uniform mixture of two or more metals or of metals and non-metals.

Alternating current - electric current that reverses direction periodically.

Aluminium - silvery grey metallic chemical element that is a good electrical conductor used for construction where lightness and strength are desired.

Alumina - aluminium oxide, found in bauxite.

Ammeter - an instrument used for measuring electrical current.

Ampere - unit of measurement for electrical current.

Amplitude - the height of the crest above or depth of the trough below the middle position of a wave.

Anion - an ion which is negatively charged, attracted to the anode in an electrolytic cell.

Anode - A positively charged electrode, towards which electrons move.

Anthracite - a form of coal which is hard and has lost most of its volatility.

Arthropods - any of a phylum (Arthropoda) of invertebrate animals having segmented bodies to which jointed antennae, wings, or legs are articulated.
<table>
<thead>
<tr>
<th>Atomic number</th>
<th>this is the number of protons or electrons in any atom of an element.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATP</td>
<td>adenosine triphosphate.</td>
</tr>
<tr>
<td>Battery</td>
<td>a device of two or more cells that changes chemical energy to electrical energy.</td>
</tr>
<tr>
<td>Bauxite</td>
<td>a mineral ore composed mainly of aluminium oxides and hydroxides.</td>
</tr>
<tr>
<td>Bimetallic strip</td>
<td>a compound bar made of two different metals fastened together; one expands more than the other when heated, thus resulting in curvature of the bar.</td>
</tr>
<tr>
<td>Bituminous</td>
<td>a form of coal with a high percentage of carbon present.</td>
</tr>
<tr>
<td>Brick</td>
<td>blocks made from clay and fired in a special oven called a kiln.</td>
</tr>
<tr>
<td>Capillarity</td>
<td>the tendency of the surface of a liquid to rise or fall in a narrow tube.</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>a colourless, odourless, extremely poisonous gas formed by incomplete combustion of carbon compounds, used as fuel to extract metals from ores.</td>
</tr>
<tr>
<td>Carboniferous</td>
<td>a period of geologic time during which the majority of coal was produced.</td>
</tr>
<tr>
<td>Carnivore</td>
<td>(i) mammal that feeds chiefly on flesh.</td>
</tr>
<tr>
<td></td>
<td>(ii) a plant that feeds on insects.</td>
</tr>
<tr>
<td>Cathode</td>
<td>a negatively charged electrode from which electrons flow.</td>
</tr>
<tr>
<td>Cellulose</td>
<td>a substance that forms a large part of the walls of plant cells, the woody part of trees and other plants.</td>
</tr>
<tr>
<td>Cement</td>
<td>a compound made from calcium carbonate found in limestone, silica (sand) and iron oxide found in clay.</td>
</tr>
<tr>
<td>Chemical bonding</td>
<td>the linking of two or more atoms together to produce a new substance.</td>
</tr>
<tr>
<td>Chlorides</td>
<td>these are salts produced from the reaction of hydrochloric acid and metals.</td>
</tr>
<tr>
<td>Chlorophyll</td>
<td>the colouring matter of leaves and other green parts of plants occurring in small bodies (chloroplasts) within the cell.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>a fatty substance that can clog the arteries.</td>
</tr>
<tr>
<td>Clay</td>
<td>a rock substance made chiefly of alumina, silica, mica and water; and broken by erosion into fine particles.</td>
</tr>
<tr>
<td>Compound</td>
<td>substance made by combining different elements. It has completely different properties from those of the elements combined.</td>
</tr>
<tr>
<td>Conduction</td>
<td>transfer of heat from one particle to another as they vibrate. Occurs best in solids.</td>
</tr>
<tr>
<td>Conductor</td>
<td>a substance that carries electric current.</td>
</tr>
<tr>
<td>Convection</td>
<td>transfer of heat in fluids, liquids and gases where convection current can be set up.</td>
</tr>
<tr>
<td>Covalent bonding</td>
<td>bonding of atoms of non-metals by sharing electrons to form molecules.</td>
</tr>
<tr>
<td>Cracking</td>
<td>a method for breaking down complex hydrocarbons into smaller hydrocarbons.</td>
</tr>
<tr>
<td>Crest</td>
<td>the highest point in a wave between two successive troughs.</td>
</tr>
<tr>
<td>Crust</td>
<td>outer position of earth as contrasted with the underlying positions composed of denser matter.</td>
</tr>
<tr>
<td>Decibel</td>
<td>unit of loudness of sound.</td>
</tr>
<tr>
<td>Deflagorating spoon</td>
<td>an instrument which is used to hold the metal while observing the reaction of the metal with oxygen, while heating.</td>
</tr>
<tr>
<td>Ecology</td>
<td>the study of organisms in terms of their relationships with other organisms and with their environment.</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>a section of the biosphere in which living and non-living things interact and inter-relate.</td>
</tr>
<tr>
<td>Electricity</td>
<td>the energy properties of electrical charges in motion.</td>
</tr>
<tr>
<td>Electrode</td>
<td>any conductor through which an electric current enters or leaves a medium as an electrolyte. (See anode and cathode).</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
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<td>-------------------------------</td>
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</tr>
<tr>
<td>Electrolysis</td>
<td>the decomposition of an electrolyte by the passage of an electric current through it.</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>a chemical substance that dissociates into ions in solution or in molten form and conducts electricity.</td>
</tr>
<tr>
<td>Electromagnet</td>
<td>a device consisting of a soft iron core with a coil of fine wire around it, which becomes a magnet only when current flows through the coil.</td>
</tr>
<tr>
<td>Electronic configuration</td>
<td>the arrangement of electrons present in each shell of any atom, from the innermost shell to the outermost shell.</td>
</tr>
<tr>
<td>Electroplating</td>
<td>the process in which an object placed in an electrolyte is coated with a thin layer of metal when electricity is allowed to pass through.</td>
</tr>
<tr>
<td>Element</td>
<td>substance that contains particles of only one kind. Each element has its own special properties.</td>
</tr>
<tr>
<td>Emulsify</td>
<td>droplets of one liquid are dispersed in another liquid medium.</td>
</tr>
<tr>
<td>Endosperm</td>
<td>food stored in the ovule of a plant seed for the early nourishment of the embryo e.g in monocotyledonous plants.</td>
</tr>
<tr>
<td>Energy</td>
<td>the ability to do work.</td>
</tr>
<tr>
<td>Epidermis</td>
<td>a thin layer of cells covering an organism.</td>
</tr>
<tr>
<td>Epiphyte</td>
<td>A plant that grows upon another plant purely for support. It is not rooted in the ground e.g orchid.</td>
</tr>
<tr>
<td>Erosion</td>
<td>the removal of soil particles by agents such as wind and water.</td>
</tr>
<tr>
<td>Fossil</td>
<td>any trace of plant or animal life of a previous geological age found in the earth's crust.</td>
</tr>
<tr>
<td>Fossil fuel</td>
<td>material from the earth used to produce heat or power by burning</td>
</tr>
<tr>
<td>Fractional distillation</td>
<td>a distilling process for separating equally soluble liquids that have different boiling points.</td>
</tr>
<tr>
<td>Frequency</td>
<td>the number of waves passing a given place in one second.</td>
</tr>
<tr>
<td>Fuel</td>
<td>any substance which can be consumed with the production of energy.</td>
</tr>
<tr>
<td>Gallium</td>
<td>a bluish-grey metallic chemical element.</td>
</tr>
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<td>Term</td>
<td>Definition</td>
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</tr>
<tr>
<td>Gaseous fuel</td>
<td>Gaseous substances used to produce heat or power by burning.</td>
</tr>
<tr>
<td>Generator</td>
<td>a device used to convert mechanical or other natural energy to electrical energy.</td>
</tr>
<tr>
<td>Graphite</td>
<td>a steel - grey to black soft crystalline form of carbon- used in &quot;lead&quot; pencils or electrodes.</td>
</tr>
<tr>
<td>Group</td>
<td>column of the Periodic Table. There are eight groups in the Periodic Table.</td>
</tr>
<tr>
<td>Gypsum</td>
<td>a soft crystalline mineral usually white, composed of hydrated calcium sulphate used in cement.</td>
</tr>
<tr>
<td>Heat</td>
<td>a measure of the total internal energy of movement of the particles in an object. It depends on temperature and mass.</td>
</tr>
<tr>
<td>Herbivore</td>
<td>an animal that feeds chiefly on plants.</td>
</tr>
<tr>
<td>Humus</td>
<td>material that makes up the organic component of soil, being formed from decayed plant and animal remains.</td>
</tr>
<tr>
<td>Hydrocarbon</td>
<td>one of the series of organic compounds comprising carbon and hydrogen only.</td>
</tr>
<tr>
<td>Hydroelectricity</td>
<td>the production of electrical charges with water as its raw material.</td>
</tr>
<tr>
<td>Igneous</td>
<td>pertaining to or formed by heat or fire, especially pertaining to soil formation.</td>
</tr>
<tr>
<td>Inert gases</td>
<td>unreactive gases. They belong to group (viii) of the periodic table e.g. Argon, Neon.</td>
</tr>
<tr>
<td>Infra sound</td>
<td>sound waves below the audible frequency of human beings; that is below 20 Hz.</td>
</tr>
<tr>
<td>Insulators</td>
<td>materials that resist the passage of heat and electricity e.g. non-metals.</td>
</tr>
<tr>
<td>Ionic bonding</td>
<td>the linking of atoms of metals with non-metals by losing and gaining of outer most electrons to form new compounds.</td>
</tr>
<tr>
<td>Ion</td>
<td>an electrically charged particle.</td>
</tr>
<tr>
<td>Iron</td>
<td>a greyish metallic chemical element, highly malleable and ductile; used chiefly for used chiefly for making steel. Symbol Fe. Essential for all plants and animals.</td>
</tr>
<tr>
<td>Kaolin</td>
<td>a fine, white to grey clay composed of hydrous aluminium</td>
</tr>
</tbody>
</table>
silicates, used as a filler and for rubber, ceramics and cement. Also called China Clay.

**Kilowatt-hour** - a commercial unit of electrical energy: The amount expended by 1000 Watts of power in one hour.

**Kilowatt-watt hour meter** - an instrument that measures electrical energy used in a circuit over a period of time.

**Kwashiorkor** - a protein deficiency disease; the person exhibits swollen belly, scaly skin and hair loss.

**Legislation** - the process of enforcing law to govern a particular issue.

**Lignite** - a form of coal which is called "brown coal".

**Limestone** - a hard sedimentary rock composed mostly of calcite, occurs in various colours and in modified forms as dolomite, marble, used for building stone and as a flux.

**Loam** - a rich, fertile soil that is a mixture of sand, silt, clay and humus and has a texture just right for cultivation of crops.

**Logging** - the process of cutting down trees to produce wood materials.

**Lodestone** - an iron core consisting of iron oxide that has magnetic polarity.

**Longitudinal waves** - waves in which the movement is perpendicular to the vibration of the particles.

**Magnetite** - a black mineral composed of iron oxide (Fe₃O₄) and impurities.

**Malleable** - able to work without breaking; hammered or pressed into shape; a term used in describing metals.

**Mass number** - the total mass of all the particles in the nucleus of an atom, or the mass of the number of protons and neutrons.

**Mesophyll** - the inner green tissue of a leaf, lying between upper and lower epidermis.

**Metals** - substances which are good conductors of heat and electricity. They are found mostly to the left of the Periodic Table.
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<tr>
<th>Term</th>
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<td>Molluscs</td>
<td>any of a phylum of invertebrate animals having a soft, unsegmented body, usually covered with a hard shell secreted by a covering mantle, and muscular feet.</td>
</tr>
<tr>
<td>Non-metals</td>
<td>substances which are poor conductors of heat and electricity. They are found mostly to the right of the Periodic Table.</td>
</tr>
<tr>
<td>Ore</td>
<td>a mineral or group of minerals from which useful substances, especially metals, can be obtained e.g. magnetite is an iron ore.</td>
</tr>
<tr>
<td>Organic</td>
<td>having to do with compounds containing carbon. Organic compounds are carbon-containing compounds produced by all living things.</td>
</tr>
<tr>
<td>Oxide</td>
<td>any compound containing oxygen.</td>
</tr>
<tr>
<td>Oxidation</td>
<td>the combination of a substance with oxygen, as burning of coal.</td>
</tr>
<tr>
<td>Parallel circuit</td>
<td>a circuit in which the devices are arranged so that the same voltage is applied at each device.</td>
</tr>
<tr>
<td>Pathogens</td>
<td>any agent capable of causing disease e.g. bacteria and viruses.</td>
</tr>
<tr>
<td>Peat</td>
<td>the first stage of coal formation. It is used as a heating fuel.</td>
</tr>
<tr>
<td>Periods</td>
<td>rows of the Periodic Table. There are seven periods in the periodic table.</td>
</tr>
<tr>
<td>Periodic table</td>
<td>table of elements, with some information presented in groups and periods.</td>
</tr>
<tr>
<td>Petroleum</td>
<td>a thick heavy liquid, formed from decayed organic matter.</td>
</tr>
<tr>
<td>pH</td>
<td>the measure of concentration of hydrogen ions in an aqueous solution; a measure of the acidity or alkalinity of a solution.</td>
</tr>
<tr>
<td>Photoelectric cell</td>
<td>a cell which is energised by light.</td>
</tr>
<tr>
<td>Pollution</td>
<td>the state of being contaminated by many agents.</td>
</tr>
<tr>
<td>Potential difference</td>
<td>the electrical pressure, expressed in volts, between two points in a circuit, or between two charged bodies.</td>
</tr>
<tr>
<td><strong>Precipitate</strong></td>
<td>any substance, usually solid which settles out of a solution due to chemical change such as electrolysis or the addition of another chemical to the solution.</td>
</tr>
<tr>
<td><strong>Quartz</strong></td>
<td>a common mineral consisting of silica; crystalline and colourless when pure.</td>
</tr>
<tr>
<td><strong>Radiation</strong></td>
<td>transfer of heat that can occur where there are no particles. It only warms the object on which it falls.</td>
</tr>
<tr>
<td><strong>Reactivity series</strong></td>
<td>a list of elements from the most reactive to the least reactive one in relation to their reactivity with oxygen, water and acid.</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td>the turning back of a wave (e.g. light or sound) from a surface.</td>
</tr>
<tr>
<td><strong>Re-forestation</strong></td>
<td>re-planting of trees to maintain tree population in the forest.</td>
</tr>
<tr>
<td><strong>Refraction</strong></td>
<td>the change in direction or bending of the waves when travelling from one medium to another.</td>
</tr>
<tr>
<td><strong>Reverberation</strong></td>
<td>see 'echo'.</td>
</tr>
<tr>
<td><strong>Rheostat</strong></td>
<td>a device that is used to vary the resistance in an electrical circuit.</td>
</tr>
<tr>
<td><strong>Rock</strong></td>
<td>a naturally occurring hard mixture of minerals frequently containing metal ore or gem crystals.</td>
</tr>
<tr>
<td><strong>Sand</strong></td>
<td>fine particles of rocks commonly found on beaches; most is silica, a compound of silicon and is similar in composition to quartz.</td>
</tr>
<tr>
<td><strong>Sedimentary</strong></td>
<td>formed by or pertaining to sediments.</td>
</tr>
<tr>
<td><strong>Sedimentation</strong></td>
<td>the deposit of rock materials in any place by either water, air or any other means.</td>
</tr>
<tr>
<td><strong>Seismograph</strong></td>
<td>a sensitive apparatus for recording and measuring vibration at or below the earth's surface.</td>
</tr>
<tr>
<td><strong>Series circuit</strong></td>
<td>a circuit in which all devices are connected one after the other, with voltage divided among the devices.</td>
</tr>
<tr>
<td><strong>Simple distillation</strong></td>
<td>evaporation of liquid and condensation of the vapour back to the liquid state.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td>Siderite</td>
<td>iron carbonate, a mineral that is used as an iron ore.</td>
</tr>
<tr>
<td>Silica</td>
<td>colourless crystalline or white powdered chemical occurring naturally in quartz and agate etc. - used to manufacture glass.</td>
</tr>
<tr>
<td>Slag</td>
<td>the waste material from refining materials or separation of coal from its ore usually dark grey in colour - used for surfacing roads.</td>
</tr>
<tr>
<td>Slate</td>
<td>a finely-grained metamorphic rock usually breaks into sheets; generally grey, red or black; used for roofing, construction and blackboards.</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>a lumpy white inorganic base that absorbs water and carbon dioxide from air, called caustic soda.</td>
</tr>
<tr>
<td>Soil fertility</td>
<td>this refers to the level of nutrient value of the soil.</td>
</tr>
<tr>
<td>Soil profile</td>
<td>the layers of a vertical section of soil.</td>
</tr>
<tr>
<td>Solar cell</td>
<td>a photo electric device that converts solar light energy into electricity.</td>
</tr>
<tr>
<td>Solar cooker</td>
<td>a device which uses the rays of sunlight to cook food substances.</td>
</tr>
<tr>
<td>Solar dryer</td>
<td>a device which utilizes the heat of the sun to dry substances.</td>
</tr>
<tr>
<td>Solar panel</td>
<td>a device to trap sunlight.</td>
</tr>
<tr>
<td>Solar power</td>
<td>the thermonuclear energy radiated from the sun as light rays, infra red rays etc.</td>
</tr>
<tr>
<td>Solar still</td>
<td>a device which uses the rays of sunlight to carry out the process of distillation.</td>
</tr>
<tr>
<td>Solid</td>
<td>has molecules arranged in a regular way. Molecules move slightly in place; but do not change position.</td>
</tr>
<tr>
<td>Solid fuel</td>
<td>a type of fuel in the form of powder or grains mixed with an adhesive mixture.</td>
</tr>
<tr>
<td>Sound</td>
<td>a type of energy produced by vibrations; moves through a medium in longitudinal waves; not transmitted through a vacuum.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sub-atomic particles</td>
<td>smaller particles found within an atom. e.g. protons, neutrons and electrons.</td>
</tr>
<tr>
<td>Sulphates</td>
<td>salts formed from the reaction between metals and sulphuric acid. e.g. Calcium sulphate.</td>
</tr>
<tr>
<td>Sulphur</td>
<td>a yellowish non-metallic chemical element.</td>
</tr>
<tr>
<td>Temperature</td>
<td>the hotness or coldness of an object.</td>
</tr>
<tr>
<td>Thermostat</td>
<td>device to keep an appliance at a fairly constant temperature; may involve use of a bimetallic strip.</td>
</tr>
<tr>
<td>Timbre</td>
<td>the distinctive quality of sound of any musical instrument or voice, determined by the presence of overtone.</td>
</tr>
<tr>
<td>Transition elements</td>
<td>elements found between Group II and Group III of the Periodic Table e.g. Zinc, Silver, Gold.</td>
</tr>
<tr>
<td>Transverse waves</td>
<td>waves in which the movement is parallel to the vibration of the particles.</td>
</tr>
<tr>
<td>Trough</td>
<td>the lowest point in a wave between two successive crests.</td>
</tr>
<tr>
<td>Turbine</td>
<td>a machine which changes the mechanical energy of a moving liquid or gas into a rotary form of mechanical energy.</td>
</tr>
<tr>
<td>Ultra sound</td>
<td>sound waves above the audible frequency of human beings, that is above 20,000 Hz.</td>
</tr>
<tr>
<td>Valence shell</td>
<td>the outermost shell of an atom.</td>
</tr>
<tr>
<td>Vocal cord</td>
<td>one of two ligaments stretched across the opening of the larynx, vibrating when air passes over them to produce sound. Muscles attached to the vocal cord tighten and relax to regulate the pitch and quality of the sound.</td>
</tr>
<tr>
<td>Voltmeter</td>
<td>an instrument for measuring the difference in potential between any two points in an electric circuit.</td>
</tr>
<tr>
<td>Watt</td>
<td>a unit of electrical power.</td>
</tr>
</tbody>
</table>
Wave

- any disturbance or vibration by which energy is transmitted through a medium.

Wavelength

- the distance between successive crests or successive troughs of a wave. This is also the same as the distance between any two successive points at the same phase.
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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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