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## Contents

<table>
<thead>
<tr>
<th>Unit</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How the scientist works</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Safety first</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>- Safety in the laboratory</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>- Safety equipment in the laboratory</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>- Safety information</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>- Spectacular mixes</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>- Looking at things in the laboratory</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>- Looking at things in the school yard</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>Measuring in science</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>- Four basic quantities</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>- History of measurement</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>- Measuring lengths</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>- Measuring mass</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>- Measuring temperature</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>- Measuring time</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>- Measuring areas</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>- Measuring volumes</td>
<td>49</td>
</tr>
<tr>
<td>3</td>
<td>Signs of life</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>- Characteristics of living things</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>- External features related to each characte</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>- Collecting and storing living things</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>- Storage and preservation</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>- Classifying living things</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>- Making a key</td>
<td>70</td>
</tr>
</tbody>
</table>
4 Mixing and separating
   - Solutions
   - Separating mixtures
   - Some common separation techniques

5 Energy and matter
   - Energy
   - Energy and force
   - Matter
   - Matter an energy
   - Changing state

6 Properties and changes
   - Physical properties of substances
   - Chemical properties of substances
   - Physical changes
   - Chemical changes
   - Conservation of mass and energy

7 Looking at life cycles
   - Watching plants grow
   - Watching animals grow

8 Projects and strategies for revision
   - A guide to projects
   - Measuring devices
   - Making and testing a water filter
   - Project work
   - A visit to a place of interest
   - Revision

Glossary
Index
Foreword

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

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

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

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

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

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

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

Safety first

A child picked up a soft drink bottle containing a liquid; thinking that the liquid was cream soda, he drank it. He was seriously injured because the liquid he had drunk was bleach.

Could this accident have been avoided? In science we learn about many things, living and non-living. In order to find out, we often need to see, smell, hear, taste or feel. We must do these in such a way that we cause no harm to ourselves, others or the environment.

In this unit, we will learn about:

- ways of making and recording observations using tables
- describing chemical reactions
- describing the reactions of chemical substances with water
- classifying substances as: liquid, gas, solid, soluble in water, insoluble in water, metals, non-metals, wood, plastic and glass
- classifying living things

Safety in the laboratory

Using flames

The flame that you use in your heating experiments, whether from a bunsen burner or an improvised methylated spirit lamp, is one source of possible danger. Usually a blue or an almost invisible flame is used. This is the hottest type of flame. When we heat things in the laboratory, all combustible material (e.g. paper) and flammable gases, liquids and solids, should be placed far away from the burners. Pupils with long hair should tie it up properly. Furthermore, pupils should not lean over any person heating a substance. Pupils with 'loose' shirt sleeves should not stay close to the flame of the burner. Pupils should also avoid wearing clothing like nylon
Glassware

Test tubes, beakers, conical flasks, and measuring cylinders, to name a few, are examples of laboratory equipment made of Pyrex, a type of glass that can withstand a lot of heat. These pieces of equipment, however, cannot withstand a slight tap with a piece of metal or even the shock if dropped from a height.

They are fragile. If broken, they can cause serious cuts. We should never hold them with soapy hands or greasy fingers.

Look at the picture in Fig 1.4. Can you describe how a bottle containing chemicals should be held while carrying it around?

Handling chemicals

In the laboratory, we would be handling substances which are either stored in bottles or in plastic containers. These containers are labelled with names of substances and appropriate symbols of warning. These should be read first before use.
Substances in unlabelled bottles should always be treated as dangerous.

Appropriate symbols and their meanings can be found on the safety chart provided in Fig. 1.18. These symbols refer to dangerous chemicals as follows:

**Harmful substances**: These can cause vomiting if tasted or swallowed.

*Flammable substances*: These are substances that can be easily ignited if heated or exposed to flames. Common examples of these are alcohol, ethanol and acetone (propanone).

*Corrosive substances*: These can burn skin, tissues and clothing. They attack metals and many other substances. Examples of two corrosive substances are hydrochloric acid and sodium hydroxide (caustic soda). Corrosive substances sometimes react with metals to produce poisonous gases. When handling corrosive substances, we should avoid spillage on surfaces or on ourselves.

It is necessary to use protective clothing such as laboratory coats, safety goggles and appropriate gloves.

*Toxic substances*: These are substances that can cause death if swallowed, or even if their fumes are inhaled. Examples of these are hydrochloric acid, carbon monoxide and compounds of lead, mercury and arsenic.
The substances labelled toxic are extremely dangerous and should be handled with greatest care and caution.

![A toxic substance (hydrochloric acid)](image)

**Explosive substances**: These are substances that can explode if exposed to flames, air, heat or even moisture.

Sometimes a sudden shock or even friction can cause these substances to explode.

![An explosive substance (sodium)](image)

**Radioactive substances**: These are substances that give off harmful rays that can cause lasting damage to body tissues. These should be handled by teachers only, and should be treated the same way as toxic substances. Uranium and radium are two radioactive substances.

![A radioactive substance (radium)](image)

**Using electricity**

The electricity supply in the laboratory is another source of possible danger.

A shock from as low as thirty volts can be fatal. Therefore, we should not tamper with switches or electrical outlets. Also, since water conducts electricity, we should never hold appliances or switches with wet hands.
Uneven surfaces

Uneven surfaces can cause falls and cuts. Therefore, laboratory desk tops and floors should be even.

If surfaces are uneven, then greatest care should be taken when moving chemicals, glassware or delicate and expensive equipment along these surfaces.

Special care should be taken not to leave cleaning equipment and other utensils in passage ways.

Behaviour in the laboratory

Our attitude towards our task, others and our environment is of great importance. Listening and carefully reading and obeying instructions cannot be over-emphasised.

Furthermore, co-operating in group work, helping classmates, in various ways, and keeping the work area in the laboratory clean and tidy are other behaviours that should not be neglected. What about seriousness and interest in the task before us? Good attitude leads to good behaviour. Good behaviour leads to safety in the laboratory.

Safety equipment in the laboratory

Experience has taught us that in spite of care being taken, accidents do occur. Therefore the best position to be in, is to be prepared for such emergencies. Safety equipment must therefore be in place.

Fire extinguishers

If we know how fire starts, we can be in a better position to extinguish or even control it. Basically there are three things which must be present before a fire starts—fuel for the fire, a supply of oxygen or air for the fire and heat to give the ignition temperature. In a laboratory, there are usually three things to stop a fire once it has started.

Fig. 1.13 The fire bucket
The fire bucket: This is a bucket painted in red and labelled FIRE. This bucket contains sand. When thrown on a fire, sand prevents air from reaching the flame and the flame goes out.

Fig. 1.14 The fire blanket

The fire blanket is another piece of equipment that can be used to put out a fire. This is made up from a material which does not burn. The blanket also stops air from getting to the fire.

Fig. 1.15 The fire extinguisher

Finally there is the fire extinguisher. This is usually available in different sizes and compositions. Some fire extinguishers help to smother flames by preventing air from getting to the fire. Others cool the burning area below ignition temperature causing the flame to go out.

Be prepared! Read the instructions on the fire extinguisher in your laboratory.

Water for washing

Another important item in a laboratory is clean, pure water for washing. The emergency may arise when an acid or an alkali gets into a student's eye. The immediate thing to do is to get this harmful corrosive substance out of the eye as quickly as possible. Much clean water is needed to flush out the harmful chemical.

Fig. 1.16 Method for washing eyes

An eye wash from the first aid kit could also be used to flush the eye. (see Fig. 1.17)

Fig. 1.17 An eye wash
The first aid kit

First aid as the name suggests is treatment of a temporary nature that eases the situation or prevents further injuries. The first aid kit is a little cupboard having a cross as an identity symbol and important items that can be used as immediate aid in case of accidents. Here is a list of items that can be placed in a first aid kit. (Note that many deadly diseases are spread through contact with human blood. Thus, proper training is needed before attempting to give first aid)

<table>
<thead>
<tr>
<th>EMERGENCY</th>
<th>ITEMS IN FIRST AID KIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruises</td>
<td>cotton-wool, swabs, cleaning lotion, mercurochrome</td>
</tr>
<tr>
<td>Cut</td>
<td>wool, swabs, cleaning lotion, adhesive dressing, bandage, soap, slings, antiseptics</td>
</tr>
<tr>
<td>Wounds</td>
<td>tourniquet and bandages</td>
</tr>
<tr>
<td>Fire burns</td>
<td>gauze</td>
</tr>
<tr>
<td>Acid</td>
<td>wash bottle, sodium hydrogen carbonate</td>
</tr>
<tr>
<td>Fracture</td>
<td>splints</td>
</tr>
<tr>
<td>Insect bites or stings</td>
<td>alcohol, sodium hydrogen carbonate, vinegar</td>
</tr>
<tr>
<td>Headache</td>
<td>acetaminophen</td>
</tr>
<tr>
<td>Liquid entering eye</td>
<td>eye wash</td>
</tr>
</tbody>
</table>

Safety information

In the laboratory we would be handling chemicals, glassware and a variety of equipment. Some of these can cause bodily harm. Therefore we need to know how to handle these materials safely. Information on safety can be acquired by reading labels, directions on equipment use and most important, safety information charts.

Here is a safety chart. It tells about some rules to follow when you are in the laboratory.

<table>
<thead>
<tr>
<th>LABORATORY RULES</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Never enter lab without teacher's permission.</td>
</tr>
<tr>
<td>* Never start activities before reading instructions and labels carefully.</td>
</tr>
<tr>
<td>* Never turn on gas without teacher's permission.</td>
</tr>
<tr>
<td>* Never taste, eat or drink in the laboratory.</td>
</tr>
<tr>
<td>* Never run in or out of laboratory.</td>
</tr>
<tr>
<td>* Never remove anything from lab without teacher's permission.</td>
</tr>
<tr>
<td>* Never throw solids down sink.</td>
</tr>
<tr>
<td>* Never use your fingers to stir or hold chemicals.</td>
</tr>
<tr>
<td>* Never put things other than plugs into electrical sockets or operate electrical equipment with wet hands.</td>
</tr>
<tr>
<td>* Never play with safety equipment.</td>
</tr>
<tr>
<td>* Never play in a laboratory.</td>
</tr>
</tbody>
</table>

Here is another chart of rules that gives information on things you should always do in a laboratory.
LABORATORY RULES

- Always wait for teacher’s permission before entering the laboratory.
- Always report accidents quickly.
- Always move carefully when carrying equipment and chemicals.
- Always keep work bench/place clean and tidy.
- Always clean up spilt liquid quickly.
- Always read labels carefully before using contents of a bottle.
- Always make sure you know what to do in an emergency.
- Always clean up after your work is done.

Activity 1.1: After reading the above charts do the following activities.

1. Make a safety chart to be used in your kitchen (or playground).
2. Give reasons why we must pay attention to the rules on your chart.

In our roadways, streets and factories there are symbols that are used to give warning. In our use of chemicals there are appropriate symbols of warning, too.

Here is a chart to illustrate some symbols of warning in the use of chemicals.

**Spectacular mixes**

Several changes can occur when chemicals are mixed. These changes can be observed by using the senses of touch, sight and smell. In this section, we are going to observe the reactions of chemicals on mixing and record our observations. We may have some surprises. So be prepared!
Mixing some chemicals

Activity 1.2: Mixing chemicals.
You will be given some substances dissolved in water. Here are some examples.

![Fig. 1.19 Bottles with chemicals](image)

These chemicals are in labelled bottles.

Note very carefully the name of each chemical. Remember to put the stopper back on the bottle immediately after you have poured what you want. If you do not cover them each ime, there is a danger of the covers being mixed up. Remember too, to wash out the test tube with water after you have finished with each pair of chemicals. Always wash your hands after doing activities with chemicals.

Follow these instructions carefully. Your teacher will demonstrate to you how to pour the chemicals from a bottle to a test tube. You should also refer to the paragraph on handling chemicals safely.

Fig. 1.20 Pouring a chemical into a test tube

Fig. 1.21 Wafting gas towards nostril

When scientists do experiments they record their observations so that others can know and follow what they are doing.

Students, you too need to record your observations clearly so that others can follow and understand exactly what you have been doing. Instead of writing your observations in sentences, you can follow the pattern shown in the table below. This is what is called **concise** or brief reporting.
Study Table 1.1 carefully. Your teacher will discuss your observations and help you to record your observations in a table.

From the experiments we have just completed you will have noticed that some pairs of chemicals on mixing changed colour, gave off bubbles or fizzed, while other formed thick, solid-like substances.

When two or more chemicals are mixed and bubbles rise to the surface of the mixture we say the mixture fizzles or effervesces. During this process gas is given off.

Any thick, solid-like substance formed from mixing different chemicals, is called a precipitate.

Lead nitrate and acetic acid are colourless chemicals. We also observed that where these chemicals are mixed there is no change in colour. Mixtures like these are called colourless mixtures.

Compare your results with those of other students in the class but do not play around. Are they the same? Are they not spectacular?

You mixed two chemicals and got such colours as rust brown, or dark blue and orange and some even became solid.

Most of the substances we got after mixing a pair of chemicals were completely different from the ones with which we started. We will discuss more of this in Unit 6.

Activity 1.3: Some experiments with lime juice.

We need:

1. small pieces of indicator paper – red and blue litmus paper.
2. sodium carbonate (washing soda).
3. sodium bicarbonate (baking soda).
4. sodium chloride (common salt).
5. half of a lime or lemon.
6. watch glasses or empty bottle caps.

What to do: Read instructions carefully before beginning to work.

1. Squeeze a drop of lime/lemon juice on to a piece of red and a piece of blue litmus paper separately.
2. Put a small portion of each substance, using a spatula or small plastic spoon, on separate watch glasses.

3. Squeeze a drop of lime/lemon juice on to a little of sodium chloride.

4. Squeeze a drop of lime juice on to a little sodium bicarbonate.

5. Squeeze a drop of lime juice on to a little sodium carbonate.

In each case, what did you notice happen to the substance when lime juice was added?

6. Touch a piece of dry red litmus and a piece of dry blue litmus separately on to sodium bicarbonate.

7. Touch a piece of wet red and a piece of wet blue litmus separately on to sodium bicarbonate. Did you observe any changes?

8. Touch a piece of wet red and a piece of wet blue litmus separately on a fresh portion of salt. Are there any changes in the colour of the litmus paper?

9. Touch a piece of wet red and a piece of wet blue litmus separately on a fresh portion of sodium carbonate. What do you observe? What did you observe about the litmus paper, when touched on the substances in steps 8 and 9?

Fig. 1.22 Mixing chemicals

You would have observed that two substances fizzed, while one did not when lime juice was added. You would have also noticed that the blue litmus changed to red. Substances which change blue litmus to red are called acids. What is the taste of the lime juice? What other substances do you know and have at home that are sour? The substances which change red litmus to blue are called alkalis. Those which change litmus paper to mauve or do not affect it at all are neutral substances.

Now name the substances which are acids and alkalis in your experiment.

Later in the course we will discuss these kinds of substances in more detail.

Remember to use a table for concise reporting.
More mixing

In the last section, we used our senses of touch, sight and smell to observe the reactions of pairs of chemicals on mixing. We also used a table for concise reporting. In this section, we will continue to observe but this time we will observe what happens when some common substances are mixed with water.

We already have some ideas of what might happen when substances are mixed with water. Some might seem to disappear, while others might not. Some will either sink to the bottom or float to the surface. What substances do you know which might seem to disappear in water, or sink to the bottom, or float to the surface after a while? We are also going to put these substances in groups according to how they look and behave in water.

Activity 1.4: Mixing solids with water

On your desk or work bench are some common substances. Remember we must follow the instructions carefully.

1. Pour about 5 cm$^3$ of water in a test tube.
2. Put one spatula of any one of the substances into the test tube.
3. Shake and leave to stand for a few minutes.
4. Observe carefully and record your observations in the table below.
5. Repeat the activity using a different substance and fresh water each time.

Use a clean spatula each time to avoid contamination.

<table>
<thead>
<tr>
<th>Substances</th>
<th>What happens in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powered Milk</td>
<td></td>
</tr>
<tr>
<td>Soap powder</td>
<td></td>
</tr>
<tr>
<td>Flour</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td></td>
</tr>
<tr>
<td>Baking powder</td>
<td></td>
</tr>
<tr>
<td>Crushed moth ball</td>
<td></td>
</tr>
<tr>
<td>Crushed chalk</td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1.23 Some common substances

A bowl of sand
MIXING SUBSTANCES WITH WATER

Fig 1.24  Making a cup of coffee

Look at the picture in Fig. 1.24. Which of the substances shown in the picture will dissolve in water?

Remember to keep your work place tidy and do not throw solids down the drain. Do not taste unless instructed to do so.

to stand? Substances like sugar do not settle or float to the surface, but seem to disappear. Where is the sugar? Is it still in the water? When you make a drink, you add sugar and stir. How does the drink taste? What is the taste of sugar? Does that suggest anything to you? Substances which seem to disappear in water are still there. When substances seem to disappear in water, we say they dissolve. These substances are said to be soluble in water. Which substances are soluble in water? Substances dissolved in water form solutions.

Then there are others which did not seem to disappear, but settled out at the bottom or floated to the surface after a while. These substances are insoluble in water. Which substances are insoluble in water? Do these form solutions with water?

Can liquids dissolve in water? Here are some liquids. Let us find out which ones are soluble or insoluble in water.

Fig 1.25  Common household liquids

What did you notice about the substances when mixed with water? Did they all seem to disappear in the water? Did any sink to the bottom or float to the surface when they were left

Activity 1.5: Mixing liquids with water

1. Pour about 3 cm³ of honey in a test tube containing about 3 cm³ of water.
2. Shake and leave to stand for a while. What have you observed?
3. Record your observation using a table similar to the one in the previous activity.
4. Repeat, using the other liquids in Fig. 1.25. Which liquids are soluble in water? What did you notice about the substances that did not dissolve?

**Activity 1.6: Mixing gases with water**

What about gases? Can they dissolve in water too?

Your teacher will provide you with a covered test tube of carbon dioxide. Can you see anything in the test tube? Of course not. The test tube seems empty, but it is actually full of carbon dioxide.

1. Invert (upturn) the tube in a beaker of water, with its mouth below the surface of the water.
2. Remove the cover.
3. Hold it there for a while (see Fig. 1.26).

What have you noticed about the level of the water in the test tube?

Does the test tube still have the same volume of carbon dioxide? Where is the gas? Surely the carbon dioxide must have dissolved a little in the water.

Fishes live in water. From where do they get their oxygen? Actually fishes use their gills to extract the oxygen dissolved in the water.

What happens when a bottle of soft drink is opened? Fill a glass with some soft drink. What do you notice? Of course, bubbles are given off or we say it fizzes. We know that when some substances fizz, a gas is given off. Where did the gas in the soft drink come from? The gas must be dissolved in the liquid. The gas that bubbles off the soft drink is carbon dioxide. The carbon dioxide was dissolved in the drink while it was being made. The gas is forced into the drink under pressure, so the manufacturers are able to get much carbon dioxide to dissolve. When the bottle cap is removed or when the drink is poured into a glass, the pressure of the gas is released and the extra gas that was forced in comes out as bubbles. But some of the gas remains dissolved in the drink and gives it a pleasant and slightly acid taste. You can show that tap water contains a dissolved gas by gently heating and observing bubbles rise.
Water can dissolve most substances. Water dissolves more substances than any other liquid; yet there are many substances that water does not dissolve. Because of water’s ability to dissolve most substances, important life processes like digestion and respiration can take place in our bodies and in other living things.

**Using tables for grouping**

Grouping of substances is a skill scientists often use after making observations. When we put substances in groups, we say that we classify them. Each group shows the differences between the substances and within each group there are similarities. We are now going to put the substances from the three activities described in this section into groups, using tables.

List all the substances used in the three activities.

Your list should look something like this:

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>air</td>
<td>paint</td>
<td>nail polish</td>
</tr>
<tr>
<td>sugar</td>
<td>vinegar</td>
<td>flour</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>water</td>
<td>fruit juice</td>
</tr>
<tr>
<td>soil</td>
<td>liquid detergent</td>
<td>honey</td>
</tr>
<tr>
<td>powdered milk</td>
<td>salt</td>
<td>baking powder</td>
</tr>
<tr>
<td>oil</td>
<td>kool-aid</td>
<td>crushed moth balls</td>
</tr>
</tbody>
</table>

While working with the substances in the second activity, we noticed that some of these substances were soluble in water, while others were insoluble.

We are now going to place each of them into groups according to how they behave in water.

**Substances mixed with water**

<table>
<thead>
<tr>
<th>Soluble in Water</th>
<th>Insoluble in Water</th>
</tr>
</thead>
</table>

Can you think of any other way in which we can group these substances?
Earlier in this unit we also used a variety of substances. Make a list of them in your book. Here are some of the substances: red litmus paper, lime juice, blue litmus paper, acetic acid, baking powder, copper II sulphate solution, washing soda, lead nitrate solution, sodium carbonate solution.

All these substances are in the group of non-living things. From the list of substances pick out those which are solid or liquid and place them in a table like the one used earlier. Look at your list closely. In what other groups can we place these substances? We can place them in groups according to how they behave on mixing. Therefore our table could look like the one below.

As we look even closer at our list of substances we are sure to find many more groups in which to place them. Remember that within each group there will be similarities

<table>
<thead>
<tr>
<th>PAIRS OF SUBSTANCES WHICH CHANGED COLOUR</th>
<th>PAIRS OF SUBSTANCES WHICH EFFERVESCED</th>
<th>PAIRS OF SUBSTANCES WHICH FORMED A PRECIPITATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

22
Looking at things in the laboratory

Look around the laboratory. What have you noticed about the things in the laboratory? There is a variety of equipment and materials which are used for various activities. In order to study them closely we must group them. Even though you have had some ideas about grouping substances, you would find the following activities very challenging.

Activity 1.7: Things found in the laboratory.

Walk around the laboratory and make a note of the things you see. Your list should be quite long. Do not forget to include in your list live and mounted specimens that may be present in your laboratory. Even though some things look different, they are similar in some way, for example, the beaker and the rule. They are made of different kinds of materials, but they are both used for measuring. Read the markings on the beakers and note the quantity that each measures.
Grouping things in the laboratory

Many of the things in the laboratory can be grouped as solids. Did you have any gas in the laboratory? In what other groups can we place the things? Another way of grouping these is to break them into groups of metals and non-metals.

<table>
<thead>
<tr>
<th>METAL</th>
<th>NON-METALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We can think about the purpose of the instruments. Let us list the measuring instruments. The group of measuring instruments might look like this:

- rule
- thermometer
- beaker
- measuring cylinder
- balance
- stop clock

Now we can think about the quantities each instrument measures. Write them down in the table below:

<table>
<thead>
<tr>
<th>INSTRUMENTS USED FOR MEASURING</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

In what other ways are these materials different? We can make groups by thinking about the types of materials the non-metal things are made of. Whether they are made of glass, plastic or wood. Now place them in the groups.

<table>
<thead>
<tr>
<th>GLASS</th>
<th>WOOD</th>
<th>PLASTIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Can you think of other ways in which to group the things in the laboratory? What about the furniture in the laboratory? Think about groups in which to place them.

Looking at things in the school yard

Activity 1.8: Things found in the school yard.

There is a variety of things out there in our school yard to which we seldom pay much attention. We are now going to take a trip around the school yard to observe and collect samples of things found in the yard. Do not forget that we will need to take jars, bottles, plastic bags, nets...
and small boxes with holes in which to collect and store things while on the trip. Remember to look under leaves and stones, at the edge of ponds or trenches, as well as in them. Be careful! There may be some harmful animals and plants around. Remember to make a note of where the things were found. It may not be possible for us to take all of the things we find back to the laboratory e.g. dogs, cows.

**Listing things found in the school yard.**

Here are some of the things we might have on our list.

- fish
- earthworm
- butterfly
- lizard
- bird
- soil

You are sure to have a much longer list. Did you notice any water?

**Grouping things found in the school yard**

Although all the things were found in the school yard, we will by now have noticed that there are differences and similarities between them. They would either belong to the group of living or non-living things. List each under the correct group name in the table below.

<table>
<thead>
<tr>
<th>LIVING</th>
<th>NON - LIVING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are so many living things around us, that we must place them in groups in order to study them. Look at the living things. How are they different? Can we place them into two other groups? Yes, of course. We can place them into the group of plants and animals.

**Fig. 1.28 Common living and non-living things**
PLANTS AND ANIMALS FOUND IN THE SCHOOL YARD

<table>
<thead>
<tr>
<th>PLANTS</th>
<th>ANIMALS</th>
</tr>
</thead>
</table>

Now let's look at each group separately. Plants can be placed into two groups.

Flowering
Non-flowering

Flowering plants bear flowers while non-flowering plants do not bear flowers. See if you can list the names of the flowering and non-flowering plants collected.

Look closer at flowering plants. Let's see if we can sort these plants into two other groups as shown in the table below.

TYPES OF LEAVES

<table>
<thead>
<tr>
<th>NET-VEINED</th>
<th>STRAIGHT-VEINED</th>
</tr>
</thead>
</table>

Did you notice that the plants with straight-veined leaves have jointed stems and their leaves are long and narrow? You may also have observed that net-veined leaves are broad and these plants have no jointed stem.

The plants with straight veins and narrow, long leaves belong to the group of monocotyledons while those with net veins and broad leaves belong to the group of dicotyledons. Your table would then look like this:

<table>
<thead>
<tr>
<th>DICOTYLEDONS</th>
<th>MONOCOTYLEDONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>mango</td>
<td>grass</td>
</tr>
<tr>
<td>hibiscus</td>
<td>rice</td>
</tr>
<tr>
<td>pigeon pea</td>
<td>sugar cane</td>
</tr>
</tbody>
</table>

Remember there are many other ways in which things can be grouped. Try to see how many other groups you can get.

Animals can be divided into two main groups. We can easily see that there are some common features present in some animals, while those features are absent in others.

Animals with backbones
Animals without backbones

Animals with backbones are called vertebrates. We cannot see whether an animal has a backbone just by looking at it and we cannot cut up live animals to find out. How can we find
out? We can get clues from dead animals. Are there any other clues? Animals without backbones are called invertebrates.

Scientists have divided animals with backbones into five groups. Features of some of these groups are stated in the following chart.

Place the vertebrates collected into these five groups. What is common in each group? Can these groups of vertebrates be further divided? We will look at vertebrates more closely later in this course.

ANIMALS WITH BACKBONES

- Animals that feed on milk (mammals)
- Animals with feathers (birds)
- Animals with wet scales and fins (fish)
- Animals with dry scales (reptiles)
- Animals with smooth damp skins (amphibians)

Into which of these groups would you place each of the animals in Fig 1.29?

Fish
Duck
Earthworm
Spider
Frog
Cat
Centipede
Butterfly
Lizard
Snail

Fig 1.29  Animals with backbones and animals without
Make a list of other vertebrates and place them in groups.

Always return live animals to their habitats at the end of an activity.

Non-living things in the school yard can also be classified. Make a list of all the non-living things collected. Did you include air in your collection? Some of the non-living things were once alive because they were once parts of a living tree or an animal, for example dried leaves, a bone; others like sand and water were never alive.

Now place the non-living things into the table below.

**GROUPING NON-LIVING THINGS**

<table>
<thead>
<tr>
<th>ONCE ALIVE</th>
<th>NEVER ALIVE</th>
</tr>
</thead>
</table>

Have you noticed any similarities within each group?

**Exercises**

1. Design a poster or a warning sign that you can put in your laboratory concerning eating food and drinking in a laboratory.

2. Collect two labels of drugs used in agriculture or from a medicine bottle and give the following information.
   a. Name the drug
   b. Draw the safety symbol given.
   c. What safety information does this symbol give you?
   d. What will happen if this substance touches your skin or is swallowed?
   e. How should you store this substance?
   f. How should you dispose of the container of this substance?

3. a. List three things you should never do in the laboratory.
   b. List three things you always do to promote safety in the laboratory.

4. a. Draw five safety symbols used in science.
   b. Name two chemicals for each symbol.

5. Read the following story and discuss in groups what safety rules were broken.

   It was Thursday and Ravi was early for his science class. His teacher had not come so he entered the laboratory. Ravi felt hungry. He got out his lunch and ate part of it. He was then thirsty and drank water from a container that had been originally labelled toxic but from which the label had been removed. He then heard a whistle, and in his effort to run out of the laboratory, stumbled over a stool which he had left in the passage way.

6. Why is it important for scientists to observe and record their observations?

7. Why is it better to record observations in a table than in sentences?
8 Give the meaning for each of the following words: - precipitate, effervesce; colourless.

9. Give one example of pairs of substances which effervesce, form a precipitate, form a colourless mixture.

10 How does an acid affect blue litmus paper? Name two other substances at home which may have the same effect on the blue litmus.

11 In the lime juice experiment which substances were alkalis?

12 Ian placed two pieces of litmus paper on a watch glass, so that they did not touch. One piece was red and the other blue. He then squeezed a few drops of orange juice on to the litmus papers. He observed that the blue litmus changed to red, and the red litmus did not change. His friend was sure that the red colour from the red litmus caused the blue to change to red. How do you think he can convince his friend that the colour of the red litmus did not affect the blue?

13 Use other citrus fruits at home and observe their effects on baking soda and washing soda.

14 Name two solids which dissolve in water.

15 What is formed when one substance dissolves in another?

16 What do we mean when we say a substance is insoluble in another substance?

17 Name three substances which are insoluble in water.

18 Suppose you were given an unknown solid, how would you find out if the substance is soluble or insoluble in water?

19 Why do bubbles rise to the surface of a glass of soft drink after it has been poured?

20 What is the purpose of: (i) a measuring cylinder (ii) a balance?

21 What is the difference between a beaker and a measuring cylinder?

22 Write down as much as you can about a mammal.

23 How is a reptile different from an amphibian?

24 Which of the following statements are true?
   (a) Balances are used to measure length.
   (b) The measuring cylinder measures volume.
   (c) The rule is used to measure mass.
   (d) The microscope helps us to see small things like cells.

25 Which of these is usually found under a rock? spider, millipede, butterfly, dog.

26 Look around your yard at home. Collect and group as many living and non-living things as you can find.
WE HAVE LEARNT THAT

- safety is necessary when using flames, handling glassware, chemicals and electricity.
- it is important to display the right attitudes and behaviours.
- the fire extinguisher and the first aid kit must be part of the laboratory equipment.
- safety information can be presented on charts and by symbols.
- observation is one of the most important skills needed when we work like a scientist. We use our senses of smell, touch and sight to observe the reaction of substances when mixed.
- scientists record their observations clearly and simply.

therefore the best way to record your observations is to use a table. A table is used for concise reporting.
- chemicals behave differently on mixing together. Some pairs form a precipitate, other pairs effervesce or give off a gas. Some change temperature, while others remain colourless.
- substances which are acids turn blue litmus red. The word “acid” means “sour”. Alkalis turn red litmus blue.
- when a substance seems to disappear in another substance, for example water, we say that it has dissolved.
- when a substance dissolves in water, we say it is soluble in water. Such a substance forms a solution in water.
- substances that do not dissolve in water are said to be insoluble in water and do not form solutions with it.
- solids, liquids and gases can dissolve in water.
- when substances are grouped or classified they are placed in different groups, but within each group there are similarities among the members of the group.
- classification is an important skill used by scientists.
- carbon dioxide is the gas which is dissolved in soft drink.
- water dissolves more substances than any other liquid.
- in the laboratory there is a variety of equipment. We can group them according to their purposes and the types of materials of which they are made. There are living and non-living things in the laboratory.
- there are also living and non-living things in the school yard.
- living things can be classified as plants and animals. Each group is different, but among the members of each group there are common features.
- animals can be divided into two groups:
  - vertebrates are animals with backbones, and invertebrates are animals without backbones.
- vertebrates can be divided into five groups (fish, amphibiains, reptiles, birds and mammals).
- plants can be divided into two groups (flowering and non-flowering).
- non-living things belong to the group of "once alive or never alive".
2 Measuring in science

Measurements are very important in our everyday lives. In this unit we will be learning:
• about the history of measurements,
• how to estimate quantities such as time, mass, length, volume, area and temperature.
• how to measure these quantities using standard units of measure.

Kate: "I don't know how to begin"
Mary: "I would like to make a cake for my mother!"

Kate: "Yes?"
Mary: "I don't know how to begin"

Kate: "Aren't you in the Home Economics class?"
Mary: "No!"
Kate: "I made a cake, just last week, for my brother. It came out just right!"
Mary: "How did you make it?"
Kate: "I took some butter, then some sugar, eggs, flour and baking powder. I mixed them all together.
Then I placed the mixture and baked it in the oven."
Mary: "Do you think I can do it?"
Kate: "Sure! I guarantee your cake will come out just like mine."
Mary: "I'll try!"
Kate: "By the way, Mary, Mother wasn't there!"

Do you think that Mary would be successful in making her cake? Give a reason for your answer.
Four basic quantities

For Mary to have a wonderful cake, she needs to know four important things:

- 'how much' butter, sugar and flour i.e. she needs to know the mass of butter, sugar and flour.
- 'what size' of pan. If she makes a fair amount of mixture but puts it in a pan that is very large, then the cake would be thin like a biscuit. She needs to know the length (or width) of the pan.
- 'how long' she should bake it. She needs to know the time in which the cake should be baked.
- 'how hot' the oven should be. She needs to know the temperature of the oven.

Each of these quantities — mass, length, time and temperature—is expressed using a number and a unit. For example, the mass of a breadfruit might be 2 kilograms. The basic unit of length is the metre (m). For measuring small lengths, smaller divisions of the metre are used. Two of these divisions are the centimetre (cm) and the millimetre (mm). There are also larger units of the metre. One of these is the kilometre (km).

\[
100 \text{ centimetres (cm)} = 1 \text{ metre (m)}
\]
\[
1000 \text{ millimetres (mg)} = 1 \text{ metre (m)}
\]
\[
1000 \text{ metres (m)} = 1 \text{ kilometre (km)}
\]

The basic unit of mass is the kilogram. There are units smaller than the kilogram (kg). Two of these are the gram (g) and the milligram (mg).

\[
1000 \text{ grams (g)} = 1 \text{ kilogram (kg)}
\]
\[
1000 \text{ milligrams (mm)} = 1 \text{ gram (g)}
\]

The basic unit of time is the second (s).

\[
60 \text{ seconds (s)} = 1 \text{ minute (min)}
\]
\[
60 \text{ minutes (min)} = 1 \text{ hour (h)}
\]

The basic unit of temperature is the degree Celsius (°C).

We need to take great care when writing scientific units. Here are some rules to remember:

- Always put a space between a unit and the number preceding it e.g. 2 km not 2km.
- Pay attention to which unit symbols are written in capital letters and which in common letters.
- Do not add 's' to symbols for plural — 2 km means two kilometres.
- Do not put full stops when writing symbols. The only symbols containing a full stop are in. (inches), m.p.h. and r.p.m.
- Note that the spacing should be 15 °C, not 15 °C.

History of measurement

Today we have various instruments for measuring mass, length, time and temperature.

However, before the dawn of civilisation there was little need for measurement. Man was interested only in the needs of his own family and relied on his judgement when it came to matters of 'how much' or 'how far'.
Early in his history, man discovered that he needed units of measurement in order to buy and sell land or goods. He, therefore used certain objects to serve as units of length and mass.

Length was usually measured in relation to some part of the human body.

Mass was measured in relation to certain plant seeds, and to stones of a certain weight.

During that time, science was not so developed for man to understand the nature of heat and why bodies became hot. He hadn’t the knowledge of how materials behaved when they were heated. Hence, it was very difficult for man to develop a device and a unit for measuring temperature.

In days of old, man used the movement of the moon across the sky to reckon time. The origin of our calendar goes back to the time when the Egyptian farmers watched the seasons of the year. They had learnt that the seasons are the guide to the planting and harvesting of crops. They reckoned time by the appearance of the moon. They made a calendar which divided the year into twelve moon months of thirty days each and added a holiday of five feast days at the end. This gave them 365 days. This same calendar has come down to us 6000 years later. Clocks were developed to divide the days into parts. In the earliest times there was no need to do this with any great accuracy. It was sufficient to rely on devices such as the sundial, water-clock and sand-clock.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubit</td>
<td>The average length of a man’s arm from elbow to the tip of his fingers.</td>
</tr>
<tr>
<td>Inch</td>
<td>Width of a man’s thumb taken at the first knuckle.</td>
</tr>
<tr>
<td>Foot</td>
<td>The average length of a man’s foot.</td>
</tr>
<tr>
<td>Yard</td>
<td>Standardised by King Henry I of England. A length measured from the tip of his nose to the end of his outstretched hand.</td>
</tr>
<tr>
<td>Grain</td>
<td>The weight of a barley corn seed gathered from the middle of an ear.</td>
</tr>
<tr>
<td>Stone</td>
<td>The average weight of a stone in the field.</td>
</tr>
</tbody>
</table>

Fig. 2.2 The origin of units of measurement
A need for standards

You have seen some ways in which man measured mass, length and time. However, these ways did not work well. Let us see why.

Activity: Select a laboratory bench and measure its length in 'hand spans'. (A 'hand span' is the distance between the tip of the thumb and the tip of the 'little' finger of the outstretched hand).

Fig. 2.3. A hand span

If your length in 'hand spans' is a whole number and part of a hand span, express that part as an approximate fraction of a hand span e.g. 13.5, 15.75 etc. Work in groups of six or seven and record your measurements in a table like this.

Table 2.2 Measurements of the length of a laboratory bench, using 'hand spans'.

<table>
<thead>
<tr>
<th>Name of student</th>
<th>Length of laboratory bench</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfred</td>
<td>13.5</td>
</tr>
<tr>
<td>Bibi</td>
<td>15.75</td>
</tr>
<tr>
<td>Billy</td>
<td></td>
</tr>
<tr>
<td>Cathy</td>
<td></td>
</tr>
<tr>
<td>Devindra</td>
<td></td>
</tr>
<tr>
<td>George</td>
<td></td>
</tr>
</tbody>
</table>

Answer all these questions:
1. Whose measurements are the same?
2. Why are they the same?
3. Whose measurements are different?
4. Why are they different?
5. Since we measured the same desk, why didn't we all get the same answer?

From your answers you should be able to see that if we do not measure lengths using a fixed standard we would end up with different answers for the same length. Hence, when we standardise a unit we make reference to a standard or fixed length from which all other measurements are taken.

The standard unit of length is the metre. An early definition of the metre is the distance between two fine scratches made on a certain platinum iridium rod kept in Paris. The metre is further divided into 100 equal parts, each part being called a centimetre. The centimetre is subdivided into 10 equal parts, each part being called a millimetre. You can see why it is called a millimetre or one thousandth of a metre.

In your laboratory you have metre rules. These rules are the same length as the standard metre.

1 millimetre = 1/10 centimetre
1 centimetre = 1/100 metre
1 millimetre = 1/10 of 1/100 metre = 1/1000 metre

Measuring lengths

In the previous section we used 'hand spans' to measure the length of a laboratory bench. Almost every result was different. We saw that we needed a standard. In measuring lengths the
standard instrument is the **metre rule**.

Study Fig. 2.4. We want to measure the length of the line "MN".

**Fig 2.4 (a)** Measuring the length of a line 'MN'
Position of eyes at point A

Your eyes should be directly above point 'M', that is, at 'A' for a proper reading to be taken. This position is shown in Fig. 2.4(a).

Your eyes should be perpendicular to point 'M' as you place the beginning of the scale of your rule at 'M'.

**N.B.** The beginning of the scale of your rule may not be at the edge of the rule.

**Now move your head along.** Position your eyes to be perpendicular to the other end of the line i.e. to 'N'. This new position is shown in Fig. 2.4 (b) at point 'B'. Your eyes should be directly above 'N' as you read the scale, at point 'N'.

**Fig 2.4 (b)** Measuring the length of the line 'MN'
Position of eyes at point B

It is important to remember that the eyes should be directly above the point at which the measurement is being taken. This position is shown at position A. If the reading is taken with the eye viewing along 'CN' as in Fig. 2.4 (c) it will appear too high.

If the reading is taken with the eye viewing along 'DN' it will appear too low. Fig. 2.4 (d).

The accuracy of your measurements does not depend only on how you read the instrument, but also on the scale that is read.

How long is the line in Fig. 2.5. Is it 9 cm? or is it 8.9 cm?
Fig. 2.5(a)  Measuring the length of a line.
Note where the line ends in Fig. 2.5(a)
The line stops just before 9 cm.

Fig. 2.5 (b)  Measuring the length of a line
Note where the line ends in Fig. 2.5(b)
The line stops just before 9 cm. In this figure it is possible to count the number of small spaces between 8 and 9 cm. The line stops at the 9th space. This represents 8.9 cm.

Activity 2.1: Estimating lengths
Here are some exercises for you.
1. Measure the lengths of various objects e.g. exercise books, desk tops, distances between lines.
2. Copy the table given and then carry out the following instructions:
3  Estimate or make a guess of the length of the lines numbered 1 to 5.
4  Record your estimates in your table.
5  Now measure the lines to the nearest millimetre.
6  Record your measurements in your table.
Compare your estimates with your measurements. Were you good in making estimations of length?

Here are the lines:
1. 
2. 
3. 
4. 
5. 

Measuring lines

<table>
<thead>
<tr>
<th>LINE NUMBER</th>
<th>ESTIMATED LENGTH</th>
<th>MEASURED LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity 2.2 Measuring lengths
1. Measure the circumference and diameter of a cylindrical object or a circular object.
2. Copy the table below in your exercise books and record your results in the various columns.

<table>
<thead>
<tr>
<th>Object</th>
<th>Circumference</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A coin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A milk can</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A test-tube</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A coffee bottle cover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A nut-butter bottle cover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A cake pan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Measuring mass

We learnt how necessary it is to standardise our measurements. In that Section, we also learnt that the standard unit of mass is the kilogram. We will, however, in our everyday life, be dealing with objects whose masses are less than or greater than one kilogram.

In the market or shops, we can buy plantains, eddoes, sugar, flour and other goods. We often purchase these 'goods' in pounds and ounces. These are units of measurement for mass in the British System of units.

However, in the Metric System we always measure masses in grams or kilograms. We sometimes use the term weight when we really mean mass.

For example, we say that the weight of the plantains is five pounds. What we really mean is 'the mass of the plantains is five pounds'. Similarly in the Metric System of units we cannot say that the weight of the object is five kilograms. When we speak about the mass of an object, we are referring to the amount of matter that makes up that object. An object of a certain mass would have the same mass no matter where that object is taken – to the Moon or to any of the planets. In measuring the mass of an object we use the balance.

There are many kinds of balances. The 'scale' and weight' that the shop keeper uses, is one kind of balance. The triple beam balance, the lever arm balance and the equal arm balance, are balances we use in the laboratory.

Fig. 2.6 The lever arm balance

How to use the Lever arm balance.
1. Set the balance on a level surface.
2. Adjust the levelling screw (adjusting screw) by turning it clockwise or anticlockwise until the lever-arm points to zero.
3. Place the object whose mass is to be found on the scale pan.
4. Wait until the arm settles to a steady reading and record the mass.

Activity 2.3: Measuring mass
1. Obtain an empty tomato paste can.
2. Determine the mass of the can.
3. Fill the can with each of the named substances in turn: water, coconut oil, kerosene, sand, clay.
4. Determine the mass of each can full of the substance.
5. Record your results as shown:
Mass of empty can = ................. g
Mass of can + water = ................. g
Mass of can + oil = ................. g
Mass of can + kero = ................. g
Mass of can + sand = ................. g
Mass of can + clay = ................. g

From your results, calculate the mass of each of the substances. Do all the substances have the same mass?

Estimate (guess) the mass of each item listed below. Then determine the mass of each item by using a balance. Record your results as shown in the table.

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated mass (g)</th>
<th>Measured mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>orange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>banana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lawn-tennis ball</td>
<td></td>
<td></td>
</tr>
<tr>
<td>small rock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>size-D cell</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Were you good in making estimates?

**Measuring temperature: How hot is it?**

In our everyday life, sometimes we hear persons say — ‘It is very hot today’ or ‘This room is very hot’ or ‘Don’t touch the electric iron, it is hot’. When we express our feelings in this way about the ‘hotness’ of an object or our surroundings, we are speaking about the temperature of the object or surroundings. Temperature is a measure of the degree of ‘hotness’ or coldness of an object.

In the previous sections, we learnt that there was a need to have standards for length and mass. Similarly, we need to have a standard for temperature. The sense of touch is not a reliable ‘instrument’ for measuring temperature. Perhaps the following exercise will help you to understand why we cannot rely on our sense of touch to measure temperature.

**Activity 2.4: Measuring temperature**

Can we trust our sense of touch to indicate hotness?

1. Obtain three beakers and fill one with ice-cold water, the other with tap water and the third with warm water (70 - 80° C).
2. Place the index finger of your right hand and that of your left hand into the warm water and cold-water, respectively.
3. Remove your fingers from the hot and cold water and place them both in the tap water.
4. Describe, how your fingers felt when they were placed in the tap water.

![Fig 2.7 Trying to sense hotness](image)
Could we rely on our sense of touch to measure temperature? Both of your fingers were placed in the same water - the tap water, yet they felt different. If a thermometer had been used in the same manner, the difference in temperature between the tap water and the hot or the cold water would have been shown. We use an instrument called a thermometer for measuring temperature.

Temperature is measured in degrees. Two temperature scales are currently in use - the Celsius scale and the Fahrenheit scale. The two scales would give different readings if we measure the temperature of an object - say a beaker of melting ice. On the Celsius scale the reading would be 0 °C whereas on the Fahrenheit scale it would be 32 °F. Similarly, if we were to measure the temperature of boiling water, under certain conditions, we would get a reading of 100 °C on the Celsius scale and 212 °F on the Fahrenheit scale.

It is necessary for us to know the temperature of objects, substances or even our surroundings. Have you ever seen what happens to a cake which has been baked in too hot an oven? The nurse will also need to know the temperature of a patient to determine whether or not the patient has a fever. The normal body temperature is 37 °C. A knowledge of the temperature of the atmosphere assists the weatherman in making forecasts. Workers in a foundry need to know the temperature of the furnace. Most of the countries of the world now use the Celsius scale of temperature in industry as well as in everyday life.

**Making instruments to measure temperature**

When solids, liquids or gases are heated they expand — they occupy a larger space or volume. When they are cooled, they contract i.e. they become smaller. These exercises will show you how substances behave when they are heated.

**Activity 2.5: Effect of heat on air**

1. Obtain a drink bottle or any similar bottle.
2. Place a deflated balloon over its mouth.
3. Make sure that the balloon is properly secured on the mouth of the bottle by tying it with a piece of string.
4. Place the bottle with the balloon in a beaker of warm water. The beaker should be large enough to hold the bottle.

Now answer the following questions:
1. What is in the empty bottle?
2. What happens to the balloon when the bottle is placed in the water?
3. Explain why the balloon behaves in this way. Remove the bottle with balloon from the water and let it stand in the open air for a while.
4. What have you now noticed?
5. Give an explanation for your observations.

**Activity 2.6: Effect of heat on liquids**

Heating and cooling a bottle with a refill/straw through its cork.
1. Obtain a medicine bottle with a rubber stopper.
2. Obtain an empty refill of a ball point pen (i.e. the plastic tube that contained the ink) or a clean plastic straw.
3. Pierce the rubber stopper with a small nail.
4. Push the refill from the top of the stopper
through the stopper until the refill comes to
the surface of the other side of stopper.
5. Fill the medicine bottle with coloured water.
6. 'Cork' the bottle with the stopper.
7. The coloured water will rise in the refill.
Mark the level of the liquid in the refill with
your pen. (You may need to attach a card-
board to the refill and put your marks on the

Place the bottle in :-
(a) the palm of your hand
(b) warm water
(c) cold water

In each of the cases (a), (b), and (c), let your
class-mate mark the level to which the liquid
rises or falls.

Now answer these questions.
1. In which case does the level
   (a) rise most?
   (b) fall the most?
2. Why does the level rise or fall?
3. In which case does the level rise the most?
4. What causes the level of the liquid to rise or
   fall?

Making a 'liquid'-in-'glass'
'thermometer'

In making a 'liquid-in-glass' thermometer, we
usually use one of the two liquids, alcohol or
mercury. These two liquids are chosen because
they have special properties. Thermometers which
use alcohol are mainly used in cold countries
because alcohol freezes at a temperature far
below 0 °C. However, they cannot be used to
measure temperatures greater than 78 °C since
alcohol boils at that temperature. Mercury or
'quick silver' is used in many thermometers
because it boils at 360 °C. Hence this type of
thermometer can be used to measure
temperatures up to 360 °C. This thermometer
cannot however, be used in very cold regions of
the earth.

Here is how a thermometer is made.

First a long glass tubing (about 25 cm in
length) with a fine bore is obtained. One end of
the tubing is sealed by heating it in a flame. A
bulb is then blown at this sealed end. This is done
by constantly heating the sealed end in the flame
and at the same time blowing hard from the open
end so as to form a bulb. The tubing is now filled
with either coloured alcohol or mercury. The
liquid is allowed to fill the bulb and a small
portion of the stem.

Calibrating the thermometer

To calibrate the thermometer i.e. to mark a scale
on the stem, the following procedure is carried
out. The bulb of the thermometer is placed in a
filter funnel of pure melting ice. The mercury
contracts until it moves no further in the stem. A
mark is then made on the stem. This point is
labelled 0 °C and is the lower fixed point on the
Celsius scale.

The bulb of the thermometer is now placed
over steam. The mercury in the bulb expands
until it can move no further up the stem. A mark
is then made on the stem of the thermometer.
This point is marked 100 °C and is the upper fixed
point on the Celsius scale. The top of the stem is
then quickly sealed by heating it with a hot flame.
This is to prevent air from entering the
thermometer.
The laboratory thermometer

The laboratory thermometer, like any other thermometer, e.g. the clinical thermometer (the one that a nurse uses), is very fragile. It must be handled with care.

- Always hold the thermometer by its stem.
- Never hold the thermometer by its bulb.
- Only one person should hold a thermometer to take a reading.

Here is a diagram of a laboratory thermometer

The length of the stem between the 0°C mark and the 100°C mark is now divided into 100 equal divisions. Each division corresponds to 1°C

Activity 2.7: Using a laboratory thermometer

1. Examine a laboratory thermometer carefully. The bulb of the thermometer contains
mercury or the shiny substance called 'quicksilver'. This is the part of the thermometer which should be placed in the substance to be measured. The stem of the thermometer is a capillary tube of very fine bore.

2. Place the bulb of the thermometer in some warm water. Notice what happens to the mercury thread. When the temperature changes, the mercury in the bulb expands and moves into and up the capillary tube. The mercury is seen as a fine 'thread' in the tube. Note the temperature reading on your thermometer.

The scale on this thermometer is in degrees Celsius. The scale is marked or inscribed on the stem. This thermometer can measure a temperature of 10 degrees Celsius below the freezing point of water or ice. It is marked –10 °C. Place the thermometer in a mixture of salt and ice. Record the temperature.

The thermometer can also measure a temperature of 110 °C or 10 degrees above the boiling point of water.

Above the mercury in the tube, there is no air. It is a vacuum.

Use your thermometer to measure the temperature of:

1. The air in the classroom.
2. Some tap water in a beaker.
3. The air just above the surface of the soil near the lab.
4. The classroom at:
   (a) 9.00 a.m  (b) 10.00 a.m
   (c) 11.00 a.m  (d) 12.00 noon
   (e) 1.00 p.m  (f) 2.00 p.m

Measuring time

At what time does school start? When is your birthday? How much longer is it before vacation time?

Can you imagine what would happen if our time-keeping instruments were not exact? Today, because of advances in modern electronics, we have time-keeping devices which are very accurate e.g. clocks used to time events at games such the Olympics.

Why do we want to know about time? We want to know about time to order our events in sequence and to know how long they would last. Can you think of some other reasons? It is quite interesting to note that plants as well as animals are time-conscious. Can you think of some activities that animals do as well as what plants carry out at certain times?

Time is usually measured by some event that continually repeats itself in what is believed to be a regular manner. Here is an example—the motion of a planet. Can you think of some others?

Some ancient ways of measuring time

We learned in the previous section that people in ancient times used the moon to measure time. One moon-month was the time taken by the moon to go through all its phases. As life grew more complicated and people wanted to meet each other and order their events, they needed to be able to tell the time of day. Man had to think of ways of measuring how the time was passing during a day.
The first time-keeping instruments used was the **shadow clock**. This consists of a piece of stick pushed into the ground. (see Fig. 2.11). Beyond the tropics, the shortest shadow is at noon and points to the north in the northern hemisphere and in the southern hemisphere, it points to the south. Can you tell in which hemisphere Guyana is?

Look at the diagram. In which hemisphere is the shadow clock being used?

![Fig. 2.11 The shadow clock](image)

The **sundial** consists of a horizontal circular plate called the **dial plate** and a triangular bar called the gnomon. The edge of the **gnomon** is called the style. For this device to give accurate time, the angle which the gnomon makes with the dial plate must be equal to the local latitude of the location where it is to be used. Furthermore the gnomon must point to the north or south. Can you identify the difficulty here if there is little or no sunlight or if you are indoors?

The Chinese, Egyptians and Romans invented **water clocks** to mark off the hours of the day and night indoors. See Fig. 2.13

![Fig. 2.13 The water clock](image)

Here is something for you to do. Make a shadow clock in your school compound. Mark the position of the shadow at noon, when school begins in the morning and when it begins in the afternoon. Draw the model in your science book. Earlier, you were told of other ancient time-keeping devices. Look at the Fig. 2.12 and try to identify the different features of the sundial.

![Fig. 2.12 The sundial](image)
Fig 2.14  The hour glass

Here is another ancient timer, the hour glass or sand glass. (see Fig. 2.14)
Can you say what this timer is used for today? How is it used?

Fig 2.15  The Japanese lamp clock

Fig. 2.15. shows the diagram of a lamp clock used by the Japanese. Can you explain how this clock works?

The candle clock shown in Fig 2.16. gives an idea of what a candle clock looks like. Can you explain how this clock works?

Fig 2.16  The candle clock

The year and the day

The day and the year have always been natural units of time. Man knew about the passing of the day long before he knew about the cause of it. The day was considered to be the time between one sunrise and the next. The day was divided into twenty four units. The year, however, was based on the earth’s movement around the sun – once in 365 days.

Modern ways of measuring time

Today, instruments for measuring time are great in variety. The advent of the integrated circuits and other important developments in the world of electronics have contributed greatly to the vast improvement in time-measuring devices. Although spring and pendulum clocks are still in operation, we are now presented with clocks in digital forms. We have night dials and even clocks that ‘talk’ and tell the time hourly (see Fig 2.17)
minute. The *second*, however, is now used as the *standard* unit of time in the international system. The second is based on a certain number of vibrations of the caesium atom. The time interval of vibration is constant and does not vary or change.

**Using clocks**

Clocks are now available in a variety of shapes and designs. Apart from telling time they are used as ornamental decorations. They are now made so that one could be in bed, hear the time and also see the time in the dark because of the luminous dials. Can you list some important activities that would be impossible without using clocks? Can you name some types of clocks which you have seen?

**Measuring areas**

Imagine that you are a farmer. You need some fertiliser. The label on the package says that 1 kg of the fertiliser can be used for 500 m² of soil.

Would you know how much of the fertiliser you should buy for your fields?

The problem just described is one involving *area*. If we could calculate the area of your field, we would then be able to calculate how much fertiliser you would need. Thus, if the area of a field is 10 000 m², then the quantity of fertiliser to be bought is 2 kg.
Like the farmer, the agricultural scientist finds an understanding of area quite useful. In fact, all scientists make use of ideas about area at one time or another. An understanding of area helps too, in many of our daily activities. Let us therefore see how much we can learn about area.

**What is area?**

Area is a measure of the size of a surface. Look at the two rectangles below. Can you tell by just looking, which one has a larger size? Which is larger, A or B?

![Figure 2.19](image1) Which is larger, A or B?

Let us now divide up each rectangle into squares 1 cm x 1 cm. (See Fig. 2.20). On counting the number of squares, we notice that rectangle A has 20 squares, whereas rectangle B has only 18. Thus A has more square centimetres than B. We say that A has a larger area than B.

![Rectangles A and B divided up into square centimetres](image2)

**Making instruments to measure area**

Since area is simply the number of square units contained by a surface, we can make some simple instruments to measure area.

**The quadrat**

Biologists use a quadrat to enclose an area 1 m². A quadrat can be made by nailing together four sticks to form a square 1m x 1m.
Activity 2.8: Making and using a quadrat.
1. Make a quadrat.
2. Place it on the ground in your school yard, and then count how many plants of a certain kind are on the 1m² of that soil that you chose.

Squared paper

Haematologists (persons who study about blood) use a glass slide ruled up in tiny squares to measure tiny areas. They often count the number of red blood cells (r.b.c.) or white blood cells (w.b.c.) within a small area. In that way they can tell if your r.b.c. count or your w.b.c. count is high or low.

We could use the idea of the glass slide ruled up in tiny squares as a pattern in making an area measurer.

Activity 2.9: Making a squared paper Area Measurer.
1. Make an area measurer like this. Use a sheet of airmail or 'onion skin' paper.
2. Mark off, on opposite sides of the paper 1 cm spaces. Work accurately.
3. Connect the corresponding dots.
4. Paste one end of the chequered sheet onto a sheet of thin cardboard. This cardboard should be the same size or slightly bigger than the 'onion skin'.
5. Place the object whose area you want to measure between the onion skin and the cardboard backing. (See Fig. 2.24) You should now have a chequered sheet on thin cardboard, of the same size as or even bigger than the sheet.
6. Make another area measurer, using a sheet of metric graph paper instead of your 'homemade' chequered sheet, and mount it on thin cardboard.

Measuring area of regular shapes

Look again at the rectangles in Fig. 2.20. The number of square centimetres in A is 20. Did you notice that this number is the length (5 cm) x the width (4 cm)? Can you see a similar pattern in rectangle B? In fact, for any rectangular shape the area can be calculated using the formula –

\[
\text{Area} = \text{length} \times \text{width}.
\]

Area is always measured in square units. When the unit used for measuring each side is centimetre (cm), the area unit is square centimetre (cm²). When the sides are measured in millimetres (mm) the area unit is square millimetres (mm²). When the sides are measured in metres (m), the area unit is square metres (m²).

The farmer should know that 1 hectare = 100 m x 100 m = 10 000 m². If you pay careful attention to your mathematics courses, you will
learn of formulas for other regular shapes. We mention two here:-

Area = \( \pi \times (\text{radius})^2 \) for a circle

Area = base \( \times \) perpendicular height for a triangle.

**Measuring area of regular surfaces**

*Activity 2.10:* Using an area measurer.

1. Get a sheet of newspaper and container with a little water. (You could add some dye or ink to the water to make its effect more prominent).
2. Spill a little water on the newspaper.
3. Draw a line around the edge of the water-spill. We will now try to find the area of this irregular shape. (See Fig. 2.23).
4. Use the area-measurer you made, slipping the irregular shape under the chequered sheet.
5. Then use the metric graph paper, ruled in cm and mm, to measure the irregular area outlined. It might be best to place the news-sheet on the graph paper and trace the outline on the graph sheet using carbon paper.

6. Count the number of whole square centimetres within the outline. Mark each whole square with a tick (\( \checkmark \)).

7. How many squares are there? Next, count all the incomplete squares. Mark each incomplete square with a cross.
Measuring volumes

Question: How much space does the object take up? How much space is in the object?

The nurses arrive at the primary school. They set out their equipment. The children form a line. The nurse places the hypodermic needle into the diphtheria and tetanus vaccine bottle and draws up some of the liquid. (See Fig. 2.25). She injects the measured vaccine into a pupil’s arm.

How many incomplete squares are there? Half that number. (In dividing by two, the large bits compensate for the little bits). Add the two figures. The approximate area of the irregular shape is $10 + \frac{12}{2}.$

i.e $10 + 6$

$= 16 \text{ cm}^2$

Activity 2.11: Using (a) 'home-made' area measurer and (b) metric graph paper to measure irregular shapes.

1. Try to estimate the area of a mature hibiscus leaf and of a small young hibiscus leaf.
2. Use your 'home-made' area measurer to find the approximate area of the larger leaf.
3. Use the metric graph paper to find the approximate area of the smaller leaf.

Note: You should do each measurement at least three times. The average would be more accurate.

What if the nurse had measured the vaccine incorrectly?

Could the child get seriously ill from an over dose of vaccine? Would the child be immunised if too little vaccine was used?

As with area, an understanding of volume and how volume is measured is important. This understanding is useful in all branches of science as well as in daily living. In this section we will be learning how to measure volumes.
What is volume?

By volume we mean a quantity of space. Volume includes air space if the object is hollow. Can you suggest how much kerosene-oil fills a one-burner stove or how much gasoline fills the tank of a car? Write down your estimate of the volume of each.

You may have written down pints, and fractions of a pint; gallons and fractions of a gallon. This is the System of Imperial Units. But, as scientists and mathematicians, we must refer to volumes using the International System of Units.

Common units of volume used by scientists are the cubic metre (m³), the cubic centimetre (cm³) and the cubic millimetre (mm³). The volume called 1 litre (l) occupies 1000 cm³. One cubit 1 cm³ is therefore 1 millilitre (1 ml).

Making instruments to measure volume

Activity 2.12 : Making a measuring instrument.

Work in groups of two or three.

1. Make an open cube of side length one centimetre using cardboard. (See Fig 2.26a). What would its volume be? Let us see! The area of the bottom of the cube is 1 cm x 1 cm. That is 1 cm². The height of the cube is 1 cm. So the volume would be 1 cm² x 1 cm. That is 1 cm³.

2. Make another open cube with the length of each side two centimetres. (See Fig. 2.26b) What would the volume of the second cube be? Surely 2 cm x 2 cm x 2 cm i.e 8 cm³.

(a) Does eight cubic centimetres of sand fit into cube (b)? (Find out by using the small cube i.e (a), of volume 1 cm³, to fill the second cube, (b).

How many of the small cubes, i.e (a), would it take to fill the cube, (c), where the side-length is three centimetres? (See Fig. 2.26 c)

The area of the bottom of the cube is 3 cm x 3 cm = 9 cm². The height of the cube is 3 cm. So the volume would be:

9 cm² x 3 cm = 27 cm³.

(b) Does 27 cm³ of sand fit into this cube? Find out by using the small cube to fill the cube in Fig. 2.26(c).

How many 1 cm³ are in the cube in (c)?

Fig 2.26  (a) A cube 1 cm x 1 cm x 1 cm
(b) A cube 2 cm x 2 cm x 2 cm
(c) A cube 3 cm x 3 cm x 3 cm

3. Get a transparent bottle, dry sand and a funnel. The bottle must be of uniform cross-section, and not be larger than about 4 cm in diameter.

4. Fill the 2 cm x 2 cm x 2 cm cube with sand and, having placed the funnel in the mouth of the bottle, empty the sand into the bottle. Shake the bottle gently to ensure that all the sand goes down and that the surface of the sand is level.

5. Stick a strip of paper along the bottle and on it mark the level of the sand. Write ‘8 cm³’ beside the mark.

6. Fill the cube again, empty all the sand into the bottle, and get the new surface of the sand
Make another mark on the strip at the new surface of the sand and write '16 cm³' beside the new mark.

7 Repeat until the bottle is full. Empty the bottle. You have *calibrated* the bottle and now have a measuring bottle.

If the level is in between two marks, estimate the number of cubic centimetres. To improve on accuracy you should take two or even three readings of the same volume and find the average.

**Irregular solids**

A famous scientist once got into a full bath. Of course water overflowed. But in that moment Archimedes discovered a way of finding out the volume of irregular solids. He ran out of the bathroom, as he was, shouting "I've found it! I've found it!". The over-flow method of measuring volume is called measurement by 'displacement.'

**Activity 2.14: Measuring volumes of irregular objects**

1. Collect some irregular objects.

2. You will need your measuring instrument, a large vessel e.g. a jar, a large tin or trough and a funnel.

3. Place the vessel in the tin, then fill it to the brim and carefully immerse one of the objects.

4. Collect the water that overflowed into the tin.

5. Using the funnel, pour the water that overflowed, into the measuring instrument.

6. Read the level of the water.

7. Repeat steps 3-6 two or three times and find the average volume of that object.

8. Repeat steps 3-6 for the other irregular objects.

Still working in groups use the measuring instrument you have made to find the volume of a soft-drink bottle. Work carefully and accurately as follows:-

**Activity 2.13: Measuring the volume of a soft-drink bottle.**

1. Fill the soft drink bottle to the brim with water.

2. Using a funnel in the mouth of the measuring instrument, pour the water into it.

3. *Put your eye on a level with the water level* (called the meniscus). (See Fig. 8.1) Read off how many cubic centimetres of water there are.
Regular solids

Activity 2.15: Measuring volumes of regular solids
1. Collect some regular objects, e.g. a rectangular block of metal, glass, or wood.
2. Find the volume of each object, by displacement of water.
3. Measure the length, breadth and height of the regular objects.

What is the relationship of these dimensions to the volume found by displacement?
We can calculate the volume of regular objects using the formula \( V = l \times b \times h \) where 'V' represents volume, 'l', length, 'b', breadth and 'h' height.

Changing the shape

Still working in groups make some models of rectangular solids of Plasticine, kneaded clay or stiff dough.

Find the total surface area of each and then the volume. Do this by measuring lengths. Alter the shape to make the solids more flat. Find the new surface area.

Exercises
1. State why measurement units had to be standardised.
2. State three situations in everyday life where measurement is important.

3. Convert the following to metres
   (a) 147 cm
   (b) 84 cm
   (c) 63 cm
   (d) 973 mm

4. A book has 200 pages and has a thickness of 8 mm. What is the thickness of a leaf of the book in mm?

5. A ream of paper (500 sheets) is made up of sheets each 0.05 mm thick. What is the thickness of the ream in cm?

6. A certain type of paper has a thickness of 0.1 mm. How many sheets of this paper would be needed to make a thickness of 2.0 cm? If a ream of paper is 500 sheets, how many reams of this paper are required?

7. Make a two - metre measuring tape by cutting strips of cardboard and pasting them together, end to end.

   (a) Using a metre, mark off your tape in centimetres.
   (b) Paste the tape on the wall.
   (c) Measure the height of the boys and girls in your group and record their heights to the nearest cm.
   (d) Collect all the recorded heights from the other groups and construct a bar chart using the collected data.

Here is an example for you.
Table 2.3 shows part of a list of heights of pupils in a class and how their heights have been grouped.
RECORDED HEIGHTS

Table 2.3

<table>
<thead>
<tr>
<th>Heights(cm)</th>
<th>Number of pupils</th>
<th>Height shown on graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>121 — 123</td>
<td>1</td>
<td>122</td>
</tr>
<tr>
<td>124 — 126</td>
<td>1</td>
<td>125</td>
</tr>
<tr>
<td>127 — 129</td>
<td>2</td>
<td>128</td>
</tr>
<tr>
<td>130 — 132</td>
<td>2</td>
<td>131</td>
</tr>
<tr>
<td>133 — 135</td>
<td>3</td>
<td>134</td>
</tr>
<tr>
<td>136 — 138</td>
<td>5</td>
<td>137</td>
</tr>
<tr>
<td>139 — 141</td>
<td>6</td>
<td>140</td>
</tr>
</tbody>
</table>

The figures in the table have been used to construct the bar-chart shown in Fig.2.28.

9. Try the following:
   Obtain the following items:
   50 'common-pins' of the same size
   50 tooth-picks all of the same size

   Put one 'common' pin on your balance. Are you able to measure its mass accurately in this way? Can you think of how we may find the mass of one pin? Determine the mass of the tooth-pick and a one-cent piece.

10. Determine the mass of each of the following:
    a pencil, a twenty-five cent piece, a ball-point pen, an exercise book.

11. Obtain the following items:
    an orange, a banana, a lawn-tennis ball, a small rock, a size-D battery (cell).

12. Determine the mass of the following objects from the readings taken from a lever arm balance to register the following masses. The first answer is 146

From the data that you have collected from your class, answer the following questions.
<table>
<thead>
<tr>
<th>Object</th>
<th>1st Beam</th>
<th>Centre Beam</th>
<th>3rd Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>100</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>2.5</td>
<td>400</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>200</td>
<td>40</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>9</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>G</td>
<td>8.9</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>H</td>
<td>5.5</td>
<td>500</td>
<td>50</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>J</td>
<td>7</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

11. Give positions of the sliding masses on the three beams of a triple beam balance to register the following masses. The first is done for you.

<table>
<thead>
<tr>
<th>Mass</th>
<th>1st Beam</th>
<th>Centre Beam</th>
<th>3rd Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>164</td>
<td>4</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>9.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>221</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>608</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>103</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. Who is right?

Atosha, Shona, Raymond and Ravi were arguing. They had been playing on a swing in Shona's yard. "The swing went fastest with me on it," boasted Atosha. "What do you mean by fastest?" asked Raymond. "It swung more often," replied Atosha. "It swings faster because you are the heaviest. Anything swings faster with a heavier lump on it," chuckled Shona. "I swung the fastest because the length of the rope was longer when I was on the swing," added Raymond. We all swung at the same rate, said Ravi, trying to stop the argument.

What experiment can you do in the laboratory to find out:

(a) if Shona is right?
(b) if Raymond is right?
(c) if Ravi is right?

(Make sure you state what laboratory equipment you would use).

13. In Unit 1, when you mixed chemicals, you observed colour changes, fizzing and temperature changes.

Do these mixing exercises again, and answer the following questions:

(a) How long do the chemicals take to give a complete colour change?
(b) How long does the fizzing last?
(c) How long does the temperature remain constant?

14. Draw a clock like the one in Fig. 2.29 and label as shown in the diagram.
Fig 2.29 The twenty-four hour clock

(a) What kind of clock do you call this one?
(b) What time would the clock read at midnight?
(c) Write down what would one a.m. be on this clock?
(d) What would twelve noon be?

15. If 4 litres of paint will cover 30 m² of surface, how much paint will be needed for a wall 15 m x 3 m?

16. A piece of metric graph paper is divided up into cm and mm.
   (a) How many mm are there in 1 cm?
   (b) How many mm² are there in 1 cm²?

17. (a) How many cm are there in 1 m?
   (b) How many cm² are there in 1 m²?

18. Use your area measurer to find the area of this shape, in mm².

19. (a) Calculate in mm² the area of a flat side of a $5 coin by measuring its diameter and using the appropriate formula.

20. (a) Calculate the area of a $20 note by measuring the lengths of its sides and using the appropriate formula.
   (b) Find the area of the $20 note using your area measurer.

21. "Leaves from a mature Hibiscus plant are larger than leaves from a mature guava tree." Carry out an experiment to find out if this statement is true.

22. (a) Can you make a large area fit into a small space? (Hint: Use a piece of paper and fold it to form an accordion shape.)
   (b) Now look at the following:
      (i) a fish gill
      (ii) a gasoline filter from a car.

23. Find the areas of the following:
   (a) the cover of a match box
   (b) the bottom and sides of a tomato paste tin can.
   (c) a set square.

24. (a) If each of 40 pupils is to be given 0.25 litre of milk, how much milk, in ml (millilitres) has to be made?
   (b) If a 2 litre pot is used, how many times must that amount of water be boiled to prepare the milk for the 40 pupils, allowing 0.25 litre for each child.

25. (a) A House-Service truck, with crates of soft-drinks, has a covered tray 2.5 m high. Assuming that each crate is 30 cm high, how many crates can be packed in one column from floor level of the tray to the roof level?
(b) Assuming that each bottle of drink has 250 ml how much drink is in the 24 bottles in each crate?

26. Given that the height of a stack of one hundred such notes is 1.8 cm, calculate the approximate volume of one note.

27. (Practical)

Calibrate a boiling tube in ml. (cm$^3$). Paste a strip along the length of the boiling tube. Use the same portion of a measuring cylinder. Add 1 ml of water to the boiling tube. Mark the water level on the paper. Add another 1 ml of water. Mark the new water level. Continue until you get to the top of the tube.
Summary

WE HAVE LEARNT THAT

- the four basic quantities in science are mass, length, time and temperature.
- each of the basic quantities has a unit.
- how humans devised ways and means of measuring things before they developed a standard for each quantity.
- there is a need to establish standard units of measurements.
- the accuracy of your measurement depends on how accurate you are in reading the measuring instrument.
- the mass of an object is the amount of matter that makes up the object.
- we measure mass in kilograms and grams.
- temperature is a measure of the degree of 'hotness' of a body.
- temperature is measured in degrees Celsius or degrees Fahrenheit.
- when objects or substances are heated they expand and when they are cooled they contract.
- the temperature of pure melting ice is 0 °C at standard air pressure.
- the temperature of pure boiling water is 100 °C at standard air pressure.
- some instruments used in measuring time long ago are sundials, water clocks, candle and lamp clocks.
- the emergence of the day and year as units of time is based on the movement of the planet earth.
- the modern ways of measuring time involves using specialised clocks.
- the use of clocks plays an important part in ordering our daily events.
- the standard unit of time is the second.
- in all branches of science in daily life an understanding of area is useful.
- area is a measure of the number of square units enclosed within a surface.
- some common units of area are m², cm² and mm².
- two instruments for measuring area are the quadrant and squared paper.
- area of regular shapes can be found by measuring lengths and using appropriate formulae.
- in all branches of science in daily life an understanding of volume is useful.
- volume is a measure of quantity of space.
- some common units of volume are m³, cm³ and mm³.
- one litre occupies 1000 cm³. One 'cm³' is therefore one 'ml'.
- an instrument you can make for measuring volumes is the measuring bottle.
- the volume of an irregular solid can be measured by the 'displacement of water' method.
- the volume of a regular shape can be found using the formula: \( V = l \times b \times h \) where 'V' represents volume; 'l' length; 'b' breadth and 'h' height.
3

Signs of life

In this unit we will learn

- the characteristics of living things.
- the feature(s) of an organism that is(are) related with each characteristic.
- how each external feature of an organism is adapted for its function.
- to use the laboratory and environment with due care and consideration.
- how to collect and store organisms.
- how to make simple classifications of living things.

Characteristics of living things

Earlier in this book you looked at things in the laboratory and in the school yard. You later grouped them into living things and non-living things. Living things were then grouped into plants and animals. What was it about plants and animals that helped you to group them as living things?

Here you are going to look more closely to observe the activities that are common to them, that is, the life processes or characteristics. Let us now walk around the school yard. Remember to take along a pencil and notebook.

Here is a list of non-living things someone could have observed in a yard.

List of non-living things found in a yard

<table>
<thead>
<tr>
<th>Wooden palings</th>
<th>Wood chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal pipes</td>
<td>Rocks</td>
</tr>
<tr>
<td>Bones</td>
<td>Waste bin</td>
</tr>
<tr>
<td>Earth</td>
<td>Water</td>
</tr>
<tr>
<td>Empty bottles</td>
<td>Polythene bags</td>
</tr>
<tr>
<td>Dead leaves</td>
<td>Blocks of wood</td>
</tr>
</tbody>
</table>

Here is another list with the names of plants and animals that could have been seen in a yard.

List of plants and animals found in a yard

<table>
<thead>
<tr>
<th>Plants</th>
<th>Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby-cucumber vine</td>
<td>Gnat</td>
</tr>
<tr>
<td>Sourie tree</td>
<td>Red ants</td>
</tr>
<tr>
<td>Mango tree</td>
<td>Spider</td>
</tr>
<tr>
<td>Shame-bush plant</td>
<td>Butterfly</td>
</tr>
<tr>
<td>West Indian cherry tree</td>
<td>Green lizard</td>
</tr>
<tr>
<td>Suriname cherry tree</td>
<td>Snail</td>
</tr>
<tr>
<td>Moss</td>
<td>Millipede</td>
</tr>
<tr>
<td>Soldiers’ parsley</td>
<td>Kiskadee</td>
</tr>
</tbody>
</table>
How do the living things in the second list differ from the non-living ones in the first list?

**Movement**

Think about the animals listed. What is the first thing you are likely to observe them doing when you look at them? Is it not that each would be moving? Animals fly, walk, pounce, run, crawl, jump or climb! Plants also show movement, but it is usually the leaf, stem, root or flower that does the moving.

**Growth**

A vine can take over a paling unless it is pulled away. With time, a mango tree grows taller than a house. The small millipede lengthens. The kiskadee gets bigger. So a second characteristic of living things is **growth**. Growth can be measured as an increase in length or weight.

![mature plant](image)

![sapling](image)

**Nutrition**

How do living things grow? Is it not as they eat food? Once they take in more food than their bodies need for energy, repairs and replacement, they get bigger or grow! Third, then, in our list of activities common to living things is **nutrition** — the taking in of food to nourish the body.
Respiration

As you looked at the various animals, did you see their bodies moving inwards and outwards? They were taking in air or, in other words, they were breathing.

Fig. 3.4(a) Living things respire

Excretion

When a fire burns, waste gases are given off and often ashes are formed. These waste substances are usually poisonous. Living organisms, as they burn up food to carry out their various activities, give off waste substances. These wastes need to be removed, else they too could poison the body. So the fifth characteristic of living things is excretion — getting rid of waste substances that were once part of the body. What are they?
Sensitivity

Non-living things cannot react to their surroundings. Living things can! The night is hot, a person sweats. The sweat evaporates. The persons becomes cool. That characteristic is sensitivity – being aware of changes in your surroundings, and being able to respond to the change.

Reproduction

There is one characteristic of living things that no non-living thing can show. A car moves, a car engine takes in fuel, needs air and gives off waste gases. Chemists could cause a crystal to grow. But never can a non-living thing produce more of its own kind. That characteristic is shown only by living things. The seventh characteristic, then is reproduction – producing more of the same kind.

External features related to each characteristic

How are living things able to carry out the life processes we discussed earlier? Let us now look at the external features which help the organisms to carry out these common activities.

There are two ways in which you could proceed with your study. You could begin with the characteristics of living things in mind, and look for external features related to each of the characteristics.
Let us imagine you in the school garden. You are focusing in on the characteristic of "Nutrition". As you look at, say, a grass plant you ask yourself how it feeds; what external features of the plant contribute to its nourishment. What are your guesses? Write them down. You may have written: "The roots are connected with nutrition". Draw the root system. Discuss how this kind of root system helps in nutrition. Your report might look like this: Fig. 3.9

On the other hand, you could observe the external features of the organisms; and, later, in the classroom, link each feature with the relevant characteristic.

Try to be as thorough as possible in your recording. Have the names of the organisms and descriptions of the external features. (If you do not know the name of a living thing, collect one and number it. Later on, efforts would be made to identify it.)

Still working on nutrition as one of the characteristics of living things and looking at an animal in the school yard, e.g. a bird, you could
describe and draw its beak, its feet, its eyes, etc. You should try to state how the shape or position of these parts helps in feeding.

![Fig 3.10 Beaks and feet to show adaptations in birds for feeding](image)

When you go back to the classroom the information you have gained has to be reviewed. Each group could refine its findings, and present its work to the class for more discussion.

Do learn from one another as each group makes its presentation and please share freely of your knowledge. "Knowledge is public."

**Looking at external features**

You will discover that each feature of a plant or animal has some function. This is an important principle in Science and especially in Biology. **The structure is suited to the work it has to do.**

Take, for example, our limbs. They are for movement on land — walking, running, jumping etc. The structure of the limb is such that it is most efficient in causing the type of movement in which the person is engaging. **Fig 3.11 shows some limbs that are used on land, in the air and in water.**

![Fig 3.11 Limbs used on land, air and water.](image)

As you study each feature, do the following:

(a) describe and if possible draw the structure associated with it.
(b) state what function the structure carries out.
(c) describe how the shape or position of the structure helps it in carrying out its function.
Collecting and storing living things

Earlier in this course we collected living things from the environment. After classifying them, we returned the animals to their habitats. However, it is sometimes necessary to capture and store organisms for future study. Here in this unit we are going to learn some techniques of collecting, preserving and storing organisms. We are also going to study a few of the organisms and classify them according to their external features.

Methods of collecting

We are all aware that there are thousands of different kinds of organisms out there in our environment. Therefore there would be different methods of capturing and collecting these organisms. We must first select an area or a site from which to collect the organisms and take along suitable equipment for collecting.

Some equipment needed

Here are some items of equipment we would need on our field trip.

![Fig. 3.12(a) Note book, pad and pencil](image)

![scissors](image)

![glovers](image)

![bottle](image)

![Forceps (tweezers)](image)

![Trowel](image)

![plastic bag](image)

Fig 3.12 (b) Equipment used when collecting

We must remember to take care not to destroy the habitat of animals or an entire plant or tree when we may only need a sample of leaves or flowers. It is also important to bear in mind the safety of our classmates, ourselves as well as the environment.

Collecting small land animals

When collecting small land animals we may use our hands to take up or dig out the organism from the ground. Here is where we may need to wear a pair of gloves.

Another method is setting traps. These traps are for small crawling insects. For these traps we can use jam jars sunk into the ground with their tops level with the surface.
The lids will be positioned to allow animals to enter. Food or a killing solution may be used, depending on the type of animal to be captured.

**Collecting small aquatic creatures**

Collection of small fishes and aquatic insects (i.e. insects that live in water) can be done by using nets. The nets are swept into the water against the current. The catch must be placed in as much water as possible. Why do you think that the catch must be placed in water?

**Catching flying organisms**

In the case of butterflies and other flying insects, a sweep of the net through the grass or air may capture many specimens. How do you think these specimens should be stored?

**Small tree-borne organisms**

Insects and other small animals can be captured and collected by simply dislodging them out of trees. This is done by spreading a few sheets of newspaper under the tree, then hitting the tree with a stick. The insects will drop on the paper. They can then be collected and placed in containers.

**Collecting plants**

The methods of collecting plants are quite simple. We collect samples of different types of leaves, flowers, fruits, seeds or even roots by using pruning shears or scissors. These are used to cut leaves and flowers. A trowel can be used to uproot little plants. Try not to destroy the entire tree when you may want only a few leaves. We must also ensure that we do not take more than we need.
The methods discussed are but just a few. Do you know of any other methods of collecting that we may use?

We have not discussed the collection of large animals, since pictures can be used instead. (Some of these animals can also be observed in their habitat, in pens, at the zoo or in museums).

Remember that whatever specimens have been collected must be placed in labelled containers. A note must be made of where and when the organisms were collected. If stones and logs were removed during the exercise, they must be replaced.

Storage and preservation

Well, we have just completed a very interesting exercise. We have followed all safety rules and have returned to the laboratory/classroom with a large collection of organisms.

Now we are going to preserve and store our organisms for future study. It may be necessary to kill some organisms. But where there is an excess of the same kind of organism, for example, too many earthworms, select a few for preservation and return the others to their habitat. The killing of excessive amounts of organisms must be avoided. Why must we avoid excessive killing of organisms?

Chemicals for killing and preserving

Small animals such as spiders and insects can be killed by placing them in a bottle containing cotton wool soaked in chloroform. They can be preserved by drying. Large soft-bodied animals such as some invertebrates and vertebrates are killed by the same chloroform method. They are preserved by being placed into 70% alcohol or 4% formalin. Animals with shells, such as crabs and snails, can be left so that the soft parts can decompose. The shells can then be washed out and kept.

The spreading board

When preserving specimens like butterflies and pondflies, their wings are spread out into position and pinned while their bodies are still soft. Most adult insects dry without spoiling or changing shape. A spreading board made from cardboard or softwood may be used. The diagrams below show how to make and use a spreading board for drying specimens with large wings.

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Preserving flowering plants

Preserving flowering plants is something most of us would have done sometime ago. We simply place the plant or parts of plant between several layers of newspaper. Ensure that the parts of the plant are flat. Then place a weight, which may be a few heavy books on the paper. Leave it for a few days in a dark, dry, airy cupboard. Non-flowing plants, like mosses, are just left to dry out.

The display

Now that we have preserved our organism, we do not simply pack them away in a cupboard or in a box. We have to label each specimen and display them. Labels make a collection more interesting and useful. The labels should give the name of the specimen, the place from where it was collected, date it was collected, and the name(s) of collector(s) may be added.

In order to store and at the same time display the specimens they can be mounted in specimen boxes or cases while others can be left in the jars containing alcohol. The dried plants and leaves can be stuck to white sheets of paper or cardboard and labelled. Or a plant album can be made by sticking the plant or parts of the plant into a note book. All these can be displayed in the Science corner either on the wall or on shelves. To prevent our collection in the display specimen boxes or cases from being destroyed by other small animals we can place a few moth balls or moth flakes among the specimens in the boxes or cases.
Classifying living things

We have already classified living things earlier in the course, but here we are going to classify them according to their external features. While we were preserving the specimens, we would have noticed some things about the different animals we were handling. We may have noticed the presence or absence of legs or wings or antennae. These and more are examples of external features of animals.

Activity: 3.1: Classifying animals

Select as many different kinds of animals from your collection. Use tweezers and a hand lens if necessary to examine each animal. Note the features. Do their bodies look alike? Now let us classify. For example, put all those that have a pair of wings in one group. Put in another group all those that have 4 wings like butterflies.

The two groups would look like this.

Another group may have animals with legs present. This group can further be divided in groups such as animals with three pairs of legs or more than three pairs. For this activity we can also consider features like the mouth parts, the body covering, the segments of the abdomen. Try to identify as many features for your classification. Select any external feature and make a chart showing the differences and similarities between the animals.

When classifying the plants we can consider the shape of leaves, the texture of leaves, the colour and number of petals of flowers. You may also select a particular feature and make a chart to be displayed in the Science corner.

Selecting features for classification

**Features present in animals**

Look at this picture of students in the science class.

(a) A group of students

(b) Showing ability to roll the tongue

Fig 3.18: Classifying animals

Fig 3.19: Features of mammals
They all belong to the group of vertebrates called mammals. (How do we recognise mammals?) Humans are just a small set within the group called mammals. We are a species. Other species of mammals are dogs, bats, elephants and many more with similar, basic features.

As we look around the class we will notice that the general appearances of individuals are similar. This means that any organism which has our appearance belongs to the same species, humans. But within this species there are also differences which are called variations. What are some of the variations among the students?

Here are some possible variations among the students in the class.

- colour of hair
- height in centimetres
- colour of eyes
- shape of the ears
- ability to roll the tongue
- right and left-handedness
- length of hand-span
- pulse rate

Can you think of others? (Remember that you should not name a physical handicap as a variation). These variations can be used to identify and name the students.

Now let us see if we can select features which are identical among the other groups of organisms, for example, invertebrates. There are so many of them so we are going to study only a few. Look at the specimens of insects in Figure 3.20. What are some of the possible variations? What are some common features?

Here are some of the variations among insects.

- long sucking mouth parts
- four long straight wings
- mouth parts for biting and chewing

Can you identify these variations among the three insects shown?

![Grasshopper (sucking mouth parts)]

![Housefly](Wings)

![Mosquito](Head)

Fig. 3.20 Variations among insects

Let us now look at variations in reptiles. They may have:

1. (a) Legs present  
   (b) No legs present

2. (a) Zig zag pattern on skin  
   (b) No zig zag pattern on skin

Now identify some variations in birds and fishes.
Write them all down.
Features present in plants

**Activity:** 3.2: Looking at trees.
Name as many trees as you can. Here are pictures of a few trees (Figure 3.21).

Can you tell the differences among them? Here are a few features which will help us to classify them. The fruits and flowers of some trees are well known by most of us. These will help us in identifying trees easily. The general shape of a tree, the height of the tree, the stoutness of its trunk are other features which will help us to name trees. Even though the leaves are sometimes very high up, these also can help us in identifying and naming the tree. The bark and kind of roots (like buttress roots) are two other features which help us to identify the tree. Can you think of any other features by which we can identify a tree?

**Making a key**

A key is a special table which is used to help us to classify and name both animals and plants. The key consists of special features of organisms in a group and shows the variations among the members. For example, here are pictures of reptiles.

![Fig. 3.21 Variations among trees](image)

![Fig. 3.22 Reptiles](image)
We look for the variations in the reptiles. Then we ask ourselves questions, such as, Are legs present? Are there patterns on their bodies? We then use these as clues:

Reptiles with  
1. (a) Legs present.  
    (b) No legs present.  
2. (a) Zig-zag pattern on skin.  
    (b) No zig-zag pattern on skin.

To use the key, look at animal A in Fig. 3.22 and then at clue. Notice that clue 1 is made up of two parts. If legs are present you go on to clue 2.

Look at Animal A again. Is a zig-zag pattern present on the body? There are no legs present, therefore you can name the animal. Look at Animal B and apply the same procedure.

Your key should then look like this:

\[ \text{Reptiles} \]
\[ \begin{align*}
1. & \quad \text{Legs present} \\
   & \quad \text{(legged lizard)} \\
   & \quad \begin{cases} 
   \text{(b) No legs present.} \\
   \text{2. (a) Zig-zag pattern on skin} \\
   \text{(b) No zig-zag pattern on skin} \\
   \text{(b) No zig-zag pattern on skin) \\
   \text{(b) No zig-zag pattern on skin) \\
   \text{(b) No zig-zag pattern on skin.)} \\
\end{cases}
\end{align*} \]

Scientists use this same method in order to name the many animals in the world.

Below are features which will help you to identify some invertebrates. Make a key (similar to the one just shown) that will help you classify any arthropods into one of the four groups.

Fig 3.23 Some invertebrates
Now select the vertebrate group. Make a key and use it to name some animals present in this group.

Look at the trees in Figure 3.21. Make a key that would help in classifying and naming them. You must look for the variations among them such as their shapes or the kinds of leaves, fruits and flowers.

Here is a key which will help us to identify and name leaves. The leaves were first divided in two main groups: those with single blade and those with a divided blade. Then each group was further divided as shown in the diagram below. This is known as a spider key.

**Activity:** 3.3 Making a key for leaves in the school yard.

Select as many leaves as you can and make a key to help someone identify them.

---

**Fig 3.24** Spider key
Exercises

1. Column A has eight 'statements'.
   Column B has the seven characteristics of living things, in alphabetical order.
   Match Column A with Column B, by writing the appropriate number next to each letter.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Organism leaves Point I and reaches Point II</td>
<td>(1) Breathing</td>
</tr>
<tr>
<td>(b) Seeing, hearing, smelling, tasting and touching</td>
<td>(2) Excretion</td>
</tr>
<tr>
<td>(c) Snowman gets taller; copper sulphate crystal gets heavier</td>
<td>(3) Growth</td>
</tr>
<tr>
<td>(d) Child's chest going in and out</td>
<td>(4) Movement</td>
</tr>
<tr>
<td>(e) Roots absorb water and mineral salts.</td>
<td>(5) Nutrition</td>
</tr>
<tr>
<td>(f) Getting rid of carbon dioxide, sweat, urine.</td>
<td>(6) Reproduction</td>
</tr>
<tr>
<td>(g) Began with one gram. Ended with one kilogram.</td>
<td>(7) Sensitivity.</td>
</tr>
<tr>
<td>(h) Began with one organism. Ended with one hundred of the same kind.</td>
<td></td>
</tr>
</tbody>
</table>

2. (a) Which of the two groups of living things (plants or animals) tends to show the characteristics of living things more clearly?
   (b) Why do you think this is so?
   (Hint: Most plants are green.)

3. (a) Make a list of twelve non-living things and of twelve living things.
   (b) Of the living things you listed choose one plant and one animal and describe how each one
   (i) feeds
   (ii) responds to things
   (iii) breathes
   (iv) grows

4. What is the difference between the movement of animals and that of plants?
5. Ten statements are given below. Name the chief characteristic(s) of living things that each statement suggests.

Statements

(a) The blue-saki caught a juicy worm in its beak.
(b) The egret flapped its wings and soared away.
(c) The worker honey bee collects pollen in the pollen-baskets in one pair of its legs.
(d) The wings of the humming-bird beat several times each second as it hovers over one spot.
(e) The worker honey bee sucked nectar from the little blue salvias with its proboscis.
(f) The ant seems to 'butt' other ants with its feelers.
(g) The groups of students measured the lengths of the tails of each white mouse.
(h) The kitten raised its head and sniffed with its nostrils.
(i) The fishes were out of the water; their gill covers flapping up and down.
(j) Each of the 'eyes' of the potato could give rise to a new plant.

External features

(a) Beak of a woodpecker.
(b) Blossoms of a lime tree.
(c) Feathers of a fowl.
(d) Feet of a duck.
(e) Fins of a fish.
(f) Internodes of the stem of a sugar cane.
(g) Lateral line of a quermian.
(h) Legs of a grasshopper.
(i) Limbs of a dog.
(j) Mouth parts of a marabunta.
(k) Nostrils of a cat.
(l) Operculum (gill covers) of bangamary.
(m) Stomata of lime tree leaves.
(n) Tail of tadpole.
(o) Teats (nipples) of a dog.
(p) Whiskers (visbrissa) of a cat.
(q) Wings of a fowl.

6. Name the function(s) of each of the twenty external features listed.

7. Name two pieces of equipment one may need to carry on a field trip to collect living things.


9. Do you think the same methods of preservation used at school can be used at home?

10. Observe an organism with segmented body using a hand lens, then make a drawing of the organism.
11. Make a plant album containing at least five different plants found in your backyard or street.

12. Describe two external features, one from plants, one from animals, associated with each characteristic of living things. Use a table such as this.

<table>
<thead>
<tr>
<th>Characteristics of living things</th>
<th>External features of plant</th>
<th>External features of animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Breathing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Excreting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Feeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Reproduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Sensitivity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. (a) Name three amphibians.
    (b) Write down two variations among these amphibians.

14. Look at the insects you have preserved and write down as many variations as you can.

15. Select about six students (boys and girls) in your class. Note the variations between them, then make a key from which someone else can recognise them.

16. Look at the trees in your backyard at home. Identify the variations. Draw pictures of their leaves, flowers and fruits to show the variations. Use these variations to make a key.
WE HAVE LEARNT THAT

living things (plants and animals) exhibit these seven characteristics
- they MOVE. They change their position or their location.
- they GROW. Their bodies increase in size and/or in weight.
- they NOURISH themselves. They take in nutrients to nourish their bodies.
- they RESPIRE. They take in air to oxidise food.
- they EXCRETE. They get rid of waste substances that were produced in the body.
- they are SENSITIVE. They are aware of changes in their environment and respond appropriately.
- they REPRODUCE. They produce more of their same kind.
- all living things must carry out these life processes:
  movement, growth, nutrition, respiration, excretion, reproduction, sensitivity.
- every organism has observable external features.
- every feature has a function.
- every feature is adapted so that it can do its work most efficiently.
- every feature helps the organism to carry out one or more characteristic of living things.
- living things belong to different classes but within each class there are important differences between the members of that particular class.
- snakes and lizards belong to the class of reptiles.
- in each species of organisms there are variations.
- a key provides clues to help one to name the organisms.
Solutions

Very early in this course we made a few solutions. In our everyday life we use many forms of solutions: whether it is a cup of tea for breakfast, or soap solution for washing; whether it is a bottle of aerated drink to quench our thirst; or lubricating oil for our engines, we use several types of solution daily. In this unit we are going to learn:

- how to prepare a variety of solutions,
- how to separate mixtures in the laboratory using a number of separation techniques,
- how to deal with waste products from the sugar and rice industries and those in the laboratory.

Types of solutions

As we found out earlier solutions can be made by dissolving solids in liquids, liquids in liquids and gases in liquids. We will now study these and some other types of solutions in some detail.

Solids dissolved in liquids

*Activity 4.1*: Preparing clear, colourless solutions with solid and liquid.

You will need water, sodium chloride, ammonium chloride, sucrose, magnesium sulphate.

1. Pour about 5 cm$^3$ of water in a test tube.

2. Add one small spatula of sodium chloride to test tube and shake.

3. Leave to stand and record observations.

4. Repeat experiment using a fresh test tube of water each time and dissolve the other solids provided.

What have you noticed about all the solutions made?

Liquids dissolved in liquids

*Activity 4.2*: Preparing clear, colourless solutions by dissolving liquid in liquid.

1. Measure about 10 cm$^3$ of water in a small beaker and add about 5 cm$^3$ of ethanol.

2. Shake and leave to stand.

Has the ethanol dissolved? Does the solution have a colour?

Now repeat the experiment with bleach, acetic acid, vinegar. Compare the solutions you have made.

Gas dissolved in liquid

Earlier in the course we found out that carbon dioxide dissolved in water was the gas present in aerated drink. All the aerated drinks are not clear, colourless solutions. Can you tell why? What do you think about tap water? Is it a solution of gas and liquid? Let us find out.
Activity 4.3: To find out if tap water is a gas-liquid solution.

1. Place a short-stemmed funnel in a rubber stopper in the mouth of a large 1000 cm³ flask.
2. Make sure that the stem of the funnel is not below the base of the stopper so that gas can pass through the stem.
3. Fill the flask with tap water until it is almost to the top of funnel, and invert a test tube full of tap water in the funnel.

![Diagram of experiment](image1)

Fig 4.1 Does tap-water contain dissolved gases?

4. Using a retort stand, clamp the flask firmly on a tripod fitted with gauze.
5. Heat the water with a hot flame until it is almost boiling.
6. Observe all the changes in the flask and in the test tube. You will notice that a gas collects in the test tube. Where did the gas come from? What kind of solution is tap water?
7. Now look at the solutions we have made or used thus far. Can you distinguish them by sight? They are all clear, colourless solutions and look alike. It is therefore very important to remember to read all labels carefully before using contents of containers or bottles.

Solid solutions

Pure metals are soft and weak. Metals, however, can be melted separately and mixed together to form stronger metals. This mixture is also called a solution. We can go on to explain that this mixture of liquid metals when cooled, forms a solid. This solid is called an alloy; for example, a mixture of copper and tin. Some alloys involve non-metals dissolved in metals. Do you know of any such alloy?

![Alloy examples](image2)

Fig.4.2 Some benefits of alloying

Alloys are very important in our everyday lives. The coins we use are alloys. These alloys do not rust easily. The electrical cables which transmit very high voltage have a steel core to provide the strength needed by the cable. Steel is a mixture of iron and a non-metal, carbon. Can you name some other uses of steel in the home? Solder is another important alloy. It is made from a mixture of tin and lead. It can be easily melted with a soldering iron and used to join materials such as copper wires.
How much dissolves?

Surely, we all have had the experience of making a glass of lemonade and have found out that after we have added sugar and stirred, the lemonade was sweet, but there was still sugar at the bottom of the glass. The sugar crystals remained at the bottom no matter how much more we stirred. The sugar would not dissolve further. We would sometimes drink the lemonade and wash away the excess sugar down the drain. Oh, what a waste!

Dissolving different substances

Here we are going to find out how much substance (solute) can dissolve in a given quantity of solvent. In this case the solvent is water.

Activity 4.4: How much salt can dissolve in half a test tube of water?
1. Half fill a large test tube with water.
2. Add 1 spatula of salt to the water.
3. Shake until all the salt dissolves.
4. Continue to add one spatula at a time, shaking the test tube each time, until no more of the salt seems to dissolve.

Repeat the experiment using ammonium chloride. Record your observations in a table as shown.

Dissolving various substances in \( \frac{1}{2} \) test tube water

<table>
<thead>
<tr>
<th>Substance</th>
<th>No. of spatulas dissolved in ( \frac{1}{2} ) test tube water.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What have you noticed about your solutions? Can you explain why there is some salt settling at the bottom of the test tube? It is obvious that when this happens it means that no more salt can dissolve in the water. The solution formed is said to be saturated. The solvent cannot dissolve any more of the solute at that temperature, which is room temperature.

What do you think must be done so that more salt can dissolve in the same amount of water?

Dissolving at different temperatures

Here we are going to use the Bunsen burner, if it is available at your school (a spirit burner can also be used). Ensure that the air-holes on the burner are closed before lighting the gas. Then light the burner and slowly open the air-holes so that air can enter and mix with the gas. The flame must be small and bluish-green. During this activity you must pay attention to the safety rules related to the use of the Bunsen burner.

Activity 4.5: Heating a saturated solution.
1. Heat the salt solution you made earlier up to about 60 °C.

Be careful to keep shaking the solution while heating to avoid ‘bumping’.

What have you noticed about the salt crystals at the bottom of the test tube?

Do you think any more salt can now dissolve in the solution? Let us find out.

2. Add one more spatula of salt and stir.
3. Continue to add one spatula at a time until no more dissolves.
You must work quickly or the water in the test tube will cool.

4. Now increase the temperature of the solution to 65 °C.
5. Add one spatula of salt at a time until no more dissolves.
6. Repeat the experiment using ammonium chloride.
7. Adding one spatula at a time observe how many spatulas of ammonium chloride will dissolve at 70 °C and 75 °C.
8. Record your observations in the table below.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Temp °C</th>
<th>No. of spatulas required to saturate half test tube of water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Allow your solutions to cool. What have you observed? Are the substances more soluble in hot water than cold water?

When hot saturated solutions cool, they cannot hold as much of the solute, so the extra substance comes out of the solution in the form of crystals. Most substances dissolve more in hot water than in cold water.

Separating mixtures

While on a picnic with friends at the beach, Kei accidentally caused sand to get into the salt she had carried. What should they do?

- "If I were at school, I could separate the sand from the salt," said Ravi.
- "How would you manage that?" inquired Joni.
- "I know," said Nevada. "He would look at the mixture with a hand lens and pick out the salt."
- "That would take too long," replied Ravi.

How could the children solve this problem? In the above account, Ravi wished he was at school, because he would have at his disposal the necessary equipment that would enable him to separate the sand from the salt. But separations of mixtures can be done almost anywhere and not only at school.

Earlier we discovered that when we mixed some substances with water they dissolved. Those mixtures formed solutions. But there are some mixtures in which the substances do not dissolve. Therefore, when we want to separate mixtures into their constituents or components, we must take the following into consideration.

- the properties of each constituent.
- the constituent of the mixture we want to retain.
- safety precautions to be taken.

Some separation techniques

Filtration

Filtering is like "straining" with a very fine sieve. Can you think of six situations where you "strain" things in your home? Do you use the same size sieve every time?
Complete the following table.

**FILTRATION IN THE HOME**

<table>
<thead>
<tr>
<th>Filtering done in the home</th>
<th>Materials used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Straining fruit drink</td>
<td>Muslin, Cotton</td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
</tr>
</tbody>
</table>

In the laboratory, we use special equipment for filtering. We use filter paper. This paper has such fine pores that it stops most undissolved particles in mixtures that are filtered. If filter paper is not available, paper of news-print quality may be used. Fig. 4.3 shows how to set up the filtration apparatus.

4.3 (b) Carrying out filtration

After filtering, the matter that remains on the filter paper is called the residue; the liquid that is filtered is called the filtrate. Let us do what Ravi might have done in the laboratory to separate sand from the mixture with salt.

**Activity: 4.6 Separating sand from salt.**

1. Pour the mixture of sand and salt in a beaker half full of water.
2. Stir for a few minutes.
3. Filter the mixture.

What is left on the filter paper?
What is in beaker?
Can you see any salt? Do not taste!

Let us now see if we can get the salt. Which must we use, the residue or the filtrate?
Evaporation

Evaporation is another separation technique that is widely used. It allows us to separate the dissolved solids or solutes from the solution. Evaporation takes place all the time in our environment. Have you noticed that pools and trenches and pasture land dry up without regular rain? Can you explain what happened to the water?

Activity: 4.7 Separating salt from water

1. Measure 10 cm³ of salt solution (the filtrate) and pour it into an evaporating dish.
2. Heat until you see the first crystals appear.
3. Do not allow it to dry out completely.
4. Remove the heat.

What have you noticed in the evaporating dish? Now the children have both the sand and salt from the mixture of sand and salt.

The children could have simply left the salt solution (filtrate) in an evaporating dish on a desk in the laboratory until the water 'dries out'. But that would have taken a few days. There are times when we need to "speed up" or increase the rate of evaporation. In the previous activity we used heat. Let us try to find out which kind of container is best for evaporation.

We will use the salt solution left from the previous activity.

Activity 4.8: Which kind of container is best for evaporation?

1. Measure 10 cm³ of salt solution and pour it into an evaporating dish.
2. Check the time and start heating the salt solution in the dish.
3. Heat until you see the first crystals appear.

Note the time taken for these crystals to appear.

4. You may continue heating for another five minutes.
5. Repeat stages 1 to 4 using a round bottom flask and a test tube.

Do not change the heat source. Ensure you use the same volume of salt solution in each container.

Evaporation using different containers

<table>
<thead>
<tr>
<th>Container</th>
<th>Time taken for crystals to appear (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporating dish</td>
<td></td>
</tr>
<tr>
<td>Round bottom flask</td>
<td></td>
</tr>
<tr>
<td>Test-tube</td>
<td></td>
</tr>
</tbody>
</table>

(a) Using an evaporating dish

Fig. 4.4 Evaporating a solution using three types of containers
Using alternative heat sources

In the preceding activity, we saw how the sun's heat was used to carry out evaporation. The sun's heat is an alternative (and a cheap one at that!) to using heat from burning fuels.

Fig. 4.5 shows a simple model of a solar dryer. The sun's heat is used in this dryer to evaporate water and thus dry small amounts of fish and fruits.

Can you name examples in everyday life where evaporation is used?

**Fig. 4.5** A solar dryer

---

**Activity 4.9:** Evaporation using the sun's heat.

1. Pour about 5 cm$^3$ of salt solution into a plate (or a flat dish) and place in the sun shine.
2. Record your observations.

Note how long it takes for all the liquid to evaporate. Do you think evaporation can take place indoors without using a heat source or direct sunshine?
Purifying substances.

Obtaining pure substances is often very important. Some substances might contain foreign bodies that are either harmful to us or generally undesirable. In the problem encountered in the beginning of this unit, sand which was mixed with salt, was not desirable. Obtaining pure substances often involves a number of separation techniques.

Most of the separation techniques involve physical methods. Here are some situations where it is desired to get rid of "impurities". How would you purify the mixtures listed below?

(a) Rain water with suspended or floating matter.
(b) Flour with weevils inside.
(c) Iron filings mixed with rice.
(d) Rice with "bhushi" in it.

In our major industries such as sugar, rice, bauxite and gold, the impurities have to be gotten rid of. Physical as well as chemical means of separation are used. Lime (calcium oxide) is used to precipitate dirt from cane juice; water is used to separate padi from the husks; sieves are used to sift out gold-bearing particle and mercury is used to dissolve out gold; heat is used to drive off water and other impurities from bauxite; water is used to wash off bauxite overburden.

Some common separation techniques

Distillation

Unlike evaporation, this process can restore more than one component in a mixture. Distillation involves evaporation followed by condensation. In evaporation, liquid is changed to vapour. In condensation, vapour is changed back to liquid, usually by cooling.

One apparatus used for distillation is the Liebig Condenser (see Fig. 4.6 (a). This equipment can be used with a flask to obtain both the solute and solvent from a solution.

Distillation can be used to separate liquids of different boiling points. When this is done it is called fractional distillation.

This is the technique used to separate the different types of fuel (e.g. kerosene, gasoline, diesel) from crude oil.

As a separation technique, distillation is also a purifying process. Distilled water can be obtained from impure water for laboratory purposes or for car batteries. This process can produce fresh water from seawater, but it is very expensive for it requires a lot of heat. However in the tropics, solar energy is used and millions of gallons of fresh water are produced. Look at Fig 4.6 (a) and (b). They illustrate two methods of distillation.
Can you name mixtures which can be separated by the method of sedimentation? Give some examples in your home.

Here is a chart of some other separation techniques and what they separate.

<table>
<thead>
<tr>
<th>Separation techniques</th>
<th>What they separate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Filtration</td>
<td>Insoluble substance from mixture e.g. sand in salt solution</td>
</tr>
<tr>
<td>2. Crystallisation</td>
<td>A solid from a solution e.g. salt from salt solution</td>
</tr>
<tr>
<td>3. Separating funnel</td>
<td>Immiscible liquids e.g. water and oil</td>
</tr>
<tr>
<td>4. Distillation</td>
<td>a. A liquid from a solution containing a solid e.g. water out of salt solution</td>
</tr>
<tr>
<td></td>
<td>b. Two liquids with different boiling points e.g. Methylated spirits in water</td>
</tr>
<tr>
<td>5. Sieving</td>
<td>Some suspended matter in liquids; solids of different sizes e.g. flour and rice</td>
</tr>
<tr>
<td>6. Chromatography</td>
<td>Similar substance in solution e.g. dyes in a mixture</td>
</tr>
<tr>
<td>7. Centrifuge</td>
<td>Particles in suspension e.g. powder in water</td>
</tr>
</tbody>
</table>

Sedimentation

In this process, suspended matter is allowed to settle and the liquid can be **decanted**. This process is used to treat water in long tanks. The chemical, alum or aluminium sulphate, is added to help floating particles to **coagulate** (i.e. to come together).
Here are annotated diagrams to illustrate some separation techniques mentioned in the chart.

(a) The centrifuge

(b) The separating funnel

(c) Paper chromatography

Look at Figure 4.8 which illustrates the whole process of sugar production. Can you identify any separation techniques?

Fig 4.7 Methods of separation

Separations in industries

Earlier we observed how various separation techniques were carried out. Let us now examine the separation techniques in the sugar industry.

Fig 4.8 Stages in the manufacture of sugar
Separation in the rice industry

There are two types of rice produced in Guyana, white rice and parboiled rice. In this section we would look at how parboiled rice is made.

First, the paddy is placed into large tanks filled with water and left for three days. The solid paddy settles and the light "wind seeds" which float are removed. Here we see sedimentation used to separate the solid paddy from the light shells.

The paddy is now steamed in the tanks and dried. This process removes some of the unpleasant odour and makes the grains easy to be shelled.

The paddy is then taken to be milled. In this process the paddy is passed through an aspirator, which separates the light trash and 'wind seeds'. The paddy is then passed to the separation compartment where pieces of bricks are removed. It is then passed into a chamber with a huge magnet. The magnet removes pieces of metals.

The paddy is then hulled, that is, the shell or bhusi is removed and separated by a sieving process. The grains are then polished by rubbing against rotating strips of leather. The rice grains of different sizes are then taken to the coning process where the bran is removed and separated from it by sieving. The different sizes of grains namely 'whole grain,' 'broken' and 'chips' are again separated by sieving.

Fig 4.9 Stages in rice production
Dealing with waste products

In our laboratory work as well as in our industries we use a number of separation methods. After we have obtained our "pure" substance, we are left with other substances which we call waste. What should we do with this waste?

It is generally unsafe to pour chemicals down the sink because they can cause reactions and produce products that are harmful to us and our environment. Dumping chemicals in rivers produces the same effect. Here are some suggestions for dealing with waste products.

- Some substances can be put to use e.g. "bhusi" might be used as pig feed, potassium permanganate can be used as a germ killer in chicken farms, the liquor dirt from the cane juice can be used in making foot paths (and so can the bauxite overburden).
- Some substances can be recycled e.g. the mercury can be got back after use in the gold industry.
- Other substances could be burned at an isolated location which is far from running water.

Exercises

1. Describe how to prepare a saturated solution. Give the name of the solute and solvent used.
2. List two ways in which one can make a saturated solution unsaturated.
3. What are formed when hot saturated solutions cool?
4. (a) List the materials that would be needed if you are to separate sand from salt.

(b) How many separation techniques were employed? Name them.

(c) What can you say about the time taken by each process?

5. Write the meanings of the following words:
   - filtrate
   - residue
   - evaporation
   - suspended matter

6. (a) Briefly explain why cigarettes carry filters.

(b) Do the filters make the cigarettes safe to smoke?

7. What is sieving? Identify one situation in your home and one in a named factory where sieving is done.

8. Briefly describe how you would separate a mixture of sand and sugar using the following headings: Aim, Apparatus, Procedure.

9. Some iron filings get into your salt and flour. How would you remove the filings?

10. Water boils at 100 °C. Alcohol boils at 85°C. How can water be separated from a mixture of alcohol and water?

11. "Distilled water is often produced during cooling". Discuss this statement.

12. Arrange the stages in figure 4.9 using a numbered sequence.
Summary

WE HAVE LEARNT THAT

• a solution is a homogeneous mixture. It is the same throughout.
• some solutions look very much alike, so it is important to read labels of containers.
• an alloy is a mixture of two or more substances, one of which is a metal. This mixture has properties different from the separate components.
• a saturated solution is one in which no more solute can dissolve at that temperature.
• hot water usually dissolves more solute than cold water.
• when hot saturated solutions are cooled, crystals are formed.
• selecting a method of separation involves consideration of the properties of mixture and the equipment available.
• filtration helps to separate solid particles from liquids.
• evaporation involves using a heat source.
• making pure substances involves a number of separation techniques.
• waste products in the laboratory and in industry can be disposed of safely, put to good use, or recycled.
• selecting a separation technique depends on what is wanted and the characteristics of the ingredients of the mixture.
• distillation involves the processes of evaporation and condensation.
• sedimentation involves allowing particles to settle; it can sometimes be aided by addition of alum.
• there are many separation techniques.
• separation techniques are used in the sugar and rice industry.
5 Energy and matter

Energy

We often hear about energy. What is energy? All living things need energy in order to survive. Living things need energy to move. Non-living things like machines, from simple to complex, also need energy in order to work or function properly. Energy does work for us, or enables us to work.

In this unit we will learn about:
- what energy and force can do
- different sources of energy
- the various forms of energy
- energy conversion
- solids, liquids and gases
- what happens when solids, liquids and gases are heated
- diffusion
- pressure and its usefulness

Fig. 5.1 The boy is using energy to run. Look at his muscles

Fig. 5.2 The girl is using energy to ride the bicycle
Energy and force

Most of us can ride a bicycle. Can you ride one? What makes a cycle move when you are riding it? Is it the energy that moves the cycle? Or is it the force that you apply to the pedals to move the chain and wheel that causes the motion? It is both the energy and force which make the bicycle move, as we shall now explain.

Forces can move things or stop things from moving. When you are riding a bicycle you are applying force on the pedals, by contracting the muscles mainly in your legs. For this to be done your muscles need energy. Where do you obtain your energy? We shall now look at some sources of energy, that is, where the energy comes from.

Some sources of energy

Our energy is obtained from food, and without food we would die. In our body the food is burnt up by a process called respiration and energy is released.

Where does a ship, a car or an aeroplane obtain its energy to move? Long ago, sailing ships used the energy of the wind to push them across the water. Today ships, cars and aeroplanes have engines which use fuels that provide the energy to move them. The engine of a ship turns the propellers in the water and hence the ship moves. The engine of the car turns the wheels of the car. The engines of an aeroplane give out very hot gases which keep the aeroplane in motion in the air.

The sun is a great source of energy. In fact, all energy comes directly or indirectly from the sun. The energy from the food we eat comes from the sun and so is the energy from gas, oil, coal and wood.
Forms of energy

There are different forms of energy. The different forms of energy can be used to do many things.

Kinetic energy

Any moving object has kinetic energy. A moving car with passengers has kinetic energy. The passengers, although seated in the car, have kinetic energy because they are moving with the car. Similarly, a hurricane has kinetic energy because it is a mass of air moving at a very fast rate. The energy it has can damage buildings, uproot trees and even cause floods. List four objects that have kinetic energy.

Potential energy

Harry lifts a book from the floor and places it on the laboratory bench. Harry had to use energy in lifting the book from the floor to the bench. He transferred this energy to the book! The book on the lab bench has potential energy or stored energy. If the book is placed at the edge of the bench it could fall and hit the floor making a loud sound. It can also break objects e.g. glassware if they are placed in its path.

The wound-up spring of a toy-car or a mechanical watch also has potential energy. As the spring uncoils, the energy is used in turning the parts of the car or watch.

Some people have ‘over-head’ water tanks on their premises to assist them in the event of a water shortage or to boost the water supply in their homes. The water in the tank has potential energy. Water flows from the tanks into the pipes because it has potential energy. High waterfalls have plenty of potential energy at the top.

List four examples of objects that have potential energy e.g. a bunch of mangoes
hanging from a limb in a tree.

Kinetic energy and potential energy are sometimes referred to as mechanical energy.

**Other forms of energy**

A burning candle not only gives us light energy but also heat energy. We can produce heat also by using electrical energy. The electric iron, electric lamp and electric toaster all produce heat energy when they are switched on.

Another form of energy is chemical energy. The foods we eat contain chemical energy. It is the chemical energy in foods that enables us to do work. A torch light cell (battery) also has chemical energy. We can use the chemical energy in the cell to produce electricity.

There is another form of energy that some countries are presently using to produce electricity. This energy is nuclear energy. It is energy obtained from the nuclei of atoms.

**Sound energy** is another form of energy. When objects are made to vibrate at a fast rate, sound is produced. If a stretched guitar string is plucked, a sound is heard. The vibrating string produces sound. The air around us transfers these vibrations to our ears and we hear. If someone blows through a reed a sound is heard. The flute, saxophone and trumpet all produce sound when air is forced through them.

**What energy can do**

Earlier in this section, we stated that energy enables us to do work. We also looked at different forms of energy. Let us see what these different forms of energy can do.

1. What can light energy do?
   - Certain chemicals are affected by light. One such chemical is Silver Nitrate. Ask your teacher to place a few drops of silver nitrate solution on a piece of white paper and leave it exposed to the light for a while. Observe what happens and record your observations.
   - The photographic film of a camera has certain chemicals which are affected by light. Light from an object affects the film. When we take a ‘picture’ of an object with a camera, the light from the object forms a ‘picture’ or image of the object on the film. When the film is developed, we can get a ‘picture’ of the object.
   - Certain chemicals are stored in dark bottles to prevent the chemicals from changing or deteriorating. Light causes certain chemicals to change their structure.
   - The coloured curtains in your home fade after they have been exposed to light over a period of time.

2. What can electrical energy do? (electricity)
   - Set up the simple circuit having two torch-light cells (two batteries) a bulb and a switch. Press the switch and note what happens.
   - Set up a simple circuit, similar to the one above, having two torch-light batteries, a toy motor, a piece of wire and a switch. Press the switch and note what happens.
3. What can **heat** energy do?

**Activity 5.1** Demonstrating heat energy

1. Make a paper spiral and suspend it above a lighted candle. (Be careful not to allow the paper to burn). Note what happens to the spiral.

2. Place a deflated balloon over the mouth of a test-tube. Ensure that the balloon is securely fixed to the test-tube. Heat the test-tube gently and note what happens.

**Fig. 5.8** Hot air raising paper

**Activity 5.2** Demonstrating chemical energy.

1. Hold a small piece of magnesium ribbon in a pair of tongs and heat the free end in a flame. Do not look at the magnesium while you are doing this.

2. Note what happens.

4. What can **chemical** energy do?
Fuels, like kerosene, gasolene, wood, coal and candle-wax when ignited give us heat and light. These substances have chemical energy.

5. What can kinetic energy do?
   - Place two empty cans, one on top the other. Obtain a ball and roll it slowly toward the cans. Repeat this exercise two or three times increasing the speed of the ball each time.
   - What can you say about the energy of the moving ball as you increase its speed?
   - What happens to the cans each time the ball collides with them?
   - Are the cans thrown further away as the ball moves faster?

6. What can potential energy do?

Activity 5.3: Demonstrating potential kinetic energy

1. Place a rubber band between your thumb and index fingers of one hand.
2. Fold a piece of paper several times.
3. Place the paper on the rubber band and stretch it as shown.
4. Release the paper on the stretched rubber and observe what happens. Please do not do this to hit any one with the paper.

What kind of energy does the stretched rubber band have? What kind of energy does the moving paper have?

5. Place a small block of wood on the edge of lab bench so that it falls on its own. Note what happens.
6. Place a larger wooden block on the lab bench and allow it to fall. Note what happens. Is there any difference in your observations?

Energy change

In the section “What Energy Can Do” we looked at various situations involving energy. Let us examine or discuss a few of the given situations.

Spinning a motor with a battery

The battery has chemical energy. This is converted to electrical energy in the wire. The motor converts the electrical energy into kinetic, sound and also heat energy.

Conservation of energy

Energy cannot be created nor destroyed. It can only be changed from one form to another. This is called the principle of conservation of energy. When a candle is burned, the energy (chemical) from it is not destroyed but it is converted to light and heat.
As we had mentioned before the sun is our main source of energy. We all need energy to do our daily work. We get our energy from the food we eat. Our food comes from plants and animals. The animals we eat will have eaten plants if we trace the food chain. So all the food we eat comes directly or indirectly from plants. Plants get their energy from the sun; during a process called photosynthesis, **the plant utilises the sun's energy**. Therefore the energy in our food comes from the sun. All living things depend on the sun for their source of energy. The energy from the sun is not lost but is only changed to other forms of energy.

**Matter**

All around us there are living and non-living things. There are things that cannot be seen – the gases in the air for example. There are objects we see like household furniture, pots and pans. There are things that were manufactured for pleasure or to make life easier – radios, T.V sets, refrigerators and stoves are just a few. These things are all part of our environment.

All of the objects stated are forms of matter. This section will deal with the nature of things around us – matter. i.e. with the nature of matter.
What is matter?

Activity: 5.4: Observing a solid

Fig. 5.13 Solids: rocks

Select any object from your surroundings and describe it. Write statements about

(a) its physical appearance
(b) its shape
(c) its uses

Let us look at one example—a granite rock (a rock that is used in road-building). The rock is grey in colour. It glitters or sparkles when placed in sunlight. It has small crystals which reflect light. It has sharp and jagged edges.

* It is irregular in shape.
* It occupies space i.e. it has a certain volume.
* It has mass.

Activity: 5.5: Observing a gas

Fig. 5.14 Air filled balloon

Let us look at another situation. Obtain a balloon and determine its mass. Inflate the balloon and tie its mouth. Determine the mass of the inflated balloon.

Now answer these questions.
1. What is the difference in mass between the inflated balloon and the deflated balloon?
2. What does this difference in mass represent?
3. Is the balloon occupying space?

The air inside the balloon has a certain mass and it occupies space. Although we cannot see the air it exists. It fills the balloon. Air is a mixture of gases—oxygen, nitrogen, carbon dioxide and a few others. Gases fill the containers into which they are placed.

Activity 5.6: Observing a liquid

Here is another exercise for you to do. Obtain a beaker and a conical flask and determine the mass of each.

1. Pour 50 cm³ of water into the beaker and determine the mass of beaker and water.
2. Transfer the 50 cm³ of water from the beaker to the conical flask and determine the mass of the conical flask and water.
Now answer these questions.

1. What is the mass of the water?
2. Is the water occupying space?
3. How much space does the water occupy?
4. Is the shape of the water in the beaker the same as the shape of the water in the conical flask?

The water in the beaker occupies space and has mass. It takes the shape of the container into which it is placed. All liquids take the shapes of their containers.

Matter, whether solid, liquid, gas, semi-solid (jelly-like), occupies space or has volume. Matter, whether large or small, also has mass.

Here are some exercises for you.

1. List three properties of:
   (a) a solid
   (b) a liquid
   (c) a gas

2. List two properties that solids, liquids and gases have in common.

3. Put the following list of substances into the groups—solid, liquid, gas: kerosene, baking-powder, sugar, oxygen, carbon dioxide, lemonade, milk, wood, glass, coconut-oil.

**Building blocks of matter**

In the previous section of this unit we looked at the states of matter—solid, liquid and gas. We looked at the similarities and differences among the states of matter. But is matter just one big lump of material? Let us see.

**Activity 5.7: Dividing up matter.**

1. Take a sheet of paper 10 cm square and divide it into two equal parts.
2. Divide the sheets from 1 into 2 equal parts.
3. Divide the sheets from 2 into 2 equal parts.
4. Repeat this procedure until you can no longer do so easily.
5. Gather up all the tiny bits of paper.

Would the tiny bits of paper, if pasted together give you your original sheet of paper?

1. Obtain a piece of chalk and break it into tiny bits.
2. Put the tiny bits in a mortar.
3. Use the pestle and grind the bits of chalk into a fine powder.
4. Try to pick up one particle of chalk ‘dust’.

Could you count the number of chalk particles in your mortar? We have ground a small bit of chalk into millions of tiny particles. Let us assume that we can take one tiny chalk particle and grind it into thousands of miniature particles. Do you think we could see one of those particles?

Every substance is made up of tiny particles. The tiny particles that make up matter are called atoms and molecules. They are so tiny that we cannot see them even with a microscope.

**What makes particles move?**

In our previous section, we learnt that matter is made up of tiny particles. We also learnt previously that energy can do lots of things. An object
may or may not move when energy is supplied to it. Let us investigate how particles behave when they are heated.

**Activity 5.8: Heating air**

Set up the apparatus as shown in Fig.5.15

![Diagram of apparatus](image)

From this exercise we observed that the heat energy from the candle caused the smoke to move through the box from B to A. If you place your hand a little way above chimney A, you can feel the hot air warming your hand. This is so, because the particles of air rise or move when they are heated. The smoke particles also move when they are heated.

Fig 5.15 Heating air in a box

1. Light the candle and place it in the position shown.
2. Light a piece of tightly wrapped paper and allow it to smoulder (smoke).
3. Hold the smouldering paper over chimney B and observe what happens.
4. Hold the smouldering paper over chimney A and observe what happens. Now answer these questions:
   1. What is in the 'empty' box?
   2. What did you observe when the smouldering paper was held over chimney B?
   3. What do you think caused the smoke to move in that way?
   4. What kinds of energy is the candle supplying to the air and smoke?
   5. Which kind of energy is causing the smoke to move?
   6. Why didn't the smoke move from A to B inside the box, when the paper was held over A?

Now set up the apparatus as shown in Fig.5.17

1. Heat the test-tube and observe what happens to the water-level in the tubing.
2. Allow the test-tube to cool and observe what happens.
3. Place some ice around the test-tube and observe what happens to the level of the liquid.

Now answer these questions

(i) What is inside the test-tube?
(ii) What is happening to the particles in the test-tube as they are heated?
(iii) Why does the level of the liquid in the tubing fall?
(iv) Why does the level of the liquid in the tubing rise?

From this activity we observe that the particles of air in the test tube occupy a larger space when the air is heated. Hence the level of the liquid falls in the tubing. When the test-tube is cooled, the particles in the air occupy a smaller space. Hence the level of the liquid rises. When the air is heated, the particles move and occupy a larger space or volume. The particles do not increase in number. They merely increase in speed and exert a greater push on the water.

The particles in any gas behave in a similar manner when the gas is heated. We can picture the particles of a gas in a container in the following diagram.

The particles are randomly moving about in the container.

Fig. 5.18 Arrangement of particles in a gas

**Activity 5.9: Heating a solid**

Let us look at how a solid behaves when it is heated.

Fig. 5.19 The ball and ring experiment

The ball will just pass through the ring at room temperature. Heat the ball strongly. Place it on the ring and observe what happens.
1. Does the hot ball pass through the ring?

2. Why doesn’t the hot ball pass through the ring?

3. What happened to the ball when it was heated?

4. Place the hot ball in some cold water. Determine if the cold ball can pass through the ring.

We see that when a metal is heated, it expands. It contracts when it is cooled.

The particles in a solid are not free to move about as in a gas. The particles are tightly packed together and are held in place by forces. When a solid is heated the particles vibrate or move to and fro. The more heat energy we give to them the faster they vibrate and move a little farther apart. Hence the solid expands when heated.

We can picture the particles in a solid as shown below.

![Arrangement of particles in a solid](image)

**Fig. 5.20 Arrangement of particles in a solid**

Activity 5.10: Heating a liquid

Let us look now at how a liquid behaves when it is heated.

![Arrangement of particles in a liquid](image)

**Fig. 5.22 Arrangement of particles in a liquid**

Set up the apparatus as shown in Fig. 5.21. Place the flask into a beaker of hot water and observe what happens.

1. What happens to the level of the liquid in the glass tube?

2. Explain what happens when the flask is placed in the hot water.

When a liquid is heated, the particles that make up the liquid move a little farther apart. Hence, they occupy a larger space or volume. The level of the liquid rises. In a liquid the particles are closer together than the particles in a gas. They are free to move around. That is why liquids easily take the shapes of their containers. Here is a diagram that shows how the particles are arranged in a liquid. Particles are held together by weak forces so they move about easily.
**Matter and energy**

This section deals with matter and energy relationships. Matter and energy are closely related. A brick that has been released from a catapult has motion energy. The moving brick can do lots of things – break a window pane or injure someone. We learnt earlier about the different forms of energy and what each form can do. In this unit we will look at heat energy and what it can do to solids, liquids and gases.

**Changing of state**

Matter can exist in three different forms – solids, liquids and gases. Sometimes these forms are referred to as states of matter. Matter is made up of particles. When energy is supplied to the particles of which matter is made, the particles move more quickly and further.

In a solid the particles are closely packed. There are bonds between the particles, keeping them in a definite shape. The particles have energy, but the close packing and the bonding keep them in; they merely vibrate. When the solid is heated, the energy of each particle is increased. It vibrates more according to the amount of energy supplied, so the particles move; little energy causes little vibration, much energy causes much vibration. When the energy supply causes the particles to break away from one another and the bonds to be broken, that would be the melting point. At that stage, the substance would no longer be a solid, but a liquid.

In a liquid, the particles are not as closely packed as in a solid. There are not bonds, as in solids, holding the particles together. When the liquid is heated, the energy of each particle is increased. The particles move more and more further apart. When the liquid boils, it becomes a vapour or gas.

![Fig. 5.23. Particles in the three states of matter](image)

Let us investigate these changes of state with ice.

![Fig. 5.24 Melting of ice](image)

**Activating 5.11 Melting ice**

1. Place some crushed ice in a beaker.
2. Record the temperature of the air outside the beaker.
3. Place the thermometer in the ice and record the temperature.
4. Leave the thermometer in the ice.
5. Leave the beaker, with the thermometer, on the lab bench until the ice has melted, and record the temperature every minute.

6. Gently heat the beaker after the ice has melted. Continue to record the temperature every minute until the water boils and for a further five minutes.

7. Record your observations in the table shown.

<table>
<thead>
<tr>
<th>TIME IN MINUTES</th>
<th>TEMPERATURE °C</th>
<th>OBSERVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. What did the boiling water change into?

For a solid to be changed into a liquid, heat energy is needed. This change from solid to liquid is called **melting**. The melting point of a substance is the temperature at which it changes from solid to liquid. The melting point of ice is 0 °C.

For a liquid to be changed into a gas or vapour heat is needed. The temperature at which this change occurs is called the **boiling point** of the liquid.

Let us look at another experiment.

Questions

1. What was the temperature of the air?
2. What was the temperature of the ice?
3. What did you observe on the sides of the beaker just before heating?
4. Did the temperature of the ice rise while it was melting?
5. What did you notice when the water started to boil?
6. What was the temperature of the boiling water?
For this activity you can use wax. Set up the apparatus as shown in the diagram.

1. Record the temperature of the wax. (This would be room temperature).
2. Heat the beaker and record the temperature of the wax every minute.
3. Cease heating when all the wax has melted.

Questions

1. What is the melting point of the wax?
2. Did the temperature rise as the wax changed from solid to liquid?

We have seen from our activities that melting takes place at a particular temperature for each different substance viz. ice, wax. Similarly, each liquid boils at a definite temperature. Water boils at 100 °C under certain conditions.

Can you explain what happens to a pool on the road? The pool ‘disappears’ or dries up after a few hours. This is called evaporation. Evaporation takes place at any temperature. However, it can be increased if the surrounding temperature is high.

Boiling takes place from within the liquid. Bubbles are seen rising from the bottom to the top of the liquid. Evaporation takes place at the surface of the liquid where the particles find it easy to escape.

Wet clothes on the line become dry because of evaporation. Some methylated spirits placed on the back of the hand causes the hand to feel cool. This is because the methylated spirits evaporates.

Why not do this exercise yourself? Try it! What do you feel?

Here are some questions:

1. The temperature of melting ice is ................
2. The temperature of melting wax is ................
3. When a substance changes from solid to liquid we say it ................
4. When a substance changes from liquid to gas we say it .............. or ............
5. The temperature at which a solid changes into a liquid is called its ............
6. The temperature at which a liquid changes into a gas or vapour is called its........
7. We are heating some water when bubbles break through the surface of the water rapidly; we say the water is ............
8. In an open container water can only be heated to ............... °C.
9. Water disappears when placed in an open saucer. It changes from a .............. to a ............
10. If the heat is increased after water is boiling the temperature (increases, decreases, remains the same).
11. Evaporation is the process in which a .............. changes to a ............
12. Liquids are (sometimes, always) evaporating.
Effects of moving particles

Earlier in this chapter, we learnt that all matter, whatever its state, is made up of particles. These particles move at random in liquids and gases. Can you recall why these particles move?

In liquids and gases, the particles are farther apart than in solids. Would the spaces between particles in liquids and solids allow other particles to move among them? Let us investigate this.

Investigating diffusion

Activity: 5.12: Investigating movement of particles.

You need solid potassium permanganate (VII) (also known as potassium permanganate), water, a beaker, a narrow glass tube of length 9 cm for a transparent drinking straw.

Place a few crystals of potassium permanganate in the glass tube and hold it in the beaker, so that the end with the potassium permanganate crystals touches the base of the beaker.

Gently pour some water into the beaker. Do not shake or stir. Carefully remove the glass tube. See Fig.5.26. Observe and write what you observe.

Where does colour in the liquid first appear? How long does it take for all the water to become coloured? Where is the colour of the liquid deepest?

Particles of potassium permanganate on the surface of the crystals move away from the solid and go into the spaces among the moving particles of the water. The colour is deepest near the crystals since this is where most of the particles are before they spread out. After a while the crystals disappear but the solution has a deeper colour at the bottom. When the particles of potassium permanganate spread evenly among the particles of water the solution has one colour.

Diffusion is the word we use to describe the spreading out of particles. When making tea, we pour boiling water on tea leaves, which are either loose or in bags. If we do not stir, we can see how the brown colour spreads or diffuses throughout the liquid. The spread of the colour is due to the movement of tea particles among the water particles.

Let us do another activity where we observe diffusion of water vapour and ammonia vapour.

Activity 5.13: Diffusion of gases.

You need two strips of red litmus paper, two jam jars with covers, cotton wool, dilute aqueous ammonia, water.

1. Place some cotton wool in each jam jar.
2. Pour a little aqueous ammonia on the cotton wool in one jar and water on the cotton wool in the other jar.
3. Wet the strips of litmus.
4. Hang a piece over the top of each jar as shown in Fig. 5.27.
5. Cover both jars.

6. Observe for several minutes.

Write what you observe. Does the colour of litmus in both jam jars change? What colour does the litmus have in the jar with the ammonia? What colour does the litmus have in the jar with the water? Was the litmus paper touching the cotton wool in either jar?

One jar had ammonia. The particles of ammonia spread among the air particles and reached the litmus. The other jar had water, and the particles of water vapour similarly spread among the air particles and reached the litmus. Both water vapour and ammonia diffused in the air. We detected diffusion easily with the ammonia because ammonia always makes red litmus turn blue. We could have detected the water by using anhydrous copper sulphate. Water turns this white substance blue.

Sometimes we detect diffusion by odour. Perfume vapour, the vapour from bread while baking, and from other foods when cooking, all diffuse through the air and reach our nostrils.

Liquids may also diffuse in liquids. When we are making lemonade, we squeeze a lime or lemon into a whole jug of water. We expect the sourness of the lime or lemon to diffuse throughout the solution. Stirring makes the diffusion take place more quickly. When we dilute a mouth-wash the small quantity of mouth-wash diffuses through the whole solution.

Think of the things you use at home and at school. List five solids which diffuse in water, five gases which diffuse in air, and five liquids which diffuse in other liquids. Your teacher will check to see if you are correct.

Investigating air pressure

Force and pressure

Any time a force pushes against or presses against a surface we say that pressure is exerted. When the force is exerted over a large area the pressure is less than when the same force is exerted over a small area. An activity may help you to understand this.

Activity: 5.14: Comparing what happens when the same force is pushed against different areas.

You need a hammer, a small piece of board and a seed box.

![Force extended on a large area](image)
1. First place the plywood flat on the soil in the seed box.

2. With as much force as you can, hit the board with the hammer (see Fig. 5.28). Record what happens.

3. Now change the position of the board so that only an edge touches the soil in the seed box (see Fig. 5.29).

Once again, strike the board with as much force as you can but this time strike it on the top edge. Record what happens.

When the same force acted on the smaller area, the board dug deeper into the soil because the pressure on the soil was larger. Forces produce pressures on surfaces. But the pressures depend on the surface areas.

Moving particles hitting a surface

Try this other activity.

Activity: 5.15: Shooting paper with peas (or rice) 'bullets' and with air.

1. Hang a sheet of paper over a string or wire supported by two stands.

2. Blow some peas from a straw or tube (see Fig. 5.30).

3. Observe and write what happens.

4. Now blow air towards the paper using the straw or tube.

5. Observe and write what happens. Compare your observations with peas and with air.

You would have noticed similar results are obtained in both cases. It means that something other than the peas (or rice grains) also caused the paper to move. According to the particle theory, when you blew without using the peas, particles of exhaled air pushed the paper.

The two examples show that moving particles exert a pressure on the surface they hit. When a balloon swells, it is because the moving particles of air in the balloon exert a pressure on its inner surface.

Air pressure in all directions

Air pressure is exerted in all directions. Trying these activities will help you see this.

Activity: 5.16: The inverted glass of water.

Fill glass completely with water and place a card to cover the top of the glass. Hold the card and gently turn the glass downward. Remove
your hand from the card. It does not fall. What is holding the card up? (Caution: This experiment should be done over a container).

**Fig. 5.31** Diagram showing air pressure upwards

**Activity: 5.17:** Empty glass placed under water.

For this activity you need an empty glass and a basin of water. Upturn the glass and holding it vertically press it down into the water (see Fig. 5.32). What are your observations?

Why does the water not go into the glass?

**Activity: 5.18:** Icicle bag experiment.

For this activity you need – 1 teaspoonful of yeast, molasses, water, icicle bag, rubber band, glass tubing, rubber bung with one hole, conical flask.

1. Put about 1 teaspoonful of yeast in about 5 cm³ of water in a 125 cm³ conical flask.
2. Add about 1 cm³ of molasses to the contents in the conical flask and swirl the mixture.
3. Stop the conical flask with the bung which is fitted with a glass tubing.
4. Attach to the free end of the tubing, a narrow plastic bag (icicle bag) tightly.
5. Record your observations.

**Fig. 5.33(a)**

Icicle bag deflated at beginning of activity

**Fig. 5.33(b)**

Icicle bag becomes inflated as the gas moves into it
Measuring air pressure

In the laboratory, pressure can be measured by a special instrument called the manometer. Weathermen use a barometer to measure the pressure of the atmosphere. Your teacher may show you both instruments. Tyre repair shops and gas stations use pressure gauges to measure air pressure. (Pressure gauges are also used by welders to measure the pressure of the gases in the welding tanks).

Using air pressure

Many useful devices are operated by air pressure. Dropping tubes, syringes, pipettes, siphons, drinking straws, animal drinking fountains, are just a few. Here are diagrams to illustrate some of the devices mentioned. Can you figure out how they work by air pressure?

![Diagram of manometer, barometer, and pressure gauge](image)

![Diagram of various air pressure devices](image)

Fig. 5.34 Measuring air pressure

Fig. 5.35 Diagram showing some devices making use of air pressure
Exercises

1. Which one of the following does not possess kinetic energy?
   (a) a fast moving cricket ball
   (b) a stationary book on a shelf
   (c) falling raindrops
   (d) a spinning top

2. A stretched rubber band has what kind of energy?
   (a) kinetic  (b) nuclear
   (c) potential  (d) solar

3. The food we eat is an example of what kind of energy?

4. Which one of the following shows the energy changes associated with lighting a bulb using a battery and connecting wires.
   (a) electrical — chemical — light
   (b) light — heat — chemical
   (c) heat — light — electrical
   (d) chemical — electrical — light

5. State whether the following is true (T) or false (F)?
   (a) Energy can be created
   (b) Light is a form of energy
   (c) All energy comes from the sun
   (d) Gasoline is an example of nuclear energy
   (e) When we burn a candle, the energy in it is destroyed.

6. Making a toy sprinkler
   (a) Select a tin with a lid.
   (b) Punch many small holes at the bottom of the tin.
   (c) Punch one small hole in the centre of the lid.
   (d) Fill the tin with water and replace the lid.
   (e) Cover the hole on top of lid with your finger to stop the sprinkler. Remove your finger from the hole to let the water sprinkle.

Uses: This device can be used indoors to water plants.

7. Select the best answer
   (i) When air is pumped in a tube
      (a) the air particles increase in speed in the tube
      (b) more air particles are put into the tube
      (c) the air particles increase in size
      (d) the air particles decrease in size
   (ii) What do we mean when we say air is compressed?
      (a) Air particles are scattered.
      (b) Air particles are forced into a container.
      (c) Air particles are heated.
      (d) Air particles are cooled.
   (iii) Solids diffuse in liquids because the particles in liquids
      (a) are closely packed
      (b) have spaces between them
      (c) attract other particles
      (d) repel each other
8. Underline the correct word(s) in brackets.
   a. All matter is made up of (atoms, molecules, particles).
   b. Molecules are (closer together) (farther apart) in liquids than in solids.
   c. Molecules are (closer together) (farther apart) in gases than in solids.
   d. When gases are cooled, the particles move (closer together) (farther apart).
   e. The particles in a solid vibrate (faster, slower) when they are heated.

Complete each sentence with a word that will make it a true statement.

9. When solids are heated they get larger; we say they ......................

10. When solids get smaller, we say they ..............................

11. Liquids, solids and gases expand when they are ..........................

12. Liquids, solids and gases contract when they are ......................

13. Liquids, solids and gases, all occupy space and have ......................

Give written explanations for each of the following situations.

14. When fruit is canned, the glass jar is usually filled to the top with hot fruit and syrup. When the jar is examined later on it is found to be no longer full.

15. The metal cover on a jam jar can be loosened if hot water is poured on the metal.

16. A football is pumped up outdoors where it is warm. It is used and then taken indoors where the temperature is much lower than outdoors. It becomes softer.

17. A student measures an object with a metal rule and records a length of 25 cm. He heats the metal rule, and measures the same object with the hot rule. He does not get the same result.

18. Solids are made up of particles which are very close together and not free to move. A metal rod is held in the hand and placed in the fire. Eventually, the end that is being held becomes hot.

19. The arrangement of particles in a solid, liquid and gas.

20. Make a drawing of a bottle of air. Use dots to represent the molecules. Now draw another bottle and show the molecules after the bottle has been heated.

21. Do you think that a gas can diffuse through solid? Give a reason for your answer.
    (Hint: Can a large quantity of rice grains be put into a bucket that is full?)
Summary

WE HAVE LEARNT THAT:

- energy enables us to do work.
- there are different sources of energy but all energy comes from the sun.
- there are different forms of energy – heat, kinetic, potential, electrical, chemical, sound, and nuclear.
- energy can be converted or changed from one form to another, but energy cannot be created nor can it be destroyed.
- things in our environment can be classified as living matter or non-living matter.
- matter can be classified as either solid, liquid or gas.
- solids, liquids and gases occupy space or have volume.
- solids, liquids and gases have mass.
- solids, liquids and gases expand when they are heated.
- solids, liquids and gases contract when they are cooled.
- heat energy can change the physical state of a substance.
- when a solid changes into a liquid, we say it melts.
- the melting point of a substance is the temperature at which it changes from solid to liquid.
- the boiling point of substance is the temperature at which it changes from liquid to gas or vapour.
- diffusion is the spreading of particles of one substance among particles of another.
- solids can diffuse in liquids
- gases can diffuse in gases
- liquids can diffuse in liquids
- air pressure is the force of moving air particles pressing on a surface.
- air pressure can find many useful applications.
When we studied living things in Unit 3, we were able to recognise them by the way they looked and behaved — that is, by their characteristics. We can also look at the appearance or behaviour of non-living things such as metals, non-metals and solutions. Each group has its own characteristics; each behaves in a particular way under certain conditions. These characteristics or behaviours are called properties of the substances. The properties of substances may be physical ones or chemical ones.

In this unit we will learn about:

- the differences between the physical and chemical properties of a substance
- the differences between physical and chemical changes
- using suitable terms to describe physical and chemical properties
- conservation of mass and energy during a chemical change.

**Physical properties of substances**

The physical properties of substances are those properties which we can recognise using mainly our senses of touch and sight as well as by using scientific instruments.

Properties such as colour, density, solubility, hardness, freezing point, boiling point, electrical conductivity are all physical properties. Let us try to find out other physical properties of substances.

**Activity 6.1: Identifying physical properties of some materials.**

You need: - a sheet of sandpaper, a piece of cloth, wood, sand, sponge, stones, water, oil, metal objects, cork.

Now study the substances carefully and identify their physical properties. Record your observations in a table such as the one below.

<table>
<thead>
<tr>
<th>Substances</th>
<th>Physical properties</th>
</tr>
</thead>
</table>

113
We noticed that these substances are different from each other. Now let us look at water and oil. They are both liquids. They are similar in this way, but, like living things, there are differences between the two liquids. We are going to compare the heaviness of oil and water. In what other ways is water different from oil?

Activity: 6.2 : Comparing the mass of cooking oil and water.

1. Weigh an empty 250 cm$^3$ beaker on the balance. (Remember to adjust the balance to zero before placing the beaker on the pan).
2. Read the scale accurately.
3. Measure 50 cm$^3$ of water and pour into the beaker. Weigh the beaker with the water. Record and calculate the mass of 1 cm$^3$ of water.

Your readings should be recorded as follows:

<table>
<thead>
<tr>
<th>Substances</th>
<th>Density (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>brass</td>
<td>8.5</td>
</tr>
<tr>
<td>carbon dioxide</td>
<td>0.002</td>
</tr>
<tr>
<td>copper</td>
<td>8.9</td>
</tr>
<tr>
<td>cork</td>
<td>0.25</td>
</tr>
<tr>
<td>oxygen</td>
<td>0.0014</td>
</tr>
<tr>
<td>iron</td>
<td>7.9</td>
</tr>
<tr>
<td>methylated spirit</td>
<td>0.8</td>
</tr>
<tr>
<td>petrol</td>
<td>0.7</td>
</tr>
<tr>
<td>gold</td>
<td>19.3</td>
</tr>
<tr>
<td>glass</td>
<td>2.5</td>
</tr>
<tr>
<td>mercury</td>
<td>13.6</td>
</tr>
<tr>
<td>sand</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Do you expect solids to be more dense than liquids or gases? Verify your answer by studying your table.

Here is another physical property that we can investigate.

Activity: 6.3: Do all substances conduct electricity?

This activity may be done in small groups. Each group needs a simple series circuit as shown
Gases also have physical properties. One physical property of gases is colour. Chlorine is greenish-yellow. Nitrogen dioxide is brown. Gases like oxygen and carbon dioxide are colourless. What other physical properties do gases have?

In Unit 1 we looked at the behaviour of substances in water. Some dissolved while others did not. The ability of substances to dissolve or not is another physical property.

**Chemical properties of substances**

Substances can also be identified by their chemical properties. But chemical properties are quite different from physical properties. We cannot use our senses alone to tell the chemical makeup of substances. For example, ordinary paper and asbestos paper look similar. They both have many of the same physical properties. Now let us see how they are different.

Ordinary paper burns when placed in a flame; asbestos paper does not. Why is this so? The paper burns because it combines easily with oxygen, while asbestos does not combine with oxygen.

Do you know any other substances that do not burn?

**Caution: Asbestos must not be burnt in the laboratory**

Chemical properties of substances tell us whether the substances stay the same or change into other substances under certain conditions. They indicate how the substances would react with other substances.
Let us now find out some chemical properties of certain substances.

**Activity 6.4**: Heating substances in air.
You will need a variety of substances such as wood, a leaf, paper, a small piece of foil paper, magnesium ribbon, copper wire or foil, ammonium dichromate.

Hold a piece of wood with a pair of tongs over a Bunsen burner flame. What have you noticed? Repeat the experiment using the leaf and paper.

Now hold a piece of foil paper with a pair of tongs over the flame. Repeat using a piece of magnesium ribbon. Do not look directly at the magnesium while it is burning as it burns with a very bright flame.

<table>
<thead>
<tr>
<th>Substance</th>
<th>What happens when it is heated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Place a very small quantity of ammonium dichromate on a tin lid or in a crucible. Heat it gently by placing it on a gauze over a tripod. Stand well back while you are heating this substance. As soon as something begins to happen remove the flame.

![Fig. 6.2 Heating wood in a flame](image)

Record your observations in a table as the one shown.

![Fig. 6.3 What safety precautions a student should take when observing the heating of a substance?](image)
Another chemical property we noticed was that magnesium and ammonium dichromate obviously changed completely to something new. When they cooled they did not change back to the substances with which you started. Metals react with the air too, and because of this, some metals like sodium are stored in oil.

![Sodium stored in oil](image)

Now let us look at some chemical properties of a few liquids. We have already learnt in Unit 1 that some liquids reacted with other liquids. Some changed their colours while others effervesced or formed precipitates. We also learned that some substances caused litmus paper to change its colour. Some liquids would have the same physical property such as colour, but many have different chemical properties. How can we find out the chemical properties of liquids?

> Remember, we do not taste or even smell unknown substances.

**Activity 6.5: Liquids and Litmus**

Identifying unknown liquids by their chemical properties.

You will be given six test tubes labelled A–F. Each containing different colourless solutions.

1. Prepare a table for recording your observations.
2. Now carefully pour a small portion of the contents of test tube A into a watch glass or tin lid.
3. Test the solution by dipping a piece of blue litmus paper into it. What have you noticed?
4. Now dip a piece of red litmus in the solution. What have you noticed?

Repeat the experiment using the other solutions and fresh pieces of blue and red litmus paper each time.

You must have discovered that some of the liquids turned the blue litmus paper red. What do we call substances that turn blue litmus red? Other liquids turned red litmus blue. Name the substances that turn red litmus blue.

We now know that some of the liquids were acids and the others were either alkalis or neutral substances. We could not have identified them by sight alone.

We tested the liquids with a substance that changed colour. This substance is called an indicator. What is the indicator we used in our experiment?

The effects these liquids have on the litmus paper tell us about one of their chemical properties.

**Investigation and recording**

**Check yourself**

Select two solids and two liquids from your kitchen. Investigate and record two physical and two chemical properties of each one. Take Care!
Physical changes

Substances around us are changing all the time. Some of the changes we may have observed, while there are others we may have never noticed. The changes in substances are of two kinds: Physical and chemical.

Examples of physical changes

In Unit 4 we mixed substances with water and some dissolved. Dissolving is an example of a physical change.

Activity: 6.6: Dissolving copper sulphate in water.
1. Add a spatula of copper sulphate to about 10 cm³ of water.
2. Stir until it dissolves.

What have you observed? Remember that when we dissolve sugar in our tea or drink, it would taste sweet. The taste indicates to us that the sugar is still in the water. How can we tell? (Remember, we must not taste substances to test them). The colour of the solution suggests that the copper sulphate is still there. Let us find out if we can get back the copper sulphate.

Activity 6.7: Can we get back the copper sulphate?
1. Pour just a little of the copper sulphate solution into an evaporating dish or a tin lid.
2. Place the dish with the solution over a Bunsen burner flame and observe. Do not allow it to dry out completely over the flame.
3. When most of the water is dried out remove the flame, and allow to cool.

Did we get back the copper sulphate? What is left in the evaporating dish? What has become of the water? It has disappeared; we say it evaporated. The water was changed to water vapour which is a gas.

When water is heated enough it boils. It changes to a gas called steam. Steam is water vapour at the boiling point of water (i.e. the temperature at which water boils). When the steam cools, it condenses and changes back to liquid water. (See Fig.6.5).

![Fig.6.5 Water changing to steam which then condenses back to water](image)

The white cloud we see above a pot of boiling water is not steam. Steam cannot be seen. What then is the cloud we see? Actually the white cloud is made of tiny drops of liquid water formed when steam comes out of the pot and condenses in the cooler air. This process is called condensation. Can you explain how the clouds are formed in the sky?

Activity 6.8: What happens when ice is warmed? (See also activity 5.11).

This is a group activity. The group should not be larger than four students. Each group will need a small dish or tin lid and a cube of ice. Ensure that the ice cube has straight sides and square corners.
The first member of the group will measure the length and breadth of the ice cube and record the measurements. The other members will now take turns in holding the ice cube over the dish as long as they can. Write down everything you observe while holding the cube, including its measurements.

Compare the four measurements. Make a drawing to show the size of the ice cube each time it was measured. Did the size of the ice change? What else did you see? Can you explain what happened? Can you remember having a glass of iced drink? What did you notice happen to the ice?

When water freezes it turns to solid. The temperature at which water freezes is the freezing point. Ice melts and turns into liquid when the temperature rises above freezing point; i.e. when it is warmed. The next activity will help us to understand melting.

Activity 6.9: The candle

1. Take a candle and look at it carefully. Notice that the wax is solid.
2. Light the wick and notice what happens to the wax. Where does the wax melt? What causes it to melt? Where does the liquid wax turn solid?

The last three activities in this section have shown us that (a) water can be a liquid as well as a solid and a gas and (b) wax can be changed from solid to liquid then to solid again.

All these processes are reversible. Can you think of any other substance that behaves in this manner?

Characteristics of physical changes

The changes just described are all physical changes. When physical changes take place no new substances are formed. For example, when liquid water freezes, it becomes solid water, ice. These changes can then be easily reversed; for example, ice melts and becomes liquid again. A change of temperature can change the state of a substance.

Rocks are liquid deep down in the earth. This is so because the temperature below the earth's surface is very high. In St. Lucia, there is a volcano at Soufriere. When the volcano erupts, liquid sulphur is thrown out and it cools and turns solid.

Fig. 6.6 The volcano at Soufriere, St Lucia

Chemical changes

In Unit 1 we mixed liquids together. In those activities we noticed that the mixtures produced substances quite different from the ones we started with. These are examples of chemical changes. When these new substances were formed some of the mixtures felt hot, while others felt cold. We are now going to look at a few more example of chemical changes.
Activities showing chemical changes

Activity 6.10: Burning wood (Refer to fig 6.2)

Take a piece of wood and put it over a Bunsen flame. What have you noticed? Can anything be done to the ash to get back the piece of wood we started with?

Activity 6.11: Heating iron filings and sulphur together.

Mix a spatula of sulphur and some iron filings together. Can they be separated? Explain how you would do this.

Now heat the mixture over a flame. What have you noticed? Can the iron filings now be separated from the sulphur?


1. Heat a small amount of sulphur gently in a test tube over a Bunsen burner flame. When the sulphur melts, allow it to cool.

2. Heat the sulphur again, this time in a deflagrating spoon. Notice what happens now. Was the change in each of these two instances temporary or permanent?

The substances which are formed when materials are burnt in air are called oxides. The materials react with the oxygen in the air.

Some materials give off a gas when burnt. Did you smell anything when you were heating the sulphur? It gives off a gas with an irritating odour; this gas is called sulphur dioxide. When magnesium ribbon burns, a white ash is formed called magnesium oxide. When a new substance is formed in a reaction we say that a chemical change has taken place. Chemical changes occur not only in the laboratory but also in nature. For example, when we eat our food it is changed to substances which are simpler for our bodies to use. This is called digestion. Also one of the most important chemical changes takes place in plants. This process is called photosynthesis during which plants use sunlight to make plant food from simple substances.

Characteristics of chemical changes

We can now summarize some characteristics of chemical changes.

When chemical changes occur, completely new substances are formed. It is usually very difficult to reverse the changes. During these changes heat is usually either given off or absorbed by the substance.
Can you think of chemical changes that occur in your home? What characteristics do they have?

Conservation of mass and energy

Mass is the amount of "stuff" in an object. During a chemical reaction the total mass of the particles that react equals the total mass of the products. For example the mass of the iron filing plus the mass of the sulphur equals the mass of the iron sulphide and any other substance(s) produced.

Therefore scientists have made a theory which states that matter is not created or destroyed during a chemical change.

Energy is the ability to do work. Energy exists in different forms such as heat, light, sound. During a chemical reaction these forms of energy are either given off (or evolved) or absorbed.

Living things depend on energy which is obtained during respiration when oxygen reacts with glucose. As we already know, photosynthesis cannot take place unless the plant absorbs the energy of sunlight. In our everyday activities we depend on the energy given off when coal, petrol and oil burn. In these activities the energy is not created or destroyed but only changes from one form to another. For example, when coal burns, the chemical energy stored in the coal changes to heat and light energy. Can you think of any other activities at home or in the factories in which energy is changed from one form to another?

Exercises

1. What is meant by the properties of a substance? Give examples of both physical and chemical properties.
2. How can you find out whether a substance is an acid, an alkali or a neutral substance?
3. Here is something to be done at home. Ask your teacher for a piece of blue and red litmus paper. Look around your kitchen or even the First Aid Kit or cupboard for some liquids or even solids and test them with litmus paper, entering results as in the table below. Remember to wet the solids before carrying out your test.

<table>
<thead>
<tr>
<th>Acids</th>
<th>Alkalis</th>
<th>Neutral substances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. What did both ice and wax need to cause them to melt?
5. Give two examples of chemical changes and two examples of physical changes which take place at home.
6. How is a chemical change different from a physical change?

![Fig. 6.8 Mixing chemicals with water](image)
7. Mix some citric-acid crystals and baking soda in a dry dish as in Fig. 6. 8. Has a chemical change taken place? Give a reason for your answer. Add this mixture to water. Has a chemical change taken place? How can you tell? What made the difference between your first and second result? Do you think the same thing will happen if you put the mixture in a wet dish? Try it.

Summary

WE HAVE LEARNT THAT

- physical properties of substances can be observed by using our senses of sight and touch. Instruments are also used to help detect physical properties.
- some physical properties of a substance are its colour, texture, ability to dissolve, density, and ability to conduct electricity.
- chemical properties may be noted when the substances react with other substances. For example, magnesium ribbon burns with a bright flame in air. Some substances change the colour of litmus.
- density is the mass of 1 cm³ of a substance.
- density is used in science to compare the heaviness of substances. It is expressed in g/cm³.
- physical change is a change in which no new substance is formed.
- chemical change is a change in which a new substance is formed.
- some substances can change from one state to another:

  liquid ⇄ solid ⇄ liquid ⇄ gas

- physical changes are easily reversible while chemical changes are not easily reversible.
- energy cannot be created or destroyed but can change from one form to another.
In this unit we will learn about:

* some characteristics of living organisms
* parts of a flowering plant
* the life cycle of a flowering plant
* the life cycle of animals e.g. mosquito and butterfly.

Watching plants grow

In Unit 3 we grouped living things according to their external features e.g. all plants that bear flowers were grouped together. Another way of grouping living things is according to their life cycles. In this section we will be learning about the life cycle of a dicotyledonous plant (refer to p. 20).

![Diagram of the life cycle of a flowering plant]

**Fig. 7.1** Life cycle of a flowering plant.
Structure of a dicot seed

It is easy to begin describing the life history of a plant at the seed stage, so let us study the structure of a dicotyledonous seed.

Activity: 7.1: Collect, observe, draw

1. Collect different kinds of dicotyledonous seeds. Examine them dry. Draw the dry seeds.

2. Soak the seeds overnight in much water. Examine the soaked seeds. Squeeze them and note if and where water oozes out.

3. Remove the tough coat if you can and gently separate the two cotyledons or seed leaves. (Seeds that have two cotyledons are called dicotyledonous).

4. Use a hand lens or other magnifying glass and draw the young plant that is between the seed leaves.

5. Try to label every feature you have drawn – testa, hilum, micropyle, cotyledons radicle and plumule.

Fig. 7.2 Different sorts of seeds

Fig. 7.3 A dicotyledonous seed

You would have noticed that not all seeds are exactly the same but they all have two main parts – an embryo and a food store.

The whole structure within the testa is the young plant. It is called the embryo.
Germination of a seed

What should we do to get seeds growing? Before you go on reading this section, try to remember what you have done on ‘Germination’ and what you have learned about it. Write down what you can remember.

Look now at the experiments illustrated below.

1. Dry, left in the lab
2. Damp, left in the lab
3. Under water, left in the lab
4. Damp, left in the fridge

How do they differ?

For experiment 1, the seeds are dry. In experiments 2, 3 and 4 they are wet. So the water supply differs. In experiments 1, 2 and 4 the seeds have air. In experiment 3 the air in the water has been boiled off. Oil has been poured on the cooled boiled water so that no air can dissolve in the water. So the air supply differs.

Experiments 1, 2 and 3 are done at room temperature. Here, in the tropics, room temperature is warm. But experiment 4 is done in a refrigerator. It is cold. So the temperature conditions differ (see Fig. 7.4).

An experiment with all the conditions present is called a control experiment, as in 2. You can compare and contrast the results of the other experiments against the results of the control experiment. In each of the other experiments one of the factors is absent – 1, no water; 3, no air; and in 4, no warmth.

Activity 7.2: Observe, measure, tabulate

1. Set up your experiments using jam jars and peas or other seeds which germinate quickly as illustrated in Fig. 7.4
2. Note the date when you do so. Look at them every day after that until the first set of foliage or green leaves appear. Write down what you observe each day. Date your observations.
3. Measure the length of the roots and the shoots.
4. Record all the measurements you make in Table 7.1.
Table 7.1 Growth of a young plant

<table>
<thead>
<tr>
<th>Time in days</th>
<th>Growth</th>
<th>Length in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>(Control)</td>
</tr>
<tr>
<td>Air</td>
<td>No water</td>
<td>Water</td>
</tr>
<tr>
<td>Warmth</td>
<td>Air</td>
<td>Warmth</td>
</tr>
<tr>
<td>Root</td>
<td>Shoot</td>
<td>Root</td>
</tr>
<tr>
<td>Shoot</td>
<td></td>
<td>Shoot</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>No Air</td>
<td>Warmth</td>
</tr>
<tr>
<td>No Warmth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>Shoot</td>
<td>Root</td>
</tr>
<tr>
<td>Shoot</td>
<td></td>
<td>Shoot</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>No Air</td>
<td>Warmth</td>
</tr>
<tr>
<td>No Warmth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>Shoot</td>
<td>Root</td>
</tr>
<tr>
<td>Shoot</td>
<td></td>
<td>Shoot</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The time intervals are regular – each day. So time could be recorded in the first column on the left.

Record each length in its appropriate space.

What is the purpose of getting all this information? It is to be able to make conclusions that are valid. In class, you all will discuss the various readings and draw valid conclusions from them. Later, your readings could still be of use e.g. for giving relevant examples and for making graphs called 'growth curves'.

Did the germination take place as you had expected? Was soil necessary for germination? Try to design an experiment to find that out. Remember that every experiment needs a control.

The factor being investigated in this case is soil. Since the control experiment is to have all the relevant factors, the control experiment in this instance should have water, air, enough warmth and soil. The other experiment would have water, air and enough warmth alone but no soil. Set up these experiments. (see Fig. 7. 5)

**Activity: 7.3 : Observe, record**

1. As in the last case, note the date when you set them up.
2. Look at them every day after that and until the first set of foliage leaves spreads open.
3. Give both sets of seeds sufficient but equal amounts of distilled water.
4. Record your measurements, presenting them in a table.
The seed has sufficient food stored in it for the embryo to grow into a seedling. The seedling develops a root system to draw water and minerals from the soil. It develops foliage leaves, to make food. By the time the stored food, in the cotyledons, is all used up, the seedling is able to keep on growing, provided the raw materials are available. What are these 'raw' materials? Where are they found? The raw materials, found in the soil and in the air, are water, dissolved mineral salts and carbon dioxide. That is why regular wetting of seedlings in a nursery and of plants is necessary, to supply the water the plants need. That is why good soil is used in gardens. That is why manure, compost, plant ash and/or fertilisers are added to garden soil, to give a good supply of the various mineral salts the plants need.

Cover the healthy seedling with a paper bag. Continue watering the soil. Remove the paper bag after a week. Describe the seedling.

If the seedlings are left in the dark, they may continue to grow for a while, but the new leaves would not be green.

The stems would be tall and weak. If the tall pale plants, termed etiolated plants, are put in the sun, the leaves would develop chlorophyll and the plants might survive. If they are left in the dark they would eventually die. This shows that sunlight also is needed.

So for the continuous growth of seedlings, water, mineral salts, carbon dioxide (in air) and sunlight are necessary. The seedlings would then grow and develop into mature plants that flower, form fruits and set seeds. The black-eye pea plant has a life cycle of six weeks. Some tomatoes have a life cycle of three months.

**Looking at flowers**

**Activity 7.4:** Observe, draw

1. Look at flowers in your neighbourhood, in gardens or growing wild by the roadside.

2. Collect some flowers, breaking them off so that you have some stem and leaves. If the flowers go limp, hold the stem under water and cut it about an inch from the end. The flower should survive.

3. Examine the flowers. Count the number of the different parts.

4. Separate the flowers into groups. Put the flowers with floral parts in multiples of three in one group. That group would tend to have long, narrow leaves.

5. Put the flowers with floral parts in multiples of five or seven in another group.
Fig. 7.6 Section through flower.

That group would tend to have broad leaves.

6. Concentrate on the flowers of the latter group. Cut the flowers with a razor blade to get halves that resemble each other.

7. Examine the half flowers. Use a hand lens or magnifying glass.

8. Draw both the whole flowers and the half flowers.

9. Label your drawings fully.

In the very centre is the pistil. The pistil consists of the ovary, style and stigma. The ovary contains the female cells.

Flowers vary in many ways yet most consist of these four parts: sepals, petals, stamens and pistil. In some flowers there are no sepals or petals, only stamens and pistil. The stamens and pistil are the essential organs, essential for the work of flowers i.e. for reproduction. The ovary develops into the fruit; the ovules into the seed.

The variety in flowers has to do with variations in the process of reproduction. In some flowers the parts are separate, in others the parts are joined, forming a tube. In some flowers the stigmas appear beyond the anthers; in others they occur below the anthers. In some flowers the stamens are free; in others they are attached to the petals. In some plants only some flowers have ovaries, while the others have stamens. Many variations occur, all with good reason.

Humans benefit from flowers. Quite apart from the pleasure we get from attractive fragrant flowers, human benefits from the food supply of
fruits and of seeds that develop from flowers.

But even more importantly humans benefit from flowers by being able to plant the seeds that develop in the fruits formed from flowers. Each seed has a plant in itself after its own kind. Mangoes beget mangoes. So it is that we have a complete life cycle with the stages:

Watching animals grow

In this section we will be learning about the life cycles of a mosquito and a butterfly. Beginning at the egg stage, we will follow the hatching of the eggs and the growth and development of the larvae and pupae until the next set of eggs is laid by the adult.

The life cycle of a mosquito

The Anopheles mosquito can take the organism that causes malaria form one person to another. We will now study the life cycle of this mosquito

Fig. 7.7 Life cycle of a mosquito
The egg

The eggs of the Anopheles mosquito are laid singly on the surface of still water which is exposed to sunlight and in some cases, with much surface vegetation. Each egg is elongated and oval, and is usually pointed at one end with a pair of lateral floats. It is about half a millimetre in length. (See Fig. 7.7). It hatches within two to three days into a larva.

Activity 7.5: Observing mosquito eggs.

1. Search for such eggs.
2. Keep them in a transparent container with a cover of muslin or of mosquito net tightly tied on.
3. Observe the eggs and describe them in detail.
4. If you do not find the eggs, collect larvae instead.

Fig. 7.8 (a) Anopheles mosquito eggs (lateral view)

The larvae are aquatic. i.e. they live in water. Each larva lies parallel to the surface of the water with two pores, one at the anterior end and one at the posterior end, admitting air from the atmosphere into its body, (see Fig. 7.8 b). Mosquito larvae can move. They are called wrigglers. They strain minute plants and animals from the water for their food. As they feed, they grow. But their exo-skeleton does not stretch as does our skin. Their skin bursts, to reveal a new larger skin. The larvae shed their outer skin, or moult, four times. The fourth moult produces a pupa. The larval stage lasts for around five to seven days. Factors that affect the length of the larval stage are water, warmth and food supply.

Activity: 7.6: Observing mosquito larvae.

Search for mosquito larvae and collect them. Keep them in a transparent container with water, grass and some mud in it. You should add some bread or flour on which the larvae could feed.

1. Observe the larvae.
2. Describe them in detail.
3. Draw them and label the drawings.

The pupae are aquatic. Each pupa has
large anterior section, of the head and thorax; and a relatively thin posterior section, of the abdomen. The respiratory tubes, or syphons, are at the anterior end. They open into the air. (see Fig.7.8c)

Through the pupal case you could see the position of the compound eye and that of the developing legs. The pupae can move. They are called 'tumblers'. They do not feed. A change is taking place. The organisation of the body is changing, from an aquatic form to that of a terrestrial one. When the pupal case bursts, an adult mosquito emerges, from the water, into the air. The pupal stage lasts one day or two. Observe the pupae. Describe them in detail. Draw them and label the drawings.

Attached to the thorax is a pair of narrow wings that are spotted. Also attached to the thorax are three pairs of long, slender, jointed legs. The abdomen is slender and segmented and has a few scales.

The adult is not aquatic as are the larvae and pupae. It is terrestrial i.e. it lives on land. The male mosquitoes emerge before the female ones. They remain near the breeding places. As the females emerge, the males mate with them. There is usually just one mating to provide male cells to fertilise all the eggs in the female. The female sucks a meal of blood for its eggs to become fertile. It lays about fifty to one hundred eggs at a time, and during a lifetime lays about a thousand eggs.

The adult

The word mosquito means “little fly”. The adult is small and fragile. The body consists of three parts – head, thorax and abdomen. The head has two antennae. They can sense warmth and enable the female mosquito to find the warm-blooded animals on which it feeds. There is a proboscis for sucking up juices or blood. The proboscis is surrounded by lances for piercing the skin. The head bears two large compound eyes.
The name given to the changes that take place from the hatching of the egg to the emergence of the adult is metamorphosis. In this instance, metamorphosis is complete. (In some cases e.g. cockroach, it is incomplete. The young nymphs resemble the adults). The mosquito is nocturnal in habit. During the day it hides in dark cool places e.g. in bushes, in long grass, behind furniture and under beds. The male sucks juices of plants and fruits. The female sucks blood. Some species prefer human blood, but some species feast on birds’ blood, some on horses’ blood, some on cows’ blood, and some on monkeys’ blood. The body of the female makes an angle of 45° with the skin of the person whose blood it is sucking. Other mosquitoes have their bodies paralleled to the skin (see Fig.7.9). The life span of some species of Anopheles is one or two months.

We do not want to breed mosquitoes. They are dangerous insects. Keep the container tightly covered with muslin or with mosquito netting. Observe the adults through the material and describe your observations in detail. Try and draw the adults and label the drawings. After that, please destroy the adult insects. You may place a lid on the container to cut off the air supply.

**Mosquitoes and diseases**

(a) The type of mosquitoes.

There are three particular types of mosquitoes that engage our interest in Guyana because of public health. They are the Anopheles, Culex and Aedes. Ways in which they could be distinguished are given in the chart.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Anopheles</th>
<th>Culex</th>
<th>Aedes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>Laid singly.</td>
<td>Laid singly, then the female uses her legs and forms them into a raft of 100 or more.</td>
<td>Laid singly. Eggs remain separate, stuck together in a row.</td>
</tr>
<tr>
<td></td>
<td>Laid in still water e.g. stagnant pool, puddles, ponds, gutters.</td>
<td>Laid in still water e.g. latrines, septic tanks, in pools formed by uneven surface of land.</td>
<td>Laid on the side of containers, in trees hole just above water level; in vats vases, drums, tanks and in watering gutters.</td>
</tr>
<tr>
<td>Larva</td>
<td>Lie parallel to the surface of the water</td>
<td>Lie at an angle of 45° to the surface of the water.</td>
<td>Hang at right angle to the water</td>
</tr>
<tr>
<td>Adult</td>
<td>Has spotted wings</td>
<td>Dark brown in colour. Has white lines on body.</td>
<td>Almost black in colour. Silver white bands, stripes.</td>
</tr>
<tr>
<td></td>
<td>Abdomen has few scales</td>
<td>Abdomen and wings covered with scales.</td>
<td>Abdomen covered with scales</td>
</tr>
<tr>
<td></td>
<td>When feeding female’s body makes angle of 45° with surface</td>
<td>When feeding their bodies are parallel to the surface.</td>
<td>When feeding their bodies are parallel to the surface.</td>
</tr>
</tbody>
</table>
(b) The diseases they spread.

Mosquitoes are vectors; they carry diseases from an infected person to many others.

The female Anopheles mosquito is the vector of Malaria.

Malaria is caused by a protozoan called Plasmodium. When a female Anopheles mosquito bites a person with malaria and sucks in some of the person’s blood, the mosquito becomes infected, usually for life.

The plasmodium develops in the mosquito which can then pass it on to another person. Malaria can kill. About a million children in the world die of malaria every year. Others are left weak and are unable to work or to study properly. The usual drug given is chloroquin. Malaria was eradicated from Guyana by the work done by the late Dr. Giglioli and his team. But it has come back across our many borders.

The Culex mosquito is the vector of round worms—Nematode worms—that cause Filariasis—swelling of the feet, legs and arms, and the feeling of intense pain.

The Aedes mosquito is the vector of the virus causing dengue fever (also called 'breakbone' fever).

- Sleep under nets.
- Use insect repellents.
- Wear protective clothing e.g. long-sleeved shirt.
- Burn mosquito coils.
- Burn grass or leaves.
- Kill mosquitoes.
- Remove/destroy all breeding places.
- Fill up puddles of stagnant water with stones and earth.
- Pour oil on the surface of stagnant water and in latrines.
- Screen water drums, inlet pipes to vats, the aeration pipe of septic tanks etc. Change the water in vases, at least twice weekly.
- Cover water pots and other containers with cloth. Keep gutters in good repair, not sagging, nor clogged.
- Turn upside down, or bury, receptacles like coconut shells, plastic containers and tyres that might store stagnant water.
- Put small fish, which eat larvae, into ditches and ponds.

(c) Prevention measures

It is much better to prevent these diseases than to have to cure them.

To prevent malaria, filaria, yellow fever and dengue fever, we must stop 'mosquitoes' biting people. We must do things like these:

- Keep mosquitoes away.
- Place screening doors and windows in a house.

The life cycle of a butterfly

Look at the life cycle of a butterfly as drawn in Fig. 7.10. In this part of the section it is the life cycle of the Monarch Butterfly that would be studied.

The egg

The eggs of the Monarch butterfly are laid singly on the under-side of a leaf of the plant
The larva

The larvae of butterflies, and of moths, are called caterpillars. They are elongated. The body consists of head, thorax and abdomen, but the segments are similar in size.

Activity 7.7: Observing the adult butterfly laying eggs

1. Watch a butterfly.
2. Note the plant on which it alights.
3. Examine the leaves of that plant.
4. Collect a leaf on which there are eggs, put it in a jam jar and cover the mouth of the jar with muslin or mosquito netting.
5. Examine the leaf each day.

If you do not see the eggs, you could break off the twig on which the butterfly alighted and put the stem of the twig in water to keep the leaves fresh. In a day or two you may see larvae that may have hatched from the eggs.

The head segment has simple eyes and two antennae. It has jaws, on the under side of the head, that move from side to side like a pair of scissors. The three segments of the thorax bear three pairs of short true legs.
Five segments of the abdomen have false legs or claspers for grasping the food plant. Almost all the segments of the body have spiracles that allow air in and out of the caterpillar.

**Activity 7.8:** Observing the development of the caterpillar.

1. Look at the larvae each day.
2. Try to be as precise and accurate as possible.
3. Use a hand lens to magnify the features you draw.
4. If you have a range of crayons you could try to colour the caterpillar; try and get the colour as exact as possible.
5. If you don't have crayons give a word picture instead.
6. Label your drawings.
7. You could measure a caterpillar each day to calculate how much it grows.

**Questions**

1. What precaution could you take to increase your degree of accuracy?
2. Could you not put each caterpillar in its own labelled jar?

The caterpillars of butterflies like to climb. After their last moult, they hang as pupae, by silk threads, from leaves of their food plants. The caterpillars of moths, however, spin cocoons of silk threads and bury themselves in the ground.

**A pupa**

The pupa of the Monarch butterfly is beautiful – pale green with glistening yellow bands and dots. It is called a chrysalis. It hangs from a leaf of the food plant. It does not feed. When the pupal case bursts, a beautiful butterfly emerges. Observe the pupa and record your observations.

**The adult**

At first the wings are crumpled, but as blood courses through them they stiffen.

The Monarch butterfly is of a rich orange colour with black bands and white dots. The head has two long slender antennae with knobs at the end; a pair of compound eyes and mouth-parts formed into a long slender tube – the proboscis – for searching for nectar and sucking it up. The thorax has two pairs of wings and three pairs of legs. The abdomen is short and slender. When the butterflies emerge from their chrysalises, they feed and mate and the females lay eggs on their food plants.

There are differences between butterflies and moths. By and large the body of a moth is fatter than that of a butterfly.

The antennae of butterflies are long and slender, with knobs at the end. Those of moths are feathery.

![Monarch butterfly](Fig.7.12)

When a butterfly comes to rest it holds its wings upright over its back. The brilliant colours of the dorsal upper surface are hidden. The ventral lower surface blends with the...
surroundings. A moth, at rest, spreads out its wings parallel to the surface on which it rests. The sober-coloured fore wings cover the brightly coloured hind wings.

Most butterflies fly and feed during the day. They are diurnal. They visit brightly coloured flowers and feed on the nectar. Most moths fly at night, i.e. they are nocturnal. The flowers they visit for nectar are usually white and have a strong fragrance, e.g. jasmine and frangipani.

**Importance of the butterfly**

Butterflies add colour and beauty to our landscapes.

Unless ripe pollen grains reach the stigmas of the same kind of flower, the ovaries of the pistils cannot develop into fruit nor the ovules into seeds. Butterflies are pollinators. When a butterfly visits a flower it uncoils its proboscis, searches for nectar and sucks it up. As it does this its hairy body traps pollen grains.

It is usual for insects to visit flowers of the same kind, one after another. So when the butterfly, with pollen on its body, visits another flower of the same species, the pollen gets dusted on the stigma of the flowers. Pollination can then take place.

However, butterflies could also be of harm to humans. They are many, and they lay hundreds of eggs. The larvae eat leaves. Great is the destruction of crops that could be caused by butterflies.

**Exercises**

1. Make a series of drawings to illustrate the growth and development of a dicotyledonous plant from a seed to a seedling with foliage leaves to a mature plant, bearing flowers.

2. Use coloured paper to construct a likeness to a pea seed or bean seed. This a collage. Show its parts, outside and inside. Label the collage.

3. Use coloured paper to construct a likeness to a flower of a named dicotyledonous plant. Label its parts.

4. Make posters about the Anopheles mosquito. Let each poster tell one important fact about the mosquito.

5. Describe the illness of a child who had contracted malaria. Tell how the child was cured of it.

6. Make posters about malaria. Let each poster tell one thing that could be done to prevent malaria.

7. Make a large drawing of a named butterfly. Using coloured labels, name the parts of its body.

8. Use a magnifying glass to look at a butterfly visiting flowers. Try to find out just how it feeds. Describe how it uses the different parts of its body.
Summary

WE HAVE LEARNT THAT

• one way of grouping the very many living things in our world is by looking at life cycles.

• within a seed lies the potential of a mature plant of the same species. Water, air and enough warmth are needed for a seed to germinate.

the germinated seed grows into a seedling, using the food stored in the cotyledons in the seed.

• the seedling has a root system and foliage leaves. It can support itself. However, to support itself, it needs sunlight, water, air and enough warmth. It also needs a soil, to provide nutrients for it to grow and develop into a mature plant.

• the mature plant flowers.

• through the essential organs – the stamens and the pistil – flowers reproduce after their kind.

• from flowers, fruits are formed. In the fruits are seeds. Each seed has the potential of a mature plant of the same kind.

• mosquitoes are dangerous. They carry deadly diseases e.g. malaria.

• each sub-family of mosquitoes is a vector of a specific disease e.g. Anopheles is a vector of malaria.

• malaria fever is a killer. It is caused by the protozoan – Plasmodium.

• prevention of the diseases carried by mosquitoes is better than curing them after they have been contracted.

• butterflies are beautiful.

• butterflies can be distinguished from moths.

• butterflies are valuable as pollinators.

• the caterpillars of butterflies, never-the-less, could cause much harm as they eat the leaves of food plants.
Projects and strategies for revision

A guide to projects

In this Unit we will learn about:

- Making charts, devices and instruments from discarded and easily available materials.
- Designing labels, posters and other forms of graphics.
- Constructing models that help to demonstrate science concepts.
- Preparing for field studies.

Making a classification chart

Earlier in this course, we observed our environment and classified things found there.

We can make a chart to show this classification (see below). Our report will state where, when and how the observations were made.

Things in the environment

<table>
<thead>
<tr>
<th>Living things</th>
<th>Non-living things</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pictures or drawings or names could be used.</td>
<td>Pictures or drawings or names could be used.</td>
</tr>
</tbody>
</table>

Making a chart to show the history of a measuring instrument

Charts like these are based on readings and research. We can collect pictures or make drawings that were used at particular times. For example, if we wished to show how man measured time, we can show various types of timing devices he used through the ages (see Unit 2).

Table 8.1 Naming timing devices through the ages

<table>
<thead>
<tr>
<th>Time period</th>
<th>Type of timing device</th>
</tr>
</thead>
<tbody>
<tr>
<td>About 5000 years ago</td>
<td>Shadow clock (see Unit 2)</td>
</tr>
<tr>
<td>Around year 996</td>
<td>Simple mechanical clock</td>
</tr>
<tr>
<td>Middle Ages (12th - 16th century)</td>
<td>Sundials, water clocks, candle clocks</td>
</tr>
</tbody>
</table>

Making a chart to show the use of a measuring instrument

A chart showing how to read a measuring cylinder is given below as an example. The chart must be fairly large with suitable drawings and directions as to how to read the measuring cylinder.
Construction projects

These projects could take the form of models or actual devices. These are usually made from discarded material. When these devices are made, they must be tested to see how well they work.

However, in making a device we must go about our task in a scientific way. We have to do some research on how it is constructed. We also have to select appropriate materials that can be used in making it. After we have made our device, we must be able to test it to see how well it works. Finally we must be able to make drawings of the device, write a report on how it was constructed, and, using results obtained in testing it, state how well it works. Examples of devices that we can make are devices to measure length, mass, volume, time and temperature.

Measuring devices

In this section, you will be doing some simple construction projects. You will be using some of the knowledge which you have gained from previous units.

In general, two stages are involved in the making of a measuring instrument. Firstly, you would need to collect, and if necessary, assemble materials to make your instrument. Secondly, you would need to calibrate (i.e mark a scale on) the device. Standard laboratory equipment usually help here.

After you have made your measuring instrument, you should use it to measure the length, volume, mass (or whatever) of various objects. In order to judge how accurate your measuring device is, you would need to check results obtained with your instrument against those obtained using standard laboratory instruments.
**Devices for measuring length**

A model ruler

1. Trace a copy of a ruler and cut it out.
2. Stick it onto a strip of cardboard and use it.

**Devices for measuring mass**

Using a triangular wedge of wood as a knife-edge, balance a flat strip of wood approximately 50 cm long in a horizontal position. Use this arrangement along with a scale pan and rider to make a simple balance. (see Fig 8.2)

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![Diagram](https://via.placeholder.com/150)

**Fig 8.2 A simple balance**

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**A metre rule**

Use a flat piece of wood to make a metre rule calibrated in centimetres.

**Devices for measuring volume**

1. Use a bottle of uniform cross-section to make a measuring cylinder.
2. Calibrate a clear plastic drinking straw (e.g. milk-shake straw) to measure small volumes.

**Devices for measuring time**

Make a sand glass or water clock to measure a specific time period. (see Unit 2)

**Devices for measuring temperature**

Using a glass tube or plastic straw and a suitable container as a bulb, construct a thermometer.
Making and testing a water filter

In previous units we learnt how to separate mixtures using various techniques e.g. filtration, distillation, evaporation. The technique used in separating substances in mixtures depends on the component(s) we would like to retain or keep.

Filtration (or sieving) as we can see, is a widely used method of separation. In this section we look in some detail at the process. We take filtration in the water purification industry as an example.

A water purification filter

The sand-bed filter is a type of filter that is used to filter water for drinking, cooking and other purposes. Fig 8.4 shows a typical sand-bed filter used at a water treatment plant.

When in use the water is forced into the tank. The arrows show how the water flows into the tank and out of the tank.

As the pressure is maintained the water trickles through the sand. Most of the solid particles in the water are trapped in the sand. Occasionally the filter becomes clogged with solid particles. It is cleaned by forcing compressed air into the tank to loosen the sand. It is then flushed out with water. The sand from the filter is prevented from entering the distribution pipes by a very fine mesh at the bottom of the tank. The tank can filter approximately 30 000 litres of water in an hour.

Making your own filter

You can make your own filter in the following way.

Obtain a one-pound tin-can e.g. a ‘Milo’ can or any suitable container and punch holes in the bottom of the container. Punch the holes with a one-inch nail.

Place a layer or two of cotton cloth in the can to cover the holes. Fill 2/5 of the can with white sand that has been previously washed so as to remove debris. Over the sand, place some fine gravel to about 1/5 of the can. Over this fine gravel, place some coarse gravel to about another 1/5 of the can.
Fig 8.4 A sand bed filter at a water treatment plant

Testing your sand-bed filter

Make some muddy water by mixing some clay in 2 litres of water (or collect some muddy water from a trench). Suspend your filter in a convenient position where you can pour in the muddy water. Place a container under the filter to collect the water. Record the time you start to pour in 1 litre of muddy water. Measure the volume of water collected and record the time it took to filter the water. Repeat the process using the other litre of muddy water.

Questions:
- What is the purpose of the coarse gravel?
- What is the purpose of the sand?
- What is the purpose of the cotton cloth?

Copy and complete the following table from the tests carried out using your filter.

Results obtained from testing a sand bed filter

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of water poured in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of water poured in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of water collected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance of water collected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time taken to collect water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions:
- How effective is your filter in removing impurities?
- Did the results in test 2 differ from those in test 1?
- How do you think the filter will be behaving by test 20?
- What can be done to improve the rate of filtration?
Project work

In the first part of this unit you were introduced to project work which involved making some simple devices. Project work however does not only mean designing and building pieces of equipment from materials. It also involves studies e.g. a study of our environment. Such a study is sometimes called a field study.

Our environment is made up of both living and non-living things. Both living and non-living things are important to us; but so, too, are our industries.

There are many industries in our environment. There are industries which manufacture foods, beverages, cosmetics, drugs and paints for our use. There are also industries which manufacture foods and drugs for domestic animals. One such industry is the Stock Feed Factory — a place where poultry feed is manufactured. This should be a place of interest to you, the science student, for a field study.

A visit to a place of interest

We should, as science students, develop an interest in field work. This involves travelling to various places of interest and finding out as much as possible about those places in order to gain first hand knowledge about the place.

Planning

Of course, in making field-trips, we have to plan well ahead of the time we intend to visit the place. All arrangements should be made well in advance so that we can have a successful tour.

Let us assume that we would like to visit the Stock Feed Factory. Your teacher would make arrangements with the factory for your visit and also make any transportation arrangements. Your parents would need to know about the trip.

Questions in mind

For each visit to a place of interest such as a factory, you should have in mind some important questions which you hope would be answered during the visit. Here are a few questions you could possibly ask about a Stock Feed Factory.

1. What is the purpose of the visit?
2. What type of feed does the factory produce?
3. What raw materials are used in making the feed?
4. Are some or all the raw materials easily available?
5. Are some or all of the raw materials imported?
6. Are any separation techniques involved?
7. What processes are involved in mixing the raw materials to produce the feed?
8. In what proportions are the materials mixed to produce the feed?
9. What is the importance of each material in the feed?
10. How is the final product tested for quality?
11. Could the quality be improved if the proportion of materials is varied?
12. What sort of wastes are produced?
13. What is done with the waste?

These are only a few questions that you might ask about the industry.
Research

In order to be able to know what questions to ask on your trip it often helps to find out as much as you can about the industry before the visit. This can be done by reading textbooks, going to the library or talking to people like farmers who use the feed for their poultry.

Activity: Preparing for a field trip.

Choose a factory in your area which you would like to visit and prepare a list of questions similar to those that have been given.

Revision

Revision of work is important, not only because we all want to pass examinations, but also to help us to find out what we really understand, and lay a better foundation for studying more. The exercises and summary at the end of each section will help in your revision. Each unit of work needs to be revised. This section gives suggestions of some of the things, like riddles and games, which you can do in large or small groups.

Games

If about six to eight of you plan to revise together you could fix a time by which you check how well you know each chapter. You may want to start by using some of the exercises given. You may also plan to have a different member of the group prepare questions on a unit. When you meet at the agreed time you will all have a chance to answer. Here are some games you can play once you have prepared the questions.

Take them down

In this game the participants strive to be at the head of the line by answering questions. Here is how this game is played. The questions are collected and the pupils are arranged in a semicircle. One end is called the head and the other end the tail. The questioning begins at the head. If a pupil answers he or she moves one place ahead. If the pupil does not answer he moves one place backward. The person who ends up taking down someone most times is called the winner.

Team versus team

Here the class is divided into about five teams A to E. Each team can be questioned by pupils of another team. The teams would play each other on a knock out basis until two end up in the finals, etc.

Quiz competition

This can be done in a number of ways. There must be a timekeeper to check the time and a recorder to recall the points scored by the participants and the teams.

Stump the panel

In this game a panel of about four or five is formed from members of the class. They would sit in front of the class while the children in the class ask questions. If one of the panelists cannot answer, the child who asked the question gives the answer and replaces that panelist.

Perhaps you can find alternative ways of playing games that have been mentioned. Do play them and revise your work. You might have noticed that playing these games involves a lot of planning. Why not start early and make your questions? Here are some samples to begin with.
Exercises

1. Name two ancient and two modern instruments used for measuring time.

2. Give two examples of laboratory work which use the unit of time.

3. Name four units used for measuring time.


5. Why are some living things almost similar in colour to their habitat?

6. List some living things and point out some physical characteristics that would indicate that they are alive.

7. Combustible or flammable materials are those substances that
   (a) can get wet
   (b) can burn
   (c) are solid
   (d) are gases

8. Pyrex materials are (i) made of glass (ii) easily broken (iii) withstand lots of heat (iv) made of metal
   (a) i, and iii only
   (b) ii and iv only
   (c) i, ii, iii
   (d) i, ii, iv

9. We would classify acids and caustic soda as
   (a) flammable substances
   (b) explosive substances
   (c) corrosive substances
   (d) radioactive substances

10. What do you think would be the effect of five-finger juice on these substances?
   sodium carbonate
   sodium chloride
   sodium bicarbonate
   litmus paper

11. What substances do you know that will effervesce when mixed with other substances?

12. What is formed if bubbles rise to the surface when substances are mixed?

13. Fishes breathe in oxygen while in the water. How did the oxygen, that they breathe, get into the water?

14. Why do scientists classify substances? What do they look for when classifying?

15. Describe how to make a salt solution.

16. Why is it necessary for humans to use units of measurement?

17. Name one way that humans measured time long ago.

18. One unit of measurement was the cubit.

19. The 'mass' of a box is 2 kilograms. What do you understand by the term 'mass'?

20. Name the instrument that is used in measuring mass.

21. What do you understand by the term 'temperature'?
22. Name the instrument that is used for measuring temperature.

23. Name a unit in which temperature is measured.

24. The standard unit of time in the International System based on the vibration of the caesium atom because—
   (a) the vibration is constant
   (b) it is used to make clocks
   (c) it is expensive
   (d) it is rare

25. Which of the following is basic unit of time?
   (a) day
   (b) year
   (c) week
   (d) second

26. Some clocks show time in the dark because they—
   (a) are luminous
   (b) make sound
   (c) work fast
   (d) none of the above

27. Name two groups to which things in the laboratory belong.

28. In what way(s) are the fish and the reptile similar?

29. What is the difference between monocotyledonous plants and dicotyledonous plants?

30. The material left on the filter paper after a filtration process is the—
   (a) filtrate
   (b) residue
   (c) sediments
   (d) scum

31. A solution was made from salt and water. The salt is called the—
   (a) solution
   (b) solute
   (c) residue
   (d) solvent

32. Which of the following is the best instrument used to separate a sample of ice with iron fillings?
   (a) filter funnel
   (b) sieve
   (c) magnet
   (d) filter paper

33. Which of the following separation techniques is not used in the rice milling industry?
   (a) sieving
   (b) distillation
   (c) sedimentation
   (d) evaporation

34. Name four situations in your home where you will use separation techniques.
35. Which of the following separation techniques is suitable for purifying water with germs in it?
   (a) evaporation
   (b) distillation
   (c) sedimentation
   (d) filtration

36. Which of the following is suitable for production of water for laboratory use?
   (a) evaporation
   (b) distillation
   (c) sedimentation
   (d) filtration

37. Why should science students develop an interest in field work?

38. What can students gain by visiting a place of interest?

39. List three things that must be done before visiting a place of interest.

40. List three techniques by which we can separate mixtures.

41. Sugar crystals are separated from molasses by (distillation, evaporation, centrifuging).

42. In a sand-bed filter the purpose of the sand is to .........................

43. List three forms of energy and name a source from which each can be obtained.

44. Name the form of energy that each of the following possesses.
   (a) a hurricane
   (b) a handful of sugar
   (c) some water at 50° C.

39. In which of the following are the particles closest?
   (a) solids
   (b) liquids
   (c) gases

40. When a gas is heated it increases in
   (a) mass
   (c) volume
   (d) the number of particles.

41. Heat energy in a solid is transferred from particle to particle by:
   (a) vibrations
   (b) actual motion of the particles
Summary

WE HAVE LEARNT THAT

* projects are some things that we do on our own.
* projects provide information from which others can learn.
* the first step in doing a project is to do some research.
* after a project is completed, a report should be written up.
* filtration (sieving) is a widely used process.
* we can use a sand-bed filter to remove debris from water.
* tests can be designed for a filter.
* our environment is important to us.
* we can gain knowledge about places by making field trips.
* field trips should be well planned.
* research before a trip is helpful.
Glossary

Acids - Substances sour in taste and which turn blue litmus red.

Alkalis - Substances which turn red litmus blue.

Alloy - Mixture of two or more metals.

Aspirator - An apparatus for producing suction or collecting material by suction.

Atom - Smallest particle of an element which retains the properties of that element.

Barometer - An instrument used to measure the pressure of the air.

Boiling point - The temperature at which a liquid boils.

Bunsen Burner - A heat source used in the laboratory and which uses methane as fuel.

Calibrate - To mark a scale on an instrument or device in order to determine a correct reading.

Characteristic - An identifying quality or trait. Something which distinguishes a thing, person or group.

Chemical change - An irreversible change in which a new substance is formed.

Chemical energy - Energy contained in substances e.g. food

Chemical properties - Those properties that tell whether a substance would remain the same or change under certain conditions.

Chloroform - A dense liquid used as a solvent and as an anaesthetic.

Chrysalis - Inactive stage of development between larva and adult of an insect, especially a butterfly.

Classify - To put things of similar characteristics into groups.

Coagulate - The coming together of particles.
Combustible - Capable of burning easily.

Condensation - The changing of a gas to a liquid.

Conductor - A substance through which heat or electricity can flow readily.

Cotyledon - Part of a seed containing stored food used for growth of the plant embryo; seed leaf.

Crystals - Solids with regular shapes and angles.

Decant - To pour off liquid to leave sediment behind.

Density - The mass of 1 cm\(^3\) of any substance.

Device - A piece of equipment designed for a special purpose or function.

Dicotyledonous - Having two seed leaves, net-veined leaves and tap roots.

Diffusion - The movement of the particles of one substance through another.

Dissolve - To cause to disperse or disappear.

Distillate - The liquid product formed by the condensing of vapour during distillation.

Distillation - A process that consists of converting a liquid into a gas or vapour by heating and condensing the gas or vapour back to a liquid.

Energy - That which makes it possible to do work.

Evaporate - Change from liquid to vapour or gas.

Excretion - The getting rid of waste substances that were once part of the body.

Expand - To get bigger.

Filter - A porous article through which a liquid is passed to separate insoluble particles.

Filtrate - A substance that has passed through a filter.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtration</td>
<td>A process of passing a liquid containing insoluble substances through a filter.</td>
</tr>
<tr>
<td>Foliage</td>
<td>The leaves of a plant or a clump of plants.</td>
</tr>
<tr>
<td>Force</td>
<td>A push or a pull.</td>
</tr>
<tr>
<td>Germination</td>
<td>The process by which a new plant begins to grow or sprout from a seed.</td>
</tr>
<tr>
<td>Graphics</td>
<td>Writing or drawings that give clear descriptions.</td>
</tr>
<tr>
<td>Habitat</td>
<td>The place where an organism lives.</td>
</tr>
<tr>
<td>Impurities</td>
<td>Things in a substance that make the substance impure.</td>
</tr>
<tr>
<td>Invertebrate</td>
<td>Animals without backbones.</td>
</tr>
<tr>
<td>Kinetic energy</td>
<td>Energy associated with motion.</td>
</tr>
<tr>
<td>Manometer</td>
<td>An instrument used to measure pressure of a gas.</td>
</tr>
<tr>
<td>Mass</td>
<td>The quantity of matter in a body.</td>
</tr>
<tr>
<td>Matter</td>
<td>Anything which has mass and occupies space e.g. solids, liquids and gases.</td>
</tr>
<tr>
<td>Melt</td>
<td>To change from solid to liquid.</td>
</tr>
<tr>
<td>Melting point</td>
<td>The temperature at which a solid melts.</td>
</tr>
<tr>
<td>Molecule</td>
<td>The smallest particle of a compound that can exist.</td>
</tr>
<tr>
<td>Monocotyledons</td>
<td>Plants with straight veined leaves and one cotyledon or seed leaf e.g. grass</td>
</tr>
<tr>
<td>Nuclear energy</td>
<td>Energy obtained from the nuclei of atoms.</td>
</tr>
<tr>
<td>Physical changes</td>
<td>Changes where no new substances are formed during a reaction–always reversible.</td>
</tr>
<tr>
<td>Physical properties</td>
<td>Those properties which we can recognise using our senses and instruments that aid these senses.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>------------</td>
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</tr>
<tr>
<td>Potential energy</td>
<td>Energy stored in a body.</td>
</tr>
<tr>
<td>Pressure</td>
<td>Force acting on an area.</td>
</tr>
<tr>
<td>Project</td>
<td>A task or problem that is engaged in according to a specific plan by an individual or a group.</td>
</tr>
<tr>
<td>Pyrex</td>
<td>A type of glass that can withstand a lot of heat.</td>
</tr>
<tr>
<td>Reaction</td>
<td>Action involving a change when chemicals are mixed.</td>
</tr>
<tr>
<td>Residue</td>
<td>Something that remains after a part is taken e.g. substance left on filter paper.</td>
</tr>
<tr>
<td>Respiration</td>
<td>The burning of food and oxygen to release energy.</td>
</tr>
<tr>
<td>Reproduction</td>
<td>Producing more of the same kind.</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>The process of forming or depositing settlements.</td>
</tr>
<tr>
<td></td>
<td>The process of allowing solids to settle in a liquid.</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Being aware of changes in the surroundings and being able to respond to the changes.</td>
</tr>
<tr>
<td>Soluble</td>
<td>Can be dissolved.</td>
</tr>
<tr>
<td>Solute</td>
<td>Dissolved substance.</td>
</tr>
<tr>
<td>Solution</td>
<td>A liquid containing a dissolved substance.</td>
</tr>
<tr>
<td>Solvent</td>
<td>Substance capable of dissolving one or more other substances.</td>
</tr>
<tr>
<td>Vector</td>
<td>An organism that transmits a disease-causing agent.</td>
</tr>
<tr>
<td>Vertebrate</td>
<td>Animal with backbone.</td>
</tr>
<tr>
<td>Volume</td>
<td>The amount of space taken up by anything.</td>
</tr>
</tbody>
</table>
Index

A
Accuracy 35, 57
Acids 30
Alkalis 18
Alloy 78
Alum 85
Aluminium sulphate 85
Ammonium chloride 77
Ammonium dichromate 116
Anhydrous 106
Annotated diagrams 86
Aquatic 65
Aqueous 105
Area 31, 49
Asbestos paper 115
Aspirator 87
Atoms 98
B
Balance 24, 140
Bar chart 52
Beaker 24
Boiling point 103
Bonds 102
Breathing 60
Bulb 40
Butterflies 137
C
Calendar 33
Calibrate 140
Carbon dioxide 21
Catapult 102
Caterpillar 137
Celsius 32
Centrifuge 85
Chart 138
Chemicals 9, 93
Chloroform 66
Chlorophyll 127
Chromatography 85
Circuit 93
Circumference 36
Civilisation 32
Classify 22
Clinical 41
Coagulate 85
Collecting 64
Colourless 30
Condensation 84, 89
Conductors 115
Conservation 95, 113
Constructing 138
Contract 39, 101
Control 125
Conversion 90
Copper 78
Copper sulphate 17
Crystals 79, 82, 105
Cubit 33
Cylindrical 36
D
Day 33
Decanted 85
Density 113, 114
Designing 138
Devices 109, 139
Diameter 36
Dicotyledons 26
Diffused 106
Diffusion 90, 105
Digestion 120
Digital 44
Dilute 106
Displacement 51
Display 67
Dissolve 16, 20
E
Effervesce 17
Electrical 93
Electricity 11, 93
Embryo 124
Energy
electrical 93
heat 93
kinetic 92
light 93
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