PROTOTYPE

NCDC
NATIONAL CURRICULUM DEVELOPMENT CENTRE

GENERAL SCIENCE TEXTBOOK

SENIOR ONE

LOWER SECONDARY CURRICULUM

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This material has been developed as a prototype for implementation of the revised Lower Secondary Curriculum and as a support for other textbook development interests.

National Curriculum Development Centre
P.O. Box 7002,
Kampala- Uganda
www.ncdc.co.ug

Contents

Preface

This Learner's Book has been written in line with the revised General Science curriculum. The knowledge and skills which have been incorporated are what is partly required to produce a learner who has the competences that are required in the 21st century.

This has been done by providing a range of activities which will be conducted both within and outside the classroom setting. The learner is expected to be able to work as an individual, in pairs and groups according to the nature of the activities.

The teacher as a facilitator will prepare the learning materials, and this book is one of the materials to be used to support the teaching and learning of General Science.

Associate Professor Betty Ezati
Chairperson, NCDC Governing Council

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Last but not least, NCDC would like to acknowledge all those behind the scenes who formed part of the team that worked hard to finalise the work on this Learner's Book.

NCDC takes responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for effectively addressing the inadequacies. Such comments and suggestions may be communicated to NCDC through P. O. Box 7002 Kampala or email: admin@ncdc.go.ug.

Grace K. Baguma
Director, National Curriculum Development Centre

Chapter 1: Introduction to General Science

Key Words	***By the end of this chapter, you will be able to:***
▪ science ▪ natural sciences ▪ social sciences ▪ technology	*a) highlight some of the science issues that were studied in the primary school.* *b) understand the difference between natural science and social science, and between science and technology.* *c) identify some daily phenomena that can be explained using scientific knowledge.* *d) understand how science and technology affect society.* e) *understand that in some instances in which science and technology have been misused.*

Introduction

In your primary school science, you studied that all the living or non-living things around us involve science. Do you remember any of the things you studied about science? Indeed, it has never been more important to understand the scientific world around us. Our newspapers, televisions and social media are all full of stories showing concern over global warming, plastics, genetically modified products and many other issues. To understand all these issues, we need scientific knowledge. In this chapter, you will explore the different materials made by the use of science. You will also find out about the science world and how it can be used to modify nature, and also discover that science and its applications are all around us.

Activity 1.1: Finding out about science

Figure 1.1 shows some aspects of science that we encounter everyday. Study it and answer the questions that follow.

Figure 1.1: Some aspects of science

1. Identify any living things in the **Figure 1.1**.
2. Which science aspects in **Figure 1.1** are non-living things?
3. Name the science aspects in **Figure 1.1** that are humanmade.

Now, what is science? Humans are curious by nature. This curiosity has driven them since time immemorial to explore the world around them. Over time, manipulation and controlling nature for the benefit of humans has become an objective of exploration.

Science is a body of knowledge that explains about the universe around us. The universe is made up of living and non-living things. That is why science is also referred to as the study of living and non- living things.

1.1: Branches of Science

Science can be divided into the natural sciences and social sciences. Both natural and social sciences use experiments and observations to test the truth of knowledge.

Natural Science

Natural science is concerned with describing, predicting, and understanding things that happen in nature. It is based on evidence from observation and experimentation. Natural science can be divided into life science (biological science) and physical science though some aspects in these branches overlap. In school, science can be studied under subjects such as Chemistry, Biology, Physics and Agriculture.

In **Activity 1.2** below, you are going to explore more about scientific happenings in the natural sciences.

Activity 1.2: Finding out about natural happenings

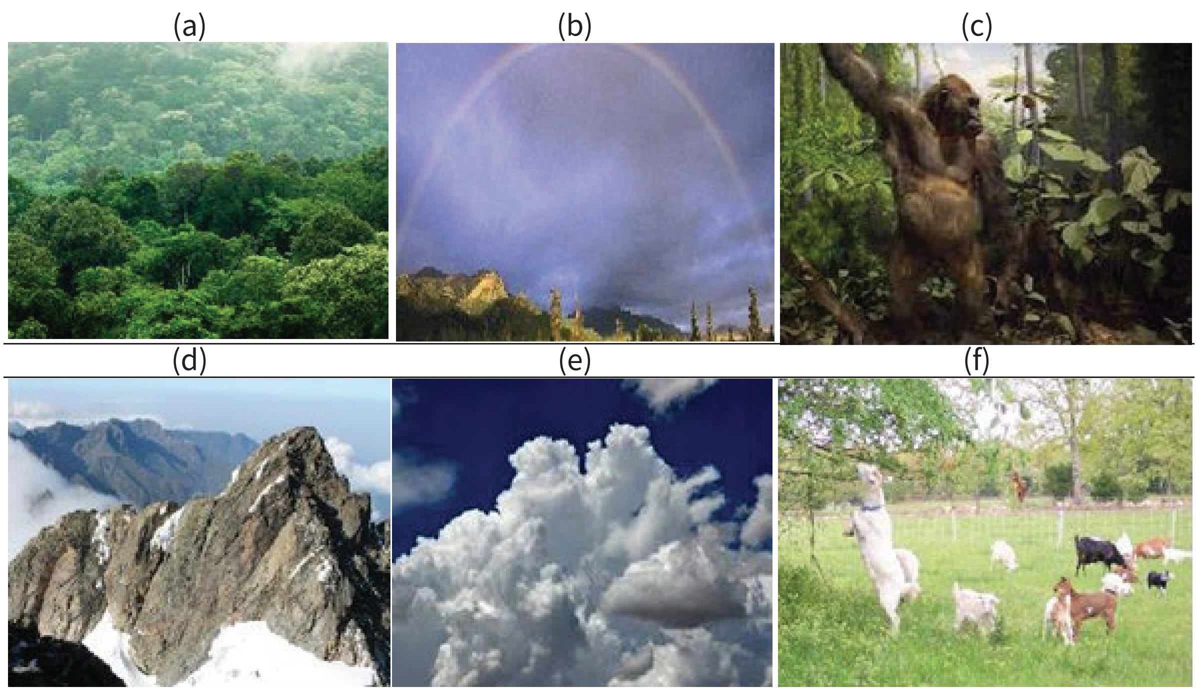


Figure 1.2

a) **Figure 1.2** above shows the natural happenings in the world around us. In pairs, describe the happenings in each picture.
b) In your groups, identify other natural happenings that are not indicated in the pictures, but can be explained using the knowledge of natural science. Present your answers to the class.

The Scientific Method of Investigation

Human beings are sensitive to their surroundings. They use different senses to detect what is happening. This is called observation. Learning science involves using scientific method which tries to explain the nature of events based on results. A careful observation leads to a thought or an hypothesis about the observation. This thought is used to make prediction that can be tested by experiment or observation. The prediction is done before an experiment or observation is carried out to confirm it.

The steps of scientific method can be summarized as follows:

1. Make an observation or observations.
2. Ask questions about the observations and gather information.
3. Form a hypothesis—a tentative thought about what has been observed, and make predictions based on that hypothesis or tentative explanation.
4. Test the hypothesis and predictions in an experiment that can be reproduced.
5. Analyze the data and draw conclusions. Accept or reject the hypothesis or modify the hypothesis, if necessary.
6. Reproduce the experiment until you get consistent reults.

Inquiry and scientific method are important to science education and practice. Every decision we make is based on inquiry and scientific methods to solve problems. Therefore, studying science helps you to develop critical thinking skills that can be used in studying other subjects.

Activity 1.3: Applying the scientific method to find the nearest path to school

Question: What is the nearest route to your school?

Hypothesis: Using the main road to the school is the nearest.

Experiment: Walk to school a couple of times using alternative routes and measure the time taken. Make sure to include the hypothesis route (the route you tentatively think is the shortest). Record the time for each route.

Analysis: Analyse the time taken by each route and then select the quickest.

Conclusion: Determine whether your route hypothesis was correct.

Discussion: Share your test results to help others get to school in time.

Think of any other problem and use the steps in the scientific method to solve it. Present your report to the teacher.

Social science is concerned with society and the relationships among individuals within that society. Social science has many branches that include economics, history, geography, linguistics, political science, psychology and sociology. Social scientists study individuals and society.

Activity 1.4: Finding out about social relationships

Figure 1.3: Social interactions

a) **Figure 1.3** above shows some of the social interactions. In groups, identify some of the social interactions that can be seen in the pictures.
b) Now that you know the meaning of natural and social sciences, discuss with a friend the differences and similarities between the two forms.

Science and Technology

Science is the systematic study of the structure and behaviour of the natural and physical world through observations and experiments. Study of science evolved with the civilization of human beings.

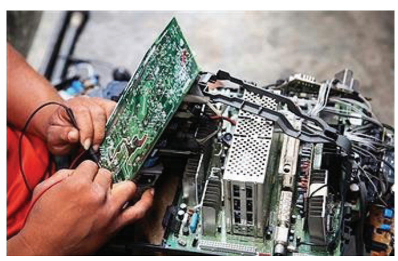
Technology is a skill, an art or ability which is used to create and develop products and acquire knowledge. Scientists use their knowledge to develop technology, and then use technology to develop and improve science. It is for this reason that science and technology is an integrated term in today's world.

Thus, while the goal of **science** is to find knowledge for its own sake, the goal of **technology** is to create products that solve problems and improve human life. Simply put, **technology** is the practical application of **science**. In **Activity 1.4** below, you will explore the different technologies and how they have helped humankind.

Activity 1.5: Finding out about different technologies

Figure 1.4 below shows different technologies. Study it and answer the questions after.

(a)



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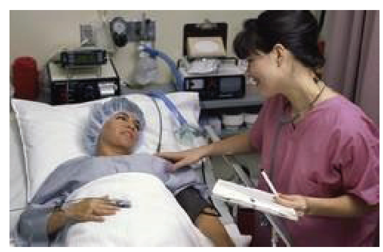

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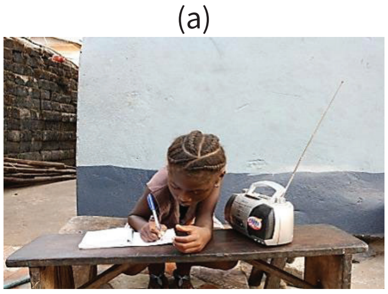


(e)

(f)

(g)

Figure 1.4

a) How has technology helped to improve the human welfare?
b) Mention any other technologies that are not indicated in the pictures above.
c) Discuss with a friend how the technologies you mentioned above have improved the wellbeing of humankind.

Effects of Science and Technology

So far you have seen that science and technology are essential in improving the quality of life. However, they may cause some negative effects, and some of which are shown in **Figure 1.5** below.

Figure: 1.5: Some negative effects of science and technology

Some of the effects of science and technology are environmental pollution, depletion of natural resources, technological unemployment, creation of unsatisfying jobs and loss of personal privacy.

Activity 1.6: Finding negative effects of science and technology

In your groups, search the Internet or use the library to identify any other negative effects of science and technology not mentioned above. Present your findings to the class.

Activity of Integration

a) As a class, visit the composit or dumping site in your school. By looking at the materials at the site, identify items produced using application of science and technology. Discuss how these items can affect our environment when poorly disposed of.

b) Suggest how best your school can manage the identified items.

Chapter Summary

In this chapter, you have learnt that:

- science is divided into social sciences and natural sciences.
- natural sciences are studied using scientific method.
- most of the daily happenings can be explained using scientific knowledge.
- science and technology contribute a lot to our welfare.
- science and technology have sometimes been abused by human beings.

Chapter 2: Health Hazards and Safety

Key Words	By the end of this chapter, you will be able to:
▪ hazard ▪ accident ▪ risk ▪ safety ▪ safety signs ▪ first aid	a) understand the term hazard. b) know examples of hazards in the home and school. c) identify warning safety signs. d) understand safety precautions to prevent hazards. e) describe "first aid" and explain its role. f) know the contents of a first aid box and their uses. g) describe how to administer first aid to common hazards (scald, burn, cut, electric shock, fracture, fainting, bites, chemical contact).

Introduction

In Chapter One, you learnt that the study of science involves carrying out experiments. This leads to discoveries of useful products which we use daily. When an experiment is carried out, it may involve the handling and use of equipment and chemicals. Many pieces of equipment may harm us if not used responsibly. For safety use of equipment and chemicals, it requires following the rules and guidelines set. In your home, if you step in a hot fireplace, you will get burnt; if you eat rat poison, you will die. Can you think of any materials used in your home or school which can be harmful when not well handled?

In this chapter, you will learn the common hazards that occur in the home and school, and how best you can help someone who has got an accident. You will also learn the safety signs that inform us of the type of hazards that might result from irresponsible use of some chemicals.

What is a hazard?

Have you ever slipped on a muddy ground? What about stepping on a bare nail? You may have had bodily harm. Anything that may cause harm to a person or damage to an object is called a hazard.

A **hazard** is any source of **potential** damage, harm or adverse health effects on something or someone. Hazards can be biological, chemical physical or psychosocial. For example, viruses are a potential hazard because they can cause disease; chemicals we use in the home or school, radiation or even stress are potential hazards. Can you think of any other common hazards in your school and home?

What are the hazards in the home and school?

There are many activities done in the home and at school. Some can be potential sources of danger.

Activity 2.1: Finding out the common hazards at home

a) Identify the activities performed by both children and adults at home.
b) Which of the activities done at home can be categorized as hazards?

You will realise that activities such as cooking, playing, or even eating can be hazards. Accidents such as burns, falls and poisoning result from some of the above activities.

Activity 2.2: Finding out the common hazards at school

At school, you are involved in a number of activities. You play, work in the school farm and also do experiments in the school laboratory. These can be hazardous as well.

a) **Table 2.2** below contains items that can be found in your school laboratory. What are the likely hazards associated with them? Indicate the danger each item poses to the users.

Table 2.2: Possible Dangers of Materials in School

Material	Possible danger
Glass	
Source of heat	
Acid	
Metal	

b) Explain how you can prevent the possible dangers you have identified in the table above.

Safety Signs

How do we identify hazards in our daily life? We normally identify hazards through experience. When an insect bites or stings you, or fire burns you, you will try to avoid it. However, for materials produced in industry, they come with signs to warn you against potential danger if not well handled or used. At the same time, safety signs are always provided at different suitable places to protect users from hazards. It is the responsibility of the users to ensure they interpret the rules and take heed of the potential dangers. You should ensure that you can read, understand and interpret these safety signs. Safety signs are symbols that warn users about the possible dangers caused by misuse of a substance or a tool.

Activity 2.3: Finding safety signs and their meaning

a) In pairs, discuss what kind of danger each sign in **Figure 2.1** stands for?

b) Now search from the Internet and find out the meanings of the safety signs you discussed in a) and compare your findings with the answers you discussed in your pairs.

Figure 2.1: Safety sign

Some Safety Equipment in the School Laboratory

The school laboratory contains materials such as dangerous chemicals and acids, glassware, heat source and sharp metals. These are potential hazards to laboratory users especially the learners. Can you think of any hazards that can affect you in the school laboratory? Remember that we must always use safety equipment to protect us from potential hazards when using the laboratory. **Figure 2.2** below shows some of the required materials for safety in the laboratory.

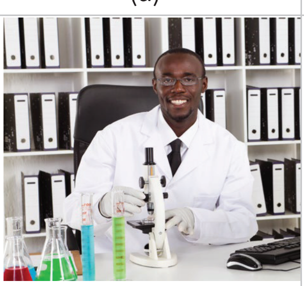
		
(a)	(b)	(c)
		
(d)	(e)	(f)

Figure 2.2: Some safety equipment in the school laboratory

Activity 2.4: Identifying safety equipment in the laboratory

In your groups, identify the equipment displayed above. Suggest any other equipment that would be required in the laboratory for safety.

Accidents

Have you ever heard of a person who had an accident? Many times vehicles cause accidents leading to injury or death of people. Can you think of any accident you have witnessed in your life? An accident is an unexpected or unintended bad thing that happens and often damages something or injures someone. Some accidents may be prevented if circumstances leading up to them are recognized and acted upon before they occur.

Our concern should be focused on factors that lead to accidents and how to avoid them. Accidents occur at home, at school and at work. They include cuts/wounds, fires, poisoning, drowning among others.

Activity 2.5: Identifying common accidents and how to avoid them

State the common accidents that occur at home and suggest the methods by which you can avoid them.

Causes of Accidents

Generally, the causes of accidents at home or at school are similar. They include:

- Lack of knowledge of work-related hazards
- Improper or unintended use of equipment
- Inexperience in the work
- Distractions, lack/loss of attention to task

For the school laboratory, in particular, the causes of accidents are

- broken, damaged glassware or equipment.
- electric shock.
- wet floors that may lead to falls.
- unauthorized experimental procedures.
- corrosion due to some reagents/chemicals coming into contact with the skin.

General Safety Control Measures in the Laboratory

Safety in the school laboratory is everyone's concern and the aim is to ensure that no one gets hurt or becomes ill. The following control measures briefly outline ways of preventing accidents:

a) Do not enter the laboratory or use equipment without permission.
b) Do not eat or drink in the laboratory.

c) Be aware of safety signs and adhere to them.
d) In the event of an accident, inform the teacher immediately.
e) Be aware of the location of fire extinguishers/fire blankets, first aid box and eye wash station.
f) Wear eye protection as instructed.
g) Long hair should be tied back and dangling jewelry, baggy clothing etc. be secured.
h) Hands should be washed after laboratory practical work.
i) Do not run: pay attention to where you are going.

Activity 2.6: Understanding why we have laboratory rules

In your groups, discuss the reasons for the laboratory rules listed in the table below.

Rule or precaution	Likely danger being avoided
Do not run or move unnecessarily in the laboratory.	
Wear safety glasses, tie up long hair, and tuck in ties and loose clothing when in the laboratory.	
Do not eat or drink anything when in the laboratory.	
Always wear closed shoes and a laboratory coat when in the laboratory.	
Do not perform any experiment unless under the supervision of the teacher.	
When heating chemicals, make sure the mouth of the test tube is not facing you or your neighbour.	
Put all the solid waste in the dustbin.	
After the experiment, clean your utensils and wash your hands with clean water.	
In case of an accident, burn, or splash of some chemical, wash with plenty of cold water. Inform your teacher immediately.	

Rule or precaution	Likely danger being avoided
In the case of any unusual smell, report to the teacher or laboratory attendant immediately.	

First Aid

Now that you understand what hazards and accidents are, what do you do when someone gets an accident? The most important thing is to provide immediate help or treatment to someone who has got an accident. This immediate help is called **first aid**.

Since first aid is emergency treatment, its aims are based on three '**P**'s:

- Preserve life: Stop the person from dying.
- Prevent further injury: Stop the person from further injury. If possible, an injured person should not be moved.
- Promote recovery: Try to help the person to heal his/her injuries.

For first aid to be successful, you should follow the following guidelines:

a) Check the scene and the victim.
b) Counsel and assure the victim that all will be fine.
c) Call for more help, e.g. the ambulance.
d) Give care as much as possible.

Activity 2.7: Indicating the reasons for the following guidelines

Give reasons for using the guidelines provided in the table below.

Guideline	Reason
Check the scene and the victim	
Counsel and assure the victim that all will be fine	
Call for more help	
Give care as much as possible	

First aid helps in ensuring that the right methods of administering medical assistance are provided. Knowing how to administer first aid to a person in **emergency situation** is important. Can you imagine that it only takes six minutes for the human brain to expire due to lack of oxygen!

The First Aid Box

A successful first aid depends on the tools used. The tools are kept in a first aid box as as shown in **Figure 2.8** below. Typical contents of a first aid box include adhesive bandages, strength pain medication, gauze and disinfectant. Specialized first aid kits are available for various regions, vehicles or activities, which may focus on specific risks or concerns related to the activity.

Activity 2.8: Identifying the contents of a basic first aid box

Look at the first aid box shown in **Figure 2.3** below and

a) idenyfy its contents.

b) state applications of its conents.

Figure 2.3: A first aid box

First Aid Procedures

First aid procedures depend on the type of injury. Each injury has its own type of procedure that promotes quick recovery. Some of the procedures are discussed below:

Breathing failure: The patient has no breathing movements. Rescue breathing is needed.

Severe bleeding: This can result in death if not treated promptly. However, great care should be taken to avoid blood contact to prevent contracting contagious diseases.

Poisoning: This is the result of harmful substances in the body. They can be swallowed, inhaled, injected or absorbed through the skin. Oral poisoning is the commonest. Poisoning shows the following signs in **Figure 2.4**.

Figure 2.4

Bone, joint and muscle injuries and fractures: These sometimes may not be life-threatening but may cause further injuries if not well handled. They may also be deep within the body and not seen physically outside the body.

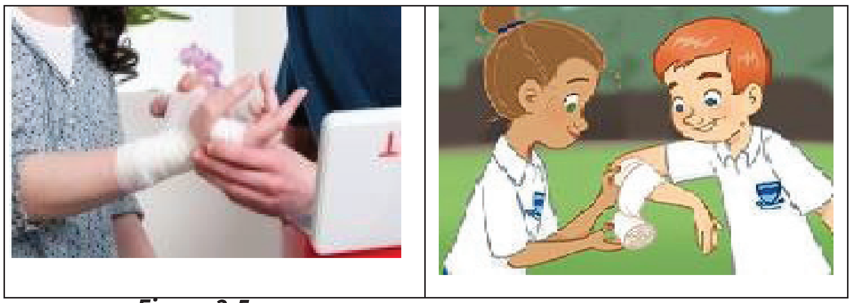


Figure 2.5

Burns: This results from hot liquids, chemicals, fire and electricity. Major first aid steps involve stopping the burning and cooling the burn with cold water as is shown in **Figure 2.6** below.

Figure 2.6

Nosebleeds: It may result from an infection, a blow, or dry air.

Fainting: This is a temporary loss of consciousness, usually caused by little blood flow in the brain.

Drowning: This is defined as respiratory impairment as a result of being in or under water. Drowning typically occurs silently, with only a few victims able to wave their hands or call for help. After rescue, symptoms may include breathing problems, vomiting, confusion, or unconsciousness.

Figure 2.7 below shows some of the emergency actions in case one nearly drowns.

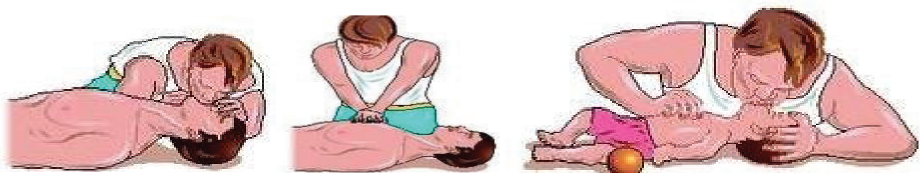


Figure 2.7: First aid for near drowning

Snakebites: There are many different poisonous snakes in our environment. Some are aggressive while others bite when disturbed. Poisonous snakebites cause swelling and pain to the victim. Always treat all snakebites as if it is by a poisonous snake, especially if you **don't** know the type of snake that bit a person. Have the person lie down in a position so that the wound is below the heart. Keep the person calm and at rest, remaining as still as possible to prevent venom from spreading. Cover the wound with loose, sterile bandage or clean piece of cloth.

Other bites and stings: Some insects and animals can bite or sting, hence causing serious wounds. Can you identify some of them?

Activity of Integration

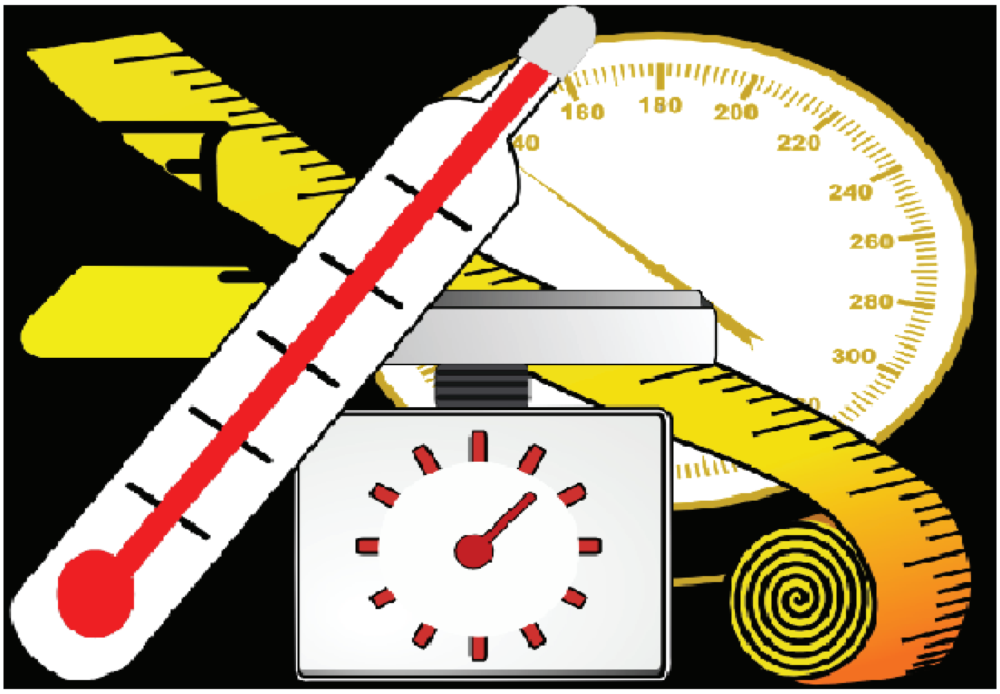
A local tourist is planning to climb a rocky and heavily forested mountain in one of the national parks in Uganda. Think of possible accidents that can happen to the tourist, and prepare a preventive message for him/her. Prepare tools he/she should carry along in case of the accidents you have mentioned above.

Chapter Summary

In this chapter, you have learnt:

- the meaning of hazard.
- the various hazards in the home and at school.
- that some accidents may be prevented if circumstances leading up to them are known and acted upon before they occur.
- that laboratory rules can prevent possible accidents that could occur if the laboratory is used irresponsibly.
- that accidents occur at home and at school, and how to minimise them.
- the forms of first aid that can be given to different forms of accidents.
- that safety signs are symbols that warn users about the possible dangers caused by misuse of a substance, equipment etc.

Chapter 3: Measurements, Density



Key Words	By the end of this chapter, you will be able to:
▪ measurement ▪ estimation ▪ length ▪ mass ▪ weight ▪ time ▪ volume ▪ density ▪ estimating ▪ floating ▪ sinking	*a. understand the meaning and importance of measurement and state instances where it is applied.* *b. know the fundamental quantities and the instruments used to measure them.* *c. estimate and measure different physical quantities using appropriate equipment and express them using appropriate units.* *d. determine volume of irregular objects.* *e. understand the meaning of fundamental/base and derived physical quantities and state their examples.* *f. understand the meaning of density and solve simple numerical problems on density.* *g. relate the density and relative density of substances.* *h. determine the densities of different solids and liquid.*

Introduction

Do you know how much water or salt you must put in your food? To do this you estimate the amount to be used.

Matter has many properties. One important characteristic of matter is that it possesses physical properties. Physical properties of matter can be measured or observed. Before you proceed to estimate and measure these properties of matter, you should understand how scientists work.

Figure 3.1: Observing using a microscope

Scientists study anything in the environment around us. It is very important that we learn about our environment. When we are finding out about our environment we are doing what scientists typically do.

Before we can study any of these things we must learn *how* to study them. This is what we did in the first chapter. You will learn how scientists work by studying things. We call these **scientific processes**. By studying things you will learn to observe, record, think and work in a scientific way.

Observing and Recording

When we **observe** in science, we normally use four of our senses to notice things.

- We use our sense of *sight* to look at things.
- We use our sense of *touch* to feel things.
- We use our sense of *hearing* to listen to things.
- We use our sense of *smell* to smell things.
- We do not usually use our sense of taste as that could be dangerous.

Estimating and Measuring Physical Quantities

How long or tall are the objects in your classroom? Can you make an estimate? An estimate is a guess you make without sufficient information about the correctness or accuracy. As scientists, you need to carry out measurements in order to come up with actual measurements called scientific measurements. For example, when you use a ruler to find the height of something, you are measuring.

Making Accurate Measurements

If you shoot an arrow twice at a target and take the average of the two measurements, will the test be reliable and more accurate? You may need to shoot an arrow more than twice to be able to get a more accurate average for the target. Discuss with your friend and decide how many times you are going to shoot your arrows to make your results accurate on your target. Do not forget to record your results. How well did your results agree with your predictions? Finally, would you like to arrange a class competition for the best design? What must you do to make the competition fair?

Recording and presenting your results

In this section you will use the results you obtained in the earlier section called 'Estimating and measuring'. You will do a lot of **recording** in science. You may need to record things you notice. We call these **observations**. You may need to record measurements you have made. There are many ways you can record.

You can:

- make rough notes of things you did or observed outside the classroom.
- describe what you did and what you observed.
- write your results in a table.
- plot a chart or graph of your results.
- make a drawing or diagram of something you did or observed.
- take photographs or make a tape recording.
- use different kinds of computer applications to record your results.

Presenting your results is different from recording them. When you present results, you put them down in a way that other people can easily understand. How you present your results depends on who wants to read them. Usually this will be your teacher and perhaps the other learners in your class.

You will write the results in your exercise book, but there are some other ways of presenting them.

- Make a poster showing your results.
- Draw a picture showing what you did.
- Use computer display software to show your results.
- Make a comic strip or cartoon showing what you did and what you found.
- Write a play or a poem or a story showing what you have found out.
- Make a model of what you have discovered.

Scientific Measurements

Four basic physical quantities of measurement are introduced in this section: mass, length, time and temperature. Volume and density measurements are derived from length and mass. Modern scientists use a version of the metric system called the International System of Units, abbreviated as SI. Any measurement done on any physical quantity is given a unit. For example, you can weigh sugar in terms of kilogram. When you measure length, it can be done in metres or centimetres.

Physical Quantity	Name of SI Unit	Abbreviation
Mass	Kilogramme	kg
Length	Metre	m
Time	Second	s
Temperature	Kelvin	K
Area	Square metre	m^2
Volume	Cubic metre	m_3
Mass density	Kilogram per cubic metre	kg/m^3

Instruments used to measure quantities are shown below. Can you identify them?

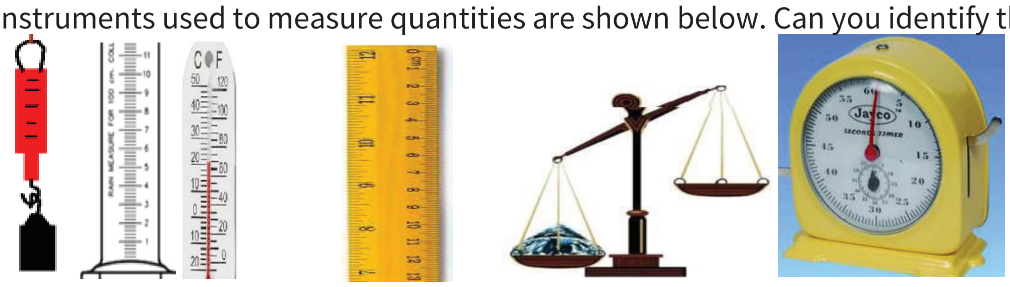


Figure 3.2 Instruments used to measure some physical quantities

Measuring Length

You are probably familiar with a lot of these measurements. Length is about a distance. **Distance** answers questions such as "how far?", "how long?", and "how high?"

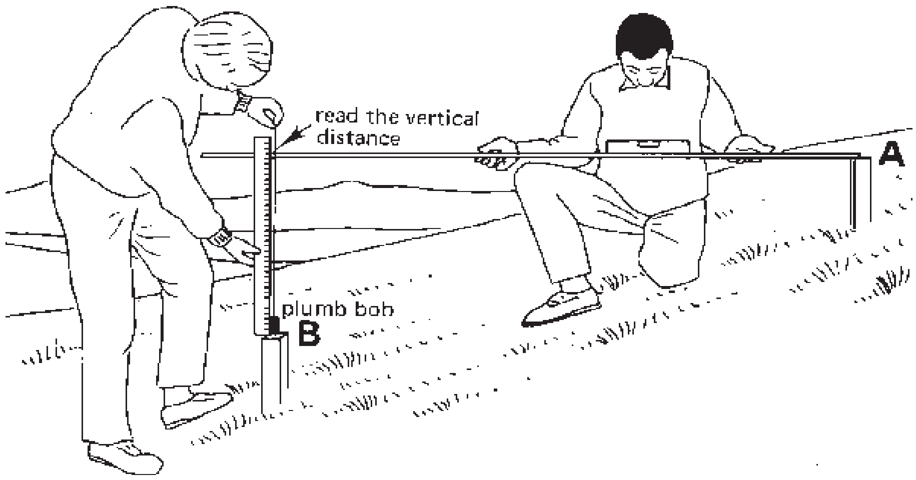


Figure 3.3: Measuring distance between two points

Remember that we measure length in metres (m). You already read that the metric system is based on units of ten. Here is a starter list but they go on and on.

1 centimeter = 10 millimetres
1 meter = 100 centimetres = 1,000 millimetres
1 kilometer = 1,000 metres = 100,000 centimetres = 100,000,000 millimetres

Using decimals when we measure
We can write length using decimals. If you are 1 m 26 cm tall, it means that your height is 1.26 m.

There are 10 mm in 1 cm. We can measure small things using centimetres and millimetres. Measure the length of your thumb in centimetres and millimetres. If it is 5 cm and 6 mm then you can write it as 5.6 cm.

Look at your friend and try to think how many metres tall he or she is. When you are doing this you are **estimating**.

In this section you will estimate how long something is and then you will **measure** it to see how good your estimate was. Remember that you should always record your work. Write down all the estimates and measurements you make in this section in a table. You will be using some of these results later.

Activity 3.1: Finding out how tall someone in the class is

Key question

How tall are you and your friend?

What you need

- Ruler

What to do

Work with your friend.

1. Look at your ruler and work out how long a metre is. You could cut a piece of string 1 m long to help you.
2. Estimate your height and your friend's height.
3. Think of a way of measuring your friend's height accurately (to the nearest centimetre) and measure him or her.
4. Record the result.

You are not only **estimating** and **measuring**, you are also **planning** when you are thinking up a good way of doing the work. How did you do it? Perhaps you made a mark on the wall or the doorpost at the exact height of your friend. Did you ask your friend to take off his or her shoes first?

Did you know that one stride of a normal adult is about 1 m?

Assignment: Find how long the football pitch is.

Science, Technology and Society

Sometimes the length is too small or too big to use the measuring instruments used in **Activity 3.1** above. For very small length like the thickness of an iron sheet, engineers use a special instrument called the micrometre screw gauge. For the inside and outside diameter of tubes, engineers use Vernier calliper. A farmer may use the length of his stride to estimate the length of his garden.

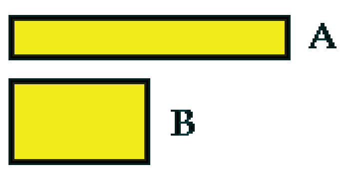
Micrometre screw gauge

Vernier callipers

Measuring Area

Every unit of **length** has a corresponding unit of area, namely the area of a square with the **length** of it sides given. Thus, areas can be measured in square metres (m^2), square centimetres (cm^2), square millimetres (mm^2), square kilometres (km^2), square feet (ft^2), square miles (mi^2) and so forth.

Compare the **amount of space** covered by two different figures below. Do these figures occupy the same space or not?



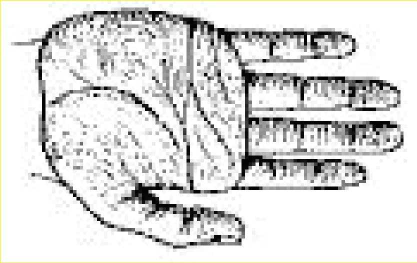
You cannot tell unless you measure their length and breadth. You then multiply the length by the breadth. If you measure the sides of the rectangle in *centimetres (cm)*, the area will be in *square centimetres* (cm^2). If you measure the sides of the rectangle in *metres (m)*, the area will be in *square metres* (m^2).

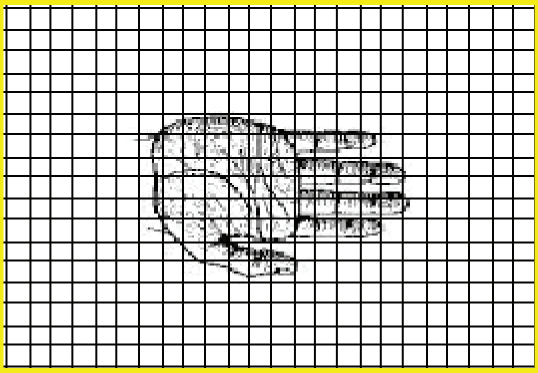
Assignment

Estimate the area of a tabletop at home. Then measure the sides and calculate the area. How good was your estimate? How would you measure the area of an irregular shaped figure or of a figure which differs in shape? For example, how would you measure the area of your palm? Compare your palm with that of your friend. Is your friend's palm bigger or smaller than yours? Explain how you would get the area of your palm.

A challenge

Design an investigation to measure the area of your palm.





Here is an idea to help you. Use paper with centimetre squares drawn on it. Estimate the area of your hand and then carry out your investigation to see how good your estimate was.

NOTE*: Regular shapes such as square, rectangle, triangle, circle have formulae for calculating their area. Can you remember the formulae for calculating the area of these shapes?*

Measuring Mass

Mass is the amount of matter in an object. If an object is moved to a different planet its **weight** will change but its mass will be the same. Do you know your mass?

In our daily conversations we usually talk of weight, not mass. You will learn later that mass and weight are not the same. When you talk about the weight of your plate of food, you are probably talking about the mass of your plate of food.

There are a couple of ways to measure mass. The most common method is to use a balance. There are different types of balance scales, but they all measure either mass or weight. What kind of substances can be weighed by the balances below?

Figure 3.4: Tripple beam balances and an electronic balance

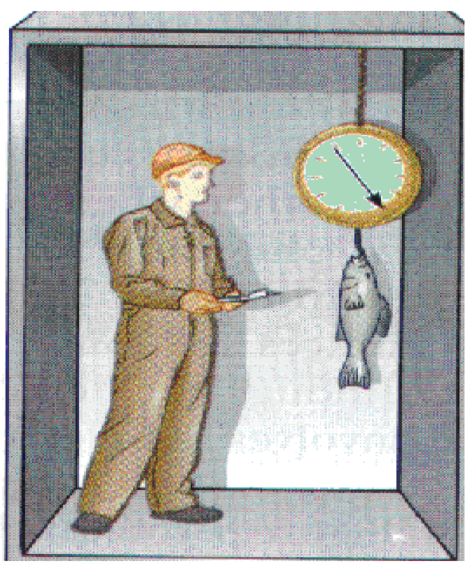


Figure 3.5: Weighing a fish using a spring balance

We measure mass in *grams* (*g*) and *kilograms* (*kg*). For example, the man in the diagram is measuring the weight of fish. There are 1,000 g in 1 kg.

One litre of water has a mass of about one kilogram. So if you do not have a 1 kg mass for the next activity, you can use a 1 litre bottle of water.

Activity 3.2: Estimating the mass of an empty 20-litre jerry can

Key question
What is the mass of your empty 20-litre jerry can?

What you need
- Bathroom scales (or a balance reading to 1 kg)
- 1 kg mass
- 20-litre jerry can
- 100 g mass

What to do
1. Handle the 1 kg and 100 g masses to get some idea of how heavy they are.
2. Estimate how heavy your 20-litre jerry can is.
3. Check your estimate by weighing the 20-litre jerry can on the bathroom scales.
4. Was your estimate close to the actual mass?
5. Repeat the experiment with something much lighter, such as your plastic mug. Then repeat it with something much heavier, such as yourself.

The mass of small objects such as a plastic mug is usually measured in grams. The mass of larger objects such as your 20-litre jerry can or yourself is usually measured in kilograms.

Measuring Volume

Measuring the volume of a rectangular object

Do you remember how to calculate the volume of regular solids like a rectangular block? You measure the **length** and the **width** and the **height** and then multiply them together. If you measure the sides of an object in *centimetres (cm)*, the volume will be in *cubic centimetres (cm^3).* If you measure the sides of an object in *metres (m)*, the volume will be in *cubic metres (m^3).* There are 1,000,000 (1 million) cm^3 in 1 m^3. The next activity will show how you can do this. First estimate the volume and then measure it.

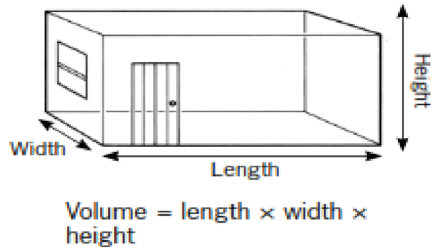
Activity 3.3: Finding the volume of a classroom

Key question
What is the volume of the classroom?

What you need
- Ruler

What to do
1. Estimate the length and width and height of the room and multiply them together to estimate the volume of the room.
2. Now measure the length and width and height with a ruler and calculate the real volume of the room.

How close was your estimate? Did you do better than your friend?



Fiure 3.6: Volume of a room

A useful way of estimating lengths such as these is to imagine how many tall people can lie down along the length of the room. Each tall person is about 1.65 metres tall.

Measuring the volume of a liquid

It is easy to measure the volume of a rectangular object by measuring its sides. How would you measure the volume of a liquid? Another common unit of volume is the *litre* (l). One litter of a liquid can be measured using a measuring cylinder, beakers, cups and conical flasks.

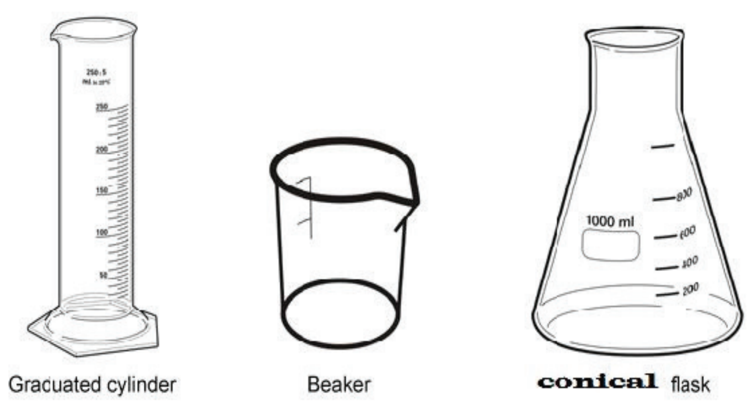


Figure 3.7: Instruments for measuring volume

We often use this unit when we talk about the volume of liquids. There are 1,000 cm^3 in 1 litre.

Activity 3.4: Finding the volume of a liquid

Key question

How can we measure the volume of a liquid?

What you need

- A small bottle containing water
- Measuring cylinder

What to do

1. Estimate the volume of the liquid in the bottle. Try to think how many cubic centimetres there are in it.
2. Pour the liquid into a measuring cylinder. Remember to read the bottom of the meniscus. (The meniscus is the curved surface of the liquid, caused by the way the

liquid is attracted to the sides of the cylinder by what we call surface tension). **Figure 3.8** shows you how to do this.

Can you make your own measuring cylinder out of a plastic bottle?

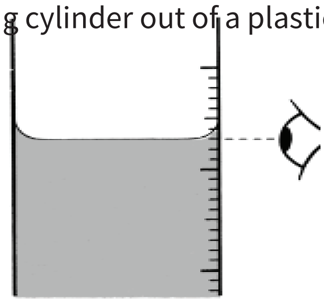


Figure 3.8: Reading volume of a liquid

We often measure volume in litres. When you buy milk or cooking oil you will probably buy it in litres or half litres. One litre is the common way to refer to 1,000 cm^3.

Did you know?
For more accurate and specific measurement of the volume of liquids, a burette and a pipette are used. Note that these instruments are delicate and should be handled with care.

Figure 3.9 (a) burette ***(b) pipette***

Measuring the volume of an irregular shaped solid

A regular solid is one with straight sides, for example a book. An irregular solid does not have straight sides, for example a stone. We can measure the volume of irregular shaped solids by putting them in water in a measuring cylinder and finding out how far the water rises. We can only do this for objects which sink in water.

Activity 3.5: Measuring volume of a stone (irregular object)

Key question
How can we find the volume of a stone or any other irregular object?

What you need

- Measuring cylinder
- Water
- Stone (small enough to go into the measuring cylinder)

What to do

1. Estimate the volume of the stone.
2. Put some water in the measuring cylinder and read the volume (*x* cm^3) .
3. Put the stone in water in the cylinder and read the new volume (*y* cm^3).
4. The difference between the two volumes is the volume of the stone.

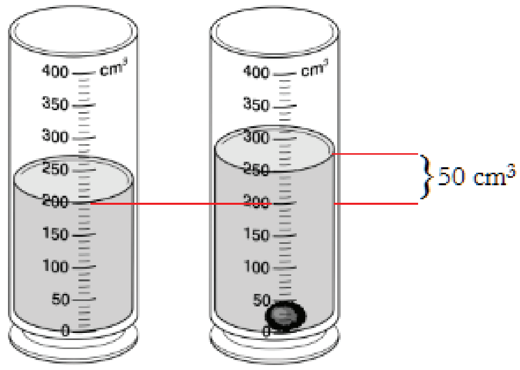


Figure 3.10: Measuring volume of irregular object

The stone in the above activity has a volume of 50 cm^3. How good were you at estimating the volume?

You can use the stone to measure the volume of an object that floats, such as a small piece of wood. First find the volume of the stone with a rubber band round it. Then attach the piece of wood to the stone with the rubber band. Then find the volume of the stone and the wood fastened together in the same way. Finally, subtract the volume of the stone (and rubber band) that you found first from the volume of the stone and the wood fastened together.

Volume of stone with rubber band around it = $x\ cm^3$
Volume of stone with rubber band around it and the wood fastened together = $y\ cm^3$
Volume of wood = $(y - x)\ cm^3$

Measuring Time

Our great grandfathers used several ways of measuring time, e.g. flowing sand, the shadow, heartbeat and cockcrow. However, many of these methods were inaccurate or unreliable, so engineers developed more accurate clocks for measuring time. **Figure 3.11** shows some methods of measuring time.

Figure 3.11: Measuring time

Which method are you familiar with? The SI unit for time is seconds, abbreviated ''s''. There are 60 seconds in one minute and 60 minutes in one hour. Bigger units for measuring time include days and years.

How good are you at estimating time? Can you count so that you say one number each second? Try it.

A good way of measuring a second is to make a pendulum by tying a stone to a piece of string. If the string is 1 m long the stone moves from one side to the other in 1 second.
We measure time in seconds.

Galileo Galilei was a very famous physicist who lived 400 years ago in what is now Italy. He used a pendulum to measure time when he did experiments in physics

Activity 3.6

Key question

Can you estimate time?

What you need

- Clock or watch
- 1 m pendulum

What to do

You must work outside with two friends.

1. Mark out a short distance, say about 100 m that you can run (a good idea is to run across a football field).
2. One of you will run the distance; the second will estimate the time and the third will measure the time it takes to run the distance.
3. Do this three times so that each of you has a chance to run, estimate and measure.
4. Do the experiment several times to see if you get better at estimating time.
5. Record your results to the nearest second in a table like the one below.

Name	Time (seconds)	
	Estimated	***Actual***

Scientific Notation and Significant Figures in Measurements

When making measurements in science, it is important to understand that the way a measurement is taken affects its accuracy. These are called significant digits or significant figures.

Please Note

> *Significant figure* is each of the digits of a number that are used to express it to the required degree of accuracy. It consists of digits that are known for certain and the first digit that is estimated.

Rounding means making a number simpler but keeping its value close to what it was. The result is less accurate, but easier to use; for example, 3.52 cm to 3.5 cm.

Decimal place is the position of a digit to the right of a decimal point. A time of 6.50 hours has two decimal places; 5 is the first and 0 the second decimal figure.

Rules for Finding Significant Figures

Rule 1: All non-zeros digits are significant figures.
Example: Distance of 4362 m has 4 significant figures.

Rule 2: All zeros occurring between non-zero digits are significant figures.
Example: Mass of 605 g has 3 significant figures.

Rule 3: All zeros to the right of the last non-zero digit are not significant.
Example: Weight of 4500 N has 2 significant figures.

Rule 4: Zeros right of a decimal point and left of non-zero digit are not significant.
Example: Area of 0.00325 m^2 has 3 significant figures.

Rule 5: All zeros right of a non-zero digit in the decimal part are significant.
Example: Height of 1.4750 cm has 5 significant figures.

 **Exercise 3.3:**	State the number of significant figures in the following measurements: 300 cm (b) 0.105 km (c) 0.050 g

Rules for rounding off significant figures

Rule 1: If the digit to be dropped is less than 5, the preceding digit is left unchanged.
Example: 1.54 is rounded off to 1.5.

Rule 2: If digit to be dropped is 5 or greater than 5, the preceding digit is raised by one.
Example: 2.49 is rounded off to 2.5.

Rule 3: If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is raised by one if it is odd and left unchanged if it is even.

Example: 3.750 is rounded off to 3.8 and 4.650 is rounded off to 4.6.

Rule 4: When dealing with figures in operations i.e. multiplying and dividing figures with different significant figures, the answer takes the **lower** significant figure.

Exercise 3.4	A rectangular block of wood has a length of 5.24 cm, a height of 3.645 cm and a width of 0.63 cm. Calculate the volume of the block of wood. Give the answer to the appropriate number of significant figures and decimal places.

Scientific Notation (Exponential or Standard Notation)

Scientific notation is a short and convenient way of writing or expressing very large or very small numbers using powers of 10. Examples are shown below:

(a) 40 can be written as 4×10^1 (b) 2000 is written as 2×10^3 (c) 0.0003 is written as 3×10^{-4}

Since very large or very small numbers are written using fewer digits, scientific notation helps to make working with digits easier and with fewer mistakes, for example:

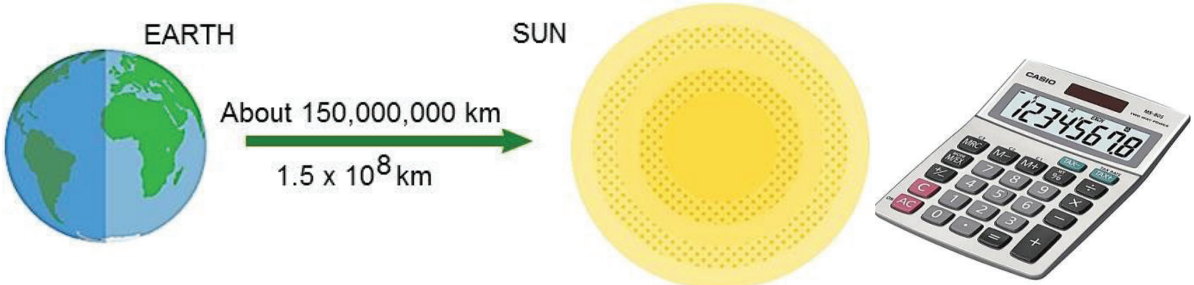


Figure 3.12: Scientific notation helps to write very large or very small numbers using less digits

Meaning of Density

Figure 3.13: Comparing objects

Assignment

Look at the objects in **Figure 3.13** above. Which is the biggest? Do you agree with your friend? This is not a simple question to answer.

Do we mean, which object has the greatest mass, or which object has the most matter in it? Or do we mean, which object has the greatest volume, or which object takes up the greatest amount of space?

Some objects in **Figure3.9** have a small mass but a large volume. The polystyrene block is one of them. The brick, however, has a large mass but a small volume. We say that the brick has a large **density** but the polystyrene block has a small density. What is density?

The **density** of a substance is the mass of 1 cm^3 of it. It is known as '**mass per unit volume'**. The density of gold is 19.3 g/cm^3, the density of copper is 8.9 g/cm^3 and the density of water is 1 g per cm^3.

What does it mean when we say that the density of copper is 8.9 g/cm^3?

You can find the density of an object if you know its mass and its volume. To find the density of a substance we divide its mass by its volume:

$$density = \frac{mass}{volume}$$

Think back to what you did in Chapter 2 to remind yourself how you measure mass. Do you remember the different ways of measuring the volume of something? Do you remember how to measure the volume of an irregular solid such as a stone?

Units of density

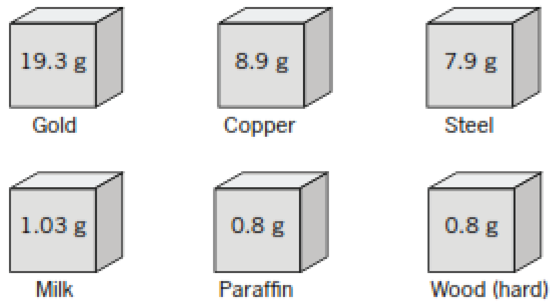
The units of density will depend on the unit you used to measure mass and volume. If you measure the mass of a substance in grams and the volume in cubic centimetres, the density will be in grams per cubic centimetre. We can write this unit in two ways: **g/cm^3** or **$g\ cm^{-3}$.** It is also expressed as **$kg\ m^{-3}$.**

The Density of Different Substances

Density can help us to identify substances. Density can also tell us whether an object will sink or float.

Comparing substances with the same volume

Look at the different objects in the diagram. They all have the same shape and the same volume. They are cubes with a volume of 1 cm^3.



All the cubes above have the same volume but different mass. The lightest cube is 1 cm^3 of paraffin wax and wood (hard), which has a mass of less than a gram. The heaviest cube is gold, which has a mass of more than twenty times the mass of the paraffin cube. We say that gold is *denser* than paraffin.

Determining Density

To determine the density of a substance we need to know its mass and its volume.

Activity 3.6: Determining the density of different substances

Key question

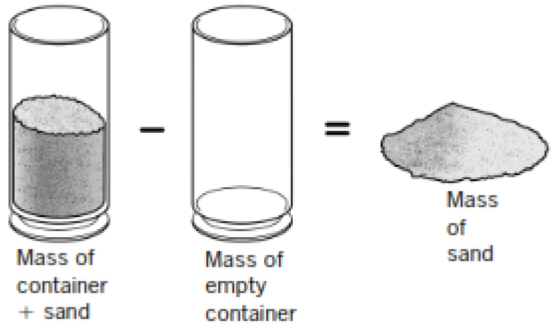
How can we determine the density of different substances?

What you need

- Water
- Sand
- regular solids with rectangular sides (pieces of metal or wood or plastic specially cut, or objects such as a book or a brick)
- Ruler
- measuring cylinder
- weighing scales

What to do

1. Find the mass of each substance. To do this for water and sand you first have to find the mass of a container, put the water or sand in it, and then weigh it again. You then subtract the mass of the empty container from the mass of the container filled with water or sand. This will give you the mass of the water or sand.



2. Find the volume of each substance. You can measure its length, width and height and calculate the volume, or use a measuring cylinder.
3. Divide the mass by the volume to find the density.

The substances you used in **Activity 3.7** were either regular solids or substances that you could pour into a measuring cylinder to measure their volume. How would you find the density of an irregular solid such as a stone?

Changes in Density

You earlier on learnt that all matter is made of moving particles. In solids, liquids and gases the particles vibrate all the time. In liquids and gases, the particles can also move around. You also learnt that when substances are heated, the particles move faster and need more space to move. So when the substance expands, its volume increases.

If the volume of a substance increases but its mass stays the same, its density must decrease. So when substances are heated and they expand, their density gets less. When substances cool down, their density increases.

Density and its Application to Floating and Sinking

Floating and Sinking

If we drop a lump of steel into water, we notice that it sinks to the bottom. Why is this so? The next activity gives you the answer.

Activity 3.8

Key question

Why do some solids sink in water but others float?

What you need

Some different solids such as:

- pieces of metal
- plastic
- wood, etc.

What to do

1. Take different solids and put them in water.
2. Observe whether they float or sink.
3. Measure their mass and volume.
4. Calculate their density.

Try to find a rule which tells you whether an object will float or sink in water. The table shows the density of some substances. Look at the solids in the table. Some of them float while some sink in water.

Those substances with a density of less than that of water (1 g cm^{-3}) will float in water. What can you say about the densities of the objects that sink?

Substance	Density (g cm^{-3})	Substance	Density (g cm^{-3})
Aluminium	2.7	Methylated spirits	0.8
Brass	8.5	Paraffin	0.8
Copper	8.9	Petrol	0.7
Cork	0.3	Polyethene	0.9
Glass	2.5	Sand	2.6
Gold	19.3	Tin	7.3
Steel	7.9	Wood	0.6
Lubricating oil	0.9	Water	1.0

Assignment

Predict, observe, and explain

Take a used ballpoint pen top. It is made out of polythene. It has a density of about 0.9 g cm^{-3}. Do you think it will float in water? *Predict* what will happen if you put it in some methylated spirits (density 0.8 g cm^{-3}). Try it to find out if your prediction is correct. What do you *observe*? *Explain* your observation.

In West Nile, people living along the Nile use canoes (*o'bo*) made out of wood. The canoe is able to float on water. Can you explain why? The wood is less dense than water.

Figure 3.14: A boat floating on water

Most large ships are not made out of wood, but out of steel. We can see from the table that a lump of steel will not float because it has a density of 7.9 g cm^{-3}. How then can a large ship, made of steel float?

Figure 3.15: A ship and ferry floating on water

This ship is made of steel and weighs 105,000 tonnes but it can float on water. The ship is made of steel but inside it there are many other things, including air. Air has a very low density. The air and the steel together have a density that is smaller than 1 g cm^{-3}. As this is less than the density of water, the ship will float.

Assignment

Predict, observe and explain

Take two empty cool drink cans. Crush one and make it as small as you can by stamping on it. Put both cans in a bucket of water.

Predict what happens.

Observe what happens.

Explain your observation.

Floating in the sea

The density of seawater is greater than that of freshwater because of the salt dissolved in it. The density of seawater is about 1.03 g cm^{-3}. Try the next activity that uses seawater and see if you can explain your observation.

Activity 3.7: Comparing floating in sea and freshwater

Key question

How deep does a block of wood float in freshwater and in seawater?

What you need

- small block of wood
- bowl
- water
- salt

What to do

1. Put some freshwater in the bowl. Float the block of wood in it. Make a mark on the wood where the water level is.
2. Make some saltwater (seawater) by dissolving some salt in freshwater—use quite a lot of salt.
3. Float the same block of wood in your saltwater. Mark the water level on the wood.
4. Were the two levels the same?

You will have found out that the block of wood floats higher in saltwater than in freshwater. This is because the density of the saltwater is higher than that of freshwater. The salt particles mixed with the water particles make it denser. Why is it easier to float in the seawater than in the fresh river water?

Assignment

Predict, observe and explain

Put a fresh egg in a beaker of water. What do you observe? *Predict* what will happen if you add salt to the water and stir (don't break the egg!). Add salt and stir and *observe* what happens. *Explain* your observation.

Why does ice float on water?

Have you ever wondered why ice floats on water? Because it floats, it must be less dense than water. But if you cool down a liquid and it changes into a solid, it contracts all the time and so its density increases. Ice should not float on water; it should sink to the bottom. When all other liquids change to solids, the solid forms at the bottom of the liquid, not at the top.

Why is ice different?

When water cools, it contracts like other liquids and its density increases. But below 4 ^{0}C, just before it freezes, it expands. It does not continue to contract like other liquids. This is because the molecules of water begin to rearrange themselves into a different structure.

In the new structure the molecules are further apart than they were in the warmer liquid. This is the structure of the particles in the ice crystals. Ice is less dense than water because the particles are further apart in ice than they are in water just above freezing. So ice forms on the top of water, not at the bottom.

Floating and sinking in air?

If a balloon is filled with a gas which is less dense than air, such as hydrogen or helium, it will go upwards. Meteorologists use balloons filled with hydrogen to find out what the weather high up in the atmosphere is like.

Hot air is less dense than cold air. This is because everything expands when it gets hot. If a mass of air expands, its volume will increase while its mass stays the same, so its density will go down. Hot air will rise above cold air.

Figure 3.16 Cumulus clouds forming over hills.

Look at the photograph above. These clouds are called cumulus clouds. They often form over hills that have become very hot in the sun, so hot air currents are produced going upwards. These clouds carry a lot of water as they rise up in the sky. When they reach the high cold air, the clouds turn into rain and we get a heavy storm.

Exercise

1. A log of wood has more mass than a copper coin, but it does not sink in water. Explain why.
2. Calculate the density of the substances below.
    a. A lead lump: mass 9.2 g; volume 0.8 cm^3.
    b. A cork: mass 2 g; volume 8 cm^3.
3. Explain why a person fishing uses a cork and a lead weight.
4. The density of a metal is 8.9 g cm^{-3}. What does it mean? What is the importance of this value?
5. A rectangular piece of glass has a mass of 145.8 g and measures 2 cm by 9 cm by 3 cm. Find its density and express your answer in kg m^{-3}.
6. 200 cm^3 of a liquid of density 0.7 g m^{-3} is mixed with 100 cm^{-3} of liquid of density 0.9 g m^{-3}. Assuming there is no loss of liquid during mixing, and uniform mixing was done, find the density of the mixture.

Density and Purity

We can use density in the same way. Pure gold always has a density of 19.3 g cm^{-3}. If you want to know whether a gold object is made of pure gold you should find its density. If it is not 19.3 g cm^{-3}, it is not pure gold. Pure substances always have the same density. This density is different from that of all other substances.

Density and Relative Density

Relative density, or **specific gravity**, is the ratio of the density (mass of a unit volume) of a substance to the density of a given reference material. Specific gravity usually means relative density with respect to water. The term "relative density" is often preferred in scientific usage. It is defined as a ratio of density of particular substance with that of water.

If the relative density of a substance is less than one, then it is less dense than the reference; if it is greater than 1, then it is denser than the reference. If the relative density is exactly 1 then the densities are equal, that is, equal volumes of the two substances have the same mass. If the reference material is water, then a substance with a relative density (or specific gravity) less than 1 will float in water. For example, an ice cube with a relative density of about 0.91 will float. A substance with a relative density greater than 1 will sink.

Activity of Integration

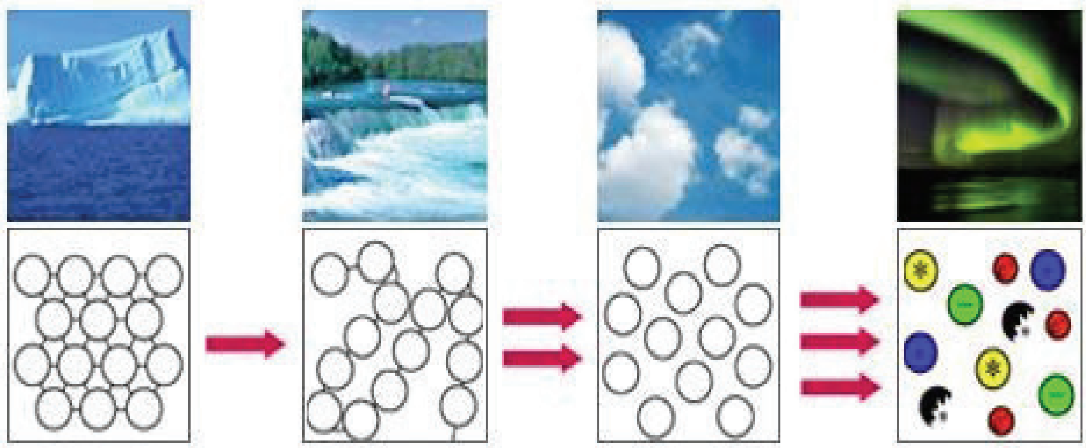
A chief finds a glittering stone which he shows to the family. The family assures him that the stone is pure gold but he doubts. Prepare a message about what you can do with the stone to give the chief and his family the best advice.

Chapter Summary

In this chapter, you have learnt:

- what estimating and measuring mean.
- how to measure a variety of physical quantities and their unit.
- the meaning and use of significant figures.
- the scientific method of inquiry.
- the meaning of density and its implications in terms of floating and purity.

Chapter 4: Matter



Key Words	By the end of this chapter, the learner will be able to:
▪ plasma ▪ diffusion ▪ particle theory ▪ Brownian motion ▪ change of state	a) understand what matter is and identify different states of matter. b) use the knowledge of kinetic theory and particle nature of matter to explain the states of matter and their properties. c) know the factors that affect the rate of diffusion of a gas. d) use the scientific knowledge of the particle theory to explain common phenomena such as gas pressure, drying clothes, rain formation and making a cup of tea. e) understand the processes of change of state such as melting, boiling, evaporation, condensation, freezing and sublimation in terms of either heat gain or heat loss. f) compare physical and chemical changes. g) categorise processes in daily life as physical or chemical changes.

Introduction

When you are at the shores of either a lake or river or at a beach, you see many grains of sand. What do you think these grains of sand are made of? In this chapter, you will understand the behaviour of the different states of matter

Figure 4.1: Heaps of sand at the lake shores

Grains of sand and everything else you see, hear, smell, touch, and taste are made of matter. Matter is anything that has mass and takes up space. Matter exists in many shapes, colours, textures, and forms. Water, rocks, living things, and stars are all made of matter. The study of matter is important because it guides us to classifying things.
To understand matter, you need to take a closer look at it. As you observe or examine matter more closely, more of its parts and their arrangement are revealed. We can use these parts to classify matter into four states: solids, liquids, gases and plasma.

Assignment 4.1

Look at **Figure 4.2**. Make a table with three columns labelled ‘solid’, ‘liquid’ and ‘gas’. Write all the solid things you can see in the picture in the column labelled ‘solids’. Do the same with the other two columns. Get physical substances you have listed as solids or liquids from your class or outside the class and observe them critically.

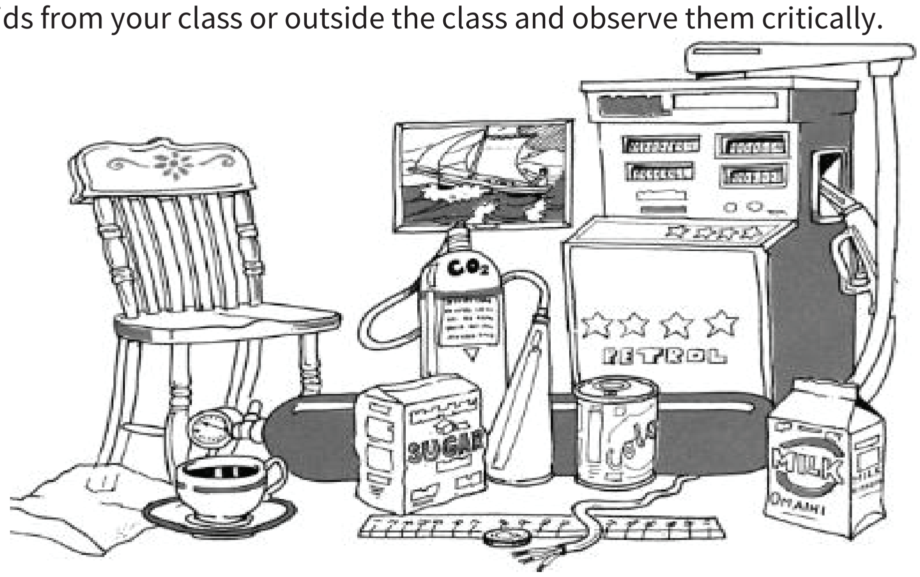


Figure 4.2: Group of assorted items

Can you describe what a solid is? Can you describe a liquid and a gas? Here are some descriptions.

Properties of Solids, Liquids and Gases

A solid

- It cannot move unless something or someone moves it.
- It keeps its shape unless it is broken.
- Its volume stays the same (unless it is heated or cooled).

A liquid

- It can flow.
- It takes the shape of the container.
- Its volume stays the same (unless it is heated or cooled).

A gas

Have you ever smelt the flavour of food when it is being prepared in the kitchen? What if one opens a bottle of perfume from one corner of the room, can a learner in another corner smell the perfume? This is what happens.

If someone is cooking in the kitchen it does not take long for the smell to travel around the house to other rooms. Gas particles from car exhaust fumes, perfumes or flowers move through the atmosphere. Our noses detect smell of the small particles. The particles in gaseous form move through air from food or any other thing that has smell and this movement is called **diffusion**. Gas has the following properties:

- It can flow: it will spread out as far as it can.
- It will change its shape.
- Its volume will change when it spreads out.

Did you know that liquids and gases are referred to as **fluids?**

Of recent, another state of matter has been discovered. This state of matter is called **plasma.** You do not find naturally occurring plasmas too often when you walk around. They are not things that happen regularly on earth. While natural plasmas are not often found around you, humanmade plasmas are everywhere. You encounter it every day, but you may not recognize it.

Here are some examples of forms of plasma: lightning and stars (including sun).
Plasma has these properties:

- Plasma is an ionized gas

Plasma is the common state of matter

- Plasma is a very good conductor of electricity and is affected by magnetic fields.
- Plasmas like gases have an indefinite shape and an indefinite volume.

Different Properties of Matter

The properties of substances depend on how the particles in these substances are arranged and how they are held together.

To investigate the properties of solids, liquids and gases, including shape, pouring and compressing, it is important to study the arrangement of and the forces between the particles and their movements.

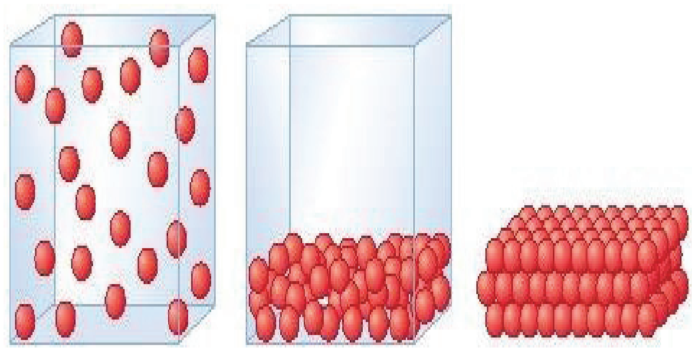


Figure 4.3: Arrangement of particles in the different states of matter

Particles in Solids

It is easier to run on land than to swim in water. Why is this? Particles are held together by forces. The forces holding water particles together are much greater than the forces which hold air particles together. Therefore, when you swim in water you use more force to break the water particles apart.

The particles in solids have fixed positions. They are in lines next to each other. The forces of attraction between the particles are strong. The particles can vibrate but cannot move past each other. They are close together and touch each other.

Particles in Liquids

The particles in liquids vibrate and can move past each other. They are close together and touch each other as in a solid. The forces of attraction between the particles are not as strong as in solids to support them in one position, so liquids take up the shape of the container.

Particles in Gases

The particles in gases are not touching each other; they are a long way apart. They vibrate like particles in solids and liquids. They are also moving quickly around and so they spread out. If compressed, they move closer together.

The next activity compares a liquid with a gas. It provides *evidence* for the idea that particles are close together in a liquid and far apart in a gas.

Activity 4.1: Finding out if gas or liquid can be compressed

Key question
Which is easiest to compress: a gas or a liquid?

What you need

- a syringe
- water

What to do

1. Draw some air into a syringe.
2. Close the opening with your finger so the air cannot get out.
3. Press down on the plunger (piston) as shown in the picture. Observe what happens.
4. Do the same with a syringe containing water. Observe what happens.
   (Illustration of a syringe is missing to demonstrate the above activity)

You must have found out that it was easy to compress (squeeze) the syringe full of air, but impossible to compress the water.

This tells us that the water particles are already close together and cannot be pushed closer together. In gas, the particles are far apart and can easily be pushed closer together.

The Particle Theory of Matter

Describing the composition of matter is not easy since the actual composition can only be inferred rather than observed. Suppose you take a piece of charcoal and break it into tiny pieces and then break these tiny pieces into dust. It is still charcoal. Then take the dust and further divide it until it is no longer visible. These invisible particles are still charcoal. As early as 400 B.C., the Greek philosopher, Democritus, thought that matter could be broken down until it can no longer be subdivided. He called these invisible particles **atoms** (from the Greek word meaning not divisible). By observing how particles behave in water and smoke, scientists developed a model to identify the composition of matter.

- All matter is made up of extremely tiny particles which have spaces between them.
- Each pure substance has its own kind of particles, different from the particles of other pure substances.
- Particles attract each other.
- Particles are always moving.
- Particles at a higher temperature move faster on average than particles at a lower temperature.

There are things we experience in our daily life which also explain that solids, liquids and gases are made of small particles which we cannot see with our naked eyes. For example, when sugar mixes (dissolves) in water we cannot see what is happening. Scientists use the idea of **particles** to explain what is happening. The particles are so small that we cannot see them.

What do you think happens to the sugar particles in the crystals when they dissolve in the water?The sugar particles move away from the sugar crystals into the water.

Figure 4.4: A vehicle raising a cloud of dust on a murram road

If rock breaks it can form fine powder which we call dust. When you travel on a dusty road, you may have noticed that very fine grains of dust stay in the air for a long time and can also easily get inside the vehicle. You can even see very fine dust with your naked eye. But each grain of dust is made up of even smaller particles which you cannot see. It takes millions of small particles to make the grain of dust which you can see.

Think about air

We cannot see air particles because they are very much smaller than grains of dust. We know that they exist because we breathe in air particles. We also feel the wind when many air particles are moving and hitting us.

What Evidence is there to confirm particles?

We cannot see particles because they are very small. But scientists believe they exist. This is a **scientific theory**. Scientists think up theories to explain their observations. Then they look for **evidence** that their theory is correct. Evidence is something that you can see or hear or touch that can be explained by the theory.

The next activity provides some *evidence* for particles. You will make an observation that can be explained by the theory of particles.

Activity 4.2: Investigating evidence of particles using balloon filled with air

Key question

How can we explain what happens to a balloon full of air?

What you need

- a balloon
- string

What to do

1. Blow up a balloon.
2. Tie the string tightly around the neck of the balloon many times.
3. Look at the balloon every day to see if it has changed size.

Did you see that the balloon gets smaller and smaller? This is because the air is escaping. How is it escaping? Can you think of an explanation why the balloon goes down? Here is an explanation that uses the theory of particles. When the balloon goes down, it is *evidence* for the theory of particles.

Look at **Figure 4.5** below. It shows the rubber skin of the balloon. The skin is made of rubber particles packed closely together. But there are places where the air particles can get out through holes between the rubber particles. The air particles inside the balloon are constantly moving around and hitting the skin of the balloon. A few manage to get out of the balloon.

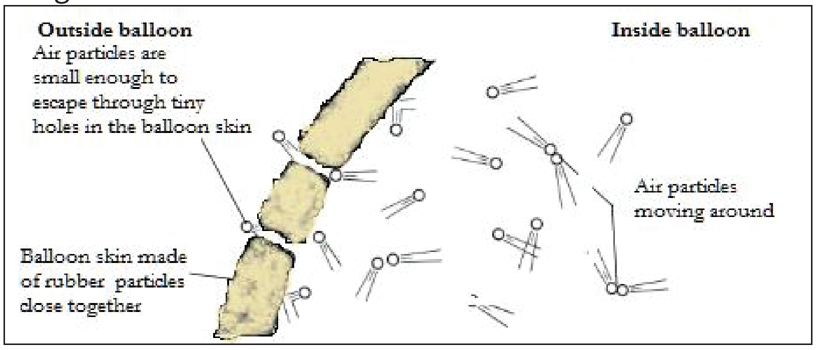


Figure 4.5: Investigating gas diffusion

Solids and liquids are also made of particles. When we mix a cold drink powder (a solid) in water (a liquid), we notice that the powder seems to disappear into the water. The water takes the colour of the powder and tastes different.

The next activity provides more *evidence* for particles. This time the particles are in a liquid.

Activity 4.3: Investigating evidence of particles using liquid

Key question

How do we know that solids and liquids are also made of particles and are in a state of motion?

What you need

- a crystal of potassium permanganate
- a drop of ink
- water
- two small containers (tops from jam jars are suitable)

What to do

1. Fill the containers with water.
2. Carefully place a crystal of potassium permanganate in the water of one container.
3. At the same time a friend should carefully place a drop of ink in the water of the other container.
4. Do not move the containers. Look at what happens to them during the rest of the lesson.
   Leave them overnight and observe again. What is the difference between them?

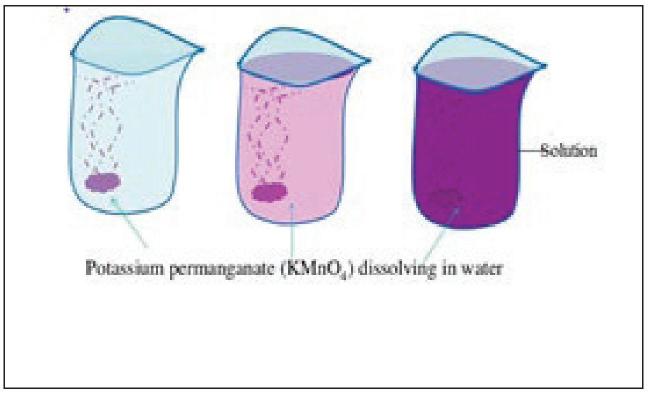


Figure 4.6: Investigating solid diffusion

What happened to the crystal of potassium permanganate? What happened to the colour of water?

Each particle that leaves the crystal moves in between the particles of water and spreads. You cannot see the particles because they are very, very small. When particles of a substance spread from one region to another, the process is called **diffusion**. After some time, all the particles from the potassium permanganate crystal have spread evenly throughout the water to form a **solution**. This is why the crystal cannot be seen any more. It has **dissolved**.

Think of coloured liquid like ink. What would happen to the colour of water if a drop of the ink is put into the glass of water? The particles in the ink will also diffuse (spread) throughout the water until the colour becomes the same throughout the solution.

Brownian motion

Brownian motion is the perpetual irregular (non-uniform, zig-zag, erratic) motion exhibited by small particles immersed in a fluid. Such random motion of the particles is produced by the collisions they suffer with the molecules of the surrounding fluid. Brownian motion can be observed under a microscope.

Brownian motion is observed by confining smoke in a smoke (glass) cell, illuminating the cell with a powerful source of light and then observing the smoke particles under a powerful microscope.

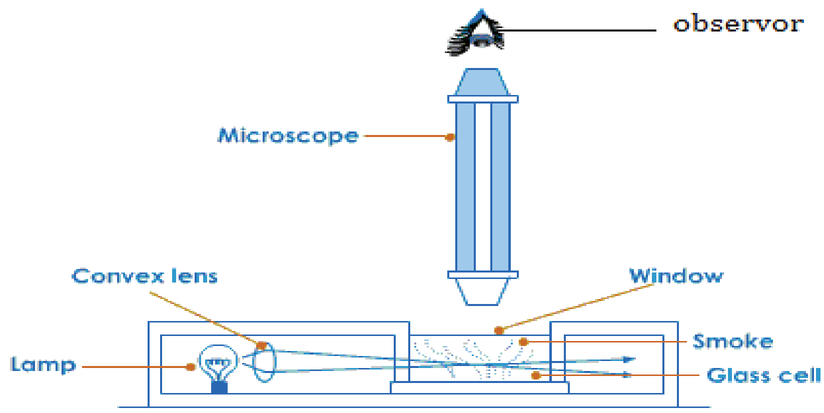


Figure 4.7: Smoke cell experiment

The particles are seen moving in all directions. Raising the temperature of the cell increases the random motion of the smoke particles.

Diffusion in gases

If someone is cooking in the kitchen, it does not take long for the smell to travel around the house to other rooms. This is because of diffusion. Gas particles from car exhaust fumes, perfumes or flowers diffuse through the atmosphere. Our nose detects the small particles. This is how we smell things around us.

You do not have to mix the gases by waving your arms around—it mixes on its own. You can easily show this with a gas that has a smell such as butane in a burner. One person should turn on the burner for a few seconds in the front of the classroom. Are you able to smell anything?

Activity 4.4: Investigating particles in gases

Key question

How do we know that gases are also made of particles?

What you need

- Liquid bromine
- Two empty gas jars
- Cover plate

Note that bromine vapour is poisonous

What to do

1. Fill one of the gas jars with bromine gas and carefully cover it with cover plate.
2. Invert the gas jar and place it on top of a jar full of bromine with its cover.
3. Carefully remove the cover plate and let the two open ends of the jars be in contact.
4. Do not move the jars. Look at what happens to the bromine gas.
5. What is the difference between two jars?

This can be explained by the idea of particles.

Each particle that leaves bromine vapour moves in between the particles of air in the jar on top. The bromine gas spreads (diffuses) rapidly into the air to produce a uniform pale brown colour in both jars. You cannot see each particle because the particles are very, very small. But you see the brown colour spreading throughout the two jars.

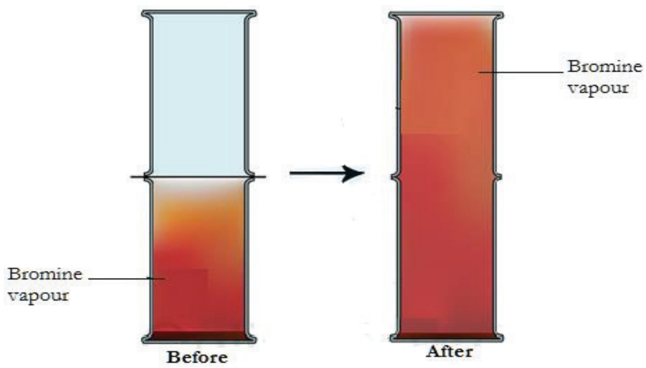


Figure 4.8: Gas diffusion

Diffusion in gases is quick because the particles in a gas move quickly. Gas particles are further apart than liquid particles and so other gases can diffuse between them easily. It happens even faster in hot gases.

What happens to particles in a solid when they are heated?

Look again at the pictures which show the particles in a solid, a liquid and a gas.

In a solid, the particles are arranged in lines next to each other. You know that when you heat a solid, such as ice, it will turn into a liquid. When you heat the solid you are giving it **energy**.

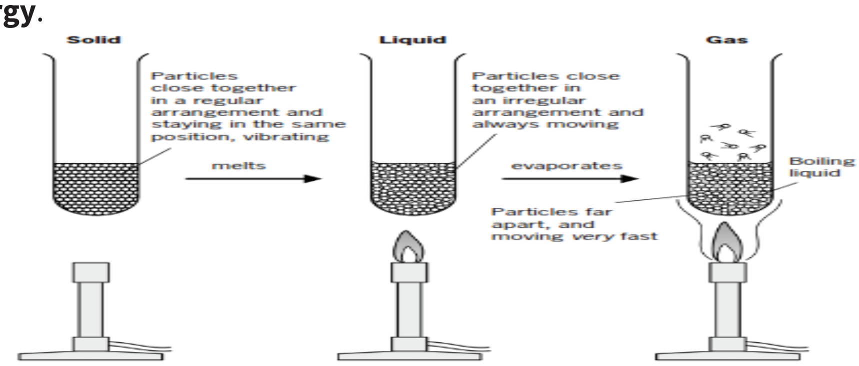


Figure 4.10: Effect of heat on states of matter

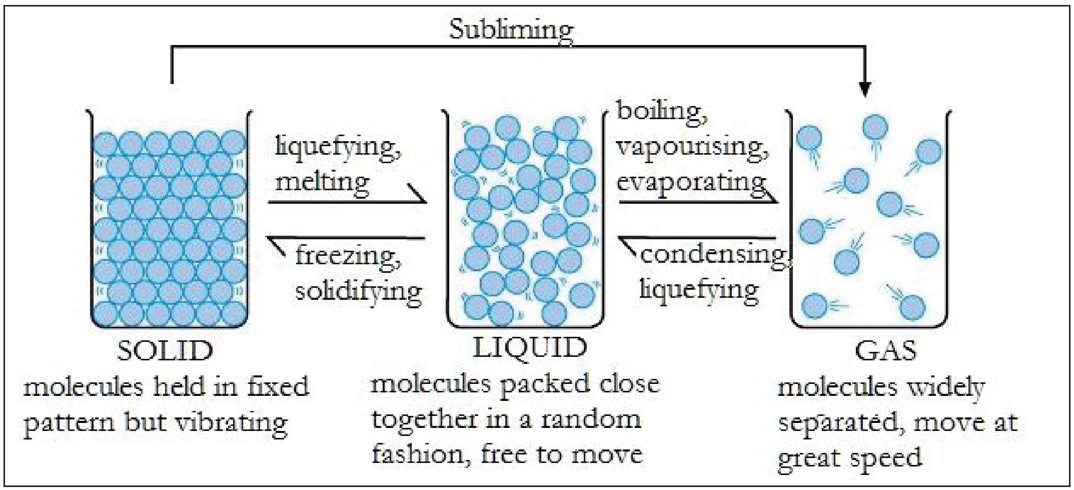
The energy is heat energy and it makes the particles in the solid vibrate faster. The heat energy is turned into movement energy of the vibrating particles. If the particles are given more energy, some of them will vibrate so hard that they start moving past each other. They have so much energy that they can overcome the forces holding them in one place.

What happens if you add more energy? The particles move around faster and faster. Some of them get enough energy to overcome the forces holding them together. They escape from the liquid. They become gas particles.

Assignment 4.2

A play on change of state

Write a short play that shows everyone what happens when ice particles turn to water particles and water particles turn to water vapour. Everybody in your class should be water particles. At the beginning you are particles in ice. You are in rows but you are vibrating. The ice is warmed and you vibrate faster.



Exercise

1. You have learnt that matter is made up of small particles. Give some experimental observations that show this.
2. Engineers need to know that substances expand when they are heated. Give three examples where engineers use this information to design things.
3. Explain the following observations by using the idea of moving particles:
   a) Wet clothes hanging on a line become dry even in cold weather.
   b) If you put some sugar in tea, the tea will become sweet even if you do not stir it.
   c) A car tyre is full of a gas, air, but the part of the tyre underneath the wheel does not look flat.

Many of the uses of the different states of matter rely on them changing from one state of matter to another. For example, purifying water relies on a change of state from liquid to gas and back again, as does the formation of rain.

It is very important to understanding that when things change from one state to another, it requires energy (heat) gain or loss. Substances can move from one state to another when specific **physical conditions** change. For example, when the temperature of a substance goes up, the particles in the substance become more excited and active. If enough energy is placed in a substance, a state change may occur as the matter moves to a more active state.

In this section, the particle model will help you to explain how substances change from one state to another. An example of this is the changing of ice water to water (liquid) and to water vapour (gas) during boiling of water.

1) Can you give examples of substances which are always in a solid form but you change them into a liquid form before use?
2) How do you do it?
3) Why do you put drinking water and other drinks in a fridge?

Look at the diagram below and explain what happens to the arrangement of particles, and forces holding the particles together when energy heat increases at every state. Do the same to explain when heat energy decreases at every state.

Assignment
With a friend discuss the economic applications of change of state.

1. Imagine cubes of ice are left on a table in room. What will happen to the ice cubes and Why? Do you think that there is any way to speed up this change? Is there any way to slow down this change?
2. What happens when water is put in a pan and heated?
3. What happens when water vapour comes in contact with a cold bottle of soda and why?
4. If a cup of water is put in a freezer compartment of a fringe, why do you think it will change into ice?

Physical and Chemical Change

Matter undergoes changes all the time. These changes may be as simple as change in size, change in shape or even change in states e.g. ice melting into water, piece of bread broken into small pieces, or salt dissolve in water. The changes may be complex leading to the production of new substances. These changes can be classified as physical and chemical changes.

Activity 4.5: Observing changes

Key question
What is the difference between a physical and chemical change?

What you need
- a candle
- wood splints
- match stick

What to do
1. Light the candle.
2. Let the candle wax melt.
3. Allow the wax to drop on the flow.
4. Observe and record what you see.
5. Light the wood splints and allow them to burn until they all turn into ash.
6. Observe and record what you see.
7. Determine which change each of the above substance undergoes. Give reasons for your answer.

Physical Changes

Figure 4.11: A melting candle wax is a physical change

A physical change is one where a substance changes but does not form a new substance. This kind of change occurs when a substance changes from one state of matter to another, e.g. melting, freezing, evaporation condensation and crushing substances.

Examples of physical change

- Breaking of a plate into pieces
- Melting of ice
- Boiling of water
- Cutting of grass
- Sharpening of a knife

Chemical Changes

A chemical change occurs when a new substance is formed. The new substance formed may behave differently or even appear different from the original substance. Such a change is easily seen. However, the change may not easily be seen in some instances.

Figure 4.12: Chemical changes

The only indication could be change in colour, production of heat or light or drop in temperature.

Examples of chemical change

- Paper changing to form ash
- Ripening of fruits

- Cooking of eggs to form white and yellow solid
- Decomposition of plant to form soil
- Rusting of iron
- Hardening of concrete

Exercise

1. Identify five chemical changes you have encountered in your everyday life.
2. When a candle is burning, it undergoes both physical and chemical changes. Identify the physical and chemical changes that it undergoes.

Activity of Integration

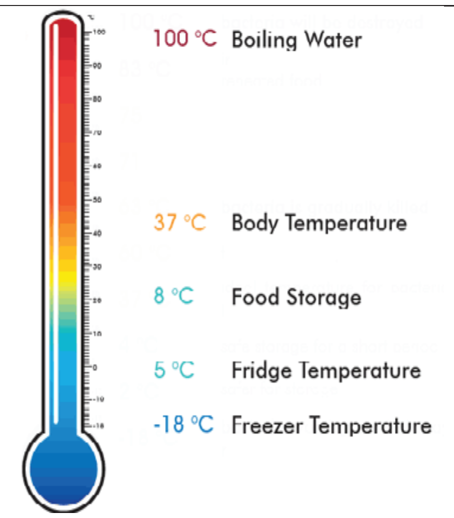
A factory worker discovers a substance that flows but is kept in powder form. When opened, it quickly evaporates. The worker cannot manage to classify the substance into any state of matter in order to use it properly. Design a message that helps the worker to properly classify the substance.

Chapter summary

In this chapter, you have learnt that:

- all substances are made up of matter.
- matter can exist in four states: solid, liquid, gas and plasma. Particles in these states are arranged differently.
- solids, liquids and gases expand when they are heated because the particles move further apart.
- particles of a liquid and a solid are close together. This is why liquids and solids cannot be compressed easily.
- states of matter undergo different changes of state when the conditions of temperature change.
- processes in everyday life can be classified as physical or chemical change.

Chapter 5: Temperature and Thermometers



Key Words	***By the end of this chapter, you will be able to:***
▪ temperature ▪ temperature scales ▪ thermometric property ▪ upper fixed temperature ▪ lower fixed temperature ▪ clinical thermometer ▪ digital thermometer	*a) compare temperature and heat.* *b) understand the meaning of thermometric properties.* *c) demonstrate how temperature scales are obtained from thermometric properties.* *d) solve simple numerical problems related to temperature scales.* *e) compare mercury, alcohol and water as thermometric liquids.* *f) demonstrate the construction and use of clinical thermometer.* *g) convert temperature from one scale to another.* *h) understand the daily variations in temperature of the atmosphere.*

Introduction

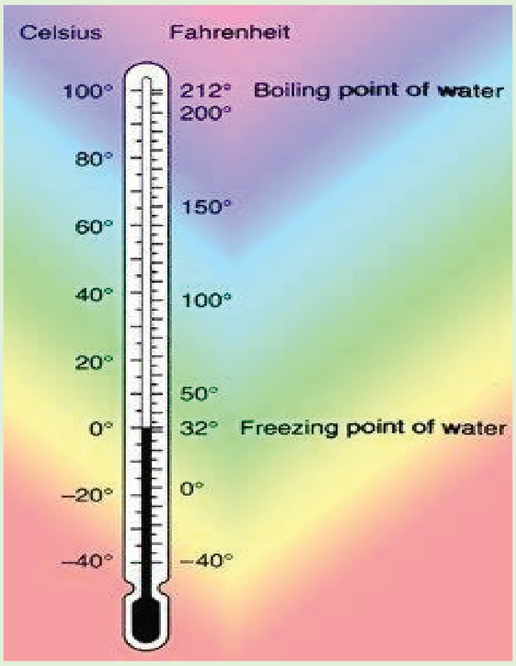
Have you ever noticed that when you visit a medical centre because you are not feeling well, the doctor gets a small instrument and places it in your mouth or under your armpits then removes it after a while and takes the reading? Have you ever wondered why? This is because he wants to measure the temperature of your body. In this chapter, you will understand how temperature is measured.

Measuring temperature

What is temperature? How good are you at estimating temperature? Here are some clues to help you.

- A comfortable temperature for working is 25 °C.
- A cold morning is about 19 °C to 21 °C.
- A hot day is about 29 °C.

All these temperatures are in degrees Celsius (°C) but sometimes in Fahrenheit (°F). This temperature scale is based on the freezing and boiling points of water. The temperature that water froze at was called 0 °C (32F) and the boiling temperature of water was called 100 °C (212 °F) at sea level.



From the above illustrations, it can be seen that the temperature of a body depends on the scale used. Hence temperature is the **degree of hotness on a chosen scale.**

Temperature is a measure of the average kinetic energy of the particles in a sample of matter. The kinetic energy (the energy a body has due to its motion) of each atom of the body will influence how hot the body will be. If individual atoms or molecules of a body have high kinetic energy, then the body will have a high temperature, and vice versa.

Measurement of temperature is done using a thermometer. It is expressed in terms of units or degrees; for example, Kelvin (K) or degrees Celsius (^{0}C).

Activity 5.1: Measuring temperature of the environment

Key question
How hot is it at various places around the school?

What you need
- A thermometer

What to do
Estimate the temperature at different places around the school: some inside, some outside in the sun and some outside in the shade. Then measure the temperature in these places with a thermometer. Do not forget to record your results in a table like the one below.

Place	***Temperature(^{o}C)***	
	Estimated	***Actual***
Classroom		
Under tree		
Laboratory		

You should have tables with all your estimates and all your measurements. Did you find that you got better at estimating as you worked through the activities?

Assignment
Listen to the weather forecast or check for the forecast in a newspaper. What is the temperature of the hottest and coldest parts in Uganda for the day recorded?

Thermometers

A thermometer is an instrument for measuring and indicating temperature. Types of thermometer include liquid thermometer, gas thermometer, magnetic thermometer and many others.

Thermometric Property
The thermometer makes use of a physical property of a thermometric substance which changes continuously and measurably with temperature. The physical property is referred to as thermometric property.

Examples of Thermometric Properties

Thermometric Property	*Type of Thermometer*
Volume expansion of a gas	Gas thermometer
Volume expansion of a liquid	Laboratory or clinical thermometer
Volume expansion of a solid	Bi-metallic strip thermometer
Wave length changes	Pyrometer
Pressure change of a fixed mass of gas	Constant – volume gas thermometer

How a Liquid-in-glass Thermometer Works

A liquid thermometer consists of a tube with a bulb and a narrow capillary or bore. When the thermometer is put in a warm or hot substance, the liquid in the bulb expands forcing its way past the constriction to a length that corresponds with the temperature of the substance.

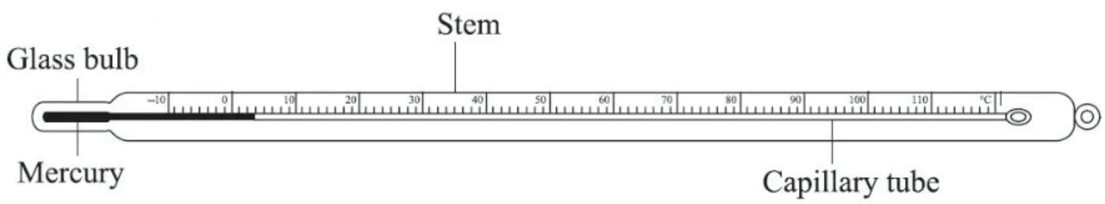


Figure 5.1: A laboratory thermometer

Bulb: It stores the liquid used in calculating temperature readings. The bulb is made of thin wall of glass or stainless steel to enable quick transmission of heat between the thermometric liquid and body.

Bore: It gives the liquid a route of travel as it expands and contracts. It is very narrow so it makes the thermometer more sensitive and accurate.

Stem: This surrounds the bore and the liquid in the thermometer. It is also a magnifying glass to enable easy reading of temperature.

Expansion Chamber: This provides space where gases and air inside the capillary collect as mercury rises. Gases compress inside the expansion chamber until the mercury flows back into the bulb as temperatures fall.

Please Note

A thermometer is said to be sensitive if it can record a very small temperature change. The sensitivity of the thermometer can be increased by using a large bulb and a narrow capillary tube.

Clinical Thermometer

This is the thermometer doctors and nurses normally use in the hospitals to measure the temperature of the human body.

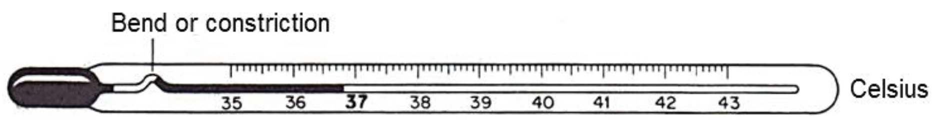


Figure 5.2: Clinical thermometer

These thermometers are suitable for measuring body temperature because:

a. mercury which is used as the liquid is very sensitive to temperature changes.

b. scale is limited between 35 ^{0}C to 43 ^{0}C, the only range needed for medical purposes.

c. There is a constriction or bend which breaks the mercury column and prevents its backflow. This allows enough time for a reading to be taken.

For your study: Based on the features of the clinical thermometer, suggest best practices of the proper handling of a clinical thermometer.

Temperature Scales

Temperature scales provide a way of measuring and putting a quantity on how hot or cold a material is.

There are four major temperature scales that are used around the world:

a. Celsius

b. Kelvin

c.Fahrenheit

Fahrenheit and Celsius are frequently used in everyday life in the home, while the Kelvin scale is more commonly used in industries.

(a) Celsius scale

Temperature is measured in a unit of degrees Celsius. The Celsius scale ranges from 0 ^{0}C which is the freezing point of pure water to 100 ^{0}C which is the boiling point of pure water. The interval between these two points is divided into 100 equal parts to which each part represents a change of 1 ^{0}C.

(b) Kelvin scale

This is the scale used in the SI and has all the temperature measured being positive. In the Kelvin or absolute scale, the freezing point of water is 273 K and the boiling point of water is 373 K. The Kelvin (K) is the SI unit of temperature.

Relationship between Celsius Scale and Kelvin Scale

Since 0 ^{0}C corresponds with 273 K, and 100 ^{0}C is equivalent to 373 K when converting from the degrees Celsius to degrees Kelvin, a value of 273 ^{0}C is added to the temperature; and when converting temperature from Kelvin scale to Celsius, a value of 273 ^{0}C is subtracted from the temperature.

Examples

1. Convert 500 K temperature reading to Celsius scale.

Solution

To convert from Celsius to Kelvin's, we add the given degree to 273 K.

Implying $T = \theta + 273$

Therefore, to get the Celsius reading we subtract 273 from the Kelvin reading:

$\theta = T - 273$

Therefore, for 500 K,

$\theta = 500 - 273$

$= 227\ ^0C$

2. Convert 30 ⊠C temperature reading to Kelvin scale.

Solution

To convert from Celsius to kelvins, add the given degree to 273 K.

Exercise 5(a):	(a) Convert the following temperature readings to Celsius scale: (i) 1000 K (ii) 234 K (iii) 100 K (iv) 783 K (b) Convert the following temperature readings to Kelvin scale: (i) 40 ^{0}C (ii) 68 ^{0}C (iii) 34 ^{0}C (iv) 25 ^{0}C

Fixed Points on a Thermometer

A fixed point is a well-defined temperature which can be used as a reference point in measuring other values of temperature.

Lower fixed point: This is the temperature of pure melting ice at standard atmospheric pressure. It is determined by inserting bulb of a thermometer in melting ice and noting the temperature that remains constant.

Upper fixed point: This is the temperature of steam from pure water boiling under standard atmospheric pressure. It is determined by holding a bulb of a thermometer in steam over boiling water and noting the temperature that remains constant.

Activity 5(a): Verifying accuracy of the lower fixed point

	*What you need:*	• Cracked ice and a beaker or saucepan • A thermometer
	Caution:	Thermometer is fragile. Handle it carefully.

Procedure (steps):

(a) Fill a beaker with cracked ice as shown in **Figure 5.3**. After the water begins forming from melting ice, place the bulb end of the thermometer well into the ice but leave the lower fixed point on the scale uncovered so that you can still read it.

Figure 5.3: Determining the lower fixed point on a thermometer

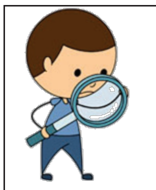
a. Gently stir for five minutes. What do you observe?
b. Read and record this observed temperature of the melting point in data table.
c. Repeat the entire procedure for a second and third trial, recording all results in a table.

Results

1st trial	*2nd trial*	*3rd trial*	*Average*

Please Note	When determining the upper or lower fixed point on a thermometer, water used must be pure because the presence of impurities lowers melting point of ice and elevates (increases) the boiling point of water

Activity 5(b): Verifying accuracy of the upper fixed point



What you need:	• Beaker or saucepan, thermometer and water • Bunsen burner/charcoal stove.
Caution:	**Use gloves or cloth to avoid burns and scalds.**

Procedure (steps)*:*

a) Pour water in the beaker until it is half full. Put the beaker over a heat source as shown in **Figure 5.4** and boil the water for some time.

b) When the water begins to boil vigorously, write down what you observe about the mercury level in the thermometer?

c) Remove the thermometer from the water and hold it in the steam.

d) Read and record this observed temperature of the boiling point in the data table below.

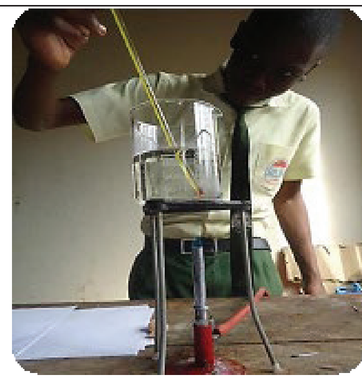


Figure 5.4

Take two readings and in each case record your values in the table below.

Results:

1st trial	*2nd trial*	*3rd trial*	*Average*

Questions:

a) Are all three values in the three trials the same?

b) Is the upper fixed point of the thermometer accurate? If not, give a possible explanation for the difference.

Calibration of the Thermometer

Calibration refers to the process of determining, checking or rectifying the graduation of an instrument giving quantitative measurements. Proper calibration of an instrument allows scientists to take and produce accurate and useful information, and make measurements to ensure safety.

The following steps are taken to calibrate a thermometer:

a) Determine the lower fixed point of the thermometer by inserting bulb of a thermometer in melting ice and noting the temperature that remains constant. Mark the point on the thermometer.

b) Determine the upper fixed point by holding bulb of a thermometer in steam over boiling water and noting the temperature that remains constant.

Mark the point on the thermometer

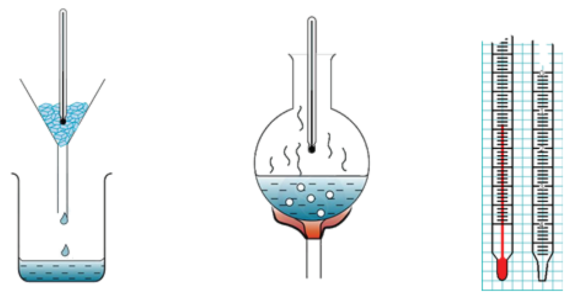


Figure 5.5: Calibration of the thermometer

Freezing point of water (0 ^{0}C) Boiling point of water (100 ^{0}C)

Make 100 divisions

(c) Divide the difference between the two points into 100 equal points. Mark the points as a scale along the stem either in Celsius scale or Kelvin or both.

Determine any temperature, θ by calculation using;

$$\theta = \left(\frac{L_\theta - L_o}{L_{100} - L_o} \right) x 100^o C$$

L_θ = length of the liquid column at temperature θ;
L_o = length of the liquid column at lower fixed point;
L_{100}= length of the liquid column at upper fixed point.

Example

A mercury thermometer is calibrated by immersing it in melting pure ice and then in boiling pure water. If the mercury columns are 6 cm and 16 cm respectively, find the temperature when the mercury column is 8 cm long.

Solution

l_o = 6 cm,
l_{100} = 16 cm
l_θ = 8 cm
θ = ?

$$\theta = \frac{l_\theta - l_0}{l_{100} - l_0} x100 = \frac{8-6}{16-6} X\ 100 = \frac{2}{10} X\ 100 = 20\ ^0C$$

Activity 5(c): Calibrating an unmarked thermometer

What you need	• Unmarked liquid-in-glass thermometer (or scale covered with masking tape) • Half metre-rule, beaker, ice and water • Source of heat
Caution:	**Use gloves or cloth to avoid burns and scalds.**

- Unmarked liquid-in-glass thermometer (or scale covered with masking tape)
- Half metre-rule, beaker, ice and water
- Source of heat

Use gloves or cloth to avoid burns and scalds.

Results:

	Height of liquid column (cm)
Lower fixed point (L_0)	
Upper fixed point (L_{100})	
Your body temperature (L_θ)	

Questions:

a) Calculate the temperature of your body.
b) Comment on the accuracy of your answer in (a) above.

Procedure (steps)

1. Put the unmarked thermometer in melting ice as shown in **Figure 5.6**.
2. Measure and record the height of level of the liquid column from the bottom of thermometer at 0 °C as L0.
3. Put the thermometer in boiling water as shown.
4. Mark the height of level of the liquid column from the bottom of thermometer at 100 °C as L100.
5. Measure your body temperature using the unmarked thermometer by recording the length of the liquid column at the temperature to be measure as Lq.

Figure 5.6: Calibration of a thermometer

	Height of liquid column (cm)
Lower fixed point (L_0)	
Upper fixed point (L_{100})	
Your body temperature (L_θ)	

Questions:

a) Calculate the temperature of your body.
b) Comment on the accuracy of your answer in (a) above.

Exercise 5(b)	The length of mercury column of a thermometer at ice point and steam point are 2.0 cm and 22.0 cm respectively. The reading of the thermometer when the mercury column is 9.0 cm long is?

Thermometric Liquids

Properties of substances that vary uniformly with temperature are exploited in the creation of thermometers. A thermometric liquid is a liquid that has thermal properties that make it suitable for use in a thermometer. An example is a large and uniform thermal expansion with increase in temperature.

Reasons why mercury is usually preferred to the alcohol as a thermometric liquid

- It is a better conductor of heat than alcohol; and therefore, responds more readily to changes in temperature.
- It is opaque and makes reading easy.
- It expands regularly.
- It has a high boiling point, 357 °C whereas alcohol has low boiling point, 78 °C, can easily vapourise at the surface.

Advantages of alcohol over mercury as a thermometric liquid

- It expands much more for a small temperature change due to the higher expansivity than that of mercury.
- It has a lower freezing point than mercury, i.e., it freezes at -115 ^{0}C; and is therefore, suitable for measuring very low temperatures (mercury freezes at -39 ^{0}C)

Disadvantages of alcohol as a thermometric liquid

- It is colourless and needs colouring
- It is a poor conductor.
- It has a somewhat irregular expansion.
- Has a low boiling point; and therefore, cannot be used to measure high temperature.

Assignment
Suggest reasons why water is never used as a thermometric liquid although it is fairly abundant.

Variations in Daily and Atmospheric Temperature

Have you ever wondered why it is normally colder at night than during the day? The difference between the temperature of the day and at night is called **diurnal change** in temperature.

The change in temperature from day to night is brought about by the daily rotation of the Earth. The earth receives heat during the day by solar radiation, but continually loses heat by surface radiation. Warming and cooling depend on an imbalance of solar and surface radiation. During the day solar radiation exceeds surface radiation and the surface becomes warmer. At night, solar radiation ceases, but surface radiation continues and cools the surface. Cooling continues after sunrise until solar radiation again exceeds terrestrial radiation. Minimum temperature usually occurs after sunrise, sometimes as much as one hour after. The continued cooling after sunrise is one reason that fog sometimes forms shortly after the sun is above the horizon.

Atmospheric temperature is a measure of temperature at different levels of the earth's atmosphere. It is governed by many factors, including incoming solar radiation, humidity and altitude.

The amount of solar energy received by any region varies with time of day with seasons and with latitude. These differences in solar energy create temperature variations. Temperatures also vary with differences in relief and with altitude.

The amount of ground-level atmospheric temperature ranges depends on several factors, such as:

- The average temperature
- The average humidity
- The regime of winds
- The proximity to large bodies of water, such as the sea

It is hotter near the earth's surface because heat from the earth warms this air. As the altitude increases the number of air molecules decreases, thus the average of their kinetic energy decreases. However, temperature increases with altitude above a certain height because of increasing amounts of ozone.

Activity of Integration

The daily activities at your school are being affected by weather variation, especially temperature. As a science student, prepare a temperature chart and a message about how the chart will be useful. This chart will help the school to run smoothly.

Chapter Summary

In this chapter, you have leant:

- the difference between heat and temperature.
- how temperature scales are established.
- the conversion of temperature scales.
- the qualities of mercury, alcohol and water as thermometric liquids.
- the construction of a clinical thermometer.
- the causes and effects of the daily variation in atmospheric. temperature

Chapter 6: Diversity of Living Things

Key Words	By the end of this chapter, you will be able to:
• life processes • classification • the cell • taxonomy • levels of organization • monera • protoctista • arthropoda	a) *know the processes that are characteristic of all living things and their importance.* b) *know the parts and functions of typical animal and plant cells.* c) *understand the levels of cellular organisation in multi-cellular organisms.* d) *know the seven levels of taxonomy.* e) *understand the two-word naming system of living organisms.* f) *know characteristics of organisms in the following categories of living things: monera, protoctista, fungi, plantae, arthropoda, chordata and viruses.* g) *analyse the uses and harmful effects of organisms in kingdom monera and fungi.* h) *know the main characteristics of insects and understand the lifecycles of a housefly, cockroach, mosquito, bee and butterfly.* i) *appreciate the useful and harmful aspects of a housefly, cockroach, mosquito, bee and butterfly and devise methods of controlling them.*

Introduction

In the world today there are millions of different types of organisms that exist both in water, air and on land. These organisms have been grouped according to their external characteristics and how close they are to one another. This process is called **classification**. This chapter, therefore, will help you identify, appreciate and group/classify the different animals and plants and become familiar with their importance.

Characteristics of Living Things

These are life processes common to all living things. They feed (nutrition), take in and use air (respiration), produce and remove waste (excretion), grow and develop (growth), move (movement), produce young ones (reproduce) and respond to changes in their environment (sensitivity). Each life process has particular functions that are important to living things for their survival.

Activity 6.1: Identifying life processes

Key question

Can you tell a life process from the pictures below?

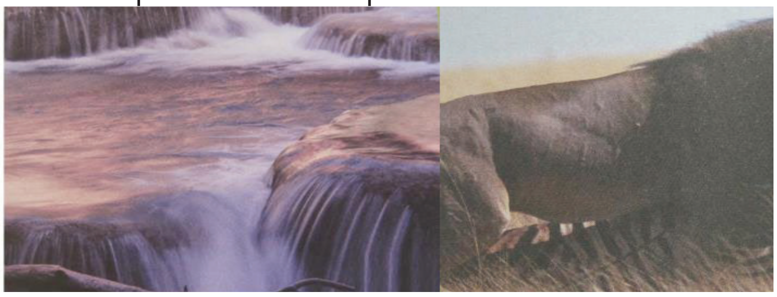


Figure 6.1 (a) A water fall; Fig 6.1(b) a lion eating a zebra

What to do:

Observe the pictures in **Figures 1.1(a)** and **(b)** above.

i) Which of them is a life process and why?

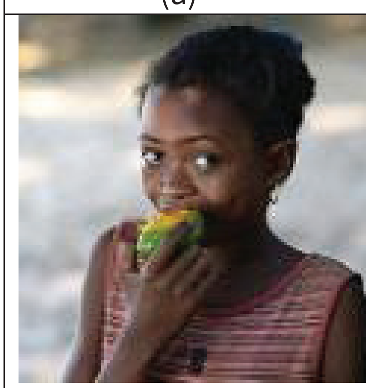
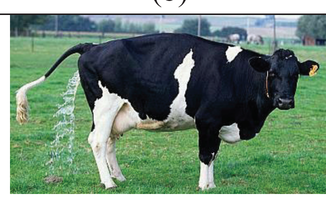
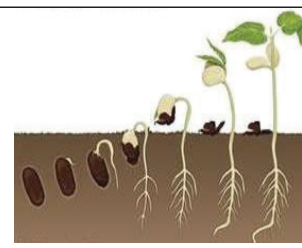
ii) Which of them is not a life process and why?

Activity 6.2: Finding out life processes and their importance

Key question
Can you tell a life process?

What you need
- Pictures of living things involved in life processes

What you do
The pictures below show living things involved in life processes.
i) In pairs, study the pictures carefully.
ii) Identify the life process shown in each picture and state its importance to the living organism, and fill the answers in table provided below the pictures.

 (a)	 (b)	 (c)
 (d)	 (e)	 (f)

Life process	Importance to living organism
(a)	

Differentiating between Animals and Plants

As you have seen, both plants and animals are living things and have common characteristics. However, some of the characteristics in plants and animals are carried out in different ways.

Activity 6.3: Finding out differences between plants and animals

Question: What are the characteristic differences between plants and animals?

What you need

- A plant in a pot or any standing live plant.
- A small animal, e.g. a grasshopper/cockroach in a glass container.

What to do

In groups of five, discuss the differences in characteristics of plants and animals.
Fill in the table below, indicating clearly the differences in characteristics between plants and animals.

Characteristics	**Plant**	**Animal**
Feeding		
Growth		
Movement		
Excretion		
Structure		
Irritability		

Cells

It is believed that the world has millions of organisms living in it, ranging from those composed of one cell (single-celled) such as bacteria to those with millions of cells (multi-celullar) such as humans. Scientists have also discovered that all these living things are composed of the same basic units. The basic unit of all living things is the **cell**. Imagine the bricks that make up a house. Each cell is like a brick on a house.

Examples of cells are shown below

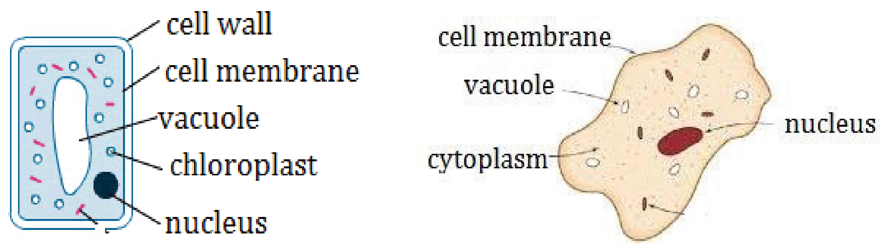


Figure 6.2: (a) plant cell ***(b) animal cell***

Functions of the Different Parts of a Plant Cell

Cell wall: contains cellulose to provide support needed by the plant cell.
Cell nucleus: controls all the processes in the cell.
Cell membrane: controls the flow of substances in and out of the cell.
Cell vacuole: filled with cell sap.

Functions of the Different Parts of an Animal Cell

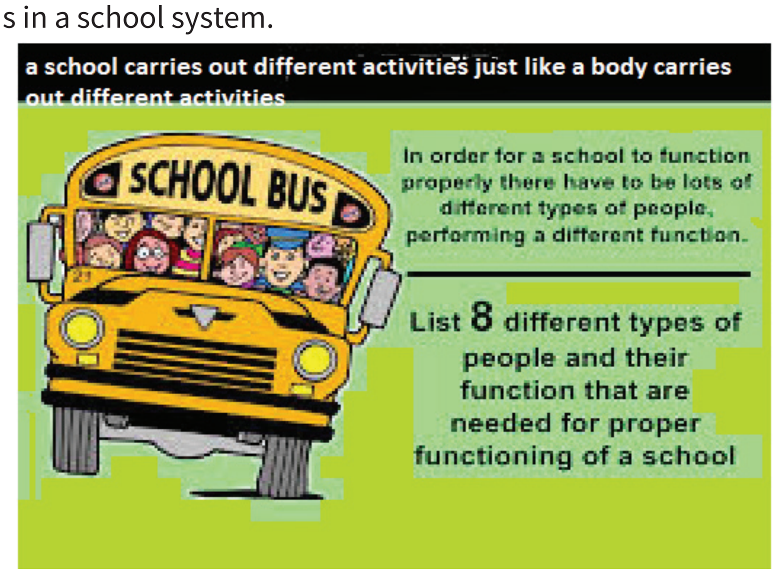
Cell membranes: surround the cell and control what goes in or comes out.
Cytoplasm: contains the chemicals of life in the cell.
Vacuole: act as storage areas in the cell that contain air, water, wastes and food particles.

Question:

Now that you have seen the parts of both the plant and the animal cell, can you state the differences between them?

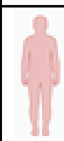
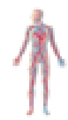
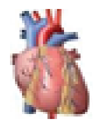
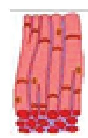
Groups of Cells (Levels of Organisation)

People in a group can perform more complex tasks than one person. Consider what happens in a school system.



Like people, similar cells in our bodies are organized in groups to make them work more effectively.

A group of **similar cells** performing a particular function is a **tissue**, e.g. muscle tissue.
A group of **different tissues** form an **organ** to perform a particular function, e.g. heart.
A group of **different organs** form an **organ system** to perform a particular function, e.g. circulatory system.
A group of **different organ systems** form an **organism**, e.g**.** a human.

Level of cell organisation	Description	Example
Organism	*A group of* ***different organ systems*** *form an* ***organism.***	 Human
System	*A group of* ***different organs*** *form an* ***organ system*** *to perform a particular function e.g. circulatory system.*	 Circulatory system
Organ	*A group of* ***different tissues*** *form an* ***organ*** *to perform a particular function.*	 The heart
Tissue	*A group of* ***similar cells*** *performing a particular function is a* ***TISSUE.***	 Muscle tissue
Cell	*The basic unit of a living thing.*	Muscle cell

Classification Systems

When you are given a large and varied group of things to organise, the first thing to do is to try and sort them out into smaller or simpler groups by looking at their similarities and differences. You would actually put them into groups or classes. This is called **classification**, e.g. in the school library books are sorted and arranged according to subjects, authors or educational levels. In the same way scientists have grouped organisms. This helps them to identify organisms easily, and understand how these organisms relate with one another.

The modern System of Classification

Today, organisms are grouped into units called taxa, starting from the largest taxa called the kingdom. The table below shows the taxonomic units for humans.

Taxonomic units	Man
Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Primate
Family	Hominidae
Genus	*Homo*
Species	*Sapeins*

Naming of Living Things

In 1735, Linneaus developed the binominal system of naming organisms where each organism is given two names. These names are called scientific names.

Rules followed when naming and writing scientific names

1. First name is the name of the genus to which the organism belongs and is written beginning with a capital letter.
2. The second name is the name of the species to which the organism belongs and is written beginning with a small letter.

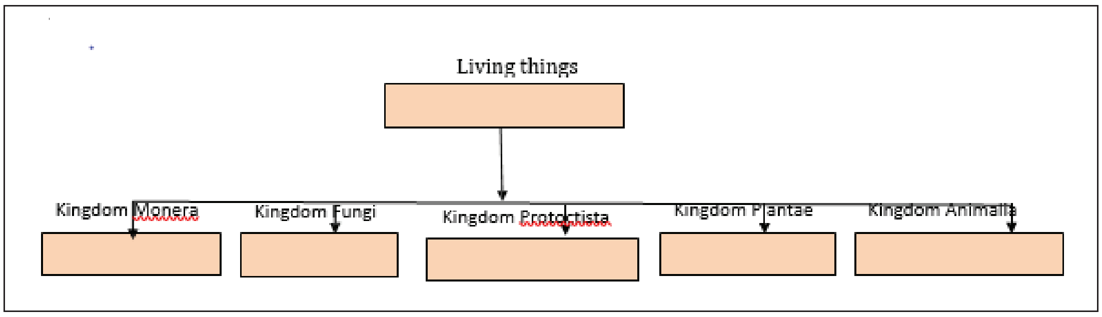
The two names are separately underlined if hand written and in italics when printed, e.g. for human the scientific name would be ***Homo sapiens.***

Key points to note

- Organisms are classified into seven different groups from the largest to the smallest group, i.e. kingdom, phylum, class, order, family, genus and species.
- Each organism has a scientific name developed from the genus and species it belongs to.

Classification of Living Things

Originally, living organisms were grouped into two main kingdoms known as the two kingdom system. However, with the current discoveries of differences and similarities in these organisms, a new system was developed known as the five kingdom system as illustrated below.



Kingdom Monera

General characteristics

- They are single-celled organisms.
- They do not have a true nucleus.
- They have no nuclear membranes.

- They have thin cell membranes composed of a protective cell wall.
- They are tiny organisms only visible under the microscope.
- They mainly undergo asexual reproduction through multiple fusion although on a few occasions they may reproduce sexually by conjugation.

Figure 6.3: Monera

Useful and Harmful Aspects of Monera

1. Bacteria cause diseases in humans and animals like tuberculosis, cholera, pneumonia, anthrax.
2. Bacteria cause food spoilage leading to food poisoning.
3. Bacteria help in the process of decomposition by breaking up organic wastes.
4. Bacteria add soil fertility by fixing nitrogen to nitrates.
5. Some bacteria are used in treatment of sewage.

Protoctista

This kingdom is divided into two sub-kingdoms i.e. protozoa and green algae. Examples of protozoa include euglena, amoeba trypanosome and paramecium. Example of algae is the green algae commonly found growing on the surface of ponds, lakes and slow moving spring.

Characteristics of Organisms in Kingdom Protoctista

- They are single-celled organisms.
- They have a distinct nucleus.
- They reproduce by binary or multiple fission.
- They have varied methods of feeding i.e. others make their food through photosynthesis; others capture their food (phagocytes); others decompose their food, and others switch from being heterotrophs to autotrophs.

Fungi

Fungi occupy varied habitats. They include: toadstools, moulds, mushrooms, yeast and bracket fungus.

Figure 6.4: Fungi

Characteristics of organisms in this kingdom include:

- They have nucleus membrane.
- They lack chlorophyll and so do not make their own food. They feed on decaying living things.
- Their cell walls are made of chitin but not glucose.

Uses of Fungi

- They help in the formation of manure since they cause the decay of dead organisms.
- They are used in the baking industry to raise the dough.
- They are used in the drug industries to produce antibiotics, e.g. penicillin.
- They are a source of food, e.g. mushrooms.

Project work: Making yoghurt

Make research about the process of making yoghurt. Identify and collect the resources required. Explain the scientific reasoning behind the process as you carry out this project.

Harmful Effects of Fungi

i) They cause plant and animal disease, e.g. potato blight in potatoes, ringworms and athletes foot on humans.
ii) ii) They cause rotting and spoilage of food, e.g. fungal growth on bread, cakes, and fruits.
iii) They grow on wooden surfaces, causing them to rot and decay.

Kingdom Plantae

Plants include trees, bushes, ferns, mosses, weeds and grasses. Their cells contain a green pigment known as chlorophyll that traps sunlight which the plant uses to make its own food (photosynthesis). They are multicellular and their cells have a nucleus and a cell wall made up of substance known as **cellulose.**

Figure 6.5: Kingdom plantae

Activity 6.4: Finding out the features of plants

What are the characteristic features of the following plant species?

What you need

Mosses, fern and mango seedling; hand lens, clean slides, cover slip and microscope.

What to do

1. In groups of six, collect specimens of mosses, ferns and mango seedling.
2. Examine your specimens, draw and name their pants.
3. State the major characteristic that differentiates each of the above from the others.
4. Fill in the table below to show the divisions in which each of the specimens belongs.

Plant species	**Characteristic features**	**division**		
Mango				
fern				
mosses				

General Characteristics of Organisms in the Plant Kingdom

i) They have cell walls that have cellulose.
ii) They make their food through the process of photosynthesis.

Phyllum Arthropoda

These organisms belong to the animal kingdom. They derive their name from two Greek words, arthro - joint and pods - foot. The arthropods are divided into five main classes, namely: diplopoda, chilopoda, insecta, crustacea, arachinida. Some arthropods are shown below. Can you identify them?

Figure 6.6: Some arthropods

General Characteristics of Arthropods

- They have segmented bodies.
- They have an exoskeleton.
- Their bodies are divided into three equal parts: the head, thorax and abdomen.
- They have jointed limbs.
- They use spiracles for gaseous exchange.
- They have separated sexes.
- They have a complete digestive system from mouth to anus.

Activity 6.5: Finding out the features of arthropods

What are the main observable features/characteristics that can be used to group arthropods into their respective classes?

What you need

Photographs or specimens or different arthropods

What to do

Examine the specimens provided, look at their external features and note the similarities and differences.

Using the above differences and similarities, group your organisms into classes. Present your work in the table below.

Name of the organism	External features identified	Class to which it belongs

Class Insecta

This class is the largest class of arthropods. It includes all insects like cockroaches, houseflies, grasshopers and butterflies.

Figure 6.7: Some insects

Characteristic of insects

Activity 6.6: Finding out the main characteristics of insects

What you need

Any of the following insects: cockroach, butterfly, housefly or butterfly.

What to do

In groups of four, examine the specimens provided. Look at their external features.

1. What do you see?
2. How is that insect adapted to its environment?
3. Does this organism qualify to be called an insect? Give reasons for your answer.
4. List down the characteristics of insects.

Growth and Development in Insects

Insects undergo gradual change during their growth and development from simple egg through different stages till adulthood. This process is known as metamorphosis. Metamorphosis can be complete or incomplete.

Complete Metamorphosis

In a complete metamorphosis, the insect goes through four stages of development i.e. **eggs** which then develop into **larva** then **pupa** and finally **adult.** Examples of insects that undergo complete metamorphosis include mosquitoes, housefly and butterfly and beetle.

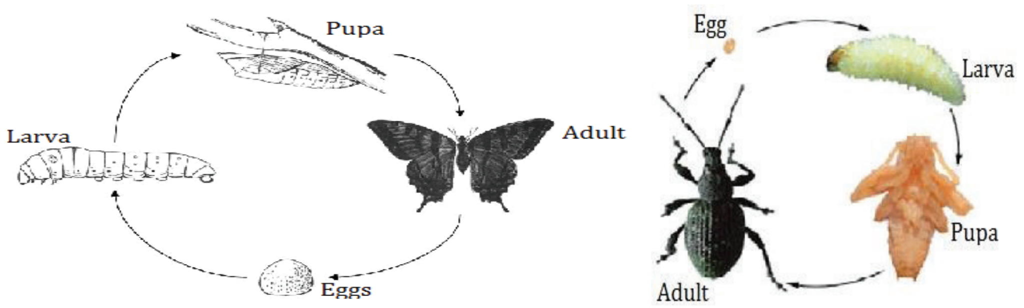


Figure 6.8: Complete metamorphosis of a butterfly and beetle

Incomplete Metamorphosis

In an incomplete metamorphosis, the insect goes through three stages of development i.e. **eggs** which then develop into **nymph** and finally **adult.** Examples of insects that undergo complete metamorphosis include grasshoppers, locusts and cockroaches.

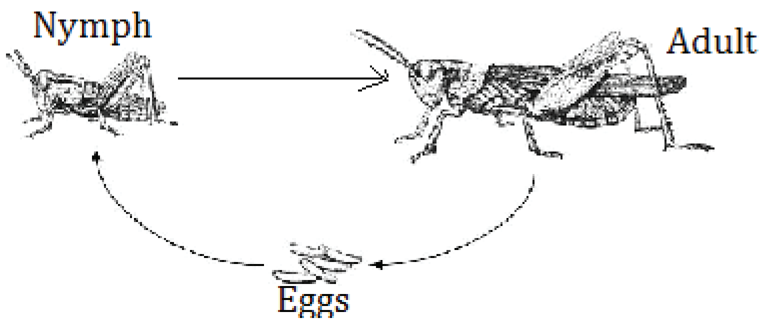


Figure 6.9: Incomplete metamorphosis of a grasshopper

Economic Importance of Insects

Activity 6.7 Describing importance of insects

Look at the pictures below of some insects:

What to do

a) In groups of four, discuss the usefulness and harmfulness of each of the insects shown in the picture above.
b) What methods can you use to control the harmfulness of insects?
c) Write down what you have discussed and choose one member of your group to present your findings to the class.

Activity of Integration

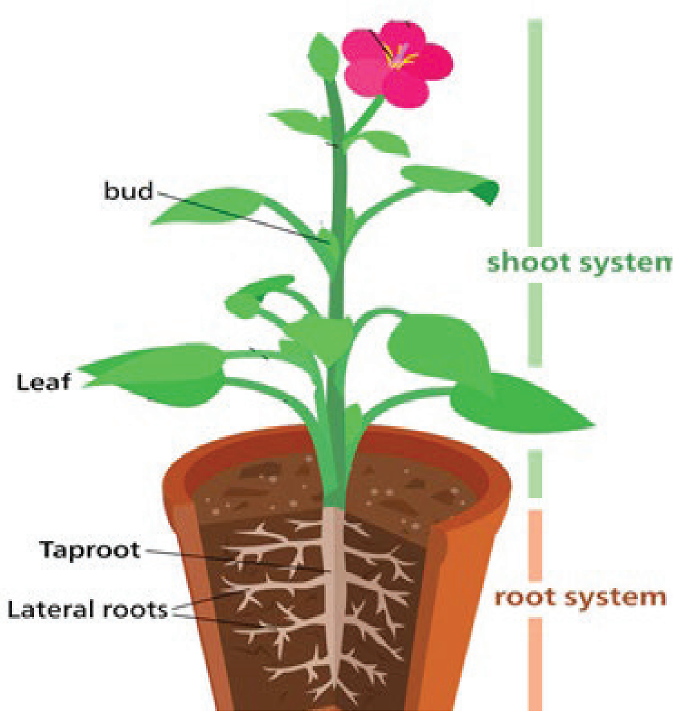
Acertain community has observed a strange animal that partly leaves on land and in water. The organism is hostile to both humans and their livestock. To control the animal, one needs to understand its characteristics and classify it. As a student of science, you are asked to prepare a message that will help the community to classify this animal in order to control it since it is causing discomfort to the community.

Chapter Summary

In this chapter, you have learnt:

- that plants and animals have similar life processes, though they occur differently.
- that cells are the basic units of living things.
- that there are different levels of taxonomy.
- the binary system of classification of organisms.
- the main characteristics, usefulness and importance of the organisms in the different kingdoms.
- the main characteristics, usefulness and importance of the organisms in phylum arthropoda.

Chapter 7: Plant Structure

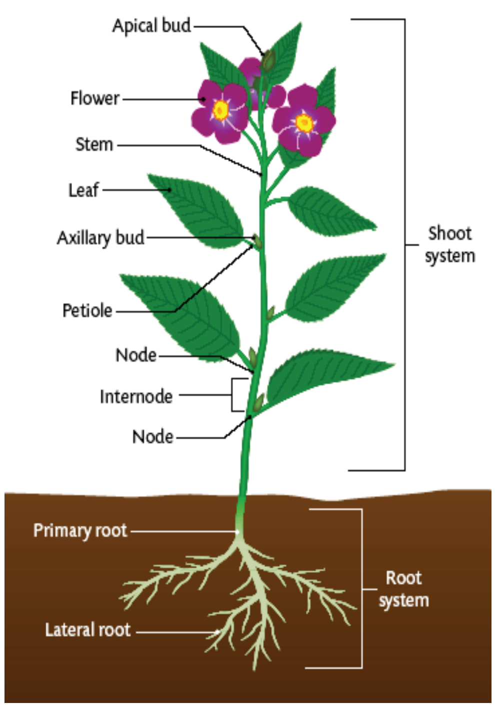


Key Words	***By the end of this chapter, you will be able to:***
▪ root system ▪ shoot system ▪ cotyledon ▪ modified stem ▪ modified roots ▪ modified leaf	*a) know the external parts of a typical flowering plant .* *b) know the functions of a root, stem, leaf, flower and fruit to a plant.* *c) understand the various ways by which different plant parts are used by the society.* *d) understand that there are modified roots, stems and leaves, and identify their functions to both the plant and society.*

Introduction

In Chapter 6, you learnt about the plant kingdom. The flowering plants are the most numerous of all the divisions in the plant kingdom. The world comprises a variety of flowering plants (angiosperms), totalling to about 250,000 species. Many tropical species may not yet be named.

When you look at a plant with the idea of identifying it, it is helpful to resolve this question first: "Is this a monocot or a dicot?" This would not be difficult for you to make out if you are familiar with structures of plants!



Flowering plants are characterized by a root system and a shoot system. The root system absorbs water and nutrients from the soil. The shoot system is composed of the stem, leaves, and flowers. This system allows the plant to obtain food and to reproduce. Both the root system and shoot system work together to enable flowering plants to survive on land. Both the root and shoot system can be used as food for human consumption.

Figure 7.1: A typical flowering plant

General Structure of the Flowering Plant

Flowering plants are either monocotyledons or dicotyledons. How do you distinguish between them?

Activity 7.1: Differentiating between monocotyledonous and dicotyledonous plants

What you need

Bean and maize plants

What to do

Examine your specimens by looking at the following: arrangement of flowers and flower parts, size/shape of leaves, venation of leaves. Present your work in the table below.

	Dicotyledons	Monocotyledons
Arrangement of flowers		
Size of leaves		
Leaf venation		
Arrangement of vascular bundles		

Activity 7.2: Exploring parts of a plant

In this activity, you will explore parts of a plant that are used as food in your community. Choose a partner to work with. For each of the plant parts listed below, state whether the parts used as food are fruits, leaves, stems or roots.

Cabbage, sugar cane, Irish potato, carrot, spinach, onion, cassava, sweet potato, yam

Roots

The roots of a flowering plant are very important. The general root structure comprises the main roots, root hairs and root cap. The key function of all roots is to anchor the plant as well as absorb nutrients and water from the soil.

Activity 7.3: Plant roots

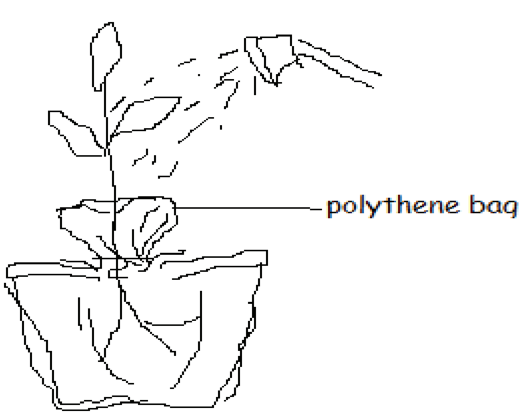
Do plant roots take in water?

What you need

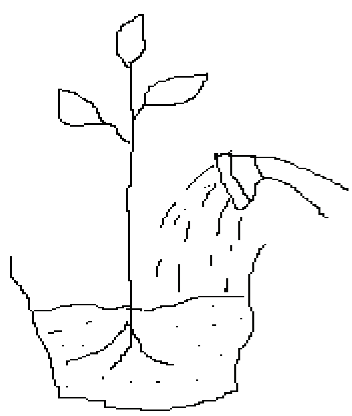
- two potted plants
- a plastic bag
- a piece of string
- water

What to do

1. Make sure that the plants are about the same size. Before the activity starts leave both plants without water for three days so that the soil in both pots is dry.
2. Put the pot of one plant in the plastic bag and tie the neck around the bottom of the stem with a string. Water the leaves and stem of this plant each day.
3. Leave the other plant uncovered. Pour the same amount of water in the soil of this second plant.



(a) water the leaves of the plant


(b) water the roots of the plant

What do you conclude? Watch the plants and record what happens. How are the roots important to the plant?

Types of Root Systems

1. *Fibrous roots* are roots which have no clearly defined main root. They are slender, of the same size and all grow from the base of the stem.
2. *Taproots* are roots that are larger and longer than the rest. Taproots grow straight down, some as deep as 15 feet. Taproots develop from the initial root that emerges from the seed.
3. *Adventitious roots* are roots of some plants that originate above ground from stems or leaves.

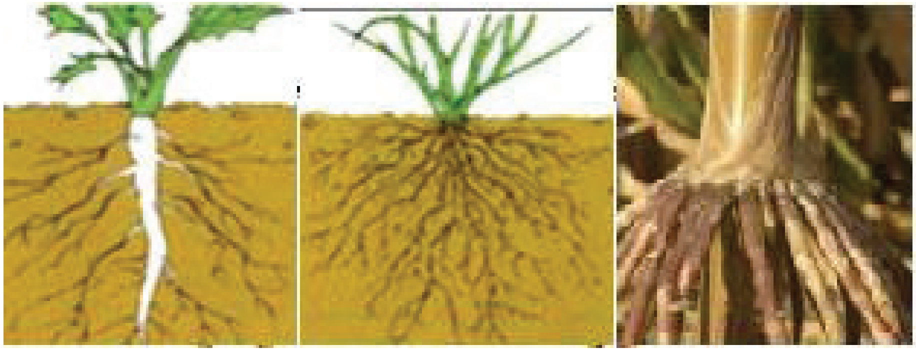


Figure 7.2: Root types

Transverse sections of roots of monocots and dicots are shown below.

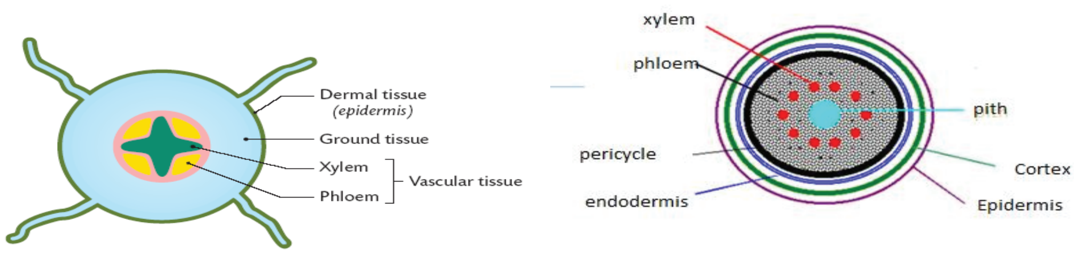


Figure 7.3: (a) A typical dicot root ***(b) A typical monocot root***

Can you notice any differences in the transverse structures of the two types of roots above?

Functions of the Root Parts

Each part of a root has a particular function. To identify the functions, do the activity below.

Activity 7.4: Identifying functions of parts of a root

In the table below, match the part of the root with its function:

Part	Function
Epidermis	supporting the root
root hair	transporting water and minerals
Cortex	absorbing water
Xylem	transporting food
phloem	absorbing water

Modifications of Roots

Different roots are modified to suit specific functions in addition to supporting the plant and absorbing water and minerals. The change in the structure of the roots is an adaptation to their surrounding environment. Many roots are modified into different forms to perform specific plant functions.

Activity 7.5 Describing specialised roots

For each of the specialized roots shown in the diagram below, state the function for which the roots are modified.

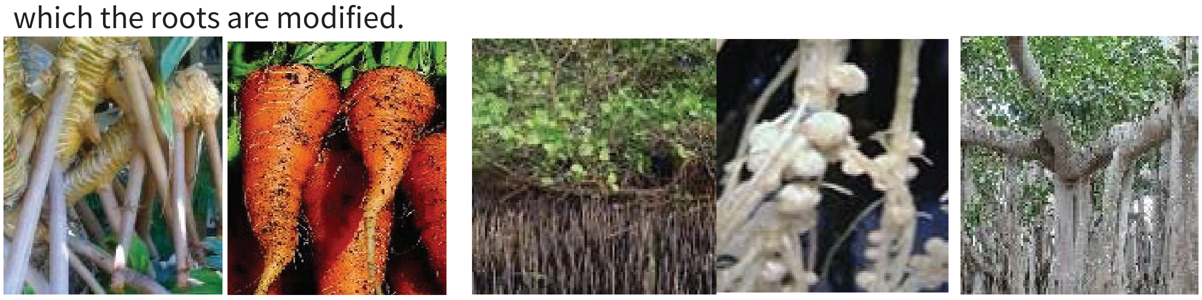
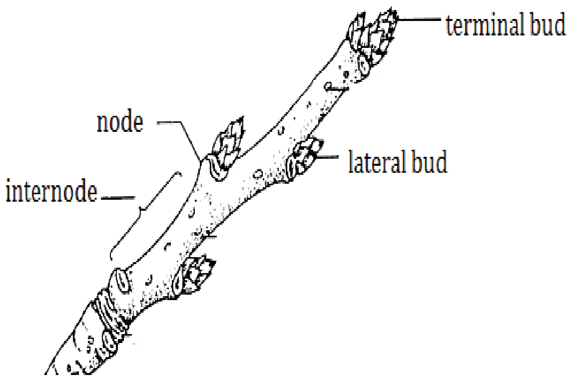


Figure 7.4: Types of specialised roots

Stems

The stem is part of the plant that is between roots and leaves. Some stems are long and large while others are small and short like in cabbage.



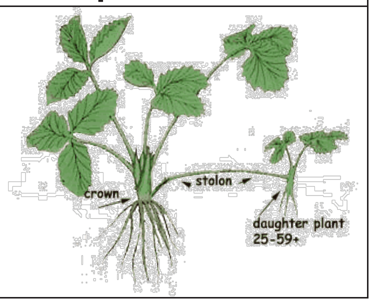
The diagram shows part of a stem of a flowering plant. The stems of some plants, including potatoes, grow partly underground. Most stems of plants consist of nodes, internodes, buds and leaves. A node is the part of the stem from which leaves or buds arise. The part between two nodes is called the internode. A bud is an embryonic stem which has a potential for further plant growth. It may develop into a leaf, a flower or both.

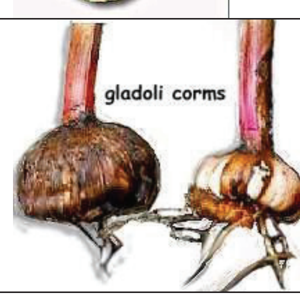
Function of Stems

The functions of a stem are to display the leaves to light; the flowers for pollination; the fruits and seeds for dispersal, and as a transport link between the roots and leaves.

Stem Modifications

Plants often modify their stems for special functions. These modifications can have unusual shapes, and can grow above as well as below the ground. Some stems are modified for special functions such as water storage like in cactus, food storage like in the Irish potato and vegetative reproduction like in couch grass. The table below shows examples of some stem modifications.

Modification	Example
Stolons or runners—are horizontally oriented stems that grow along the soil surface. Their function is vegetative production. Example: number of grasses have stolons.	

Tendrils and twining shoots—coil around objects and help support the plant.	
Succulent stems—are modified to store large amounts of water and are common in desert plants. **Thorns**—are modified stems that protect plants from grazing animals. **Spines** are modified leaves. How can you tell the difference?	
Bulbs—are stems surrounded by fleshy leaves that store nutrients. A bulb consists of a stem from which modified fleshy leaves develop.	
Rhizomes—are underground stems that grow near the soil surface. They typically have short internodes and scale leaves, and produce roots along their lower surface. They store food for renewing growth of the shoot after periods of stress. Example: ginger, canna.	
Corm—is a short swollen underground stem. It is flattened and is the main storage organ.	
Tubers—are swollen regions of stems that store food for subsequent growth. The irish potato is an example.	

Activity 7.6: To show that an Irish potato is a stem tuber

Observe a fresh Irish potato tuber and identify the following parts of the stem: bud, node, internode. What do you notice?

Leaves

They are found on the shoot system.

The Parts of a Leaf

The main parts of the leaf are shown in the figure below.

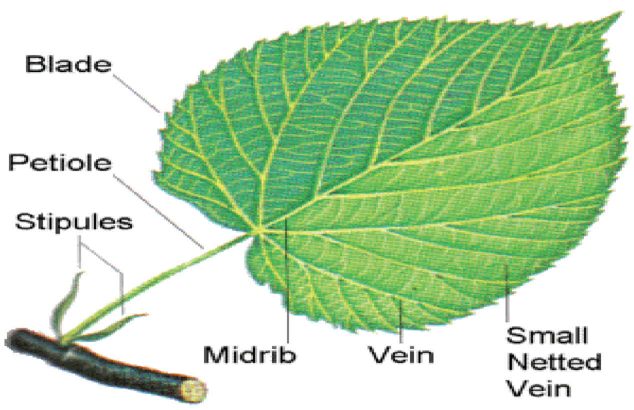


Figure 7.5: Main parts of a leaf

Most leaves have two main parts:

1. The blade or *lamina*, which is the broad, flat part of the leaf.
2. The petiole, or leafstalk, the stem-like part of the leaf that joins the blade to the main stem. Leaf veins originate from this stalk.

Did you know?

The arrangement of veins on leaves is called venation. Observe the veins from different leaves and state the appearance of the veins.

When leaves grow during a season with moderate rainfall and sunshine, they grow into the wide based leaves. If no sunlight is near the leaf bud, it will grow a longer petiole (leaf stem) until it finds sunlight. The overall effect of this is that very little sunlight will reach the ground under a tree as the leaves have captured almost all the available light.

Activity 7.7: Studying leaf shapes

i) Collect leaves from fifteen different plants around the school compound and group them according to similarities in their shapes.

ii) What general observations can you make about leaves of common plants around you?

iii) What can you conclude about the shapes? Compare the shapes of the leaves you collected with those shown in the **Figure 7.6** below.

Figure 7.6: Shapes of leaves

Functions of Leaves

You should have noticed that many of the leaves are flat and broad. This is related to some of the functions of leaves.

1. Photosynthesis—the making of food in a plant. Through this process they obtain the food they need to live.
2. Gas exchange—they take in carbon dioxide and release oxygen through the leaves.
3. Transpiration—they lose water through their leaves. As a result, fresh water enters the leaves through the midrib and veins.
4. Food storage.

Leaf modifications

Like other organs, leaves are often modified for functions other than photosynthesis. Some leaf modifications are indicated in the pictures below:

Figure 7.7: Leaf modifications

What special features do the above leaves possess? What is the importance of the features? Answer these questions by filling in the table below.

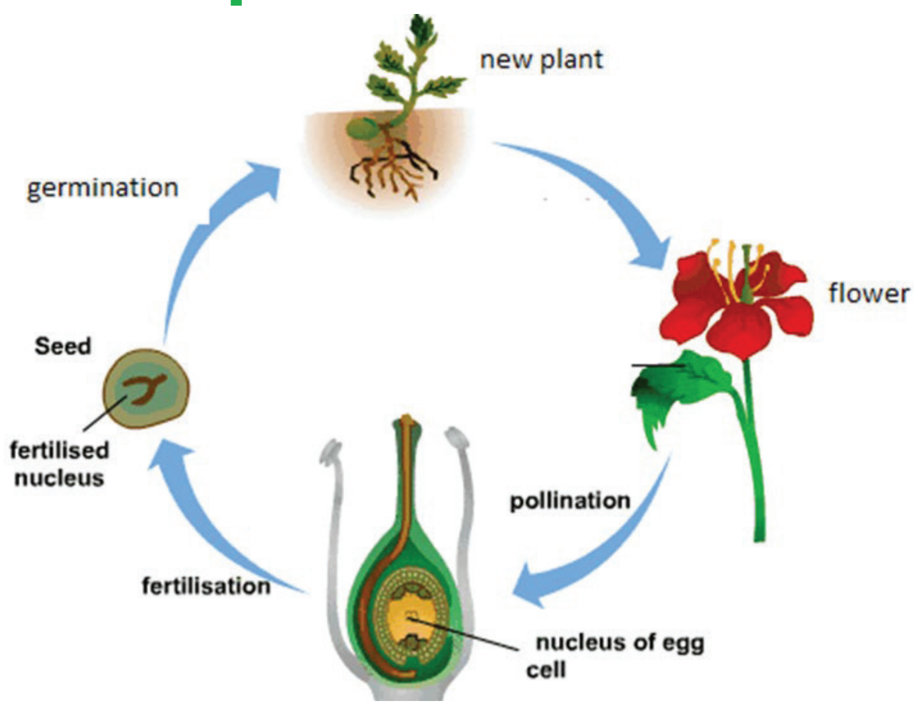
Function	Feature
Protection	
Reproduction	
Climbing	

Chapter Summary

In this chapter, you have learnt that:

- plants are made up of two major systems i.e. the root and the shoot system.
- roots, stems and leaves have different functions for the plant and society.
- roots, stems and leaves can be modified to perform other functions.

Chapter 8: Reproduction in Plants



Key Words	By the end of this chapter, you will be able to:
▪ pistil ▪ stamen ▪ pollination ▪ cross pollination ▪ fertilization ▪ dispersal ▪ vegetative reproduction ▪ grafting	*a) understand the meaning of pollination and describe the types and agents of pollination.* *b) understand the meaning of fertilization and identify its products.* *c) compare seeds and fruits.* *d) understand the meaning of fruit/seed dispersal, its agents and importance to the plant species and farming.* *e) understand that there are other parts of a plant other than the seed that can develop into a new plant of the same kind.* *f) practise vegetative propagation by cutting, grafting and suckers and give examples.* *g) know the advantages and disadvantages of vegetative propagation.*

Introduction

In Chapter 7, you learnt about the different parts of a plant. The different parts have different functions. Some of the parts are used to generate new plants, a process called reproduction. Reproduction means producing offspring for the survival of the species. In this chapter, you will learn the various methods of reproduction in plants and how farmers can use these methods to improve their agricultural production.

Reproduction in Higher Plants

Plant reproduction is the production of new individuals or offspring in plants, which can be obtained from a single parent plant or two parent plants. Sexual reproduction occurs when two parent plants give rise to an offspring, while asexual reproduction occurs when a single parent plant gives rise to an offspring. In seed plants, the offspring can be packaged in a protective seed, which is used as an agent of dispersal.

Sexual Reproduction in Plants

How do plants produce sexually? Do plants have male and female parents? These are interesting questions. Sometimes both male and female parts of a plant are found together. At times they are separate. To understand this, look at a flower.

The flower

This is the reproductive part of a flowering plant. It is found on the stem. It has different parts.

Assignment 8.1: Apart from being a reproductive part of a plant, what are the other uses of flowers?

Activity 8.1: Identifying parts of a flower

What you need

- A flower of hibiscus or other large coloured flower
- A knife or razor blade

What to do

1. Open up the flower and observe all its parts.
2. Identify all the parts of the flower as corolla (petals), calyx (sepals), anther, filament, style, stigma, ovary and stalk.
3. State functions of each of these parts.
4. Draw a generalised diagram of the whole flower, indicating all the parts.

Assignment 8.2: Try to open up as many flowers as possible and observe the parts identified in 2 above. Are there any differences or similarities?

Note: The anther and filament form the stamen. The stamen is the male part of a flower. The stigma, style and ovary form the carpel. The carpel is the female part of the flower. The anther produces the pollen grains while the ovary contains the ovules. These are the most essential parts of the flower.

Pollination

Activity 8.2: Identifying pollen grains

What you need
A large bright flower

What to do
Shake the anthers of a flower, or rub them gently between your fingers. What do you observe?

In this activity, you may have observed a powder-like substance from the anthers. This powder contains **pollen grains**. If the pollen grains are transferred from the anthers to the stigma, then the process of **pollination** will have occurred. This may occur in the same flower—**self-pollination**, or in different flowers—**cross pollination**.

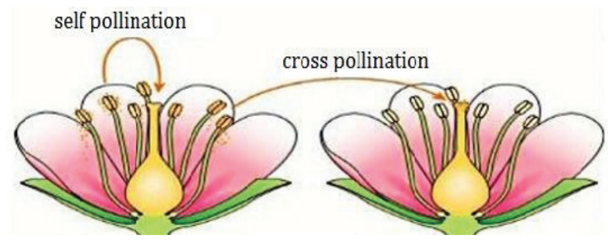


Figure 8.1: Cross and self-pollination

Figure 8.2: Cross pollination by bees

Who transfers pollen grains from the anthers to the stigma? What happens when bees and other insects or birds move from one flower to the other? What are they looking for? Look at **Figure 8.2** above. Try to describe what is happening.

Activity 8.3: Identifying characteristics of insect pollinated flowers

Insects such as bees are some of the agents of pollination. Using **Figure 8.2** above and your experience of flowers, what features are possessed by flowers that are insect pollinated? Try to collect as many flowers as possible that can be pollinated by insects.

If the flowers are not insect pollinated, then they are wind pollinated. Wind pollinated flowers differ from insect pollinated flowers as is shown in **Activity 8.3** above. Can you identify the characteristics of insect pollinated flowers?

How are plants naturally modified or adapted so that each type of pollination occurs in their flowers? Discuss with your friend or teacher.

Fertilisation

When a pollen grain lands on the surface of the stigma, it produces a tube. Inside the tube contains a male cell of the flower. The tube from each pollen grain grows down the style to reach the ovules in the ovary. Inside each ovule is an egg cell.

Pollens move down the style to the ovules and fuse with the egg cells, forming seeds. This process is called **fertilisation.** The ovary becomes the **fruit.** The detailed structure is shown in **Figure 8.3** below.

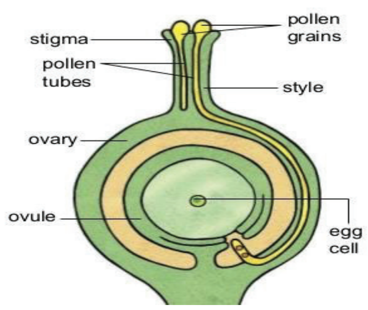


Figure 8.3

Fruits and Seeds

Where do fruits and seeds develop from? What are their functions? To answer these questions, you need to understand what happens after fertilisation in flowers. The ovule becomes a seed while the ovary becomes the fruit.

Seeds are classified as monocotyledons or dicotyledons. The seeds are shown in **Figure 8.4**.

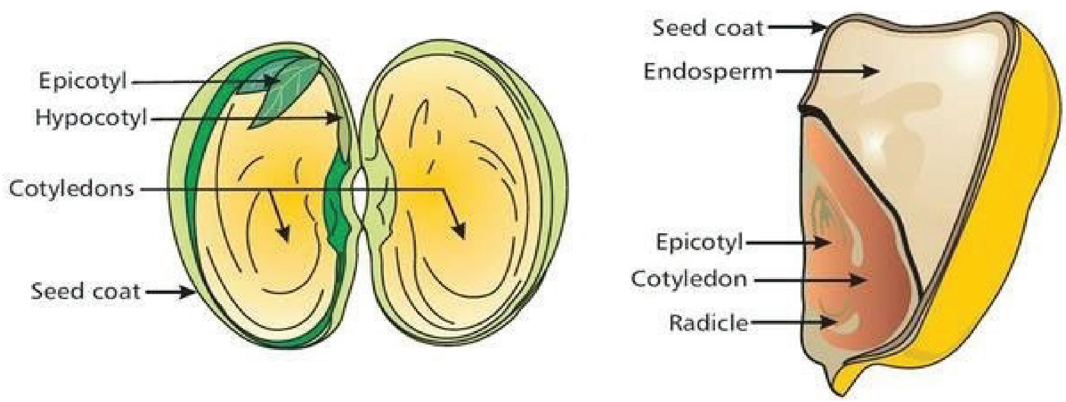


Figure 8.4: Seeds (a) (b)

Activity 8.4: Identifying monocotyledons and dicotyledons

What to do

Look at **Figure 8.4** above.

1. Identify which of the seeds is monocotyledon and which is dicotyledon.
2. State the differences between the two types of seeds.

Fruits develop from the ovary after fertilisation. Fruits have many types depending on the number of seeds and how they are arranged. Fruits and seeds are widely used by man as food.

Common fleshy fruits can be classified as drupes, berries and legumes. They are all used by man as food. They are shown in **Figure 8.5** below.

Figure 8.5: (a) avocado (drupe) (b) tomato (berry) (c) cow peas (legume)

Activity 8.5: Distinguishing between the types of fleshy fruits

What to do

Look at **Figure 8.5** above.

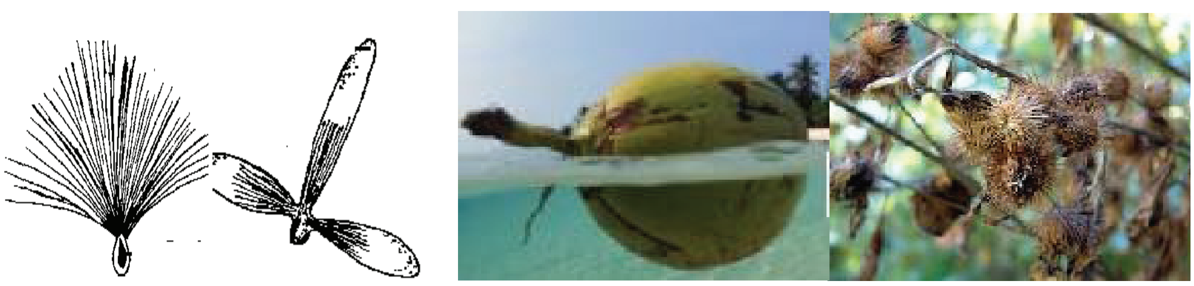
1. State differences between the three types of fruits.
2. Identify any other two fruits that belong to each of the categories.

Fruit and seed dispersal

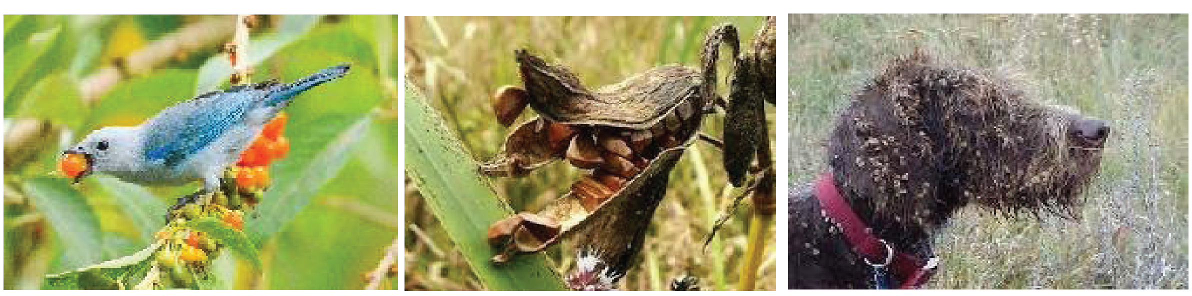
When fruits and seeds are produced, some grow near or far away from their parent plants. When we eat fruits, we may throw away the remaining seeds at a point far away from the plant. In this case, the seeds are said to be **dispersed.** Fruits and seeds are dispersed by different agents. Can you suggest some of these agents?

Activity 8.6: Identifying the agents of dispersal

Look at the pictures in **Figure 8.6** below.



(a) (b) (c) (d)



(e) (f) (g)

Figure 8.6

Identify the agent of dispersal in each diagram and suggest reason(s) why.

Vegetative (asexual) Reproduction in Plants

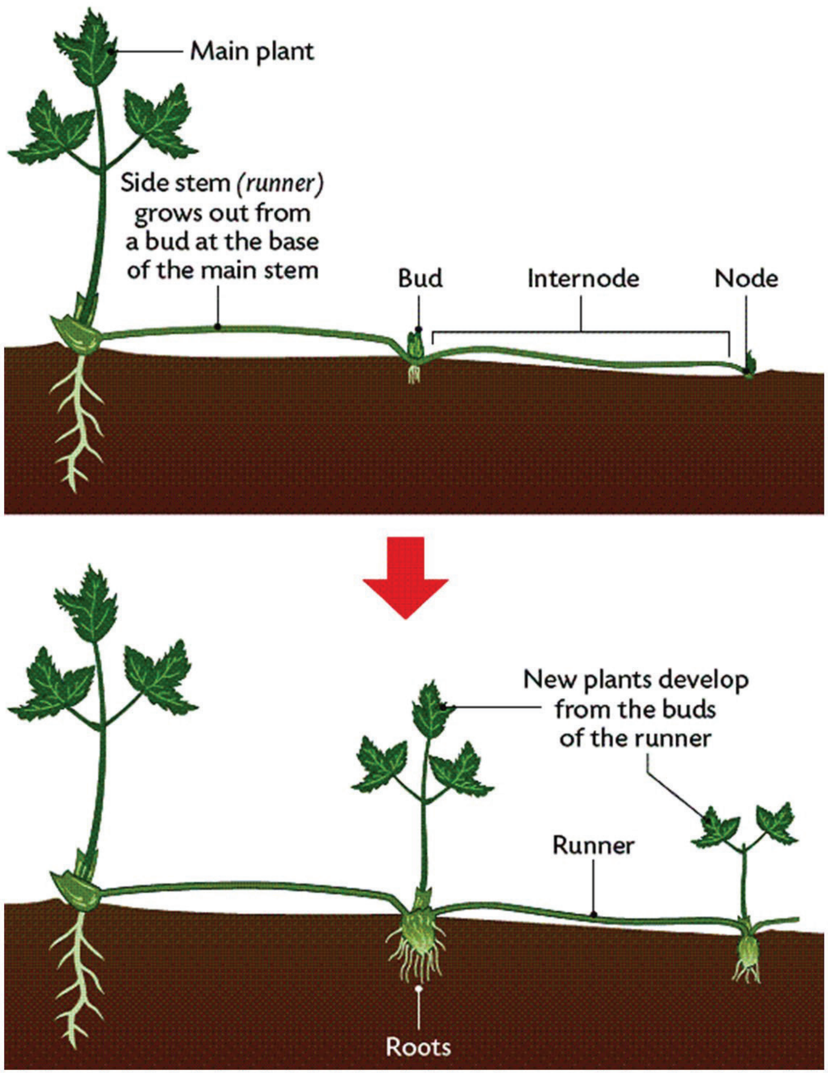


Figure 8.7: Vegetative reproduction by stems

Vegetative propagation is a form of reproduction in plants that does not involve the use of seeds and flowers. Only one parent is involved and the offspring is exactly identical to the parent. It takes the following forms:

Stems: Runners are stems that grow horizontally above the ground. They have nodes where buds are formed. Buds grow into new plants.

Leaves of some plants will grow into a new plant if they become detached from the parent plant. Other plants grow small plants called plantlets on the edges of their leaves.

Bulbs

A bulb contains an underground stem. Leaves are attached to the stem. These leaves contain much stored food. At the centre of the bulb is an apical bud. Also attached are lateral buds. The apical bud will produce leaves and a flower, while the lateral buds will produce new shoots. As the plant grows and develops, it will form a new bulb underground.

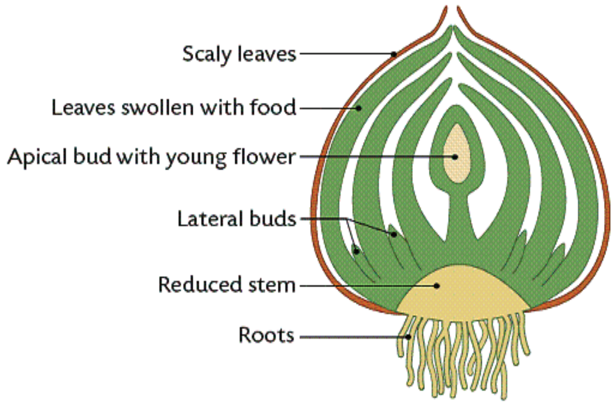


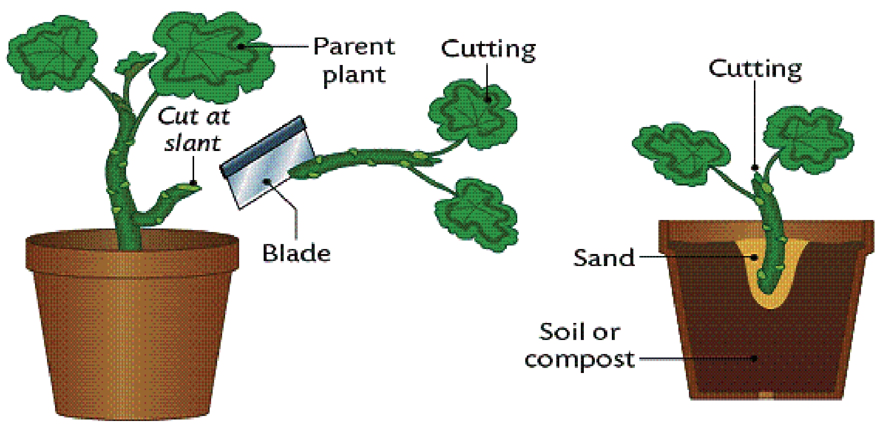
Figure 8.8: A bulb

Artificial Vegetative Reproduction

Horticulturists and farmers use artificial means to produce plants that are identical to the parent plant. Some of the methods used are:

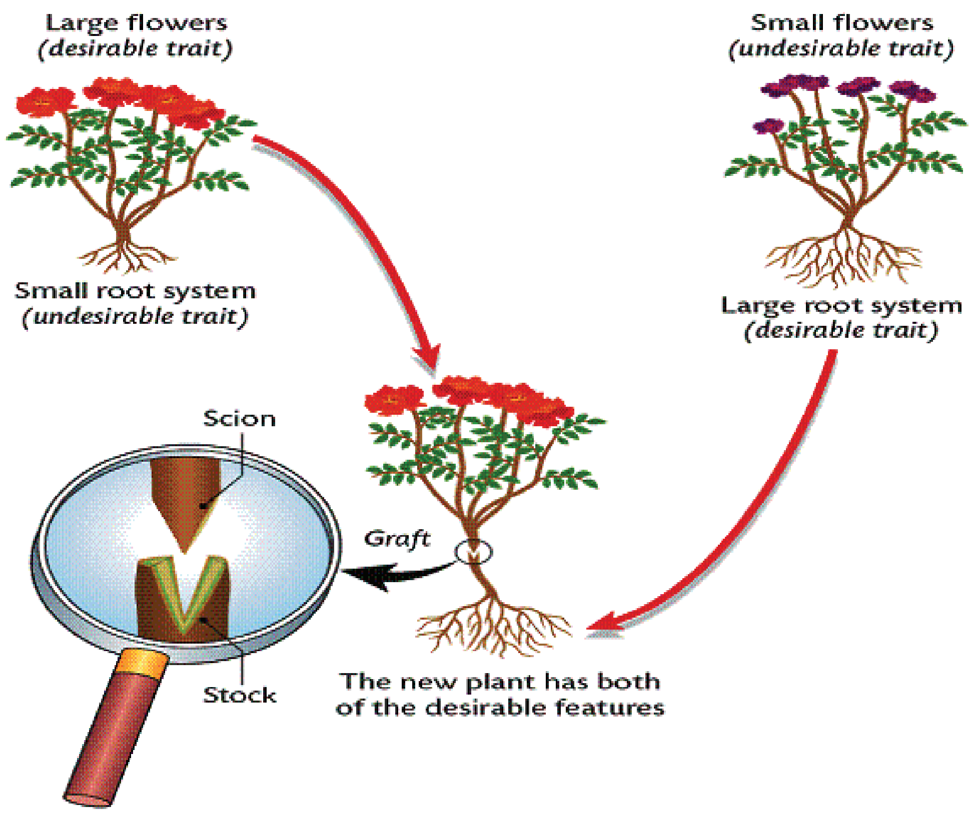
Cutting

Cutting is part of the plant that is cut off the parent plant. Shoots with leaves attached are usually used. New roots and leaves will grow from the cutting. The shoot is cut at an angle. A growth promoter may be used to help with the growth of the roots.



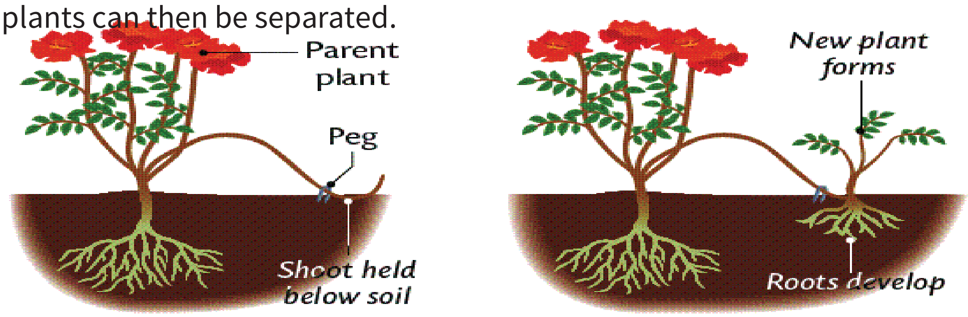
Grafting

In grafting two plants are used to develop a new plant with combined traits from the two parent plants. In grafting, the scion is the above ground part of one plant. The scion is attached to the stock which is the rooted part of the second plant.



Layering

In layering, a shoot of a parent plant is bent until it can be covered by soil. The tip of the shoot remains above ground. New roots and eventually a new plant will grow. These plants can then be separated.



Activity of integration:

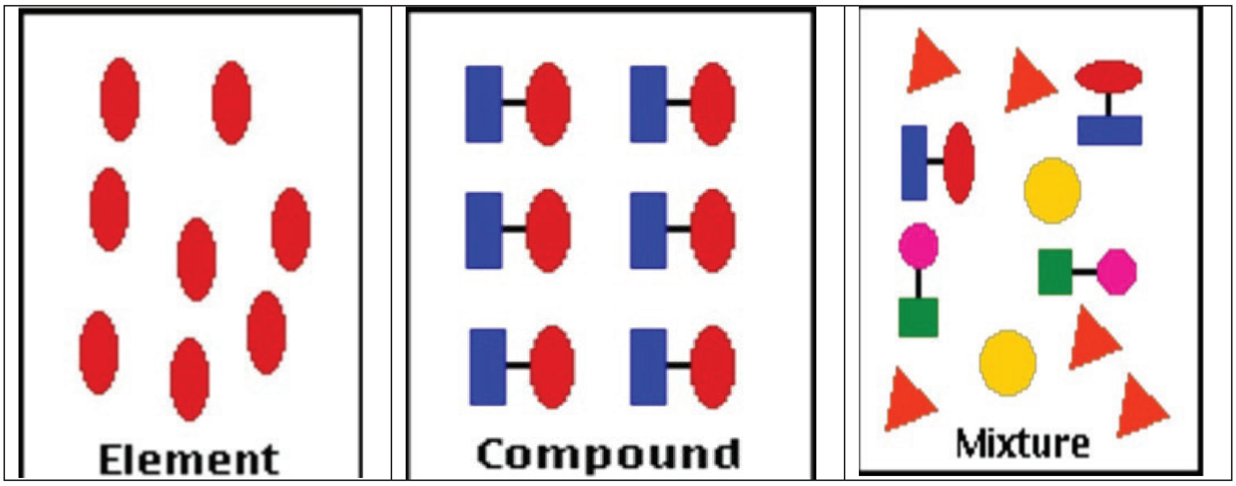
A farmer has just acquired a garden in a water logged area. An organisation is providing planting materials in form of seeds and cuttings. However, the farmer has not chosen whether to use the seeds or the cuttings. What advice would you give to the farmer in order to choose the best planting material?

Chapter Summary

In this chapter, you have learnt:

- that the flower is the reproductive organ of a flowering plant.
- that the reproductive cycle of a plant involves pollination, fertilization and seed development.
- seeds and fruits are dispersed by various means.
- plants can reproduce vegetatively without seeds.

Chapter 9: Elements, Compounds and Mixtures



Key Words	*By the end of this chapter, you will be able to:*
▪ element ▪ compound ▪ mixture ▪ miscible liquids ▪ immiscible liquids ▪ decanting ▪ distillation ▪ pure substance	*a) understand the meaning of elements, compounds and mixtures.* *b) compare between metals and non-metals using laboratory tests.* *c)demonstrate how the purity of a substance can be determined.* *d) demonstrate methods by which mixtures can be separated.* *e) compare mixtures and pure substances; mixtures and compound.* *f) compare miscible and immiscible liquids.* *g) apply methods by which miscible and immiscible liquids can be separated.*

Introduction

In Chapter 4, you learnt that matter exists in three common states: liquid, gas and solid. We also discovered that the fourth state of matter known as plasma also exists. We also noticed that all matter is composed of basic ingredients. These ingredients are actually elements. Combinations of these elements make up all the different things that we see, breathe, eat, drink and use. The different things are classified into pure substances and mixtures. In this chapter, you will understand the behaviour of pure and impure substances (mixtures) and how they can be used.

Elements

An element is a pure substance that cannot be broken down into smaller substances/units. Within our homes, there are many substances that are made of elements, e.g. packaging tins made from the element tin, iron sheets made from the element iron, and gold necklaces made from gold. Elements are made up of small tiny particles known as atoms. There are about 92 naturally occurring elements. However, other few elements have been made by man.

Each element has a unique symbol derived from two letters. The first letter of the symbol is written in the upper case and the second is always in the lower case. These symbols are got from either English or Latin names of the elements. Some of the symbols are shown below.

Element	Symbol
Calcium	Ca
Aluminium	Al
Lead	Pb
Tin	Sn
Silver	Ag
Iron	Fe
Magnesium	Mg
iodine	I
Mercury	Hg
Potassium	K
Oxygen	O
Zinc	Zn
Hydrogen	H
Helium	He
Gold	Au
Chlorine	Cl
Sodium	Na
Carbon	C

Discuss with a friend or your teacher why some symbols are not related to the names indicated.

Metal and Non-metal Elements

Elements are grouped into two categories: metals and non-metals depending on their properties. Metals may be solid, e.g. iron, aluminium and copper; or liquid such as mercury. Non-metals can exist as gases, liquids and solids. **Can you identify an element in each of the states of matter?**

Properties of metals and non-metals

PROPERTY	METAL	NON-METAL
Physical state	Solids, except mercury which is liquid	Solids, liquids or gases
Appearance	Shiny	dull
Melting point	High	low
Density	High	low
Malleability/Ability to fold	malleable	brittle
Ductility/ being able to be stretched into wires	ductile	Non-ductile
conductivity	Good	poor

Activity 9.1: Comparing metals and non-metals

What you need

- a piece of iron
- a piece of wood
- copper wire
- water
- aluminium source pan
- sulphur powder
- plastic cup
- beaker

What to do

Examine the above materials and **classify** each of them as metal or non-metals based on the following: their physical state, appearance, density, malleability (ability to be re-shaped), ductility (ability to be stretched into wires) and electrical conductivity. Record your answer in the table below.

Material	Property	Observation	Non-Metal	Metal

Atoms

An atom is the smallest piece/particle of matter. The word atom comes from the Greek word *atomos,* meaning ‘that which cannot be divided further’.

Activity 9.2: Atoms of elements and composition

Do atoms of elements have the same composition as the element itself?

What you need

- A piece of potato
- Petri dishes
- knife

What to do

1. In groups, cut a piece of potato and examine it carefully, what do you see?
2. Divide yourselves into two equal groups and share the potato piece. Examine your pieces thoroughly.
3. Again divide your pieces equally among yourselves and examine them again.
4. Each should divide their pieces into smaller ones until they cannot divide them any more.

Is the smallest piece of the potato different from the potato? Give reasons for your answer. What conclusion can you make about atoms and elements using your observation of the potato you have just cut?

Compounds

When atoms link together, they form small groups called molecules or lattices. The linked atoms may be of the same elements or from different elements. They are held together by special forces called **bonds**. Several of these linked atoms form a compound. A compound is a pure substance made up of two or more elements chemically combined. An example of a compound is **water**. It is made up of hydrogen and oxygen. Sodium chloride (table salt) consists of grains made up of lattice of sodium and chlorine atoms held together by atomic bonds. Compounds have different composition and behaviour from the elements that formed them i.e. water is a liquid while oxygen and hydrogen are gases.

Many of the substances that we use at home, many of the foods we eat, many of the medicines we take are made up of one or several compounds. Some of the examples are water, salt, sugar, white flour, polythene, nylon, polyester, aspirin, paracetamol, etc. Can you identify the other compounds used at home?

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Mixtures

A mixture is a substance that contains two or more substances added together but not chemically combined. Mixtures do not form new substances. The substances in a mixture are not bound together and so can easily be separated, e.g. a mixture of water and sand, sugar and water, oil and water. Mixtures can be separated by physical means.

Mixtures can be solid: solid mixtures; liquids: solid mixtures. These may be soluble or non-soluble or liquid: liquid mixture which may be soluble or non-soluble. Air is a mixture of gases.

Methods of separating mixtures

Solid-solid Mixture

These can be separated by considering the physical state of its components, e.g. a mixture of iron fillings and zinc fillings can be separated using a magnet, iodine and sand can be separated using sublimation, salt and sand can be separated by dissolving and filtration, and beans and maize through sorting.

Activity 9.3: Recovering water mixed with sand

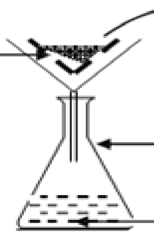
Can you recover water which has been mixed with sand?

What you need

- sand
- filter paper
- filter funnel
- retort stand
- water

What to do

1. Fold the filter paper into half and then into half again. Now open it to make a cone.
2. Fix the filter paper into the filter funnel and hold it over a clean beaker.
3. Pour the sand/water mixture onto the filter paper and allow it drain as shown below.



a) What do you see in the beaker?
b) What do you get on the filter paper?

Activity 9.4: Recovering salt mixed with sand

1. Can you recover dry salt which has been mixed with sand?
2. What can you do to separate dry salt from the sand?
3. Plan and carry out your own activity. Write down all the procedures and observations made.

Liquid-liquid Mixture

Activity 9.5: Making miscible and immiscible liquids

1. Mix some ethanol with an equal volume of water in a beaker and state what is observed.
2. Mix some water with an equal volume of kerosene/oil in a beaker and state what is observed.

If liquids mix together completely to form a uniform solution, they are referred to as **miscible liquids**. Those that do not mix together are called **immiscible liquids**. Can you suggest examples of each category of liquids?

Activity 9.6: Recovering oil mixed with water

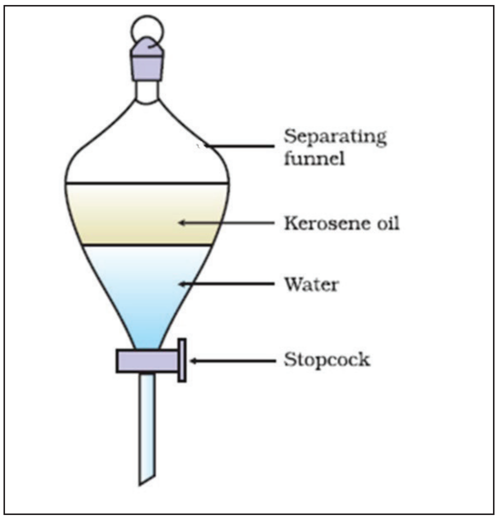
Can you recover oil which has been mixed with water?

What you need

- oil and water mixture
- separating funnel
- retort stand

What to do

- Pour the mixture of oil and water in the separating funnel.
- Allow the mixture to sand till it makes two distinct layers as shown below.



Open the tap or stopcock slowly. What do you observe?

Activity 9.7: To separate water from ethanol or purifying local alcohol

1. Mix water and ethanol in equal amounts in a distillation flask, or put about $100cm^3$ of local alcohol (tonto).
2. Fix a cork (fitted with a thermometer) at the top of the flask and connect a condenser to the flask as shown in the figure below. Put a beaker at the end of the condenser.
3. Heat the mixture in the flask and note the temperature at which droplets of liquid begin to form in the beaker.

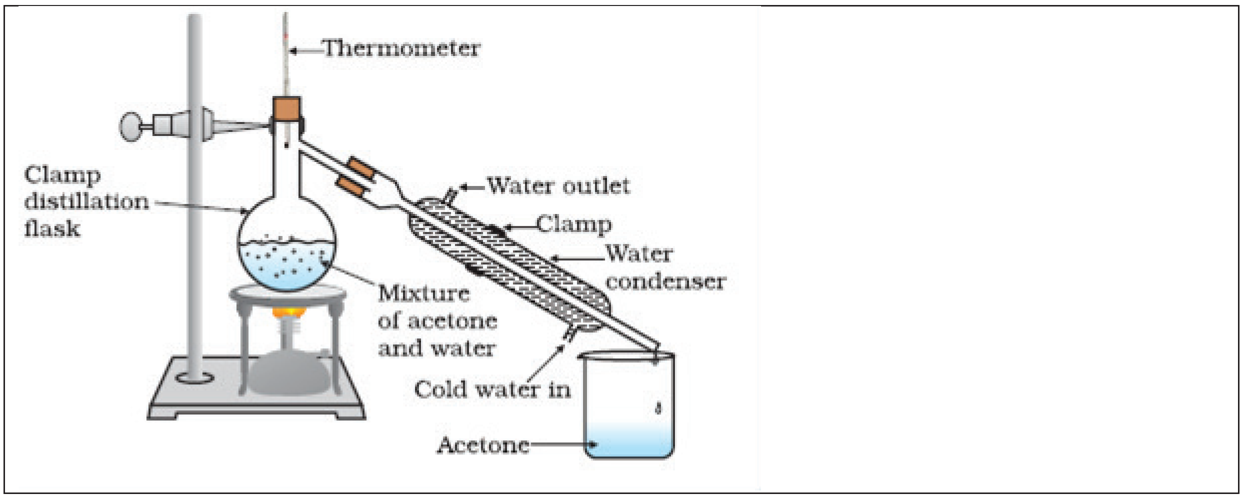


Figure 9.2: Fractional distillation apparatus

Note: The above method is called fractional distillation. It works because the two liquids have **different boiling points**.

Science, Technology and Society

Fractional distillation is applied in:

- *isolation of oxygen and nitrogen from liquid air.*
- *refining petroleum into different products.*
- *making wines and spirits.*

Activity 9.8: Making a cough mixture

What you need

- saucepan
- glass rod/wooden rod
- burner/stove
- packing bottles
- knife
- lemon fruits
- ginger
- honey
- mango tree bark and leaves
- water

What to do

1. Cut fresh/green 3 lemon fruits and 200g of ginger into small pieces.
2. Place the cut parts in a saucepan.
3. Add the crushed pieces of mango bark or mango leaves (100g) to the saucepan.
4. Measure distilled/rain/tap clean water to the saucepan.
5. Heat on the burner/stove to boiling till most of the water has evaporated.
6. Allow to cool then add honey. Stir and cover with a net/cover.
7. Leave the mixture to cool further.
8. Filter the mixture and measure the required volumes and package in bottles.
9. You have made a cough mixture. Now calculate the unit cost and selling price. Try to market the products.

Activity 9.9: Identifying mixtures and their uses

Name 5 other mixtures that are important in our everyday life and state what they are used for.

Determination of Purity of Substances

Many things around us are mixtures of more than one substance. Those that consist of one substance are said to be **pure** substances. Sugar, salt, iron, copper are pure substances. Soil, air, milk and rock salt are mixtures of two or more substances and are said to be **impure**. Impure substances are called **mixtures**. They are made up of two or more substances that are not chemically combined.

Activity 9.10: Identifying pure and impure substances

In the table below, list any four pure and four impure substances.

Pure substances	Impure substances

How can you distinguish a pure substance from an impure one?

In many impure substances, the parts forming a mixture can be easily seen. For example, in a mixture of sand and water, the sand and water can be easily differentiated. But in other cases such as a mixture of salt and water, the mixture looks as if it contains one substance. In order to tell that you are dealing with a pure substance, it is important to look at the properties of the substance. Pure substances have a definite sharp melting point and boiling point. On the other hand, the presence of an impurity changes the boiling point of the substance.

Activity of Integration

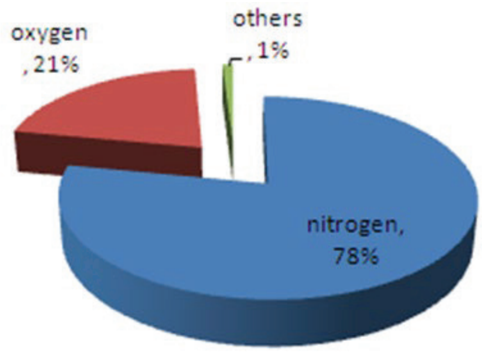
A certain community is faced with a problem of water shortage, especially during the rainy season. This is because the surface run of deposits many materials in their streams making the water dirty. Using the knowledge of mixtures, how can such water be purified so that it is properly usied for drinking? Prepare local purifiers for this purpose.

Chapter Summary

In this chapter, you have learnt that:

- substances are classified into elements, compounds and mixtures.
- elements are grouped into metals and non-metals, and they have different properties.
- the method of separation of mixtures depends on the nature of the mixture.
- the methods of identifying pure substances.

Chapter 10: Air, Burning and Rusting



Key Words	***By the end of this chapter, you will be able to:***
• air • combustion • air pollution • exhaust gases • greenhouse effect • global warming • rusting	*a) know the components of air, their proportions and uses.* *b) show how air is a mixture and not a compound.* *c) understand the methods of separation of the major components in air.* *d) determine the percentage of oxygen in air.* *e) demonstrate the properties of oxygen and carbon dioxide based on their reactions.* *f) know the uses of oxygen and carbon dioxide both in nature and industry.* *g) demonstrate how substances such as magnesium, sulphur and carbon undergo combustion.* *h) understand the meaning of rusting, how it affects iron materials/tools and the various methods of preventing it.* *i) understand the term air pollution, and identify the main examples of air pollutants.* *j) analyse the effects of air pollution and the steps needed to prevent, control or mitigate air pollution.*

Air as a Mixture of Different Gases

Figure 10.1: Earth shape

The Earth is covered in a layer of gases called the atmosphere. The beautiful blue, green and brown planet earth is the only one around our sun that has an atmosphere of air and oceans and rivers of water. Because of this, it is the only planet in our solar system that has life on it. Air and water are essential to us and to all other living things. You will learn more about our atmosphere in this chapter.

In primary you found out that air is mainly a **mixture** of oxygen and nitrogen. The pie chart shows the proportions of these gases in the air. Air also contains small amounts of other gases.

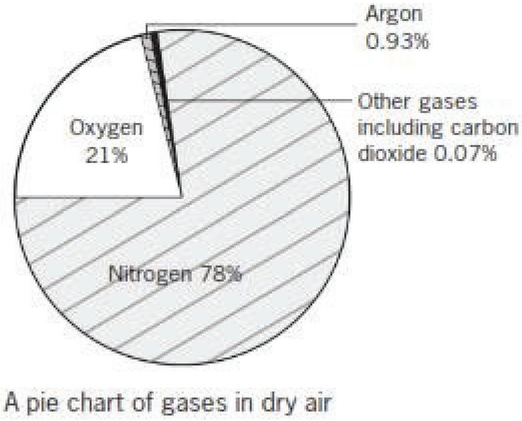


Figure 10.2: Composition of gases of the atmosphere

Oxygen

Oxygen is a gas that is essential to us. Without oxygen our muscles would not get the energy they need and so we would die. Oxygen has no colour and no smell. It is quite soluble in water, and animals that live in water use this dissolved oxygen in the same way that we use the oxygen in the air. Fish take in the dissolved oxygen through their gills. Some animals that live in water, such as whales and dolphins, have to come to the surface to breathe in the oxygen because they do not have gills.

Oxygen and Burning

Oxygen is very important to us because it is used for respiration and combustion. When elements and compounds burn, they combine with oxygen. The next activity shows what happens when a candle burns.

Activity 10.1: Investigating what happens when a candle burns

What happens to candle wax when it burns?

What you need

- candle
- water
- beaker
- dropper
- test tube
- fresh limewater

What to do

1. Hold a beaker of cold water for a short time above the candle flame as shown in **Figure 10.3(a)** below. What do you see on the beaker?
2. Take a sample of the air just above the flame in a dropper as shown in **Figure 10.3(b)** below.
3. Bubble it through a small amount of fresh limewater in a test tube. You may need to repeat this before you see anything.

In this activity you used limewater to test for the carbon dioxide gas. When you bubble carbon dioxide through fresh limewater the water turns milky.

This activity shows that when candle wax burns, two products are formed: water and carbon dioxide. Water is formed when hydrogen combines with oxygen, and carbon dioxide is formed when carbon combines with oxygen.

Candle wax is a hydrocarbon. Hydrocarbons are compounds that are made of atoms of hydrogen and carbon only. (Butane, petrol and diesel are also hydrocarbons.) We can write an equation for the reaction that happens when a hydro carbon burns:

hydrocarbon +oxygen ⟶ carbon dioxide + water (+ energy)

The reaction gives out heat energy which is called combustion.

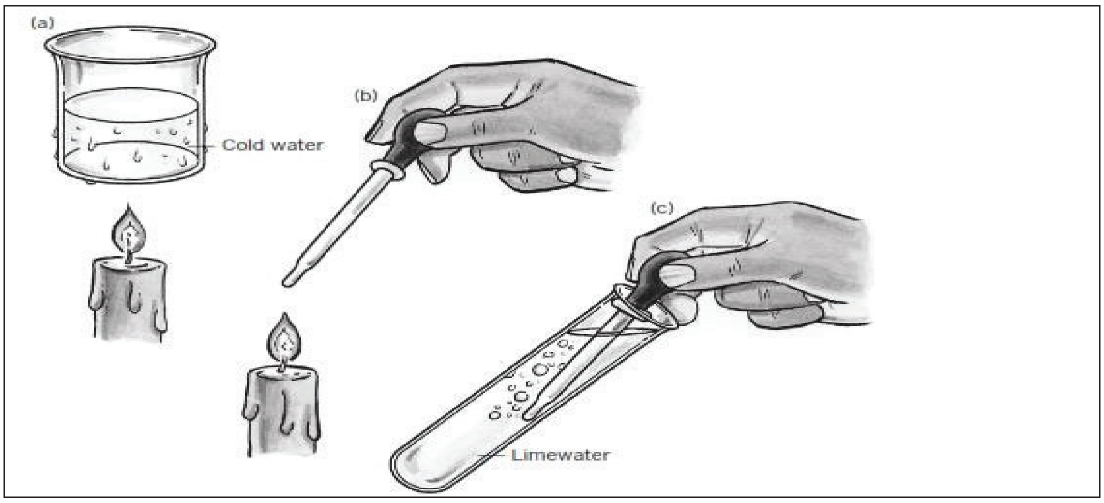


Figure 10.3

If you repeat **Activity 10.1** using a burning stick instead of a candle, you will get the same results. The stick is made of cellulose, which is a carbohydrate. Carbohydrates are compounds made of atoms of carbon, hydrogen and oxygen. These will also give carbon dioxide and water when they burn.

Carbohydrate + oxygen ⟶ carbon dioxide + water (+ energy)

This is a very important chemical reaction because it happens inside all living things. In your body, as you read this, a carbohydrate called glucose is converted into carbon dioxide and water to provide you the energy to live. The glucose comes from the food you eat. You breathe in oxygen and you breathe the carbon dioxide and the water vapour. This reaction is called **respiration**.

Combustion is chemically the same reaction as respiration. The main difference is that respiration happens more slowly; when you respire you do not burst into flames!

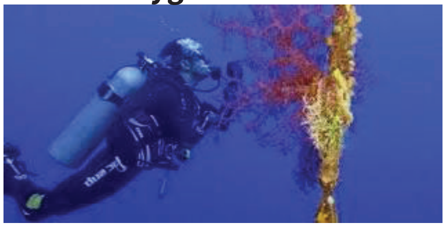
Making Oxygen in Industry

Oxygen is an important gas in industry. It is made from air by first cooling the air until it is a liquid and then distilling it. In this process the air is first passed through a filter to remove the dirt particles. The air is then turned into a liquid by cooling it down to –200 °C. As the air cools down, water vapour is removed as ice. At about –80 °C the carbon dioxide is also removed because it changes to solid carbon dioxide, which is a white solid that looks like ice but is much colder!

The liquid air is pumped into a **fractionating column**. It is slowly warmed. The gases boil off one by one, and are collected in cylinders. Nitrogen boils off first at –190 °C and then the liquid oxygen boils at –183 °C. This process is called **fractional distillation** of liquid air. **Figure 10.3** below showa fractional distillation taking place in the tower in the background.

Figure 10.3: An air separation plant

Uses of oxygen



Divers breathe a mixture of oxygen and helium stored in the tanks on their backs.

A patient on oxygen in hospital

You will find cylinders of oxygen in hospitals and in some workshops. Oxygen is used in hospitals to help people breathe when they are seriously ill. In workshops it is used with another gas called acetylene to weld pieces of steel together.

A very important use for oxygen all over the world is in steel making. The crude iron made from iron ore contains a lot of impurities such as carbon and sulphur. Oxygen is blown through the liquid iron and these impurities burn in it and come out as carbon dioxide and sulphur dioxide gases.

Oxygen is also used in places where we need it for breathing or burning but where there is not enough air. Examples are when diving under water, in high-flying aircraft and in rockets.

Nitrogen

Nitrogen is the major component of the atmosphere, though it is not an active component. It is a major component required by plants to grow. It is fixed into the soil by a number of processes.

Nitrates

Nitrogen exists freely in air. It also exists in compounds with other elements. Ammonia (NH_3) gas is a compound of nitrogen and hydrogen; nitric acid (HNO_3) contains hydrogen and oxygen. Nitric acid reacts with bases to form salts called nitrates.

Nitrates are important because plants need them for growth. Plants get the nitrates either from the remains of other plants when they die and rot, or from animal dung, such as from cattle, which eat plants. We can also provide plants with nitrates by making nitrate fertilizers.

Nitrogen from air is fixed into the soil by bacteria called nitrogen-fixing bacteria. The bacteria turn nitrogen from the air into nitrates. Plants use the nitrates to produce proteins and other compounds that contain nitrogen. Animals eat the plants and so they obtain the nitrogen needed to make them grow.

Nitrates are all very soluble in water. This can cause problems in the wet season in Uganda. The nitrates in the soil dissolve easily in water after it rains. So the soil in Uganda will not contain much nitrate. If too much nitrate gets into water, this can cause pollution.

Carbon dioxide

Making carbon dioxide

Carbon dioxide is the gas that makes cool drinks fizzy. If you drink soda water you will know that it has a slightly sharp taste because carbon dioxide makes the drink acidic.

Most of the carbon dioxide used in fizzy drinks is made using yeast. Yeast is a small organism that is very common in nature. It feeds on sugars found in things like fruits and starchy foods as bread and potatoes. It changes the sugar into alcohol and carbon dioxide.

Test for carbon dioxide

If you bubble carbon dioxide through fresh lime water, the lime water turns milky. Lime water is a solution of calcium hydroxide (lime) in water. Lime water is made by shaking the calcium hydroxide with water and then filtering the mixture. The clear solution is lime water.

Uses of carbon dioxide

The main use for carbon dioxide is putting the 'fizz' in fizzy drinks. Carbon dioxide is dissolved in the drinks under pressure. More gas is dissolved than the liquid can hold under normal pressure and it is quickly sealed in a tin or a bottle.

When you take the top off the tin or bottle the compressed gas bubbles out of the liquid. Carbon dioxide can also be used to put out fires, so it is used in certain kinds of fire extinguishers.

Production by combustion of fuels

The main source of carbon dioxide is the burning of fuels in machines and also the 'burning' of food in our bodies and in other living things. Most of this carbon dioxide goes into the atmosphere.

Air Pollution

What is air pollution? We say the air is polluted when it contains a substance that is not normally present in air. A substance that is normally present in air can also pollute the air.

This happens if much more of the substance is present than is normal. Air pollution is usually caused by human activities. We can classify air pollutants into two groups: solid particles and gases.

Air Pollution by Solid Particles

Most solid particles come from burning. Smoke and ashes are formed during bush and grass fires. Mineral dust comes from the soil, while volcanic eruptions also send a lot of dust into the air. These solid particles make buildings and clothes dirty. They also stop some of the radiation from the sun and this makes plants grow slower. The particles get into the lungs and cause breathing problems. The dust also stops the rays from the sun that cause sunburn. This is why sunburn is always worst after rain because the rain washes the dust out of the air.

Activity 10.2: Measuring the amount of dust and smoke particles in air

Key question

How can we measure dust and smoke particles in the air?

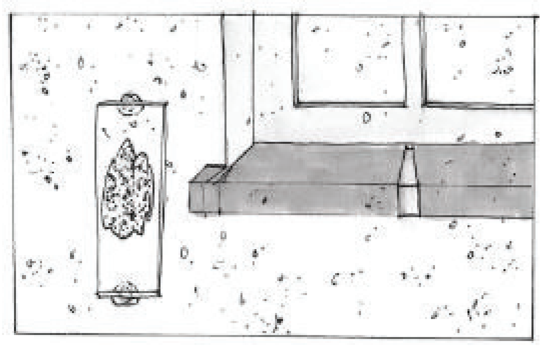
What you need

- microscope slides (or strips of clear plastic)

- Vaseline
- hand lens
- cloth pegs

What to do

1. Coat the microscope slides or clear plastic strips with a thin layer of Vaseline.
2. Use the pegs for clothes or prestik to attach the slides or plastic strips to objects outside.



3. Leave them for a week.
4. Use a hand lens to study the particles stuck to the vaseline. You may be able to estimate the average number of particles stuck to each square centimetre.

If the strips are placed vertically, they will catch windblown particles which are too light to settle. You will find many dust particles on the vaseline. If the lens is good enough, you could count the number of particles you see in every square millimetre. To do this you should put the slide on top of some millimetre graph paper.

Find out if there is any activity going on in your area that could cause dust particles to be in the air. Try repeating this activity just after rain. What differences would you predict?

Assignment 10.1

1. What evidence can you use to show that air is polluted?
2. Make a list of any activities in your area that could cause air pollution.

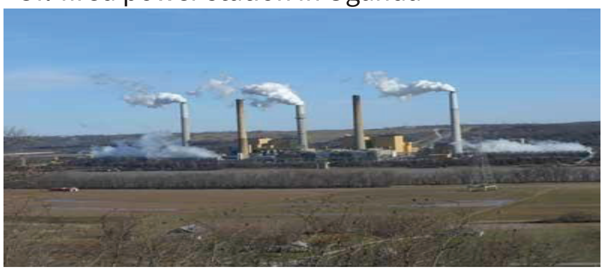
Pollution by Gases

The second group of pollutants is compounds in a gaseous state. Sulphur dioxide, nitrogen oxides, carbon monoxide and carbon dioxide are some of the main gaseous pollutants.

Sulphur dioxide

Sulphur dioxide is a gas that is present naturally in air. It is given off when dead vegetation decomposes. Human activities sometimes cause much more sulphur dioxide to go into the air than is normal. This happens in places where smelting of copper ore is carried out. The process of smelting copper ore produces a lot of sulphur dioxide. When you breathe the gas you will feel an irritation of the nose and throat.

Oil-fired power station in Uganda



Coal and oil were made from plants and animals that lived long ago. In all plants, there are compounds that contain sulphur. When these fuels burn, some sulphur dioxide is formed. Therefore, most power stations, such as the oil-fired power station in the picture produce some sulphur dioxide. Sulphur dioxide dissolves in rainwater and makes it acidic. This is known as acid rain. Acid rain affects plants; it damages the waxy coating that protects leaves and it prevents chlorophyll formation. It also damages stone and concrete buildings.

Pollution by Vehicles

Vehicles burn petrol or diesel fuel in their engines. Both of these are hydrocarbons. When hydrocarbons burn completely they form carbon dioxide and water. But they burn inside the engine in limited air, many other compounds are formed. Many of these compounds are pollutants such as oxides of nitrogen, unburnt hydrocarbons and carbon monoxide.

Nitrogen oxides are formed when the nitrogen and the oxygen in the air combine inside the engine at high temperatures and pressures. They are poisonous gases. They dissolve in rain, making it acidic. They corrode metal and stone and can damage people's lungs.

Carbon monoxide and **unburnt hydrocarbons** are produced because carbon fuel is burnt in a limited supply of air. We call this incomplete combustion. Carbon monoxide is poisonous. It has no smell, taste or colour; and when it gets into the bloodstream, it prevents blood from taking oxygen around the body. Unburnt hydrocarbons can cause lung problems, including lung cancer.

In sunny climates where there is no wind, all these polluting gases in the air can start reacting together to form new substances. Many of these are particularly nasty and cause breathing problems and soreness to the eyes. This mixture is called photochemical smog. It is particularly bad in very big cities such as Tokyo, Mexico City and Los Angeles, but it can occur on windless dry periods in Kampala. Many cities are now banning cars from their city centres and instead people use electrically powered trains and buses.

New cars that are now being built give out fewer oxides of nitrogen, unburnt hydrocarbons and carbon monoxide. These cars have small devices in their exhaust pipes called catalytic converters, which convert all these gases to less harmful substances. In Uganda environmental tax is being levied by Uganda Revenue Authority (URA)on imported cars which are more than five years from date of their manufacture.

Pollution from Houses

Smoke, unburnt hydrocarbons, carbon monoxide and sulphur dioxide are produced when we use coal, wood or paraffin for cooking and heating. These pollutants are usually spread out by the wind. This kind of pollution can cause serious illness and even death.

Pollution by Carbon dioxide

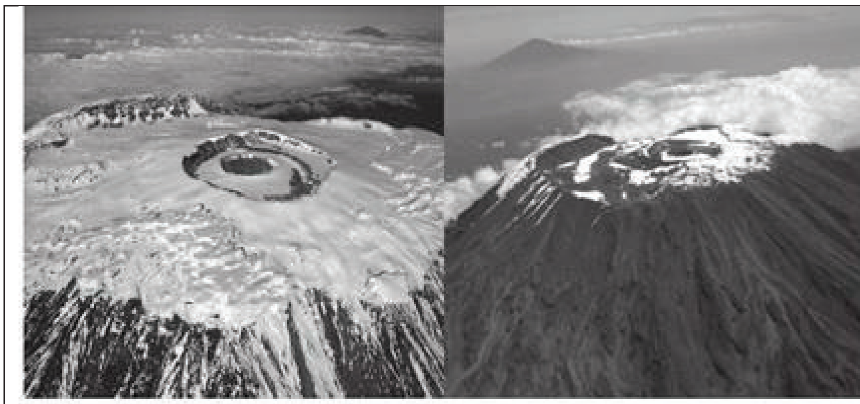
Carbon dioxide is put into the atmosphere by combustion and respiration. It is taken from the atmosphere by photosynthesis. In the past, these two processes balanced each other, but nowadays scientists are worried that more carbon dioxide is being produced by burning than is being used up by photosynthesis.

Carbon dioxide allows heat to reach the earth from the sun, but stops heat from the warm earth from escaping back into space. It acts like a blanket around the earth. This is known as the ***greenhouse effect***, and we know now that the earth is slowly warming up because of it. This is called ***global warming***. Scientists have made predictions about what they think might happen as the atmosphere warms up.

Here are some of their predictions:

- There will be changes in our weather. Some places will become hotter and others colder. Some places will become wetter and others drier.
- The weather will become more violent. There will be more hurricanes and heavy storms. This is because more energy is stored in the hotter atmosphere.
- The ice in glaciers and at the North and South Poles will melt. This will cause the sea level to rise and flood coastal areas. It will also cause more flooding in rainy seasons because less water is held back as ice in the glaciers.
- Ocean currents may change. The melting of ice at the North Pole will affect the

main currents in the Atlantic Ocean. This will affect weather all over the world.



Pictures of Mt. Kilimanjaro before the ice melted (left) and after the ice melted(right).

Assignment 10.2

Look for evidence that supports the predictions about global warming, as well as evidence that suggests that scientists may be wrong in their predictions. You can look for this evidence on the Internet or in newspapers and magazines.

Assignment 10.3

What can we do about air pollution? Here are some questions to answer.

- How can we reduce the burning of wood, coal and oil?
- What else is being burnt that could cause pollution?
- How can we keep the dust down?
- How does using less electricity cause less pollution?
- Can we use other forms of energy, such as solar energy, instead of electricity?
- What forms of energy are used in your area, and do they cause air pollution?

Rusting of Iron

Look at the Figure 10.10 below.

Figure 10.10: Rusted nails and iron sheets

What has happened to the nails and the iron sheets? Why is it that the nails and iron sheets changed colour with time? These and other questions can be answered by understanding the process of **rusting**.

Rusting is a chemical process. It involves iron materials combining with some other substances in the environment. The red or orange coating that forms on the surface of **iron** when left in the open is called **iron rust.** Iron rust is a chemical compound.

What conditions are required for rusting?

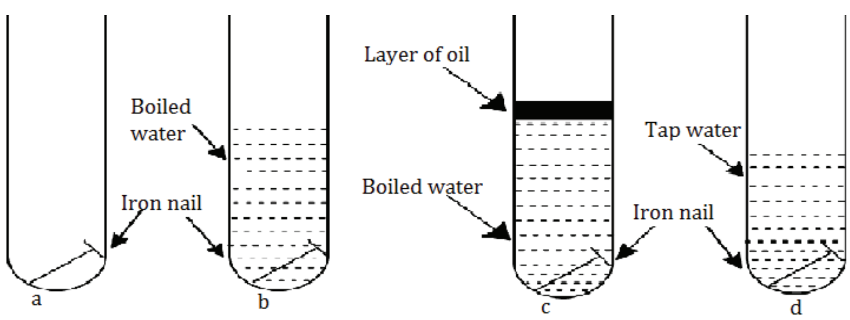
Activity 10.3: Investigating the conditions necessary for rusting of iron

What you need

- iron nails
- some oil
- source of heat
- tap water
- boiling tubes

What to do

1. Obtain two clean iron nails
2. Put one of the nails in a boiling tube as shown in (a) below.
3. Boil some water until it is about to boil and put it in the boiling tube with a clean nail as shown in (b) below.
4. Add a layer of oil to the surface of the boiled water as shown in (c) below.
5. Put the other clean nail in a boiling tube and pour tap water as shown in (d) below.
6. Leave it to stand for about 5 days.



a) After the period, check the iron nails. What do you observe?
b) Which condition for rusting is being investigated?
c) Why was the water in step 3 above boiled?
d) What other condition is required for rusting, apart from the one in this activity?
e) Plan and carry out an activity to show that this condition is required for rusting.

Effects of Rusting

Look again at **Figure 10.10** on the previous page. How has rusting affected the materials indicated? You notice that the materials have changed their appearance due to rusting. Can you mention other ways in which rusting affects our tools?

Preventing Rusting

Now that you have seen the conditions necessary for rusting and its effects, it is important to look for methods by which rusting can be prevented. To prevent rusting, one needs to keep the iron utensils away from both air and water.

How is this done?
Some of the methods include covering the article with a layer of oil or grease, or mixing the iron with other metals or alloying and plastic coating of the articles.

Activity of Integration

A community is complaining about the bad air they breathe. You have been invited to give a speech for a village meeting about the causes of this bad air. Write what you would tell this community in terms of

a) the causes of the bad air.
b) how to prevent the occurrence of the bad air.

Chapter Summary

In this chapter, you have learnt that:

- the main gases in the atmosphere are nitrogen and oxygen with small amounts of other gases, such as argon and carbon dioxide.
- oxygen is chemically very reactive and combines with other elements to form oxides of the elements. This process is called oxidation. Nitrogen does not easily take part in chemical reactions.
- oxygen and nitrogen are obtained from liquid air by fractional distillation. The pure oxygen is used in hospitals, in welding and in steel making. The main use for nitrogen is the manufacture of nitrate fertilizers.
- many human activities cause air pollution. Solid particles (smoke and dust) or gases can pollute the air.
- some gases such as carbon dioxide and methane can cause air temperature to rise if the amounts of these gases in the air increase. This is known as global warming and scientists and governments are trying to work out ways of stopping more of these gases being produced.
- rusting results from exposing iron articles to air and moisture for a long time.
- rusting can be prevented by covering the items with oil or grease alloying the articles or plastic coating them.

National Curriculum
Development Centre,
P.O. Box 7002, Kampala.
www.ncdc.go.ug