General Science

Student Textbook

Grade 7

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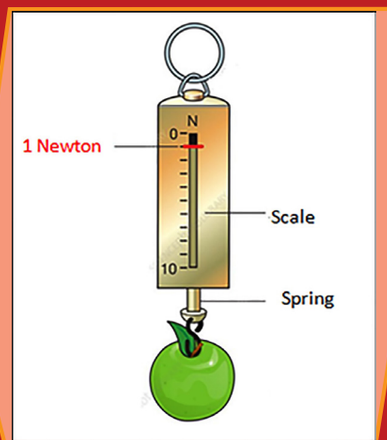

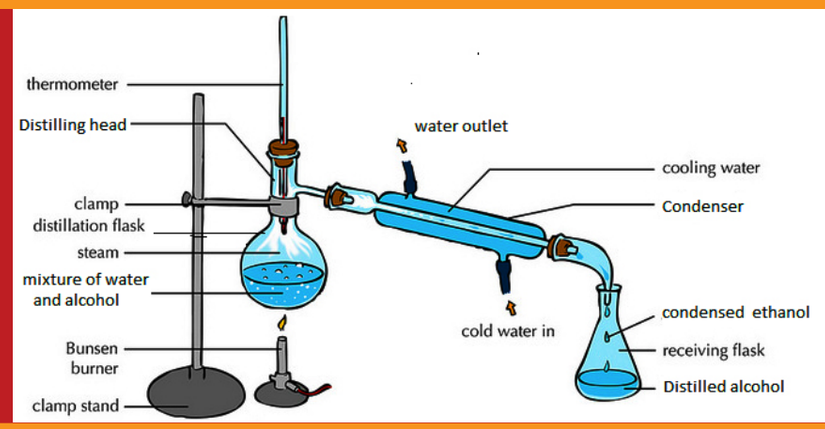

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Scholars Council

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Introduction

Rationale for the Curriculum Reform

Different studies have been conducted to improve the relevance and quality of Ethiopian general education. Worth mentioning are the Education Road-map (2018) and Cambridge Assessment Studies (2019). On top of these, the Ministry of Education and Amhara National Regional State Education Bureau carried out repeated monitoring and assessment of the school curriculum. The study and assessment reports consistently reiterated that the previous general education curriculum had weaknesses. Some of the weaknesses were: The curriculum focused on low-level cognitive domain of learning; the presentation of some contents in the curriculum did not consider students' age and maturity level, and the curriculum did not acknowledge indigenous knowledge systems. Furthermore, the curriculum did not adequately encourage students to develop scientific thinking skills such as observing, classifying, inferring, measuring, communicating, predicting, identifying variables, constructing hypotheses, tabulating and graphing data, defining variables, designing investigations, and experimenting. It also did not provide adequate opportunity for students to develop 21st-century skills such as critical thinking, problem-solving, global and cultural awareness, digital literacy, oral and written communication, creativity, collaboration, decision making, and the like. To alleviate these shortcomings, a new curriculum framework and syllabus have been developed. General science textbooks are developed on the bases of the new curriculum framework and grades 7 and 8 general science syllabus.

General science curriculum

Based on the new curriculum framework, general science textbooks are prepared for middle school students (grades 7 and 8). General Science education includes physics, chemistry, and biology subjects. General Science education aims to equip students with foundational science knowledge and skill that serve as a base for secondary education . It intends to nurture scientific inquiry skills which students use on their day to day lives and in learning science. In addition, it aims to cultivate among students science processes and 21st-century skills that can be used in their day-to-day life and academic career.

To achieve these major goals of general science education, the textbooks are prepared based on the principles of inquiry-based, problem-based and context-based learning. Inquiry is the intentional process of identifying problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments. Inquiry-based learning involves posing questions, making observations, reading books to find out what others have learned, planning investigations, gathering, and analyzing information, reflecting on what was learned in the light of new evidence, and proposing explanations and predictions. It encourages students to use critical thinking skills that include designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and communicating findings to deepen students understanding through logic and evidence.

Problem-based learning allows students to become the drivers of their learning. Problem-based learning uses complex, real-world issues as the classroom's subject matter, encourage students to develop problem-solving skills and learn concepts instead of just absorbing facts. It promotes students' conceptual learning and skill development. It helps students to acquire knowledge and skill in the context of real-world problems. It engages the students in solving meaningful problems.

Context-based learning is using students' prior knowledge, experience, and context as a base for the new knowledge and skill development. It encourages students to recall, relate, describe, or apply knowledge from relevant prior experience that can be used as a foundation for the new knowledge.

Teachers, students, and parents will take part in the knowledge construction process. It is important that teachers, students, and parents engage in observations, experiments, and construction of knowledge. Hence, the textbooks are intended not only to provide adequate knowledge and skill but also develop among students learning to learn skills.

Implementation of the new learning and teaching techniques and methods

General science textbooks include many activities that are helpful to put into practice the aforementioned learning-teaching methods. The activities are designed based on students' prior knowledge, skill, and experiences. They are aimed to connect students' life experience with classroom science, to develop students' science process, inquiry, and 21st-century skills. To achieve the aims of these activities, students should prepare themselves before class, and should be active participants in the classroom. Teachers should encourage students to work on the activities before class. During the teaching-learning process, the teachers are not expected to provide answers for each activity before the students work on it. The students should be given enough time, needed materials, and clues while they are working on the activities. The teachers should lead students' work very closely and scaffold them when necessary.

Contents in the textbooks require appropriate utilization of instructional time and extending learning to home and libraries. It is also indispensable that every student brings his or her textbook to class. Parents should also assist students in carrying out different activities. It is critical that teachers ensure that all activities and contents in textbooks are properly covered and learned by students.

Dear students, please take good care of the textbook!

Learning requires effort, experimenting, and exercise!

We wish you a successful academic year

Unit 1

Basic Concepts of Science

Learning outcomes: At the end of this unit, you will be able to:

- Explain the nature of science.
- Describe the main branches of science.
- Explain the difference between science and technology.
- Explain how science and technology affects human behavior, practice and ways of thinking.
- Appreciate the contributions of famous Ethiopian scientists to science and technology.
- Identify basic and derived units of measurements .
- Explain the concept of measuring physical quantities.
- Explain the difference between scalar, vector physical quantities, fundamental and derived physical quantities.
- Identify different laboratory tools.
- Demonstrate safe ways of using apparatus in the laboratory.
- Practice precautionary measures in the laboratory.
- Apply laboratory safety rules and procedures.
- Identify potential hazards when doing laboratory Experiment s.

1.1 Nature of science

1.1.1 Definition of science

In order to understand what science is, it is necessary to deal with the key characteristics of science. Discuss Activity 1.1 in groups and reflect your positions to your teacher.

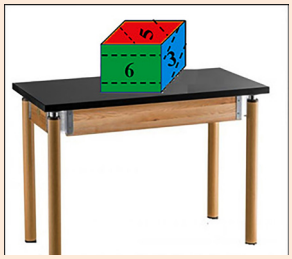
Activity 1.1

The following statements describe some aspects of science and scientific knowledge. Discuss in groups whether you agree or disagree with the statements.

1. Scientific knowledge is absolute and unchanging.
2. Science always involves Experiment s.
3. There is single scientific method that all scientists follow.
4. Scientific theory and scientific law represent the same concept.

Activity 1.2

Consider a cube placed at the center of a Table as shown in the picture and answer the questions below. (Note that when you are working in a group, do not turn, lift or open the cube to see what is on the bottom).



1. What do you observe on the Table ?
2. Based on your observation,
   - A. What number is on the bottom of the cube?
   - B. What is the color of the bottom face?
   - C. What is the pattern of the bottom face?

(Justify your answers based on your observations)

When doing Activity 1.2, you demonstrated some characteristics of the nature of science and you did in a similar manner as scientists do. For example you:

- Worked in group
- Observed the cube
- Inferred answers based on your observation and experience
- Supported your answers (inferences) with evidence from your observation.

You also used your creativity and imagination to determine patterns and relationships. Scientists make inferences in a similar way as you did when they attempt to find answers to questions about natural phenomena.

In your discussion, you probably came up with different answers to the questions. The existence of different answers to the same question based on the same evidence is another characteristic of the nature of science. In the same manner, scientists can come up with different ideas based on the same set of data.

In general, the characteristics of the Nature of Science (NOS) and their respective descriptions are given in Table 1.1 below.

Table 1.1 Characteristics of nature of science

Characteristics of Nature of Science	Description
Scientific knowledge is based on empirical evidence.	Empirical evidence in the form of quantitative and qualitative data is the base of scientific knowledge.
Scientific knowledge is tentative.	Scientific knowledge should not be viewed as absolute. It can be changed with the existence of new evidence.
Scientific knowledge is the product of observation and inference.	Scientific knowledge is developed from a combination of observations and inferences.
Scientific knowledge is the product of creative thinking.	Scientists often use creative methods and procedures throughout their investigations.
Scientific laws and theories are different kinds of scientific knowledge.	A scientific law is a description of relationship or pattern based on observations. Scientific theories are a well-supported explanations for scientific phenomena.
Scientists use many methods to develop scientific knowledge.	There is no a single “scientific method” used by all scientists.
Science is a social Activity that possesses inherent subjectivity.	Science is a result of social or collaborative effort and personal background or experience affects our observations.

Therefore, science is not only a body of knowledge. It is also described as a way of knowing the natural world through investigating observation and evidence using creative and imaginative ways.

Activity 1.3

Read individually the following text about telephone invention and identify the statements which describe the characteristics of the nature of science. Match the identified statements with the different characteristics of the nature of science.

Brief history of telephone invention

Telephone is one of the most important inventions. It lets people talk to each other at the same time across long distances. It is one of the greatest inventions in communication technology. The invention changed the way we communicate today.

Many inventors were working on electronic voice transmission during the time of the invention of telephone. However, Alexander Graham Bell was the first to be awarded a patent for the electric telephone in 1876. He developed new and original ideas by building on older ideas and developments. He drew his inspiration from teaching deaf and observation of his hearing-impaired mom. His endless scientific curiosity, creativity and understanding of sound and electricity led him to invent the telephone. His invention has become a base for today's wireless telephones.

1.1.2 Branches of science

Science can be divided into three major branches. These branches are life science, physical science and earth science. While life science studies living things, physical science studies about non-living things. Earth science is concerned with the study of earth's structure, properties, and processes.

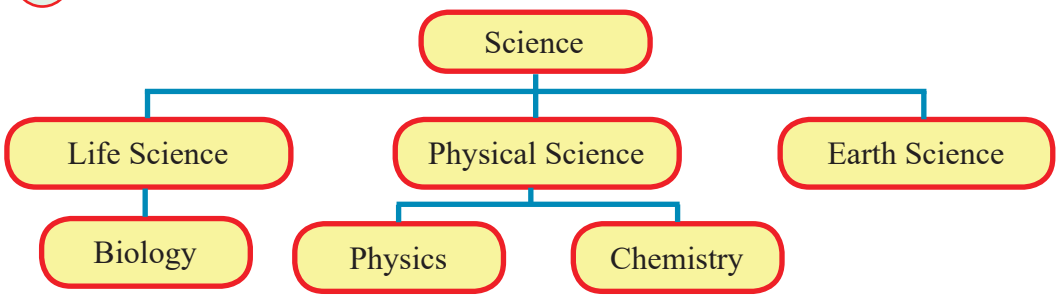


Figure 1.1 Branches of science

1.1.3 Conventional and indigenous knowledge

Activity 1.4

Imagine that you are caught with a common cold in a place where there is no health institution such as clinic, hospital, and pharmacy. What do you do to get rid of the disease?

Activity 1.5

Read the following scenario and discuss the questions below. The scenario is about a girl and a boy who were caught with malaria, and what they did to be cured from it.

Scenario

The girl went to a hospital to get her doctor immediately after she recognized some symptoms of malaria. The doctor diagnosed her and found malaria from her blood test. The doctor then gave her some medicines. After she had taken the medicines, she recovered from the disease.

On the other hand, the boy went to an old man's house when he felt a headache. The old man lived near the boy's house and was experienced in traditional medicine. When the boy arrived, the old man asked him some questions in relation to his headache. After the old man listened to the boy carefully, he went to a garden and came with some leaves. He squeezed the leaves with water into a beaker and gave it to the boy. The boy then drank the traditional medicine. After some time, the boy got relief from his headache.

Questions

1. If you were the person who had been caught with malaria, where would you go to recover from your illness? To the hospital or to the old man? Justify your choice.

Indigenous knowledge and conventional knowledge represent two knowledge categories. They are obtained by different ways of looking at the world around us. Conventional knowledge is acquired through the method of conventional science. Terms such as "modern knowledge" and "western knowledge" are often used to refer to conventional knowledge. This type of knowledge system has the following characteristics.

- It is tentative
- It is evidence supported
- It is based on observation and inferences
- It is systematically documented
- It is learned by formal education.

Indigenous knowledge is a knowledge system built up by a group of people in a given culture. It is obtained through the accumulation of experiences, informal education and intimate understanding of their environment. Indigenous knowledge is also called "traditional knowledge", "local knowledge" or "native knowledge". This knowledge system has the following characteristics

- It is based on experience and acquired from observations over time
- It is unwritten and known through oral traditions
- It is embedded in culture
- It is unique to a given society
- It is subjective and long term wisdom.

In our surrounding there are many examples of indigenous knowledge. Some of them are the following.

- Traditional medicine
- Traditional alcohol production
- Drying (for food preservation)
- Traditional weaving

- Tracing and crop rotation (for soil conservation)
- Traditional water conservations

Project work

It is known that Ethiopia is very rich in different indigenous knowledge. By asking your parents, write as many types of indigenous knowledge as you can and report to your teacher. Your report should contain the local names of the indigenous knowledge and their benefits and weaknesses, if they have.

1.1.4 Science and technology

Activity 1.6

1. How are science and technology related? How are they different?
2. What do you think are the effects of science and technology?
3. Which has a more direct effect on society? Science or technology? Justify your answers.

The relation between science and technology are reciprocal. A scientific explanation of a phenomenon leads to a technological development that serves a societal need. Conversely, a societal need results in a technological solution, which then leads to a scientific explanation. However, technology often has a more direct effect on society as it solves practical problems and serves human needs. Science and technology have some differences as shown in the following Table 1.2.

Table 1.2: Difference between science and technology

Science	Technology
◆ It is the process of exploring new knowledge.	◆ It is the practical application of scientific knowledge.
◆ It is always useful.	◆ It can be useful or harmful.
◆ It emphasizes discovery.	◆ It emphasizes invention.
◆ It is used to make predictions.	◆ Technology simplifies human life.
◆ It advances scientific knowledge and discovery.	◆ It advances the standard of living in societies.

Activity 1.7

Read the following two paragraphs and discuss the questions below.

History of light bulb

More than 150 years ago, inventors began working on a bright idea. The idea was to invent the light bulb. Like all other great inventions, the light bulb can't be credited to one inventor. It was a series of small improvements on the ideas of previous inventors. This led to the idea and the invention of light bulbs we use in our homes today.

It was Thomas Edison who discovered the light bulb in 1879. Thomas Edison did not stop his contribution to improve electric lighting after the invention. He was working to improve the bulb that made the use of light bulbs practical.

Questions

1. Is the development scientific or technological? Which statement in the paragraphs supports your answer?
2. What benefits did scientific and technological development provide to society?

Activity 1.8

Do the following questions at your home and present your answers to your classmates.

1. List some examples of technologies that are used by the community in your surrounding and discuss how these technologies solve practical problems of the community.
2. Do these technologies have risks? If they have, what are their risks?

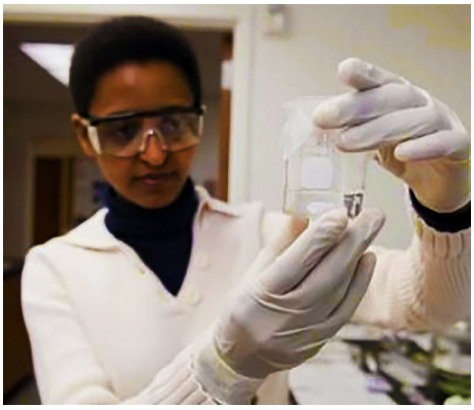
1.1.5 Scientists and ethical discipline

Since science is a human Activity , it relates to different human values. The diverse set of values that contribute to the regulation of scientific activities is said to be scientific ethics or scientific discipline. Scientific ethics is extremely integrated into the ways scientists do their work. Thus, the reliability of their work and the scientific knowledge they investigated depends upon whether they follow the ethic or not. Some of the ethical disciplines in science are the following.

1. Integrity and honesty in reporting scientific data.
2. Careful analysis of scientific results to avoid error.
3. Proper crediting of sources of information, data, and ideas
4. Objective interpretation of results without bias.
5. Informing members of the community about any risks of the scientific investigation.

1.1.6 Ethiopian scientists

There are many scientists around the world who contributed to the development of science and technology. The following are some of the Ethiopian scientists who played a big role in technological advancement.

Ethiopian Scientist	Major contributions
 *Dr. Kitaw Ejigu*	◆ Inventing two aerospace mechanisms which were patented under National Aeronautics and Space Administration's (NASA) new technology. ◆ Creating space shuttles and rockets that assisted in planetary science. ◆ Innovative creations of the Global Positioning System (GPS), and a revolutionary and dynamic flight simulator for the Boeing Company.
 *Dr. Sossina Haile*	◆ Outstanding research in ceramic science ◆ Developed new ways of using solar energy to make fuels like hydrogen and methane. ◆ Investigated solid electrolytes
 *Professor Gebisa Ejeta*	◆ Investigated 'sorghum' with high nutritional quality; Which tolerates drought and cold and Which has resistance to pests, diseases and the parasitic weed.

Dr. Rediet Abebe

- Co-founder of Mechanism Design for Social Good, to improve access to opportunity for historically disadvantaged communities.
- Co-founder for Black in AI (Artificial Intelligence)- A place for sharing ideas, fostering collaboration and discussing initiatives to increases black people in the field of artificial intelligence.

Dr. Aklilu Lemma

- Discovered medicine to prevent the parasitic disease, 'Bilharzia', from the fruit of a common African plant, the "Endod"

Professor Alemtsehay Mekonnon

- A respected scientist in human physiology
- Assessing the medical and nutritional value of plants.
- Examining the health hazards of medical plants to humans, animals and the environment

Activity 1. 9

1. Take one Ethiopian scientist, write a short biography of him/her and briefly describe the contributions of his/her work to the society.

1.2 Scientific measurement

Measurable quantities which are used to describe physical phenomena are called physical quantities. Length, mass, time, volume, density and temperature are some examples of physical quantities. Physical quantities possess at least magnitude (numerical value) and unit.

1.2.1 Fundamental and derived physical quantities

Physical quantities can be divided into two. These are fundamental (basic) quantities and derived quantities. Fundamental physical quantities are quantities which can be measured directly. They are not described in terms of other physical quantities. Length, mass, time, temperature, electric current, amount of substances and luminous intensity are the seven fundamental physical quantities. The units used to measure these fundamental quantities are called fundamental units. The seven fundamental quantities with their respective SI units are shown in Table 1.3.

Table 1.3 Fundamental physical quantities and fundamental units

Basic Quantities		Basic Units	
Name	**Symbol**	**Name**	**Symbol**
Length	l	meter	m
Time	t	second	s
Mass	m	kilogram	kg
Temperature	T	Kelvin	K
Current	I	Ampere	A
Amount of substance	N	mole	mol
Luminous intensity		Candela	Cd

Derived physical quantities are quantities that can be obtained by the combination of the fundamental quantities. Area, density, speed and volume are examples of derived physical quantities. All derived physical quantities have derived units. Table 1.4 presents some examples of derived physical quantities and their respective units.

Table 1.4 Some examples of derived physical quantities and derived units

Derived Quantities		Derived Units	
Name	Formula	Name	Symbol
Velocity	Distance/Time	Meter per second	m/s
Acceleration	Velocity/Time	Meter per second squared	m/s^2
Force	(Mass) (Acceleration)	Newton	$kg.m/s^2$
Work	(Force)(Distance)	Joule	$kg.m2/s^2$

Activity 1. 10

Express the derived units of the following quantities in terms of the fundamental units.

- Area
- Volume
- Density
- Power

1.2.2 Scalar and vector physical quantities

Some physical quantities are described completely by only a number and a unit (magnitude). This type of quantities is called scalar physical quantities. Scalar quantities do not require direction for their description. Time, mass, volume, density, temperature and energy are examples of scalar quantities. However, there are quantities that cannot be described fully by the use of only magnitude. To describe these quantities, both magnitude and direction are required. Quantities which have both magnitude and direction are called vector physical quantities. Displacement, velocity and force are examples of vector quantities.

Prefixes

We commonly write numbers using scientific notations. Scientific notation is the short hand representations of very large or very small numbers. For example, 1000g can be written as 1×10^3 g. But, it is possible to replace the 10^3 with the prefix called "k" (kilo). Therefore, 1×10^3 g can be written as 1kg. Table 1.5 presents prefixes, their symbols and values.

Table 1. 5 Prefixes

Prefix	Symbol	Value	Prefix	Symbol	Value
peta	P	10^{15}	femto	f	10^{-15}
tera	T	10^{12}	pico	p	10^{-12}
giga	G	10^{9}	nano	n	10^{-9}
mega	M	10^{6}	micro	μ	10^{-6}
kilo	k	10^{3}	milli	m	10^{-3}
hecto	h	10^{2}	centi	c	10^{-2}
deka	da	10^{1}	deci	d	10^{-1}

1.2.3 Measuring physical quantities

Measurement is a way of describing the natural world with numbers. Measuring something means comparing the quantity to be measured with a reference standard unit. Standard unit of measurements are unit of measurements which are well-defined, highly precise and easily reproducible. They are unchanging with respect to place, time and physical conditions. These standard units are known as System of International Units (SI units). For example, 'second' is a standard unit of measuring time. So, the duration of a second is fixed and the same to everyone at every place on earth.

Measuring Length

Length is a fundamental physical quantity that represents distance between two points. Length is often designated by "l". But, it can also be designated by symbols such as 'b', 'h', 'w' etc. The SI unit of length is meter (m). The non-SI units of length are centimeter (cm), millimeter (mm), kilometer (km), etc.

Length can be measured in two ways: traditionally and scientifically. Traditionally, length can be measured by units such as 'hand span', 'cubit', 'foot' and 'yard'. However, these traditional units are not reliable. This is because measurements using these units vary from person to person. On the other hand, the scientific way of measuring length used scientific instruments such as ruler, Vernier caliper, and micrometer to measure length. In scientific way, standard units of measurement are used to measure length.

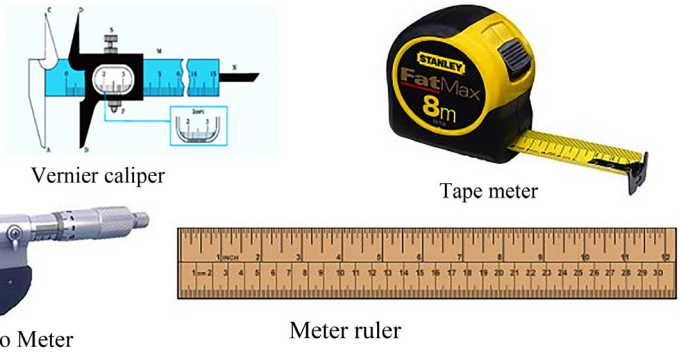


Figure 1.1: Length measuring instruments

Activity 1. 11

Form a group and do the following activities.

1. Measure the lengths of the following objects using appropriate traditional ways and write the measurements in the Table .
2. Measure the length of the objects using appropriate scientific instruments and write the measurements in the Table .

(Note: Take the measurements of the length of each objects by three different students)

Objects to be measured	Measurements					
	Traditional			Scientific		
	S_1	S_2	S_3	S_1	S_2	S_3
A. Width of the blackboard						
B. Thickness of your General Science textbook						
C. Length of your Table						

Questions

A. Which set of measurements (traditional or scientific) is more reliable? Why?

B. Are the scientific measurements of the three students equal? If not, why?

The length of an object to be measured determines the type of unit to be used. For example, centimeter (cm) and millimeter (mm) are appropriate to measure small lengths whereas kilometer (km) is suiTable for measuring longer lengths. So, we can use meter to measure the width of the classroom, kilometer to measure the distance from Bahir Dar to Gondar, millimeter to measure the thickness of an electric wire, and so on.

Measuring Mass

Activity 1. 12

1. Explain how we measure mass traditionally? Share your experiences with your peers.
2. How do you measure mass of jewelries? What is the appropriate unit to measure mass of jewelries?

Mass is a fundamental physical quantity that describes the amount of matter contained in a body. It is symbolized by 'm'. The SI unit of mass is kilogram (kg). The non-SI units of mass are Gram (g), milligram (mg), quintal, ton and so on. Smaller masses are measured using grams and kilogram while larger masses are measured using quintals and tons.

Mass can be measured both traditionally and scientifically. Traditionally, instruments such as 'kuna', 'tassa' and traditional beam balance are used to measure mass. Where as to measure mass scientifically, we use scientific instruments such as beam balance. A common type of beam balance consists of a uniform beam having two pans. To measure mass of a body, a known standard (for example 1kg) is placed on one pan, and the body to be measured is placed on the other pan. The unknown mass of the body will be equal to the known standard when the beam balance is balanced. Figure 1.2 shows different mass measuring instruments.

Figure 1.2 Mass measuring instruments

Activity 1. 13

Form a group and do the following activities.

1. How do we measure small masses such as a single grain or a single Teff?
2. Estimate and then measure the mass of the following objects and write your estimation and measurement on the space provided. Compare the estimated value with the measured value.

Objects to measured	Estimated Value	Measured Value
A. Your General Science textbook		
B. One stick chalk		
C. A duster		

Measuring Time

Activity 1. 14

1. Put your hand on your neck and count 50, 100 and 150 heartbeats.
2. Measure the time you need to count 50, 100 and 150 heartbeats.
3. Tell to your classmates and teacher how you measured the time.

Time is a fundamental physical quantity that describes the duration between the beginning and end of an event. It is designated by 't'. The SI unit of time is second (s). The non-SI units of time are Year, month, day, hour, and minutes . Similar to length and mass, time is measured using traditional and scientific ways. Traditionally, people used methods such as shadow, position of sun, cook crows and bird's crisps to estimate time. For example, bird's crisps indicate the dawning of the day. On the other hand, the scientific way of measuring time involves the use of clocks and watches to measure time. Figure 1.3 shows some time measuring watches.

A. Analogue watch B. Digital watch C. Stop watch

Figure 1.3 Time measuring devices

Activity 1. 15

Make your own sundial.

Materials required: hoe, wooden stick, marking rocks or cards

1. Find a location, that remains sunny, in your school compound.
2. Dig a hole and place a wooden stick on the hole. Make sure that the wooden hole stays upright.
3. Mark the shadow of the wooden stick every hour using a rock or a card.
4. Write the number for the hour (such as 4) on the rock or card.
5. Do you observe that the angle between consecutive cards or rocks is the same or different? Justify your answer.
6. How is your sundial similar or different from a clock?

1.2.4 Accuracy and precision in measurements

Activity 1. 16

Assume that four groups of students measured the boling temperature of water. Their measurements are recorded in the following Table . Based on the data in the Table , answer the following questions.

1. Which group has measured an average boiling temperature closest to the expected value?
2. Which group measurements are close to each other?
3. One of the students in group A was not happy with the group's result. Why do you think this was?
4. Suggest two reasons why group A's results are different to the rest of the class.

Trials	Boiling temperature of water (°C) (100°)			
	Group A	Group B	Group C	Group D
1	90.0	95.0	99.0	102.5
2	91.0	100.0	100.0	100.0
3	90.5	101.0	99.5	101.0
Mean	90.5			

Accuracy and precision are two concepts which are related to measurement. Accuracy refers to how close a measurement is to its actual or expected value. For example, in the above Activity , the average of measurements of group C is more accurate that of the other groups. This is because the average value of measurements in group C is close to the actual value (100°C).

Precision refers to the consistency of two or more measurements namely how close these measurements are to each other. For example, in the above Activity, the measurements recorded by group A are precise than the others. This is because the measurements in group A are more close to each other than the measurements in the other groups.

1.3 Common laboratory equipment, uses, safety rules and procedures in science laboratories

1.3.1 Laboratory safety rules

Activity 1. 17

1. When cooking, what safety precautions should be taken? (To avoid burns, cuts, etc.)
2. When doing science Experiment s, what similar kinds and other safety precautions should be taken?
3. To what extent is your classroom or school prepared for a kind of emergency you might have when doing science Experiment s?
4. Is there any safety equipment in your school? Look around your classroom or school for any safety related equipment.
5. Draw a floor plan of the room or building and clearly label where each item is located. Discuss with your friend or classmate?
6. Why is it important to know where safety equipment is located?

Laboratory safety involves good laboratory practice by establishing a safe environment. Laboratories can be hazardous if the rules are not followed. In a laboratory Activity , a student may handle materials which are hazardous, poisonous, flammable, and explosive. Some of these materials and equipment may also cause severe burns or cuts if they are handled improperly or carelessly. Most accidents that occur in the laboratory are a result of carelessness, impatience, improper or unauthorized Experiment ation, and disregard for safety rules or proper operating procedures. To minimize the chances of an accident in the laboratory certain rules and regulations must be obeyed at all times when one is working or observing in a laboratory. Therefore, it is not advisable for anyone to work in a laboratory without proper knowledge of the dangers involved. . The followings are some of the basic safety rules to avoid hazards and accidents during laboratory activities.

1. DO NOT perform unauthorized Experiment s or work in a laboratory alone.
2. If you get a chemical in your eye, rinse immediately with large quantities of water.
3. Long hair and loose clothing must be confined while in a laboratory.
4. Appropriate clothing must be worn at all times while in the laboratory.
5. Eating and drinking are not allowed in a laboratory.
6. Never direct the open end of the test tube toward yourself or anyone else.
7. Never pour water into concentrated acid.
8. Liquid and solid waste containers must be properly used at all times.
9. Report any accident and/or injury, however minor, to your teacher immediately.
10. Clean up any spill immediately.

1.3.2 Hazard signs (symbols) and some personal protective equipment in the laboratory

There is always a possibility of hazard or accidents in laboratories. Hazard signs are put on the bottles or containers of some chemicals. So we should understand the hazards associated with these chemicals and take extra care. There is also a possibility of fire hazard and electrical hazard in the laboratory. Hazard signs are also put on the walls at different places in the laboratory.

It is important that you are aware of the potential hazards and risks in the laboratory. It is vital that you and the whole class understand each hazard of the laboratory and take the necessary care. This can save us from different accidents that can happen in the laboratory.

Activity 1.18

Look at the following laboratory hazard signs. Then match the signs with the meanings of the signs listed below.

A. Corrosive material
B. No open flames
C. Electrical hazard
D. Oxidizing agent
E. Flammable and combustible
F. Harmful irritant
G. Poison/ toxic material
H. Flammable gas
I. Explosive hazard
J. High voltage

		
1	2	3
		
4	5	6

			
7	8	9	10

Figure 1.4 Symbols of hazard signs

1.3.3 Personal protective equipment in the laboratory activity

Science Experiment s often can lead to an unexpected hazardous situation. Wearing personal protective equipment (PPE) is an easy choice that can save you from grief. The purpose of PPE is to protect individuals from hazards during a specific task. PPE should be selected based on a hazard assessment of the specific task. When you are around hazardous chemicals or equipment (even if you are not using them), a minimum level of PPE should be applied. PPE minimizes the chance of harm from the hazard but does not alter the nature of the hazard itself.

Activity 1.19

Look at the following laboratory personal protective equipment and match images with names.

1. Safety glass
2. Fire extinguisher
3. Glove
4. Face shield

A

B

C

D

Figure 1.5 Laboratory personal protective equipment

1.3.4 Common laboratory equipment/tools

Activity 1. 20

Look at the pictures of laboratory equipment/ tools in the Table below and match their names with their functions.

1. Used to hold multiple test tubes upright at the same time.
2. Used for holding small samples or for covering beakers or evaporating dishes.
3. Used to determine the mass of chemicals.
4. Used for funneling liquids from one container to another or for filtering when equipped with filter paper.
5. Useful as a reaction container or to hold liquid or solid samples. They are also used to catch liquids from titration and filtrates from filtering operations.
6. Are sources of heat.
7. Used for addition of liquids drop by drop

8. Used to mix, heat and/or hold small quantities of chemicals for assays and laboratory Experiment s
9. Used for holding items
10. Used on a ring supports beakers to be heated by Bunsen burners
11. Used for holding test tubes when tubes should not be touched
12. Used to examine too small objects such as cells, microorganisms, etc. that cannot be seen by the naked eye.
13. Used to produce a magnified image of an object.

Equipment/ tool

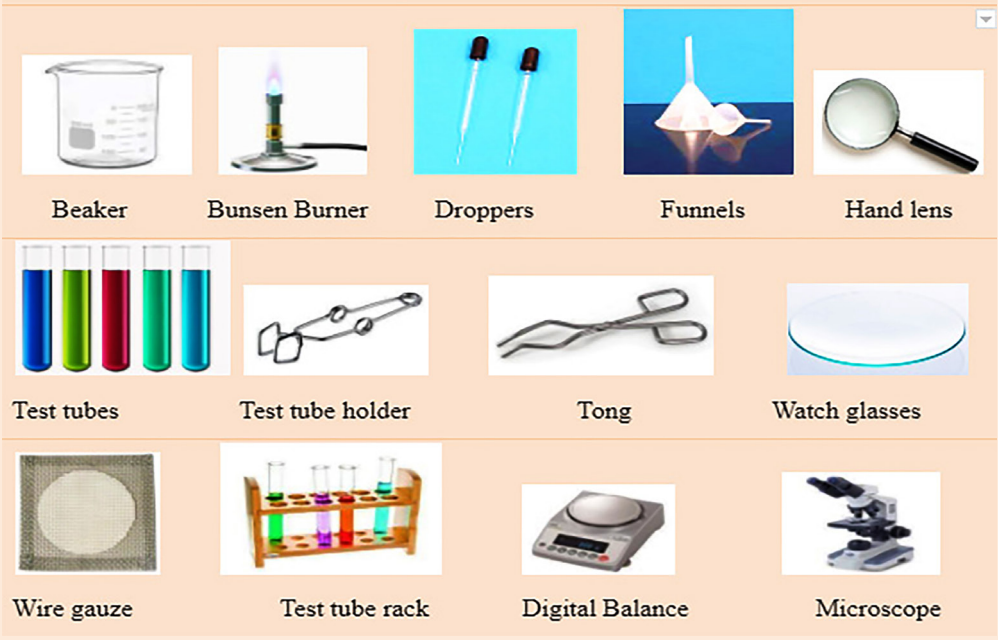


Figure 1.6 Common laboratory equipment

Activity 1.21

Assume that you are doing an evaporation Experiment to get the salt that has dissolved in water.

1. What kinds of laboratory equipment do you need? Why?
2. What are the possible hazards associated with this Experiment ?
3. What safety measures will you follow?

1.3.5 Making laboratory equipment/tools from locally available materials

For junior schools, we do not need a great deal of expensive laboratory apparatus to perform Experiment s. We can make much of the equipment from ordinary things in our home or surrounding. In this section, you are going to make some laboratory tools from local materials.

Project work

Activity 1.22

Prepare the following laboratory tools from local materials in groups. Use the pictures given above to help you imagine the design. If you need help, contact your teacher. Your teacher will assign one laboratory tool for each group.

1. Test tube holder
2. Alcohol burner
3. Test tube rack
4. Beaker
5. Wire gauze
6. Funnel

Summary

- Science can be defined as a way of knowing the natural world through investigating evidence together and making sense of that evidence to explain the natural world.
- Science has three major branches: Life science, physical science and earth science. Life science studies living things.
- Conventional knowledge is acquired through the method of conventional science and characterized by tentativeness, evidence supported, claims based on observation and inferences, systematically documented, and learned by formal education.
- Indigenous knowledge is a knowledge system built up by a group of people through the accumulation of experiences, informal Experiment s and intimate understanding of the environment in a given culture.
- Technology refers to the process of applying scientific knowledge in practical applications for various purposes.
- Technology has a more direct effect on society as it solves practical problems and serves human needs.
- Adhering to safety rules is important while working in the laboratory.
- Measurement of an object consists of units and numerical values. Traditional units of measurements are not reliable and not exact but the conventional (SI) units are more reliable.
- Physical quantities can be basic, derived, scalar or vector quantities.
- Fundamental quantities are quantities that are obtained by direct measurement, but derived quantities are obtained by combining the fundamental quantities.
- Quantities that can be described by only magnitude are called scalar quantities.
- Quantities that can be described by both magnitude and direction are called vector quantities.

Review questions and problems

I. Choose the best answer from the given alternatives

1.At one time, many people thought disease was caused by fate or misbehavior. Following the invention of the microscope, bacteria were discovered. After this, a new theory of what causes disease arose that was known as the germ theory. Why was the original theory modified?

A. It quickly became obvious that germs causes disease

B. The person who invented the microscope became ill

C. New evidence promoted revision to the original ideas

D. The proponents of the germ theory had political power

2. Which of the following is true about theory and law?

A. A theory explains a set of well tested observations; and a law describes a pattern in nature

B. Law can be changed with the addition of new evidence but theories can not

C. A law explains pattern in nature in more detail than a theory

D. Theory and law can be used interchangeably

3. Why is it necessary that scientists modify scientific theories when important new information is discovered?

A. To confuse the scientists

B. To keep the theory interesting and refresh

C. To keep the theory as accurate and effective as possible

D. To make sure the general public does not understand the theory

4. Which of the following best describes why scientists discuss and debate on Experiment al results and possible explanations in studying phenomena?

A. Because debating helps scientists to analyzing both the strength and weakness of empirical evidence

B. Because debating helps the scientists to present interesting and exciting science to the public

C. Because debating gives the scientists the opportunity to express their feeling and opinion

D. Because every scientist wants to find an accurate explanation and disproves other's explanation

5. What is the difference between science ad technology?

A. Science is the study of the natural world to gain knowledge, and technology is the use of that knowledge or practical purposes.

B. Technology is the study of the natural world to gain knowledge, and science is the use of that knowledge for practical purposes.

C. Science and technology are the same thing.

D. Science has a direct effect on society than technology.

6. In the past people stored computer data on floppy disks. Eventually, people began to use compact discs with greater storage capacity. Which of the following best describes this situation?

A. Technology leading to a less useful means of storage

B. Technology being used to create a new need or want

C. Technology being used to develop the designed world

D. Technology leading to the development of new technology

7. Which of these is an example of technology helping a scientist?

A. A scientist discusses a theory with different colleagues.

B. A scientist determines whether to investigate a volcanic eruption.

C. A scientist performs an Experiment in a laboratory setting.

D. A scientist measures the mass of a chemical on a digital scale.

8. What would you use to measure length?

A. Graduated cylinder

B. Triple beam balance

C. Meter stick

D. Spring scale

9. Which one best describes measurements that are accurate?

   A. They are very close to an accepted value.

   B. They are based on an estimate.

   C. They are very close to each other.

   D. They are not based on numbers.

10. Which one of the following is not a vector quantity?

   A. Displacement B. Force C. Density D. Velocity

11. Which one of the following is a derived SI unit?

   A. Newton B. Kelvin C. Kilogram D. Second

12. 2 hr. + 20 min + 60 sec are equal to _____ minutes.

   A. 120min B. 150 min C. 141min D. 161 min

II. Answer the following questions briefly

13. Mention some examples of technologies in the field of communication, health, agriculture and education. Briefly explain the benefits you get from the technologies

14. Explain how human needs, science and technology are interrelated?

15. Does development in technology have risks? If so, mention some risks of advancement in technology?

16. What do you think are the importance of safety rules?

17. List laboratory apparatuses and write their uses.

Unit 2

Matter in Our Surroundings

Learning outcomes: At the end of this unit, you will be able to:

- Use particle theory's postulates to explain properties and behavior of materials.
- Classify matter as an element, compound, homogeneous mixture, or heterogeneous mixture with regard to its physical properties.
- Describe the structure of solids, liquids and gases in terms of particle separation, arrangement and types of motion.
- Differentiate between physical and chemical properties and changes of matter.
- Appreciate that matter can be classified based on physical or chemical properties.
- Use properties of matter to identify substances and to separate them.
- Demonstrate scientific inquiry skills along this unit: observing, classifying, comparing and contrasting, making models, inferring, communicating, asking questions, designing Experiment s, drawing conclusions, applying concepts.

Activity 2.1

Take a spoon of sugar and grind it into a tiny pieces. Again continuously grind these pieces into a very fine powder. Next, dissolve the sugar in water Yet if you taste the solution, you know that the sugar is still there.

1. What do you think has happened to the sugar?
2. What do you think about the size and volume of sugar pieces?
3. Do you think the mass of sugar changed?
4. Write your conclusion about how matter is made of?

2.1. Characteristics and nature of matter

2.1.1 Meaning and properties of matter

Activity 2.2

In your home and class, you use many materials like tea cup, pen, textbook, shoes, and black board for different purposes. What do all these matters have in common?

As you look at your surroundings, you see a large variety of things with different shapes, colors, sizes and textures. The air you breathe, the food you eat, stones, stars, plants, animals, a drop of water, a particle of sand, etc are forms of matter.

Activity 2.3

In your surroundings you get or experience chairs, air, sound, light, banana, water, and smell of perfume. Which of them do you think have mass and occupies space and which do not?

Anything that occupies space and has mass is called matter. Matter can exist in three physical states. These are solid, liquid, or gases.

2.1.2 Particulate nature of matter

A. Particle model of matter

Activity 2.4

Fill one graduated cylinder with 50 mL of sand and another graduated cylinder with 50 mL of water. Pour 50 mL of water into the graduated cylinder filled with 50 mL of sand. Observe carefully the air bubbles that rise to the surface.

1. What is the total volume of sand and water?
2. Why is the final volume less than 100 mL?
3. What do you conclude from this Experiment ?

The Particle Theory of Matter helps us to explain why different matters have different properties.

The Particle Theory of Matter has the following key ideas:

1. All matter is made of tiny particles.
2. Particles of matter are attracted to each other.
3. Particles of matter have spaces between them.
4. Particles of matter are always in motion.
5. Temperature affects how fast particles move.
6. Particles of one substance differ from the particles of other substances.

Experiment 2.1

Title: Demonstration of the particulate nature of matter.

Objective: To demonstrate that matter is made up of smaller particles.

Chemicals: Potassium permanganate crystal or ink and water.

Apparatus: Beakers and spatula.

Procedure:

1. Pour water into the beaker till it is half full.
2. Dissolve some potassium permanganate crystals or ink until the solution is purple.
3. Transfer half the solution into another beaker and fill it with water.
4. Continue the process with other beakers, comparing the color of the solution through each dilution.

Observation analysis:

1. What happens to the color of the solution upon each dilution?
2. What does this signify?
3. What is your conclusion?

2.1.3 Explaining observations using the particle theory of matter

A. Diffusion and everyday effects of diffusion

Activity 2.5

Spray a perfume from a corner of the classroom. (You can substitute perfume with burning incense (Etan) or sendel.)

1. Do you smell the perfume or incense? Why?
2. Why was it possible for you to smell from a distance?

Diffusion is an evidence for the particulate nature of matter. It is the process by which particles of liquids or gases spread out randomly from a region of high concentration to lower concentration.

Diffusion occurs because particles in a substance are always moving around. Particles of gases diffuse quickly. The particles of gases are moving fast as a result of very weak intermolecular forces between them.

Liquids can also undergo diffusion. The rate of diffusion of liquids is slower than gases because liquids particles move more slowly due to strong intermolecular attraction force that held them.

For example, if you drop a small amount of ink into a jar of water the color will spread slowly through the water by diffusion.

Diffusion does not usually happen in solids because the particles in solids can only vibrate on fixed position due to very strong intermolecular attraction force that held particles of solids together.

B. Properties of solids, liquids and gases

The differences in the properties of states of matter are given in the following Table.

Table 2.1: Properties of solid, liquid and gaseous state

Solid state	Liquid state	Gaseous state
Have definite shape and volume	Have definite volume but no definite shape. Liquids attain the shape of their container	Gases have neither definite shape nor definite volume
Are incompressible	Are compressible to a small extent	Are highly compressible
The particles attract each other very strongly	The force of attraction between liquid particles is weaker than solid particles	The force of attraction is much weaker than liquid and solid particles
Particles of solid cannot move freely	These particles of liquids move freely	Gaseous particles are in a continuous, freely random motion
Particles are very much closer to each other	Far apart particles compared to solids	Very far apart particles compared to liquids

C. Particles in solids, liquids and gases

Activity 2.6

The following Figure s represent the three physical state of substances. Which of the following Figure s represent solid, liquid or gas? Explain.

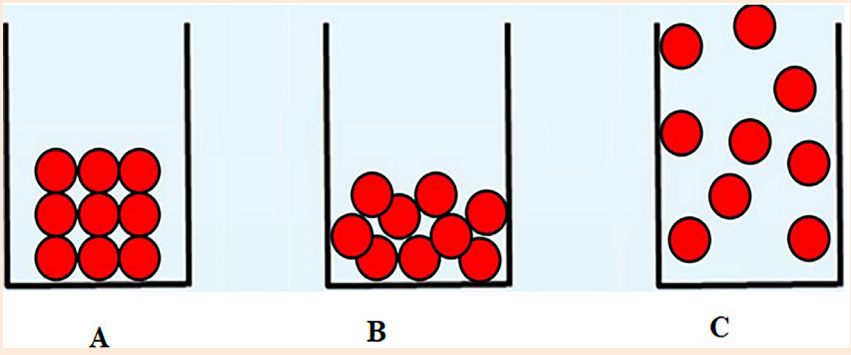


Figure 2.1: Physical states of matter

Observation and Analysis

1. In which state are the particles more closely packed?
2. In which state do you think the force of attraction is stronger?

The particles in a solid are held together strongly. The spaces between solid particles are very small. A solid has a fixed shape and a fixed volume because the particles only vibrate at their fixed position. The particles vibrate back and forth but remain in their fixed positions.

Gases always fill or occupy their entire container. Since the particles are moving constantly in all directions, they spread throughout their container, no matter what volume or shape their container is.

D. Melting, solidification, condensation and evaporation

Activity 2.7

1. If you hold a piece of ice on your hand for a few minutes what will happen to the ice? Why?
2. If a wet cloth is exposed outside to the sun, it will dry. Why? Where does the water go?
3. If you cool a bottle of water to a very low temperature in a fridge, what will happen to the water?
4. If you place a piece of butter on a hot pan, what will happen to the butter? Why?

The change of a substance from a solid to a liquid state is called melting. The reverse of melting is called freezing or solidification. As a liquid cools, the particles in the liquid lose energy and move more and more slowly and then settle into fixed position. Thus the liquid has frozen or solidified. This process is called solidification or freezing.

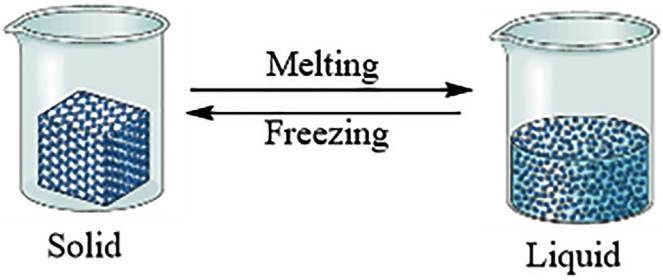


Figure 2.2 Melting and Freezing

When a liquid absorbs heat energy, the particles move more and more quickly. Some of the particles gain enough energy to break free of the other particles. When this happens, the liquid changes to a gas. The change of state of a substance from a liquid to a gas is called evaporation.

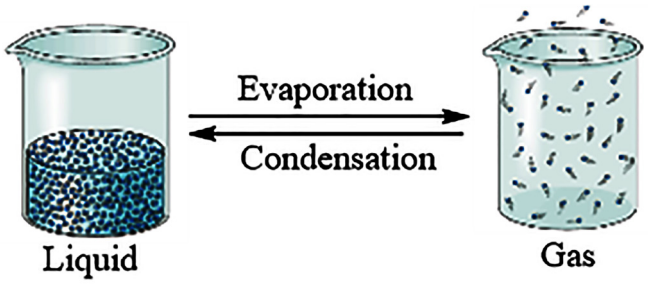


Figure :2.3 Evaporation and Condensation

The reverse of evaporation, i.e. the change of state from a gas to a liquid, is called condensation. As a gas cools, the particles in the gas lose energy and move more and more slowly until the gas condenses to a liquid.

E. Compression

Experiment 2.2

Title: Comparison of gases, liquid and solid.

Objective: To compare compressibility of gas, liquid and solid.

Materials: Three syringes of 100mL, 20 mL or 10 mL.

Chemicals: Chalk powder or soil and water.

Procedure:

1. Take three syringes with their pistons and close the nozzles of the syringes with rubber.

2. Fill syringe I with chalk powder or soil, syringe II with water and syringe III already contains air.
3. Insert back the pistons of the syringes and push the pistons.

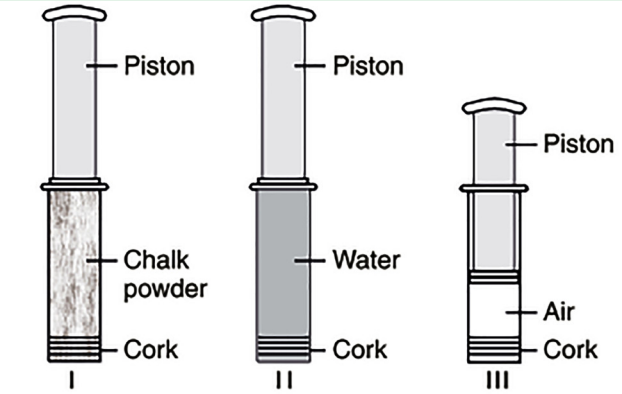


Figure 2.4 Compression using syringes

Observation and analysis:

1. What did you observe?
2. Why do you think you are able to push the piston of the syringe III containing air but it is difficult to push the piston of the syringes I and II?

Compression is the process of close packing of particles by applying external force or increasing pressure. For example, when you inflate a ball it gets harder because of the air particles are collected and compressed into the ball and pushing on the inner walls of the ball.

Activity 2.8

Take two balloons. Fill both the balloons with air. Place one of the balloons in a cold place. Place the second balloon in hot place (under direct sunshine). Which balloon explodes first? Why?

2.2 Physical and chemical properties of matter

2.2.1 Physical properties of matter

Activity 2.9

Consider materials in your surroundings such as water, common salt, sugar, wheat flour, copper wire, air, charcoal, oil, Observe the materials and answer the following questions.

1. Which of them are solids, liquids and which are gases?
2. Which of them do you think are soluble and which are insoluble in water?
3. Tell the colors of each substance to your friends?

A physical property is a characteristic of a substance that can be observed without changing it into another substance. Physical properties include;

- Properties recognized by our sense organs such as; color, taste, texture, odor.
- State of substances as solid, liquid and gas.
- Properties like density, hardness, solubility, texture, conductivity of heat and electricity, melting point, boiling point, magnetic property, etc.

2.2.2 Identification of substances using physical properties

Identification of substances can be done based on their physical properties such as color, solubility, taste, texture, odor, state of substances density, hardness, melting point, boiling point, etc.

Experiment 2.3

Title: Identification of substances based on their physical properties.

Objective: To investigate the physical state and solubility of substances.

Materials required: Four small beakers, a spatula and glass rod.

Chemicals: Five different substances (common salt, oil, sand, sugar and water)

Procedure:

1. Examine each of the substances and record your observation about their physical state.
2. Take four small beakers and add 50 mL water to each beaker. Then, add one spatula of each substance to each beaker. Stir the mixture in each of the four beakers with a glass rod and observe the solubility of each substance.

Observation and analysis:

Copy the following Table in your exercise book and record your observations.

Substance	State	Color	Soluble or insoluble in water
Common salt			
Oil			
Sand			
Sugar			

1. Does each substance have the same state after added in water?
2. Can we consider solubility of substances in water, as a physical property? Why?

2.2.3 Chemical properties of matter

Activity 2.10

Bring a small amount of milk, a lemon, paper, match, nail, tea cup to the class.

1. Add small amount of milk into a cup. Add the lemon juice into milk and mix them together.
2. Tear pieces of paper and lit it with a burning candle for 30 seconds carefully.
3. Touch one end of the nail with a burning candle for 30 seconds carefully.

Based on the above practical activities, answer the following questions.

a. What did you see on the milk after a lemon juice is added on it?
b. What did you see on paper and nail? Which one of them burns easily?
c. What do you understand from the above activities?

A chemical property is a characteristic of a substance that describes its ability to be changed into a new substance. To observe the chemical properties of a substance, you must try to change it to another substance. For example, Wood can catch fire and burns in air forming new substances water and carbon dioxide. Burning or flammability, reaction of a substance with acids, water, air etc. are some examples of chemical properties of substances. Chemical properties can be used to classify substances.

2.3. Classification of substances with composition and observable properties

Activity 2.11

Group the following substances into pure substances or mixtures. Table salt, pure water, blood, copper, aluminium, soil, sulfur, air, oxygen , carbon, tea, oil, and milk.

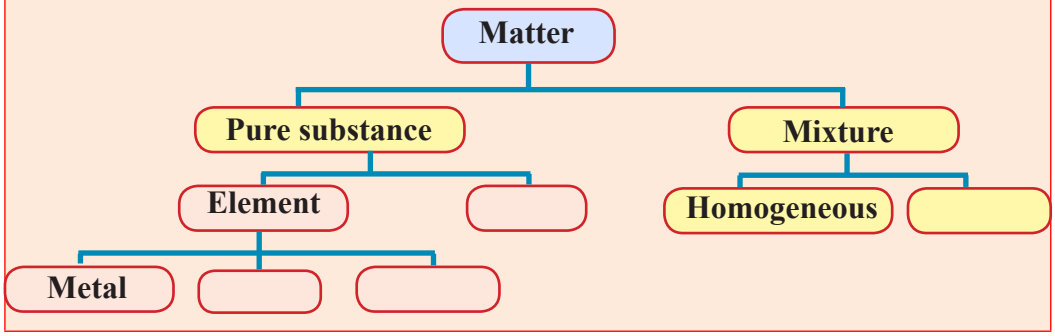
2.3.1 Pure substance and mixture

Substances around us can be classified as pure substances and mixtures. A pure substance is a material, in which all its samples have fixed composition and dis-

tinct properties. Elements and compounds are pure substances. All the samples of a given pure substance are chemically the same.

Activity 2.12

Based on your lower grade knowledge, write the type of matter on the space provided in the chart.



A. Elements and compounds

Elements

Elements are made of tiny invisible particles called atoms. An atom is the smallest particle that has the properties of an element. 118 elements have been known until now. 92 of the elements are naturally occurring. The rest are man made. Each element is made of one kind of atom.

Classification of Elements

Activity 2.13

Like animals or plants living in your surroundings, elements are all different, but they have some properties in common.

Collect the following materials from your surrounding: Aluminum sheet, copper wire, and charcoal (carbon), sulfur and compare the following properties. Which one of them do you think;

a. is shinny or not?
b. can easily bent or flattened into shapes?
c. can be broken easily?
d. is/are conductor(s) or not?
e. have common properties with others?

The elements can be classified as metals, nonmetals, or metalloid.

Metals

A metal is a substance that conducts heat and electricity well. Metals are usually solid at room temperature except Mercury. They are shiny when polished. Metals can be bent or flattened into shapes without breaking. That is, they are malleable and ductile.

Some metals are heavy having high density while and some them are light that have relatively low densities.

Examples of metals: Aluminium, Iron, Copper, Gold, Silver, Calcium, Sodium, etc.

Nonmetals

A nonmetal is an element that is a poor conductor of heat and electricity except carbon in the form of graphite. Nonmetals that are solid at room temperature will break rather than bend. These elements do not usually shine when polished. Sulfur and carbon are examples of solid nonmetals. Most nonmetals are gases at room temperature. Some examples of gaseous nonmetals are helium, nitrogen, and oxygen. Bromine, is a liquid nonmetal at room temperature.

Experiment 2.4

Title: Identification of physical properties of metals and nonmetals.

Objective: To identify physical properties of metals and nonmetals.

Materials required: Copper, iron, aluminium, lead, sodium metal, and a magnet.

Properties of metals and nonmetals

Procedure:

1. Take a magnet and check if the above metals are attracted by the magnet. Which metals are attached by the magnet and which are not?
2. Examine each metal carefully. Your record should include physical state, the color of the metal, and whether the element is magnetic or nonmagnetic.

3. Repeat steps 1 and 2 for nonmetals.

Elements	Color	State	Magnetic or nonmagnetic
Copper			
Iron			
Aluminium			
Lead			
Charcoal (Carbon)			
Sulfur			

Observation and analysis:

1. Which element can be identified by its reddish-brown color?
2. Which element is silvery-white in color?
3. Which element is black in color?
4. Which element is grayish in color?
5. Which of the elements can be attracted by a magnet and which of them are not?

Metalloids

Metalloids are a very small group of elements that have some properties of the metals and that of nonmetals. Metalloids are not as good conductors of heat and electricity as the metals, but they are better conductors than the nonmetals. Boron, Silicon, and Germanium are examples of metalloid.

Compounds

Compounds are pure substances composed of two or more elements that are chemically combined. A compound can be represented by a chemical formula, which shows the types of elements and the ratio of elements in the compound.

Activity 2.14

I. Which of the following are compounds and which are not? Why?

1. Mercury
2. Calcium chloride
3. Nitrogen gas
4. Copper oxide

II. Write the elements form which the following compounds are formed.

1. Sulfur trioxide
2. Sodium chloride
3. Calcium oxide

B. Mixture

Activity 2.15

Bring some amount of water, sugar, salt, sand and five beakers or any container to your class. In separate beakers, mix water and sugar, water and salt, water and sand, sugar and salt, and salt and sand.

1. In which of the mixtures can you see the components after mixing? Why?
2. In which mixtures do the components cannot be seen after mixing? Why?

Most of the substances you see every day in our surrounding are mixtures. A mixture is made of two or more pure substances such as elements, compounds, or both, that are mixed physically. Each substance in a mixture keeps its individual property. And also, the components of a mixture are not always composed or mixed in a fixed ratio.

Figure 2.5: Heterogeneous Mixture of fruits

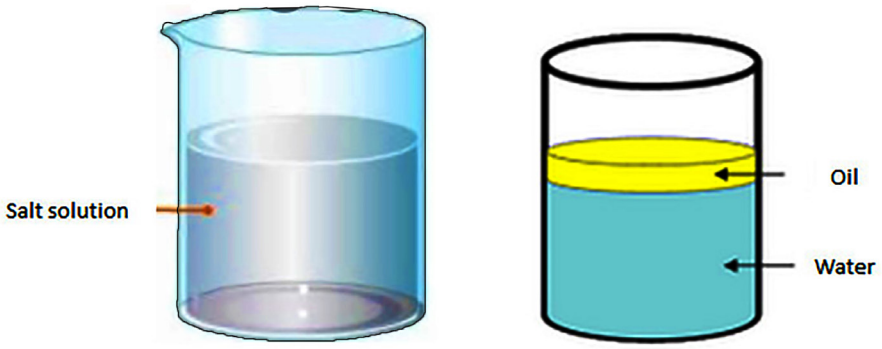
Homogeneous and heterogeneous mixture

A mixture can be heterogeneous or homogeneous. A heterogeneous mixture is defined as a mixture in which the component parts can be seen with a naked eye or with a help of microscope. A soil is an example of a heterogeneous mixture consisting of particles of sand and clay, humus, microorganisms, water and air.

Examples: a mixture of sodium chloride (Table salt) and sand, local bear, a mixture of sand and salt, blood, milk, etc.

A homogeneous mixture is defined as a mixture in which the component particles cannot be seen with a naked eye or with a help of microscope. Suppose you stir a teaspoon of sugar into a glass of water. After stirring for a little while, the sugar dissolves, and you can no longer see crystals of sugar in the water. You know the sugar is there, because the sugar solution tastes sweet.

Examples: a mixture of alcohol and water, clean air, salt solution, sugar solution, etc.



A. Salt solution B. A mixture of water and oil

Figure 2.6: Illustration of: A- homogeneous and B-heterogeneous mixtures

Table 2.2 Difference between homogeneous and heterogeneous Mixture

Homogeneous mixture	Heterogeneous mixture
Has a uniform composition	Has a nonuniform composition
Has only one phase	Has two or more phases
Components cannot be seen with necked eye or with a microscope	Components can be seen with necked eye or with a microscope

2.4 Changes around us: Physical and chemical change

2.4.1 Physical and chemical changes

Activity 2.16

Obtain a small piece of chalk.

1. Observe it and record its properties.
2. On a piece of clean paper, crush the piece of chalk with the back of a metal spoon. Describe the changes that occur.
3. Place some of the crushed chalk into the bowl of the spoon. Add about 8 drops of vinegar.

Describe what happens.

a. Do you think a new substance was formed when the chalk was crushed?

b. Do you think a new substance was formed when vinegar was added? Provide evidence for your answers.

Think It Over: Mostly chalk is a single substance, calcium carbonate.

Physical Change

In what ways can matter change? There are two types of changes in nature; physical and chemical changes.

A physical change is any change that alters the form or appearance of matter but does not form a new substance. A substance that undergoes a physical change is still the same substance after the change.

Examples: Powdering of chalk, dissolving of salt in water, melting of ice, evaporation of water, etc.

Chemical Change

A change in matter that produces one or more new substances with new properties is a chemical change, or a chemical reaction.

Examples: Burning of charcoal, rusting of iron, fermentation, photosynthesis in plants, etc

Table 2.3: Difference between physical and chemical changes

Physical change	Chemical Change
Results in no change in chemical identities of the substance	Results in a change in chemical identities of the substance
No new substance is formed	New substances with new properties are formed
The change is easy to reverse	It is difficult to reverse the change
Result in no change in the composition of the substance	Results in a change in the composition of the substance
Energy changes is not necessarily involved	Energy change (mostly heat change) is involved.

2.4.2 Importance of physical and chemical changes in our life

Activity 2.17

Consider the changes like melting butter, cooking eggs, erosion of soil, burning wood to cook food, dissolving sugar in tea, making yogurt, and chopping wood, hammering metal to make knife, rusting of iron, spoiling of food.

1. Which ones do you think are physical changes? Why?
2. Which ones do you think are chemical changes? Why?
3. Which ones do you think are harmful and which are useful changes? Why? Write a group report.

Mostly things we found in nature are not directly used as they are, but we have to modify them to fit our purpose. For example, to prepare bread or injera, the teff or the wheat must be grinded to get flour. This is a physical change. But the rising of the dough and the cooking process involves chemical change. We break wood into smaller pieces for burning while cooking food. The breaking of wood is a physical change but the burning of wood is a chemical change.

Crushing of stone for construction, melting and molding of metals to make tools, evaporation of water to get salt from sea water, melting of butter or honey, milling of grains like wheat and corn are some examples of important physical changes in everyday life.

Cooking food, burning wood or charcoal for cooking food, burning gasoline or kerosene in cars and machines, preparation of Tej or Tella by fermentation of starch in grains like corn or sorghum, baking injera or bread, souring of milk, respiration process, etc. are some examples of important chemical changes in everyday life.

Activity 2.18

From your day to day activities observe and record four changes and identify whether they are physical or chemical changes.

Give your reasons why the changes are physical or chemical changes?

Project work

Activity 2.19

There are peoples preparing local beer (Tella) and Arakie in your Villages Write all the types of physical and chemical processes /changes /taking place during preparation of Tella and Arakie.

2.4.3 Useful and harmful changes

Activity 2.20

List examples of harmful and useful changes (physical and chemical changes) in the following Table .

Harmful Change	Useful Change

What should do we minimize the harmful changes?

Some uses of physical changes

1. Freezing enables us to store and preserve meat and other food products for a long period of time. This is very useful because microorganisms such as bacteria and molds that cause the spoilage of foods die in cold places.
2. Cutting a piece of cloth to be made into shirts or any other material that can be useful is an important change.
3. Grinding of teff is useful for preparing injera.
4. Evaporation of sea water is used to get salt.

Uses of chemical change

1. Animals make use of chemical reactions to convert the food they eat to obtain energy.
2. Plants undergo photosynthesis to combine carbon dioxide and water to form glucose or sugar.
3. Changing wood into charcoal for cooking food is also another example.
4. Preparations of Tella, Tej, and bread.
5. Preparation of medicines, plastics, fertilizers and other important goods involves chemical changes.
6. Chemical industries produce their products through chemical changes. Useful materials like soap, ceramics, glass, plastics and paper are prepared by chemical changes.

There are also chemical changes that are harmful such as the rusting of iron, decaying of food and explosion of bombs.

2.5 Separation of mixtures and its application

Activity 2.21

Tea leaves are separated from the liquid with a filter. Milk is churned to separate the butter. We gin cotton to separate its seeds from the fiber. How do you separate sand mixed with salt in glass of water? Write your steps and present to your classmates.

Separation methods are those methods that can be used to separate mixtures into their components. Separation is an important processes used to purify components from mixtures.

2.5.1 Methods of separation of mixtures

Activity 2.22

1. Bring some amount of grain purchased from a shop or from your home to the classroom. Now, spread the grain on a sheet of paper. Do you find only one kind of grain on the sheet of paper? Are there pieces of stone, husks, broken grain and particles of any other grain in it?
2. Before grinding teff, you need to remove impurities that may be present in it. How do you remove the impurities?

Both homogeneous and heterogeneous mixtures can be separated by physical methods. The method to be used is chosen based on the differences in physical properties of the components such as magnetic property, solubility, density, melting point, boiling point, etc. Some of the separation methods are decantation, filtration, evaporation, magnetic separation, using separatory funnel, simple distillation and fractional distillation.

1. Magnetic method of separation

This method involves the separation of magnetic substances from nonmagnetic substances by means of magnet. Magnetic separation takes advantage of magnetism, so it is useful only for certain substances that are strongly attracted by magnet.

Experiment 2.5

Title: Separation of mixture using a magnet

Objective: To separate a mixture of iron and Sulfur using a magnet.

Materials required: Magnet, iron filings, powdered Sulfur, beaker, sheet of paper/ watch glass, and spatula

Procedure:

1. Take two spatulas of iron filings and powdered sulfur into a beaker, and mix them thoroughly.
2. Place a portion of the mixture on a sheet of paper/ watch glass.

3. Bring a magnet close to the surface of the mixture as shown in Figure 2.7

Figure 2.7: Magnetic separation

Observation and analysis

1. What type of mixture is it?
2. Which component of the mixture is attracted to the magnet?
3. What can you conclude from the Experiment ?

2. Evaporation method

Evaporation is a method used to separate out mixtures where there is/are one or more dissolved solids. In this method the liquid component drives off from the solid components by applying heat. This is because liquid components will evaporate over time through heating. Evaporation is suitable to separate a soluble solid from a liquid. In many parts of the world, Table salt is obtained from the evaporation of seawater using heat energy from the sun.

Experiment 2.6

Title: Evaporation

Objective: To separate salt from a salt solution.

Materials required: Burner, evaporating dish, tripod, wire gauze, salt, beaker, watch glass, beam balance, measuring cylinder.

Procedure:

1. Dissolve about 10g of common salt (NaCl) in 30 mL of tap water in a beaker.
2. Pour the salt solution in to an evaporating dish as shown in Figure 2.8.
3. Boil the solution until all the liquid evaporates and observe the result.

Figure 2.8: The separation of salt from a salt solution by evaporation.

Observation and analysis

1. What did you observe in the evaporating dish?
2. What would happen to the level of the liquid if the evaporating dish is covered with a watch glass? Is evaporation possible?

3. Sedimentation, Decantation and Filtration

Activity 2.23

Collect some muddy water from a pond or a river. If it is not available, mix some soil to water in a glass. Let it stand for half an hour. Observe the water carefully and note your observations. Does some soil settle at the bottom of water? Why? What do you call this process?

Sometimes, it may not be possible to separate components of a mixture by winnowing and handpicking. For example, there may be lighter impurities like dust or soil particles in lentils (misir) or peas. How are such impurities separated from lentil or pea before cooking?

Lentil or grains are usually washed before cooking. When you add water to these, the impurities like dust and soil particles get separated. These impurities washed out into water, which becomes a little muddy. Now, which will deposit to the bottom of the container lentil or dust? Why? Have you seen that the container is tilted to pour out the dirty water? When the heavier component in a mixture settles after water is added to it, the process is called sedimentation. When the water (along with the dust) is removed, the process is called decantation.

Experiment 2.7

Title: Decantation

Objective: To separate a mixture of liquid and insoluble solid denser than the liquid component.

Materials required: Two beakers, glass rod, sand, and water.

Procedure:

1. Put water and sand into a beaker, and stir them thoroughly.
2. Allow the mixture in a beaker for one minute to settle down the insoluble solid.
3. Pour the liquid above solid into another beaker as shown in Figure 2.9.

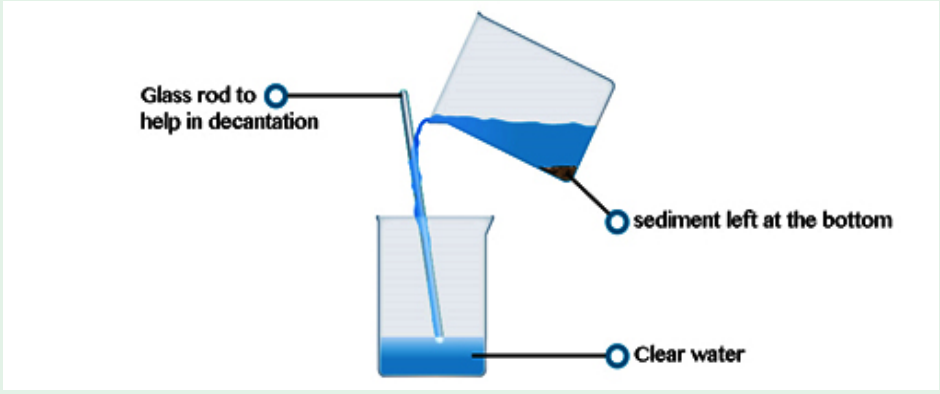


Figure 2.9: Decantation of muddy water

Observation and analysis

1. Which component of the mixture was sedimented?
2. What can you conclude from the Experiment ?

Filtration is a separation method used to separate out insoluble substances in a mixtures comprised of particles of which some are large enough in size to be captured with a filter paper. Particle size can vary considerably, in a given type of mixture. For instance, water filters can filter out bacteria (of length in order of 1 micron) and soil particles from stream water. Such process of separating insoluble particles that cannot pass through the pores of a filter paper is called filtration.

Experiment 2.8

Title: Filtration

Objective: To separate a mixture of chalk (insoluble) and water by filtration.

Materials required: Beakers, filter paper, funnel, flask, powdered chalk and water.

Procedure:

1. Put powdered chalk into a beaker containing water, and stir the mixture to mix them.
2. Pour the mixture into the funnel fitted with a filter paper and collect the filtrate in the flask as shown in Figure 2.10.
3. Observe the result.

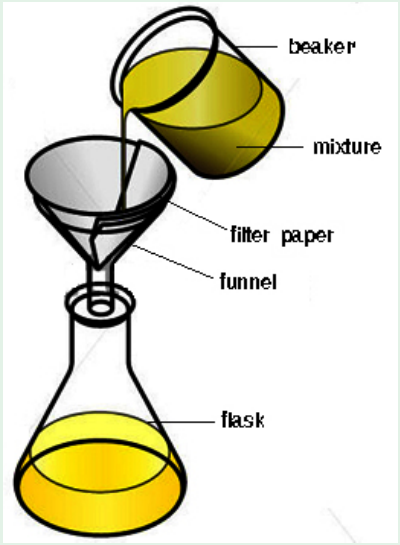


Figure 2.10: Filtration

Observation and analysis

1. Does the powdered chalk dissolve in water?
2. Which substance is collected in the flask?
3. Which substance remains on the filter paper?

4. Separation using Separatory funnel

Separatory funnel is used for separating a mixture of two liquids that do not mix with each other. For example, oil and water from their mixture can be separated by this process. If a mixture of such liquids is allowed to stand for some time, they form two or more separate layers. The components that form different layers can then be separated by decantation or using a separatory funnel.

Experiment 2.9

Title: Separation using separatory funnel.

Materials: Oil, water, separatory funnel, stand set up, clamp, funnel and beaker.

Procedure:

1. Fix a separatory funnel in a stand as shown on the Figure 2.11
2. Pour about 50ml of a mixture of oil and water through a funnel into a separatory funnel.
3. Close the separatory funnel using a lid.
4. Now shake the separatory funnel gently and slowly.
5. Now, open the stopcock of the separatory funnel to release the pressure inside the funnel.
6. Place the funnel in the stand and allow the two liquids to separate completely.
7. Take a beaker and place it below the separatory funnel and open the lid of the separatory funnel.
8. Open the stopcock of the separatory funnel and pour the lower layer of water carefully into the beaker.
9. Close the stopcock of the separatory funnel as the oil reaches the stopcock of separatory funnel.

10. Place another beaker below the separatory funnel to collect oil from the separatory funnel.

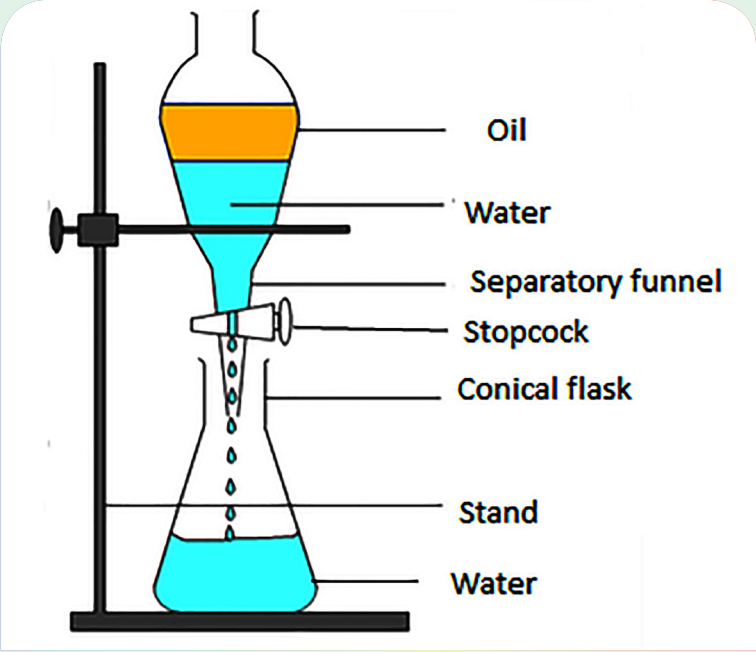


Figure 2.11: Setup of separation using separatory funnel

Observation and analysis

1. How many layers or phases are there?
2. Which component is at the upper layer and which one is in a lower layer? Why?

5. Distillation

Activity 2.24

In your community there are peoples who are preparing Araki (katikala).

1. Observe carefully how they are processing it.
2. Ask the name of materials and their functions they use in the process.

Report for your friends in a class.

Distillation is an effective method to separate mixtures composed of two or more pure liquids (components). Distillation method is based on the difference in boiling point of the components.

Distillation is a purification process where the components of a liquid mixture are vaporized and condensed and then isolated. The mixture is heated until one of the components boils (turns to a vapor). The vapor is then fed into a condenser which changes it back into a liquid. Then the liquid is collected in the receiver and it is called distillate. The substance that remains in the original container is called the "residue". Simple distillation is used to separate liquid mixtures which boil without decomposition and have enough difference in their boiling points.

Experiment 2.10

Title: Simple distillation

Objective: To separate the mixture of water and alcohol.

Materials required: Distillation flask, condenser, wire gauze, ring, stand with base, clamp, Bunsen burner, conical flask, Thermometer and beaker.

Chemicals: Ethyl alcohol (ethanol) and pure water

Procedures:

1. Mix 100 mL of ethyl alcohol (ethanol) with 100 mL of pure water in a 250 mL beaker.
2. Set up the distillation apparatus as shown in Figure 2.12
3. Add the mixture into the distillation flask.
4. Put a porous material or sand (boiling chips if there are any) in the flask.
5. Heat the distillation flask gently and observe the results.
6. See the temperature rise during distillation using the thermometer.
7. Turn off the Bunsen burner when the temperature reaches about 900C
8. You can check the odor of ethanol in the receiving conical flask.

Observation and analysis

a. What is collected in the receiver (conical flask) and what remains in the distillation flask?

b. Give the names of the apparatus used for the evaporation and condensation processes in the Experiment ?

c. Why is the condenser connected to tap water in a simple distillation set up?

d. Why does the cold water apply from bottom to top?

e. What is the need to use the boiling chips?

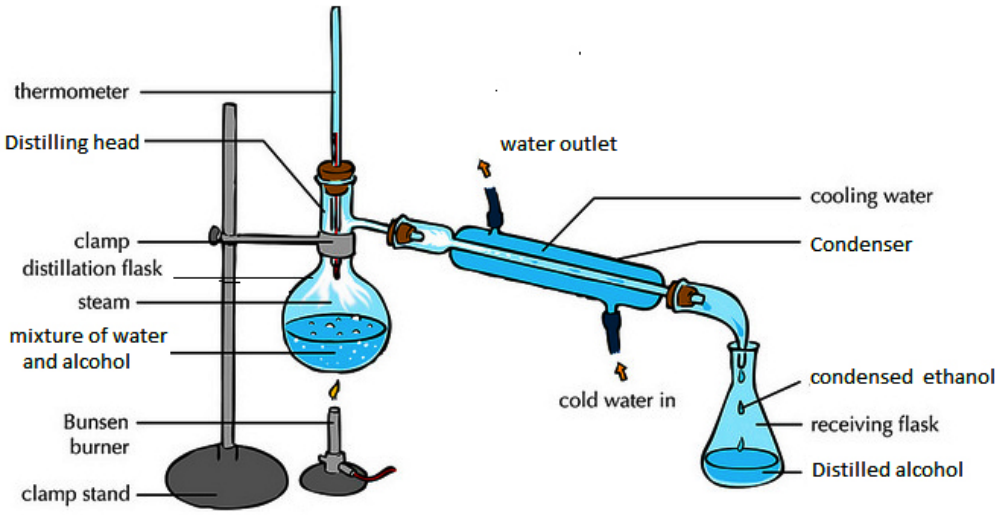


Figure 2.12: Simple distillation

2.5.2 Separating of mixtures using local materials

Activity 2.25

Identify separation methods used by people in your community;

1. In separation of teff, wheat, bean or other seeds from the chaff.
2. To clean dirty water
3. To get clear coffee from the pot/jebena
4. To get clear Tella or Tej

Mixtures can be separated using locally available materials. The followings are some of locally used materials used to separate different types of mixtures in to their components.

Figure 2.13: Sieving

Figure 2.14 Farmers separating seeds from chaff using wind

A farmer separates teff from the chaff by the help of wind. Teff particles are denser than the chaff and settles to the ground while the chaff is separated by wind.

Figure 2.15: Purification of coffee by decantation

Figure 2.16: Local preparation of araki by distillation

Summary

- Matter is made up of tiny particles.
- Every substance has two types of properties; physical and chemical properties
- Physical properties of a substance describe the characteristics of the substance that are related to physical changes.
- Substances can be identified based on their physical properties (such as state, color, odor, taste, hardness, density, melting and boiling points) and chemical properties.
- The Particle theory matter explains why different matter has different properties.
- Diffusion occurs because particles in a substance are always moving around.
- Compression is the process of close packing of particles by applying external force or increasing pressure.
- A physical property is a characteristic of a pure substance that can be observed without changing it into another substance.
- A chemical property is a characteristic of a substance that describes its ability to change into different substances of new composition and properties.
- The elements can be classified as metals, nonmetals, or metalloid.
- A physical change is any change that alters the form or appearance of matter but does not make any new substance.
- A change in matter that produces one or more new substances is a chemical change, or a chemical reaction.
- A mixture is a form of substance formed when two or more pure substances are mixed physically.
- Mixtures can be separated in to their components by physical means.

Review Questions

Instruction I: Write 'TRUE' if the statement is correct or 'FALSE' if it is not correct

1. Particles of matter are always in motion.
2. There is space between particles of matter.
3. There are no attractive forces between particles of matter.
4. A chemical change is a change results in the composition of a substance.
5. A heterogeneous mixture contains only one phase.
6. Elements are types of substances composed of two or more types of atoms.
7. Two different substances can have similar physical properties.
8. Compounds can be separated to their components by physical processes.
9. The properties of a substance that can be observed without altering its identity are physical properties.
10. The ability of iron to conduct electricity is a chemical property of iron.
11. The temperature at which a solid melts is the same as the temperature at which its liquid solidifies
12. Physical properties can be used as a basis for identifying substances.
13. Solids and liquids are easily compressible.

Instruction II: Choose the best answer from the alternatives provided.

14. Which one of the following is chemical change?

    A. Melting of ice C. Burning of charcoal
    B. Dissolving of salt in water D. Powdering of chalk

15. Which one of the following is a homogeneous mixture?

    A. Blood B. clean Air C. Milk D. muddy water

16. Which one of the following is a pure substance?

    A. Tea B. Oxygen C. Tap Water D. Milk

17. Which of the following is a compound?

    A. Tea B. Soil C. Milk D. Sugar

18. Which one of the following does not involve a change of state?

A. Freezing C. Expansion

B. Melting D. Evaporation

19. Which one of the following processes does not help in separation of mixtures?

A. Filtration B. Distillation C. Sieving D. None

20. The apparatus used to separate two immiscible liquids is

A. Separatory funnel C. Distillation flask

B. Condenser D. Filter paper

21. The two processes that take place during distillation are ____.

A. Filtration followed by evaporation

B. Evaporation followed by condensation

C. Condensation followed by evaporation

D. Filtration followed by condensation

22. The process of settling of suspended particles in a mixture is known as __.

A. Decantation B. Distillation

C. Sedimentation D. Magnetic separation

23. Which of the following substances cannot be further decomposed by ordinary chemical means?

A. Water B. Gold C. Sugar D. Table salt

Instruction III: Fill in the blank spaces.

24. Anything that has mass and occupies space is _____.

25. A method used to separate solid from liquid using filter paper is _____.

26. A mixture that has uniform composition of pure substances is _____.

27. Elements that have high conductivity of heat and electricity are _____

28. The process of close packing of particles by applying external force is known as _____.

29. The process by which particles spread out from a region of high concentration to a region of lower concentration is known as _____.

Instruction IV: Give a brief explanation for the following questions.

30. Physical and chemical changes are the two types changes in matter. What is their difference in terms of energy change and reversibility of the change?
31. Describe the properties of matter in terms of the particle theory.
32. Explain why some substances are solids, some are liquids and some of them are gases based on the particle theory of matter.
33. During distillation processes, one liquid distillates out first before the other. Why does this happen?
34. Explain diffusion and compression in terms of the particle theory of matter.
35. Why do gaseous substances have indefinite shape and indefinite volume? Give your explanation based on the particle theory of matter?

Unit 3

Elements, Compounds and Chemical Reactions

Learning outcomes: at the end of this unit, you will be able to:

- Compare elements to compounds and how they are represented by symbols and formulas.
- Write the symbols of common elements or compounds.
- Name compounds given their formula and write formula given the name of the compound.
- Use symbols and chemical formulas as a way of communicating information about elements and compounds.
- Apply the Law of conservation in writing balanced equations.
- Interpret chemical formulas of compounds in terms of the elements present and the ratios of their atoms.

3.1. Elements and their representation

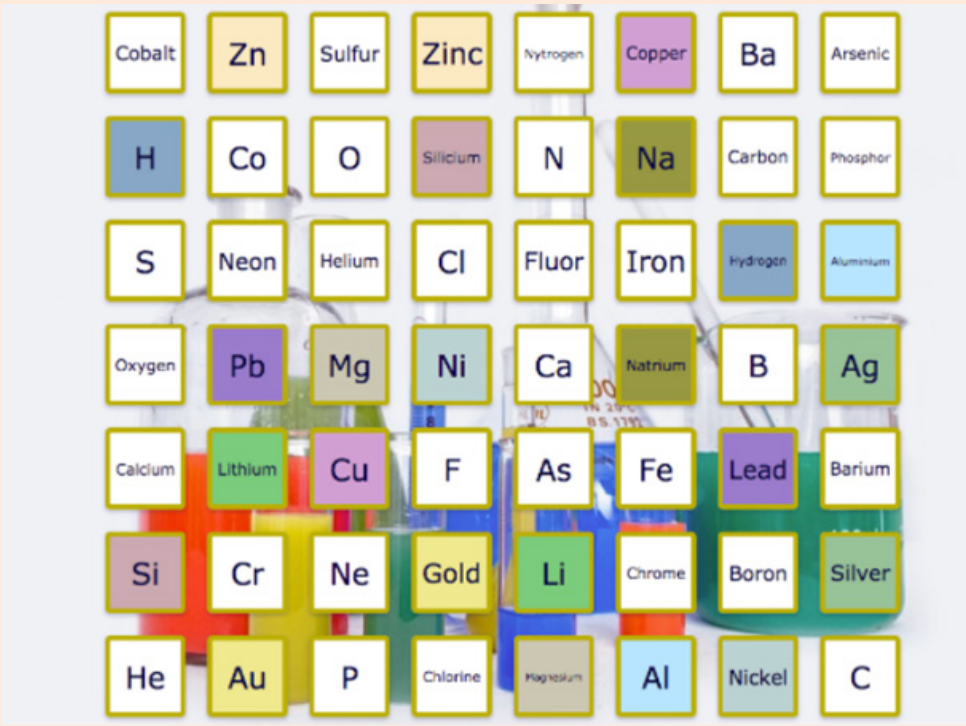
3.1.1 Common elements

Activity 3.1

Given the following naturally occurring elements: Hydrogen, Oxygen, Carbon, Potassium, Aluminium. Can you guess the symbols of these elements to represent them?

Activity 3.2

Pair Matching: Look at the chart below, match the name with the symbol of elements?



Exploration Questions

1. Arrange elements whose names begin with the same letter.
2. Do we give the same symbols for the elements whose name begin with the same letter?
3. How are the letters of the symbols arranged?
4. Give a reason why are not all elements symbolized by the first letter of their names.
5. Is there an element whose symbol is different from the first letter of its name? Why?

An element is a pure substance that cannot be broken down into any other substances by ordinary chemical or physical means. It is made up of only one kind of atom. Each element can be identified by its chemical name and symbol.

3.1.2 Chemical symbol

Chemical Symbol is a shorthand representation of chemical name of an element. It is a one or two letter designation of an element.

Examples: The chemical symbol of oxygen is O, of zinc is Zn, and that of iron is Fe.

3.1.3 Writing symbols

The chemical symbols of most elements are derived from their English name and some of them are from Latin names. In writing symbols the first letter is always capitalized. If the symbol contains two letters, the second letter is a small letter. A given chemical symbol stands for a specific element. No two elements can have the same symbol.

Table 3.1 Symbols of some common elements derived from their English names

English Name	Symbols of elements
Hydrogen	H
Carbon	C
Nitrogen	N
Oxygen	O
Sulfur	S
Aluminium	Al
Chlorine	Cl
Helium	He
Magnesium	Mg
Lithium	Li
Calcium	Ca

Table 3.2 Symbols of some common elements derived from their Latin names

English Name	Latin name	Symbols of elements
Iron	Ferrum	Fe
Copper	Cupprum	Cu
Gold	Aurrum	Au
Silver	Argentum	Ag
Potassium	Kalium	K
Sodium	Natrium	Na
Mercury	Hydrogyrum	Hg
Lead	Plumbum	Pb
Tin	Stannum	Sn

Activity 3.3

1. Write the name of the following symbols and compare their difference in relation to their names.
   i. Ca and Cu
   ii. He and Hg
   iii. N and Na
2. Write at least one element for each of the following alphabet letters that can be the beginning letter of their names. A, B, C, F, H, L, N, O

3.2. Compounds and their representation

Activity 3.4

1. From your prior knowledge and experience, you know different compounds.
   a. List the names of the compounds you know and write their chemical formula?
   b. What do you think is the basic difference between elements and compounds?

3.2.1 Compounds

Compounds are pure substances that consist of atoms of two or more different elements combined chemically in fixed ratio. The fixed ratio or number indicates the number of atoms (elements) present in a compound.

3.2.2 Meaning of formula

Activity 3.5

One of the compounds found in most fruits like lemon and orange is citric acid. The chemical formula of Citric acid is $C_6H_8O_7$

1. What types elements are found in the compound?
2. How many numbers of each element are there in the formula?

The formula of a substance is the symbolic representation of its composition. Formulas can be either formulas of elements or formulas of compounds.

The formula of an element consists of only symbol of one element whereas the formula of a compound contains the symbols of two or more different elements. The chemical formula of an element or a compound represents its composition using symbols and numbers.

Therefore, from a formula of a compound we can determine:

1. The type elements present in the compound
2. The number of atoms of each element in the compound.

Examples.

a. NaCl - contains one Sodium and one Chlorine atoms
b. Al_2O_3- contains two Aluminum and three Oxygen atoms
c. $CaCO_3$ contains one Calcium, one Carbon and three Oxygen atoms

Formulas of Molecules of atoms

A molecule of an element is an atom or group of atoms that exists free in nature. Elements in nature may exist as Monoatomic, Diatomic or Polyatomic elements.

Mono atomic elements: - They exist as uncombined single atoms.

Example noble gases (Helium, Neon, Argon, Krypton, Xenon and Radon).

Diatomic elements: - Exist as a molecule containing two atoms combined together.

These are Hydrogen (H_2), Nitrogen (N_2), Oxygen (O_2), Fluorine (F_2), Chlorine (Cl_2), Bromine (Br_2), and Iodine(I_2).

Polyatomic elements: - Other elements exist as molecules containing more than two atoms.

Example: Phosphorous (P_4), Sulfur (S_8) and others.

3.2.3 Valence number

Activity 3.6

Consider the compounds NaCl, $AlCl_3$, $MgCl_2$

1. What do you observe about the number of chlorine atoms combining with the different atoms?
2. Which element combined with more chlorine? What do we call this characteristic of atoms?

The combining power of an element with another element in compound formation is called valence number.

Elements in nature have their own combining powers to combine with others. For example, in common salt, NaCl one atom of sodium combines with one atom of chlorine. So the valence number of sodium is 1 and that of chlorine is also1. In a compound water, H_2O since 1 atom of oxygen combines with two hydrogen atoms its valence number is 2. But the valence number of hydrogen is1.

The common valence number of most common elements is 1,2,3, or 4 as shown in Table 3.3 below

Table 3.3:Valence number of some common elements.

Valance Number 1	Valance Number 2	Valance Number 3	Valance Number 4
Na	Ca	Al	C
K	Mg	N	Si
H	Zn	P	
Cl	O		
Br	S		

Some elements can have more than one valence number called variable valence number. For example, elements like Fe and Cu have more than one valence numbers as;

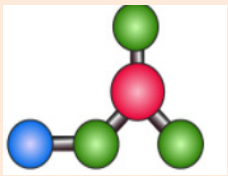
The Valance number of Fe is 2 in $FeCl_2$ but it is 3 in $FeCl_3$.

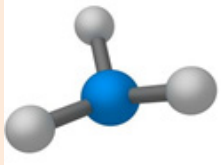
The Valence number of Cu is 1 in Cu_2O but it is 2 in CuO.

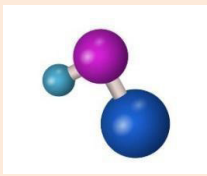
3.2.4 Formulas of binary compounds

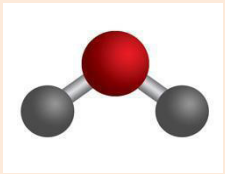
Activity 3.7

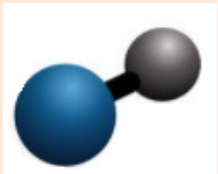
In the following molecular model each colored ball represents an element. Different size also shows a different element. Based on the color or size of balls in the following models identify which one of them are binary compounds and which ones are not?

A 

B 

C 

D 

E 

Compounds composed of only two different elements are known as binary compounds. In binary compounds elements may combine only in a one to one ratio or more than that. For example, in sodium chloride (salt) NaCl, which has one sodium (Na) and one chlorine (Cl). But in laughing gas (N_2O) that has two nitrogens (N) and one oxygen (O).

Examples of binary compounds: KCl, H_2O, CO_2, Al_2O_3, N_2O_3 , CaO,SO_3, $AlCl_3$,etc

3.2.5 Writing chemical formulas of binary compounds

If we know the valence number of elements, we can write the chemical formula of compounds. Chemical formulas are written using the valence number of the elements combined. To write the formula of a compound using the crisscross method, we use the following steps.

1. Write the symbols of the two elements side by side. Write the metal to the left and the non-metal to the right hand side.
2. Write the valence number, of each atom at the top of its symbol
3. If necessary, divide the valence number by the highest common factor to get a simple ratio.
4. Make a crisscross of valence numbers and write them as subscript numbers this will give you the formula of the compound.

Example:1. Write the formula of calcium nitride

1. Write the symbols of the two elements side by side.

   Ca N

2. Write the valence number, of each atom at the top of its symbol

   2 3
   Ca N

3. If necessary, divide the valence number by the highest common factor to get a simple ratio.

   2 3
   Ca N

4. Make a crisscross of valence numbers.

Therefore, the formula of calcium nitride will be Ca_3N_2

Similarly,

The chemical formula of Sodium iodide is NaI, Magnesium oxide is MgO, and that of Aluminium chloride $AlCl_3$

Activity 3.8

Write formulas for the following compounds.

1. Magnesium and chlorine
2. Sodium and oxygen

3.2.6 Naming binary compounds

We can use the following basic rules to give a name of binary compounds

Rules in Naming Binary Compounds

1. The name of a binary compound is the combination of the names of the two constituent elements.
2. For binary compounds that consist of metals and nonmetals, the metal is named first followed by the nonmetal.
3. The suffix -ide replaces the last letters of the name of the nonmetal. For example, chlorine is changed to chloride.

Table 3.4:Names of some nonmetals in binary compounds

Non-metallic Element	Name in Binary Compound
Chlorine	Chloride
Fluorine	Fluoride
Oxygen	Oxide
Nitrogen	Nitride

4. If the metal has variable valence numbers, the valence number of the metal used in the formula should be placed in parenthesis using capital Roman

numerals after the name of the metal.

Examples: Cu_2O – Copper (I) Oxide

$FeCl_2$ – Iron (II) Chloride

5. If the binary compound consists of nonmetallic elements only, we name the first element is named by its own name followed by the name of the second element with the suffix –ide.

Examples: HCl – Hydrogen chloride

HBr – Hydrogen bromide

H_2S – Hydrogen sulfide

6. If two nonmetallic elements form two or more compounds, we name the first element followed by the name of the second element with the Greek prefix like mono, di, tri, etc. as indicated in Table 3.5.

Table 3.5: Greek prefixes used in naming binary molecular compounds

Prefix	Meaning
Mono	1
Di	2
Tri	3
Tetra	4
Penta	5
Hexa	6

Examples

CO – Carbon monoxide CO_2 – Carbon dioxide

SO_2 – Sulfur dioxide SO_3 – Sulfur trioxide

N_2O – Dinitrogen monoxide NO_2 – Nitrogen dioxide

N.B . For some compounds, common names are used in everyday life. For example, calcium carbonate ($CaCO_3$) is known with the name limestone, sodium chloride is usually called Table salt, dihydrogen monoxide (H_2O) is named as water, Nitrogen trihydride (NH_3) named as ammonia for However, common names usually give no information about chemical composition.

Activity 3.9

1. From the of the following list, which of them are binary compounds and which are not?

   a. Br_2 b. HF c. $CaCl_2$ d. H_2SO_4

2. Write the formulas for the following binary compounds.

   a. Zinc Chloride
   b. Copper(II) oxide
   c. Magnesium bromide

3. Write the name of the following compounds.

   a. HCl b. NO c. H_2O
   d. PCl_3 e. MgS f. K_2O

4. The valence number of a metallic element X is 3. What is the formula of its oxide?

3.2.7 Polyatomic ions

Polyatomic ions are groups of atoms of elements bonded together and have an overall positive or negative charge. Polyatomic ions have characteristic formulas, names, and charges that should be memorized. In polyatomic ions the number indicating the charge indicates their valence number. The followings are common polyatomic ions with their valence numbers.

Table 3.6: Formula and valency of polyatomic ions

Valence number 1		Valence number 2		Valence number 3	
Formula	**Name**	**Formula**	**Name**	**Formula**	**Name**
OH^-	hydroxide	CO_3^{2-}	Carbonate	PO_4^{3-}	Phosphate
CN^-	cyanide	SO_4^{2-}	Sulfate		
HCO_3^-	Hydrogen carbonate (bicarbonate)				
NO_3^-	nitrate				
NH_4^+	Ammonium				

Polyatomic ions can form compounds with other monatomic (of one element) or polyatomic ions. The formula of compounds containing polyatomic ions can be written in the same way as those of binary compounds.

Examples: The formula of a compound formed from sodium and carbonate ion with a valence of 1 and 2 respectively will be Na_2CO_3 as ;

Similarly;

a. The formula of a compound formed from K and NO_3^- ion will be KNO_3
b. The formula of a compound formed from Al and SO_4^{2-} ion will be $Al_2(SO_4)_3$
c. The formula of a compound formed from Na and OH^- ion will be NaOH

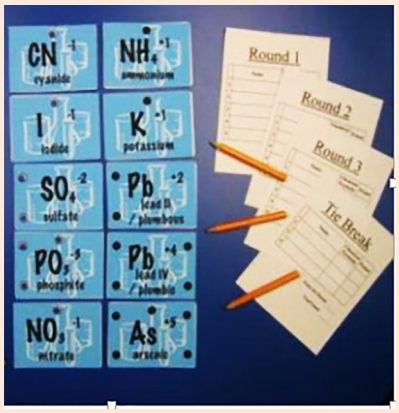
3.2.8 Naming simple chemical compounds containing polatomic ions

Activity 3.10

Naming chemical compounds and writing chemical formulas

Instruction: You will be provided or you will prepare some cards containing elements and polyatomic ions with their valence numbers. You will play the cards with your class mates in pairs or in groups. Represent formulas of compounds using the cards you get. The winner will be a student or a group who has represented and named more number of compounds.

Materials: Playing cards, 50 positive ions cards and 50 negative ion cards, 4 or more score cards, and Pencils



Information on cards

Each card has the name and the valence number of an element or a polyatomic ion printed on the card.

Rules of playing

1. Familiarize yourself with the rules for building and naming compounds.
2. Mix or shuffle the positive and negative ion cards together.
3. Then give cards to each player. The number of cards you deal will depend on the number of people playing. For example, 6 players would each receive 6 cards.
4. Put the remaining cards in the middle of the players.
5. Take or draw a card from the top of the deck or take the top card from the discard pile. The player has the opportunity to form neutral compounds at any time during their turn.
6. Write the formula of the neutral compound on the scorecard.

Hint: 1 sodium + 1 chlorine → sodium chloride, NaCl

We can use the following rules to name simple compounds containing polyatomic ions.

1. If a compound consists of a metal or ammonium ion, the name of the metal or ammonium ion is named first without changing its name.

Example: Na_2CO_3, sodium carbonate

NH_4NO_3 - Ammonium nitrate

2. Compounds that involve metals with more than one valence number (i.e. with variable valence number) are named as follows

a. Write the valence of the metal after the name of the metal using Roman numerals in a bracket.

b. Then follow rules one.

Example: $CuCO_3$ - Copper (II) carbonate $Fe_2(SO_4)_3$ - Iron (III) sulfate

Activity 3.11

1. Write down the formulas of the compounds made of the following pairs.
   a. Sodium and sulfate ion
   b. Ammonium ion and hydroxide ion
   c. Sodium and nitrate ion
   d. Magnesium and phosphate ion
2. Name the following compounds.
   a. $CaSO_4$
   b. $MgCO_3$
   c. KNO_3
   d. NH_4Cl

3.2.9 Interpreting of chemical formula

Activity 3.12

Given a chemical formula $CaCO_3$:

1. List the types of elements in this compound?
2. How many of each element are there in this compound?
3. What do you understand from your answers of question 1 and 2?

Chemical formulas have qualitative and quantitative meanings. Qualitative meaning refers to kinds of elements while quantitative meaning refers to the number of elements in a formula. Qualitatively symbols represent the identities of the elements. You can see the qualitative meanings of symbols on Table 3.7.

Table 3.7: Qualitative meaning of symbol or formula

Chemical Symbol or Formula	Qualitative Meanings
H_2O	Hydrogen and Oxygen are present in a molecule
$NaNO_3$	Sodium, Nitrogen and Oxygen are present in a compound
$3P_4$	Phosphorus is present in a molecule

Activity 3.13

Show the qualitative meaning of the following formulas of substances.

Chemical Symbol or Formula	Qualitative Meanings
$Ca(OH)_2$	
HNO_3	
$4Br_2$	

Quantitatively symbols accompanied with coefficient and subscript numbers that represent the numbers of atoms of the elements. A subscript shows the number of atoms in a formula.

For example in water molecule: H_2O represents two hydrogen atoms and one oxygen atom in water.

Table 3.8: Quantitative meaning of chemical symbol or formula

Chemical Symbol or Formula	Quantitative Meanings
2HBr	Two hydrogen bromide molecule that contains one hydrogen atom and one bromine atom each.
$5H_2O$	Five water molecules that contain two hydrogen atoms and one oxygen atom each
$3Cl_2$	Three chlorine molecules that contains two chlorine atoms each

Activity 3.14

Fill the blank spaces in the Table below.

Chemical Symbol or Formula	Quantitative Meanings
$3H_2$	
$4N_2$	
5F	

3.3 Simple chemical reactions and equations

3.3.1 Simple chemical reactions

Activity 3.15

There are several chemical reactions done at our homes by our parents. Describe the chemical reactions that occur;

1. When our parents burn wood, charcoal or kerosene for cooking food.
2. When they brew Tella or Tej
3. When they make yoghurt (Ergo)

A chemical reaction is a process in which one or more substances (the reactants) are converted to one or more different substances (the products). Substances involving in a chemical reaction may be elements or compounds. They are represented as:

Reactants → Products

Reactants are the starting materials or initial substances of a chemical reaction. Products are the end materials formed during the chemical reaction.

Consider the reaction: The chemical reaction of hydrogen and oxygen that gives water,

Hydrogen + Oxygen → water

Or this chemical reaction also represented with symbols and formulas as

$$2H_2 + O_2 \rightarrow 2H_2O$$

Therefore, Hydrogen and Oxygen are reactants and water molecules are products.

Experiment 3.1

Title: Simple chemical reaction.

Objective: To study simple chemical reactions by burning magnesium ribbon in air.

Materials Required: Bunsen burner, match, tong, and crucible.

Chemicals required: Magnesium ribbon.

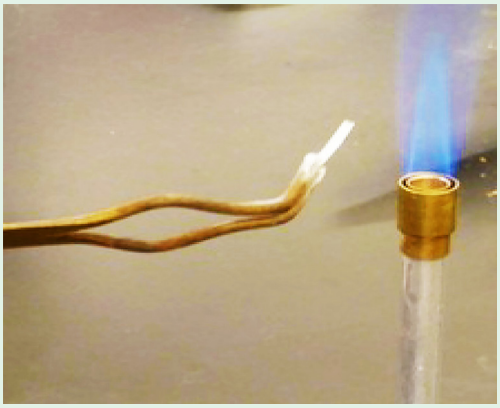


Figure 3.1: Burning of magnesium ribbon in air

Procedure

1. Hold a magnesium ribbon with a tong and heat it on the Bunsen burner.
2. Collect the product on the crucible.
3. Record your observations.

Observations and Reflection

a. What is the importance of heat for the reaction?

b. What are the reactants?

c. Compare and contrast the properties of the reactants with the product formed.

d. Investigate the chemical reaction and write your conclusion. (Your teacher guides you how you perform this practical Experiment)

3.3.2 Evidences that show chemical reaction has occurred

Experiment 3.2

Title: Simple chemical reaction

Objective: Investigating simple chemical reaction

Chemicals: Baking soda and Vinegar

Materials: Spoon or spatula, plastic cup or beaker, measuring cylinder

Procedure

1. Place 2 small spoonfuls of baking soda into a clear plastic cup.
2. Add about 125 ml of vinegar. Swirl the cup gently.
3. Look at the material in the cup. Carefully fan the air above the liquid toward you. What do you smell?

Observation and reflection

a. What changes do you see?

b. Feel the outside of the cup. What do you notice about the temperature?

Think it over

What changes did you detect using your senses of smell and touch?

Chemical reactions involve changes in properties of substances and energy. One way to detect chemical reactions is to observe changes in the properties of substances involved. Changes in properties are resulted when new substances are formed.

Some indicators for a chemical reaction taking place are;

1. Color change may indicate that a new substance has formed.

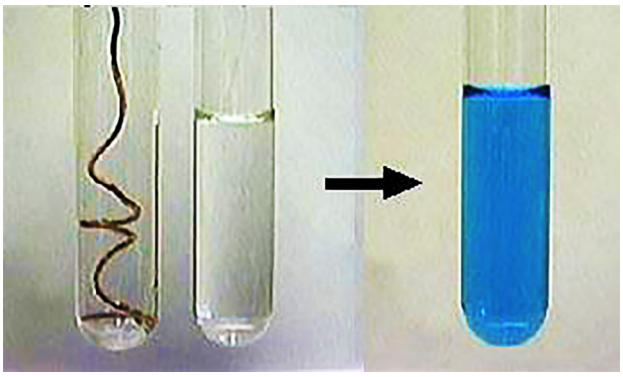


Figure 3.2: Color change of solid and liquid reactants

2. Change of physical state: The mixing of two solutions may yield a solid substance at the bottom of the reaction container.

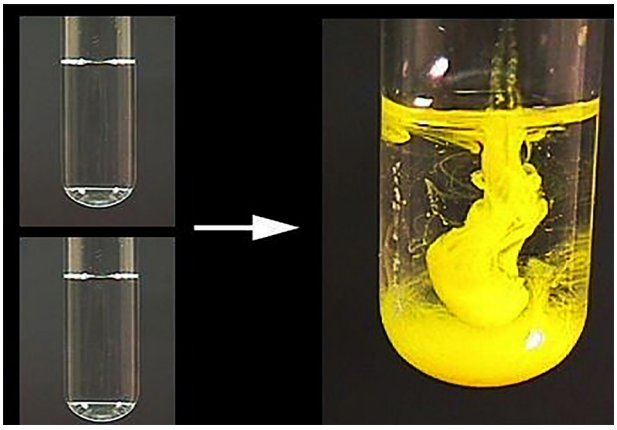


Figure 3.3: Formation of solid after reaction

3. The formation of a gas from solid or liquid reactants.

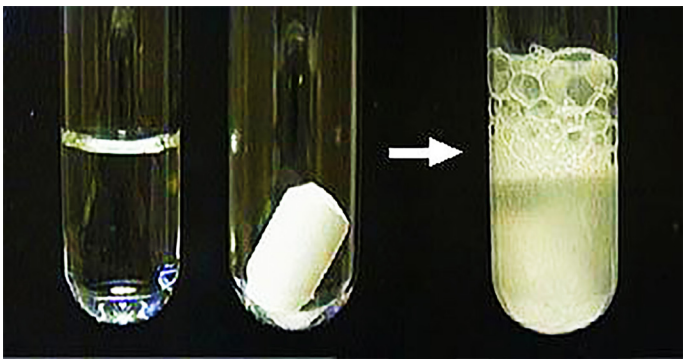


Figure 3.4: Evolving out of gas after reaction

4. Change of texture and hardness may also change. For example, moist bread dough forms a dry, porous solid after baking.
5. Changes in Energy: As matter changes, it can either absorb or release energy. Chemical reactions usually absorb or liberate heat energy. One common indication of a change in energy is a change in temperature.

N.B. All color changes, change of state, evolution of a gas and a change in energy does not necessarily mean that a chemical reaction takes place.

3.3.3 The Law of Conservation of mass

Activity 3.16

Analogy. See the following physical processes

1. If you grind a 50kg of teff in a mill what will be the mass of the powder you have?
2. If you dissolve 10g of sugar in a 50g of water, what do think is the mass of a sugar solution?
3. If you burn a piece of paper what do you think about the mass of paper before and after burning?
4. What will be the mass of ash formed if 10g of magnesium is burned in oxygen? Do you think the mass of magnesium and the mass of the ash equal? Why?
5. Take 30g of NaCl solution in one test tube and 30 g of $AgNO_3$ solution in another test tube. Mix the two solutions in a beaker. What do you think is the mass of the product in a beaker?

Notice: Measure the mass of the beaker before mixing the two solutions.

The law of conservation of mass states that mass is neither created nor destroyed during a chemical reaction. That is the total mass of the reactants is equal the total mass of the products. This is because the number and types of atoms in reactant elements and in products are equal.

For example, if two atoms of sodium react with two atoms of chlorine, they form a compound sodium chloride containing two sodium and two chlorine atoms as;

$2Na + Cl_2 \rightarrow 2NaCl$

Experiment 3.3

Title: Investigation of the law of conservation of mass

Objective: To determine the mass of substance before and after a chemical reaction.

Apparatus: Spatula, test tube, Bunsen burner, beam balance and test tube holder.

Chemicals: Iron filling and sulfur powder

Procedure:

1. Measure the mass of test tube.
2. Take 5 grams of iron filling and 9 grams of sulfur powder, mix them in a test tube.
3. Heat the mixture strongly in a closed test tube.
4. After the reaction is completed, cool the test tube and take the mass of the test tube with its content.
5. Subtract the mass of the test tube from the mass you obtained in step4.

Observation and Analysis

1. What is the mass of the new compound formed in the reaction?
2. Is there change in mass before reaction and after reaction?
3. What do you conclude from the Experiment ?
4. Write the balanced chemical equation.

3.3.4 Writing simple chemical equation

Activity 3.17

The chemical reaction between zinc and hydrochloric acid to form zinc chloride and hydrogen gas can be written shortly as: $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

a. List all the things used to write the chemical equation.

b. What is the name of substances on the left side of the arrow? List them.

c. What do we call the substances found on the right side of the arrow? List them

In order to describe a chemical reaction, we need to indicate what substances are present at the beginning and what substances are produced at the end of the reaction.

A chemical equation is the shorthand representation of a chemical reaction using formulas of reactants and products. The general chemical equation for a reaction can be written as:

Reactants → Products

In the chemical equation, the reactants are on the left side and products on the right side of the arrow "→ "

The arrow is read as "to produce" or "yields".

For example: The reaction: $C + O_2 \rightarrow CO_2$ is read as: 'Carbon reacts with oxygen to produce carbon dioxide.'

3.3.5 Balancing chemical equation

Activity 3.18

1. What do we mean balancing of a chemical equation?
2. Why do you think that all chemical equations are always balanced?

To describe a reaction accurately, a chemical equation must show the same number of each type of atom on both sides of the equation. A chemical equation is balanced to obey the law of conservation of mass.

There are several methods for balancing chemical equations. We will see two methods namely the inspection method and the L.C.M (Least common multiple) methods at this level.

N.B. *During balancing chemical equations the subscript numbers should not be changed.*

I. Inspection (Trial and error) Method

It is a method of balancing an equation by putting a coefficient before the symbol or formula by trial and error. In this method, we use the following steps to balance the chemical equations.

Step 1: Write the word equation.

Step 2: Write the symbols and formulas of the word equation.

Step 3: Put coefficients in front of the reactants and products by trial and error until the chemical equation is balanced.

Example:

When potassium reacts with oxygen it produces potassium oxide. Write a balanced chemical equation for this reaction.

Step 1. Write the word equation

Potassium + oxygen → Potassium oxide

Step 2. Write the symbols and formulas of the word equation

$K + O_2 \rightarrow K_2O$

Step 3. Putting coefficients of reactants and products by trial and error until the reaction is balanced.

$K + O_2 \rightarrow K_2O$

Here observe carefully that both O and K atoms are not balanced. To balance O insert coefficient number 2 before K_2O hence O is balanced as;

$K + O_2 \rightarrow 2K_2O$

However, K is still unbalanced because the number of K atoms are 2 on the reactant side and 4 on the product side at this stage.

Finally, to balance K, change the coefficient of K into 4 on the reactant side in front of K. Therefore, the equation is balanced:

$4K + O_2 \rightarrow 2K_2O$

Activity 3.19

Balance the following chemical equations by inspection method.

1. Carbon burns in oxygen to produce carbon dioxide.
2. Magnesium reacts with hydrochloric acid to form magnesium chloride and hydrogen gas.

II. Least Common Multiple (L.C.M) method

This is a method of balancing using the least common multiple (L.C.M) of all the total valence number of each atom involved in a chemical reaction and dividing the L.C.M by the total valence number of each element. The following steps are used to balance a chemical equation using the L.C.M method.

Step 1. Write the total valence number of each element above it

Step 2. Find the L.C.M of all total valence number and write it above the arrow

Step 3. Divide the L.C.M by the total valence number of each element.

Step 4. Write the number obtained in step 3 as a coefficient of the formula.

Step 5. Check if the number of elements of each kind on the reactant side and product side are exactly equal.

Example:

Write a balanced chemical equation for the reaction between aluminium and oxygen forming aluminum oxide as: $Al + O_2 \rightarrow Al_2O_3$

Step1. In the reactants, aluminium atom has a valence number of3. Write 3 above Al. Each atom of oxygen has a valence number of 2, the total valence number of oxygen is4. Write 4 above O.

In the product; Al_2O_3 the total valence number of aluminum is 6, write 6 above Al. In the same way the total valence number of oxygen is 6. Write 6 above oxygen as;

$$\overset{3}{Al} + \overset{4}{O_2} \rightarrow \overset{6\ 6}{Al_2O_3}$$

Step2. The L.C.M (Least common multiple) of 3, 4, and 6 is 12. Write this number above the arrow as,

$$\overset{3\quad 4}{Al + O_2} \xrightarrow{12} \overset{6\ 6}{Al_2O_3}$$

Step3. Dividing 12 (the L.C.M) by the total valence number of each atom gives

$12 \div 3 = 4$, for Al, $12 \div 4 = 3$, for O_2 and $12 \div 6 = 2$ for Al_2O_3

Step4. Writing the results of step 3 as coefficients of the corresponding formula.

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

Step5. Check-up the number of atoms present on the right and left sides

Left (reactant) side 4 Aluminum and 6 Oxygen

Right (product) side 4 Aluminum and 6 Oxygen

Since the number of atoms of each element on both sides are equal, the balanced equation will be;

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

Activity 3.20

Balance the following chemical equation using the L.C.M method

1. $Ca + N_2 \rightarrow Ca_3N_2$
2. $Na + O_2 \rightarrow Na_2O$.

3.3.7 Demonstrating balanced equation

A balanced chemical equation must obey the Law of Conservation of Mass. This is an important guiding principle to write different chemical equations. You can balance chemical equations using different materials in your surroundings. In the next Activity , your teacher will guide you how chemical equations are balanced using drawing colored circular models. The models represent the elements on the reactant and product side.

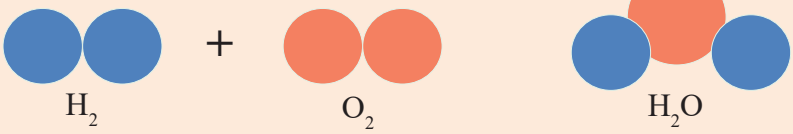
Activity 3.21

Using drawing colored circular models, write the balanced reaction of hydrogen with oxygen that gives water

Procedure:

1. Label reactants and products with different circular colors with markers, to represent each side of a chemical equation.
2. Choose one color to represent an element in the chemical reaction.
3. To create a compound, put the correct circular color together to represent a bond between atoms.
4. Count the total number of atoms you have for your reactants and products before you attempt to balance the equation. Look for the same colors on both sides of the equation.
5. Determine if you need to balance the equation by adding coefficients. This is done by comparing the numbers for each atom on the reactant side with the product side.
6. Then add any coefficients if they are needed and count how many atoms we now have. You do not need to change any subscript number to balance the equation.

Hint: -



Result

1. What are the coefficients of the reactants and products?
2. Do you think the reaction obeys the law of conservation of mass?

3.4 Uses of chemical reactions in everyday situation

Activity 3.22

You experience burning of materials when you strike a match, burn a candle, start a campfire or burn wood, etc.

Observation and reflection

1. What is burning?
2. Write three uses of burning. (Hint: We cannot drive a car if there was no burning.) Add other examples.

Think it over

Chemical reactions are used to produce most of our energy. List out reactions in groups that can be used as a source of energy in your home and present your report to the class.

Chemical reactions are an integral part of technology, culture, and life itself. Burning fuels, cooking food, smelting iron, making glass and pottery, brewing beer, and making wine and cheese are among many examples of activities incorporating chemical reactions that have been known and used for thousands of years. Chemical reactions are the basis for the geology of earth, in the atmosphere and oceans, and in a vast array of complicated processes that occur in all living systems.

Summary

- Chemical symbol is shorthand notation of the name of elements.
- Chemical formula is shorthand notation of the chemical name of elements or compounds.
- Chemical equation is shorthand representation of the chemical reaction.
- Valence number of an element is the combining power of an element with another
- Chemical formulas are written using the valences of the elements combined.
- Chemical formulas have qualitative and quantitative meaning.

- Quantitatively a formula represents the number of the elements in a given compound.
- Qualitatively a formula represents the kind of elements involved in making a compound.
- Compounds composed of only two different elements are known as binary compounds.
- Polyatomic ions are groups of atoms bonded together and have an overall electric charge.
- A chemical reaction is the process of converting reactants to products.
- Chemical reactions involve changes in properties of substances and a changes in energy.
- The law of conservation of mass states that, during a chemical reaction, mass is neither created nor destroyed.
- Chemical equation is the shorthand representation of a chemical reaction using formulas of reactants and products.
- A balance chemical equation must obey the Law of Conservation of Mass.
- In a balanced chemical equation, the total number of atoms of each element on the left hand side is equal to the total number of atoms of the same elements on the right hand side.

Review Questions

Instruction I: Write 'TRUE' if the statement is correct or 'FALSE' if it is incorrect.

1. Elements are the simplest substances which cannot be broken in to simpler substance by ordinary reactions.
2. Two elements can have the same chemical symbols.
3. Polyatomic ions can exist in nature by themselves.
4. Atoms of elements are neither created nor destroyed during a chemical reaction.
5. F_2 and 2F have the same meaning.
6. A compound contains two or more types elements that are chemically combined together.

7. Chemical equations must obey the law of conservation of mass.

8. In chemical equations reactants are written on the left while products on the right of the arrow.

9.Chemical reactions do not involve change in properties of substances.

10. Qualitative meaning of chemical formulas refers to the number of atoms present in a compound.

II Choose the Correct Answer from the Given Alternatives.

11. The chemical symbol for sodium is _____.

A. So B. S C. Na D. Sd

12. Which of the following is the correct name of $CaBr_2$?

A. Calcium bromide C. Carbon dibromide

B .Carbon bromide D. Calcium(I) bromide

13. Aluminum has a valence number of 3 and sulfur has a valence number of 2 What is the chemical formula for aluminum sulfide?

A. Al_2S B. AlS_3 C. Al_3S_2 D. Al_2S_3

14.The name of NO_2 is _____.

A. Nitrogen monoxide C. Nitrogen oxide

B. Nitrogen dioxide D. Mononitrogen oxide

15. Quantitatively the formula $3N_2$ represents _____.

A. 3 atoms of nitrogen B. 2 molecules of nitrogen

C. 3 molecules of nitrogen D. 6 molecules of nitrogen

16. The correct balanced chemical equation for the reaction between iron and oxygen to form iron (III) oxide is

A. $2Fe + O_2 \rightarrow 2FeO$ B. $3Fe + 2O_2 \rightarrow Fe_3O_4$

C. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ D. $Fe + O \rightarrow FeO$

17. The valence number of silicon (Si) in SiH_4 is _____.

A. 1 B. 2 C. 3 D. 4

18. The Latin name of potassium is _____.

A. Argentum B. Kalium C. Natrium D. Cuprum

19. Consider the following balanced chemical equation;

$3Mg(OH)_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6H_2O$

What is the coefficient of water in the chemical equation?

A. 1 B. 2 C. 3 D. 6

20. What is the correct coefficient of nitrogen, when hydrogen reacts with nitrogen to produce ammonia (NH3) in the following reaction?

$N_2 + H_2 \rightarrow NH_3$

A. 1 B.2 C.3 D.4

III Give short answers for the following questions.

21. Write chemical formulas for the following compounds.

a. Potassium phosphate b. Calcium fluoride

c. Phosphorus trioxide d. Iron(II) oxide

22. Name the following compounds

a. $MgSO_4$ b Al_2O_3 c NaCl

23. Write a balanced chemical equation for each of the following reactions.

a. Aluminum + Chlorine → Aluminum Chloride

b. Sodium + Oxygen → Sodium Oxide

c. Potassium + Water → Potassium hydroxide + Hydrogen

24. What is the chemical symbol of Silver?

25. What is the name of the starting materials in a chemical reaction?

26. What is the meaning of coefficient number and subscript in writing chemical equations?

27. During a chemical reaction heat energy may be released. Does the temperature of the reaction increase or decrease? Explain?

28. The source of electrical energy in our country is water and wind. Mention other possible electrical energy sources our country can use.

29. State and explain the law of conservation of mass.

Unit 4

Cell as the Basis of Life

Learning outcomes: At the end of this unit, you will be able to:

- Define a microscope.
- Explain the use of a microscope.
- Distinguish the different types of microscopes.
- Describe the basic parts and functions of a microscope.
- Use a microscope to observe objects.
- Define a cell.
- Explain how cell was discovered.
- Draw a cell and label its major parts.
- Describe the functions of the major structural parts of a cell.
- Distinguish between unicellular and multicellular organisms.
- Give examples of cell shape.
- Explain why cell shape and structure vary.
- Discuss the differences of cell, tissue, organ and organ system.
- Define respiration and write its chemical equation.
- Describe photosynthesis and its chemical equation.
- Develop science process and inquiry skills.
- Develop and use a model to describe the structure and function of a cell.
- Analyze and describe the relationships of the hierarchical levels (Kingdom to Species) in the classification of organisms.

4.1 Microscope

Activity 4.1

Think of a pond in your surroundings. What living things have you seen living in it? Mention some of them. Do you know there are living things in the pond which cannot be seen with our naked eyes? What instrument helps us to see these very small living things?

Activity 4.2

1. Can you name something that exists even though you can't see it with your eyes?
2. Have you ever seen a microscope? When someone gets sick, she/he probably might have gone to a clinic or hospital. The medical laboratory technicians take samples, either stool or blood for diagnosis. Can you guess the instrument they are using for identification of parasites in the stool or blood?

Do you know this instrument?

A microscope is a tool that helps us to see objects that are too small to be seen by the naked eye. It enables us to see small objects by enlarging images of the objects. Some of the most basic concepts of biology such as cells were not imaginable before the invention of microscopes. Biologists use microscopes to study organisms, cells and cell parts.

4.1.1 History of invention of microscope

Activity 4.3

1. Explain how the microscope was invented?

During the 1590s, two Dutch eyeglass makers, Zacharias Janssen and his father Hans Janssen, Experiment ed with early lenses. They realized that if you put a small object in front of a tube containing several lenses, the object would appear very large and much more enlarged when compared with a single magnifying glass. In such a way they invented the compound microscope. Since that time, new developments were made on microscopes until today's sophisticated microscopes are developed.

Robert Hooke improved microscope in 1665. He made a compound microscope. During the 1670s, Anton Leeuwenhoek, born in Holland, made microscope with a simple single lens device which had greater clarity and magnification than compound microscopes of his time.

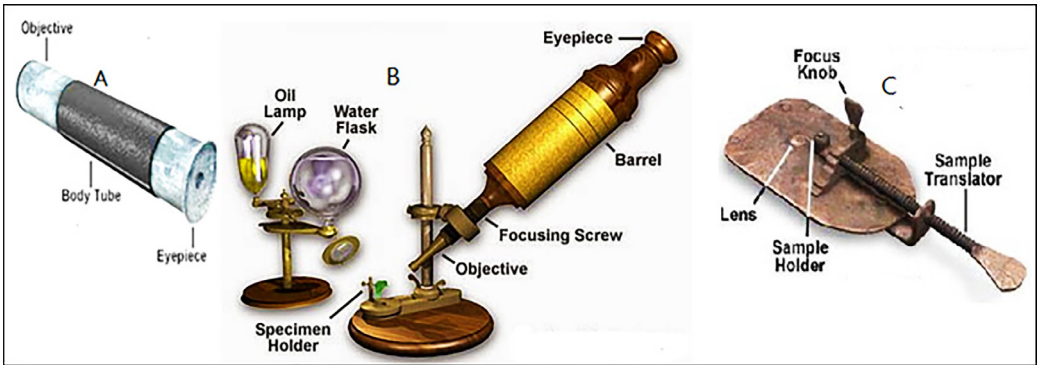


Figure 4.1 Early microscopes.(A: Zacharias Janssen and Hans Janssen's microscope, B: Robert Hooke's microscope and C:Anton Van Leeuwenhoek's microscope)

Activity 4.4

1. Discuss the works of Zaccharias Janssen and Hans Janssen, Anton Van Leeuwenhoek and Robert Hooke in relation to microscope invention.

4.1.2 Types of microscope

Today, various types of microscopes are available for use in science laboratories. Microscopes have varied applications and modifications related to their purpose.

Activity 4.5

1. Can you explain how microscopes differ from one another?
2. Look at the following diagrams carefully. If you are asked to classify them into two groups, what do you think are the criteria?

3. Name the above instruments (A to D)

Based on the number of lenses, microscopes are classified into two types: simple microscope and compound microscope. A simple microscope has a single convex lens for magnification. Simple microscopes have low magnification power; usually they enlarge objects 10 to 20 times. Simple microscopes help to enlarge small objects, letters and observe structures of insects and flowers etc.
Leeuwenhoek's microscope, hand lenses and reading eyeglasses are examples of simple microscopes.

A compound microscope is a microscope that uses two lens systems at the same time. The two lens systems are the eyepiece (ocular) lens and the objective lenses. The word 'compound' refers to use of multiple lenses in compound microscopes as opposed to simple microscopes which use a single lens. The objective lens is compounded (multiplied) by the eyepiece lens. The eyepiece lens usually magnifies ten times and is labeled 10X. The objective lenses magnify 4X to 100X. Total magnification is, therefore, the product of the magnifications of the eyepiece and objective lenses.

Compound microscopes are used to observe plant and animal cells, and microorganisms like yeast, amoeba and others.

Activity 4.6

If the size of an organism is 0.001mm, how large will it be if it is magnified by a compound microscope under low power (if the magnification of the ocular lens is 10X and the low power objective is 4X)? Hint: Actual Size = Image size ÷ Magnification.

Practical Activity 4.1 Observing objects

Materials needed: Hand lens, Samples (insects like ants, housefly)

A. Observing insects using hand lens

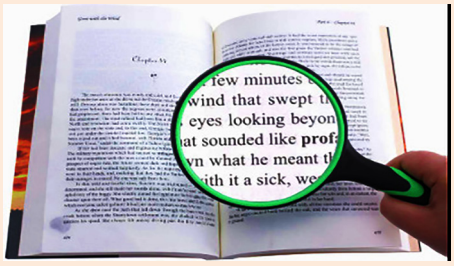
Procedure:

1. Bring sample non-poisonous insects to the laboratory or classroom.
2. Put the specimen (insect) on a Table or any surface in a bright area.
3. First look at the insect with naked eyes. Then, take the hand lens and hold it just above the specimen and move it up and down slowly until the image appears clear.

B. Observing letters using hand lens

Open a book and observe the text with a hand lens. Now, based on your observations, reflect on the following questions.

1. Compare your observations with that of the following diagrams.



2. What difference have you noticed when you observe with your naked eye and with that of the hand lens?
3. Why do you think people wear reading eyeglasses?

4.1.3 Basic parts of compound microscope

A compound microscope has different parts which should be manipulated to magnify objects. The different parts of a compound microscope and their functions are described in the Table below.

Table 4.1 Parts of a compound microscope and their functions

Part	Function
Eyepiece (ocular)	The lens at the top of the microscope that we look through. On its rim, there are certain markings such as 5x, 10x, 15x which indicate the magnification power. Ocular magnifies the image of the object.
Body tube	It is a hollow tubular structure that connects the eyepiece to the objective lenses. Light enters from the objective to the ocular through the body tube.
Arm	Holds the body tube and lenses. Used to carry the microscope.
Coarse adjustment knob	Used for quick focusing by moving the objective lens or stage up and down. It raises and lowers the stage or objective more rapidly. It is used for initial focusing.
Fine adjustment knob	It also raises and lowers the stage or objective lenses but more slowly. It allows you to make very fine focus adjustments. Fine adjustment knob is used when high power magnifications (objective lenses other than low power) are used.
Objective lenses	These magnify the image of the specimen, and project the magnified image into the body tube. Objective lenses come in various magnification powers, with the most common being 4x (low power), 10x (medium power), 40x (high power), and 100x (oil immersion objective).
Nose piece	Holds objective lenses. It can be rotated into position for different magnifications.
Stage	A platform for placement of the microscope slide.

Stage clips	Hold the slide in place on the stage.
Mirror	Reflects light up to the diaphragm.
Condenser	It is optical lens located under the stage often in conjunction with a diaphragm. It is used to collect and focus the light from the illumination (light source) on to the specimen.
Diaphragm (iris)	The opening and closing of this iris diaphragm controls the amount of light which pass through the condenser.
Base	The bottom of the microscope used for support.

Activity 4.7

1. Based on Table .4.1 and the lists of parts of a compound microscope given below, identify and label the parts of the microscope.

Eyepiece | Nose piece | Body tube | Fine adjustment knob | Arm | Base | Objective lenses | Stage clip | Stage | Coarse adjustment knob | Diaphragm

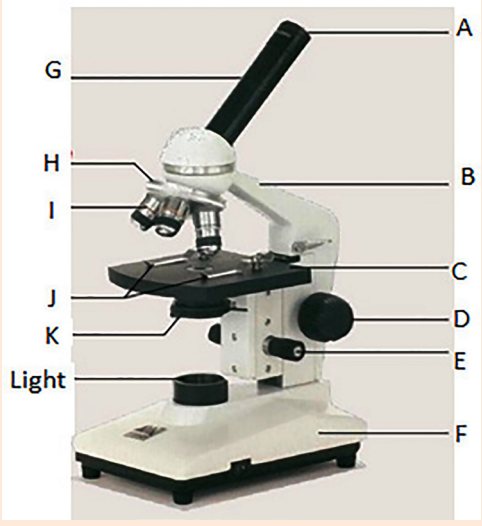


Figure 4.2 Parts of a compound microscope

Care of a microscope

Microscope is an expensive laboratory instrument that should be used with great care. So, using a microscope properly is an important skill for biologists.

Give attention to the following precautions while handling and using a microscope.

1. Always use both hands when carrying the microscope. Place one hand on the arm and the other hand under the base.
2. Carefully place the microscope on your work Table .
3. While looking through the eyepiece, carefully turn the coarse adjustment knob until the specimen comes into view.
4. Use the fine adjustment knob for final focusing of the image.
5. Use ONLY the fine adjustment knob to focus on high power. Never use the coarse focus knob on high power! If you turn the coarse adjustment knob while on high power, the objective could easily break your slide and damage the objective lens.
6. Always use cover slip when mounting since it protects the objective lens if it touches the slide.
7. Do not touch the glass part of the lenses with your fingers.
8. You should use only lens cleaner to clean lenses.

Practical Activity 4.2 Studying parts of a microscope

So far you have learnt about the different parts of a compound microscope. Now your teacher will provide you a microscope and you will be asked to identify the part and tell its function.

1. Locate the eyepiece. Note that it is marked with a number and an “X”. Is it 10X or 15X? This is where you view objects.
2. Locate the arm and the base. Hold the arm in your one hand and the base in your other hand. Can you tell the functions of these parts, base and arm?
3. Where is the revolving nose piece? Note that the objective lenses are attached to it.

Are the objectives of the same length? Look the numbers on the objective lenses? What do the numbers indicate? Which objective lens has greater number? The objective lens with greater number magnifies bigger than the one with small number.

4. Find the coarse adjustment knob. Turn it slowly upwards and downwards. What happens? Does the stage or the body tube with the objective lenses raises and lowers?
5. Locate the nose piece. Rotate it to the right or left. This is how you select the objective lenses.
6. Now, locate the mirror. The mirror is used to reflect light from an external electric light or commonly from diffused sunlight from the windows or ceiling electric light.

Warning: Never reflect sunlight directly onto the mirror!

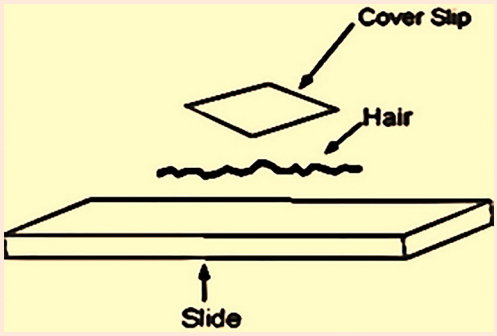
Practical Activity 4.3 Mounting and focusing

Definition of terms: Mounting means preparing a specimen on a slide for microscopic observation. Focusing is adjusting the focus to see the specimen clearly. Specimen is a sample of object, plant, animal etc. for microscope study.

Materials required: Microscope, Microscope slide, Cover slip, Dropper, Water, Hair or fiber, Forceps

Procedure

1. Place a drop of water on the middle of a microscope slide.
2. Using a pair of forceps, place a few strands of hair or fiber on to the drop of water.
3. Cover it with a cover slip.
4. Place the slide on the microscope stage and observe under low power and medium power.



Question - What does the fiber or hair look like before and after observing under a microscope?

Project work 1: Making microscope from local materials

Are you ready to make a simple microscope? Try the following and do your own!!

Materials required:

- Plastic water bottle
- Scissors or Knife

Procedures:

Step 1: Cut a plastic water bottle in half

Step 2: Sketch two notches opposite each other on the bottle.

Step 3: Add two deeper notches opposite each other in between the first notches.

Step 4: Cut out notches with scissors. The lower notches should be 2.5 cm or so below the upper notches for ease of use and to help magnify items.

Make the slides

- Step 1: Cut a flat plastic into strips to make "slides"
- Step 2: Put the specimen on one of the slides.
- Step 4: Save one blank slide to make your water drop lens.

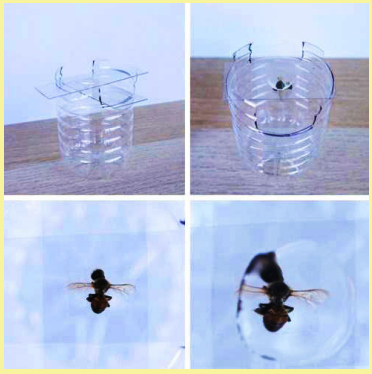
Use your microscope

Step 1: Place a slide on the lower notches.

Step 2: Place a blank slide on upper notches.

Step 3: Place a large drop of water on the blank slide.

1. Question: Now look at the specimen, what happens?
2. What is the role of water?



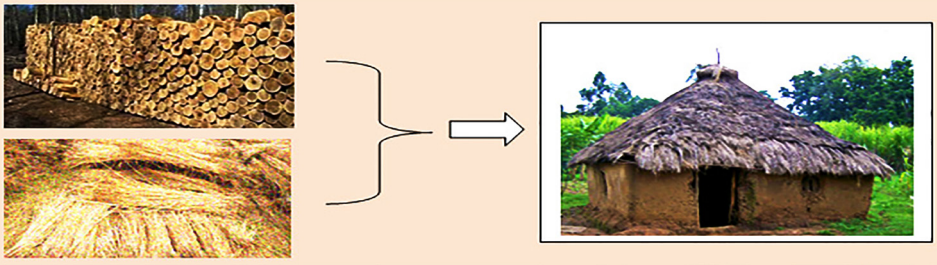
Be sure, there is enough light, the light underneath the specimen is crucial for viewing the magnified image.

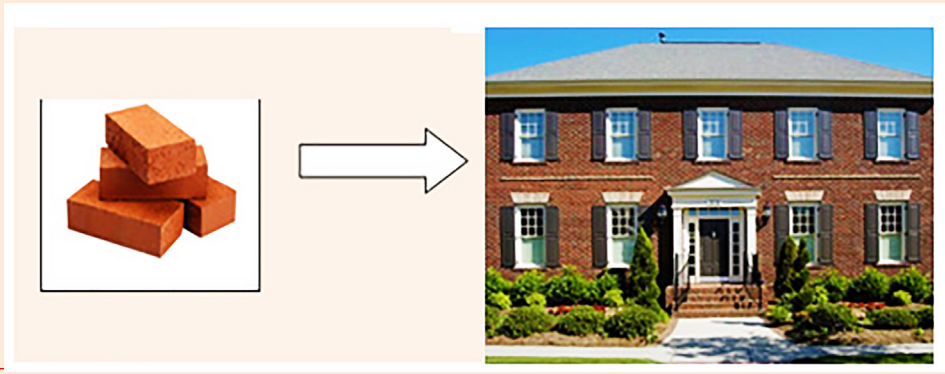
4.2 Cell

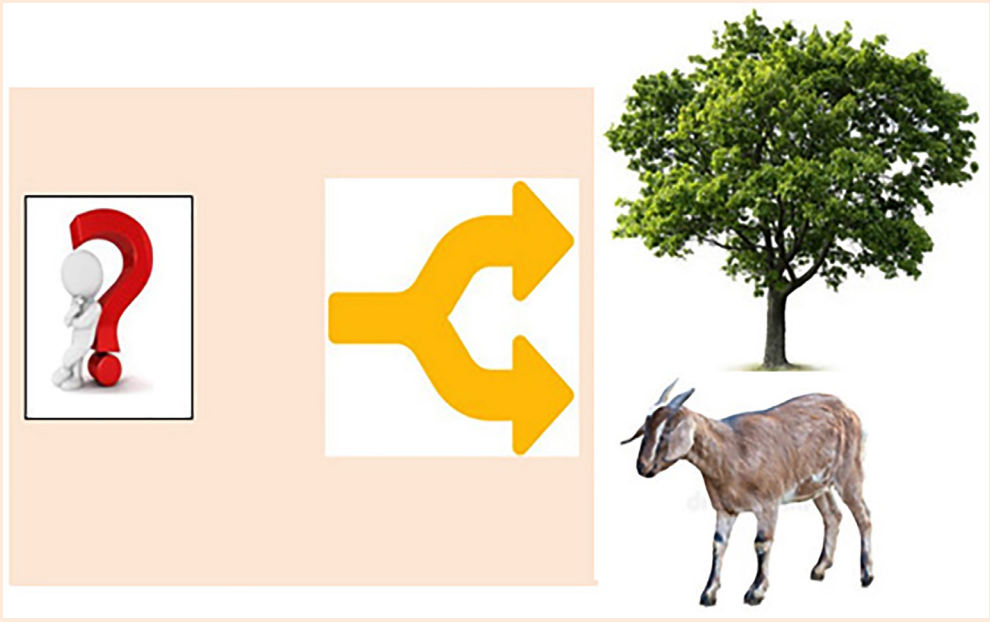
4.2.1 What is a cell?

Activity 4.8

Examine the following diagrams.







Questions:

1. What can you infer from the above diagrams?
2. What are plants and animals made of ?
3. What are you made of ?

Cells are the basic building blocks of all living things. All plants and animals are made of cells. The human body is composed of trillions of cells.

4.2.2 The discovery of cell

Activity 4.9

Read the roles of Robert Hooke and Anton Van Leeuwenhoek in the discovery of cells and describe the pictures in Fig.4.3.

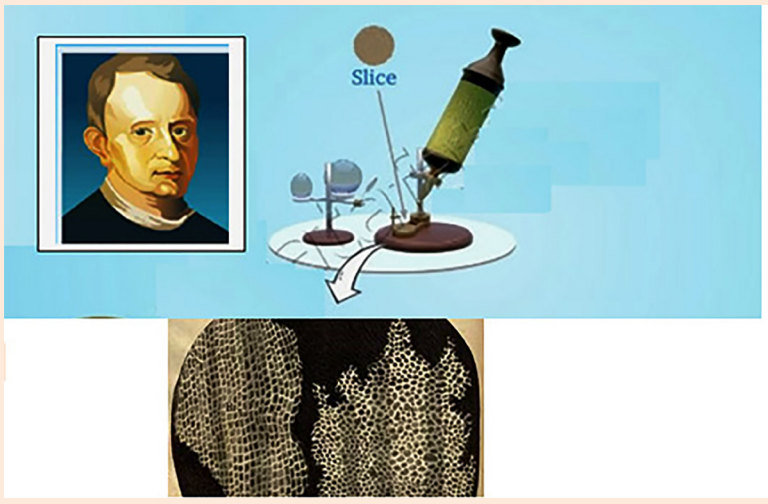


Figure 4.3 Discoveries of Leeuwenhoek and Robert Hooke

In 1665, the English scientist Robert Hooke discovered cells. Robert Hooke took a thin slice of cork from an oak tree's outer bark, and looked at cork under his microscope. He saw small boxes or compartments which looked like a honeycomb

(see fig.4.3). He called these compartments cells. Hooke actually saw the dead cell walls of plant cells (cork). He was the first person to coin the term cell.

In 1674, Leeuwenhoek observed numerous single-celled organisms swimming in a drop of pond water. He called them "animalcules" which means small animals. Most of the animalcules are now named as unicellular organisms, many of them are protozoa He also observed various cells like: bacteria, yeast cells and red blood cells. Anton van Leeuwenhoek was the first person to see living cells.

4.2.3 Structure of a cell

Activity 4.10 Teamwork: Cells are like Schools (Analogy)

Consider your School as cells and generate analogy to cells. For example, the cell membrane controls what goes in and out of the cell, much like the main gets in your school control what go into the school. Create similar analogies: to the director's office, teachers' lockers, students' or teachers' cafeteria and walkways.

As schools have various buildings and rooms to carry out their learning and teaching Activity , cells also have various compartments to do life processes. These compartments in cells are called organelles.

Even though, there are many different types of cells, they all have four common characteristics. These are:

1) All cells are surrounded by a cell membrane. The cell membrane is an outer covering that separates the cell's interior from its surrounding environment. It also controls the movement of materials into and out of the cell.
2) All cells contain cytoplasm. It is a jelly-like fluid which contains organelles. It also contains the compounds that cells need to survive such as water, salts and enzymes.
3) All cells contain DNA. DNA is important to make new cells and controls all cell functions.
4) All cells contain ribosomes, which synthesize proteins.

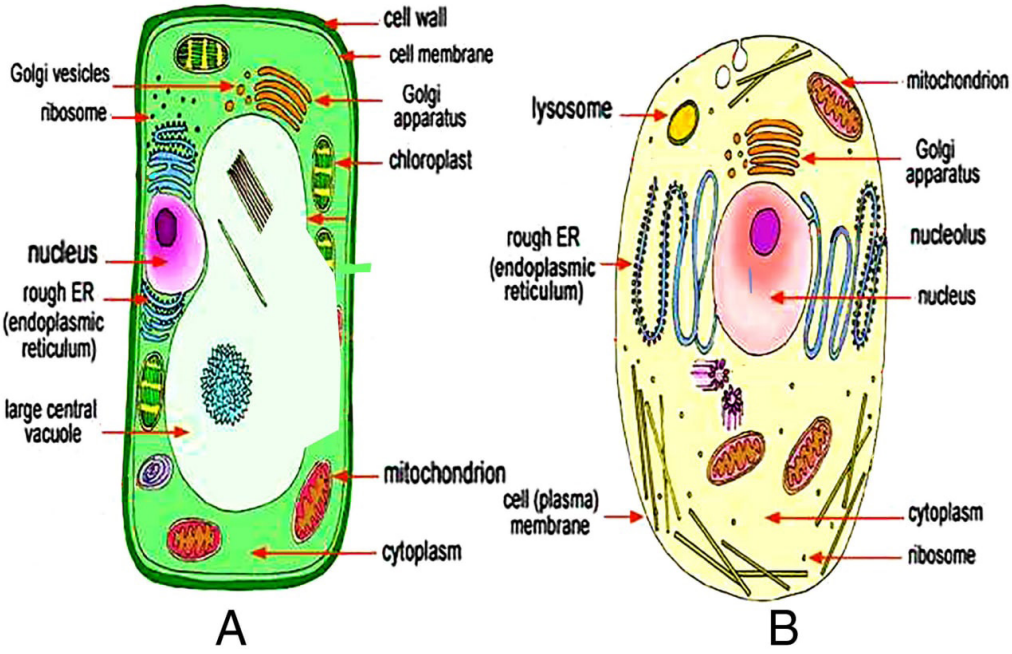


Figure 4.4 Structure of plant (A) and animal cells (B)

Activity 4.11

Refer biology book on cells answer the questions below.

A. Complet Table 4.2.

B. Identify which organelles are present in animal or plant cells only

C. Which organelles are common to both plant and animal cells?

Table 4.2 Cellular organelles and their functions.

Cell part	Function	Present in	
		plant cells	Animal cells
Plasma membrane (Example)	Separates cell from external environment; controls passage of organic molecules, ions, water, oxygen, and wastes into and out of cell	✓	✓
Cytoplasm			
Nucleus			

Ribosomes			
Mitochondria			
Cell wall			
Chloroplasts			
Endoplasmic reticulum			
Golgi body			
Vacuole			
lysosome			

Project work: 2 Constructing Cell Model

Materials required: colorless plastic bag, large seed (dry beans) or stone, water, cardboard box, plastic, glue or plant exudate(natural glue from certain plants in your area) scissors and/or a sharp knife, buttons, small sticks, rubber bands, leaves or any other local materials that could represent different cell organelles. (Hint: Use a plastic to represent the cell membrane, cardboard as a cell wall, and think of the various cell organelles while preparing materials). Here you have pictures of models for reference.

4.2.4 Cell shape and size

Cell shape

Cells in organisms have different shapes. Even in the same organism,cells have different shapes. See Fig.4.5.

Activity 4.12

The illustrations given below show different types of cells. Explain how each cell differs from the rest. Can you describe the shape of cells in Fig.4.5?

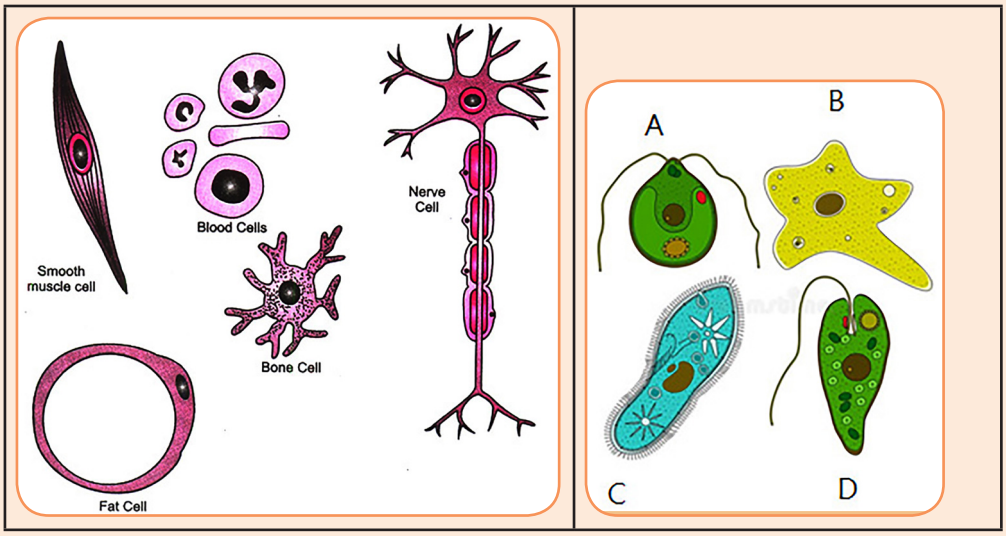


Figure 4.5 Some types of human cells (left) and some protozoa (right) with different shapes.

Why do cells vary in shape?

Cells of different organisms and even cells within the same organism are very diverse in shape, size, and internal organization. Generally, cells could be round, spherical, elongated, spindle shaped etc. Cells sometimes are very long. Some are branched like the nerve cells. The shape of cells is different because they have different functions. See Fig4.6 and note how the shape of cells is related to their function.

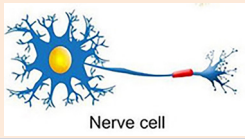
Shape	Examples	
Shape of cell:Biconcave shape Example: Red Blood Cells in Humans	This shape enables them to transport oxygen.	
Shape of cell: Spindle shaped Cells (pointed at both ends). Example: Muscle cells	Spindle shape of muscle cells allows contraction.	
Shape of cell : Long and branched cells Example: Nerve cells	With this shape they can transmit messages from one part of the body to the other.	

Figure 4.6 Shape of cells and their function

Cell size

As cells have different shapes they have also different sizes. The size of cells on average is 10 to 20 μ in diameter. Animal cells are generally smaller than plant cells. Most bacterial cells range from about 1 to 10 microns in length and from 0.2 to 1 micron in width.(1,000 microns equals one millimeter;micron is short for micrometer).

Why are cells generally small in size?

Cells generally remain small in size to transport nutrients and gases into and out of the cell and remove waste (e.g. Co_2) easily. If a cell increases in size, it becomes difficult for the cell to move nutrients and gases in and out.

4.2.5 Unicellular and multicellular organisms

Activity 4.13

Consider the following organisms.

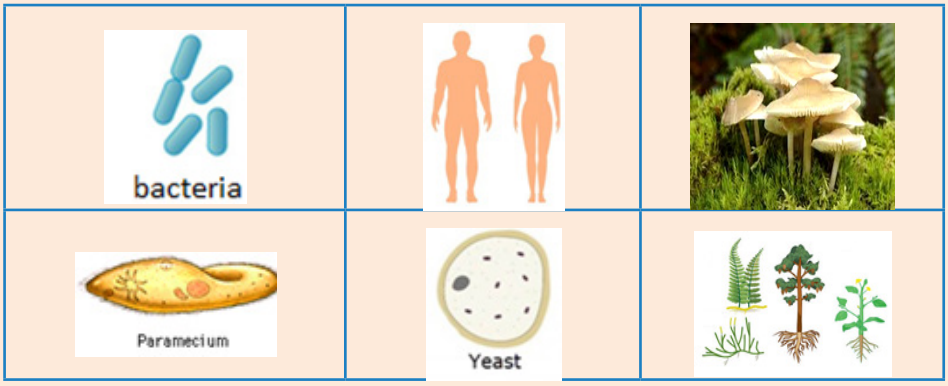


Figure 4.7 Types of organisms

Identify organisms with a) one cell, b) many cells. What can you say about the relation of the number of cells of an organism and its size?

A unicellular organism is an organism that consists of a single cell. That's all life processes such as reproduction, feeding, digestion, and excretion occur in one cell. Amoeba, paramecium, and all protozoa are examples of unicellular organisms. On the other hand, multicellular organisms are composed of many cells. All the cells work in coordination in multicellular organism. Plants, animals including humans, and most fungi are examples of multicellular organisms.

Activity 4.14

Group the following organisms either as unicellular or multicellular organisms.

Figure 4.8 Unicellular and multicellular organisms

4.2.6 Cell, tissue, organ, organ system and organism

A multicellular organism is made up of five levels of organizations: cells, tissues, organs, organ systems and organism. Studying the organization helps us to make the parts easier to understand. While cells are the basic units of an organism, groups of cells can perform a job together. These cells are called specialized because they have a special job. Specialized cells can be organized into tissues. For example, our liver cells are organized into liver tissue. Our liver tissue is further organized into an organ, the liver.

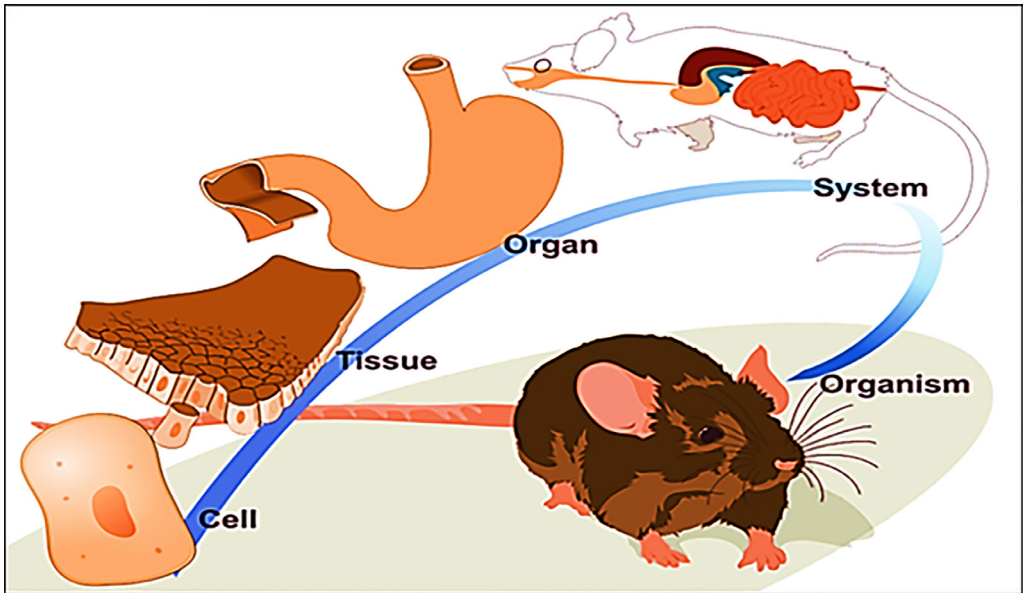


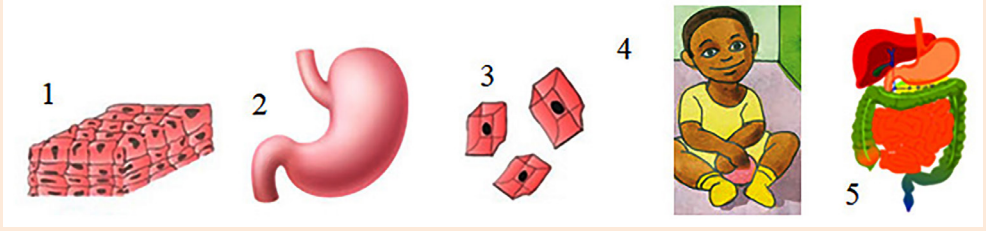
Figure 4.9 Body level of organization of a rat

Organs are formed from two or more specialized tissues working together to perform a job. All organs, from our heart to our liver, are made up of an organized group of tissues. These organs are part of a larger system, the organ systems. For example, our heart works together with our blood and blood vessels to form the circulatory system. This organ system must be organized with other organ systems, such as the nervous system and the digestive system, for our body to work. Organ systems work together to keep an organism alive. Organisms are highly complex structures which rely on many systems working together.

Activity 4.15

Look at the following diagrams carefully.

a. Try to guess what each image represents?



b. Rearrange the body parts in order of increasing complexity.

Figure 4.10 Cell, Tissue, Organ, Organ system and Organism

Activity 4.16

Consider the following levels of organizations in plant and animal bodies.

Figure 4.11 Levels of organization in a horse and a plant

a. Rearrange these levels of organization with their respective parts.

b. What structure represents an organ in the horse?

c. Name the organ system in the horse.

d. What represents an organ in the plant?

e. Take any system of yours and give an example of level of organization (other than digestive system).

4.2.7 Respiration and mitochondria

When gasoline burns in a car engine, energy is released. It is transformed in many ways, making the car function. Carbon dioxide, water vapor, and other waste gases from the burning gasoline exit through the exhaust pipe. Mitochondria are like engines in cells.

Activity 4.17

All living things need energy to survive. Without energy, life cannot exist. Where does energy come from and how? What is the role of oxygen that we inhale?

Energy is essential for normal function of the body. For example: to pump blood through our veins, inhale air into our lungs, for body movement. We need also energy for our daily life activities like writing, studying, playing football, walking; running etc

What is the source of energy that we use for all these purposes?

Cellular respiration is a multi-step process that converts the chemical energy in the food we eat into usable cellular energy. This energy used by cells is called adenosine triphosphate (ATP). ATP is produced in the mitochondria of cells. That is why mitochondria are named as the "powerhouses" of the cell.

In cellular respiration glucose (from food we eat) and oxygen (we breathe in) are used to produce energy. Carbon dioxide and water are also produced in cellular respiration. When we breathe in, our cells get oxygen needed for respiration. When we breathe out, carbon dioxide is removed from our cells.

Aerobic respiration can be summarized in a chemical equation:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} \longrightarrow \underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} + \text{Energy}$$

There are two types of respiration based on the presence or absence of oxygen. Respiration process that occurs in the presence of oxygen is called aerobic respiration. Respiration without oxygen is called anaerobic respiration. Certain

organisms like some bacteria respire anaerobically.

Activity 4.18

1. In both types of respiration, what are the inputs and outputs? Which type of respiration is more efficient and why? Do humans respire anaerobically? Explain how.
2. Do plants respire? Explain.

In both types of respiration, it is the glucose molecule that undergoes reactions to produce energy. More energy is obtained in aerobic respiration than anaerobic respiration from the same number of glucose molecules.

There are two types of anaerobic respiration:

Alcoholic fermentation- The products are energy, alcohol and carbon dioxide

Lactic acid fermentation-The products are energy, lactic acid and carbon dioxide

See the equation below for both aerobic and anaerobic respiration.

Glucose + Oxygen ⟶ Energy + carbon dioxide + water (aerobic respiration)

Glucose ⟶ Energy + Alcohol + carbon dioxide (Alcoholic fermentation)

Glucose ⟶ Energy + lactic acid + carbon dioxide (Lactic acid fermentation)

Figure 4.12 Word equation of aerobic and anaerobic respiration

During tiresome exercise like running, playing football and swimming sufficient oxygen is not available to muscles. Under such circumstances, muscles produce additional energy anaerobically. That means, we use anaerobic respiration in addition to aerobic in intense physical activities.

4.2.8 Photosynthesis and chloroplast

Activity 4.19

1. Where do plants get their food?
2. Recall the cellular structures (organelles) in a plant cell (section4.2.3). Which organelle is responsible for manufacturing food in plant cells? Why can't animals prepare their own food?

To stay alive, we need a constant supply of energy. We need energy to move, think, and grow. Where does that energy come from? It all starts with the sun. Plant cells store light energy from the sun in the form of molecules. Energy as a form of food from plants is transferred to all other living things.

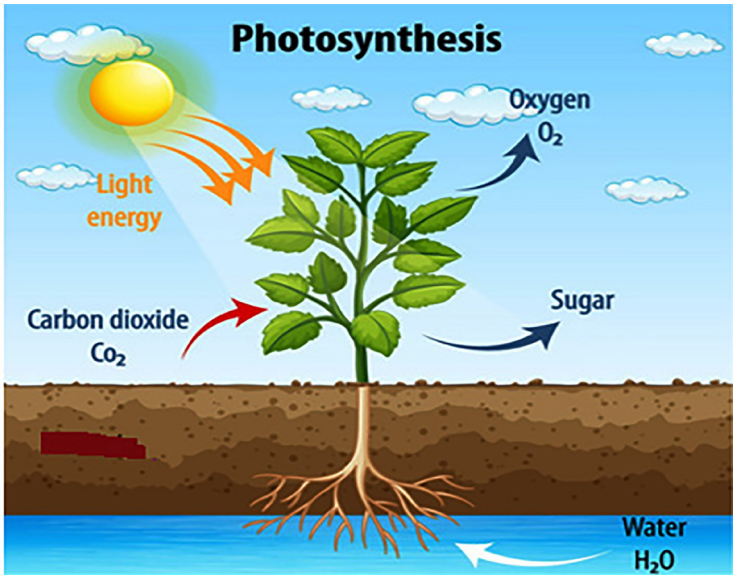


Figure 4.13 Process of photosynthesis

Activity 4.20

Look at Fig.4.13

A. What do plants need to carry out photosynthesis?

b. What are the products of photosynthesis?

Photosynthesis is a process where plants use sunlight to produce carbohydrates and oxygen. During photosynthesis, light energy is trapped by chlorophyll and used to convert water and carbon dioxide into sugar and oxygen. The process of photosynthesis can be summarized in chemical equation:

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Carbon dioxide — Water — Glucose — Oxygen

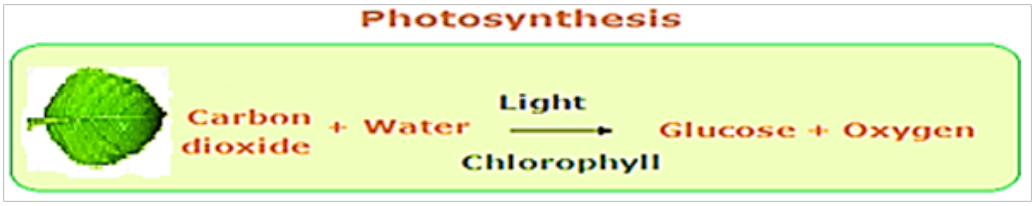


Figure 4.14 Word equation of photosynthesis

Importance of Photosynthesis

The fruits and vegeTable s we eat are obtained as a result of photosynthesis. Photosynthesis is the primary source of food for all organisms. Animals also get oxygen from photosynthesis.

Look at Fig,4.15 and study the important relationships between respiration and photosynthesis.

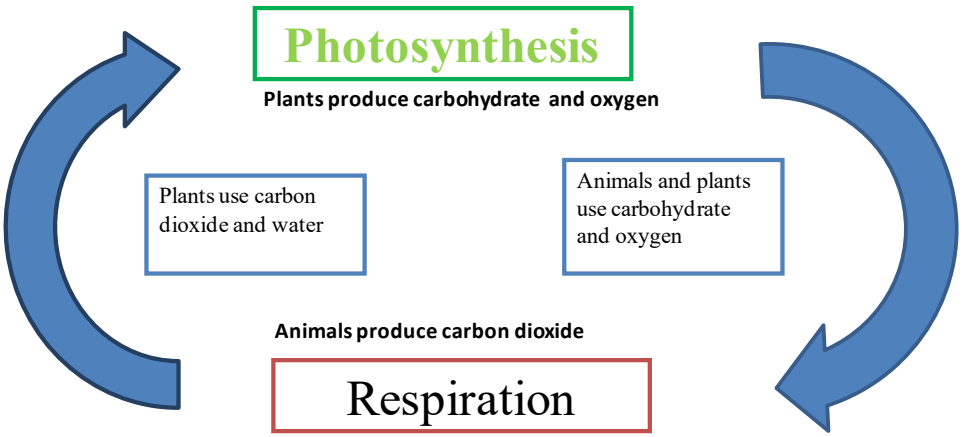


Figure 4.15 Relationship between photosynthesis and respiration

From Figure 4.15, you can understand that photosynthesis converts carbon dioxide and water into carbohydrate and oxygen. Respiration converts food into energy, water and carbon dioxide. Both processes are interrelated and living things can not exist without them (respiration and photosynthesis). The two processes are responsible for the exchange of oxygen and carbon dioxide between living organisms and the environment.

Summary

- A microscope is an instrument that can be used to observe small objects, including cells.
- Cell is the smallest structural and functional unit of an organism.
- All cells contain: plasma membrane, cytoplasm, DNA (hereditary information) and ribosomes for protein synthesis.
- Eukaryotic cells also contain membrane bound nucleus.
- Prokaryotes genetic material is not enclosed in a membrane.
- Robert Hooke in 1665 looked at cork under a microscope and described what he called the compartments he saw in the cork "cells".
- Anton van Leeuwenhoek1 called the single-celled organisms that he saw under the microscope "animalcules.
- Size of cells is limited by need for regions of cell to diffuse materials like, oxygen and other gases
- All organisms are made up of one or more cells.
- Unicellular organisms are made up of only one cell.
- Multicellular organisms are composed of more than one cell.
- Multicellular organisms have cells, tissues, organs, organ systems.
- Living things depend on the cycle of cellular respiration and photosynthesis for survival.
- Cellular respiration is a process that occurs in the mitochondria of organisms.
- In aerobic respiration in cells energy, carbon dioxide and water are produced.
- In anaerobic respiration in cells; energy, either lactic acid or alcohol and carbon dioxide can be formed.
- More energy is produced in aerobic respiration than an aerobic respiration.
- Photosynthesis needs energy from sunlight, water and carbon dioxide to produce glucose and oxygen inside chloroplasts.
- Cellular respiration and photosynthesis are biological processes responsible for the exchange of oxygen and carbon dioxide between living organisms and the environment.

Review questions

I. Multiple choice questions. Choose the correct answer from the given alternatives.

1.What do the markings like 5x, 10x, 15 x on the rim of the eyepiece indicate?

A. Indicate the magnification power C. Indicate the size of the eyepiece

B. Indicate the length of the body tube D. Indicate the power of adjustment

2.What is the correct way of carrying a microscope?

A. Hold the arm in one hand and the base on the other hand

B. Hold the body tube in one hand and the base on the other hand

C. Hold the nose piece in one hand and the base on the other hand

D. Hold the eyepiece in one hand and the base on the other hand

3. What part reflects light from an external light source up through the bottom of the stage?

A. Eyepiece B. Objective C. Mirror D. Base

4. Which structure is found ONLY in plant cells?

A. Cell membrane B. Cytoplasm C. Nucleus D. Chloroplast

5. What do the mitochondria do?

A. Make protein B. Transport materials

C. Produce energy D. Store food

6. The hard, nonliving material that makes up the cell wall of a plant cell is _____.

A. Protein B. Lipid C. Cellulose D. Carbohydrate

7. Which of the following lists the correct order for the levels of organization in the human body, from most to least complex?

   A. Organism → organ system → organ → tissue → cell

   B. cell → organ → organ system → tissue → organism

   C. Organism → cell → tissue → organ → organ system

   D. Cell → tissue → organ → organ system → organism

II. Complete the following blanks with appropriate words/phrases.

8. When focusing a specimen, you should always start with the _____

9. When using the high-power objective, only the _____ knob should be used.

10. To which part of the microscope are the objectives attached to? _____

11. A group of cells with similar structures working together are _____.

12. In cellular organization of plants, shoots and roots are examples of _____.

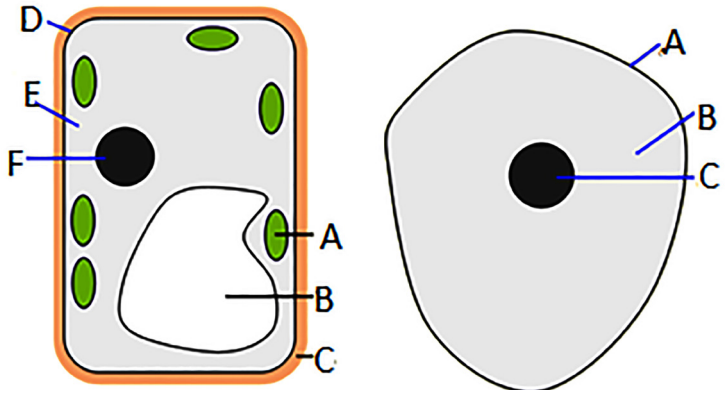
13. Glucose and _____ are the products of photosynthesis.

14. _____, water, and energy are the products of cellular respiration.

15. Photosynthesis is the process in which energy from _____ is transferred to glucose.

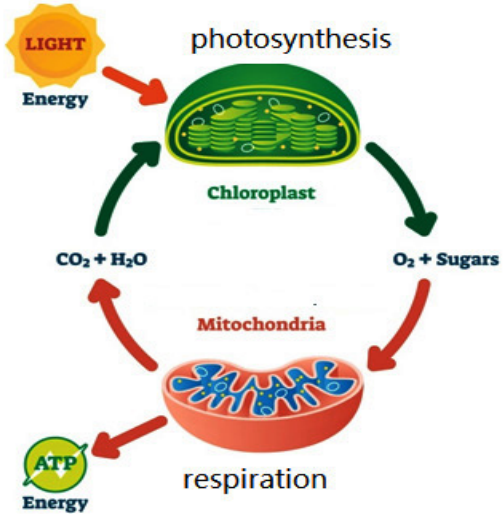
16. Photosynthesis occurs in the ____ and cellular respiration occurs in the _____.

III . Label the following diagram and identify which one is a plant cell or an animal cell.



IV. Short answer questions

1. What would happen if microscope had never been invented?
2. On a compound microscope, an objective lens magnifies an object 25 times and the ocular lens magnifies it 10 times. What is the final magnification of the image?
3. Suppose you when you look a cell under a microscope, you observe the cell has a nucleus and a cell wall. Is it an animal cell or a plant cell? How do you decide?
4. Describe the relationship between cellular respiration and photosynthesis. Discuss the functions of chloroplasts and mitochondria.
5. What happens to the energy after it is absorbed during photosynthesis?
6. How do photosynthesis and cellular respiration form a cycle of energy storage and use?
7. Evaluate the importance of plants to other organisms and the environment.
8. Use the diagram to answer the next two questions.
   a. Which process stores energy? Which process releases energy? How do you know?
   b. Why do living things need both processes for survival? Explain.



Unit 5

Living Things and their Diversity

Learning outcomes: At the end of this unit, you will be able to:

- Distinguish between living and nonliving things by describing the features that characterize living organisms.
- Discuss if movement i.e. locomotion can characterize all living things or not.
- Define classification and its purpose.
- Explain the purpose of scientific name.
- List down the hierarchical levels in the classification of organisms.
- Describe the distinguishing characteristics of the kingdom Animalia, Plantae, Protista, Monera and Fungi.
- List common examples of animals, Plantae, Protista, Monera and Fungi.
- Describe the body plan of a common animals, Plantae, Protista, Monera and Fungi.
- Describe habitats of animals, Plantae, Protista, Monera and Fungi.
- Compare the five kingdoms of living things by describing their distinguishing characteristics.
- Summarize the commonest examples of organisms belonging to each Kingdom.
- Describe the body plans of insects such as butterfly, amphibians such as frogs, mosses, liverworts, ferns, conifers such as junipers, flowering plants, Paramecium, Algae, and Mushroom.
- Relate each Kingdom of organisms to their major habitat types as aquatic, terrestrial or moist.

5.1 Living things

Why is a stone different from a butterfly? In this section, you will learn about the characteristics that distinguish living things from nonliving things.

Activity 5.1

Your teacher classifies soil, water, and Table into one group, and eucalyptus, sheep, and mushrooms as a different group.

1. Why does your teacher classify them into two different groups?
2. List down as many differences/similarities as possible between these two groups.
3. Are you a living thing? Why?
4. Classify things found in your classroom into living and non-living things.

Around us, we can find many things like stone, soil, buildings, air, water, plants, and animals. The earth in which we live is made up of several things. These things can be categorized into two groups, living and non-living things.

5.1.1 Characteristics of living things

All living organisms share several key characteristics or functions. These are sensitivity or response to the environment, reproduction, growth and development, respiration, nutrition, excretion, adaptation, homeostasis, and metabolism. All these characteristics define life. Non-living things lack all this characteristics.

Activity 5.2

Look Figure 5.1

Figure 5.1 Examples of animals and plants

a. Are they all living things? Why?

b. Do they all move from place to place? Can we say that those which cannot move are living things? What can you conclude about locomotion as the characteristic of living things?

c. Are all things that move living things?

Activity 5.3

Which characteristic of living things is shown in the pictures below?

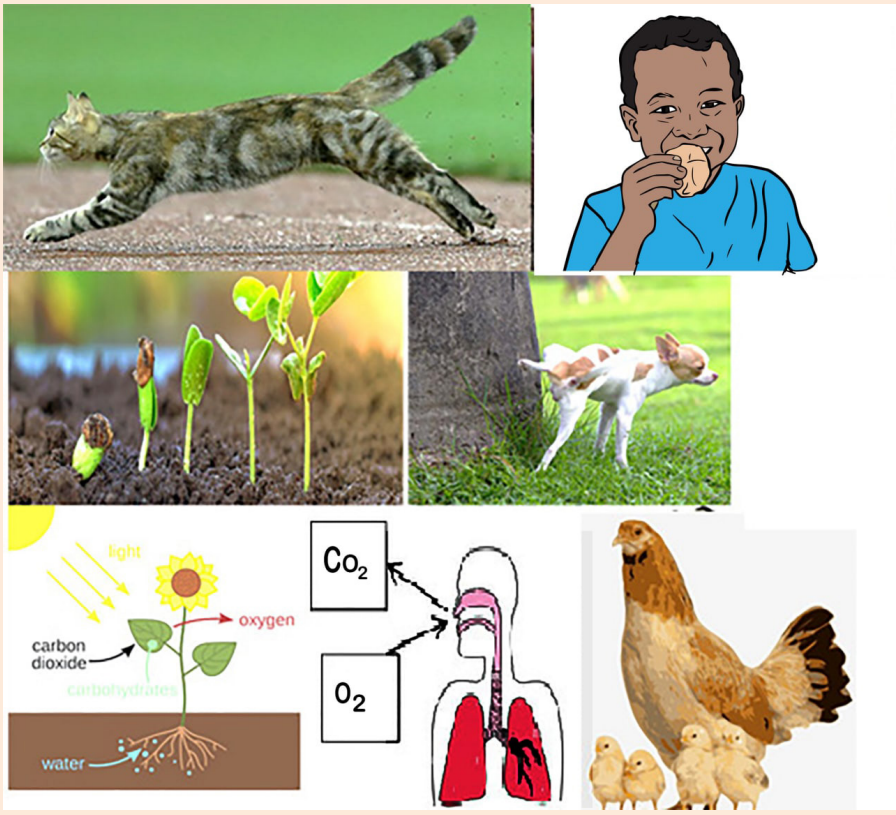


Figure 5.2 Pictorial representation of characteristics of living things

Activity 5.4

Is your hair a living thing? Why?

5.1.2 Classification and scientific names of organisms

Activity 5.5 Small Group Activity

Look at the two book shelves below and discuss the questions that follow.

Shelf A

Shelf B

1. Which shelf is properly organized and easier to search for books of your interest? Why?
2. If you are asked to organize one of the shelves, what criteria will you use?
3. What is the purpose of putting things orderly?
4. Can you give reasons why scientists classify living things?

What is classification?

Sorting living organisms into groups according to their similarities and dissimilarities is called classification. That is organisms that share similar features are placed in one group, and those with dissimilar characteristics are placed into different groups.

Uses of classification:

- It helps to sort organisms in order.
- It helps to identify new organisms by finding out which group they fit with.
- To facilitate easy study of organisms.
- It helps to understand the relationship among different groups of organisms.

Activity 5.6

You have learned that organisms are classified based on their similarities with other organisms they are related to. For example, cats are related to tigers. Look at the features of the donkey and relate it with the pictures of animals given below and answer the question.

Which animals are closely related to it (donkey), and which animals do you think are least closely related to it? Why?

Practical Activity 5.1 Outdoor Activity

In this practical Activity students move around their school compound or locality for exploration of living things. The students will work in groups to come up with a list of organisms and their characteristics. Observe any living thing you see and list its characteristics as many as possible. Movement (Moving, non-moving), wings (winged, wingless), producer, consumer, fur, feathers, legs (number of legs, no legs), cones, flowers, etc. are examples that can be used as criteria for classification.

After completing your outdoor exploration:

A. Set criteria to group the list of organisms.

b. Group them based on your criteria.

From your exploration, you have observed that living things are diversified or varied. Biological diversity, or biodiversity, refers to all of the variety of life that exists on Earth. Classification allows us to understand diversity better. It helps in the identification of living organisms as well as in understanding the variety of living organisms.

The Swedish naturalist Carolus Linnaeus (1707 – 1778) devised a system of grouping organisms into hierarchical categories according to their form and structure. Each category represents a level of grouping from larger, more general categories to smaller, more specific categories. Before Carolus Linnaeus, naturalists often named newly discovered organisms after their names; however, there was no agreement upon the way to name living things. This makes it difficult for naturalists to talk about their findings with one another. This all changed in the 1750s, when Linnaeus devised a system that standardized the way organisms are classified and named.

Activity 5.7

1. How many of you have two or more names? Don't you have a name different from your school name? What would happen if you use names interchangeably at all times, in school, outside, and at different places?
2. Why do scientists *give one and single name for every organism?*

Modern biologists adopted the Linnaeus system of classification and naming of organisms. Linnaeus gave an organism a scientific name with two parts: the genus name followed by the species name. This system of two-part names is known as binomial nomenclature. Scientific names allow scientists to communicate about particular species without confusion. Also, remember that biology is studied all over the world. One species may have many different common names in different countries even in different languages. Thus, scientific names allow scientists around the world to communicate clearly about living things.

Living things are given binomial names based on rules. What are the rules?

Rules of binomial nomenclature (scientific naming)

1. It is always written in italics (if typed) or underlined (handwritten)
2. The first is genus name and second is species name.
3. The first letter of the genus name is always capitalized.

For example, the scientific name of humans is *Homo sapiens*. In this, Homo is the genus name which comes first and begins with a capital letter and sapiens is the species name which comes second and written in small letters. Both the names are written in italic (Italic refers to a type style) in printed materials such as books, like this: *Homo sapiens*, *Felis catus* etc. When handwritten, for example, on a blackboard or your notebook, scientific names should be underlined separately, like this:Homo sapiens, Felis catus.

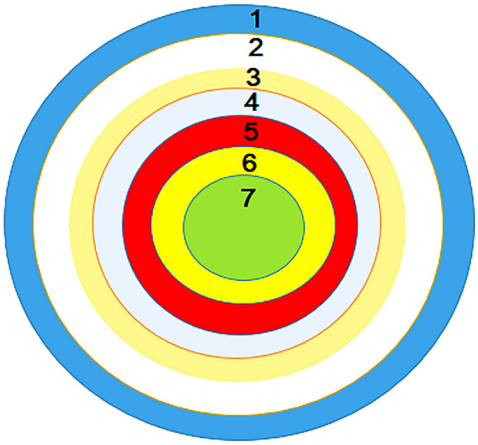
5.1.3 Hierarchy of classification

Biological hierarchy (Taxonomic hierarchy) is the process of arranging various organisms into successive levels of the biological classification either in a decreasing or an increasing order from kingdom to species or from species to kingdom. There are seven major levels of classification: Kingdom, Phylum, Class, Order, Family, Genus, and Species.

Activity 5.8

Consider your country, "kebele", zone, region, "ketena", and "woreda" as biological hierarchies.

a. Rearrange these administrative areas from the more inclusive to the least inclusive. What are the equivalent levels in the biological hierarchy?
b. Which level of the hierarchy contains a wider range of organisms? Explain.
c. Match the numbers in the diagram below with the seven levels of hierarchy (species, class, phylum, order, kingdom, genus, and family).



5.2 Kingdoms of living things

Activity 5.9

Look Fig5.3

Which kingdom do humans belong to?

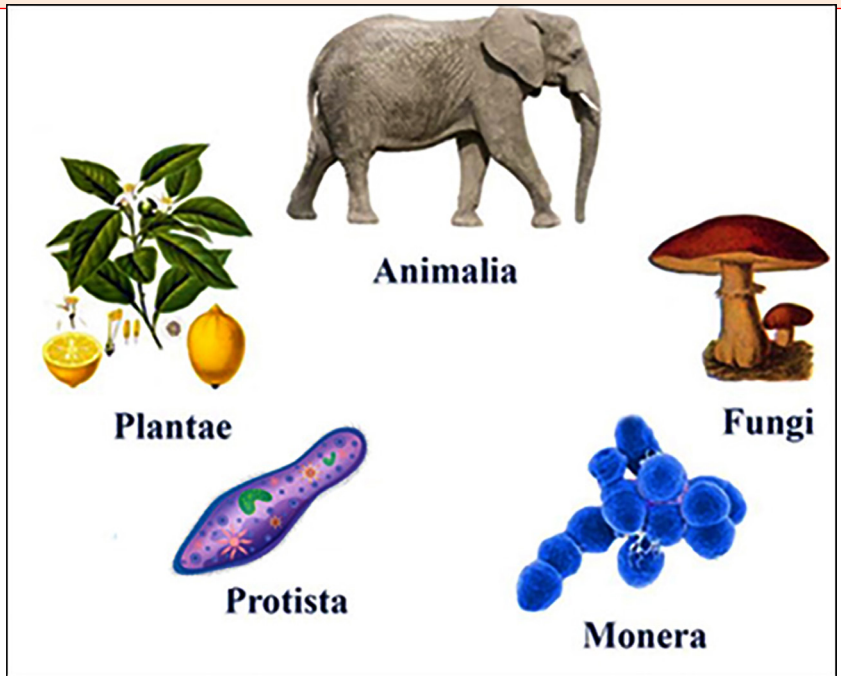


Figure 5.3 Kingdoms of living things

Whittaker gave the five Kingdom classification for living organisms. He categorized living organisms based on multiple characteristics such as cellular structure, mode

of nutrition, body organization, mode of reproduction,etc. These five kingdoms are Monera, Protista, Fungi, Plantae and Animalia.

Activity 5.10

1. Give examples of living things that belong to the five kingdoms in your area and present your work to your class.

5.2.1 Kingdom animalia

Animals are grouped in this kingdom. Animals are eukaryotic, multicellular and heterotrophic organisms.

Major characteristics of animals

- Animals are multicellular organisms.
- They are consumers (eat another organism because they cannot make their own food).
- Most animals have muscle and nervous tissue.
- Animals require oxygen, for use in respiration.
- Most animals reproduce sexually.
- Most animals can move. Since they are consumers, they need to move from place to place in search of food.
- Animal cells do not have cell walls and chloroplasts.

Major groups of Animals

Animals are usually divided into two major groups: invertebrates and vertebrates. Invertebrates are animals without backbone e.g. worms and insects. Vertebrates are animals which have a vertebral column or backbone. The five major groups of vertebrates are fish, amphibians, reptiles, birds and mammals.

Fish

General characteristics of fish

- All fish are cold-blooded (ectothermic). Cold blooded animals are not able to maintain a constant internal body temperature. The temperature of cold-blooded animals is determined by the temperature of the surrounding environment. It means their body temperature changes as the environment's temperature changes
- They are aquatic animals. That is, their habitat is water.
- Have gills, which allow them to breathe under water.
- Fish have fins. The fins are used for movement and balance in water.
- Have scales that cover their bodies.

Key Terms

Habitat: Habitat refers to the place or the location where an organism lives.

Aquatic: is a body of water in which certain organisms live naturally.

Cold-Coldblooded (ectothermic): animals that cannot regulate their internal body temperature

Gill: An organ for aquatic respiration.

Activity 5.11

A. Why do fish cannot live outside water?

b. How do fish reproduce? Is it similar to cows, cats or dogs?

Amphibians

General characteristics of amphibians

- They are ectothermic animals like fish.
- Their body is divided into the head and trunk.
- Their skin is smooth without any scales, with glands that make it moist.
- They have four legs for locomotion.
- Young amphibians have gills and adults have lungs.
- Young amphibians live in water, adults live on land.

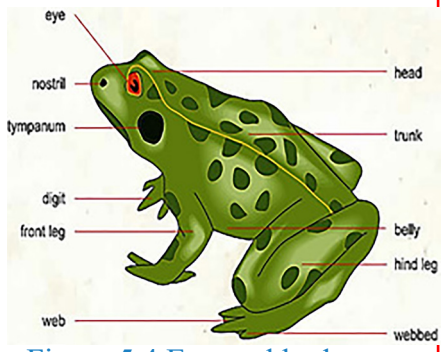


Figure 5.4 External body parts of a frog

Activity 5.12

A. Where do these animals live?

B. What do they eat?

C. How do they reproduce?

D. Have you ever collected tadpoles from ponds and played with them? What are they? Are they fish?

E. What season of the year do you see most frogs and toads? Why?

F. Have you ever heard frogs croaking? Is it the male or the female that croaks? What is the purpose of croaking?

frog and toad

tadpoles

Practical Activity 5.2: Study the external structures of frogs

Materials needed

- Container like plastic bag ,tin can, jug, large-mouthed glass
- Forceps (if not available,use your hands covered with plastics)

Procedures:

Collect some frogs from a pond, stream, river, etc. and put them in your container. Add some amount of water in the container to maintain hydration of the frog and cover it so that the frog does not escape. The container should let air or have space for air to the frog. The frogs collected are to be released at the end of your Activity , so Do NOT HARM THEM. KEEP THEM SAFELY.

- Bring the frogs to the laboratory room or classroom.
- Investigate the external body parts and answer the following questions below.
- Once done, release the frogs to their proper habitats.

Based on your observations, answer the following questions.

- Examine the hind legs. How many toes are present on each foot?
- Are they webbed?
- Examine the forelegs. How many toes are present?
- Are the toes webbed?
- Use a ruler to measure from the tip of the head to the end of the frog's backbone.
- Locate the frog's eyes. What color is the eyeball?
- Locate the nostrils and tympanum. What is their function?
- Feel the frog's skin. Is it scaly or is it slimy?

Report your results to the class.

Reptiles

Activity 5.13

a. Where do these animals live?

b. What do they eat?

c. How do they reproduce?

d. Name these reptiles.

General characteristics of reptiles

- These are creeping and burrowing terrestrial animals with scales on their body.
- They are cold-blooded animals.
- Their skin is dry and rough.
- Their body is divided into head, neck, trunk, and tail.
- They breathe with their lungs.
- Most have 4 legs and a tail.
- Members of this group are turtles and tortoises, crocodiles and alligators, and lizards and snakes.

Activity 5.14

Why do reptiles like lizards bask in the sun in the morning and go to shady areas in the afternoon?

Birds

Figure 5.5 Some types of birds

Activity 5.15

a. Where do birds live?

b. What structures enable birds to fly?

c. Can birds fly if you remove their feathers? Why?

d. What do birds have, which is not there in any other animals?

e. How do birds reproduce?

f. Are hens birds?

g. How do birds breathe? Do they have lungs?

h. Birds have no teeth, so they cannot chew their food? Then, how do they feed and digest food?

General characteristics of birds

- They have a beak, two wings and two legs
- Some feed on seeds and fruits while others prey on worms, insects, or smaller animals.
- Their beaks are adapted to many ways of feeding; seed-crushing, fruit-scooping, flesh-tearing, nectar-sipping, wood-pecking and so on.
- They have feathers.
- Birds are warm blooded (homoeothermic) animals i.e., they are able to

maintain a constant body temperature.

- Most take care of their young.
- Most birds can fly except flightless birds (e.g., Ostrich)

Mammals

Activity 5.16

See the pictures

a. What characteristics do all these mammals share?

b. Where do these mammals live (their habitats)?

Figure 5.6 Representatives of mammals

General characteristics of mammals

- Give birth to their young and feed them with milk.
- Have hair on at least part of their body.
- Have four limbs with digits ending in claws, nails, or hooves (except whales).
- Breathe with lungs.
- Are warm-blooded.

Activity 5.17

Mammals have lungs to breathe. How do mammals like whales and dolphins breathe in water?

Invertebrates

All organisms which do not have a vertebral column are often referred to as invertebrates. More than 95% of all animals are invertebrates Sea anemones, jellyfish, flatworms, nematodes, segmented worms, insects, snails, and starfish are examples of invertebrates.

Now you are going to collect some insects (invertebrates) and investigate their body structures.

Practical Activity 5.3 Study of the external structures of insects

Materials needed/methods

- Nets (Arial nets, sweep nets, aquatic nets), jars or tin can, tweezers, aspirators, Hand picking

Collect some insects from your school compound or outside and bring them to your laboratory room or classroom.

a. Count the number of legs. Is there any other animal that has the same number of legs?

b. Differentiate and count the number of body parts.

c. How many wings are there?

d. Tell about their habitat (place where you collect them).

e. Write a report on your observation.

Note: Use a hand lens for your observation.

Another invertebrate called earthworm plays a key role in enriching the soil. Earthworms eat organic waste material and excrete digested material called castings, into the soil. Castings help maintain a nutrient-rich soil.

Practical Activity 5.4 Study the external structures of earthworms

Materials needed

- Container like plastic bag ,tin can, jug, large-mouthed glass)
- Forceps (if not available, use your hands)

Procedures:

1. Collect earthworms (your teacher will help you to locate their habitat)
2. Bring them to your laboratory room or classroom and examine the external body parts and answer the following questions.

a. See the body segments and count and compare it with other groups.

b. Identify the anterior and posterior ends. Locate the mouth and anus. The sharper end is the earthworm's anterior or head-end, whereas the blunter end is its posterior or tail-end.

c. Locate the anus at the back end which is a small hole where solid waste is expelled.

d. About one-third of the way back from the mouth you should see a thicker and smoother section of the worm. What is it called? What is its function?

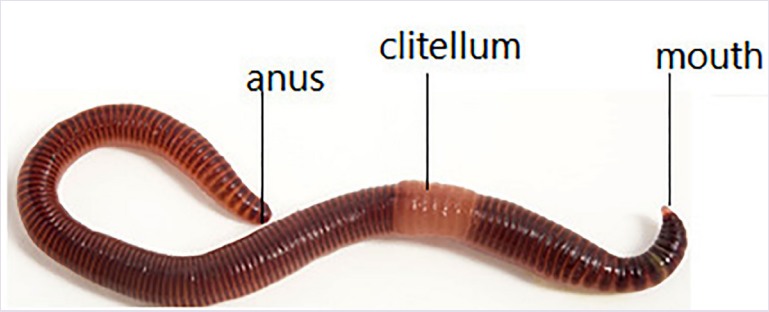


Figure 5.7 External structure of earthworm

5.2.2 Kingdom plantae

All plants belong to the kingdom Plantae.

Major characteristics of plants

- Capable of producing their own food (autotrophs) by photosynthesis.
- Cannot move from place to place
- Most have adapted to live on land.
- Cells have thick cell walls made of cellulose.
- Depending on their type plants reproduce with seeds or without seeds.

A plant kingdom is further classified into subgroups on the basis of various factors. Based on seed formation, plants can be classified as seedless plants or seed plants. Plants that do not produce seeds include ferns, mosses, and liverworts. Plants that produce seeds are divided into gymnosperms and angiosperms.

Activity 5.18

1. Give examples of seedless and seed plants from your area.
2. Identify the following plants either as seedless or seed plants.

		
Eucalyptus	Teff	Mosses
		
Fern	Wheat	Junipe

The types of plants you are probably most familiar with are trees, grasses, and flowers. These plants can produce seeds. A seed is a structure that contains a plant embryo and a supply of food inside a protective covering.

Gymnosperms are a group of seed plants whose seeds are not surrounded by a fruit. The seeds of many gymnosperms are enclosed in cones. Gymnosperms do not produce flowers. Most gymnosperms are trees such as pine and junipers.

Figure 5.8 Some gymnosperm plants

Activity 5.19

1. Contact an agricultural expert or agriculture officer in your locality and collect data about the types of gymnosperms found in your area. You can use the following questions as a starter:

a. What are the indigenous gymnosperms of Ethiopia? In what kind of habitats do they grow? For what purpose do people use them? Why should we protect them?

b. Look around your school. What kind of plants are there? Can you classify them into different groups based on a certain criteria?

Angiosperms, also known as flowering plants, produce seeds within a fruit. They are the most diverse of all plant groups and include fruit trees, roses, corn, grass, and 'Teff'.

Figure 5.9 Some angiosperm plants

Activity 5.20

1. What similarities and differences are there between gymnosperms and angiosperms?
2. Consider your main diets (plant products) that you eat every day. Are your main diets are obtained from gymnosperms or angiosperms? Explain why.
3. Think of our world without plants. What would happen?

Seedless Plants

Plants that reproduce without seeds are called seedless plants. Bryophytes and ferns are seedless plants.

Activity 5.21

How do such plants reproduce without seeds?

Bryophytes

Bryophytes are a group of small, simple, green land dwelling plants of which a few are aquatic. Bryophytes contain three groups: Liverworts, hornworts and mosses. Bryophytes reproduce by spores rather than flowers or seeds. They have a root-like, stem-like and leaf-like structure (no true root, stem or leaves).

Mosses

Liverworts

Figure 5.10 Mosses and liverworts

Mosses and liverworts are small, simple plants usually found in moist locations. You may find mosses around your house even the walls if the area is moist.

Pteridophytes are seedless plants that have root, stem and leaves. They mainly grow well in moist and shady places. Most pteridophytes have vascular tissues to transport food (phloem) and water (xylem). Pteridophytes do not have seeds or flowers either, instead they reproduce by spores. Ferns are examples of pteridophytes.

The leaves of ferns are often called fronds. If you look underneath a fern frond, you may see small patches that contain the spores. Not every frond has spores under it. Ferns have an underground stem called a rhizome from which the fronds develop.

Figure 5.11 Ferns

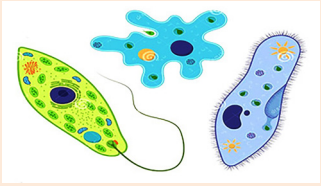
Practical Activity 5.5

Collect samples of mosses, ferns, junipers, and flowering plants and analyze their characteristics. Note their similarities and differences.

5.2.3 Kingdom protista

Activity 5.22

What are these organisms shown in the picture? Animal? Bacteria? Plant?



Fungi? Protozoa?

Kingdom Protista is a diverse group of unicellular eukaryotic organisms that are not plants, fungi, or animals. Protists have nucleus, mitochondria, and other organelles. Some have chloroplasts and can photosynthesize. They may reproduce sexually, asexually, or both. They occur in many environments, including water, soil, and inside of other organisms (parasites). The major groups of protists are protozoa and microscopic algae.

Activity 5.23

1. What do you know about malaria, amebiasis, and giardiasis? To which kingdom do you think the causative agents of these diseases belong to? Why?
2. What are the roles of algae?

Protozoa

Protozoa are single- celled organisms that occur mostly in aquatic environments and are either free living or parasitic in plants and animals. Mostly they reproduce by asexual means. Most protozoa have the ability to move by locomotory organelles like pseudopodia, flagella and cilia. Members of protozoa include amoeba, paramecium, leishmania, euglena, and giardia.

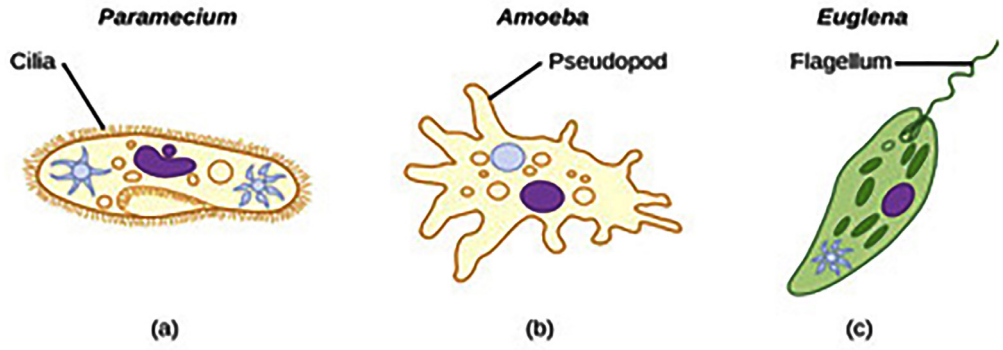


Figure 5.12 Locomotory structures of protozoa

Practical Activity 5.6

Title: Preparation of hay infusion

Objective: Culturing and observation of paramecium

Materials required:

- A small handful of hay or dried grass or leaf litter.
- Pond or river water or any natural water (untreated water) Do not use tap water.
- A large beaker or similar container
- Microscope, slide and cover slip
- Dropper

Safety: Disease-causing organisms can also flourish in a hay infusion. It is essential to ensure strict hygiene when handling the infusion (e. g. wash hands thoroughly after handling the samples)! If infusion is no longer needed, it should be disposed of and all containers or tools should be disinfected with hot water and thoroughly cleaned.

Procedures:

1. Put a small handful of hay or other dry plant residues into the container and fill it with water (pond water is preferable).
2. Cover the container loosely (e. g. with a piece of cloth) and place it in a warm, bright place (at least at room temperature, but without direct sunlight).

3. Let the mixture incubate at room temperature for several days. In 5 to 10 days the broth should turn dark and turbid.
4. Take small samples from the hay infusion with a dropper.
5. Add one or two drops of the sample on slide. Cover it with cover slip. Mount and observe under low power objective lens and answer the following questions.

Questions:

a. Do you see any moving living things?
b. Make a drawing of the organisms you observed under the microscope.
c. What is the purpose of using hay or dried grass?
d. Why pond water or any natural water (untreated water) is used, than tap water for this Experiment ?

Microscopic algae

Plant-like protists such as algae make their own food by photosynthesis. Although these protists may have chloroplasts, they do not have roots, stems, or leaves. And while all plants are multicellular, plant-like protists may be single-celled, colonial, or multicellular. Many single-celled plant-like protists are free-living aquatic organisms. Examples: Chlamydomonas, Euglena.

Practical Activity 5.7

Title- Observation of algae

Objective : To observe different types of green algae

Materials needed

- Pond water
- Beaker (any container)
- Microscope
- Slide and coverslips
- Dropper

1. Collect some algae from ponds, rivers or moist soil around your area.
2. Using a dropper, place two or three drops of pond water on a microscope slide.

3. Gently cover the slide with a cover slip and view under low and medium power.
4. Identify them by comparing with the key chart provided by your teacher.

5.2.4 Kingdom monera (bacteria and blue green algae)

Activity 5.24

Souring of milk, food poisoning, and decomposition of organic matter are due to the action of microorganisms. Can you mention these organisms? To which kingdom do they belong to? How are they different from the previous kingdoms?

Monera is a biological kingdom that is made up of prokaryotes (particularly bacteria). All bacteria are microscopic prokaryotes (without nuclear membrane) and lack membrane bound organelles. They have a cell wall composed of murein (a polymer consisting of sugars and amino acids). Some bacteria can produce their own food while others break down food and absorb it. They occur everywhere. Bacteria reproduce asexually by fission. Some move by means of flagella.

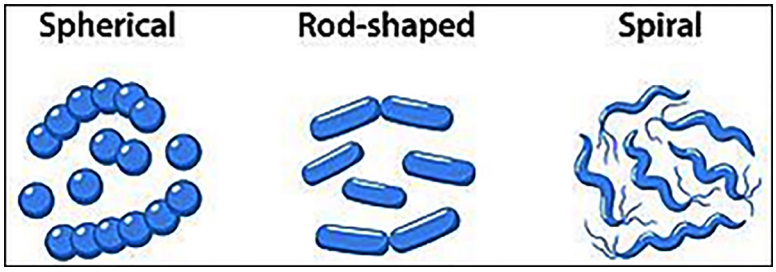


Figure 5.13 Types of bacteria (basic shapes)

Activity 5.25

a. What are the roles of bacteria in the environment?
b. Are there useful bacteria? What curdles milk?
c. Are there harmful bacteria?
d. Name some diseases caused by bacteria and explain how to prevent them from spreading.

Blue green algae

- Blue-green algae (cyanobacteria) are a group of photosynthetic prokaryotes and not true algae, but rather bacteria.
- Habitat: They are aquatic, found naturally in all types of water.
- They are photosynthetic.
- In warm, nutrient-rich (high in phosphorus and nitrogen) slow moving water, cyanobacteria can multiply quickly, creating blooms that spread across the water's surface.

5.2.5 Kingdom fungi

Activity 5.26

a. What do you understand from the diagrams?

b. What are the umbrella-like organisms?

c. What are the white and green patches on the tomatoes, oranges and breads?

Fungi (singular, fungus) live in soil, water, and even in the air. Many forms live in and on plants and animals. Mushrooms, molds and yeasts are examples of fungi.

Nor do they have many animal-like characteristics. All fungi are made of eukaryotic cells that have cell walls made of chitin. Fungi range in form from single-celled yeasts to multicellular mushrooms. Fungi do not produce their own food. Fungi get their food by breaking down organic materials and absorb the nutrients directly into their cells. Some fungi get their food by digesting the dead remains of other organisms. Others are parasites that live on plants or animals, causing diseases. Athlete's foot, for example, is caused by a fungus. Some fungi live in symbiotic relationships with algae, e.g. lichens.

Activity 5.27

1. What are yeasts (Ersho in Amharic)? What is the purpose of mixing dough with yeast?
2. Explain the roles of fungus in:

a. Homemade alcoholic drinks (e.g. Tella, Tej)?

b. In the environment?

Practical Activity 5.8

Title- Growing molds

Objective : To answer why do molds grow on injera or bread or fruits and realize that mold spores are present everywhere.

Materials needed

- Plastic bag or any other container
- Pieces of injera or bread, peel of orange
- Water

Procedures:

Trial A

1. Sprinkle water on a slice of injera or bread.
2. Put the bread/injera/ orange in the plastic bag.

Trial B

3. Take another piece of injera/bread/ peel of orange

4. Touch a dry soil with your hand and rub it on the bread /injera/ peel of orange.
5. Seal or tie both the plastic bags in trial A and B.
6. Put them in a warm place or in an empty carton and leave undisturbed.
7. Follow up the growth of your mold after three days.

Observation and result

1. What do you observe? In which trial do the molds grow well? Why?
2. What is the color of the molds?

After completion, properly dispose of all the specimens and wash your hands with water and soap.

Practical Activity 5.9

Study of mushrooms

Title- Study of mushrooms

Objective : To be familiar with various parts of a typical fungus. Study their habitats.

Materials needed

- Mushroom
- Carton or any other container to keep the mushrooms

Procedures:

1. Collect mushrooms from your school compound or your area.
2. Get a mushroom to your school laboratory or classroom.
3. Place the mushroom on a Table and examine it.
4. Identify the different parts.

Question

1. What is the function of each part?
2. Draw and label the parts.

Wash your hands with soap and water.

Summary

- The seven characteristics of living things are movement, respiration, sensitivity, growth, reproduction, excretion and nutrition.
- Classification is grouping of living things into categories based on natural relationships among them.
- Vertebrates are animals with backbones and include fish, amphibians, reptiles, birds, and mammals.
- Invertebrates are animals without backbone. Worms and insects are examples of invertebrates.
- Algae are simple water plants that do not have roots, stems and leaves but contain the green pigment chlorophyll.
- Bryophytes are land plants that do not have true leaves, stems or roots. That is why they need to live close to a water source or in moist areas on soil, tree trunks, and rocks.
- Flowering plants have flowers and when pollinated, they can ripe into a fruit that bears seeds.
- Non-flowering plants are mostly evergreen trees that have narrow, needle-like leaves. They do not have flowers, they have cones instead.
- Insect's body is divided into the head, the thorax, and the abdomen. They have three pairs of legs, two pairs of wings, and a pair of antennae.

Review questions

I. Chose the correct answer from the given alternatives

1. Which one is the correct order of hierarchy from highest to lowest rank?
   a. Kingdom → class → phylum → order → genus → family → species
   b. Kingdom → phylum → class → order → family → genus → species
   c. Genus → order→ class→ family→ species → phylum → kingdom
   d. Kingdom → phylum → order→ class→ genus → family→ species

2. Binomial nomenclature is a two-part naming system brought from _____ & _____.
   a. Domain and kingdom
   b. Order and family
   c. Phylum and class
   d. Genus and species

3. What is the largest group in the classification system?
   a. Species b. Genus c. Order d. Kingdom

4. Which kingdom performs photosynthesis?
   a. Animalia b. Plantae c. Bacteria d. Fungi

5. Why do single-celled amoeba and bacteria belong to different domains?
   a. Amoebas eat bacteria.
   b. Bacteria are not made of cells.
   c. Bacteria cells lack a membrane-enclosed nucleus.
   d. Amoebas are motile; bacteria are not.

6. A plant that has seeds but no flowers and fruits?
   a. Bryophytes b. Gymnosperms c.Mosses d. Pteridophytes

II. Give the vertebrate group based on "Who am I?" questions.

Who am I?				
?1	I have a backbone	I can be covered in fur/wool/hair	I carry babies in my belly	Babies are fed milk
	I have lungs	I have earlobes	Most animals in my group live on land	I am warm blooded
?2	I have a backbone	I am covered in feathers	I lay eggs	I am warm blooded
	My eggs have hard shells	I am warm to touch	I have lungs	Most in my group can fly
?3	I have a backbone	I am cool to touch	I lay eggs	My eggs are leathery to touch
	Most in my group live on land	I am cold blooded	I have lungs	My body is covered in leathery scales
?4	I have a backbone	I lay eggs	My eggs are soft jelly covered	Young have gills
	I live in water	Most do not have scales	I am cold to touch	Adults have lungs
?5	I have a backbone	I live in water	I lay eggs	I have gills
	I have fins	I am cold blooded	I am covered with scales	

III. Short answer questions.

8. List the features that define each of the five kingdoms:

Animalia	Plantae	Fungi	Protista	Monera
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

9. Bats are mammals.
   a. In what ways are they like birds?
   b. In what ways are they like other mammals?
10. What is the advantage of giving scientific names?
11. What is the importance of protists, fish, amphibians, reptiles, birds and mammals?
12. What are the roles of fungi in our daily life?
13. What are the importance of mosses, liverworts, and hornworts in the environment?
14. Both gymnosperms and angiosperms bear seeds, then why are they classified separately?

Unit 6

The Earth

Learning outcomes: At the end of this unit, you will be able to:

- Describe the shape of the earth
- Identify the evidences supporting the shape of the earth
- Name dimensions (circumferences, diameters, and angular distances) of the earth
- Describe the organization and contents of the different parts of the earth
- Differentiate between rotation and revolution of earth
- Explain the effects of motions of the earth
- Construct model of earth
- Develop science process skills
- Describe the interaction between hydrosphere, biosphere, atmospheric and lithosphere
- Explain water and carbon cycles on earth's spheres.

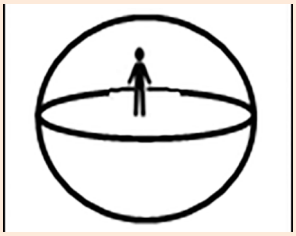
6.1 Shape and dimensions of earth

Activity 6.1

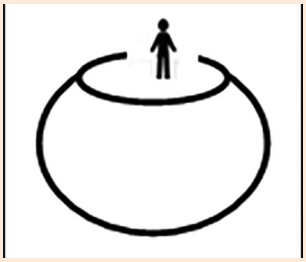
Assume that students were discussing the shape of earth in groups. The discussion in the four groups ended up with the following conceptions. Which group's conception would you support? Justify your answer.

Group 1: Earth's surface is flat and endless.

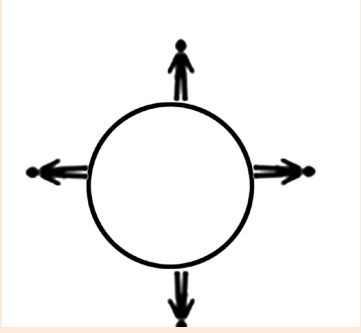
Group 2: Earth is a sphere and we live inside



Group 3: Earth is a sphere with a flat surface where we live.



Group 4: Earth is spherical and we live on.



Activity 6.2

Consider the following pictures and discuss the questions.

1. Figure 6.1 represents a moon moving through the shadow of the earth. Discuss why the shadow that falls on the moon became curved? What would happen to the shadow if the earth was flat?
2. In Figure 6.2 , it was shown that a ship is moving away from observers. What do you observe when the ship is going far away? How can you explain this situation with respect to the shape of the earth?

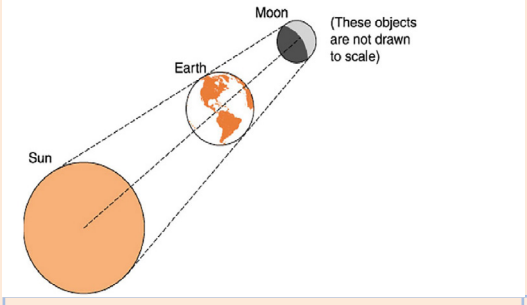


Figure 6.1: eclipse of moon

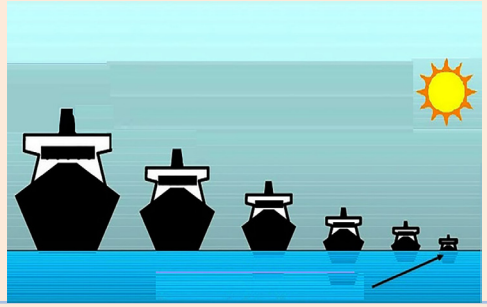


Figure 6.2: Departing ship

The shape of earth is slightly flattened at the poles and bulged in the middle. There are observational evidences that supports the idea that the shape of the earth is spherical. Some of the evidences are:

- The disappearing and reappearing of ships on the horizon
- Time differences between distant places
- Earth's shadow on the moon during a lunar eclipse
- Picture of earth from space.

Because of the slightly flattened surface at the poles and bulged surface at the equator, the earth can have different circumferences at the equator and at the poles. The circumference of the earth at the equator is called Equatorial circumference. And the circumference of the earth at the poles is called polar circumference. The dimensions of the earth are given in Table 6.1.

Table 6.1: Dimensions of Earth

Dimensions	Unit (Kilometers)	Unit (Miles)
Equatorial circumference	40,075 km	24,902 mi
Polar circumference	40,007 km	24,860 mi
Equatorial diameter	12,756.4 km	7,926.4 mi
Polar diameter	12,713.6 km	7,899.8 mi

6.2 Parts of the earth

Activity 6.3

Equipment and materials

- Boiled egg
- Knife

Procedures

1. Remove the shell from the egg. The shell of the egg is analogous to the crust of the earth.
2. Observe the next part of the egg (white part of the egg). This is analogous to the mantle of the earth.
3. Observe the third part of the egg (yellow part of the egg). This is analogous to the core of the earth.

Question

1. Think of another analogy that can illustrate internal layers of the earth

The earth is made up of three concentric layers with one over another. These layers are called crust, mantle and core.

Crust: Crust is the outermost layer of the earth. It mainly consists of silicon and aluminum. The crust has two parts. The first is the continental crust. It varies in thickness between 20 km and 90 km. The second is called oceanic crust. It varies in thickness between 5 km and 10 km. The oceanic crust is denser than the continental crust.

Mantle: The mantle is the thickest layer of the Earth. It takes about 83% of the Earth's volume. Its thickness is about 2900km. It is largely composed of iron and magnesium.

Core: Core is the central layer of the Earth. The core is mostly iron, with some nickel. It is about 16% of Earth's total volume. The core has two layers. These are inner and outer cores. The inner core is solid, and the outer core is liquid. The metallic core accounts for Earth's magnetic field.

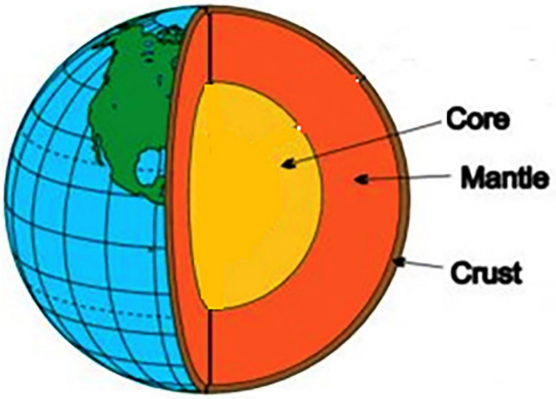


Figure 6.3: Parts of earth

6.3 Movements of the earth

Activity 6.4

We are living on a planet earth. And earth is always in motion. Even if it is moving, we feel like it is at rest.

A. What evidence can you use to support that the earth is moving?

B. What would happen if it did not move?

Earth performs two types of motions simultaneously. These motions are rotation and revolution.

Rotation: It is the movement of the earth on its axis. Earth takes 24 hours to make one rotation. When Earth rotates, different parts of the Earth face the sun. This causes a change from day to night. The part of the planet which faces the sun becomes day. And the opposite part of the earth on which the sun light do not reach

becomes night. The existence of day and night on earth is an indication of the movement of earth. (Note that an axis is an imaginary line about which the earth rotates. This axis is tilted at 23.5° from the vertical).

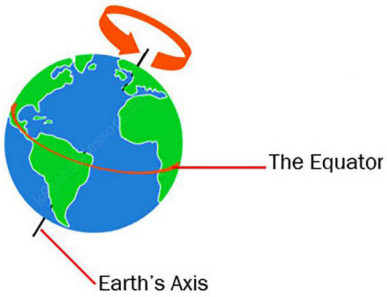


Figure 6.4: Rotation of earth

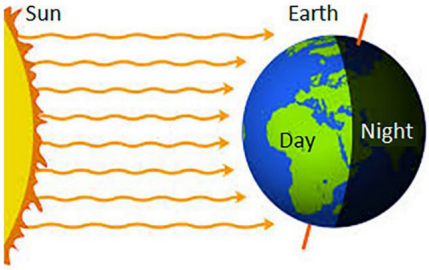


Figure : 6.5: Day and night on earth due to rotation

Revolution: Revolution is the motion of earth around the sun. The earth takes 365¼ days to complete one revolution. Because the earth's axis is tilted 23.5° from the vertical, at any time of a year, some places on Earth tilt toward the sun, and others tilt away. The places tilting toward the sun receive more solar energy and have warmer temperatures than those that tilt away. This causes different parts on earth to have different seasons: These seasons are summer, winter, spring and autumn. Figure 6.6, shows the revolution of earth and the variation of seasons in the north and south hemispheres.

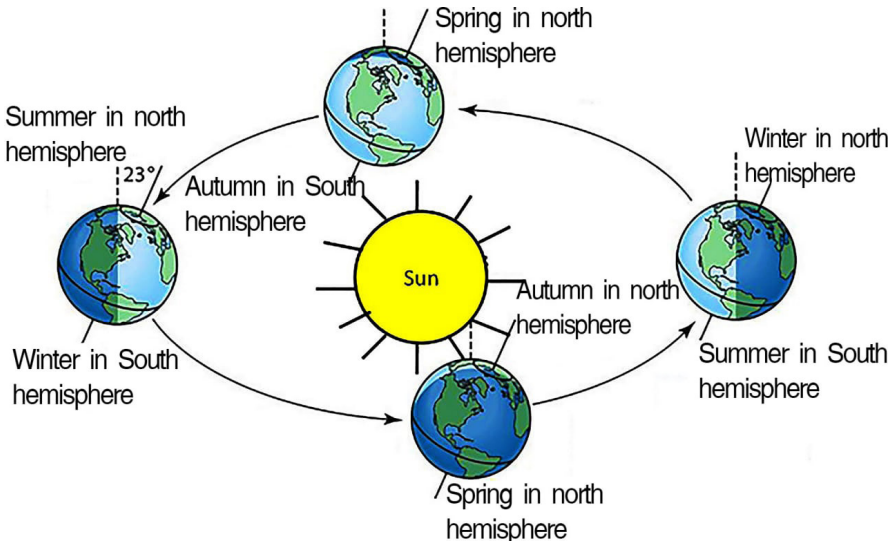


Figure 6.6: Revolution of earth and the four seasons

6.4 Earth's subsystems

A system is a collection of interdependent parts enclosed within a definite boundary. Within the boundary of the earth, there are four independent subsystems called spheres. These spheres are the lithosphere, hydrosphere, biosphere and atmosphere. These spheres are so closely connected that a change in one sphere results in a change in one or more of the other spheres.

Activity 6.5

Consider the following events and answer the questions below.

A. Human deforestation causes soil erosion.

b. Smoke in the air causes respiratory problems in people.

c. A decrease in vegetation causes an increase in soil erosion

d. An increase in vegetation increases oxygen in air

e. An increase in vegetation decreases ground water

Questions

1. Identify the causes and effects in each event.
2. Classify the causes and effects into groups based on their similarity
3. What common characteristics did the items in the same group have?

The four spheres of the earth are described as follows.

Lithosphere: The lithosphere refers to the solid and rocky crust that covers the entire Earth. It includes different landforms such as mountains, valleys, rocks, minerals and soil. The lithosphere is constantly changing due to forces and pressures from the S,un, wind, ice, water and chemical changes.

Hydrosphere: The hydrosphere includes all forms of water in the Earth's environment. The forms of water include things such as the ocean, lakes, rivers, snow and glaciers, water underneath the earth's surface and water vapor that is found in the atmosphere.

Biosphere: The biosphere is composed of all living organisms, including; plants and animals. It is believed that all life exists in the biosphere.

Atmosphere: The atmosphere refers to the air that surrounds the earth.

Since the four spheres are interdependent, the change in one sphere affects the other. For example, in the first question of Activity 6.5, human deforestation (change in biosphere) caused soil erosion (change in lithosphere). Similarly, an increase in vegitation (change in biosphere), increases oxygen in air (a chnge in atmosphere).

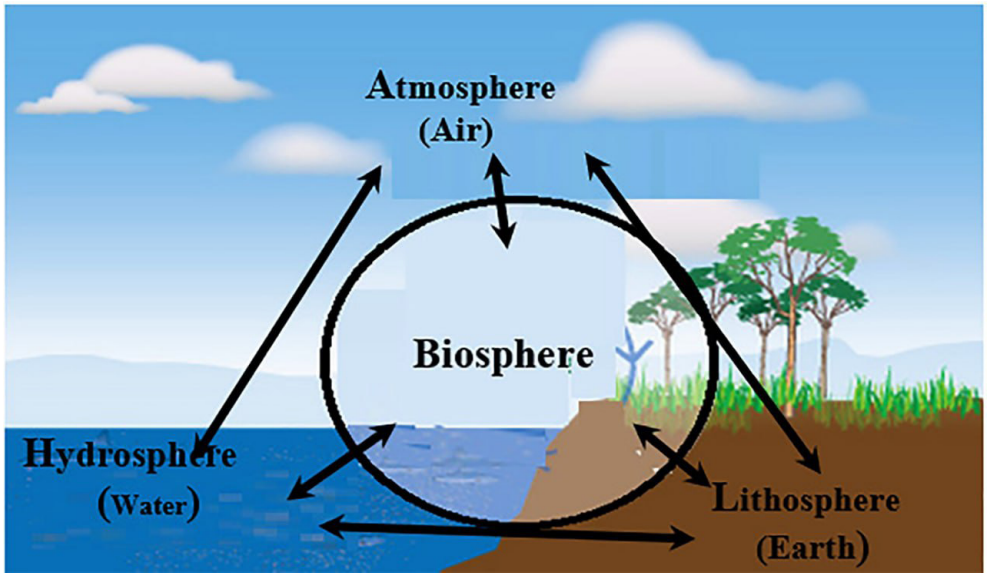


Figure 6.7: Interaction between spheres

Activity 6.6

1. Consider the following events and identify which spheres are interacting in the events.
   A. Ethiopian people are constructing the renaissance dams with rock materials and irons
   B. Water in the lake is either absorbed and became groundwater or evaporates into the air
   C. Humans generate energy by rotating turbines with water.
2. Consider your town as a system and identify the interacting spheres in the town.

6.5 Carbon and water cycles

6.5.1 Carbon cycle

Carbon cycle is one of the processes in which the interaction between the hydrosphere, lithosphere, biosphere and atmosphere can be demonstrated. Carbon is the foundation of all life on earth to form complex molecules like proteins. It is also found in air in the form of carbon dioxide.

Activity 6.7

The following statements describe how carbon and carbon compounds are consumed and released from plants and animals. Read the statements and answer the questions below.

1. Carbon enters the atmosphere as carbon dioxide from respiration (breathing) and combustion (burning).
2. Animals eat plants. Carbon compounds enter into animals through the food they eat. The animals release carbon dioxide through the process of respiration. The animals and plants then eventually die.
3. Plants use carbon dioxide to make carbohydrates in photosynthesis and release oxygen.
4. The dead animals and plants are eaten by decomposer in the ground. The carbon that was in their bodies is then returned to the atmosphere as carbon dioxide.

Questions

A. Identify the interacting spheres in the phenomenon represented by the statements

B. Describe the exchange of carbon between biosphere, lithosphere, hydrosphere and atmosphere in each case

Carbon cycle is the process where carbon compounds are interchanged among the biosphere, lithosphere, hydrosphere, and atmosphere. In the carbon cycle, the carbon present in the atmosphere is absorbed by plants for photosynthesis. These plants are then eaten by animals and the carbon gets into their bodies. These animals and plants eventually die. Upon decomposing, carbon is released back into the atmosphere. Some of the carbon that is not released back into the atmosphere eventually becomes fossil fuels. These fossil fuels are then used for man-made activities, which releases more carbon back into the atmosphere.

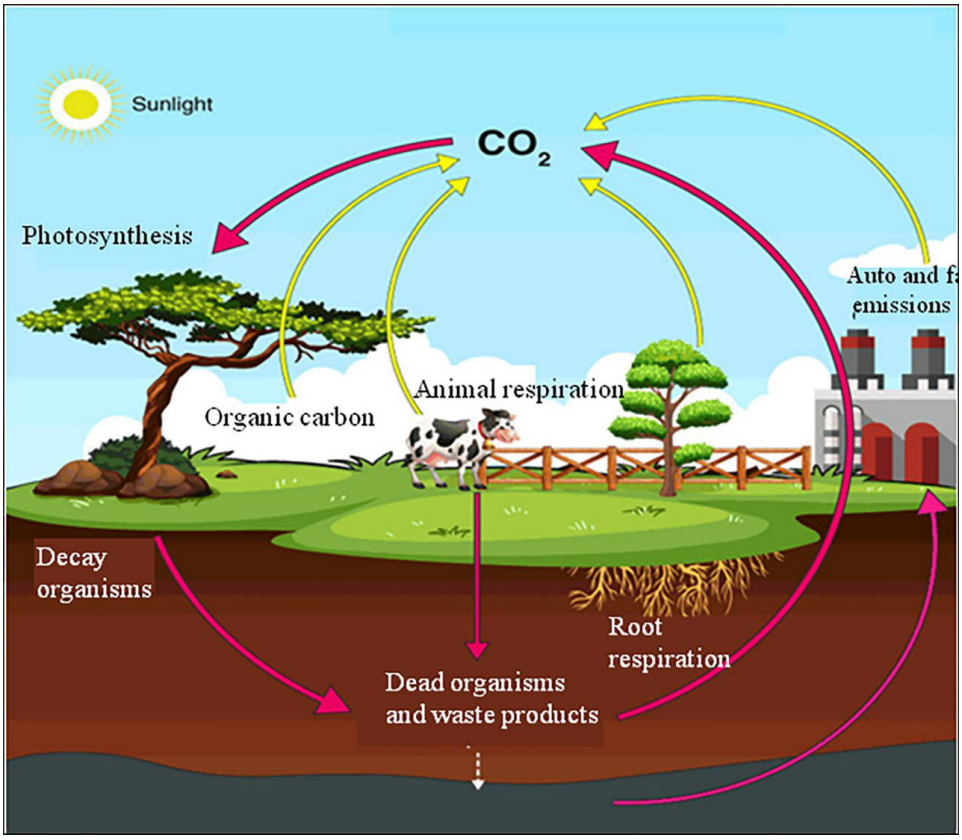


Figure 6.8: Carbon cycle

6.5.2 Water cycle

Questions

1. Discuss how water resources are used in our daily life?
2. The water we are using for different purposes has been on earth since the existence of the earth. What do you think is the reason for the existence of water after billions of years?

Activity 6.8

Material and equipment

- Electric stove (any source of heat)
- One liter of water
- Some pieces of ice
- Pans (one small and one big)

Procedures

1. Pour the water on the larger pan and put the pan on the stove
2. Make the stove on and wait until the water evaporates
3. Put some pieces of ice on the small pan
4. When the water in the larger pan begins to evaporate, hold the small pan directly above the larger pan.

Questions

A. What did you observe on the bottom of the small pan?

B. What was the purpose of the ice in the small pan?

C. What specific processes can you identify in the Experiment ?

Water cycle is a continuous circulation of water and water vapor between Earth and the atmosphere. Because the cycle is on a continuous loop, the water cycle does not have a definite starting point. In the water cycle, surface water like ocean, river and lake absorb heat energy from the sun and evaporates. The process of change of water to vapor is called evaporation. As the vapor goes up, its temperature decreases. Due to the decrease in temperature, the vapor begins to cool and changes into very small water droplets. The process of change of water vapor to water droplets is called condensation. The droplets then fall to the ground in the form of rain. This process is called precipitation. When rain droplets hit the ground, some of the water is absorbed by the soil. This water is then used by plants in the surrounding area. And some of the water moved to the ocean, rivers or lakes. Evaporation again takes place from plants and water bodies. The evaporation from plants is called transpiration.

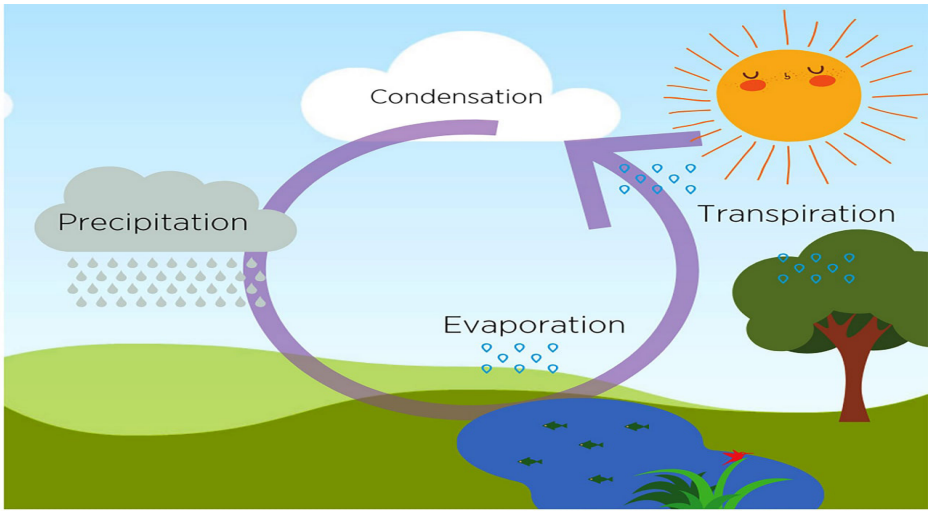


Figure 6.9 Water cycle

Activity 6.9

1. Identify which spheres are interacting during evaporation, condensation, precipitation and transpiration.
2. What would happen if the water and carbon cycles stopped?

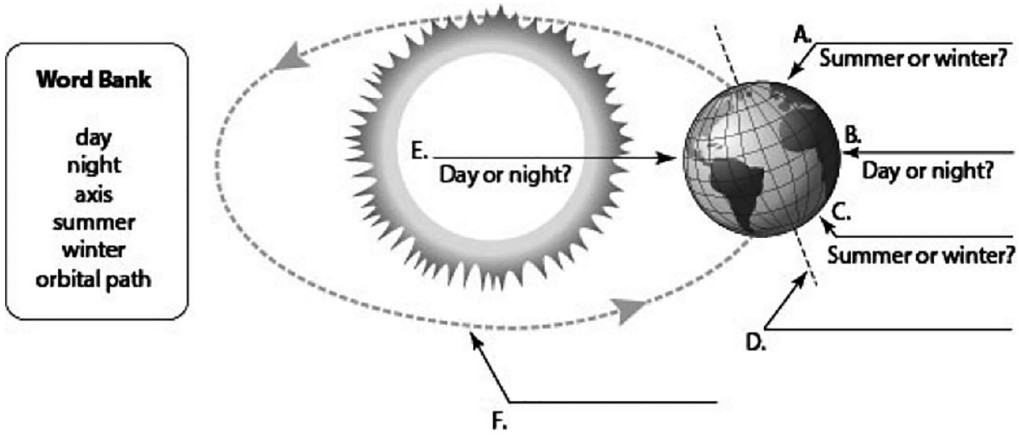
Summary

- The shape of Earth is spherical which is slightly flattened at the poles and bulged at the equator.
- The equatorial circumference of the earth is 40,075km and the polar circumference of the earth is 40,008km.
- The earth is made up of three concentric layers with one over another. These layers are crust, mantle and core.
- Crust is the outermost layer of earth and consists mainly silicon and aluminum.
- Mantle is the thickest part of the Earth layers which extends down to about 2900 km from the crust to core
- Core is the center of the earth which has two layers: an inner core which is solid and an outer core which is liquid.
- Earth performs two types of motions. These motions are rotation and revolution.
- Rotation is the movement of the earth on its axis.
- Revolution is the movement of earth around the sun.
- The four sub-systems of earth include biosphere, lithosphere, hydrosphere and atmosphere. These sub-systems are called spheres
- Carbon cycle is the process where carbon compounds are interchanged among the biosphere, lithosphere, hydrosphere, and atmosphere of the earth.
- Water cycle is defined as the continuous movement of water from the ground to the air and vice-versa.

Review questions and problems

I. Answer the following questions briefly

1. What would happen if the earth stops revolution?
2. Label the diagram with the words from the word bank.



3. List some earth sphere interactions that you experience in your own daily Activity .
4. From the following passage, identify the spheres which are interacting

Rain falls from clouds in the atmosphere to the earth and forms streams and rivers. The streams and rivers provide drinking water for wildlife and humans as well as water for plant growth. River action erodes banks and uproots plants on the riverbanks. Flooding rivers wash away soil.

II. Choose the correct answer from the given alternatives

5. An angle of 23.5^{o} is formed between the axis of earth and a line
   - A. The center of the earth to the Polars
   - B. The center of the earth to the sun
   - C. Perpendicular to the plane of the earth's orbit
   - D. Perpendicular to the equator
6. If the earth's rate of rotation decreases, there would be an increase in the
   - A. Length of the season
   - B. Number of observable stars seen night during the year

C. Length of day on earth

D. Inclination of the axis of rotation

7. During which part of the water cycle is it easiest to see water?

A. Evaporation B. Plant uptake

C. Precipitation D. Transpiration

8. When swimmers get out of the pool and sit in the sun, their wet skin dries quickly. What happens to the water?

A. It turns to vapor and moves into the air.

B. It is pulled up into the sun by gravity.

C. It condenses and moves to plant and trees.

D. It becomes part of the water in the ground

9. If a planet had no water, _____.

A. It would have no rocks.

B. It would have no insects.

C. It would have no light.

D. It would have no hills.

10. One of the main ways carbon dioxide is removed from the atmosphere is _____.

A. Photosynthesis B. Combustion

C. Respiration D. Decomposition

11. Which hemisphere is north of the equator?

A. Northern Hemisphere B. Southern Hemisphere

C. Eastern Hemisphere D. Western Hemisphere

12. When it is summer in the Southern Hemisphere, what season is it in the Northern Hemisphere?

A. Fall B. Winter

C. Spring D. Summer

13. Earth's tilt changes as it revolves around the sun.

A. True

b. False

Unit 7

Force, Motion and Energy

Learning outcomes: At the end of this unit, you will be able to:

- Describe the terms motion, force, and energy
- Explain the various types of motion
- Develop skill of manipulating numerical problems related to motion, force and energy
- Analyze data to identify patterns or relationships
- Explain the various effects of force
- Appreciate how the concepts of force, motion and energy are related
- Explain the real application of rectilinear motion, Newton's laws of motion
- List different forms of energy
- Name parts of measuring device of force
- Explain conservation of energy
- Differentiate between renewable and nob-renewable source of energy

7.1 Definition of motion

Activity 7.1

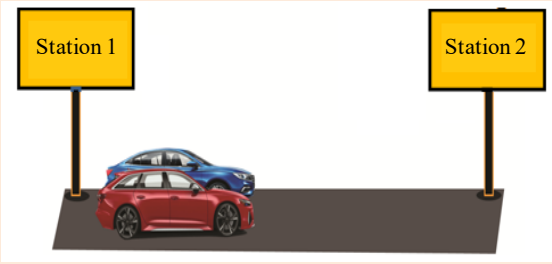
The following Figure represents two cars which left station 1 and reached station 2 simultaneously. Grade 7 students were requested to sit in small groups and identify which of the objects were moving. The ideas of their discussion were summarized and grouped into the following four themes.

Theme 1: The cars are moving but the stations are not

Theme 2: The cars and the stations are not moving

Theme 3: The cars and the stations are moving

Theme 4: It is impossible to determine



Question

If you were one of the students who participated in the discussion, which idea would you support? Explain your reason.

Motion is one of the key concepts in physics. The state of motion or rest of an object is described with respect to a point called a reference **point** or a **reference frame**. So, if an object changes its position with respect to a chosen reference frame, it is said to be in a state of motion,. Otherwise it would be in a state of rest.

Activity 7.2

Assume that you were the driver of a bus traveling from your home to school. At the moment you are in between traffic light 1 and traffic light 2 as shown in the Figure below, which (traffic light1, traffic light 2, bus, you or the ground) is in motion with respect to:

A. The ground
B. The bus
C. You
D. Traffic light 1
E. Traffic light 2

7.2 Types of motion

Activity 7.3

1. List down some examples of moving bodies you observed in your surrounding
2. Classify the moving bodies you mentioned into groups based on some common characteristics.

Motions can be classified into four types based on the kind of paths that objects follow. These are linear (rectilinear) motion, oscillatory (vibratory) motion, curvilinear motion, and rotational motion.

Linear (rectilinear) motion: It is a motion of a body in a straight line. For example, a car moving on a straight road, an airplane flying straight in air and an object falling vertically down are some examples of rectilinear motion.

Oscillatory (vibratory) motion: It is a back and forth motion a body. Examples of oscillatory motion include motion of a pendulum and motion of objects suspended on a spring.

Curvilinear motion: A motion that is taking place in a curved path is called curvilinear motion. A car moving along a curved track and motion of the moon around the earth are examples of curvilinear motion.

Rotational motion: This type of motion includes a spinning motion of a body about an axis. Motion of the wheel about its axis and motion of the second or minute hand of a wrist watch are rotational motions.

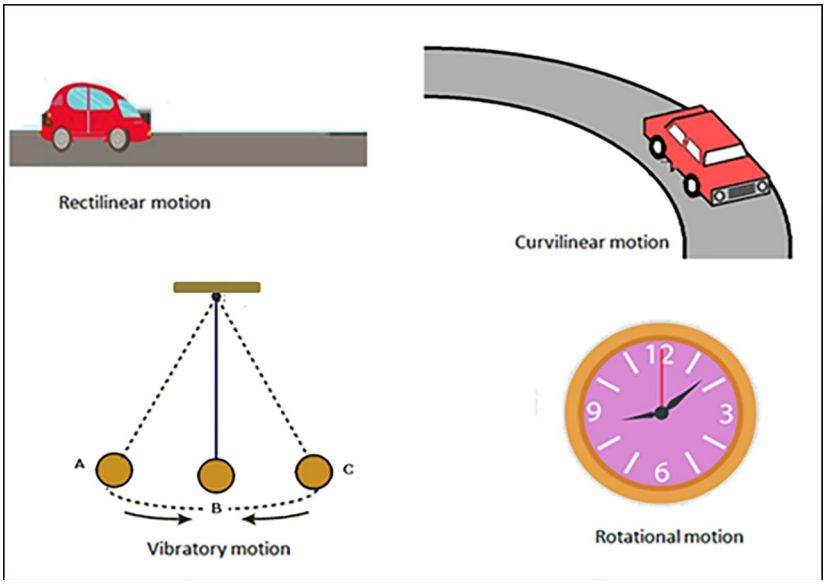


Figure 7.1: Types of motion

7.3 Motion in straight line

7.3.1 Distance and speed

One of the different types of motion is a motion taking place in a straight line. This kind of motion is also called rectilinear motion.

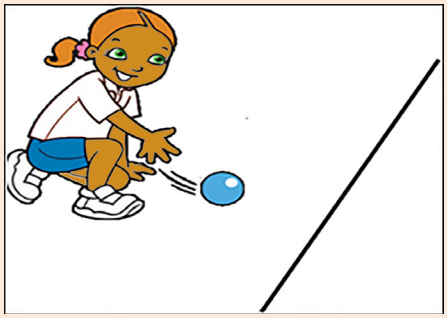
Activity 7.4

Materials and equipment

- Timer (clock)
- Meter (ruler)
- Chalk

Procedures

1. Draw a straight line on the ground with chalk.
2. Let one student gently roll a ball along the ground in a direction perpendicular to the line 1m away from it as shown in the Figure .



3. Record the time at the moment the ball crosses the line and also when it comes to rest.
4. Measure the distance between the point at which the ball crosses the line and the point where it comes to rest.
5. Three more students repeat the Activity
6. Record the measurements in the following Table

Students label	Distance moved by the ball (S)	Time taken (t)	Distance time ratio (S/t)
Student 1			
Student 2			
Student 3			
Student 4			

Questions

From your observation,

1. Which student's ball was fast?
2. Which student's ball was slow?

From the data you recorded in the Table :

1. Compare the values under column4. Which value is higher? Which is lower?
2. Which value in column 4 is associated with the fastest ball and which is associated with the slowest ball in your observation?
3. What can you say about the relation between values in column 4 and speed of the balls?

When an object moves in a straight path, it changes its position from one place to another. During its motion, the object travels a certain length of path in a unit time. The total length of path traveled by an object is said to be distance. The distance covered by an object in a unit time is called speed. For example, when we say a body is moving with a speed of 10km/hr, it means that it will cover a distance of 10km in one hour. The average speed of an object is quantitatively expressed by the following relation.

$$Average\ Speed = \frac{Total\ distance\ traveled}{Total\ time\ taken}$$

$$V_{av} \quad \frac{S_{tot}}{t}$$

Examples

1. Assume that the distance between your home and your school is 4000m. The time it takes to arrive at the school is 50 seconds. Calculate your average speed from home to school.

Given

S=4000m

t=30 sec

Required

Vav=?

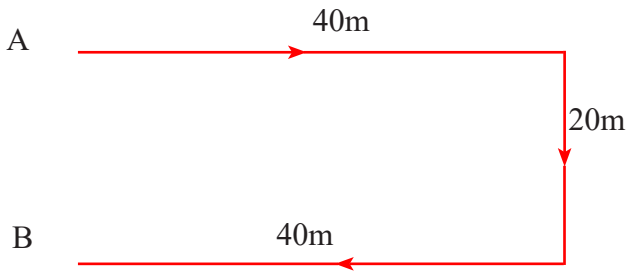
Solution

$$V_{av} = \frac{S_{tot}}{t} = \frac{4000m}{50sec} = 80m/s$$

2. To move from point A to point B, a girl walks 40m east, 20m south and 40m west as shown in the Figure . If the time she took to reach point B is 20 seconds, calculate:

   A. The distance she traveled

   B. The average speed of the girl



Solution

A. S= 40m+20m+40m=100m

B. $$V_{av} = \frac{S_{tot}}{t}, \ where\ t = 20s\ and\ S_{tot} = 100m$$

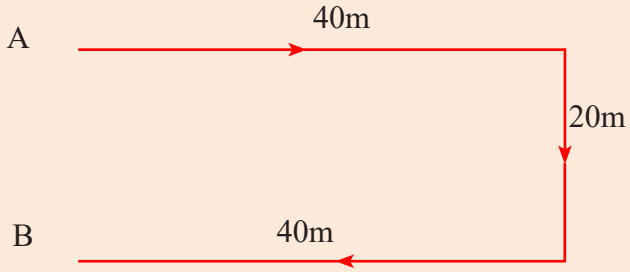
$$\Rightarrow V_{av} = \frac{100m}{20s} = 5m/s$$

7.3.2 Displacement and velocity

Activity 7.5

Consider the motion of the girl in the above example again and answer the following questions.

1. Which direction could the girl move to reach point B by traveling a short length of path?
2. What is the distance she traveled in that specific direction?
3. If she took 10 sec to reach point B in that specific direction, what would be its speed?



The concepts of displacement is different from that of distance in that the displacement has a specific direction. Hence, displacement of a body can be described as the distance traveled by a body in a specific direction.

Suppose you travel from point A to point B along two different paths ACB and APRB as shown in Figure 7.2. Then, the distance you travelled along path ACB is the sum of the length of lines AC and CB. Similarly, the distance along path APRB is the sum of the length of lines AP, PR and RB. However, the displacement is the shortest distance from A tob. This distance is the length of line AB.

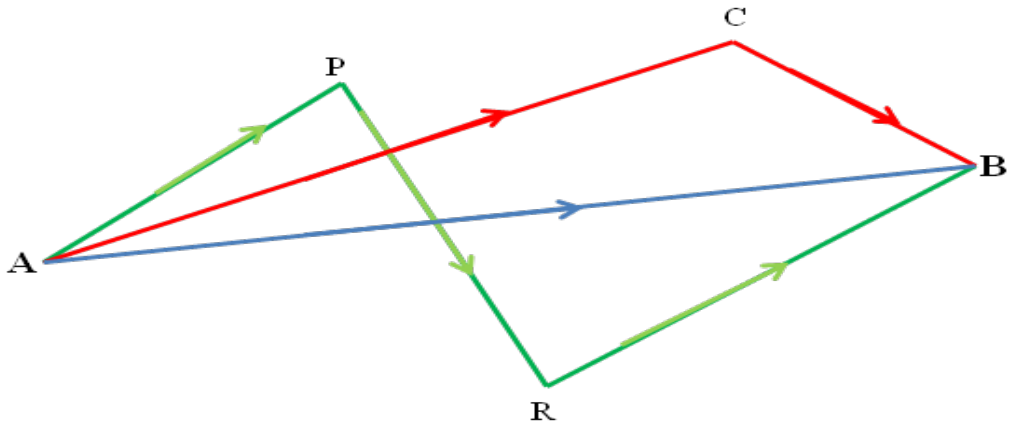


Figure 7.2: Distance and displacement

Velocity of a body on the other hand represents how fast the body moves in a particular direction. The girl's displacement in the Activity would be 20m down. The relationship between velocity and displacement is expressed as:

$$Average\ Velocity = \frac{Change\ of\ displacement}{Time}$$

$$\vec{V}_{av} = \frac{\Delta \vec{S}}{\Delta t}$$

Activity 7.6

The data of motions of two bodies A and B are measured and recorded in the following Table s.

Motion A

S(m)	0	4	8	12	16	20	24
t(sec)	0	1	2	3	4	5	6
V(m/s)							

Motion B

S(m)	0	2	4	6	8	10	12
t(sec)	0	1	2	3	4	5	6
V(m/s)							

Questions

1. Calculate the speed of the two bodies and record the results in the Table s.
2. Draw the distance-time graphs of the two motions
3. Based on the graph you draw, discuss the difference between the two motions.
4. Draw the speed-time graph of the two motions
5. Find the slope of distance-time graph. What do these slopes indicate?

7.3.3 Acceleration

Activity 7.7

1. The following statements describe different motions of a car. In which motion does the car accelerates?
   - A. A car moving at 50km/hr in straight line road
   - B. A car just begins to move
   - C. A car moving around a curved road with 50km/hr
   - D. A car that uses brakes to stop
2. What would happen to the speed and direction of the car in the case/s where the car is accelerating?

Acceleration can be described as the rate of change of velocity. It measures how much the velocity of an object changes in a unit time. Acceleration has direction. The direction of the acceleration is in the direction of the motion if the speed increases and opposite to the direction of motion if the speed decreases. The acceleration of a body changes if the magnitude of the velocity changes or the direction of motion changes or if both changes. The acceleration of a body and its velocity is related by the following expression.

$$Acceleration = \frac{Change\ of\ velocity}{Change\ of\ time}$$

$$\Rightarrow \vec{a} = \frac{\Delta \vec{V}}{\Delta t}$$

Example

1. A man starts from rest and accelerates to a speed of 20m/s in 8 seconds. What is magnitude of the man's acceleration?

Solution

$$\Rightarrow a = \frac{\Delta V}{\Delta t} = \frac{20m/s - 0m/s}{8s} = 2.5m/s^2$$

Activity 7.8

Three students 1, 2 and 3 are running to their school. The data about their motions are measured and recorded in the following Table s.

Student-1

V(m/s)	0	4	8	12	16	20	24
t(se)	0	1	2	3	4	5	6

Student-2

V(m/s)	12	10	8	6	4	2	0
t(se)	0	1	2	3	4	5	6

Student-3

V(m/s)	4	4	4	4	4	4	4
t(se)	0	1	2	3	4	5	6

Questions

I. Calculate the accelerations of the three students.

II. Draw the speed-time graph of the motions of the three students.

III. Describe the speed-time graph of a motion with positive acceleration, negative acceleration and zero acceleration

7.4 Force

Activity 7.9

Assume that a ball is on a Table as shown in the picture.

1. Is the object at rest or in motion? What evidence can you give to support your answer?
2. Will the object move by itself? When will it move?
3. How can we make it move faster? Move slower? Change its direction? Or Stop?

Force is one of the important quantities in physics. It can be described as an interaction between bodies in nature. For example, throwing a ball, holding a textbook, walking or running on a floor, cutting a paper into pieces needs force.

Forces can be classified into two main groups. These are contact force and non-contact force. Contact forces are forces that exert when two bodies are in physical contact. For example, in Figure 7.3, the pushing and pulling forces are contact forces.

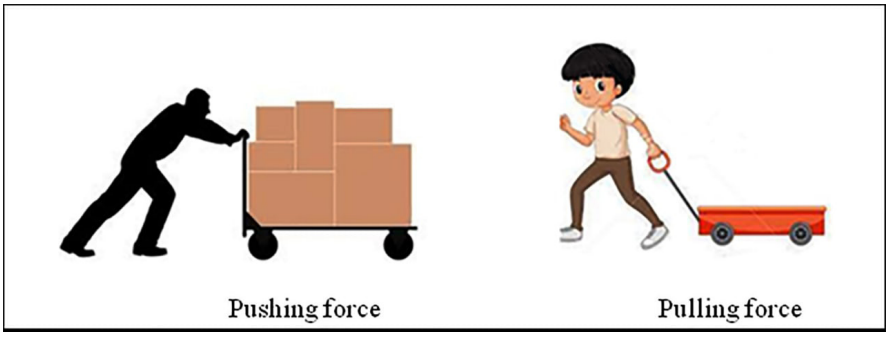


Figure 7.3 Examples of contact forces

Non-contact forces on the other hand include forces exerted between bodies which are not in contact. Force of gravity, magnetic force and electric force are

examples of non-contact force. In each case, there is no physical contact between the interacting bodies.

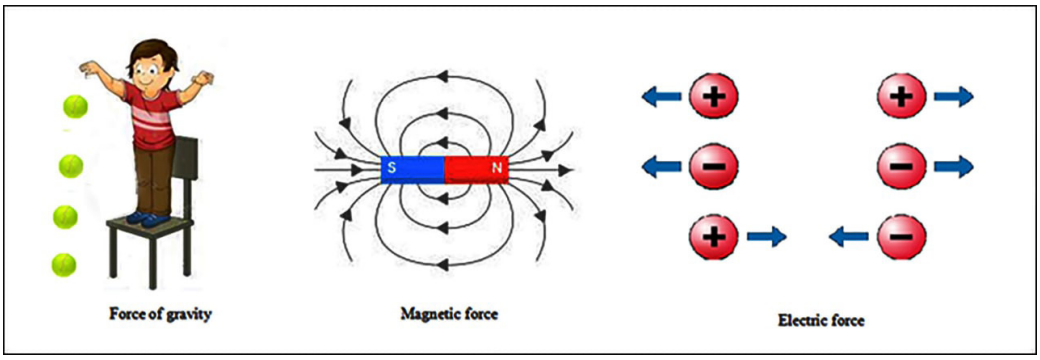


Figure 7.4 Examples of non-contact forces

7.4.1 Effects of force

Activity 7.10

The picture below shows a man kicking a ball. Assume that the ball rolls across a horizontal surface and comes to rest.

1. What causes the ball to roll on the ground?
2. Does the speed of the ball decrease or increase immediatly after the kick?
3. Why does the ball finally stop?
4. What force is acting on the ball
   A. At the instant the ball is kicked by the man?
   B. When the ball is rolling?

When a force is exerted on an object, it produces some effects on the object. Forces

can change the state of motion. For example, a body which is at rest can begin motion if force is exerted on it and will stop if force is acting on it. For example, in the above Activity , the ball stops because of the friction force that is exerted on the ball. Similarly, a moving body changes its speed (decreases or increases) as a result of force acting on it. A force can also change the direction of motion or shape of objects.

7.4.2 Force of gravity

Activity 7.11

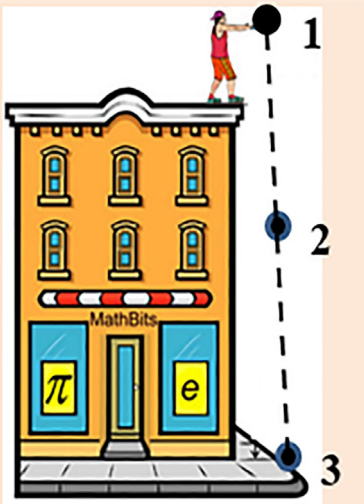
1. A ball is dropped to the ground from a building as shown in the picture below. In which of the positions does gravity act on the ball? Justify your answers.

A. Position 2 only

B. Positions 1 and 2 only

C. Positions 2 and 3 only

D. Positions 1, 2 and 3

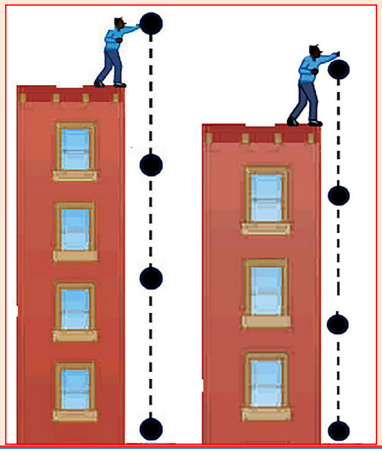


2. If a similar ball is dropped from two buildings of different heights as shown in the following pictures, in which case does force of gravity act more?

A. Big building

B. Small building

C. In both cases, force of gravity is the same



Weight of a body can be defined as a force of gravity acted on the body. Earth exerts a gravitational force of about 9.8N for every kilogram of mass on its surface.

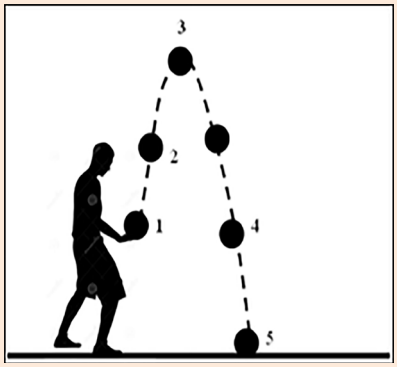
An object's weight can change from place to place as it depends on the strength of gravity acting on it. The weight of a body with mass 'm' is mathematically given by:

$$W=Mg$$

Where g is the acceleration due to gravity which is equal to 9.8m/s2

Activity 7.12

1. Identify the forces acting on the ball in the five different positions and show their directions (ignore air resistance).



7.4.2 Measuring force

An instrument used to measure force is called Newton meter. Newton meters contain a spring connected to a metal hook. The spring stretches when a force is applied to the hook. In addition to the spring and hook, regular Newton meters have support and scale as shown in Figure 7.5.

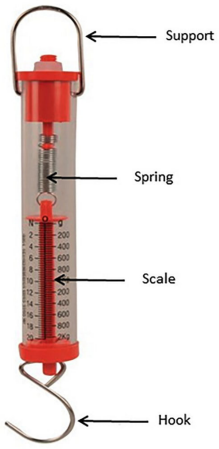


Figure 7.5 Parts of Newton meter

If an object is suspended on the hook of the Newton meter as shown in Figure 7.6, its spring stretches because of the weight of the object. The amount of stretch of the

spring is proportional to the weight of the object suspended. The bigger the force applied, the more the spring will stretch.

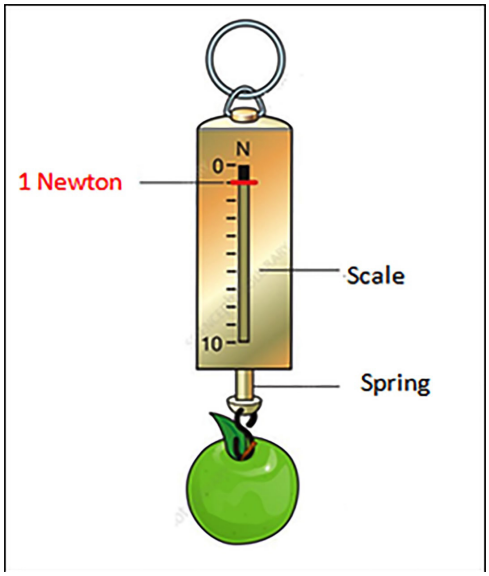


Figure 7.6 Measuring force

Activity 7.13

1. Measure the weight of 100g, 200g and 300g masses using Newton meter.
2. Calculate the weight of the masses.
3. Is there difference between the calculated and measured values? What do you think the cause for this difference if any?

7.5 Force and motion

7.5.1 Newton's first law of motion

Activity 7.14

1. Imagine you are in a bus moving with constant speed on a straight road. What would happen to you if:

A. The bus stops suddenly?

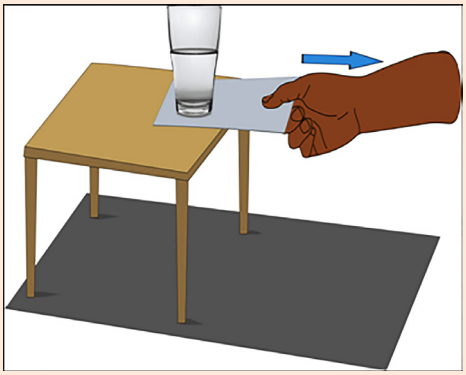
B. The bus increases its speed suddenly?

C. The bus changes its direction suddenly?

D. How do you explain these incidences in terms of force and motion?

Procedures

1. Fill the cup with water
2. Put the hard paper on the Table
3. Put the cup filled with water over the hard paper
4. Pull the hard paper slowly. Observe the motion of the cup carefully (observation 1)
5. Pull the hard paper very quickly. Observe the motion of the cup again (observation 2)



Questions

1. What differences have you observed in the two observations?
2. What do you think is the cause of the difference between the two observations?

Activity 7.15

Do the following simple Experiment and answer the questions below.

Equipment and materials

- Small cup (glass or metal)
- Water
- Hard paper

Newton's first law of motion is often called the Law of Inertia. Inertia is the tendency of an object to resist a change in its state of motion. So, Newton's first law of motion is about how an object maintains its state of motion. Newton's first law of motion states that "an object at rest will remain at rest and an object in motion will remain in motion at a constant velocity unless a net external force is acted up on it.".

This law has two parts. The first part is that an object at rest will remain at rest unless acted upon by a net external force. This implies that an object that remains at rest will have a net external force of zero acting on it. But, this does not mean

that there are no forces acting on it. It means that when you add up all the forces, you get a value of zero.

The second part is that an object in motion will maintain its motion at constant velocity unless acted upon by a net external force. This means that an object in motion will maintain a constant speed and direction unless acted upon by a net external force. Again, this does not mean that there are no forces acting on the object. It means that the sum of the external forces is zero.

7.5.2 Newton's second law of motion

Activity 7. 16

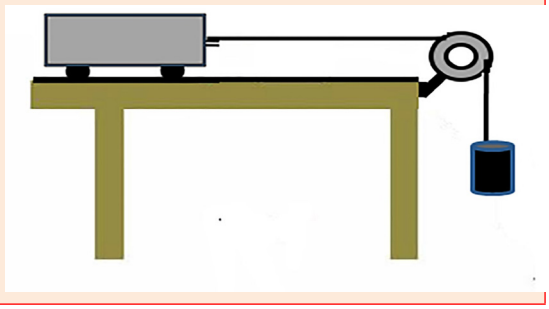
1. What makes cars move on a level road?
2. What did you experience from a car moving on a muddy road on a rainy day?
3. What factors can affect the acceleration of a body?

Activity 7. 17

Do the Experiment by following the given procedures, collect and analyze the data to determine the relation between mass, acceleration and force.

Equipment and materials

- Cart
- Pulley
- String
- Stopwatch
- Different hanging masses



Procedures

1. Set up a system consisting of a cart and hanging mass as shown in the picture
2. Measure the mass of the cart
3. Measure the weight of the hanging mass (w=mg)
4. By increasing the weight of the hanging mass step by step, observe what will happen to the acceleration of the cart (note that the acceleration of the cart can be found by dividing the weight of the hanging mass by the mass of the cart). Do this for six different weights.
5. Record the observed data in the following Table

Mass of cart =_____						
Wt of hanging mass						
Acceleration of cart						

6. Draw force versus acceleration graph

Questions

1. What can you conclude about the relationship between acceleration and force from the graph you draw?

Newton's second law states that the acceleration of a body is directly proportional to the net force acting on the body and inversely proportional to the mass of the body. The direction of the acceleration is the same as the direction of the net force. The relationship between acceleration, mass and net force is given by:

$$\vec{F}_{net} = m\vec{a}$$

Examples

1. A force of 20N is acted on a mass of 5kg. If the velocity of the mass is 20m/s after 4 seconds, what was its initial speed?

Solution

$$a = \frac{F}{m} = \frac{20N}{5kg} = \underline{\underline{4m/s^2}}$$

$$\Rightarrow but\ a = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{t_f - t_i}$$

$$\Rightarrow V_f = V_i + at\ or\ V_i = V_f - at = 20m/s - (4m/s^2)(4s) = \underline{\underline{4m/s}}$$

7.5.3 Newton's third law of motion

Activity 7. 18

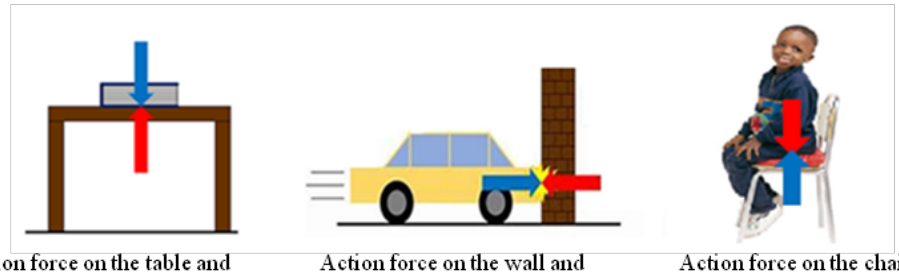
1. Did you observe the movement of birds' wings when they are flying up? How do birds' wings move? Why do birds move their wings in that way?

Demonstration

1. Fill the balloon with air, release it and observe what will happen to the balloon. What causes the balloon to move?

Newton's third law of motion tells us that if body 1 exerts an action on body 2, then body 2 exerts a reaction on body 1 that is equal in magnitude and opposite in direction. We can observe the application of this law on numerous activities in our surroundings. For example, when we want to jump up, we push the ground. The reaction of the ground is what makes us jump up. We move forward because our feet push the road backward.

It should be noted that, although the pairs of action and reaction forces have the same value and opposite directions, they do not cancel each other. This is because action and reaction forces are acted on different bodies.



Action force on the table and reaction force on the book | Action force on the wall and reaction force on the car | Action force on the chair and reaction force on the boy

Figure 7.7 Pairs of action and reaction forces

7.6 Energy

Activity 7. 19

1. Consider the following tasks and discus which task needs energy.

A. Cleaning teeth

B. Running

C. Writing

D. Cooking food using stove

E. Riding a bicycle

2. Where does the energy used to accomplish the tasks come from?

All living things need energy to stay alive and perform different life processes. For example, plants need energy from sunlight in order to make their food. Other organisms get their energy from the food that they eat. Even if we can't see energy, we recognize its existence by observing the changes that the energy caused. This implies that whenever there is a change, there is some form of energy causing the change. Therefore, energy may be described as the ability to cause change. Table 7.1 shows some processes that use energy and their respective changes.

Table 7.1: examples of use of energy and associated changes

Things that use energy	Associated changes
Turning on light in a dark room	The room changes from dark to light
Riding bicycle	The bicycle changes its state of motion
Cleaning teeth	Movement of hand
Lifting book	Change of position of the book

When energy is utilized, it will be converted from one form to another. For example, when somebody is riding a bicycle or cleaning teeth, energy obtained from food will be converted to motion energy. Hence energy can also be defined as a property of matter that can be converted to different forms when it is utilized.

7.6.1 Forms and conversion of energy

Activity 7.20

Assume that you are in a dark room at night.

A. Can you see objects found in the room?

B. How can you see at night?

C. What form of energy is used?

D. Describe the conversion of energy in the lighting of the room?

One of the easiest ways to recognize energy is to know the various forms it can take. All energy is divided into two categories,. These are kinetic and potential energy. Kinetic energy is the energy of motion and potential energy is energy that is stored. The kinetic energy of a body depends on its mass (m) and speed (v). The faster an object is moving, the more kinetic energy it has. And the more massive an object is, the more kinetic energy it has. The kinetic energy of a body of mass m moving with speed v is given by:

$$\mathbf{KE} = \frac{\mathbf{1}}{\mathbf{2}}\mathbf{mv}^2$$

The potential energy of a body depends on its mass (m), height above the ground (h) and acceleration due to gravity (g). Mathematically it is given by:

$$\mathbf{PE} = \mathbf{mgh}$$

Examples

1. How high is an object of mass 2kg from the ground if its potential energy is 40J?

Solution

$$PE = mgh$$

$$\Rightarrow h = \frac{PE}{mg} = \frac{40J}{(2kg)(10m/s^2)} = 2m$$

2. Find the kinetic energy of 4kg mass if it is moving with 4m/s.

Solution

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(4kg)(4m/s)^2 = 32J$$

Energy can exist in different forms. Some of these forms are the following.

Electrical Energy: The energy associated with the movement of electrons.

Thermal Energy: The energy that results from the movement of atoms and molecules.

Sound Energy: The energy produced by the vibration of matter in a medium.

Radiant Energy: It is an electromagnetic energy. Solar energy is an example of radiant energy.

Chemical Energy: The energy stored in the bonds of atoms and molecules.

Nuclear Energy: The energy stored in the nucleus of an atom.

Gravitational Energy: The energy associated with an object's position in a gravitational field.

Mechanical Energy: The energy acquired when work is done on objects.

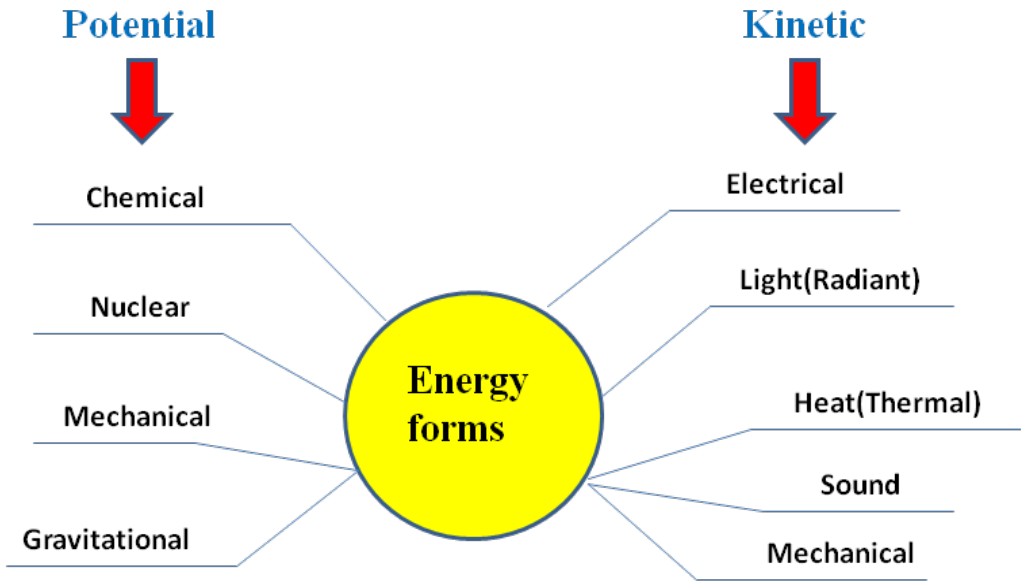


Figure 7.8: Forms of energy

Energy can be changed from one form to another. The change in the form of energy is called energy conversions. For example:

- Plants change solar energy into starches and sugars (chemical energy).
- In an electric motor, electric energy is converted to mechanical energy.
- In a battery, chemical energy is converted into light energy.
- The mechanical energy of a waterfall is converted to electrical energy in a generator.

Activity 7.21

Describe the different forms and conversion of energy in the following phenomena

I. A ball is dropped from your hand and hits the ground

II. Clamping your hands

III. Cycling a bicycle

7.6.2 Source of energy

Activity 7.22

1. In section7.6, you have learned that energy is needed to accomplish different activities. Where does our energy come from?
2. List down some forms of energy and their respective sources
3. Classify the sources of energy you mentioned into two groups based on whether it can be replaced or not?

Many substances and organisms store energy which can then be used. We call them energy sources. Energy sources have energy that is stored within them and can be used to make something happen. For example,

energy stored in petrol can used to make a car to go. Similarly, the energy stored in the foods we eat can help us to do different activities.

There are two main types of sources of energy. These are renewable and non-renewable sources. The energy sources which are limited and will be exhausted after using for a certain number of years is called

Non-renewable sources. Examples of non-renewable sources include wood, fossil fuels (crude oil, coal, natural gas) and nuclear fuels. The second type of sources includes those which provide endless supply. This type of sources is called renewable sources. Sun, wind and water are some examples of renewable energy sources.

7.6.3 Wise use and conservation of energy

Activity 7.23

1. Why do we bother about conserving energy?
2. How can you conserve energy at your homes?

As mentioned earlier, non-renewable energy sources are available in a limited amount. In addition, we are highly depends on these energy sources. As a result, the energy from these sources will finish one day. Therefore, we should think on the wise use and conservation of energy. Energy conservation includes any mechanisms that results in the use of less energy. In addition, we are highly depends on these energy sources. As a result, the energy from these sources will finish one day. Therefore, we should think on the wise use and conservation of energy.

Energy conservation includes any mechanisms that results in the use of less energy. Energy can be conserved at home, working place, schools, roads and so on For example, when you wash your school uniform and other clothes at home, soak them in water overnight. It will be easier to you to wash them in the morning and consequently, you will save your energy. Likewise, you can also save the electric energy you used in schools and at home by the use of energy efficient light bulbs and heaters.

Summary

- Motion is defined as the change in position of an object with respect to reference fame.
- Based on the paths followed, motion can be classified into four: Linear (rectilinear) motion, oscillatory (vibratory) motion, curvilinear motion and rotational motion.
- Linear (rectilinear) motion is a motion of a body in a straight line.
- Oscillatory (vibratory) motion is a motion of a body about its mean potion.
- Curvilinear motion is a motion that is taking place in a curved path.
- Rotational motion is a spinning motion of a body about an axis
- Distance, displacement, speed, velocity and accelerations are some of the physical quantities used to describe motion.
- The total length of a journey that a moving object covers is said to be distance. Displacement on the other hand, refers to the objects change in position.
- Speed is defined as the rate at which an object covers distance. It is a scalar quantity.
- Velocity is a vector quantity which refers to the rate at which an object changes its position.
- Acceleration is defined as the rate at which an object changes its velocity. If the velocity is changing by a constant amount each second, the acceleration is called constant acceleration
- Force represents interaction between bodies in nature
- Forces can be classified into two: contact and non contact force
- Contact forces are forces that exerted when two bodies are in contact
- Non-contact forces include forces exerted between bodies which are not in contact
- Force can change state of motion of a body, size and shape of objects
- All living things need energy to perform different life processes
- Energy can be defined as the property of matter that can be converted into different forms when it is used.
- Energy can exist in different forms such as chemical energy, mechanical

energy (kinetic and potential), nuclear energy, sound energy, heat energy, radiant energy

- There are two main sources of energy: renewable and non-renewable sources.
- Renewable sources are sources which can be replenished or reused
- Non-renewable sources cannot be reused since there is a limited amount available
- Energy conservation involves use of lesser energy for the same level of Activity .

Review questions and problems

I. Answer the following questions briefly and provide reasons for the questions that require justification

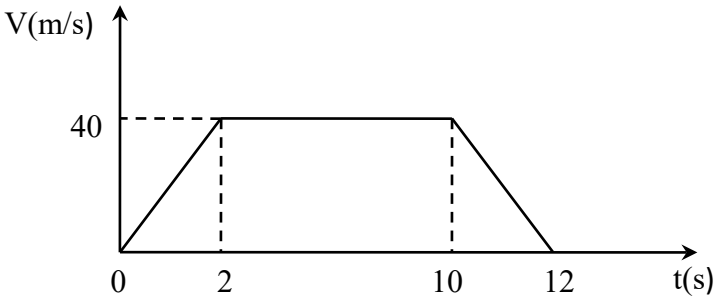
1. The graph below is the speed-time graph of a motion of a body. Answer the following questions based on the graph

   A. In which time interval/s the body was not accelerating?

   B. In which time interval/s does the body accelerate?

   C. In which time interval/s does the body have negative acceleration?

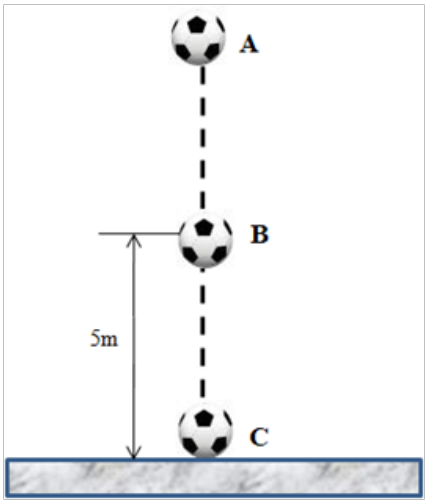
   D. How much distance is traveled by the body in the time interval 2-10 seconds?



2. A ball of mass 0.5kg is released from a height of 10m above the ground as shown in the picture below. Answer the following questions based on the picture. Try to provide reasons for your answers.

   A. In which position/s, the gravity acts on the ball?

   b. In which position/s, the ball experiences a force other than gravity?

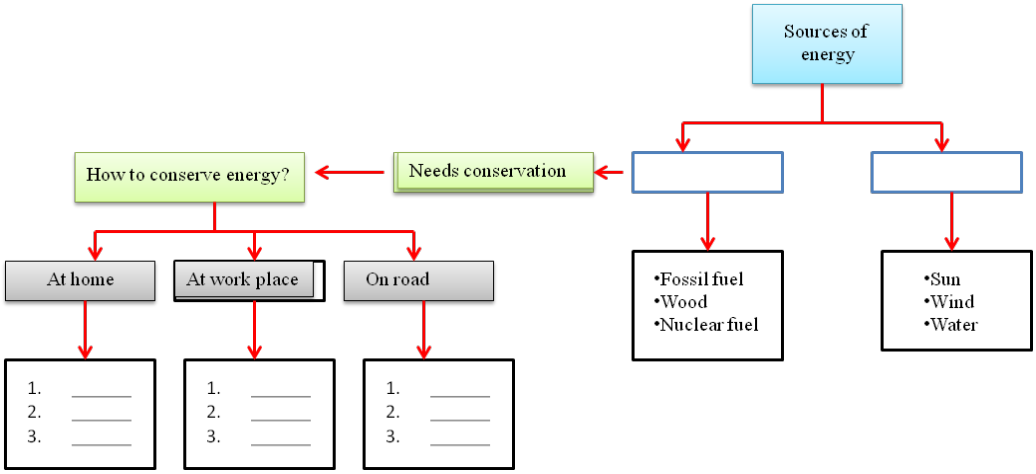


3. If the kinetic energy of a body of mass 2kg is 16J, what is the speed of the body?

4. A Lorry has twice the mass of an automobile, but the automobile drives twice the speed of the lorry. Which vehicle has the highest kinetic energy?

5. Assume that you are playing a football game with your classmates. You are the goalkeeper of your team output the ball on the ground and kick it to your friend who is near the goal of the opposite team. Identify the events where there was energy transfer in the incident. What energy transfers occur in the events?

6. Fill the empty boxes in the following concept map with the correct words or phrases.



II- Chose the correct answer from the given alternatives

7 Which of the following decreases the acceleration of a body?

A. Decreasing force acting on the body

B. Increasing mass of the body

C. Decreasing mass of the body

D. Increasing both force and mass proportionally

8. Which of the following bodies has the largest kinetic energy?

A. Mass 3kg and speed 1m/s

B. Mass 3kg and speed 2m/s

c. Mass 2kg and speed 3m/s

d. Mass 1kg and speed 4m/s

9. A child sitting on a Table is reading a book as shown in the Figure . Consider the following forces.

1. A downward force of gravity on the child.
2. A downward force of gravity on the book
3. An upward forces exerted by the chair.
4. A net downward force exerted by the air.

Which of the forces is (are) acting on the child?

A. (2) only

B. (2) and (3)

C. (2), (3) and (4)

D. (1), (2), (3) and (4)

E. None of these